LUMBERING AND WOOD-WORKING INDUSTRIES

IN

THE UNITED STATES AND CANADA

TOGETHER WITH

NOTES ON BRITISH PRACTICE AND SUGGESTIONS FOR INDIA. [by Frederick Alex. LEETE].

IN THREE VOLUMES.

Vol. I ..	..	Chapters I to VI—Logging.
Vol. II ..	..	Chapter VII—Sawmills.
Vol. III ..	..	Chapters VIII to XIV—Economic Forest Research, Wood-working industries, such as Barrel-making, Plywood, Matches, etc. and a chapter on the Water Hyacinth.

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CHAPTER VIII.

MANUFACTURE OF VENEER, PLYWOOD AND MATCHES.

Section 1.—INTRODUCTION.

168. Plywood is the name given to thin sheets of wood glued together with the fibres in consecutive layers running at right angles to each other. Three-ply is the commonest form in use. The strength of plywood is remarkable. A child could break to pieces a single sheet of wood a sixteenth of an inch thick. A Sandow would have difficulty in doing the same with three such pieces glued together with the grain crossed. The splitting of a single thin sheet could be done with a paper-knife ; the chopping of a bit of plywood would take time with a good sharp axe.

Several years ago the writer paid a visit to the Venesta Factory in London, and the fascination of watching a log being unrolled like a carpet soon developed into keen interest when it was learned that the firm's annual exports of shooks to India exceeded material for a million tea chests.

The interest then aroused has been quickened by the tour in America and particular attention was paid to the subject. It is hoped that the information collected will prove to be of value by indicating the measures necessary to attract private capital or, failing that on reasonable terms, what should be done towards starting departmental operations.

The plywood trade with India is at present in the hands of one or two big firms, which are naturally desirous of fostering their own monopolies. It is however a mistake to suppose that nothing can be done in the trade except on a large scale requiring large capital.

The first stage in the manufacture of *matches* is to peel the timber into thin veneer. As match factories have already existed in India for some years it is rather remarkable that the manufacture of plywood has, up to the present, only been started in one province. In the opinion of the writer, one reason for the slowness of development in both industries is want of systematic research. There appears to have been too much dependence on one or two well known woods and too ready an acceptance of the idea that tropical woods as a whole are unsuitable for manufacture into veneer.

The manager of one big firm, approached by the writer in England, put forward very pessimistic views on the subject, and expressed doubts as to its ever being possible to do much with tropical woods. The writer ventures to hold a different opinion and thinks that prospects are quite good enough to justify the belief that India can find an adequate supply of indigenous woods suitable for the purpose.

But, even if this conjecture proves to be well founded, before *plywood* manufacture in India can be put on a sound basis, further research work in glue is called for. The War has improved matters very considerably in this respect, for research work for aeroplane materials has already led to the almost complete removal of one of the most serious obstacles in the way of the development of the plywood trade, *viz.*, the want of a good and suitable glue *within the reach of anybody.*

Historical Notes.

In the Timber Trades Journal, for 20th March 1914 and 29th June 1918, are very instructive articles on the development of the industry. The use of plywood dates back only about 25 years and is of much more recent origin than the cutting of veneers, which goes back half a century or more. Although the first machines for peeling veneers are believed to have been invented in France, it is to America we must look for the invention of plywood and for the great strides in manufacture that have taken place since it was first introduced to the public in the form of perforated chair seats. Moreover, although the plywood industry has already attained to considerable dimensions in the United Kingdom and in Russia, and is rapidly growing in importance everywhere, most of the machinery *still comes from the United States of America.

Industrial uses of Veneers.

169. In America the extent to which veneers and plywood have established themselves in popular favour is remarkable. In India, plywood is at present only of importance in the form of tea-chests. In America, veneered wood is to be met with in a hundred different forms. Three-ply door panels are replacing solid wood to a large extent ; huge veneered packing cases are common and, to mention an article which comes next to the match-box in smallness, veneer fruit boxes have entirely taken the place of the plaited fruit basket.

It may not be without interest to note that there is all the difference in the world between trunks and boxes made of plywood and those made of wood fibre. Both kinds are so well covered that it is difficult to tell the difference when new, and shopkeepers do not always know the difference themselves, but " Do not buy cardboard if you can help it " is a good rule.

Small sizes of timber used.

Plate XCV will have served its purpose if it helps to bring home the fact that such a large part of the demand for plywood can be met with extremely short pieces of log timber. 12 feet is a maximum and 2 feet is not too small. This point is worth special note because long, clean and straight stems are the exception in the mixed forests of India. Crooked stems and branch pieces can be utilized down to a foot in diameter (see paragraph 174). In ornamental species the twisted grain in burrs and butteresses adds considerably to the value.

170. Examples of the use and manufacture of veneered wood could be multiplied indefinitely ; two are given below.

In a factory in Portland, Oregon, the writer saw the making of a veneered wood drum in which coffee is usually packed for sale. Two thicknesses of veneer are used without being glued together. The operator's machine consists of an iron drum mounted on a horizontal spindle, with a pair of small trimming saws at the sides. The first step is to wind a layer of stout paper on the drum. A sheet of veneer with the fibre at right angles to the axis of the drum is then

* There is one firm in England which makes veneer and plywood machinery (*vide* paragraph 187).

(1). Blocks of Loblolly and Slash Pine, Hickory, Gum, Magnolia and Maple used for Veneer; Bainbridge, Elberta Crate Co., Georgia
(U. S. Forest Service Photo).

(2). Air drying Vegetable Baskets;—Anderson Veneer Packing Co., Charlestown, S. C.
(U. S. Forest Service Photo).

(para 169)

clamped on, and the drum revolved. This is followed by a second sheet with the fibre parallel to the axis. Three veneer strips or bands are then rolled on with a good overlap. A tinned strip placed on the free end of each band keeps it from splitting, when a couple of nails are driven in and rivetted. The two little saws at the sides are then raised and, as the drum revolves, trim the ends of the tube clean and square. Solid wood ends are put in after removal from the iron drum.

171. The ordinary plywood tea-chest is held together by tinned strips of metal rivetted along all the edges. Solid wood battens serve the same purpose in packing cases. In the factory of The Laminated Materials Company, New Westminster B. C., the writer had an opportunity of seeing a new plan, the binding strips being themselves made of plywood. The glueing is done whilst the veneer is still wet and plastic. Strips are pressed and dried in L-shaped frames. After being dried they retain their shape and can be nailed on as usual. Another unusual feature in this factory is the peeling of the logs without preliminary steaming or boiling.

Section 2.—RESEARCH IN TIMBER AND GLUE.

Research in Glue.

172. It has already been remarked that the War has led to great developments in the manufacture of glues suitable for plywood. Research work has been vigorously prosecuted on both sides of the Atlantic and the results achieved are of immense value. Further details are given in a separate report and here it is only desired to make a few general remarks.

Prior to 1914, the only known glues suitable for plywood were proprietary articles, the trade secret of which was jealously guarded by the firms concerned. To-day, thanks almost entirely to the work done for the Allied Governments in England and America, not only is the secret of the composition of these glues no longer the exclusive possession of a few monopolists but the formulæ have been considerably improved upon. It is probable that the results will be made public, so that it is substantially correct to state that anyone can now hope to engage in the manufacture of plywood without being under the necessity of having to pay what might prove to be prohibitive royalties to one or two firms in Europe or in America.

But extensive research work still remains to be done before the problem can be said to be completely solved, and this is especially true in respect of plywood manufacture in India. Climate has a great deal to say in the matter of glues. For example, it is believed to be a fact that one of the best waterproof glues in use in England to day is not at all suitable for a tropical country like India.

The writer strongly recommends therefore that the matter be given a prominent place in research work at Dehra Dun in the near future. Moreover, stress is laid on the desirability of the research being conducted by Government. Any idea of leaving it to private initiative is to be deprecated, for it would be bound to retard progress and it would tend to foster monopolies.

The basis of one of the best waterproof glues in use in England and America is *Casein*, a substance obtained from milk. Fully half the total amount used in the States comes from South America, but the balance and fully 60 per cent. of the British supply comes from India. Owing probably to crude methods of manufacture the Indian supply is not of as good quality as could be desired, a fact which constitutes another strong argument in favour of further research in India. Not only would the prospects of industrial development in India be thereby improved, but the export trade in the raw product would also be stimulated.

Indian Timbers suitable for Veneers.

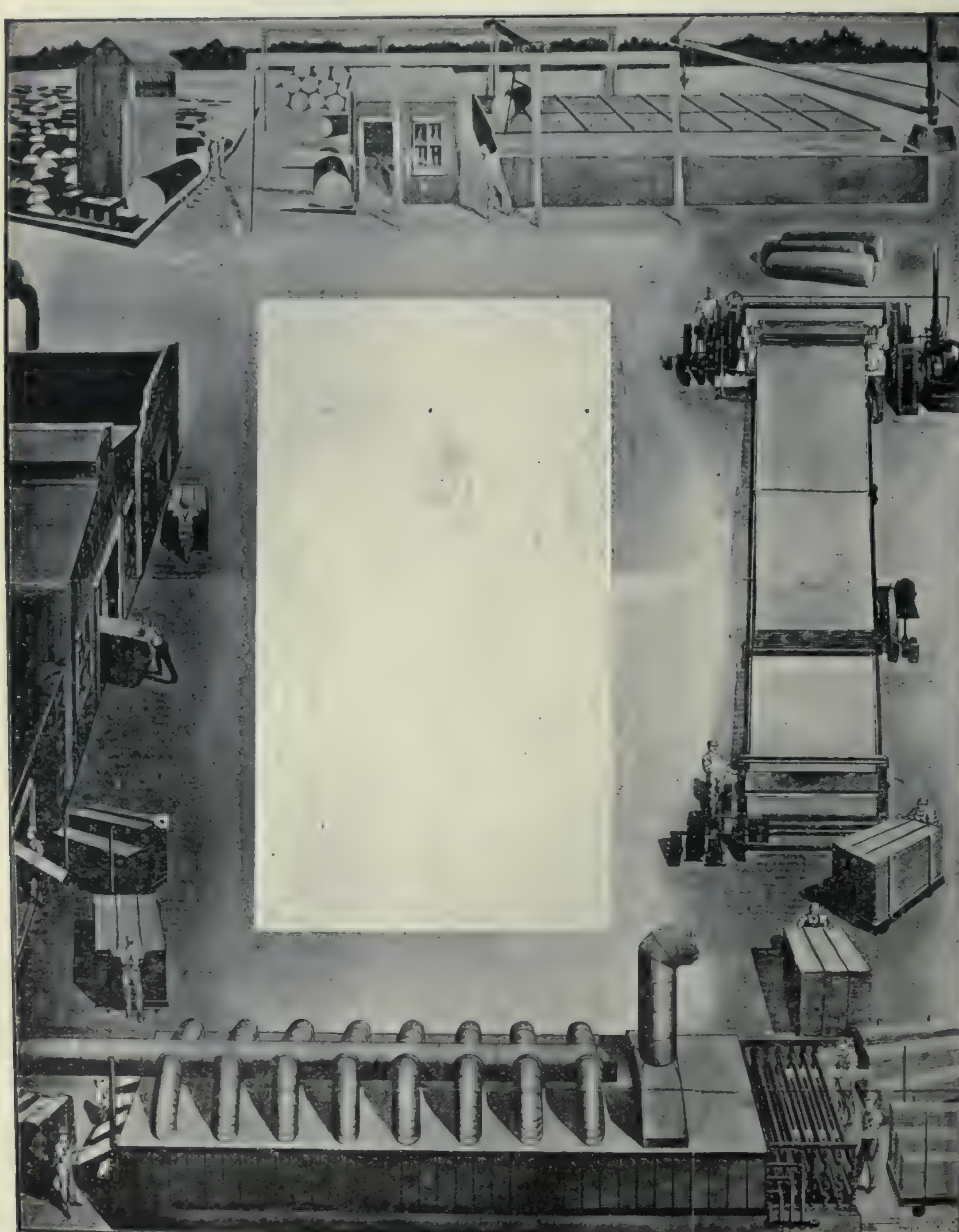
173. It is not only in respect of glue that research work could be carried on with advantage at Dehra Dun, but the Institute should also be equipped for practical study of Indian timbers for veneers. There are two other ways of attaining the same object, but neither of them is to be recommended. Samples of woods could be sent to England for testing. This has already been done in a spasmodic sort of way, and chiefly with negative results. It is far too slow and laborious a way of getting anything done. Moreover, it is open to the serious objection that the woods cannot be tested green, a matter of great importance, as veneer peeling is usually done as soon as possible after felling.

Tests in veneer peeling could doubtless be done in match factories that already exist in India. In spite of this, the writer still holds that it would be better for the Government of India to be independent rather than to be under obligations to any one firm, especially as there seems to be plenty of room for more than one firm to operate in the country. Competition should therefore be as free as possible.

174. The value of a wood for plywood purposes depends on its possessing the following characteristics, *viz.*, strength, freedom from smell and objectionable colouring matter, straight grain and a weight between 40 and 50 lbs. dry. Although the importance of the first three items depends to some extent on the use to which the veneer is to be put, this cannot be said of weight or density, and it will save a lot of trouble if officers reporting on forests, or sending in samples for testing, bear in mind that very few of the species which will not float are likely to be of any use.

In America this detail is not of much importance, because there are only one or two species with a specific gravity heavier than that of water. In India the case is very different, and, on account of weight alone, fully half the species can be ruled out at once.

There are exceptions to this rule. Species with an appreciable thickness of sapwood need not be rejected because of a heavy heartwood. Peeling with a rotary cutter has to be stopped in any case when the diameter has been reduced to about ten inches. The cores that are left are of no further use to the veneer manufacturer, and it is usual to turn them into lath, battens, small sleepers, etc., with a small circular saw. The size of the core depends on the class of timber for which the rotary cutter is designed. For a factory dealing with large logs, 4 feet in diameter or more, the lathe dogs must necessarily be very massive and take up a diameter of 10 to 12 inches. On the other hand, in a match factory such as that of Messrs. Bryant and May in London visited by the writer, none of the logs used are more than 18 inches in diameter and the majority of them are under 12 inches. The



Diagrammatic view of a Veneer Mill. (Wringer not shown).
(By permission of Messrs. The Coe Manufacturing Co.).

(para 176).

lathes are therefore very small and the dogs do not take up more than from 4 to 6 inches of diameter. This detail is mentioned because in an industry like match making, which largely depends for success on an extremely cheap supply of raw material, too great insistence on a full supply of logs of uniform diameter is not likely to be practicable in India. The factory should be equipped for economical utilisation. The writer has heard of one match concern in India which made the preposterous demand that the logs supplied to it should be not more than eight feet or less than 4 feet in girth, and not less than 8 or 10 feet in length.

175. It is to be remembered that veneer cutting and plywood manufacture can be and often are treated as quite separate industries. Some firms make veneer stock only, which they sell to firms in other parts of the world, by whom it is worked up into articles of commerce. The testing of timbers can be conducted quite independently of research in glue. After peeling, it would be a simple matter to send samples of veneers to England or America.

SECTION 3.—VENEER MACHINERY.

Veneer Machinery.

176. There are three known ways of cutting veneers. They can be (1) *Sawn*; (2) *Sliced*; or (3) *Peeled*. In the first method, extra thin saws are used. For slicing purposes there is mechanism for causing a massive knife to travel across the face of the block of wood. In some machines the knife runs in guides and the block remains stationary; in others, it is just the reverse.

Sawing and *Slicing* are principally confined to heavy and ornamental hardwoods such as mahogany, etc. It is safe to say that the veneer trade would never have developed to its present proportions if no other method of cutting had been invented. The importance and huge dimensions of the industry are entirely due to the discovery that almost any kind of wood of moderate hardness can be peeled, that is, it can be opened out like a roll of carpet or bale of paper.

A good idea of the general appearance of a veneer factory can be obtained from Plate XCVI. The series of operations is as follows:—

1. Cross-cutting of logs to stock lengths.
2. Boiling or steaming.
3. Peeling.
4. Clipping veneer to size.
5. Wringing out moisture.
6. Drying.

Steaming or boiling.

177. The writer only came across one instance (paragraph 171) of logs being peeled without preliminary treatment. Speaking of the industry in general, it may be said to be the almost universal practice to boil or to steam logs before sending them into the veneer mill. The time required is usually from 24 to 96 hours. For boiling steam heated vats are used, with flap lids and overhead lifting apparatus. For steaming a closed room something like a dry kiln is used. Boiling is the commoner method.

Rotary Veneer Cutter.

178. The machine used for peeling is nothing more than a lathe of a special type (Plate XCVII). The wood, in the form of round billets (*Bolts*), is mounted between the centres of the lathe, with powerful dogs at both ends. In front is a long knife mounted on a special type of compound slide rest, which is geared to the mandrel, so that the knife steadily advances towards the bolt by a known amount at each revolution.

Provided that the motive power is strong enough and that nothing gives way, it is obvious that a short log of wood can be literally unrolled like a piece of carpet. To a novice the length is amazing. Suppose, for example, logs 3 feet in diameter are being cut into stock one-sixteenth of an inch thick for tea chests. By the time the diameter is reduced to 12 inches, the length of the roll of veneer would not be far short of a quarter of a mile. Again, suppose that the logs are small ones, only 15 inches in diameter, and that the sapwood (3″ thick) is the only part that can be used. In theory, they would yield 130 running feet of veneer. In actual practice the length would, of course, not be so great in either case. A good deal of waste is unavoidable on the outside and deductions must be be made for knots and other internal defects.

A rotary cutter can hold logs of varying lengths. On the forward (delivery) side of the machine are adjustable cutters, by means of which the veneer can be trimmed to an even width, and can, if desired, be separated into two or more narrower widths. If logs of good length are obtainable, it is better to do this than to cross-cut the logs into shorter lengths, (corresponding to the desired width of veneer), and to put each piece through the machine separately.

Clipping Machine.

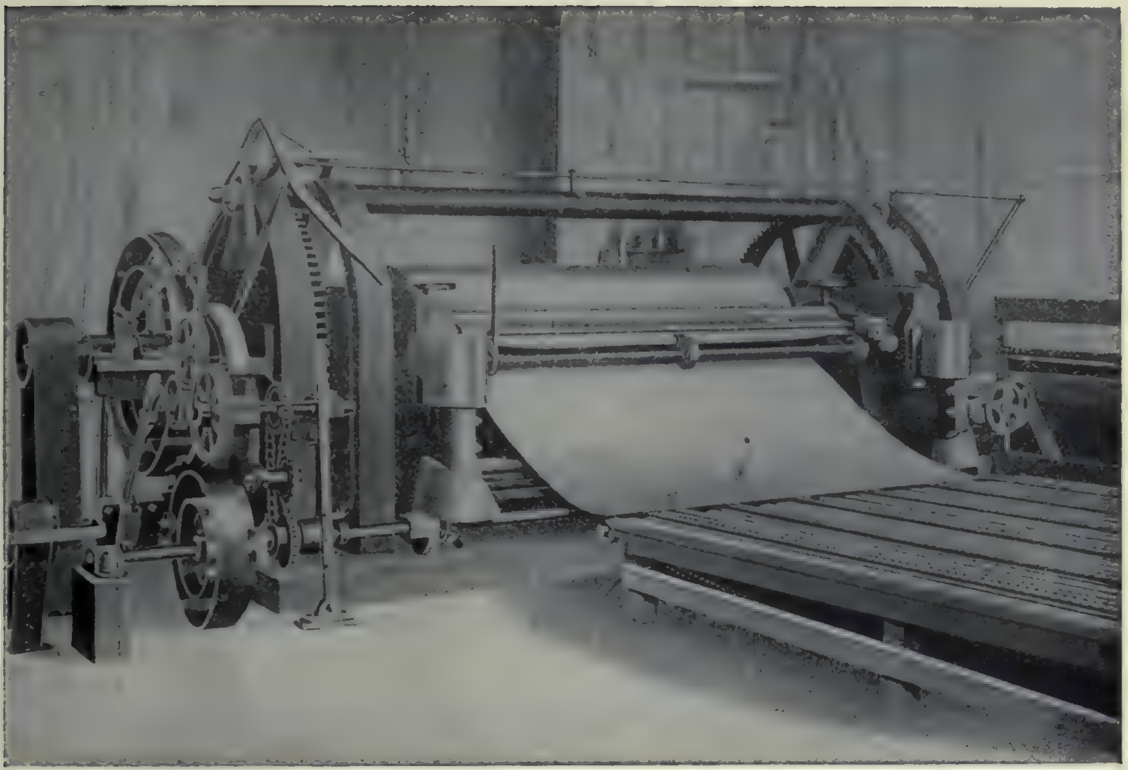
179. Beyond the rotary cutter is a long table provided with endless travelling chains, to carry the sheets of veneer forward as they are unrolled. At the end of the table is the *Clipper*, a machine fitted with a long knife having up and down motion, for cutting the veneer into stock widths [Plate XCVIII (1)]. Clippers range from the heavy power driven type to the small foot pedal machine. In a laboratory, the latter would be large enough.

Drying.

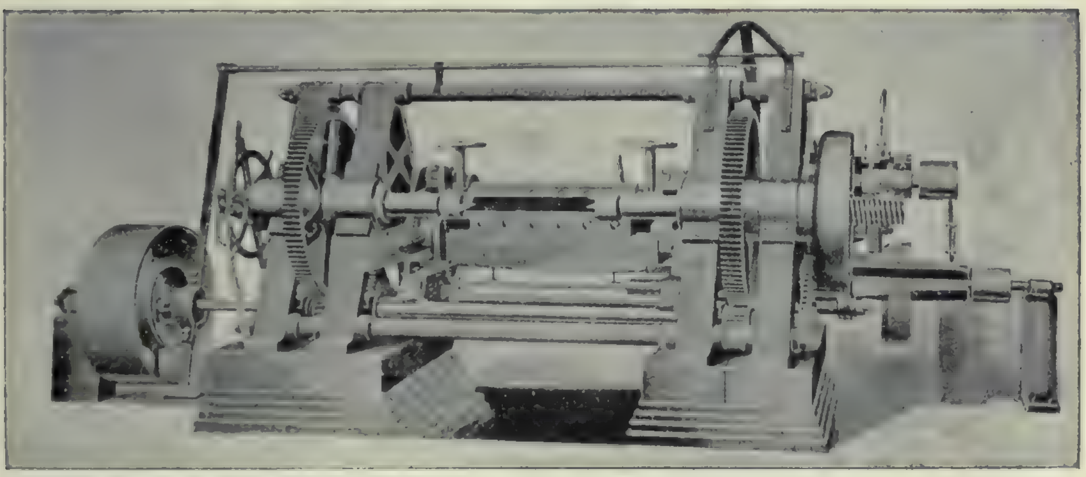
180. After being clipped to size the sheets of veneer are passed between a pair of rolls in a *Winger* [Plate XCVIII (2)], to squeeze out as much as possible of the moisture, and then they are thoroughly dried. The apparatus employed is of the following types :—(1) *Roller Machines*, (2) *Hot Plate Machines and* (3) *Open Racks*.

Roller Type Drying Machines.—The three best known patterns are—The Coe, The Proctor and The Smith.

The Coe Drier (Plate XCIX) is a long rectangular enclosed structure containing a number of pairs of power driven steel rolls. A powerful current of dry hot air is kept in circulation by means of a centrifugal blower. The distance between the upper and lower rolls automatically adjusts itself, so that sheets of varying thicknesses can be dried simultaneously.

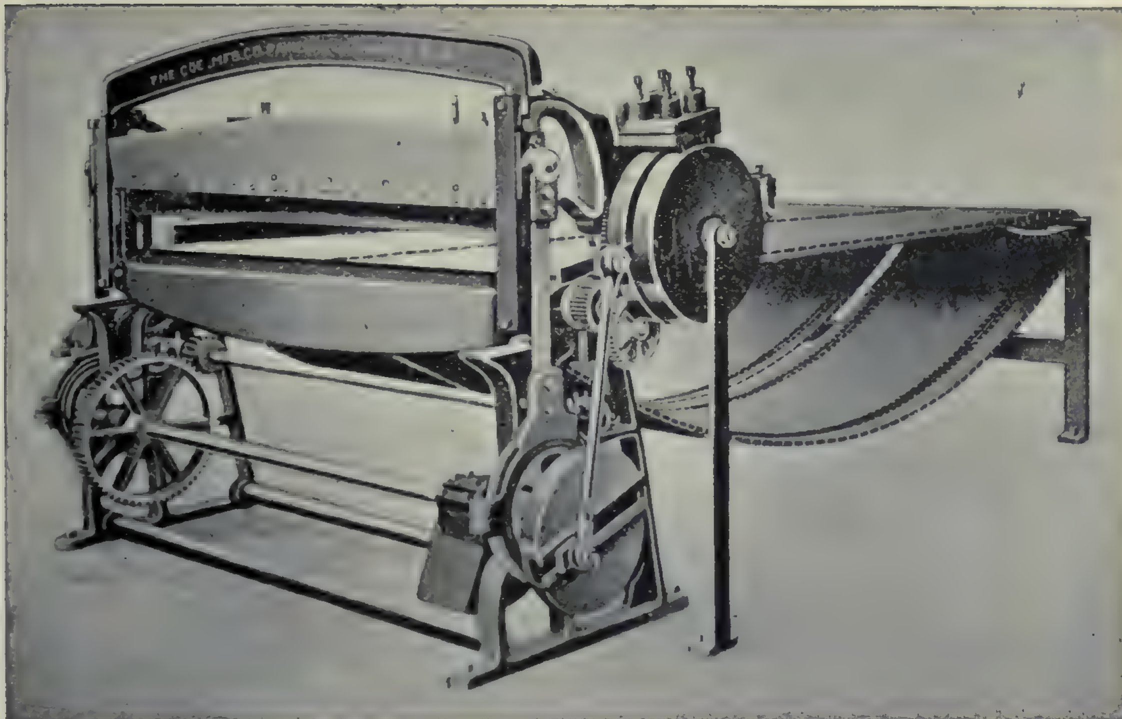


(1). Rotary Veneer Cutter, showing chain Conveyer table for carrying the Veneer forward to the Clipper.

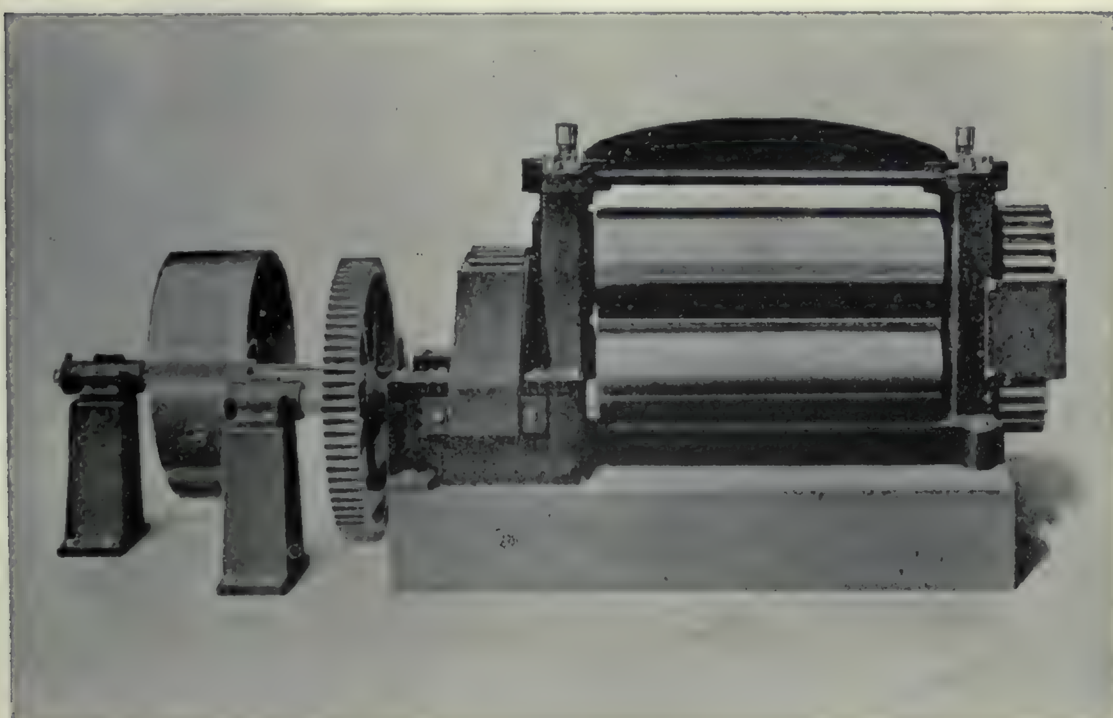


(2). Rotary Veneer cutter from the back, showing Dogs.
Diameter of Spindle 5″; Diameter of Swing 42″; Knife of any length up to 84″.
(By permission of Messrs. The Coe Manufacturing Co.)

(para 178).



(1). Veneer Clipper. Stock is fed to the machine from the right on the conveyer table ; length of knives 36″ to 76″.



(2). Veneer Wringer for squeezing out surplus moisture.
(By permission of Messrs The Coe Manufacturing Co.).

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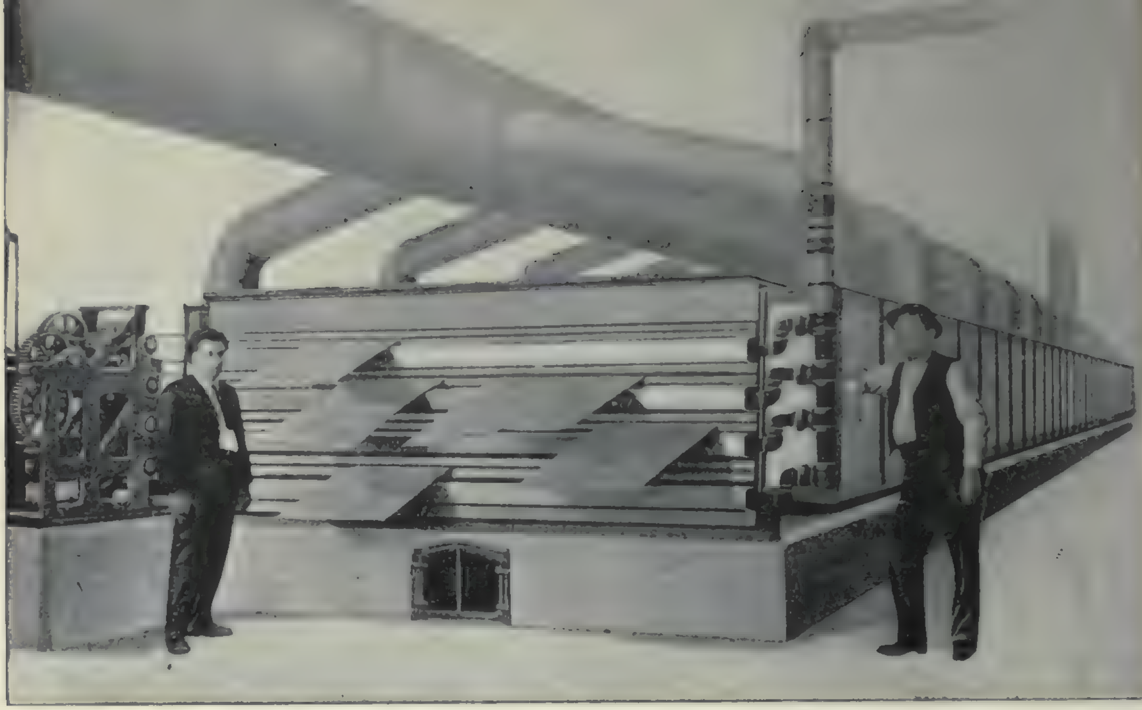
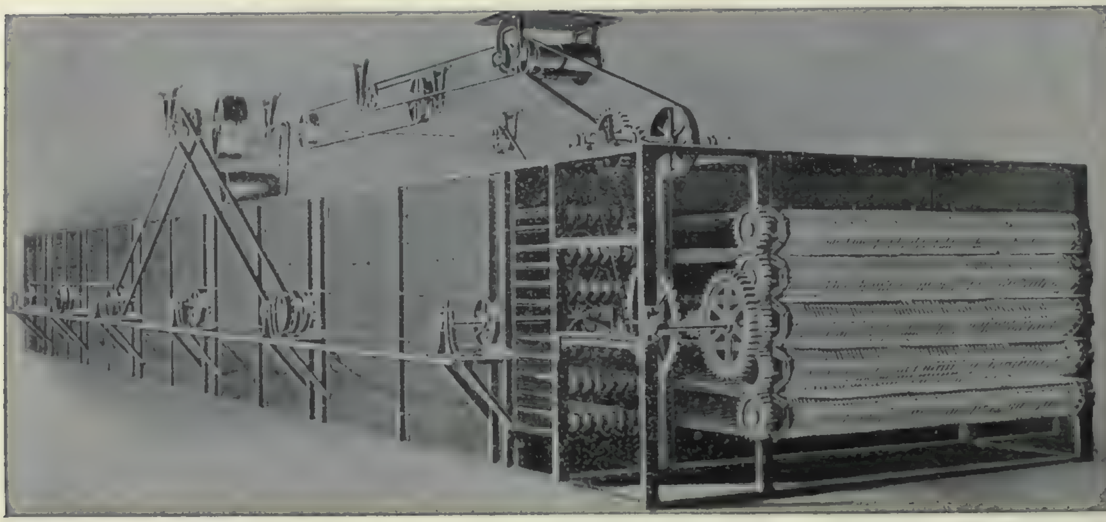
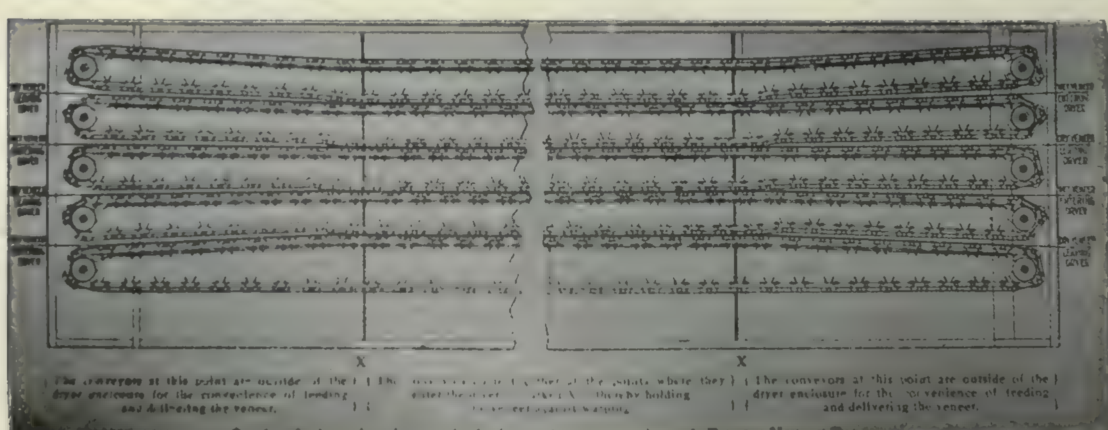


(1). Coe Veneer Drier.
(By permission of Messrs. The Coe Manufacturing Co.).





(2) Proctor Veneer Drier. Diagrammatic sectional view below.
(By permission of Messrs. The Philadelphia Textile Machinery Co.)

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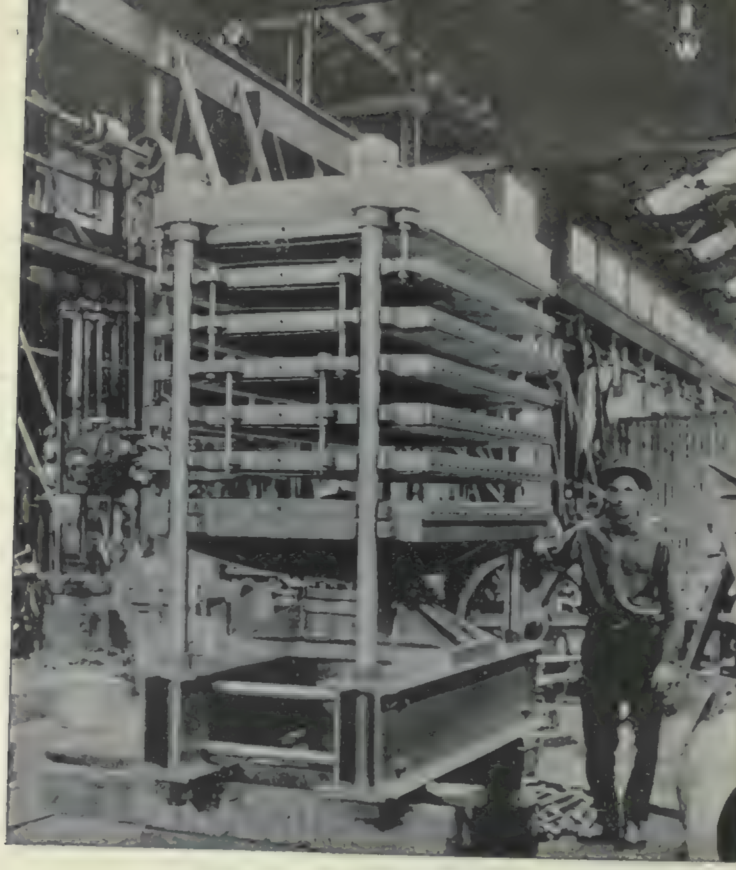
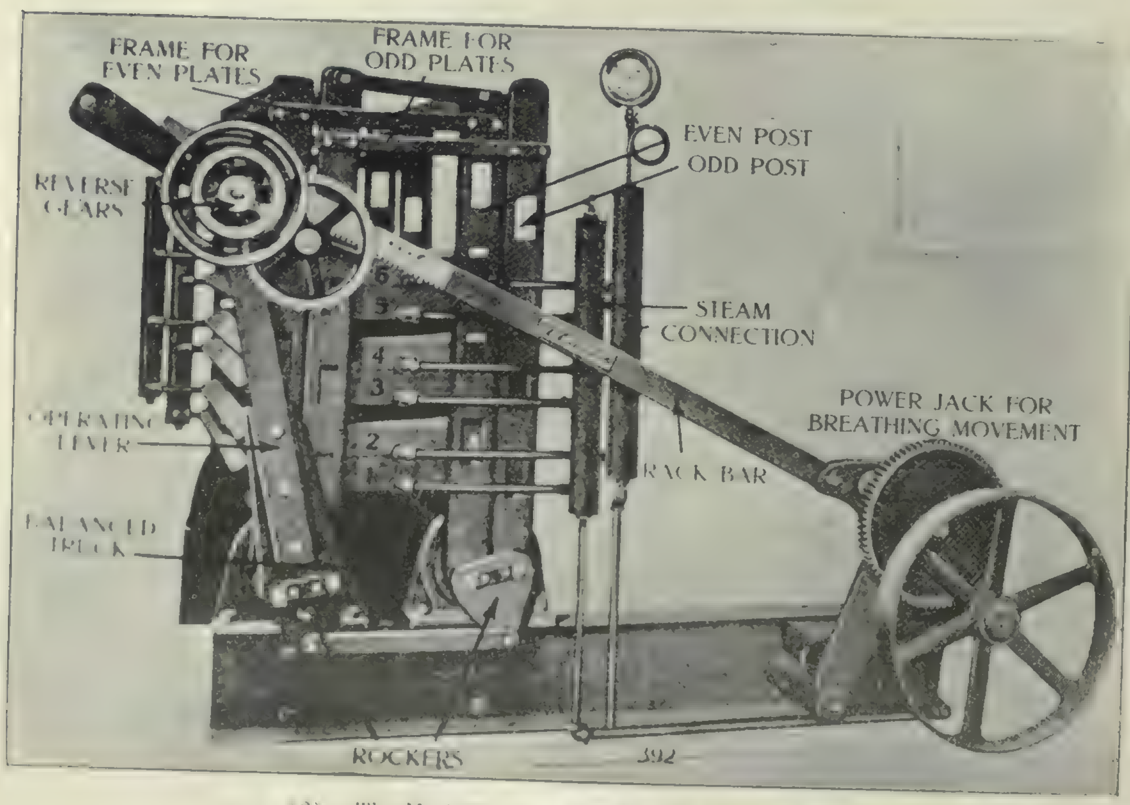


(1). Hydraulic Hot Plate Drier.
(By permission of Messrs. The Vancouver Engineering Works Co., Vancouver, B. C.)



(2). The Merit Balanced Hot Plate Veneer Drier.
(By permission of Messrs. The Merritt Manufacturing Co.).

The Proctor Drier (Plate XCIX) is much the same as the Coe type in outward appearance, but the series of rolls is replaced by endless wire conveyers in pairs. Veneer stock is fed into the machine from both ends. Heating is done by means of steam pipes inside the drier, and circulation is effected by means of a fan.

The Smith Drier is also of the box type. The veneer is drawn across a number of hollow steel plates heated by steam, by means of power driven rolls.

The Hot Plate Drier (Plate C) consists of a number of hollow steel plates in pairs and heated by steam, between which the sheets of veneer are squeezed. But it is to be noticed that if the pressure were kept on continuously during the whole of the drying process the veneer would have no chance to shrink and would therefore inevitably split itself to pieces. In order to allow for shrinkage, the machine is provided with power mechanism for automatically opening and closing the series of plates like a concertina. The motion is fairly rapid, (2 to 4 seconds), and drying is very quickly effected, taking from 2 to 5 minutes according to thickness. It is to be noted that the veneer remains stationary whilst being dried. It does not move as in the machines previously described.

The Open Rack Type of Drier is a much simpler affair. No pressure is applied. In the factory visited at Bogalusa, La, the racks are mounted on trolleys run into and out of a dry kiln of the ordinary compartment type.

In a factory visited in London, drying is done in an ordinary room containing a number of shelves or racks made of half inch steam pipes, placed close together in rows about four inches apart, and covered with plain iron sheeting.

It takes about half an hour to dry veneer by this method. The extra length of time is not a matter of importance as the apparatus is very inexpensive compared with either of the pressure types already described.

A certain amount of cockling or curling is unavoidable if drying is done without pressure, but it is of no consequence if the veneer is not too thin, say not less than one-thirty seconds of an inch.

SECTION 4.—PLYWOOD MACHINERY.

181. In the manufacture of veneer into plywood there are four sets of machines, *viz* :—(1) *Glue Spreader*, (2) *Pressing Machine*, (3) *Trimmer* and (4) *Sander*.

Plywood Manufacture.

The *Glue Spreader* Plate [CI (1)], consists of a pair of rolls which are kept covered with a layer of glue. Sheets of veneer passed through the machine become coated with glue on both sides. As the sheets come from the machine they are piled on a truck alternately with two clean sheets. Two men work together, one of them (wearing gloves) places a sheet of veneer smeared with glue on the truck, then the other places two clean sheets on top, and so on.

The Francis Press is the most popular make in America. Plate CI (2) shows a pattern in which the pressure is applied by hand (with the use of a wrench) to each of the screws in turn. The pressure is applied in the middle first of all, in order to expel air and avoid forming "pockets." The larger types of press are hydraulic.

After the desired pressure has been reached, screw clamps are put on to the pile, so that it can be bodily removed from the press and left to cool and set. The clamps are generally left on for a whole day.

The Trimmer is similar in miniature to the two trimmer table in a sawmill. The design of the trimmer depends on the stock sizes cut.

The last stage in the manufacture of plywood is to put the sheets through a sanding machine to clean the surface and give it a smooth finish. There are various designs of machines for the purpose. In one type the abrasive material is on rollers. In another it is on an endless belt.

In a factory which only makes veneers, drying by either of the methods described in paragraph 180 obviously must be done before the veneer can be stored or sold.

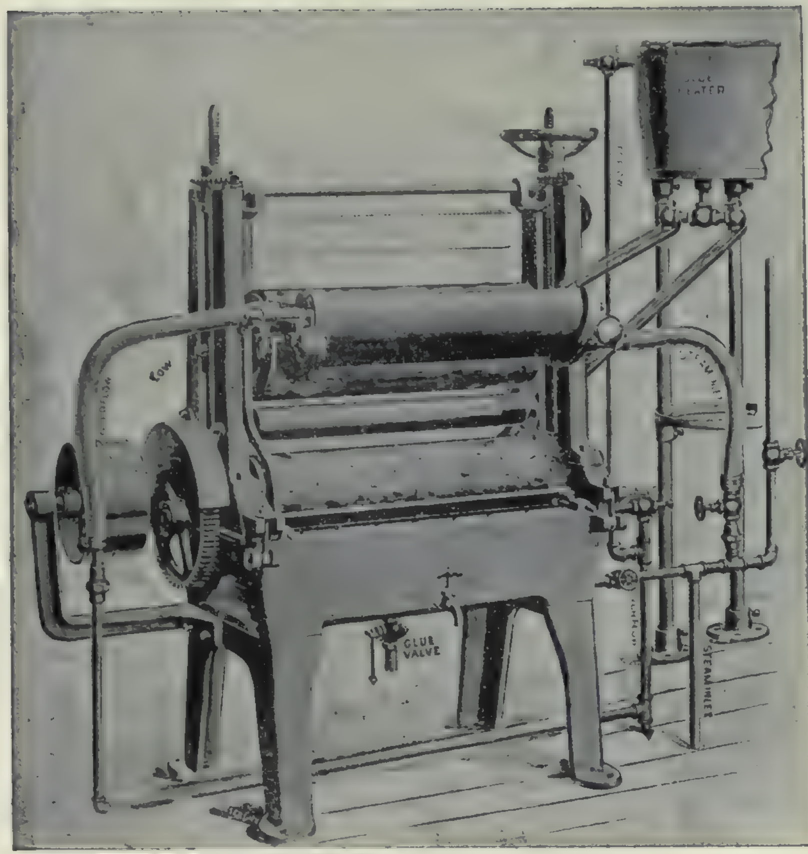
In a factory which manufactures *high class* plywood from purchased veneer stock, some provision is necessary for re-drying. Any of the kinds of driers already mentioned would of course answer the purpose, but the compartment kiln type is usually adopted, because of the smaller cost of installation. At a large factory in London, the writer saw a battery of several compartments under construction. The plywood will be piled endwise on crate-like trucks, with battens or " stickers " between the sheets. A current of heated air will be sent through the rooms by means of fans.

In a factory which manufactures its own veneer direct into plywood the arrangements for drying depend a good deal on the nature of the adhesive used. The method of maufacture is known as the " *Hot Process* " or the " *Cold Process*," according as the glue is applied hot or cold. In the case of the Cold Process, the veneer must be dried before it is glued. This is not necessary in all cases in which the Hot Process is used. An example was seen at New Westminster, B.C., *vide* the remarks in paragraph 171.

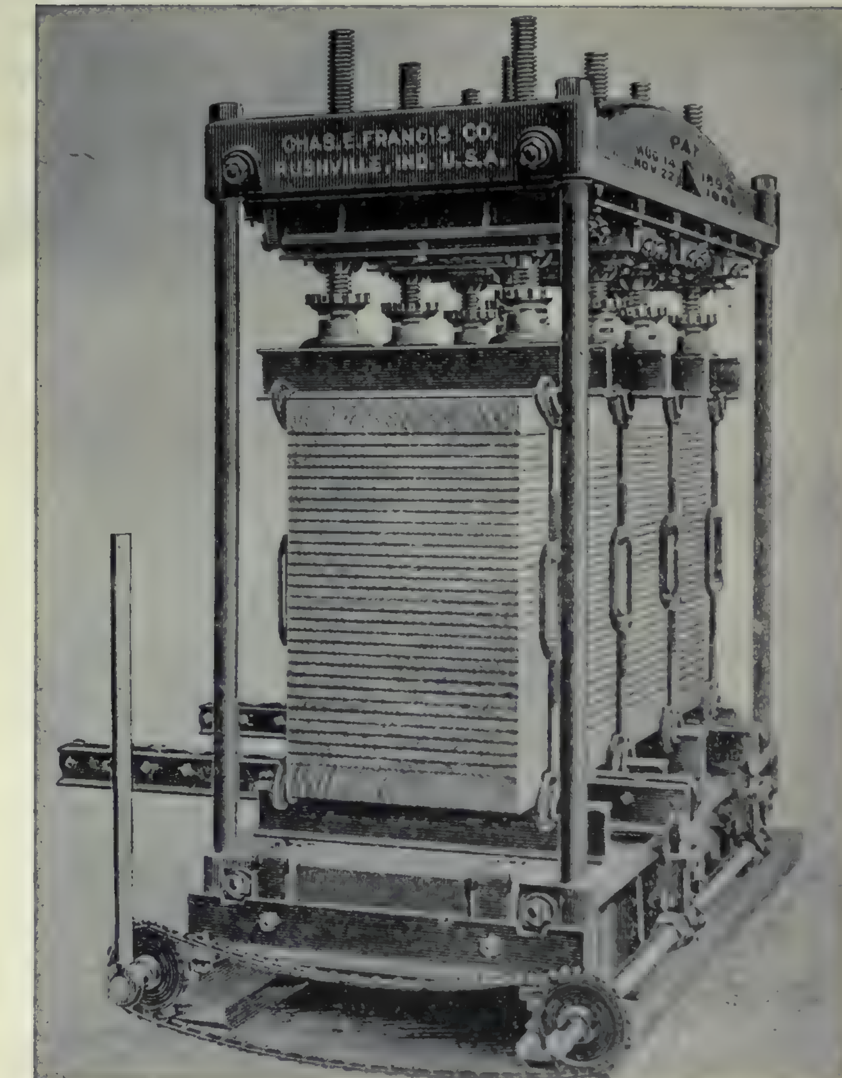
182. The foregoing descriptions hold good for all the Western veneer mills visited by the writer, *viz.*, 2 in the Southern States, 1 in California, 1 in Oregon and 2 in British Columbia. A question may very well be asked with regard to them as to what becomes of the odd pieces of veneer that are too small to cut to stock sizes. The answer is that they are wasted. The supply of raw materials is so cheap and plentiful that manufacturers cannot be bothered with the small stuff. The waste is therefore deplorably heavy in many factories and may amount to as much as 40 per cent. This is not however the case everywhere in the States and it certainly cannot be said of plywood factories in England. Moreover, it does not apply to the more valuable veneer woods.

The method of utilising small stuff is very interesting to watch. Suppose, for example, there are two pieces long enough but not wide enough to make up a stock size, (*e.g.*, box shook). They are put through two machines. The first, or *Jointing Machine*, has a little roller feed saw which trims one edge of each piece absolutely straight. They are then ready for the second or *Taping Machine* (Plate CII). Bringing two pieces together, side by side, the operator passes them through the machine between a pair of flat faced wheels carrying gummed tape. This unites them into a single sheet which can be dealt with subsequently in the usual manner. After the finished plywood has been cleaned in the *Sander* it is next to impossible to detect the join.

Plate CI.



(1). Double Glue Spreader and Heater.



(2). Francis Hand Veneer Press with retainers and unloading device.

(By permission of Messrs. Charles E. Francis Co.).

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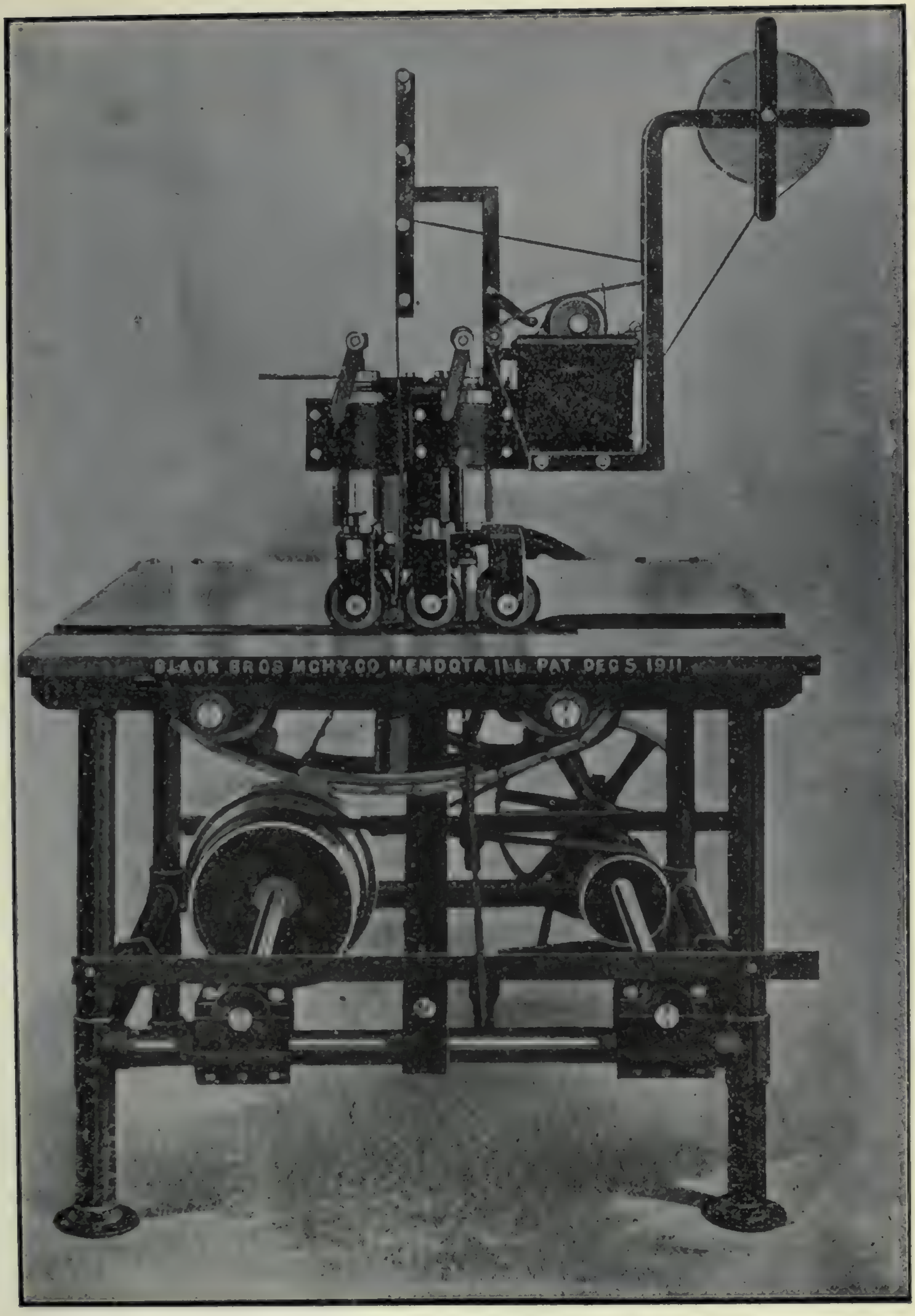

Veneer Taping Machine
(By permission of Messrs. The Black Bros. Machinery Co.).

(para 182).

183. The foregoing description is probably complete enough to show that considerable latitude as to the scale and scope of manufacture is possible. A firm can, if it likes, go in for making both veneer and plywood in a single factory on a large or on a small scale, or it can have two quite separate factories far away from each other, or it can confine its operations to either branch of the trade. It is quite possible, for example, that it would pay in India to have the veneer mill in the woods and the plywood factory in the Tea Garden. Further, extremes of humidity and temperature are to be avoided in making plywood, and so the choice of sites for this part of the industry is more restricted than for the other one.

Size of Factories.

The factory visited at Weed, California, and equipped with one Rotary Cutter, Clipper, Proctor Drier, Francis Glue Spreader and Press, Trimmer and Sander, cost $60,000 (Rs. 1,80,000) to erect and has a daily output of 25,000 square feet of $3 \times \frac{1}{8}''$ plywood cut to stock sizes.

At Helena, Arkansas, a veneer mill (not plywood) was visited which is equipped with two Rotary Cutters and Clippers and one Proctor Drier. The mill was said to cut up 25,000 B. F. of logs a day, and the waste in conversion was said to be from 20 to 40 per cent. The higher figure is reached when orders for large quantities of special sizes have to be met. The mill finds employment for 130 hands, mostly boys and girls.

The small veneer mill seen at Bogalusa, La, and equipped with one Rotary Cutter, Power Clipper and Foot Clipper and open rack dry kiln, has a daily output of 18,000 square feet. The kiln is the biggest part of the plant. The foot clipper is for trimming after drying.

Section 5.—MATCHES.

184. As matches are made from veneer stock, the few remarks it is desired to make may be included in the present chapter.

Match Making.

It goes without saying that match making lends itself to sub-division into two parts just the same as plywood.

Splint Factories should, as a rule, be located as near as possible to the forest or other source of supply. Freight is thereby saved, as the waste is heavy, amounting to as much as four-fifths of the weight of the logs. Moreover, it is desirable to do the veneering as soon as possible after felling, and whilst the wood is still green. The same argument applies to match boxes and packing cases. Only the putting on of the heads should be left to be done at the *Central Factory*.

Machinery for automatic box filling is not recommended, as it is both complicated and expensive. As labour is so cheap in India hand filling would probably be preferable.

In Sweeden, 24 cubic feet of good quality wood (measured in the round) is required to produce one million matches. With wood of poor quality the quantity of it required to produce the same number of matches may be anything up to double this amount. Logs should not be less than 10 inches in diameter.

The only firm interested in the manufacture of matches in America with regard to which the writer could get any information, was the American Splint Corporation, New York. This firm was started after the outbreak of the War, primarily to supply splints to the French Government. The Corporation is prepared to quote for machinery. The smallest plant likely to pay is one estimated to be capable of turning out 100,000 boxes (× 60=six million matches) a day.

Bryant and May's.

185. The most striking impression conveyed by a visit to Messrs. Bryant and May's Match Factory in London was the excessive amount of waste in nearly every stage of manufacture.

At least half an inch of every log (bolt) put into the rotary cutters is wasted, as the veneer is rejected until it comes off in clean sheets of full width. The floor all round the splint cutting machines is littered with splints which are swept up and go to feed the furnaces ! The box making machines are fed so fast that a fair number of badly shaped boxes are produced, and thrown away !!! The worst offenders of all are perhaps the box-filling machines. A girl feeds empty boxes to an endless belt. As the boxes move forward they are first of all automatically opened and then filled. Now and again a match sticks and the box passes forward improperly filled. A girl is kept fully occupied in pulling these " duds " off the belt and throwing them into a waste basket, likewise to be burnt. Whilst the writer stood by fully 20 per cent. of the boxes and matches were wasted in this way.

In India at any rate there should be no room for such waste of good material. As labour is so cheap it ought certainly to pay to recover, by hand sorting, a good deal of what is rejected by the machines.

In Messrs. Bryant and May's factory square matches are made from the log in the usual way. The wood is first of all peeled on a rotary cutter and the sheets of veneer are then stacked by hand into piles about 6″ high. The piles are then placed in a vertical slicer (similar to a veneer clipper) which cuts them into splints.

The making of round splints (" Swan Vestas ") is done in a different manner. Blocks of pine wood about 12″ × 3″ and 1½″ thick (*i.e.*, in the direction of the grain) are imported from America. These blocks are put into machines which punch or split them into matches. The waste in doing so is said to be very small. The " Groove " in the sticks, which is very much advertised, helps in this direction.

The cores about 9″ in diameter left from the Rotary Veneer Machines are worked up into Excelsior or Wood Wool (*vide* paragraph 207).

Section 6.—MANUFACTURERS OF VENEER AND PLYWOOD MACHINERY.

United States of America.

186. Coe Manufacturing Company, Painesville, Ohio.
Blakerslee Manufacturing Company, Birmingham, Ala.
Merritt Manufacturing Company, Lockport, New York.
St. Joseph Iron Works Company, St. Joseph, Mich.
Black Brothers Machinery Company, Mendota, III. (taping machine)

Glue Room.

Chas. E. Francis Company, Rushville, Ind. (Machinery for glueing and pressing).

Mattison Machine Work Company, Beloit, Wisc. (Sander).*

Veneer Driers.

Coe Manufacturing Company, Painesville, Ohio.

Philadelphia Textile Machinery Company, Philadelphia, Pa.

Elmer S. White Company, Philadelphia, Pa.

Merritt Manufacturing Company, Lockport, New York.

Boomer and Boschert Press Company, Syracuse, New York.

Charles E. Elmer Engineering Works Company, Chicago, III.

Canada.

Vancouver Engineering Works Company, Vancouver, B. C.

United Kingdom.

A full line of Veneer and Plywood machinery (Cutters, Glue room equipment and Plate driers), is manufactured by :—

John Pickles and Son, Hebden Bridge.

Match Making Machinery.

American Splint Corporation, 141 Broadway, New York.

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* Sanding machines are also made by most of the United States Manufacturers of Re-saws, etc., listed in paragraph 212.

CHAPTER IX.

MANUFACTURE OF BARRELS (COOPERAGE).

Section 1.—INTRODUCTION.

Introduction.

187. As India has depended hitherto for its supplies of barrels on imports, the War soon made itself felt by cutting off the supplies and, later on, it stimulated efforts to meet the demand by local manufacture. It is hoped that the notes here given will prove to be useful, although they are not as complete as could be desired.

The writer did not pay much attention to the subject in the earlier part of his tour in America, and it was not until after leaving for the Pacific Coast that it was realized that the manufacture of staves in America is practically confined to the Central and Southern States. There is believed to be none at all in Canada.

Further, the greater part of the chapter was written under the impression that most of the barrel making in England is done by hand. This is indeed what the writer was told by a trade journal, and a visit to what was thought to be a machine barrel factory confirmed this impression. The factory was found to have closed its doors, and the liquidator curtly informed the writer that he did not believe in machine barrel making at all.

Later on it came as a very great surprise to learn that the position at home is very different indeed to what might be supposed from the foregoing remarks. Over 95 per cent. of the barrels are machine made.

It is now over fifty years since Messrs. A. Ransome and Company, Newark-on-Trent, commenced the manufacture of cooperage machinery. Thanks almost entirely to the initiative and untiring efforts of this well known firm, the machine made barrel has come into its own almost as much in England as in America. There were a good many machine cooperages at home five and thirty years ago for tight and semi-tight barrels, and even earlier for cement barrels. A good deal of British machinery has also been exported to other countries. The durability and general excellence of the machines themselves is remarkable. For example, several of the machines put into a big factory in Oporto 35 years ago are still running. In one of the big London breweries the writer saw machinery still in use which was installed 20 years ago.

About 10 years ago a big strike of hand coopers took place at home. It gave a great impetus to the demand for barrel making machinery, especially for beer and whiskey casks. Since then machinery has steadily gained ground, with the result that, to-day, practically all the manufacture of casks and barrels from new stock has passed out of the hands of the hand-coopers.

The opposition of hand coopers was indeed active at one time. Amongst other stories there is one relating to a consignment of 300 wine barrels made by British machinery at a factory in Malaga, Spain, which was shipped to Herez. On arrival there some difficulty was experienced in landing the barrels owing to the hostility of hand-coopers. Even so, within a few days of being piled on the wharf, the whole consignment was burnt to ashes. Conditions have clearly improved since then, for the Malaga Factory is believed to have been running more or less continuously up to date.

In spite of the headway made by machinery, a considerable amount of work still exists for hand-coopers at home. Large numbers of barrels of all descriptions come into the country in the ordinary course of importation of liquid and solid articles of commerce. Dealing in second-hand barrels, which are knocked to pieces and re-built, forms a large part of the business of many coopers.

In North America all barrels are made by machinery. There was, therefore, no lack of material with which to illustrate this chapter. At the end of the chapter some notes on British practice are given. The latter may be taken to have a very wide application. The general conclusion arrived at is that the whole chapter could equally well have been illustrated by references to home manufacturers' catalogues.

As to the relative merits of design of British and American machines, the writer is not in a position to express an opinion. Both are believed to be good.

Publications.

188. The following journals may be commended to the notice of anyone desirous of studying the barrel trade:—

(1) *Barrel and Box*, Chicago, Ill.

(2) *Cooper's Journal*, Philadelphia, Pa.

The only text-book on the subject that the writer has been able to procure is "*Cooperage*" by J. B. Wagner. It only deals with the manufacture of slack staves and heading.

The chief manufacturers of barrel making machinery in England are Messrs. A. Ransome and Company, Newark-on-Trent. The special catalogue on the subject of barrel making machinery published by the firm contains a very good description of the different kinds of staves in use. The writer is greatly indebted to Mr. Geoffery Ransome for information given to him with regard to cooperage in the United Kingdom.

Tight and Slack Cooperage.

189. A description of plywood machinery is comparatively simple because all the machines are of one general type, irrespective of the class of veneer dealt with. The case is very different with barrels. The machines designed for one class of barrel would be useless for other kinds. All that can possibly be done in this report is to give a general idea of what barrel making by machinery is like by illustrations that came under the writer's personal observation. The reader must take it for granted that the machinery for any particular kind of barrel he may have in mind is more or less complex and more or less expensive, according as the barrel in question is of a higher or lower class than the ones mentioned here.

Barrels are divided into two main classes, *viz.*, (1) *Tight* and (2) *Slack Barrels.*

A *Tight Barrel* is one built for holding liquids or semi-solids such as beer, oil, meat, pickles, tallow, tar, etc.

A *Slack Barrel* is only intended to hold solids, such as flour, cement, miles, china, etc.

Barrels vary so much according to the nature of their contents, that a whole series of gradations exists between the obviously "tight" and "slack" types, and it is usual in the trade to treat "*semi-tight*" barrels as a separate class. Even so, doubt may sometimes be experienced in placing a particular kind of barrel. For example, herring barrels are intermediate between "slack" and "semi-tight."

SECTION 2.—RESEARCH.

190. Very little appears to be known at present as to the suitability of Indian woods in general for barrel making. The field is probably larger than is commonly supposed. A lesson may be learnt from America. Once upon a time coopers there would not look at anything but oak. In course of time supplies have gone down and prices have gone up with one wood after another to such an extent that coopers now-a-days appear to take whatever they can get, and the list of species in use is a very long one.

Research.

The writer recommends that the examination of forests and study of woods for plywood, matches and barrels be taken in hand together, as the industries may well prove to be supplementary to each other in their utilization of the species in mixed hardwood forests.

SECTION 3.—STAVES AND HEADING.

191. It has already been remarked that the bulk of the making of staves and heading from the log in America is concentrated in the Central and Southern States. The making up into barrels, however, is spread over a larger area, and finds its greatest development in the localities where there is the greatest demand for the barrels themselves. This is only what one would expect from the fact that bundles of staves are easier to ship than made up barrels. It is also correct to state that it is in the making of the staves that the greater part of the waste occurs, so that the extra freight charges in shipping roughly dressed staves are not a serious item.

Staves.

Although some staves are riven and other are made by sawing or slicing machines it is not correct to suppose that these methods correspond at all closely to the tight and slack types. Owing to improvements in machinery, sawn and sliced staves have steadily advanced in favour and now form over 90 per cent. of the total outturn. This is not to be wondered at, seeing that there is such an excessive amount of waste in the use of the axe and wedges for roughing out any kind of converted material in wood.

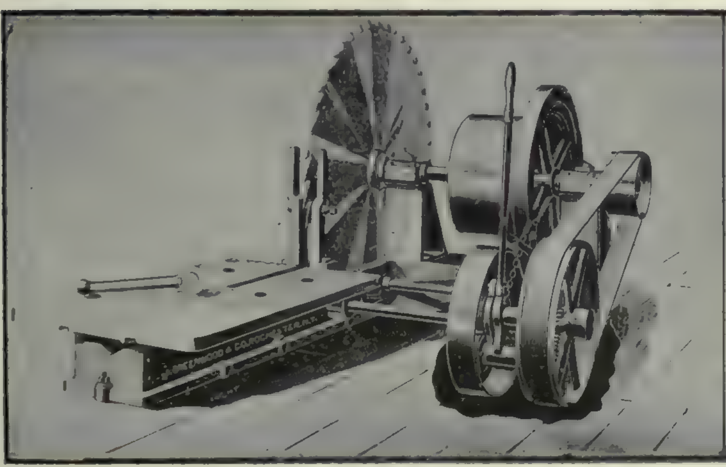
The drawback to machine made staves that vessels are opened up, and that he value of the staves for "tight" barrels is thereby reduced, can be got over as explained later on in this chapter.

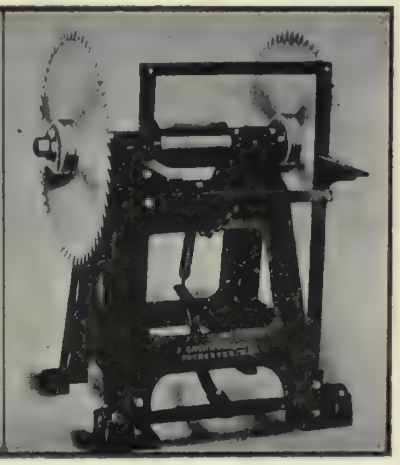
192. An opportunity for seeing something of the manufacture of slack staves was afforded at Charleston, Miss. The series of operations in such a factory is as follows. The first stage after the arrival of the logs at the mill is to cross-cut them into short lengths slightly longer than that of a finished stave by means of a drag saw.

Stave Factory.

U. S. Forest Service Photo.

(1). Small Cypress blocks from Sawmill waste to be worked up into bucket staves 1" and over.—Palatka, Florida.

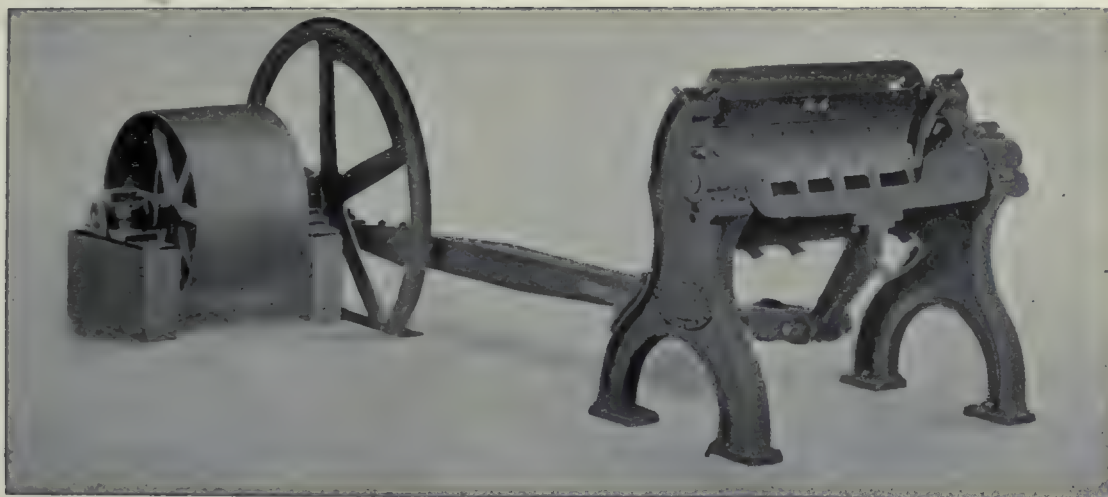




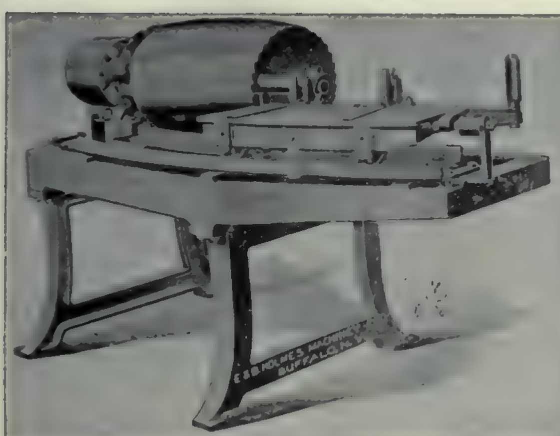
(2). Stave & Heading Bolter. (3). Stave Bolt Equalizer.

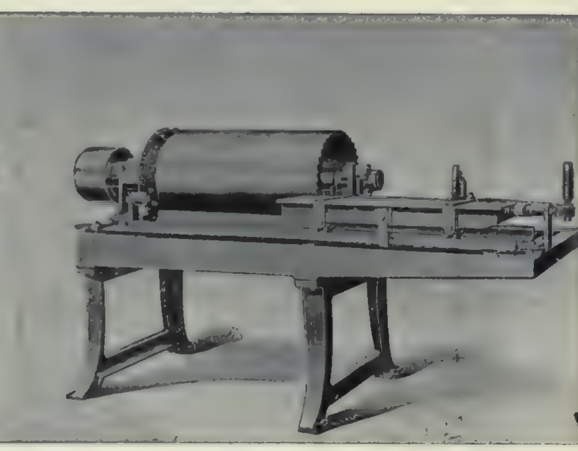
(By permission of Messrs. The Rochester Barrel Machine Co. Rochester.).

(para 192).



(1). Stave Cutting Machine.
(By permission of Messrs. The Rochester Barrel Machine Co.).

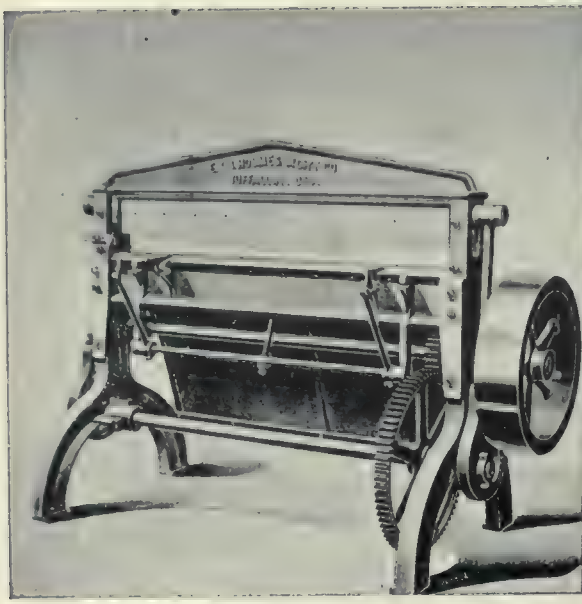


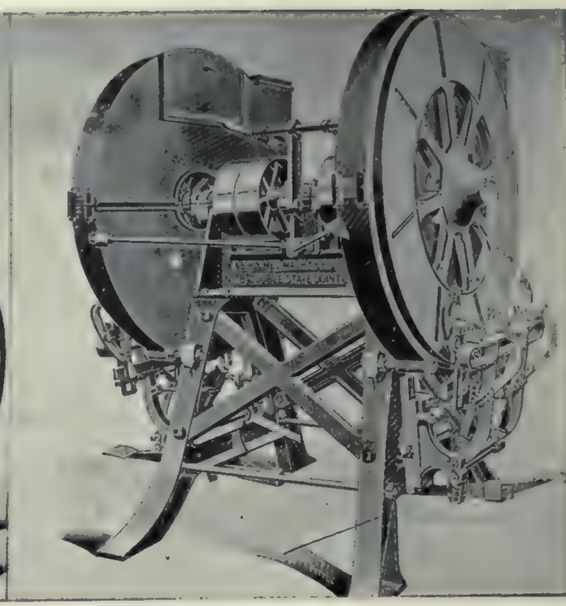


(2). Bulging Drum Saw. (3). Straight Drum Saw
(By permission of Messrs. The E. & B. Holmes Machinery Co.).

(para 192).

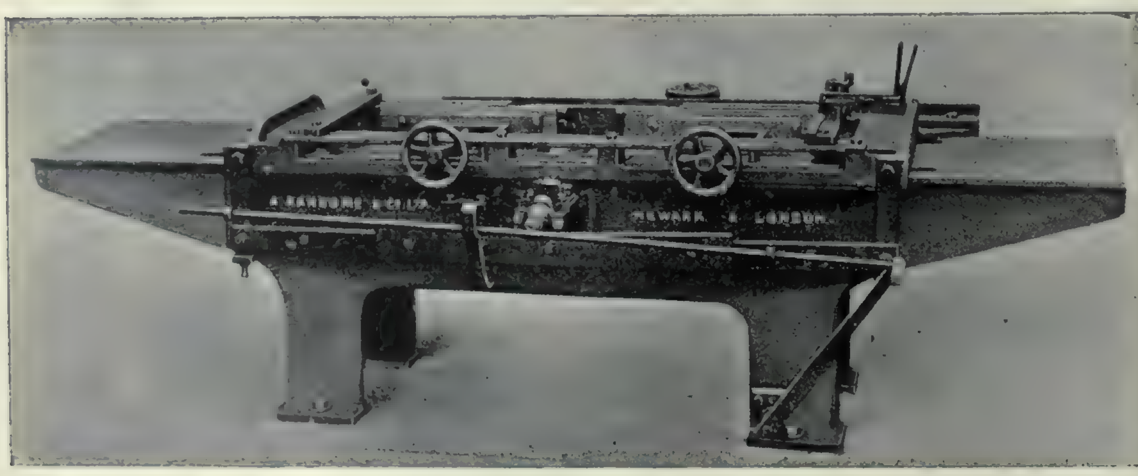
Plate CV.





(1). Slack Stave Jointer. (2). Tight Stave Jointer, Double.

(By permission of Messrs. The E. & B. Holmes Machinery Co.)



(3). Universal Stave Jointing Machine.

(By permission of Messrs. A. Ransome & Co.)

(para 193).

Although Plate CIII (1) was not taken at a factory visited by the writer it is put in because it is a good illustration of the appearance of stave bolts, and it is such an excellent example of economical utilization that it may be well brought to general notice.

After removal of the bark (if necessary) the 2nd operation is to turn the short log pieces into *Bolt* or quarter pieces. This is done on a *Boltor Saw* machine [Plate CIII (2)] the chief feature of which is the short carriage with the saw in the middle.

To ensure that the bolts will yield staves of exact length, the next stage is to put them through an *Equalizer*. As the illustration shows—Plate CIII (3)—this is simply a double trimming saw machine with a suitable carriage for the bolt.

Before the bolts are ready for the stave saw or slicer, they have to be steamed, except soft woods, just the same as for veneer peeling.

Plate CIV(1) is an illustration of a type of *Stave Cutting or Slicing Machine* which is advertised as being used for 90 per cent. of the slack stakes made in America, and as being capable of a daily output of 50,000 staves. The bolt is rocked in front of a straight edged knife having a curved face. The curvature given to the staves can be varied (for barrels of different sizes) by altering the adjustment of the knife relative to the spindles of the rocker.

Sawn Staves.

Staves can be made with an ordinary flat saw. The drawback to this method is that a good deal of material is afterwards wasted in "hollowing" and "backing" the stakes to the proper curvature. The special type of double planing machine used for the purpose is also expensive.

Sawing on the curve is therefore much more popular. The operation is performed on a *Drum Saw*. The two illustrations need very little explanation [Plate CIV (2) and (3)]. The plain cylindrical type makes staves which afterwards have to be bent to conform to the shape of the barrel, whilst the other type turns them out complete in this respect. The cylindrical type is the commoner. The writer saw one at work at Vancouver, B. C.

Special attention is invited to the fact that great importance is attached to cutting of staves as nearly as possible in a *radial* direction. On this account the cutting of logs into bolts is done radially and in large logs, where individual bolts are smaller than quarters, the same idea is followed.

The reason for this method of procedure lies in the way in which wood shrinks in drying. Speaking generally, radial shrinkage is only half that in a tangential direction. Planks or boards sawn radially tend to warp less than if cut slantwise. It is the same with staves.

Stave Jointing.

193. Another important point to notice is that no attempt is made to cut curved staves to any definite width. To do so would mean increasing the waste very considerably, as it is the exception for bolts to be parallel sided. After staves are cut all that they need is to be jointed, that is, to have their edges dressed so that the staves will make a close fit with each other when assembled and hooped.

The difference between the width at the ends and in the middle of a stave is called the *Bilge*. The absolute width of a stave is immaterial, provided that the bilge is constant. This can readily be understood in the simplest case, *i.e.*, with the "bilge" zero, for the barrel then becomes a cylinder and the width of the staves is obviously of no importance, provided that they are all cut with the same curvature.

Three illustrations of *Jointers* are given—Plate CV—two American and one British. The Tight stave machine will take staves of any length from 18″ to 36″. The cutters are fixed radially on a revolving wheel. Adjustments for varying length, bilge or joint, are easily and quickly made. For details of the British machine see paragraph 201.

Drying of Staves.

The last stage in a factory where manufacture does not go beyond the making of staves is the drying or seasoning of them. This is either done in the open air or in a dry kiln, for which reference may be made to Chapter XII of these notes.

Heading Factory.

194. The term "*Heading*" is applied to both ends of a barrel and therefore includes the bottom of a bucket or tub. Bolts for *Heading* are prepared in the same way as for staves, except that the *Equalizer* is dispensed with. Plate CVI is an illustration of a very popular type of machine* in use for sawing bolts into heading pieces. The bolt is clamped in the swinging frame; and the latter is moved forwards and backwards by hand. After each return swing the operator releases the clamp by hand and pushes the bolt inwards until it rests evenly against an adjustable stop.

After being seasoned, heading pieces are planed and jointed, and pegged together. The last stage is to cut them into circular form and to bevel the edge all round. The machine for the purpose is a wonderful piece of mechanism and very fascinating to watch.

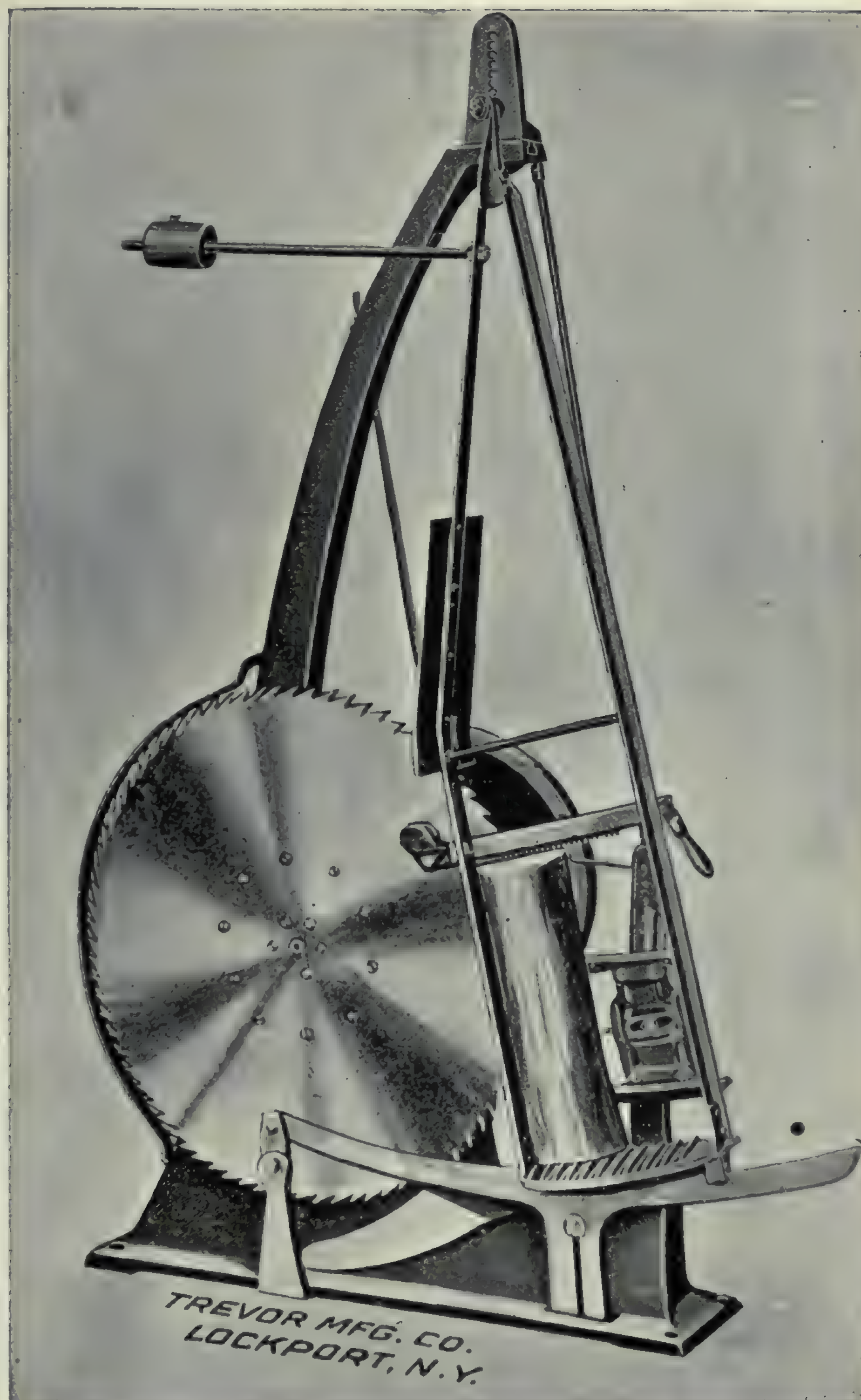
One detail of design is worth special mention as showing how far the perfection and adaptability of machinery have been carried. Any piece of wood, no matter how well seasoned, can be compressed across the grain more than lengthwise to the grain. It is the same with shrinkage in drying. As a rule tangential shrinkage is double that in a radial direction and 100 times as much as longitudinally. If a heading for a tight barrel were made perfectly round in the first instance, after it had been coopered two or three times it would become somewhat oval in shape and would cause the barrel to leak. To counteract this tendency the finished heading for tight barrels is not round but slightly oval. This form is arrived at in some factories in two operations; first rounding in one machine, and then ovaling in another, but in others it is done in one operation in a machine specially designed for the purpose.

SECTION 4.—BARREL FACTORY.

Tight Barrel making.

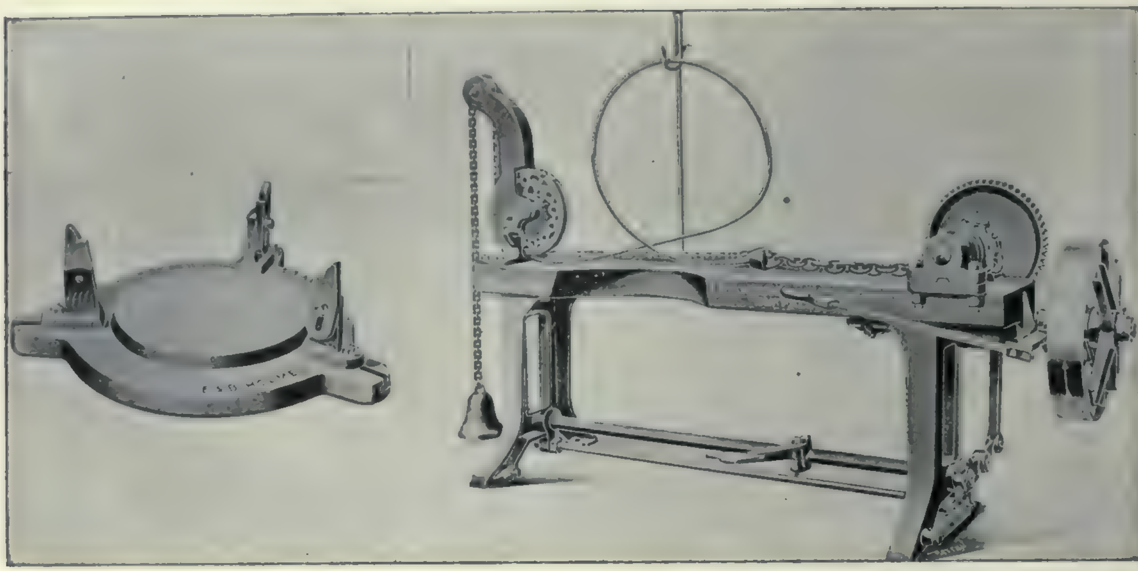
195. The making of tight barrels was seen at a factory in Detroit, Michigan. The stave and heading stock is obtained from Arkansas. The barrels are afterwards

* This type of machine is also used very largely for cutting Shingles *vide* Chapter X. For this purpose it is provided with an automatic rocking arrangement, so that the shingles are cut with the thick ends alternately at top and at bottom.



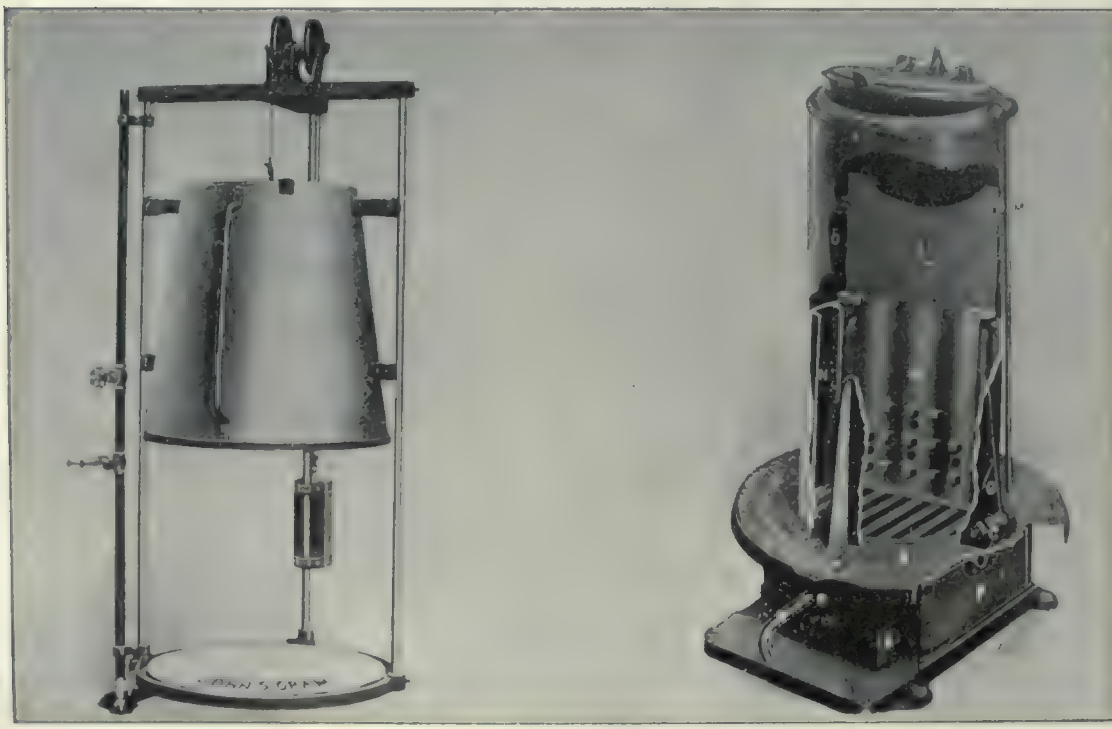
Heading Sawing Machine.
(By permission of Messrs. The Trevor Manufacturing Co.)

(para 194)



(1). Setting Up Form. (2). Power Windlass for Tight Barrels.

(1). & (2) By permission of Messrs. The E. & B. Holmes Machinery Co.



(3). Barrel Steamer ; barrel goes inside. (4). Barrel Heater ; barrel goes outside.

(3) & (4) By permission of Messrs. The John S. Oram Co.

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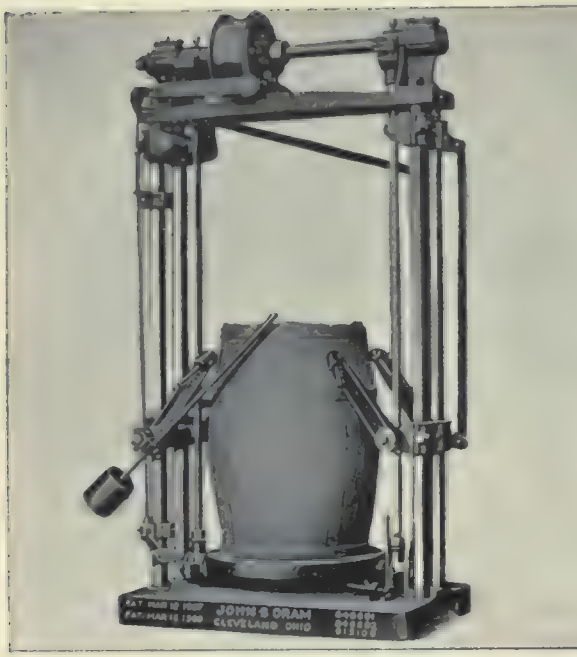
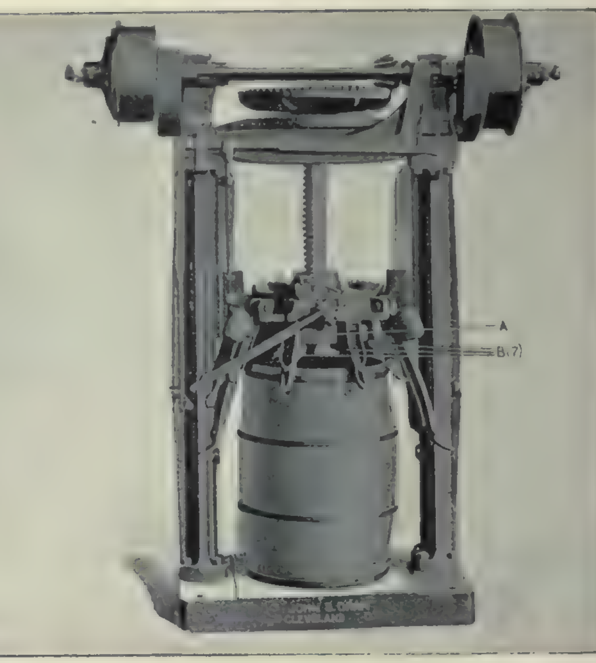
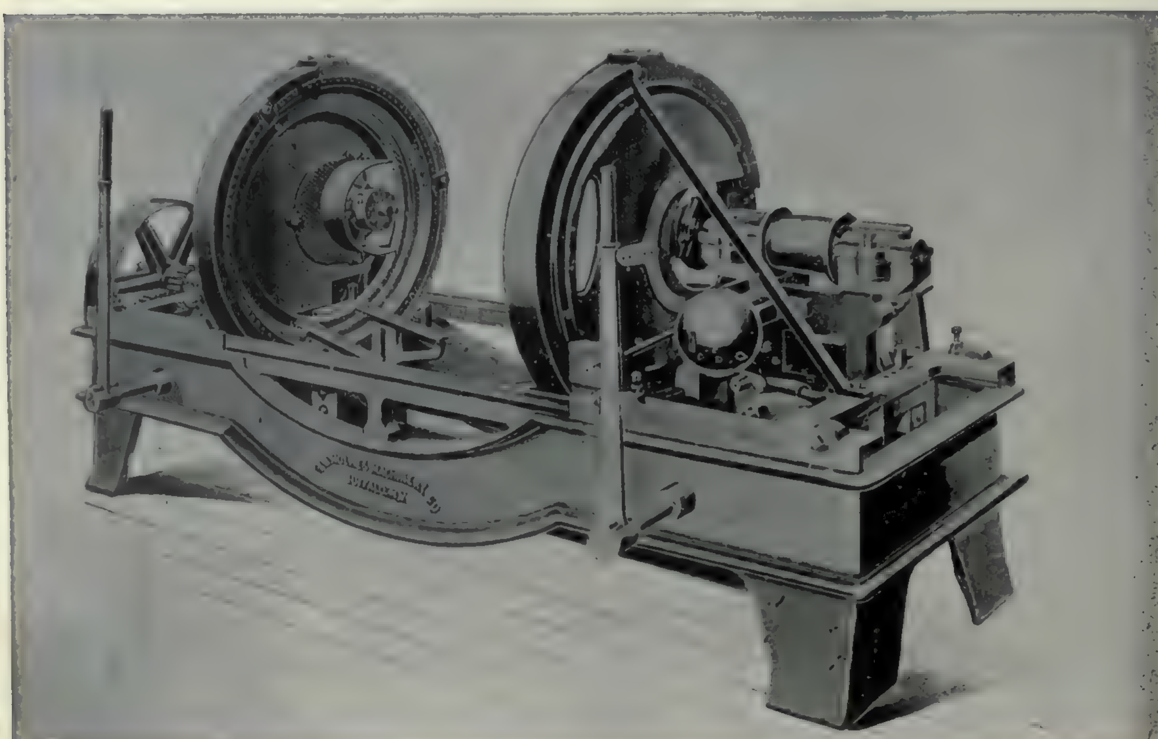




(1). Levelling Machine. (2). Trusser.

By permission of Messrs. The John S. Oram Co.



(3). Crozer.

By permission of Messrs. The E. & B. Holmes Machinery Co.).

(para 196).

used for oil, meat, pickles, varnish, condensed milk, etc. The following is a list of the machines in the factory in the order of operation :—

1. Jointer.
2. Setting up Form.
3. Steaming Oven.
4. Windlassing Machine.
5. Heating Oven.
6. Leveller.
7. Trusser.
8. Crozer.
9. Heading up Machines.
10. Outside Dressing Lathe.
11. Hooper.
12. Appartatus for testing for Leakage.
13. Bung Hole Borer.

Hoop making machines.

1. Punching Machine.
2. Rolling and Flaring Machine.
3. Rivetter.
4. Expander.

At the time of the writer's visit to *Detroit* the factory was not working at full pressure and, with 16 men, the daily output was only 225 barrels. When trade is brisk, the factory can turn out from four to five hundred.

196. The first operation in the factory is to *Joint* the stakes. Two *Double Jointing Machines*, similar to Plate CV (2), are required when the factory is working at full pressure, although only one was being used at the time of the writer's visit. The stock is purchased ready jointed, but re-dressing of the edges is necessary to get the desired bilge, and also to correct changes in shape due to stock being held for long intervals before manufacture into barrels.

Setting up is the next operation and is done by hand on a special Form [Plate CVII (1)]. On the notched heads of the three short uprights a *thick* iron hoop is placed. The operator then builds up a ring of staves inside, as tightly as possible. When it comes to the last two or three staves selection is necessary to ensure a good fit, because, as already noted, staves are not of uniform width. The building up is not as easy as it looks. It requires considerable skill to keep the embryo barrel from tumbling to pieces until the last stave has been fitted in and tapped down tight.

The skeleton barrel is then turned upside down and the hoop is hammered down until it is quite tight.

The barrel is now ready to be *steamed.* This operation takes from 4 to 8 minutes with live steam in a closed dome shaped box [Plate CVII (3)]. The next stage is to turn the barrel upside down and pass it on to the *Windlassing Machine* [Plate CVII (2)]. The wire loop seen in the picture is passed round the barrel (the free ends of the staves being uppermost) and tightened by steam power until the ends of the staves are bent inwards sufficiently to permit of the putting on of a second *thick* iron hoop.

After hammering this hoop tight the barrel is ready for being heated over a *Coke Oven* [Plate CVII (4)]. Steaming softens the wood and makes it possible to bend the staves without breaking them, and the subsequent heating dries the wood and causes it to set permanently.

The barrel now passes to the *Levelling Machine* [Plate CVIII (1)] in which it is dressed perfectly square. An additional thick hoop is placed in position and hammered down by hand. The barrel is then turned over and an extra hoop is fitted on the other end, making 4 thick hoops in all.

The barrel now comes under the attentions of the *Trusser* [Plate CVIII (2)], and power is applied to force the hoops down dead tight.

The next machine to come into play is the *Crozer* [Plate CVIII (3)], which does what is called "Chamfering," "Crozing" and "Howelling," that is, it bevels the ends of the staves and cuts the grooves for the heading at both ends simultaneously.

197. The fixing of the heads in position is done in a *Heading Up Machine* [Plate CIX (1)] in the following manner. The operator knocks off a hoop at one end and then places the barrel in the machine with this end uppermost. He has a stock of heads handy and picks up one by tapping a gimlet into it. Holding the head in position in the barrel with a foot lever he starts the machine, which squeezes in the staves until he can place a *thin* hoop in the position originally occupied by the thick one.

After the other end has been dealt with in a similar manner the barrel goes to the *Turning and Smoothing Lathe* [Plate CIX (3)] to have the outside dressed. The curved plane to be seen on the right of the picture is attached to, and can slide along, the overhead rod. It is operated by hand.

Although not seen in the factory in question, if a very smooth finish is desired, the barrel goes to a *Belt Sander*. The barrel is now ready for final hooping. The machine used for the purpose is illustrated in Plate CIX (2). The number of thin hoops used varies. In the factory in question six are put on.

The next operation is to test for leakage and to make it good. At the factory specially referred to two methods are practised, *viz.*, (1) *Paraffin*, (2) *Steam.*

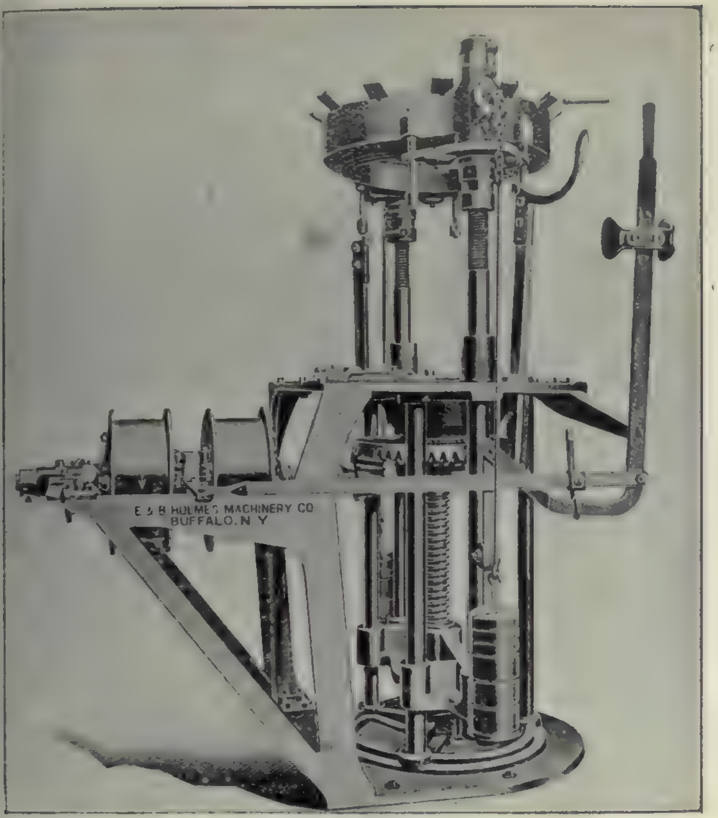
If the barrel is to be used for a purpose for which an internal coating of paraffin wax is not objectionable, then hot wax is poured in and washed round. Otherwise, steam is used. It is introduced by means of a flexible pipe and small hole where the bung hole will afterwards come. The steam is held at any desired pressure, whilst the barrel (on a stand) is slowly revolved by hand. Whereever leakage occurs small wood pegs are hammered in. Sometimes none at all are required; at other times a dozen or more minute holes have to be plugged.

The last operation is to bore a hole for the *Bung* and to fit one in.

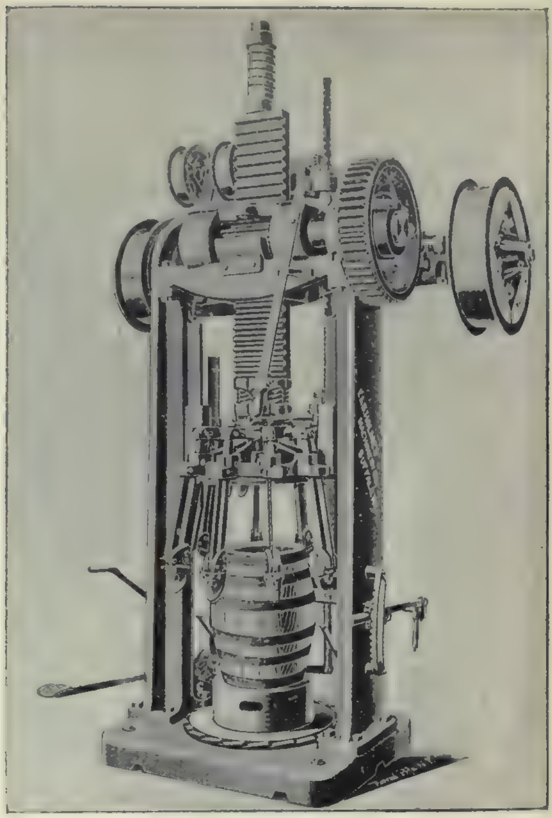
Hoop Making Machinery.

198. At the same factory the material for hoops is received in the form of bundles of strap iron of the required lengths Four machines are installed for making the strap into finished hoops.

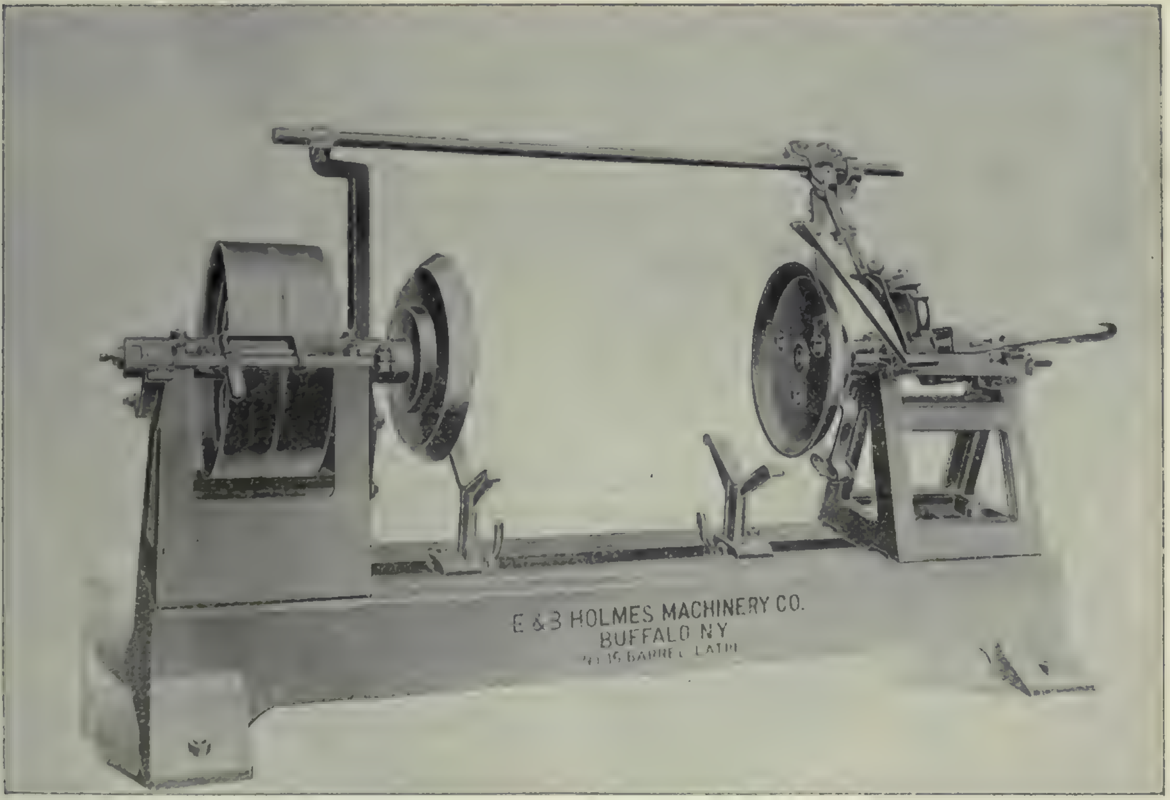
The first operation is to pass the straps, one at a time, through a *punching machine* to make the holes required for rivetting. Each strap is then passed through the *Roller*, in which it is not only curled, but one side is stretched (*Flared*) so that the strap may fit the bulge of the barrel. The third operation is to complete the hoop in a *Rivetting Machine.* For end hoops there is one more stage, *viz.*, stretching in an *Expanding Machine.*



(1). Heading up Machine.



(2). Hoop Driver.



(3). Lathe for outside dressing.

(By permission of Messrs. The E. & B. Holmes Machinery Co.)

Plate CX.

Barrel-making in a Turpentine & Rosin Factory ; Hand Windlass to the Right. Jasper, Texas.

(para 199).

199. In striking contrast to the imposing array of machines in the factory just described, the simple outfit in a small slack barrel factory seen at Jaspar, Texas, may be instanced. At their turpentine distillery The Western Naval Stores Company, Jaspar, make up barrels for resin and for rosin from staves and headings purchased from outside.

Rosin barrels.

The plant is only a small one. No steaming or heating is done. Chamfering is done with a hand tool and hoops are driven home with a hammer and blunt chisel.

The setting up is done on a Form in the same way as before. The *Windlass Machine* [Plate CIX (2)] consists of a wooden bench with a semi-circular space to hold the barrel, and a loop of wire, one end of which is fastened to the bench and the other end to the spindle of the large wooden wheel shown in the picture. After placing the barrel in position, and placing the loop round the barrel, the operator puts his weight on the iron pegs in the rim of the wheel. A good purchase is thus obtained and the staves are easily squeezed inwards until they meet and a hoop can be put on. Sometimes staves crack owing to want of steaming and the operator has to begin all over again ; but it is not a common occurrence.

200. The output of machine barrel factories depends on the class of barrel manufactured and also on whether the plant is run continuously or not. The latter proviso is one of practical importance, for many concerns in England, for example, do find it profitable to install machinery for the purpose even though it is only used intermittently.

Output of a barrel factory.

The tight barrel factory referred to in paragraph 195 with a single set of machines can turn out anything from 1,000 to 2,500 barrels per week. The writer is informed that in England it is found to pay to install machinery even where it is only used so intermittently that the average outturn is only from 60 to 100 barrels per week.

For slack barrels the figures are naturally higher, as the value of the barrels themselves is so much smaller. The demand for cement barrels is very great: a profitable minimum for them is about 1,000 barrels per week.

Section 5.—BRITISH BARREL FACTORY.

201 (1). The writer was given an opportunity of visiting a cement barrel factory at Northfleet, Kent. He was particularly glad of this because of the tongueing and grooving of the staves. Most of the machines are in multiple sets and, when all are at work, the weekly outturn is from 4,000 to 6,000 barrels. At the time of the visit only one set was in operation and the output was only 1,000 barrels per week.

British Cement Barrel Factory.

The material used is any kind of cheap softwood. The staves are imported flat sawn. Some are thicker than others, but this does not matter, and no attempt is made to make them all alike in thickness and width. The operations in order of sequence are as follows—

(*i*) *Drying.*—To ensure that all the material is thoroughly dry it is passed through a ***Sturtevant Progressive Drier.***

(*ii*) *Jointing.*—This is done on a Universal Jointing Machine (Ransome) [Plate CV (3)]. The operator packs into the carriage of the machine as many staves as it will hold—from 20 to 30 according to thickness—and clamps them tight by means of a hand wheel and screw. Pushing the carriage forwards causes it to travel over a revolving cutter. The latter is carried in a swinging frame which enables it to rise and fall as a curved template attached to the carriage passes under it. The template corresponds exactly to the desired shape of the staves. If it is desired to alter the bilge, it is a simple matter to exchange the template for another one. Adjustments are provided for giving any desired bevel to the staves. It takes about 15 seconds to joint one side of the bundle of staves. To do the other side, the bundle of staves is lifted out by hand and turned over.

(*iii*) *Tongueing and Grooving.*—The writer was particularly interested in visiting this factory because he had no opportunity of seeing tongueing and grooving of staves in America. It adds considerably to the value of the barrels and yet does not require more than one extra machine of a comparatively simple type (Ransome). The cutters run on vertical spindles. One of them is placed in advance of the other. Feed rollers carry the staves forward. To give a smooth finish to the outside of the barrels, even though the staves are not all alike in thickness, the machine is adjusted to make the tongue and groove at a constant distance from the edge that will eventually come outside.

One detail of practical importance may be noted. Care is taken to see that the staves, when finally assembled, stand in the same relation to the barrel as they did to the original tree, *i.e.*, with the inner side of each piece of wood facing inwards. It causes no delay in the working of the machine to attend to this detail; when picking up a stave the operator can tell at a glance which side to turn uppermost.

(*iv*) *Chiming, Crozing and Printing.*—In a single machine the groove (*Croze*) for the heading at each end is hollowed out, the staves are cut to exact length and the bevel (or *Chime*) is given to the upper ends.

Any desired trade mark is printed on all, or part, of the whole stock of staves. All that the attendant has to do is to keep the magazine filled. The machine does the rest. The staves are carried forward one by one on an endless chain conveyer. Before reaching the cutters the ends of the staves are automatically pressed against a fixed fence to ensure that the croze is cut at the required distance from the end. Any excess in lengh is cut off by means of a small circular saw at the opposite end.

(*v*) *Heating.*—The staves pass on chain conveyers direct from the machine just described into and through a long brickwork oven, in which they are heated by hot air from a furnace burning chips and other waste wood.

Plate CXI.

(1). Trussing Bell, open.

(2). Trussing bell closed and barrel being forced up into it; operator about to place heading in position.

(para 201).

(*vi*) *Trussing.*—The operation of assembling the staves and putting on the permanent thin hoops is a simpler one than that described in paragraph 196 for tight barrels. Thick trussing hoops are not used at all. The machine used for the purpose is known as a *Trussing Bell.* There are several patterns on the market in England. The one seen by the writer is called a Magnetic Trussing Bell (Plate CXI) as the permanent hoops are held in position by means of electromagnets in the sides of the bell. In other makes the same object is attained by grooves into which the hoops are fitted. The bell is supported by heavy iron pillars above a base plate. The bell itself is in two halves hinged together. The method of operation is as follows.

The bell is opened and two thin permanent hoops are placed in position inside it. The bell is then closed and clamped. The operator then takes a bundle of staves and piles them in a circle round a ring on the base plate with their upper ends standing up inside the bell. To get a good fit with the last stave he may have to pick and choose a bit from the stack of staves close by.

Pressure on a pedal lever brings a powerful hydraulic ram into play, lifting the base plate and forcing the ring of staves up into the bell. When the bell is opened the two hoops are seen to be firmly in position at the upper end of the half-made barrel. The latter is then turned upsidedown and replaced on the base plate. Two hoops are put on the other end in the same way as before, and at the same time a head is inserted in the manner described in paragraph 197, that is, the operator picks up a head from a pile close by, by means of a pointed tool and holds it inside the bell at the right height to engage in the croze grooves as the barrel rises.

(*vii*) *Hoop Nailing.*—When the barrel leaves the trussing bell it is to all outward appearance a finished article, but two more operations have to be performed before it is really so. The end hoops are all right but the intermediate ones are apt to slip on the curved surface of the barrel and so are nailed in position.

(*viii*) *Wood Hooping.*—The last operation is to nail a split wood hoop inside and another one outside the bottom ends of the staves of the barrel.

(*ix*) *Heads.*—The manufacture of ends (heads) for the cement barrel starts with the same kind of material as the staves. After drying the operations are as follows :—

1. Tongueing and grooving.
2. Clamping together and nailing a batten cross-wise on the inside.
3. Rounding and bevelling.
4. Printing.

(*x*) *Hoop making.*—*Vide* paragraph 198. Machines similar to American ones.

CHAPTER X.

OTHER MANUFACTURES.

205. As the shingle is so well known, and has such an established position in Burma, a description of Western methods of manufacture may not be without interest and value. The writer has seen one-man machines capable of cutting 40,000 shingles a 10-hour day (exclusive of course of the men and appliances required for getting the billets of wood ready for the machines and for sorting and bundling afterwards). The contrast between such a machine and the dozen or more push-benches which would be required for such an outturn in a Rangoon mill is very striking, and gives grounds for supposing that it would pay to make a change.

Shingles.

Shingle manufacture is a big industry in North America, as it is probably not far wrong to say that shingles are the commonest formof roofing everywhere, except on skyscrapers and buildings where special precautions against fire are taken.

At Bogalusa, La, the writer was able to see the operation of a large plant cutting shingles out of Cypress. Logs with a rotten heart and not good enough for planking are cut down the middle by a long saw. The pieces are carried forward some distance by live rolls, and then side-tracked on chain conveyers to the part of the mill set aside for shingles. After being cut into standard shingle lengths by a number of saws in a row, the billets are placed on a Bolter of the same design as the one used for staves [Plate CIII (2)]. The next operation is to remove the bark and rotten wood. This is done on a bench provided with a large circular saw ; the bolts are placed on end on the table and are turned round by hand.

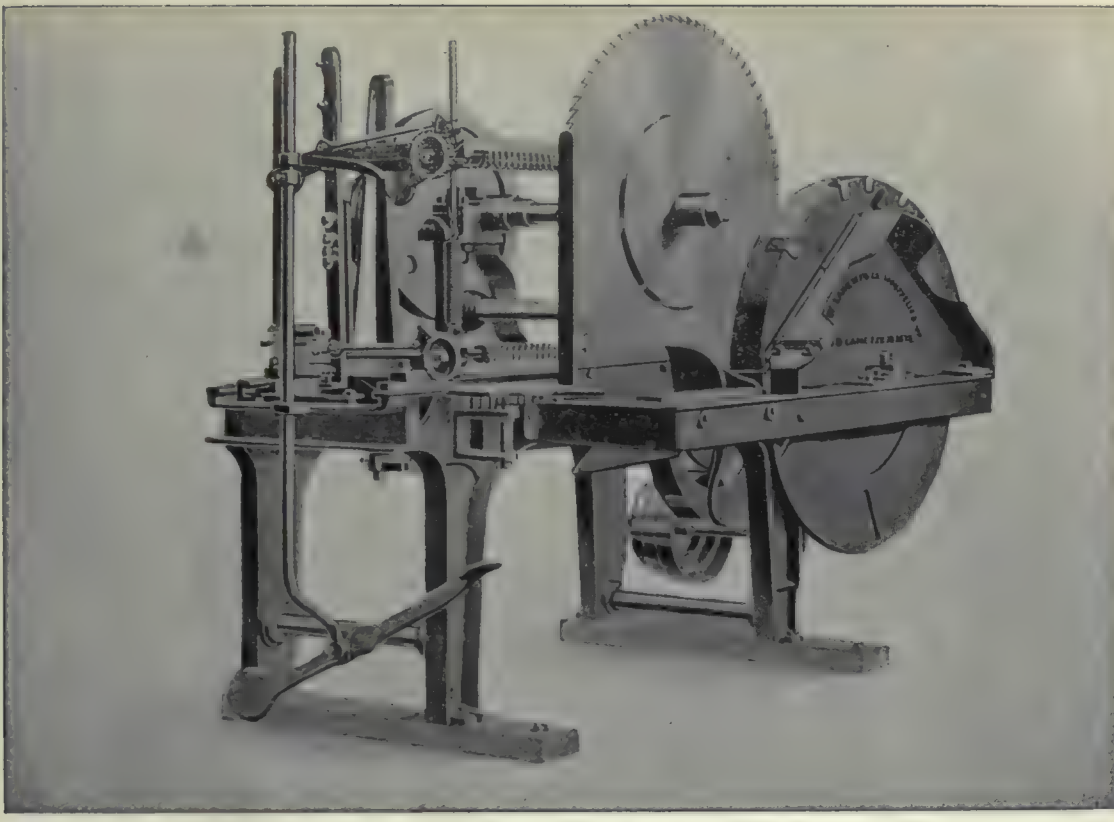
206. The bolts are now ready for the *Shingle Machine* in which they are first of all sawn into tapered pieces of the proper thickness and then trimmed to shape.

There are three well known types of machines, *viz.*, (1) Vertical and Automatic, (2) Vertical and hand feed, (3) Horizontal and hand feed. Plate CXII (1) illustrates one make of the vertical and automatic feed type. The carriage for the slicing saw is provided with clamps for holding the bolts, and there is mechanism for automatically advancing the bolt after each cut. The machine can be set to cut the shingles with the thick and thin ends upwards alternately or all thick ends upwards or downwards. By means of a foot pedal, the operator can vary the feed either way without stopping the machine. In this way he can make the most out of each bolt and yet have both hands free to pick up the shingles and trim their edges one at a time with the jointing cutter.

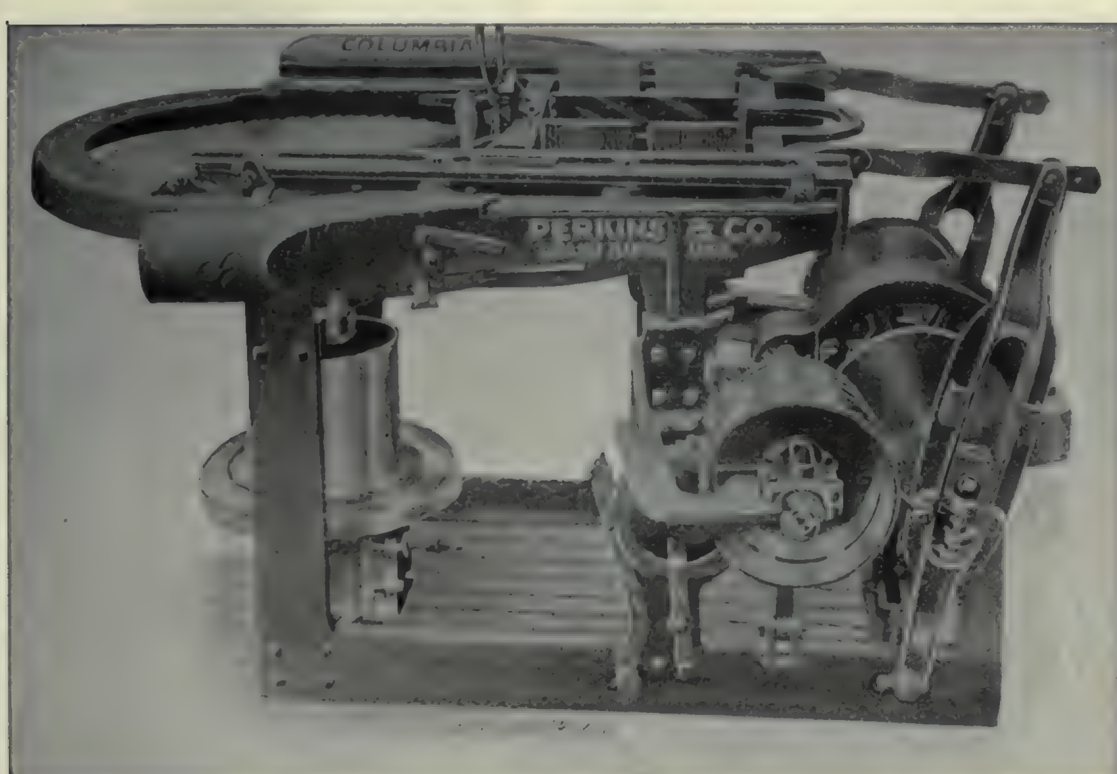
The favourite machine on the Pacific Coast is of slightly different pattern. Instead of jointing being done by cutters mounted radially on a revolving wheel or disc it is done by a circular saw.

Another type of vertical machine is the pendulum Heading or Shingle Saw illustrated and described in Plate CVI. The feed is by hand.

In the Eastern and Southern States, horizontal machines are the general rule [Plate CXII (2)]. Operators of the vertical machines claim that they are the better



(1). Automatic Shingle Saw Vertical.
(By permission of Messrs. The Lane Manufacturing Co.)



(2). Horizontal Shingle Saw—Hand Feed.
(By permission of Messrs. Perkins & Co.)

(para 206).

ones as the feed is positive. In the horizontal type, gravity alone is depended on to cause the bolt to drop after each cut, with the result that the shingles are spoilt if anything causes the bolt to stick or to drop unevenly.

The capacity of one of these up-to-date machines is said to be from 35,000 to 45,000 shingles per 10-hour day.

Formerly shingles were made by splitting and adzing. The first stage in development was to saw them from split bolts. The Bolter saw came in as the next stage; with the object of saving the first two or three shingles, which were always wasted owing to irregularities in the splitting of the bolts themselves.

Lath Mills.

207. The demand for *Laths* is so large in America that many mills have special machines for cutting them out of slabs. The standard size is $4' \times 2'' \times \frac{1}{2}''$. Where large quantities are turned out there are three machines :—

(1) *Bolter* (with a number of saws, 2″ apart) for cutting slabs, etc., into pieces, 2″ thick.

(2) *Lath Machine* (with any number of saws, ½″ apart). For stock after it leaves the Bolter.

(3) *Bundler and Trimmer.*—For tying into bundles and trimming the ends. All the work could be done on plain push benches, but the machines of the above type that are in use in the West are good illustrations of the possibility of designing apparatus for repetition work, capable of giving a maximum of output with a minimum of labour.

Sash and Door making.

208. It is hardly necessary to remark that there is very little making of doors and windows by hand in Canada or the States. Factories for the purpose exist all over the country. All the moulding, surfacing and mortising is done by machinery. Plywood panels are now very popular (the outer layers being of ornamental wood and the inner of cheap stock). Venetian shutters and gauze doors are very common.

Box Factories.

209. Impressions derived from visits to box factories vary considerably. In some cases there is a great deal of cutting of long planks into short pieces, in others the bulk of the raw material is lumber-mill waste in the form of slabs, etc. In working up small pieces that require to be stuck together to make a piece large enough for a shook, it is a common practice to cut them as thick as possible. After they have been tongued and grooved and glued together they are put through a re-saw which cuts them down the middle into two complete shooks.

Machines are used for dove-tailing, nailing, screwing and for fixing cleats.

Tool Handles.

210. The writer believes that a very useful and profitable industry could be started in India in the manufacture of tool handles. Examples can be mentioned. It is to be hoped that efforts will be made to introduce the Peavy (Volume I. paragraph 71). If it becomes popular thousands will have to be imported, but this need not apply to the handles. If no private firm will undertake to meet the demand then Government is recommended to set up a factory for the purpose.

The Canadian Forestry Corps had a small factory in Windsor Great Park for the making of tool handles of various kinds, from which operations all over the country were supplied.

Excelsior.

211. At Portland, Oregon, the making of *Excelsior Wood Wool* was seen. Short Blocks (bolts) of various hard and soft woods are reduced to shavings of any desired width and length. The special machine has a number of knives so arranged that several bolts can be dealt with simultaneously. The shavings are baled in a press for export, for packing glass, china, toys, etc. The wool is preferred to hay or straw, because of its elastic and odourless character and freedom from dust and dirt. The wood is seasoned before manufacture. Air-drying under cover is preferred to Kiln-drying.

Wood Pipe.

212. An industry which has developed very rapidly in the past ten years in British Columbia is the manufacture of wood pipes as a substitute for iron or steel. The patents belongs to the Canadian Pipe Co., Vancouver, B. C. The following details were obtained at a visit to the factory.

The ordinary pipes are made in all sizes from 1″ to 24″ diameter and of any desired length up to 24 feet. They can stand heavy pressure without leakage. The Company claims for its pipes "a classification equal to cast-iron for strength, tightness and durability and cost of upkeep, at a far less first cost." The wood used is Douglas Fir. Much larger pipes can also be made. Plate CXIII is an illustration of wood pipe, 6 feet in diameter and 4 miles long, conveying water to the power plant of a mine in British Columbia, with a head of 300 feet. The pipes are spirally bound with galvanized wire. Joints are either tongued or butt, in the latter case a coupling ring is used. The pipes are dipped into an open creosote tank. After being removed from the tank they are rolled in sawdust. Experience has shown that the internal creosoting of the pipes has not the slightest injurious effect on drinking water carried in them. Slight bends can be made of wood, for sharp angles iron bends are used.

The Company is prepared to supply complete outfits of machinery for manufacture of the pipes—Stave cutter and groover, wire winder, tongued joints, etc.

General remarks.

213. A conspicuous feature of mills in which any considerable amount of sawdust is produced is the pneumatic blower system. The rate for insurance against fire largely depends on the efficiency of this apparatus. Several mills visited were remarkable for their general cleanliness and freedom from dust.

The remark made about lumber mills, that patents do not as a rule lie in machines as a whole, also applies very generally to wood manufacture, although catalogues are apt to give a different impression. The number of different machines for any one purpose is very great, and there seems to be little to choose between many of them. Before deciding to accept tenders which are markedly higher than others, it would be as well to make certain in each case that the higher price is really for anything but a name with a good reputation.

Wood Pipe of Douglas Fir, 6 ft. in diameter, 4 miles long, head 300 ft. delivering water to a power plant in British Columbia.
(Presented by B. C. Forest Service).

(para 212).

214. LIST OF MANUFACTURERS OF MACHINERY.

Re-Saws, Planers, Matchers, Boxes, Shingles, Lath, Excelsior, Lathes, etc.

Some of the above machines are made by most of the manufacturers of Saw-mill machinery given in Chapter VII, paragraph 167, and Shingle machines by Cooperage manufacturers listed in Chapter IX, paragraph 204. In addition are the following:—

Canada.

Preston Wood-Working Machinery Company, Preston, Ont.

Canada Machinery Corporation, Galt, Ont.

Letsom and Burpee, Vancouver, B. C. (shingles).

United States of America.

Mereen-Johnson Machine Company, Minneapolis, Minn.

Morgan Machine Company, Rochester N. Y.

Saranac Machine Company, Benton Harbor, Mich.

S. A. Woods Machine Company, Boston, Mass.

Baxter D. Whitney and Sons, Winchendon, Mass.

Mattison Machine Works Company, Beloit, Wisc. (sanders).

Mitts and Merrill, Saginaw, Mich. (hogs.)

Lewis T. Kline, Alpena, Mich. (excelsior.)

Perkins and Company, Grand Rapids, Mich.

J. A. Fay and Egan Company, Cincinnatti, Ohio.

Defiance Machine Works Company, Defiance, Ohio.

Wm. B. Mershom and Company, Saginaw, Mich.

United Kingdom.

W. A. Fell and Company, Windermere.

Oliver Machinery Company, Manchester.

Thomas White and Sons, Paisley.

J. Sagar and Company, Halifax, Eng.

Also several other firms *vide* advertisements in the Timber Trades Journal.

NOTE.—The above list is admittedly incomplete. It is quite possible that the names of well known manufacturers may have been omitted by an oversight.

CHAPTER XI.

TURPENTINE AND ROSIN.

Turpentine.

215. The trail of the turpentine operator is to be met with everywhere in the Southern States. From a railway carriage window a very good idea of the extent of the operations can be obtained. One deplorable feature is certainly the way in which small trees are tapped without any regard for the future. Regeneration is generally conspicuous by its absence—owing to fire and grazing—so that there are practically no stems too small to hold a cup and it is often impossible to find a single tree that has not been tapped.

A good description of American turpentine tapping operations ("orcharding") is given in Bryant's "Logging."

The writer paid a visit to Jaspur, Texas, in order to see something of the operations of The Western Naval Stores Company. This firm is one of the largest in the States, and was specially recommended because the operations are well managed and are conducted on up-to-date lines.

Orcharding at Jaspar, Texas.

216. Tapping is done systematically in conjunction with lumber operations conducted by a separate firm. All trees over 12″ in diameter are tapped for three years before felling. There is one channel per tree between 12″ and 18″ in diameter and generally two channels on larger trees. Very few trees are more than two feet in diameter or carry more than two channels.

The channels are from 12″ to 14″ wide and are extended upwards once a week by slanting cuts about 1½″ wide, so that in the course of a working season of eight months (March to October inclusive) the length of a cut becomes about 2 feet.

The V shaped lip (or *Apron*) is composed of two strips of zinc each 7½″ long. The cup measures 10″ × 3″ × 3½″. It is made of zinc with a lip. It is held in position by inserting the lip between the Apron and a nail below. The cups are not covered except temporarily whilst the cuts are being freshened. A flat piece of zinc with a handle and hook is then temporarily placed in position to keep out chips, etc.

The operator (or "Dipper") visits each tree once a week or ten days, to renew the cut and scoop the resin into a bucket. He empties the latter into barrels at a central place in his area. The barrels are taken to the factory by mule cart.

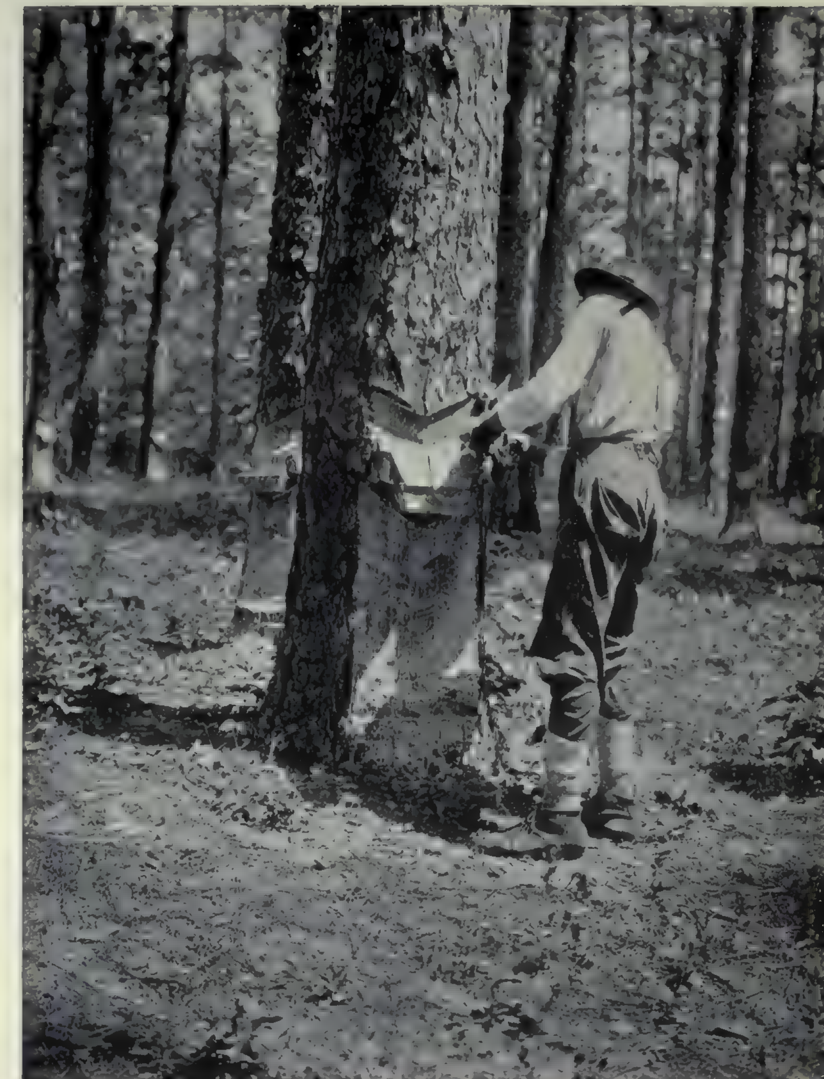
The unit of management is called a "*Crop*" and consists of 10,000 cups more or less. The yield per crop varies from three-quarters of a barrel per week in March to a full barrel in the best month, July. The capacity of a barrel of standard size is 54 gallons.

Under normal conditions, at the commencement of operations in the 2nd and 3rd years, the position of the cup is shifted to within 3″ of the top of the cut of the preceding year, *vide* Plate CXV (2). Owing to acute shortage of labour in 1918 this could not be done in all cases, as the other photograph shows.

Turpentine tapping in Long Leaf Pine ;—Bogalusa, La.

(para 215).

(1). Turpentine tapping ; position of cup not changed in 3rd season, Jasper, Texas.



(2). Turpentine tapping ; freshening a cut ;—Jasper, Texas.

(para 216).

217. In the factory at Jaspar there are 4 stills, each of which takes a charge of 10 barrels of crude resin 4 times a day, making a total of 160 barrels a day. The still is a plain cylinder with rounded bottom, standing on end over a furnace heated with wood fuel. The usual goose neck pipe at the top leads off to the condenser and is pivoted so as to be easily moved aside to permit of the introduction of a charge of resin. A platform runs right across the shed all-round the stills, and level with the top of them. All that has to be done to put in a charge is to unclamp the neck of a still, swing it sideways, and tip barrels into the opening.

Distillation Plant at Jaspar, Texas.

The condenser pipe of each still projects over an open barrel which has two pipes leading off from it—one near the bottom for water, and the other three-quarters of the way up for turpentine. There is also a plug operated by hand to serve as an additional discharge pipe for water if required.

The turpentine pipe passes through a semi-rotary pump to the storage tanks which are situated about 200 yards away, close to the railway siding. From time to time the man in charge opens the cock and pumps turpentine into the tanks. It remains there until shipped. Shipment is done in tank cars to all parts of the country.

On looking into the barrel into which the condensed water and turpentine flow, the line of division between the two can be clearly seen owing to the presence of a layer of flocculent scum known as "mother spirit." Care is taken not to let any of this scum get into the storage tanks. It is run to waste with the water.

The temperature in the still is recorded automatically by a *Recording Thermometer*. The temperature is gradually raised to 300°, and is held there for 2½ to 3 hours. By that time all the turpentine will have been driven off. If the temperature gets too high, cold water is introduced into the still, and the fire may also have to be damped.

218. The circumstance that the factory is situated on a gentle slope permits of the rosin being run off by gravity into one of four straining troughs and thence into barrels, with the different parts of the factory on ground level. The trough and barrel filling parts of the factory have cement floors.

In preparation for tapping a still a moveable strainer is placed over the corresponding trough. The strainer consists of a wooden frame with a double gauze bottom. The upper layer of gauze is No. 4 mesh and the lower one No. 40. In between them is a thick pad of cotton wool. New wool is used for each charge.

From the straining troughs the rosin is run into barrels of [illegible]00 lbs. capacity, which are closed down after the rosin has solidified. The making of the barrels has already been alluded to in paragraph 199.

After use the sticky wadding (or "*Batting Dross*") is packed into barrels and sold. The writer had no opportunity of seeing for himself what subsequently became of this waste material, but the following information was kindly supplied by Mr. C. F. Speh, Secretary-Manager of the Turpentine and Rosin Producers Association, New Orleans, in a letter dated 8th May 1918.

"Batting Dross is sold to dross recovery plants at a price per ton depending upon the current price of the lower grades of rosin. At present

I believe it brings in about $20 a ton. At these recovery plants the dross is broken up by various means, then put into a retort or extractor, and there the rosin is recovered by means of a volatile solvent. This solution is filtered, the solvent evaporated recovered, and the rosin run into barrels. Rosin made in this manner should be sold as reclaimed rosin. The grade of rosin recovered should be about two grades darker than the rosin in the batting dross, but the tendency, owing to lack of proper manipulation, is to produce E., F. and G. "

219. It was a matter of surprise to find that heating by fire, instead of by steam, is the general rule in America. The following additional extract from Mr. Speh's letter may be of interest.

" In the first place, the gum produced in the Long Leaf Pine is different from that from the Chir Pine. I believe the former will stand heating better than the latter.

" The process, while apparently crude, is nowhere nearly as simple as it looks. It requires considerable experience on the part of the stiller to produce the best results. There is a tendency recently to install either registering or recording thermometers at the still, and to use this method of stilling to somewhat replace stilling by sound. The experienced stiller can tell by listening at the outlet of the worm to what height in the kettle the gum is boiling. He must keep it in the kettle and also prevent it from going flat. In the first case, it foams over with a subsequent danger of fire, and in the latter, with one or two minutes heating, will cause a lowering of several grades ".

" Rosin is classed or graded according to colour and cleanliness. A penalty of one grade is usually imposed for improperly strained rosin. The colour ranges from black, known as B, up to X, known as Extra, and is designated as follows " :—

" B, D, E, F, G, H, I, K, M, N, WG, WW, X anything below E is generally attributable to dirt."

" The lower grades are produced either from old gum or caused by scorching. The tendency in this country is to produce a greater percentage in the pale grades. This will eventually result in a lessering in price between the palest and the lowest grades. Producers will then try to produce paler grades than they are now making in order to procure a premium."

" In this section, the vast majority of rosin produced is N and above. At this period of the year, considerable will grade X, which is a grade better than WW, and for which we now have a type. Some would also grade several grades higher than this, were there types provided for them."

" I know of no use which is made of the scum that forms between the turpentine and the water in the separator. There is so little of it that it would hardly pay to fool with it."

CHAPTER XII.

RESEARCH WORK IN SEASONING OF TIMBER.

SECTION 1.—INTRODUCTION.

220. The history of attempts to season timber by artificial means is an interesting one. Until quite recently such a strong prejudice existed against dry kilns in England that they were only used to a very limited extent, and there was very little to encourage anyone to study and develop them. In the North American continent, on the other hand, there has never been anything approaching the prejudice which existed at home and inventors have received every inducement to perfect their apparatus and improve their methods.

Introduction.

Two advantages in the use of dry kilns for timber appealed very powerfully to Americans, *viz.*, the shortening of the time required for seasoning and the reduction in weight.

Open air seasoning takes anything from six to twelve months or more, whereas in a dry kiln only about the same number of days are required to make green timber fit for industrial use. In a lumber producing country this is a matter of very great importance, for it means that the size of storage yards and the magnitude of the stocks in them can be materially reduced.

The weight of unseasoned wood is anything up to two or three times the dry weight, according to species. It can readily be understood how important a bearing this fact has on all questions of transport of timber, especially in such a big country as North America, where thousands of tons of timber are annually railed distances as great as the width of Europe. To deliver a piece of Douglas Fir in New York means a railway journey longer than the voyage across the Atlantic from New York to Liverpool, or a sea voyage twice as long.

On all accounts, therefore, there has been uninterrupted development in artificial seasoning of timber in America and, until quite recently, it is not far wrong to state that the subject had been more closely studied, and more widely practised, in North America than anywhere else in the world.

In England the story is a very different one. Prior to the War dry kilns were at a discount. The timber trade in general had little or no use for them. Architects and contractors were strongly prejudiced against them. For many years timber seasoned artificially was expressly barred from many Government contracts.

As an indication that this attitude was due to little more than blind prejudice it may be noted that, although the kiln drying in England of timber for such contracts was vetoed, no questions were asked as to what had happened to the wood before shipment to England and, as a matter of fact, most of it had been for a longer or shorter period inside a dry kiln.

As so much of the timber used in England is imported from abroad, the home timber merchant cannot under ordinary circumstances have as much use for dry kilns as might otherwise be the case. Most of the timber in a home timber yard is fairly dry by the time it gets there. Artificial seasoning of imported timber is chiefly confined to re-drying for particular manufacturing industries.

All this has been changed by the War, and the changes are certainly not likely to cease to have effect with a return to peace conditions. By force of circumstances prejudice has had to give way to knowledge and artificial seasoning now occupies a very high place in popular estimation in England.

Means had to be found for making large quantities of home grown timber available for use for war purposes in the least possible time. The insistent demands for aeroplane stock could not have been met if there had been months and months of waiting for the timber to dry in the open air. Moreover, in order to accumulate stocks at home as rapidly as possible, large shipments were made from America without waiting for drying beforehand.

On all accounts, therefore, a great demand in England for dry kilns has arisen within the past two or three years. Large numbers of kilns have been erected in different parts of the country. The results have been all that the most sanguine believers in them ever hoped for. Everybody now knows that timber can be kiln dried without impairing its value in the slightest, so that it is safe to predict that there will be no reversion to the old order of things.

Publications.

221. The following is a list of publications on the subject of seasoning and preserving timber that have come to the notice of the writer :—

(1) *Preservation of Structural Timber* (1916), by Howard F. Weiss, Director, Forest Products Laboratory, Madison, Wisc., U. S. A.

(2) *The Seasoning of Wood* (1917), U. S. Department of Agriculture Bulletin No. 552.

(3) *Seasoning of Wood* by J. B. Wagner.

(4) *The Kiln Drying of Lumber* (1917) by H. D. Tiemann, Dry Kiln Specialist, Forest Products Laboratory, Madison, Wisc., U. S. A.

(5) *Drying by means of Air and Steam* (1912) by E. Hausbrand (English translation from German).

(6) *Evaporating, Condensing and Cooling Apparatus* (1916) by E. Hausbrand (English translation from German).

(7) *Timber* (1902) by Paul Charpentier (English translation from French).

In a few months' time a valuable addition to the literature of the subject of kiln drying may be expected from the pen of Mr. S. FitzGerald, the Officer-in-charge of the dry kiln operations of the Air Board for the past two years.

SECTION 2.—SEASONING IN THE OPEN AIR.

Seasoning of Logs.

222. The writer only came across one or two instances of logs being stored for any length of time in mill yards in America. It does not appear to be the general rule in

the West, even in the case of hardwoods, although it is undoubtedly the general rule in England to keep logs for long periods before conversion. Beyond piling off the ground on skidways, no special precautions appear to be taken, such as painting the ends or storage under cover. These remarks apply to round logs.

Air Drying of Lumber.

223. For the seasoning of sawn timber in the open air, flat piling is the general rule in America although a certain amount of piling on end is also done.

A very complete set of rules is given on page 20 of United States Department of Agriculture Bulletin No. 552. The chief points are as follows :—

(1) Raising of the timber off the ground on supports.

(2) Good drainage and keeping the ground free from refuse, rotten wood and vegetation.

(3) Sloping of supports (one inch to the foot) to help moisture to drain off the timber.

(4) Spacing (three-quarters of an inch) between adjacent planks for circulation.

(5) Battens or " Stickers " ($3'' \times 1''$ to $3'' \times 1\frac{1}{2}''$) between each layer of planks for circulation.

(6) Roof protection by boards laid on top of the pile.

(7) Inclined, instead of vertical building of the pile, so that drip may fall clear instead of trickling down the sides.

(8) Spacing between piles (4 to 5 feet) for circulation.

The chief point aimed at is *free circulation of air*. If care is taken to see the foundation supports are not too far apart (not more than 4 feet except for heavy timber) and also to place the stickers (in consecutive layers) one above the other, trouble with warping can be reduced to a minimum.

The importance attached to good piling may be judged from the fact that, in America, although it is all done by manual labour and yard space is often considerable, there is never any disposition to reduce working expenses by neglecting to put into practice all the rules given in the foregoing summary.

A British hardwood timber yard does not present the same methodical appearance as a Western one owing to differences in trade customs. Rectangular and evenly dressed piles are uncommon. Edging and trimming of boards and planks are not done at the time of breaking down. The untrimmed boards and planks yielded by any given log are piled on top of each other in the same relative positions as before sawing, with " stickers " between each. Painting the ends of boards is common and also the nailing on of wood battens. Valuable hardwoods are generally stored in the form of squares under cover.

Sap Stain.

224. When freshly cut sap timber is piled in the open air to season, it frequently becomes discoloured in a few days. This staining is not due to weathering but to the growth of certain fungi living on the materials in the sap cells. It is commonly

held that the lumber attacked by stain is decayed and reduced in strength, but experiments conducted at the Madison Laboratory show that the decay is only very slight.

To be of any real use all known methods of protecting wood from sap stain have to be applied before the stain has time to show itself. If logs become stained before being sawn into lumber, nothing can be done. The inference is therefore that logs likely to be affected should be sawn up as soon as possible after felling, especially in warm weather.

Two methods of preventing sap stain are practised in the States :—

(*i*) kiln drying; and

(*ii*) dipping in a solution of bi-carbonate of soda before air drying.

In Chapter VII, paragraph 142, an illustration is given of the *Trout Dipping Tank,* and its place in the mill is indicated (Plate LXXV).

Section 3.—DRY KILNS—RESEARCH AND THEORY.

225. The opening of the *Forest Products Laboratory at Madison* marked the commencement of a great step in advance in dry kiln practice in America. A considerable number of well known makes of dry kiln were in existence all over the country, but there had been no systematic study of their behaviour on scientific lines. Too much reliance was placed on the personal skill of operators, which could only be attained by long experience.

Dry Kiln Research work by U. S. Forest Service.

The United States Forest Service set to work on totally different lines. Years of painstaking research have been devoted to finding out how wood dries, and this study has led to the invention of an entirely new form of dry kiln by Mr. H. D. Tiemann, Dry Kiln Specialist at Madison. This type of kiln is probably by far the best that exists in America to-day. The indebtedness of the lumber world to the United States Forest Service has been very great in many directions, and in none more than in this question of artificial seasoning of timber. The patents taken out for the Tiemann kiln have been dedicated to the free use of the public. *No firm has any claim to patent rights in this type of kiln as a whole*; no matter what catalogues may lead one to suppose.

226. From what has already been said in the introductory paragraph it may be gathered that British scientists have not been idle in the matter of dry kiln research. Under the stress of War a large number of new kilns would certainly have been put up in any case, but they would not have been so uniformly successful without an immense amount of systematic research.

Dry Kiln Research in England.

The two best known types of kilns in England, The Erith (progressive), and the Sturtevant (compartment), were imported from America many years ago. The British Sturtevant firm appears to have advanced further than the parent firm in the States. Their type of kiln has proved to be so well designed, and the method of operation and control is so good, that the special study instituted by the Air Board has only led to alterations in details. The recent research work itself has been chiefly confined to the making of elaborate tests of artificially seasoned wood in respect of strength and elasticity. Drying by air, Erith and Sturtevant methods have been compared in a very comprehensive manner.

It is rather remarkable that research in America and in England should have resulted in two distinct types of kilns. In a way the Tiemann kiln is the latest in order of evolution, as it resulted from comparative tests of the American Sturtevant and other types at the Madison Laboratory, but the fact remains that specialists in England are quite content with the British Sturtevant and look upon it as equal, if not superior, to the Tiemann. The writer is not in a position to express an opinion himself and proposes to describe both types.

How wood dries.

227. To enable anyone not previously conversant with the subject to realize something of the complexity of the problem of drying wood artificially, it is proposed to give a few notes on theoretical considerations. Readers desirous of skipping these notes can pass on to paragraph 229 dealing with actual kilns.

There is no literature on the subject of modern practice in kiln drying of timber in England. The writer gratefully acknowledges that his own slight insight into the subject has been chiefly acquired by a visit to Madison and by study of Mr. Tiemann's book on "The Kiln Drying of Lumber," and the notes which follow are very little more than extracts from the same work.

In Chapter IV of his book, Mr. Tiemann refers to water as existing in two forms in green wood, *viz.*:—

(1) *Free or liquid water* in the capillary spaces of fibres and vessels.

(2) *Hygroscopic moisture* in the substance of the cell walls.

The importance of the differentiation between the two forms lies in the fact that free water can be extracted without causing the wood to change in volume, whereas the slightest loss of hygroscopic moisture causes the wood to shrink. Extra heat is also required and, if the temperature falls, a certain amount of the hygroscopic moisture will be re-absorbed. There is, in fact, a definite relation between the relative humidity of the air and the amount of moisture which the wood will retain. There is a definite limit to the amount of hygroscopic moisture under any circumstances. This limit is called the *Fibre Saturation Point.*

How wood dries is described by Mr. Tiemann as follows (page 110) : —

"In order to get an understanding of the phenomena which take place as wood dries, let us consider a piece of green lumber containing 75 per cent. of water, 25 per cent. being hygroscopic and 50 per cent. free water, and follow the process as nearly as we can step by step. The evaporation must take place from the surface, and the water in the interior must pass from cell to cell until it reaches the surface. In order that there shall be any movement of the water within the stick, there must be a gradient of moisture condition or a difference of temperature between any two points. Therefore, the surface must be drier than the inside. Just how the moisture passes through the wood is not known. It may all pass through the cell walls as hygroscopic moisture or the free water may pass through the pits in the walls by capillarity as it passes off from the surface. What probably happens is this; the free water evaporates first from the surface, and if the rate of evaporation is greater than the rate at which the internal free water can pass to the surface, the hygroscopic moisture also begins to evaporate from the surface, which then begins to shrink and surface check. In this condition the columns of free water become interrupted and a retardation of the transfusion of free water from the inside takes place. This is one phase of "*casehardening.*" On the other hand, if the surface evaporation is not too rapid, a continuous flow of the free water from the centre to the surface takes place until all the free water has passed off. It is evident that the hygroscopic moisture must pass outward only through the substance of the cell walls themselves and not as the free water through the capillary spaces."

"*Casehardening*" (page 114):—" As a green piece of wood dries, shrinkage as a rule does not begin until the fibre saturation point has been reached. If the conditions of drying are such that the evaporation from the surface exceeds the rate at which the water in the centre transfuses outwardly, the free water on the surface will all disappear before the inner water can take its place. The water films or columns thus become broken with air in between, so that the remaining water has to pass out gradually by seepage along the cell walls, and further transfusion of the free water from the inside is thus retarded. This is the first stage of casehardening."

" As drying then progresses beyond the fibre saturation point, the outer shell tends to shrink, but is prevented from doing so by the wet interior. Strong tension stress is therefore set up in the outer surface with compression in the inner portion."

" This condition is shown by Fig. 21-A. (Plate CXVI), which represents a disc sawn across a plank of wood at this stage."

" If this disc be immediately slotted, as shown at Fig. 21-B., by running five parallel saw cuts nearly through, and breaking away two of the tongues thus formed, the outer prongs will at once bend outwardly as shown in the figure. This indicates temporary casehardening, due primarily to a dry surface and wet interior. If this disc be then placed in a dry room where it will dry out, it will finally assume the form shown in Fig. 21-C."

* * * * * * *

" The outer shell, which dries first below its fibre saturation point and thus tends to shrink, is prevented from doing so by the wet interior. As it continues to dry, it hardens in this expanded condition (See Fig. 21-A). The interior now continues to dry very slowly and tends to shrink but is in turn prevented from doing so by the hardened outer shell which has " set " in its expanded condition. The result is that the stresses within the block are now reversed, the outer shell being in compression and the inner portion in tension, as shown in Fig. 22-A (compare with Fig. 21-A). If the tensile strength of the wood across the grain is sufficient to withstand these stresses, the wood will dry in this condition containing permanent internal stresses, but if it is weak it will yield to the tension stresses and split open as in Fig. 22-B., usually along the medullary rays. This is the explanation of honeycombing or " hollow horning."

A correct understanding of the phenomenon of *casehardening* will help to explain most of the effects that may be observed in the drying of timber, such as

EXAMPLES OF CASE-HARDENING.

Illustrated by means of sections or discs cut across the timber perpendicular to the grain.
Tension stresses are indicated by minus sign (–) and compression by plus sign (+).

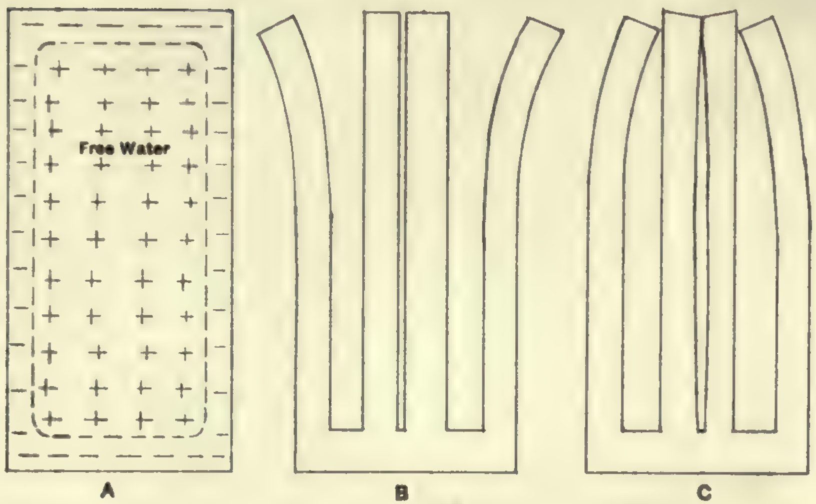


Fig. 21. First Stage.

A. Surface dried and in a state of tension; the interior contains free water and is in compression.

B. If disc A be sawn by five slits as shown, it will at once spring to this shape.

C. If B be dried in an oven or in a warm room, the tongues will finally bend to this shape and remain so permanently.

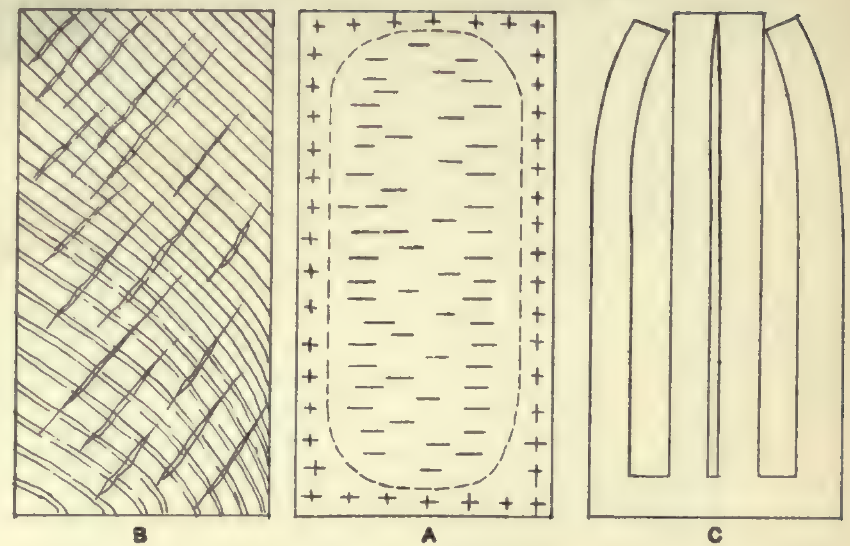


Fig. 22. Final Stage.

A. Permanent internal stresses remaining after the wood has completely dried. (exact opposite to 21 A).

B. Honey combing resulting from above.

C. If disc A be sawn by five slits as shown, it will at once assume this form *and bind on the saw.*

(After Tiemann)

(para. 227).

warping, internal and external cracking (or *checking* as it is called), etc. The effect of the re-absorption of moisture can well be studied by the behaviour of pronged sticks as in the diagrams.

The removal of casehardening is an essential preliminary to all proper drying operations, because all wood is subject to it and in a dry atmosphere, the effect is soon very pronounced. Mr. Tiemann has proved that casehardening can be removed by placing the lumber in steam, or in hot moist air, long enough to moisten the external shell. The time required is from ten minutes to half-an-hour according to species.

Principles of Kiln Drying.

228. A dry kiln should be looked upon as something more than a mere piece of apparatus for evaporating moisture, seeing that the extraction of the moisture should be done with the least possible injury to, or distortion of, the wood.

The dry kiln engineer has three factors at his disposal in controlling the drying of wood, *viz.*:—

(1) *Humidity.*—Wood cannot dry if the air in contact with it is saturated with moisture and, in other cases, the rapidity of drying depends on the *relative* humidity of the air.

(2) *Circulation.*—It is only by maintaining circulation that the relative humidity can be maintained at the proper level so that moisture can be withdrawn from the air as fast as it is evaporated from the wood under treatment.

(3) *Temperature* (page 139). "Heat is of course the factor which produces the drying. As in the case of the steam engine, the steam and the mechanism are both essential, yet it is the heat which produces the result. It acts in two ways, the heat imparted to the water converts it into vapour and, the higher the temperature, the greater is the capacity of the air or more properly the space for containing the vapour. Heat also appears to influence the rate of transfusion of the water through the wood substance. The higher its temperature the more rapidly it passes through. The temperature moreover has a marked influence on the physical character of the wood, which becomes more and more soft and plastic whilst moist as its temperature is raised. Strength is greatly reduced with increase in temperature whilst moist. Here too the effect upon different species varies greatly."

(4) *The Process of Drying* is summarized as follows (page 141) :—

(1) The evaporation from the surface of a stick should not exceed the rate at which the moisture transfuses from the interior to the surface."

(2) "Drying should proceed uniformly at all points otherwise extra stresses are set up in the wood causing warping."

(3) " Heat should penetrate to the interior of the lumber before drying begins."

(4) " The humidity should be suited to the condition of the wood at the start and be reduced in the proper ratio as drying progresses. With wet or drying wood it should usually be held uniform at a degree which will prevent the surface from drying below its fibre saturation point until all the free water has evaporated then gradually reduced to remove the hygroscopic moisture."

(5) " The temperature should be uniform and as high as the species under treatment will stand without excessive shrinkage, collapse or checking."

(6) " The rate of drying should be controlled by the amount of humidity in the air and not by the rate of circulation, which should be made ample in all of them."

(7) " In drying the refractory hardwoods, such as Oak, best results are obtained at a comparatively low temperature. In more easily dried hardwoods, such as Maple, and some of the more difficult softwoods, such as Cypress, the process may be hastened by a higher temperature, but not above the boiling point. In many of the softwoods the rate of drying may be very greatly increased by heating above the boiling point, with a large circulation of vapour at atmospheric pressure. In this case the dew-point should be maintained at 212° to prevent surface drying or casehardening. "

(8) " Unequal shrinkage between the exterior and the interior portions of the boards, and also unequal chemical changes must be guarded against by temperatures and humidities suited to the species in question to prevent subsequent cupping and warping."

(9) " The degree of dryness attained should conform to the use to which the wood is to be put. "

(10) " Proper piling of the lumber and weighting to prevent warping are of great importance."

SECTION 4.—TYPES OF KILNS, AMERICAN.

*Types of Kilns—Historical.

229. All dry kilns can be classified into two groups, *viz.*:—(*i*) *Progressive Kilns* and (*ii*) *Compartment Kilns*. In the former, the kiln is a long chamber with doors at both ends. The green timber piled on tramway cars enters at one end and is slowly moved forward day by day. In from ten to fifteen days it reaches the other end thoroughly dry.

There are several makers of *Progressive Kilns* in America The best known make in England is that of the *Erith Engineering Works Company*.

* This chapter deals only with dry kilns for lumber. For the special types of driers used for veneers reference is invited to Chapter VIII.

Excellent results have been obtained with kilns of this type, but it is not proposed to enter into any description of them in these notes for the following reason. This chapter is primarily intended to assist in starting systematic research work in India, which must precede any attempt to go in for dry kilns on a commercial scale, which is all progressive kilns are suitable for.

There is no one method of drying timber which is applicable to all species or even to any thickness of a single species. The treatment for one kind or size might be fatal to another. The one essential for successful operation of any kind of kiln is that the timber under treatment should be of one species (or of closely allied species) and of approximately the same thickness throughout the piles. It follows therefore that progressive kilns are only suitable for operations on a big scale with a limited range of species and sizes. It would be impossible to make such kilns small enough for use in a laboratory.

The *Compartment Kiln* is not open to this objection. Instead of one long room there are a number of small ones. Each compartment is worked separately from the others. After putting a "charge" of timber into a compartment the door is closed and the pile remains stationary until treatment is finished. The method lends itself to successful operation on any scale and very good results can be obtained with small compartments suitable for use in experimental work.

According to Mr. Tiemann (page 31) :—

> "A perusal of the records of the U. S. Patent Office shows that over a hundred different forms of dry kilns for drying lumber have been patented, as well as of the accessories such as doors, heating apparatus, trucks, loaders, etc. One of the earliest ones was taken out in 1862 and is operated primarily upon the principle of a hot air furnace. In addition to the hundred or more satisfactory forms of kilns for drying lumber at atmospheric pressure there are numerous patents for apparatus in which pressure and vacuum may be obtained and in which the apparatus is mechanically revolved, or moved, to secure thorough heating of the entire pile of wood or other hygroscopic material which is to be dried. Evidently many of these have failed to produce the results anticipated, or have been impractical from a commercial standpoint, since there are to-day only about twenty-five kinds in commercial use."

The idea of using artificial heat was first put into practice in France. The first big move in America was made by B. P. Sturtevant, the inventor of the progressive kiln. He made use of fans to regulate the circulation of the air and of steam pipes to heat it.

To meet the needs of operators dealing with relatively small quantities of timber of uniform thickness or species, the compartment kiln followed. Sturtevant stuck to fan circulation, although a number of designs were brought out for producing the desired circulation without the use of forced draught. To quote a phrase used by Mr. Fitzgerald, in a lecture given by him in May 1918, they made use of "*thermal circulation.*"

The Sturtevant kiln as originally invented in America remains to-day very much the same in that country. In England, however, it has been considerably improved and, as already remarked, the standard type of compartment kiln designed by Mr. Fitzgerald for the Air Board only differs in details from the designs of the British Sturtevant firm.

All the types of kilns so far touched upon have one feature in common. In all of them the moisture drawn from the timber is got rid of by being allowed to escape (in whole or part) into the open air as a vapour. Another class of kiln has been invented in America in which provision is made for the condensation of the moisture inside the kiln. Attempts have been made from time to time with varying success to accomplish this end with fan circulation and with thermal circulation. The latest type of all in America is the one already alluded to as invented by Mr. H. D. Tiemann at the Forest Products Laboratory, Madison. In this type thermal circulation and condensation are obtained by the use of cold water sprays.

Tiemann Kilns at Madison.

230. The Tiemann kiln outfit at Madison consists of three single pile kilns in a row (Plate CXVII), with a narrow passage between the centre compartment and the two outer ones. The internal dimensions of the timber piling part of each kiln are $18' \times 8' \times 10$, and the holding capacity is 2,500 B. F. (210 cubic feet approx).

The walls are of hollow tiles (bricks). The timber is piled by hand on an open framework above the heating coils. Rails and cars are dispensed with.

The main door of each kiln slides sideways, and is operated by what is known as the *Hussey Patent Door Carrier* (Plate CXVIII). There are two or three iron pins at the sides of the doors. When a door is in position, closing a kiln, these pins rest in V shaped brackets on the wall. The weight of the door causes it to make close contact with the wall. To open a door, the carrier is brought into operation. A lever is pulled down which lifts the door off the brackets and leaves it free to be moved sideways on an overhead runner.

Inside the kiln are three sets of pipes, running the whole length of the room, *viz.* :—

(1) A number of Perforated pipes, some of them fixed to the roof and the others fixed below the pile of lumber, for the admission of *live steam.*

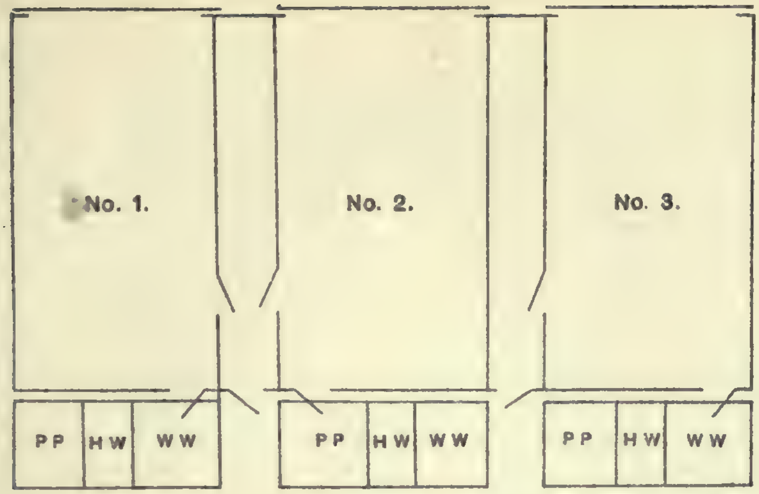
(2) A row of *Condensing pipes* along one side wall.

(3) Several rows of *Steam Heating pipes* under the pile.

Below the condensing coils along one side of the kiln, is a narrow recess about 12″ wide called the *Spray Chamber.* Near the top of this chamber is a row of spraying nozzles set in a pipe connected to a pump and well. The particular make in use at Madison is the *Graduating Vermorel Nozzle.* Along the bottom of the spray chamber is a gutter which drains into a second well.

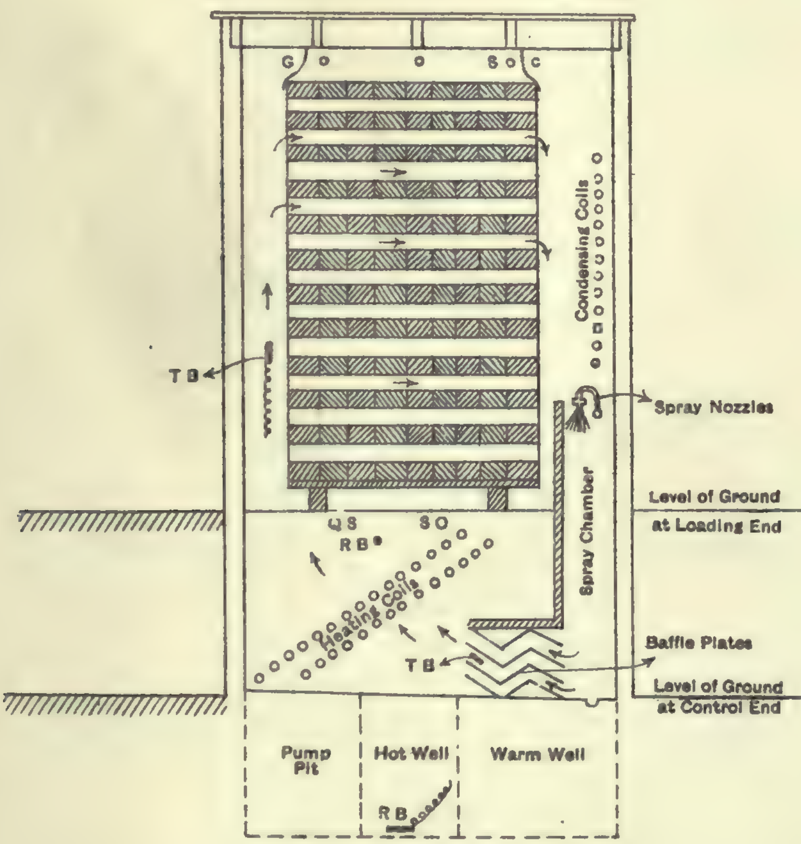
The inner wall of the spray chamber has a narrow opening along the bottom, so that air can pass from the chamber into the space occupied by the heating pipes. But the opening is not a plain one, as it is backed by a series of zig-zag *Baffle plates*, made of wood. Wet air passing from the spray chamber to the heating coils impinges against these plates and drops all mist or globules of water. This arrangement ensures that nothing but air and water vapour passes on to the heating coils, *i.e.*, the air is fully saturated but nothing more.

PLATE CXVII.



Plan

P P = Pit for Pump ; H W = Hot water Well ; W W = Warm water Well.



Sectional Elevation.

S = Steam Pipes ; C = Curtain ; R B = Thermostatic Bulb of Regulator ;
T B = Thermostatic Bulb of Recording Thermometer.

TIEMANN KILNS
AT THE
FOREST PRODUCTS LABORATORY MADISON.

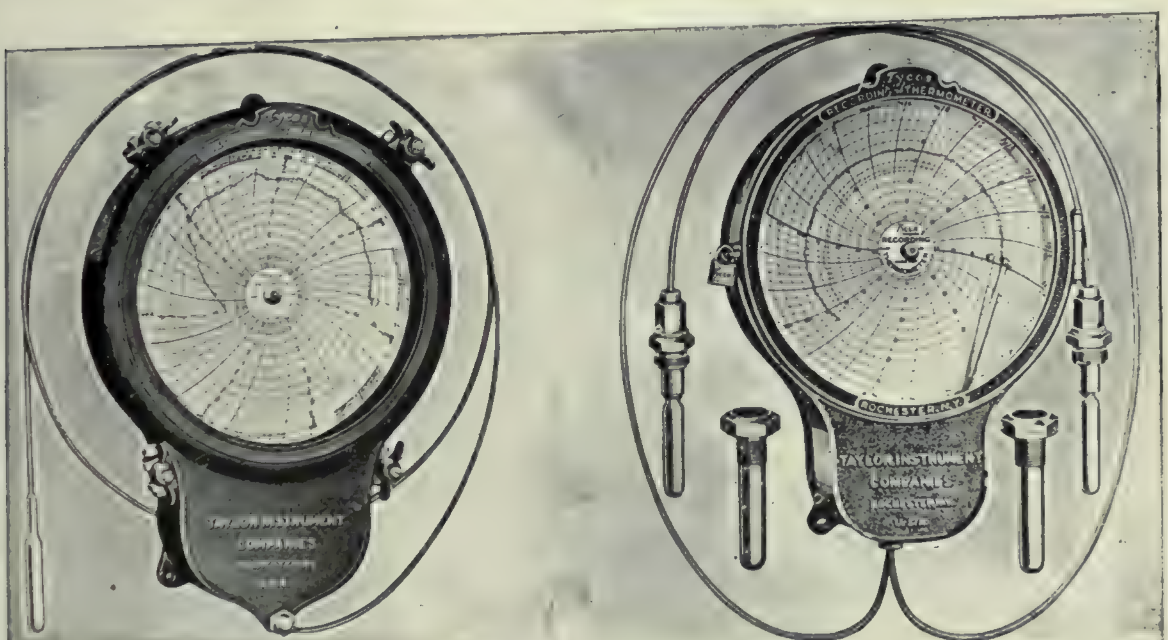
(para 230).

Hussey Patent Dry Kiln Door Carrier. Upper view shows carrier in position ready for lifting door; Lower view shows door lifted and ready to be moved sideways.
(By permission of Messrs. The Dry Kiln Door Carrier Co.)

(para 230).

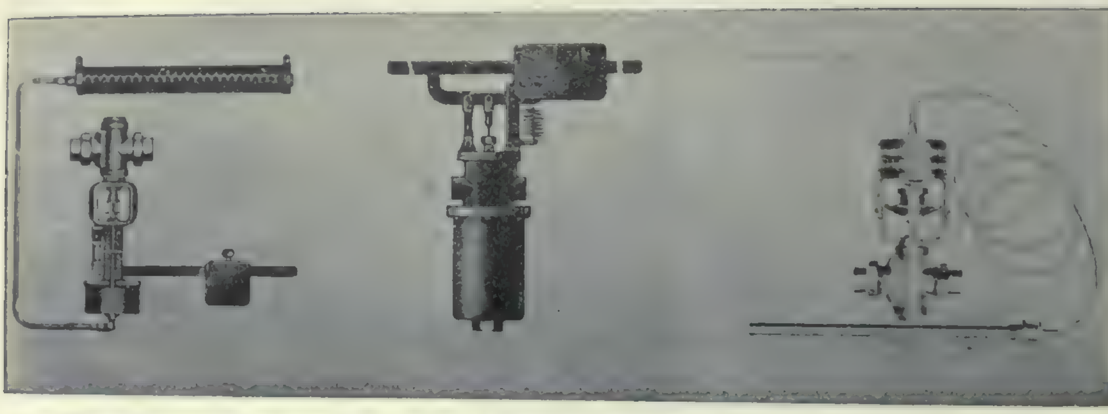
(1). Control end of Tiemann Dry Kilns at Madison, Wisc.

(para 230).

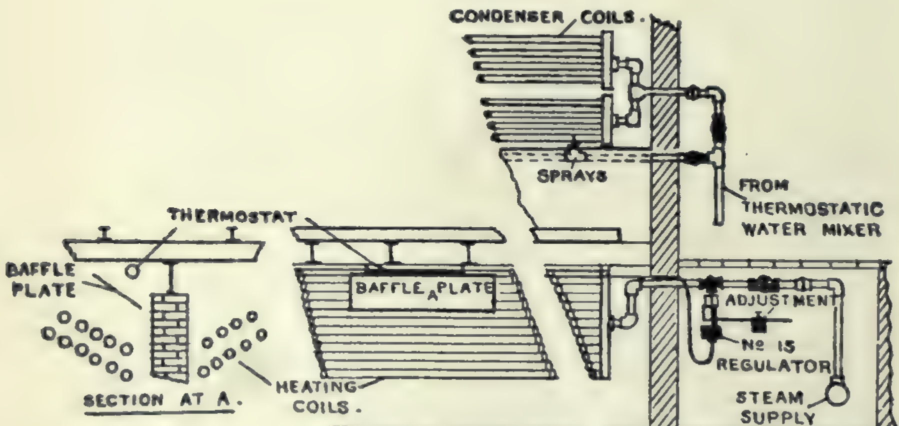


(2). Recording Thermometer—7 days' record. (3). Recording Thermometer— 24 hours' double record.
(By permission of Messrs. The Tayler Instrument Coys.)

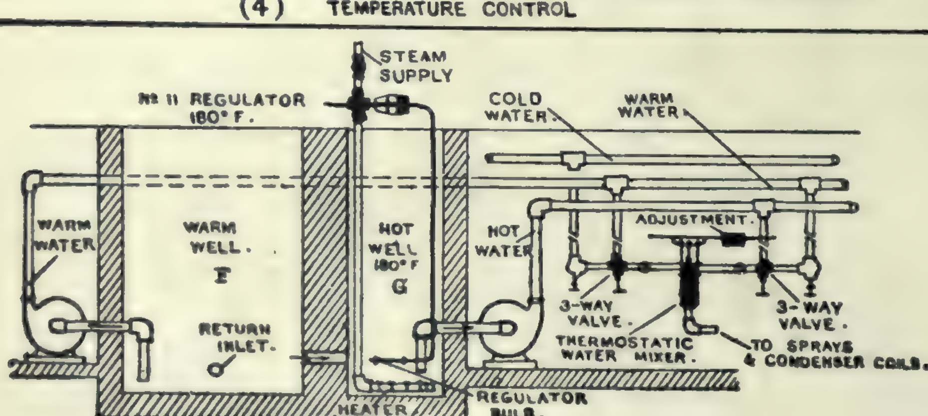
(para 233).



(1). Regulator for steam heating coils in Kiln. (2). Thermostatic Water Mixer for Spray.
(3). Regulator for steam heating coils in hot well.

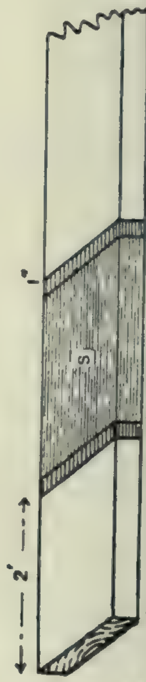


(4) TEMPERATURE CONTROL



(5) WATER CONTROL

Diagrams showing positions of Regulators in Tiemann Kilns
(By permission of Messrs. the Powers Regulator Co.)



(6) Method of cutting test pieces and samples

(para 232).

From the roof a short canvas curtain is hung the lower end resting against the pile. In this way air can only circulate through the pile and not over the top. At the end opposite to the big door and entrance for the timber is all the apparatus for the control of the drying operations. Plate CXIX shows the control end of two of the battery of three kilns at Madison. The wells and pumps are below the floor, covered by a trap door.

The maze of pipes, valves, cocks and other fittings is more complicated than would be the case in a commercial installation because the heating, condensing and steam coils are all arranged in triplicate. For each of them there are three separate sets of pipes and turn-cocks. Either one, two or all three of the sets can be used simultaneously thus affording a wide range of variation for the timber tests.

All three kinds of coils are not necessarily in use simultaneously and all the time. The steam coils are, as a rule, only used at the beginning of an operation to remove casehardening and to supplement the water spray when a temperature above 165° F. is desired; otherwise, there would be trouble with steam in the pump.

The condensing coils are as a rule only used towards the end of a test when very little circulation is needed.

Operation of the kiln.

231. In studying the method of operation of the kiln the first and most important point to be quite clear about is that there is normally an appreciable difference between the temperature of the air in contact with the heating coils and that in the water spray. *Circulation of the air is therefore set up and constantly maintained without the use of fans or any other apparatus for producing forced draught.*

The direction of circulation is indicated by arrows in the diagram. The air leaves the spray chamber fully saturated. After passing through the baffle plates it comes into contact with the heating coils and its temperature is raised so that it is no longer saturated. *Its relative humidity on entering the pile entirely depends on the difference in temperature between the spray and heating coils.* Being less than saturated. the air can take up moisture in its passage through the pile but in its subsequent contact with the cold spray its temperature is lowered and it is compelled to part with the extra moisture. Condensation takes place and drips into the gutter at the bottom of the spray chamber. On leaving the latter the air is in exactly the same state as it is supposed to have been in at the beginning of the cycle. There is therefore no reason why the withdrawal of moisture from the pile of wood should not go on indefinitely. It does in fact do so until the wood is thoroughly dry.

Automatic Control.

232. From what has been said it can readily be understood that the success of the kiln depends simply on the efficiency of the control of the temperatures of (*a*) The Heating Coils and (*b*) The Water Spray. The *Regulators* in use for the purpose are automatic, that is, after being set to any given temperatures they will maintain them indefinitely no matter what variations there may be in the outside supply of steam and water. The designs in use are indeed so good that there is no necessity whatever to keep the kiln under constant observation. It can be left absolutely alone for a whole day or more with full certainty that there will be no appreciable variations in temperatures in the interval.

The Regulators are three in number, their function is to control :—

(1) Steam supply to the heating coils in the kiln.

(2) Steam supply to the heating coils in the hot water well.

(3) Water supply to sprays.

(1) *Regulator for main steam supply.*—From Plate CXX (1) it can be seen that the apparatus consists of three parts, *viz.*, (*a*) Thermostatic Bulb, (*b*) Steam valve and (*c*) a flexible tube connecting them.

The thermostatic bulb is placed close to the heating coils as shown in Plate CXX(4), (protected from direct contact with the coils by a special baffle plate). The bulb is filled with a gas, the pressure of which acts directly on the valve, which is placed outside the kiln at the control end in the main steam supply pipe. A small lever and adjustable weight form part of the valve mechanism. Any change in the temperature of the air near the heating coils alters the pressure of the gas in the bulb and thereby affects the valve. By shifting the position of the balance weight, the effect of the pressure of the gas can be varied at will.

(2) *Regulator for steam supply for water in well.*—From Plate CXX(3) it can be seen that this regulator works on the same principle as the one just described. The position of bulb and valve can be seen in the lower diagram.

(3) *Regulator for water spray* or *Thermostatic Water Mixer.*—The appearance and position of this regulator can be gathered from Plate CXX (2) and the lower diagram. In a dry well under the floor, alongside the two water wells at the control end of the kiln, is a small steam pump by means of which water can be pumped to the spray nozzles at any desired pressure. The water itself comes from two sources, *viz.*—

(*a*) The warm water well and the cold water tank, or

(*b*) The hot well and the warm well.

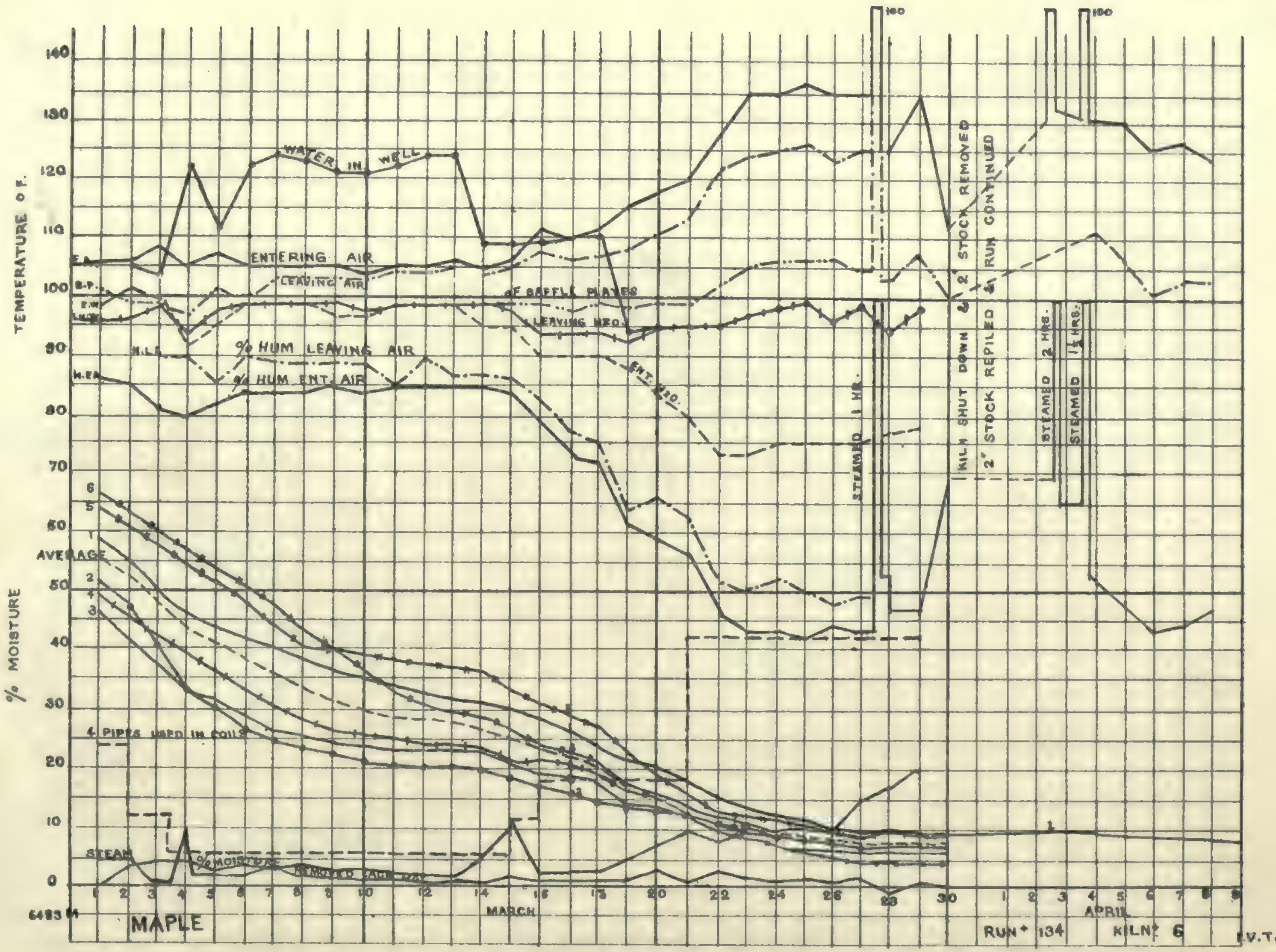
The alternatives are provided to give a greater range of temperature. The use of two wells with the regulator for the hot one economizes steam. The pipes from both sources lead to the patent mixer which automatically operates valves in each so that the water is taken in the right proportions to produce any desired temperature at the spray. Adjustment is done with a balance weight.

Recording Thermometers.

233. The regulating devices do not record temperatures and so to complete the outfit, thermometers have to be used in conjunction with them.

The dial form of recording thermometer, illustrated in Plate CXIX (2) and (3), is used at Madison, as everywhere else in America, for dry kiln work. The writer did not come across a single instance of the use of the drum type which is much preferred in England.

The dial thermometers act in the same way as the temperature regulators already mentioned, with the substitution of a pen and clockwork mechanism for the valve. Both mercury and gas filled forms are on the market.



Sample of Graph Record.-U. S. Forest Products Laboratory, Madison.

U. S. A.

(para 235).

Mr. Tiemann states that the latter is better for dry kilns. Photo (2) shows a dial which lasts for 7 days, *i.e.*, it makes one complete revolution in a week. No. (3) only lasts for 24 hours. This pattern also illustrates the fact that temperatures for two independent thermostatic bulbs can be recorded on one dial. Different coloured inks are supplied. Correct calibration is of course essential, and is attended to at regular intervals.

For the full control of the Tiemann kiln two *Recording Thermometers* are required with their thermostatic bulbs placed as follows :—

(1) In the Baffler to record the temperature of the saturated vapour *before* it passes to the heating coils.

(2) On the side of the pile of timber opposite to the spray (if there is only one pile) or in the flue between the piles (if there are two of them) to record the temperature of the air *after* leaving the heating coils.

Dry Oven and Weighing Machines.

234. To complete the references to equipment, mention must be made of the *Dry Oven* and *Weighing Machines.* The Oven is simply a small metal box with shelves for small wood samples and coils for heating to boiling point 100° C. The procedure at Madison is as follows.

Several *sample planks* are taken from different parts of the pile of timber to be tested. Two sections, 1″ wide, are cut from each plank at 2′ and 4′, respectively, from one end as shown in the diagram on Plate CXX. These small sections are weighed on a *Gramme Scale.* Each of the pieces (S) or *Samples*, as they are called from between them, is weighed on a scale recording lbs. and hundredths (Fairbanks Morse and Company).

The little pieces are heated in the oven until they cease to lose weight, being taken out and weighed several times in the interval. It generally takes from two to three days. If the original weight = W and the dry weight = D, then the *moisture per cent.* = $\frac{W-D}{D} \times 100$. As soon as this is determined, the plotting of the *Graph* for the *Samples* (S) can be commenced.

The samples (S) are weighed at the beginning of the run and weighment is repeated daily until the run is finished, a matter of possibly 20 days to a month. Care is taken to number the samples and *to put them back each day into their original positions in the pile of timber.**

Graph Records.

235. The observations taken with regard to temperature, weight and humidity, are all interpreted by means of *Graph Records.* On them the temperatures of the air and water on entering and leaving the pile are shown and also the daily loss of moisture of each sample separately. The number of coils in use at the various stages of the run is also shown. Plate CXXI is a copy of an actual record at Madison which was given to the writer. The amount of information condensed into this graph is remarkable. It contains a complete history of the run in great detail. It may be noticed that there were 6 samples under observation.

* To avoid having to open the big door every day, a small one is provided in the passage way between adjacent kilns (*vide* diagram, Plate CXVII).

Results with this type of kiln are remarkably good, and experiments can be repeated several times over with different piles of a given species of timber, with the absolute certainty of being able to formulate general conclusions in the shortest possible time, and with the least expenditure of effort on inconclusive trials. In no other type of kiln on the market in America is there the same absolute control of all the essential factors. In fact American manufacturers are showing a marked desire to incorporate these features of the Tiemann Kiln in their own designs. For experimental purposes it would be a mistake to adopt any of these composite forms although they may be of use when the requirements of Indian woods are known and the erection of kilns on a commercial scale is under consideration.

SECTION 5.—BRITISH DRY KILNS.

British Air Board Kilns.

236. The majority of the compartment kilns in England are of the forced draught type built by the Sturtevant Engineering Company, London. Owing to the excellence of the method of control invented by the firm, these kilns are capable of giving uniformly good results, so that it is only natural that the resources of this firm should have been made full use of by the Air Board. A considerable number of kilns have been put up within the past two years There have however been alterations in details as explained below.

Several years ago the firm brought out what is known as their *Triple Duct Compartment Drier*. The chief feature of this type is the provision of three main ducts from which branches are run to each compartment. Supplies of hot, cold and moist air, respectively, are maintained in these ducts by two fans and a single heater. Dampers in the branches permit of any desired mixture being supplied to each compartment independently of the others.

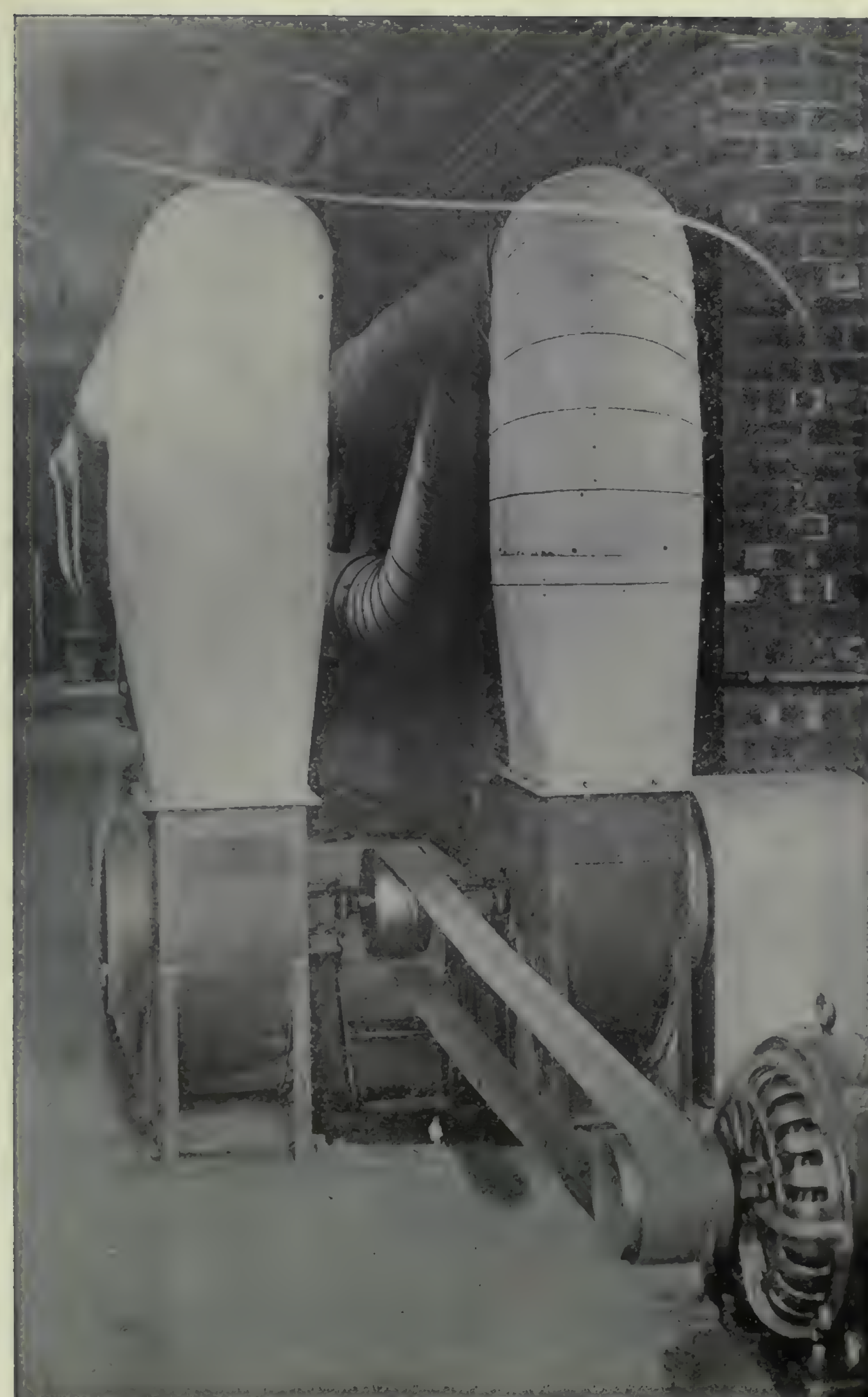
The modification introduced by Mr. Fitzgerald for the Air Board is known as *The Multiple Heater Drier.*—There are only two main ducts, instead of three, and in order to make each kiln independent as to temperature and moisture there is a separate heating apparatus for each compartment. Standard designs for this type have been worked out and it is likely to take first place in commercial operations in the future.

Commercial Multiple Heater Kilns.

237. The writer had an opportunity of seeing a 3-kiln multiple heater installation at *Homerton Bridge, London, E.* The internal dimensions of the kilns are 47′ × 17′ × 10′ (height). The kilns are side by side with an extension of the roof in front of the entrance doors. The floor is of cement. Unlike the Tiemann kiln there are no wells or underground apparatus, thereby simplifying construction.

Ordinary hinged doors are used instead of the Hussey patent (Plate CXVIII), although the latter is generally recognized as the best for dry kilns simply because of import and other restrictions during the War. Even with drawings supplied by the patentees it was found to be impossible to get the material with which to make them in England. Under normal conditions this can be done anywhere on payment of a royalty to the owners of the patent. This fact should be noted for future use in India.

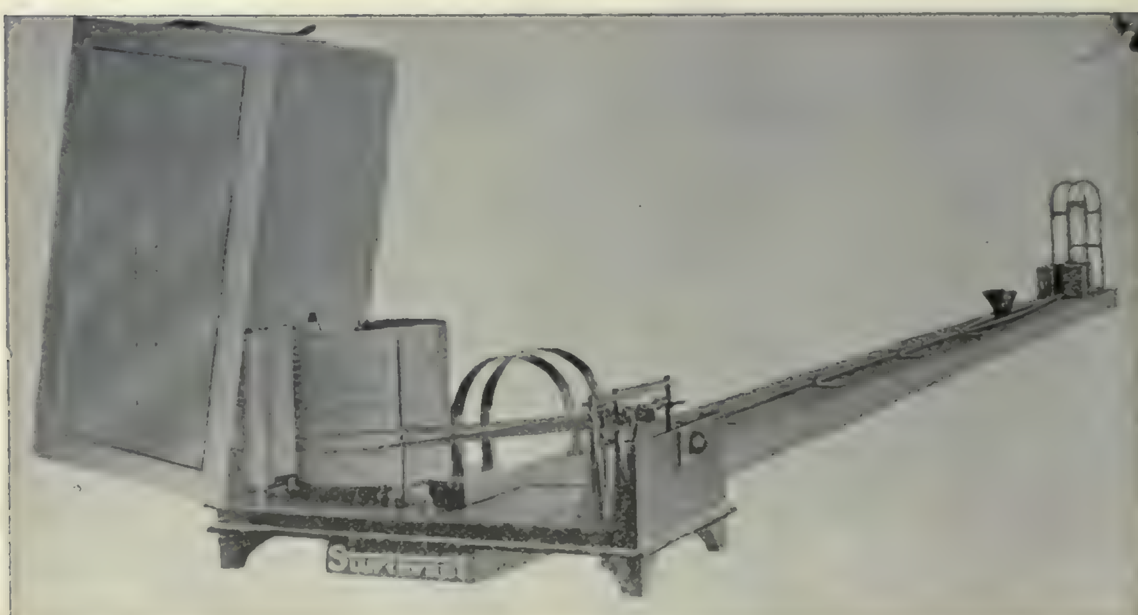
The building has two floors, the kilns proper being on the lower one. Upstairs is the apparatus for producing and controlling circulation. Inside the kilns are box-



Apparatus Room of Multiple Heater Type Kiln.
(Presented by Mr. Fitzgerald).

(para 237).

(1). Sturtevant Compartment Kilns, put up for the British Air Board.
(Presented by Mr. Fitzgerald).



(2). Wet and Dry Bulb Recording Hygrometer.
(By permission of Messrs. Pastorelli & Rapkin).

(para 238).

like projections, about 2′×2′ in section, running along the foot of all the sidewalls. On top of them are a number of sliding lids. In the middle of the right hand wall in each kiln is a vertical duct connecting the horizontal duct with the floor above. Air is pumped down these vertical ducts and is discharged into the kilns by the horizontal ducts, the distribution being regulated by the sliding lids in any desired manner.

After passing across a kiln through the pile of lumber, the air (now laden with moisture drawn from the wood), enters the left hand horizontal duct and from thence finds its way back to the upper floor by a single duct connecting all three horizontal exhaust ducts together.

Proceeding to the upper room, the appearance of the apparatus is similar, to that shown in Plate CXXII (taken elsewhere). The motor drives two fans, one inside each of the big vertical pipes. The one on the left draws air in from the atmosphere through a circular grating. The fan on the right draws the exhaust air from the kilns. A damper and outlet are provided so that any desired part of the moist exhaust air can be allowed to escape into the atmosphere and any desired part driven forward along the overhead pipe on the left.

From the two big overhead pipes branch ducts make connection with each kiln. The branch pipes join together and then pass as a single pipe into a box containing the heating coils. Leading from the heater is a connection to the vertical delivery duct in the kiln. In the branch pipes are dampers so that any desired proportions of fresh and moist air can be pumped into each compartment.

Close to the heating coils are steam spraying coils so that the moisture in the air sent into the kilns can be increased by injection of steam. It is to be noted that this is quite different to steaming the timber in a compartment with live steam. The steam is absorbed into the air before reaching the lumber; whereas, in steaming proper, hot vapour comes into direct contact with the lumber.

Operation and control of the Kilns.

238. It is claimed for the Sturtevant kiln that the circulation is *positive* at all times and can be of any desired intensity. By re-circulating the air, steam is economized. In practice it is found that about four-fifths can be used over and over again. Although the damper at the exhaust outlet is adjustable, there is rarely any occasion to alter it for lumber of similar description and it is more or less permanently set to allow about one-fifth of the moist air to escape. It is this small but continuous discharge that gets rid of all the moisture drawn from the lumber. It passes off as vapour into the atmosphere; there is no need to provide drains for condensation inside the kiln.

Automatic regulators, such as those described in paragraph 232, are not used at present (1918) in England. It is stated that the want of them gives no trouble. The variations in steam pressure and in external temperature ordinarily met with do not appreciably affect the drying. Fifty lbs is about the best pressure but a difference of 10 lbs. either way would not make more than 2° difference on the chart. Moreover, owing to the fact that so much of the air is re-circulated, differences in the temperature of the atmosphere do not have much effect. A fall of 12° to 15° at night would not show a change of more than 2° on the chart. Such small variations are of no moment. A man has to be on the spot continuously to look after the boiler and he can make an occasional small adjutsment to steam valves or dampers.

The question may well be asked how control is effected. A special type of *Wet and Dry bulb Recording Hygrometer* is used. Plate CXXIII (2) is an illustration of the one used on Sturtevant kilns in England. The instrument is mounted on a board with the wet and dry bulbs six feet away from the recording drum. The board is placed on brackets on the wall above the ducts delivering air into the kiln. The recording drum fits into a glass covered recess in the front wall *vide* Plate CXXIII (1).

An important feature of the drum type of instrument is that the length of chart is independent of the rate of revolution of the drum. The standard form makes one revolution in 7 days. If it is desired to use a 15-day or even longer chart, the method of setting up the instrument is to coil the chart on the small spool. The error in the second week owing to there being two thicknesses of paper on the drum is infinitesimal. The only precaution necessary to enable the hygrometer to give a correct record of variations in temperature and dewpoint is to see that the supply of water for moistening the wet bulb is at the same temperature as the air in the kiln.

For purposes of calibration a useful form of pocket wet and dry bulb hygrometer can be obtained from the same makers as the recording instrument.

In the course of an operation the chart gives a continuous record of the temperature and dewpoint of the air as it enters the pile of lumber. The relative humidity can be worked out and plotted if desired, but it is not necessary to do this for commercial operations in England. Messrs. the Sturtevant Engineering Company have by experiment worked out a series of charts showing temperature and dewpoint for most of the species met with in ordinary business, and the firm is prepared to supply copies to users of their kilns.

When starting an operation for a known species, the corresponding chart is placed on the drum. All that the attendant in charge has to do is to see that the pens keep close to the guide lines on the chart. Inattention or incompetence on his part leaves a record which tells its own tale. The guide charts given in Plate CXXIV are for Walnut stock, 1½″ thick and for typical sooftwood, 1¼″ thick.

239. The writer has been given working drawings and an estimate for an excellent set of four kilns specially designed for experimental purposes by Mr. Fitzgerald (Plate CXXV). The internal dimensions of the kilns are :—

Experimental Multiple Heater Kilns.

2 rooms, $10' \times 7'\ 9'' \times 6'\ 6''$ (height) = 500 cubic feet each (nearly).

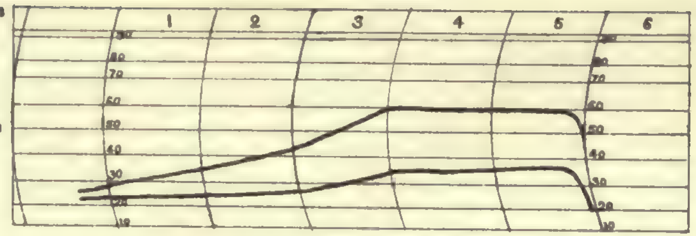
2 rooms, $8' \times 7'\ 9'' \times 6'\ 6''$ (height) = 400 cubic feet each (nearly).
Total for all the kilns =1,800 cubic feet.

Each of the large rooms can hold from 120 to 150 cubic feet of lumber and each of the small ones from 100 to 120 cubic feet according to size. The total capacity is therefore from 450 to 550 cubic feet.

The Tiemann kilns at Madison have a capacity of about 210 cubic feet of lumber (paragraph 230), so that a battery of two of them would hold a trifle less than the four multiple heater ones.

Sturtevant Guide Charts.

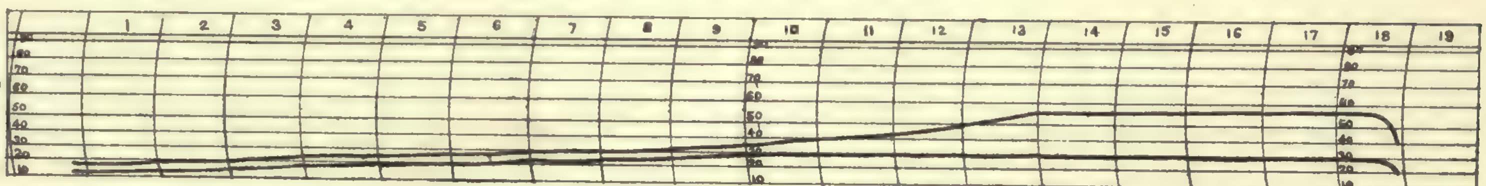
Charts drawn ⅓rd full size



TYPICAL GUIDE CHART FOR SOFTWOOD.

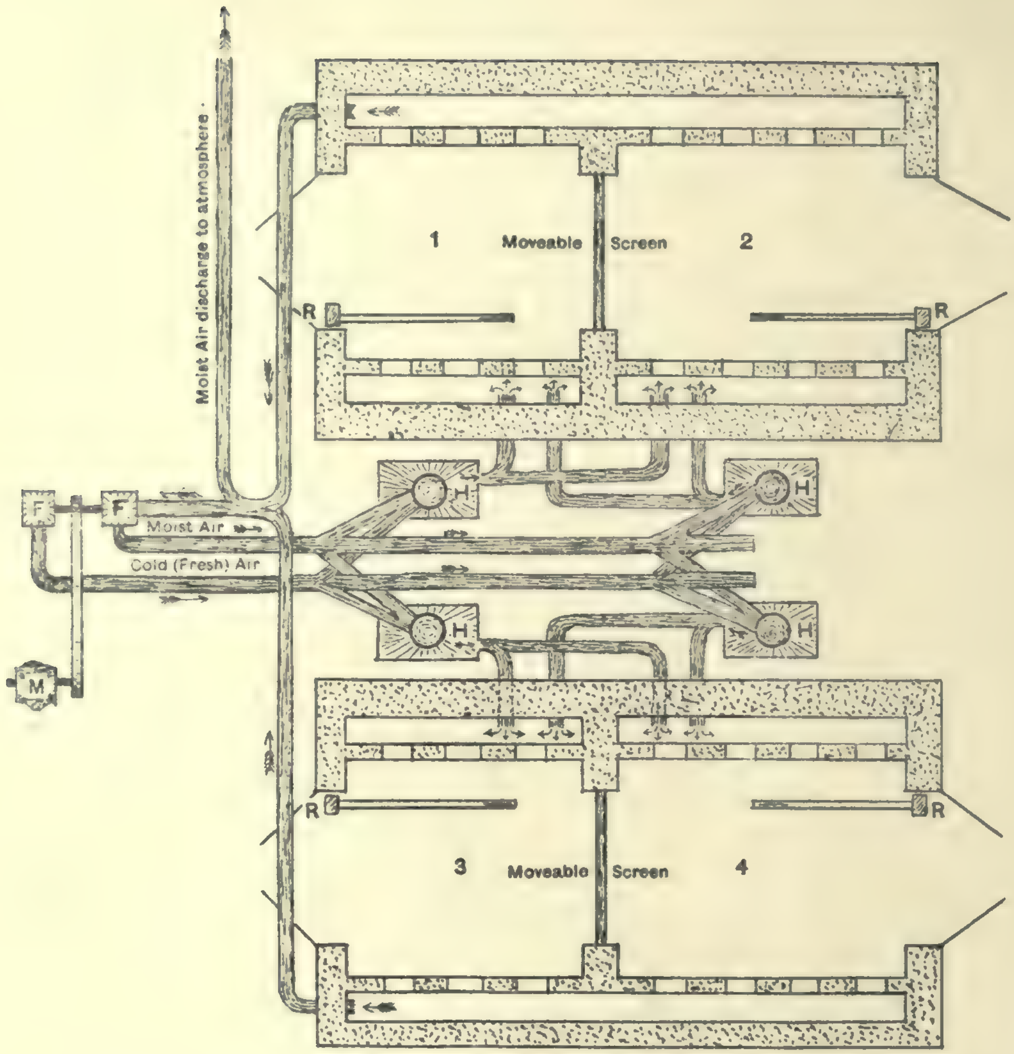
(*about 1¼″ thick*).

Charts drawn ¼th full size



Typical Guide Chart for Hardwood (*about 1½″ thick*).

(para 288).



PLAN
OF
STURTEVANT DRY KILNS
FOR
EXPERIMENTAL WORK.

Multiple Heaters—4 Compartments—Fan Circulation.

H = Heater ; F = Fan ; M = Motor ; R = Recording Hygrometer.

NOTES.—For observing the hygrometer charts, glass covered wickets are provided in the doors

The plan is diagrammatic and takes no account of elevation ; the motor and fans are on ground level, but the main delivery and discharge ducts are above the level of the ceiling, and so there is no obstruction to direct access to the doors on the left.

The various dampers for controlling the circulation are not shown.

(para. 239).

The chief points to be noted about the British design are as follows :—

(*i*) The doors for the large and for the small rooms are at opposite ends. The partition between each pair of kilns is movable. For small lots of timber each kiln can be used as a separate unit. For extra long timbers or for large lots, the screen can be removed and the pair of rooms be operated as one.

(*ii*) There are two delivery pipes from each of the 4 heaters. If desired, two heaters can be used for any one of the 4 compartments.

(*iii*) The method of admitting the air in circulation is different to the plan already described for commercial kinds (paragraph 237). Along both sides of each room are narrow chambers extending from floor to ceiling for the full length of the kilns. The delivery and exhaust pipes respectively open into these chambers. On the inner side of each chamber are a number of openings with sliding shutters. All or any of the openings can be used for a particular operation. This simple plan gives a wide range of choice. The air can either be introduced at ground level (as in commercial kilns), or there can be cross ventilation at any desired height up the sides of the pile of timber being dried.

(*iv*) There appear to be some details of design which could be altered to suit individual cases. The fans and motors are on ground level chiefly, it is supposed, in order to be easy to get at. To avoid having to go upstairs to adjust the overhead dampers, the latter are provided with cords for operation from below. The writer would prefer to put the fans and motors upstairs—as in Plate CXXII—thus giving a clear space all round the entrance doors.

If the heating coils could also be placed upstairs, the kilns could be erected back to back, thereby saving the cost of one wall and a certain amount of roofing.

The position of the recording hygrometer also appears to be capable of improvement.

As a matter of fact this detail is being attended to in the experimental kilns now under construction in London (*vide* next paragraph). The doors are being made narrower than in the drawing so that there may be room to make a recess in the brickwork for the hygrometer.

Section 6.—RECOMMENDATIONS.

Experimental Kilns for India.

240. The writer had no opportunity of meeting anyone in England having practical experience of Tiemann kilns. It is quite possible that nobody in England has yet been over to the States to see them in commercial operation. Without further study of the relative merits of the Tiemann and Sturtevant (Multiple Heater fan circulation type) it is impossible to say which would answer better in India.

In the Tiemann kiln provision is made for turning on live steam above and below the pile of lumber right inside the kiln. Steaming is made use of at the beginning of an operation in order to remove casehardening. The want of such an arrangement is apparently not felt in England but this is not likely to be the case in India owing to the greater heat and dryness of the atmosphere for part of the year. Perforated steam pipes could be added to the British design.

Steaming is at present absolutely barred for aeroplane stock in England. The only argument advanced to the writer in support of this decision rests on the results of tests carried out at Farnborough on several car loads of Douglas Fir which had been dried by the Tiemann process. The timber was condemned on account of brittleness and this was attributed to steaming.

On the other hand, in a paper read by him at the Royal Society of Arts on 5th July 1918, Professor Groom remarked as follows :—

> " One method of introducing heat and moisture into a kiln is to supply steam. Drastic steaming at high temperatures permanently weakens wood even if it be relatively brief. On the other hand, prolonged steaming or " stewing " of wood in a confined space improves the qualities of woods in certain directi ns in that it decreases their tendencies to warp and sometimes renders them more decorative by changing their colours ; for instance, beech is thus induced to become somewhat mahogany like in tint, and in resistance to warping. This off-shoot of artificial seasoning provides an additional line of enquiry leading to the improvement in the qualities of inferior woods, especially from our tropical colonies."

The drum type of recording hygrometer (Plate CXXIII) is better than the dial type used in America (Plate CXIX). The former should be used on kilns installed in India.

A set of experimental kilns of the multiple heater type described in the preceding paragraph is now being installed in London for permanent research in timber under the auspices of the *Department of Scientific and Industrial Research.* To permit of direct co-operation it would be an advantage to have experimental kilns of the same type in India.

From the point of view of the commercial operator it may be sound business to stick to the multiple heater fan circulation type, for the present at any rate in England, but it is to be hoped that research officers in England will take a broader view and that they will not rest content without setting up Tiemann kilns at home and making comparative tests with them.

The writer would like to see experimental kilns of both types built in India at Dehra Dun. The field for research is certainly large enough to justify the expense and it would be likely to save valuable time if the Government of India were to take the initiative.

Moreover, the number of species to be tested is so large and distances are so great that research work in seasoning for the whole of India and Burma cannot possibly be confined to Dehra Dun without causing serious delay and increase in working expenses. There cannot be the slightest doubt, for example, that Burma should have experimental kilns of her own. I therefore recommend that arrangements be made for them without delay. Both kinds would hardly appear to be necessary, for a start at any rate, preference being given to whichever type (British or American) can be more easily obtained.

The matter is urgent, for the development of industrial utilization of several species depends on the possibility of artificial seasoning at moderate expense,—a matter which, so far as the writer is aware, has not yet been taken up in India.

An approximate estimate of cost of the British kilns has been drawn up but it was impossible to arrive at any reliable figures for the Tiemann kiln whilst the writer was in America. Detailed estimates can be worked out in India. The Sturtevant kiln will probably be found to be somewhat cheaper to instal. Against the cost of motor, fans and ducts is the saving on underground waterproof construction of wells and drains, and also a smaller outlay on heating coils. In the cost of operation there is not likely to be much difference. The steam required for the Sturtevant fans is no greater than that required for the Tiemann pump for the spray. Exhaust steam can be used in both cases.

241. Section 7.—LIST OF MANUFACTURERS OF DRY KILNS.

United States of America.

Moline Heat Company, Moline, Ill.

Grand Rapid Veneer Works Company, Grand Rapids, Mich.

National Dry Kiln Company, Indianapolis, Ind.

Standard Dry Kiln Company, Indianapolis, Ind.

North Coast Dry Kiln Company, Seattle, Wash.

Emerson Dry Kiln Company, New York.

Hussey Doors.

Dry Kiln Door Carrier Company, Indianapolis, Ind

Control Apparatus.

Powers Regulator Company, Chigaco, Ill.

Leonard Rooke Company, Providence, R. I.

Tagliabue Manufacturing Company, Brooklyn, New York.

Taylor Instrument Company, Rochester, New York.

Bristol Company, Waterbury, Mass.

Spray Nozzles.

F. C. Myers, Company, Ashland, Ohio.

Buffaloe Forge Company, Buffalo, New York.

Veneer Driers.

(See paragraph 186.)

Canada.

Nil.

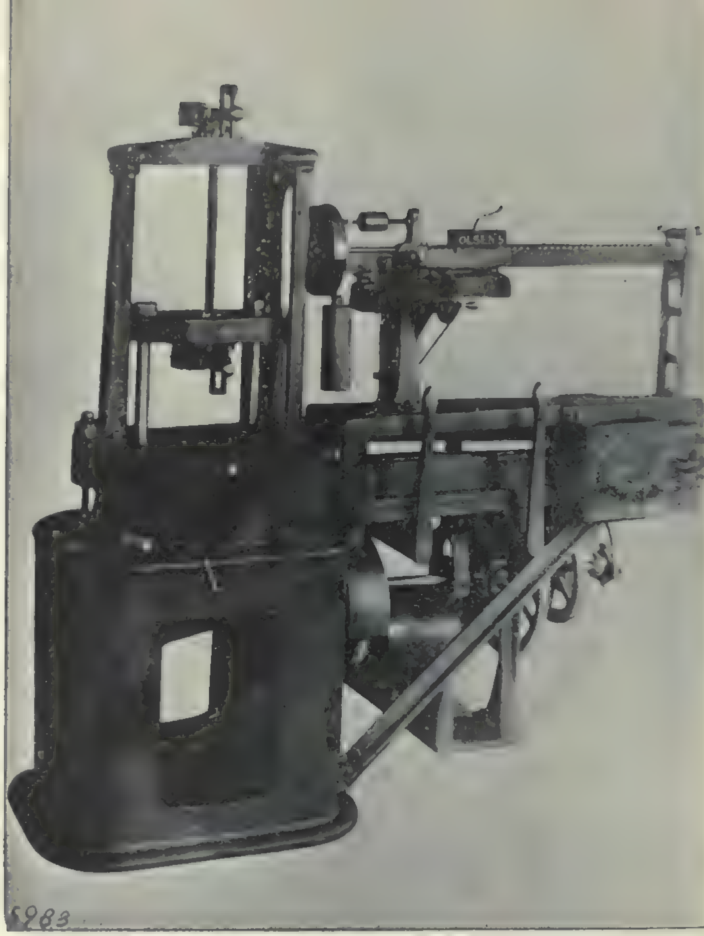
United Kingdom.

Sturtevant Engineering Company, 147 Queen Victoria Street, London, E. C.

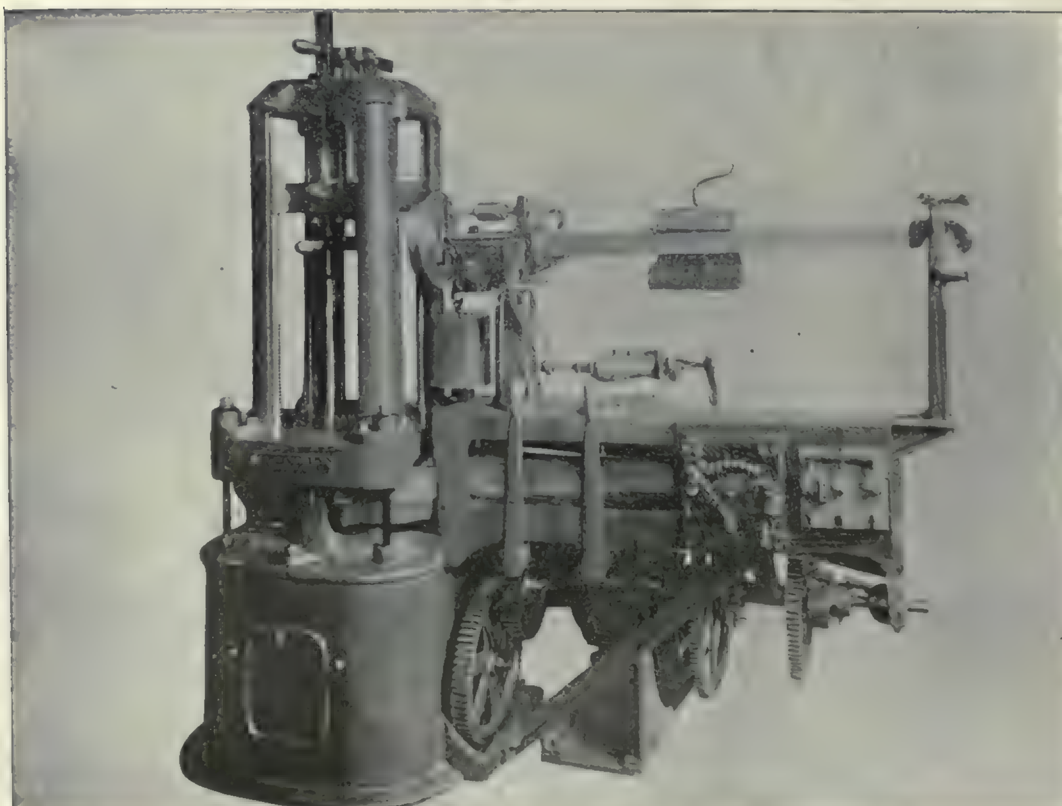
Erith Engineering Company, 70 Gracechurch Street, London, E. C. (Progressive kilns only).

Pastorelli and Rapkin, Hatton Garden, London, E. C. (Drum recording and pocket hygrometers.)

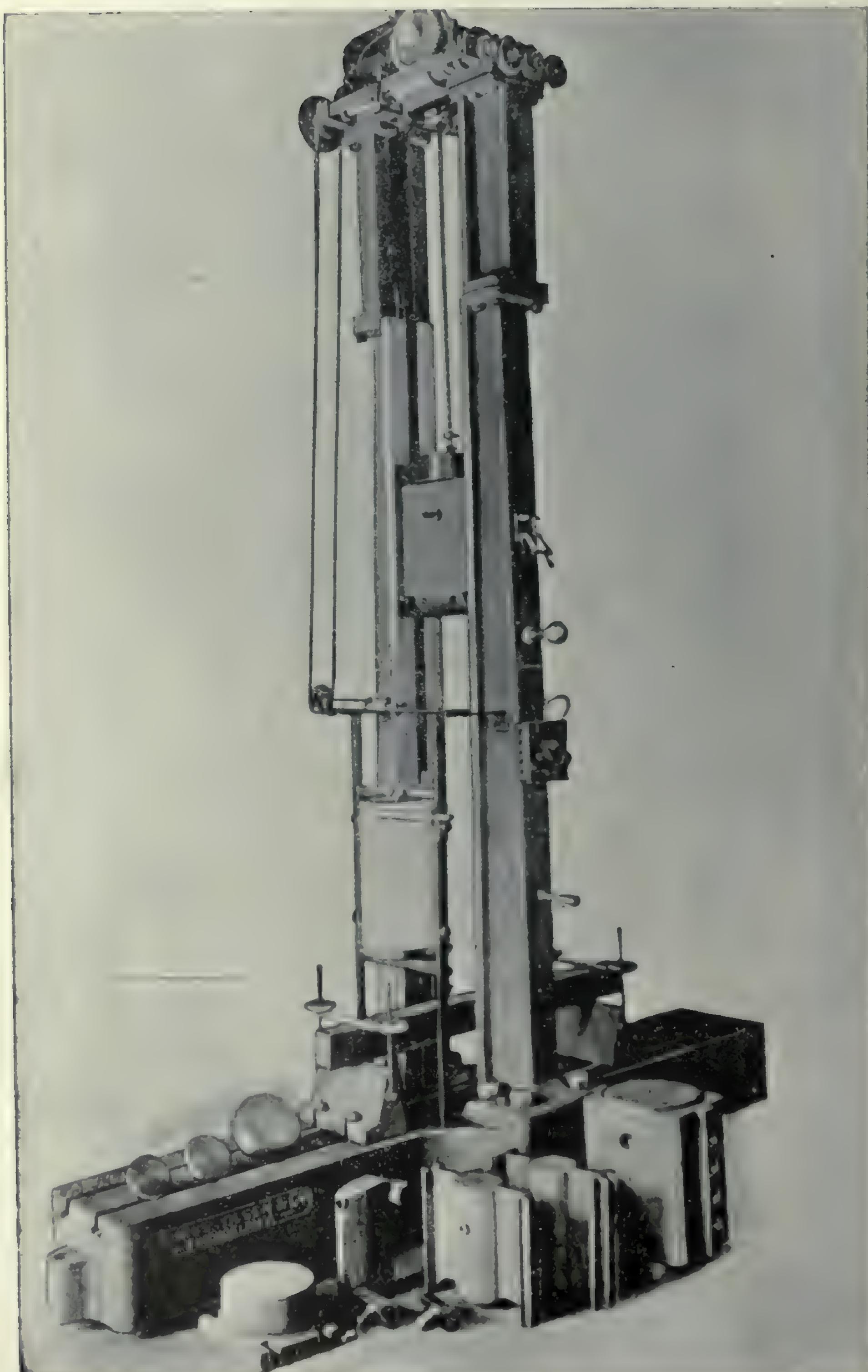
Cambridge Scientific Instrument Company, Cambridge. (Dial recording hygrometers and steam regulators.)



(1). Universal Testing Machine; 30,000 lbs; Power driven.



(2). Universal Testing Machine; 50,000 lbs; Power driven.
(By permission of Messrs. The Tinius Olsen Testing Machine Co.)



Turner Impact Machine.
(By permission of Messrs. The Tinius Olsen Testing Machine Co.)

(para 243).

CHAPTER XIII

OTHER RESEARCH WORK.

Section 1.—GENERAL NOTES.

General.

242. This report covers such a wide field that the arrangement of the notes in it presents some difficulty. Using the term "Research" to include any kind of investigation it comes into every chapter of the report. The title of the present chapter is purely an arbitrary one and is only adopted to facilitate reference to the notes.

Pathology.

The writer was unable to devote any time, either at Madison or at Montreal or elsewhere, to the extensive pathological studies which are being conducted. It is to be hoped that forest Research Officers in India will be given opportunities of getting into personal touch with similar students in Canada and the United States.

Section 2.—TIMBER TESTING MACHINE,

Timber testing.

243. At the time of the writer's visit to *Madison* the Timber Testing Branch was wholly given up to the testing of woods for aeroplanes.

The following is a list of the testing machines in the laboratory :—

(1) Olsen Universal Testing Machine,—4 screw,—10,000 lbs.

(2) Olsen Universal Testing Machine,—4 screw,—30,000 lbs. (Plate CXXVI.)

(3) Olsen Universal Testing Machine,—4 screw,—100,000 lbs.—adopted for long timbers placed horizontally.

(4) Reihle Universal Testing Machine,—2 screw,—200,000 lbs.—adopted for long beams, both vertical and horizontal.

(5) Turner Impact Machine. (Plate CXXVII.)

(6) Veneer Splitting Machine made at the laboratory. A weighted spear is dropped from a known height on to a perforated plate on which the veneer to be tested is placed.

At *Montreal*, in addition to Olsen, Reihle and Impact Machines, the *Forest Products Laboratory* also makes use of Wickstead and Avery machines (British) belonging to the Engineering School of the McGill University.

British timber testing.

244. The remarks made in Chapter IX on the recent great developments in England with regard to the kiln drying of timber apply also to the scientific testing of timber. In fact the one could not have taken place without the other. Before the War the United Kingdom was very, very far behind either the United States or Canada in this respect. None of the Engineering Colleges or Forest Schools had laboratories specially equipped for testing timber; very little was definitely known about any but a few selected species.

To meet the enormously increased demand for aeroplane stock, before the Air Board could undertake the wholesale testing of substitutes for the one or two well-known species previously used, a laboratory had to be suitably equipped. This was done at The Royal Aircraft Establishment, Farnborough. The writer was privileged to visit the Factory and spend a short time in the testing laboratory. The machines in use show obvious signs of their home-made character. They were the best that could be got together at short notice and under War conditions. Some of them were made on the spot by Major Robertson, the Officer in charge of the testing operations.

In spite of these initial difficulties the amount of work done up to date has been very great and the standard of excellence of the results is of a very high order. For the test for bending a machine has been designed which gives even better results than those in use at Madison and Montreal.

A number of British Standard Specifications for Aircraft Material were given to the writer. They should be carefully studied by anyone interested in the subject of timber testing in general.

The chief tests are for the following :—

(*i*) Dryness.

(*ii*) Straightness of grain.

(*iii*) Freedom from defects (including proportion of spring and autumn wood).

(*iv*) Compression.

(*v*) Bending.

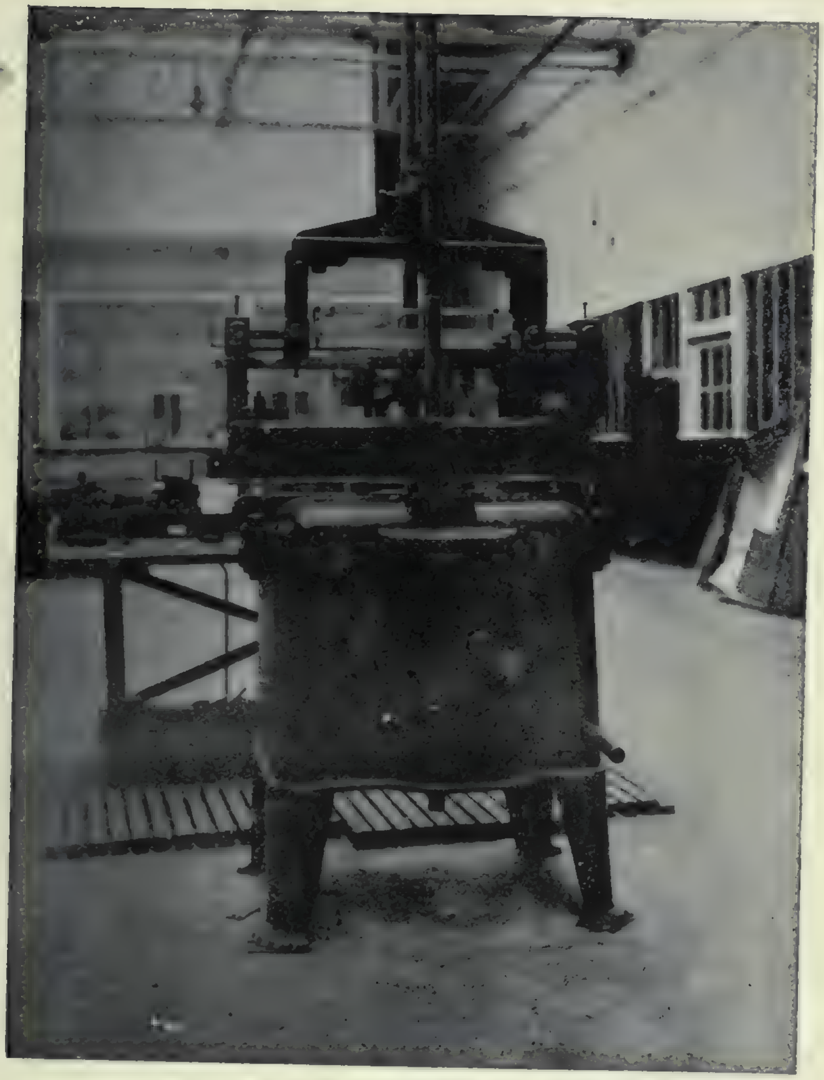
(*vi*) Brittleness.

It is of the first importance to know the moisture content of timber when being tested. *Unless this is known the results are practically valueless.* Further, if the timber has been kiln dried, it is essential that the drying is not carried too far. The Air Board therefore lays down rigid conditions with regard to artificial seasoning, the chief of which are, (1) autographic record of temperature and humidity throughout the process, (2) maximum temperature permissible, and (3) limits of moisture left in the wood at the end of the process.

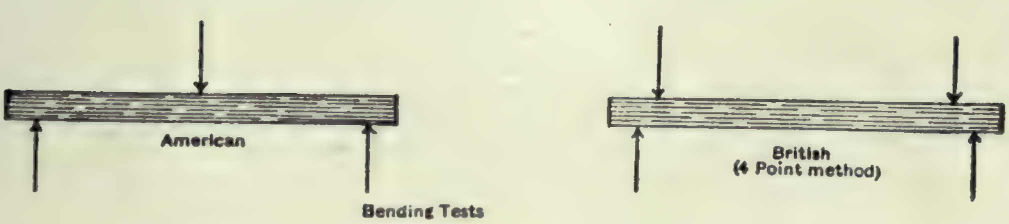
The *straightness of the grain* of a piece of wood can sometimes be accurately judged by external examination. When in doubt it is a simple matter to measure it by splitting. For Ash, the maximum inclination permissible is 1 in 10, for Walnut it is 1 in 12.

For *Compression* tests Olsen and Reihle machines are used at Farnborough.

For *Bending* tests British scientists have taken a new line. The American method of applying the load at one place is not followed. The load is applied equally on both sides of the centre as shown in the diagram. Shearing stresses are thereby eliminated. Plate CXXVIII was taken at Farnborough. The body of the machine is a Dennison Testing machine. The attachment for applying the load was made at the Physical Laboratory, Teddington. This machine has given excellent results and the design should be followed in India.



(1). Machine for Bending Tests at R. A. F. Farnborough.



(2). Diagrams showing methods of support and loading in bending tests.

(para 244).

For *Brittleness*, a simple form of machine was made at Farnborough from materials at hand. The writer is, however, under the impression that the results obtained with it are not as good as could be desired. The Turner impact machine (Plate CXXVII) is recommended in preference to it.

245. MAKERS OF TESTING MACHINES.

UNITED STATES OF AMERICA.

Tinius Olsen Testing Machine Company, Philadelphia, Pa.

Reihle Brothers Testing Machine Company, Philadelphia, Pa.

UNITED KINGDOM.

Samuel Dennison and Sons, Leeds.

Joshua Buckton and Company, Leeds,

Dial instruments for recording thousands of an inch measurements of length are made by Ames, Waltham, Mass, U. S. A.

SECTION 3.—PRESERVATION OF TIMBER.

Preservative treatment of wood.

246. In addition to "*The Preservation of Structural Timber*" by Weiss, already referred to, attention is invited to the *Annual Proceedings of the American Wood Preservers Association*. "*The Handbook on Wood Preservation,*" published in 1916 by the same Association, is a very useful book of reference. The bibliography of Wood preservation covers several pages in this book and may serve to indicate how extensive research has been in various directions. United States Department of Agriculture Bulletin No. 606 on the "*Relative Resistance of various Hardwoods to Injection with Creosote*" by Clyde H. Teesdale and J. D. Maclean, Forest Products Laboratory, Madison (1918), is a recent publication of great value.

As a text-book Mr. Weiss' volume covers the ground so completely that reference need only be made to a few special points in this report.

Cost of Pressure Preserving Plant.

247. On page 261 Weiss gives a list of manufacturers of preserving plant in America and on page 125 are estimates of cost of standard plant of various sizes supplied in 1916 by the leading firm (Messrs. The Allis-Chalmers Manufacturing Company). The following is a short summary :—

Capacity is S. G Sleepers per annum.	Cost. Converted into rupees at 3 Rs. = 1 $.
	Rs.
1,70,000	77,160
2,05,000	93,870
5,40,000	1,95,330
10,80,000	3,42,360
21,60,000	6,11,700

A quotation by the same firm for the second in the above list in July 1918 came to Rs. 2,25,000.

248. The experimental creosoting plant at the Madison Laboratory is of very much the same kind and size as that at Montreal. The writer was given a blue print of the latter. The retort is 10 feet long and 2 feet in diameter and holds 3 S. G. sleepers. The complete outfit cost about $2,000.

Experimental Pressure Plant.

Mr. Kynoch, the officer in charge of Timber Tests, would prefer to have a larger retort capable of holding 10 sleepers at a time. Mr. Campbell, Superintendent of the Laboratory, recommends having both 3-sleeper and 10-sleeper retorts in an experimental station where there is likely to be much work to be done. After a series of preliminary tests with a given species in the small retort it would save valuable time if tests on a larger scale could be taken in hand.

As a rule a commercial outfit includes an experimental retort. Messrs. The Allis Chalmers Manufacturing Company have a standard size for the same.

249. Particulars of a portable creosoting plant were obtained by a visit to the New York Office of the *Railway Tie Treating Company* (165 Broadway). The outfit is mounted on 5 railway cars : one for the Retorts, one for the Boiler and Adzing machine and 3 cars for the loading and unloading platforms. There are three retorts (4′ × 63′) which are mounted one above the other so that they can be operated by pressure and vacuum pumps independently of each other (Plate CXXIX).

Portable Creosoting Plant.

The process resembles the *Ruping* one, but differs from it in that the oil is pumped into the retort (in the form of a spray) *before* the pressure is applied, instead of afterwards. It is claimed for this modification, in conjunction with the use of three retorts in series, that the time of treatment can be reduced from 10 to 3 hours as a maximum ; 2,500 Standard gauge sleepers can be treated in 24 hours.

The weight of the heaviest car load of the outfit is 150,000 lbs. The Vice-President of the Company gave the writer to understand that the plant could not be readily designed for metre gauge tracks.

One retort is filled with sleepers and closed. Creosote is introduced in the form of a fine spray which penetrates the sleepers to a considerable extent even before pressure is applied. After it has received a full charge of creosote a vacuum is drawn by pumping the oil into sleepers in the 2nd retort and so on.

250. At the Montreal Laboratory the writer was given details of a machine invented by Mr. Kynoch for making incisions in wood. Experiments have shown that the depth of penetration of the preservative can be considerably increased thereby. The idea is a very good one and comparatively inexpensive to put into practice. The writer was requested not to publish details pending the taking out of a patent. An article on the subject may be expected shortly.

Incising Machine.

Section 4.—WOOD PULP.

251. The writer visited large mechanical pulp mills at Ottawa, Ont., and Powell River, B. C., both electrically driven. At Bogalusa, La, a large Sulphite Mill under construction was seen.

Wood Pulp.

Portable Creosoting Retorts.
(By permission of Messrs. The Railway Tie Treating Co.)

(para 249).

"The Pulp and Paper Magazine" of Canada for 4th January 1917 contains a very good article on the Paper and Pulp Industry in Canada.

Experimental Plant.

On the subject of Experimental Plant enquiries were made with the following results. At Madison the *Soda Digester* has a capacity of 100 lbs. and the paper machine gives a roll 12″ wide. Mr. Kress the officer in charge of the Pulp and Paper Branch, expressed himself to the writer against having larger plant in the laboratory. He holds that a 600 lb. digester or a 20″ paper machine would be practically as far removed from the 3-ton digester and 100″ rolls in a factory so that it would yield no better results and yet would cost far more to operate. When all is said and done, laboratory results must be used with discretion and it is impossible to say how far they will hold good on a large scale without actual trial. In the planning of operations in a laboratory, with limited funds at disposal, it should always be the policy to ask what is the *smallest* scale likely to give satisfactory results, and whether anything commensurate to the extra cost of working on a larger scale is likely to be gained.

In proof of the very satisfactory nature of the work done at Madison it is no exaggeration to say that the institution has won the full confidence of the trade. Any and all of the big paper-making firms in the States are only too glad to undertake practical tests on commercial lines of results published at the laboratory. Quite recently, as a case in point, the laboratory authorities practically took over charge of a large factory in the Southern States for some 2½ months, whilst the plant was being run at the expense of the firm, to test conclusions arrived at by experiment on a small scale in the laboratory.

Experiments have been carried out at Madison with nearly every kind of wood that grows in the United State of America. Any firm desirous of starting pulp manufacture anywhere in the States can get advice for the asking as to the best methods to use for any particular species or locality. The high position won by the laboratory may be judged from the fact that firms are eager to ask for such advice and invariably act upon it.

252. From correspondence with Dehra Dun it appears that some misapprehension exists on the subject of the making of experimental pulp paper plant. No one firm makes a speciality of it. Any good firm in the trade, either in America or in England, would undertake to build experimental plant if it were made worth their while and there is no particular point in going to the firm that made the Madison plant.

The names of a few leading firms could be selected from trade journals and they could be asked to put up drawings and estimates for *standard* machines of the desired size.

Mr. Kress emphasized one point. In pulp and paper plant there is no point in complicating matters by attempting to draw up special designs and asking firms to work to them. Extra expense, delay and trouble, with no compensating advantages, are bound to result. It is far better to simply specify the size and to leave the rest to the manufacturers.

253. At *Montreal* the pulp and paper machine (by Pusey and Jones, Wilmington, Delaware) is 30″ wide and has a longer Foudrinier wire (25 feet). The machine

without accessories, cost Rs. 38,500. It was extra expensive because a number of special adjustments were put in by the makers in order to increase the range of working. The great length of wire permits of a wide range of speed, *i.e.*, from 15 to 150 feet per minute. At Madison the speed cannot exceed 50 feet per minute as the wire is shorter. The higher speed of the larger machine makes it approach nearer to commercial conditions; but, on the other hand, owing to the faster rate of working the machine would be likely to stand idle more frequently.

The staff at Montreal have great confidence in their battery of three small digesters 12″ (diameter) × 2′ (height) for preliminary analysis. Very good results have been obtained from them.

Section 5.—GRASS AND BAMBOO PULP AND OIL SEEDS.

Grass Pulp.

254. Owing to the unlimited supply at present of raw material for wood pulp in North America research in respect of grasses has not progressed anything like so far as with wood. In 1914 the value of straw pulp in the United State of America was only $ 519,000 out of a total of $ 332,000,000 for all paper products.

Investigations are conducted by the Bureau of Plant Industry, U. S. Department of Agriculture, Wash. D. C. . The head of the branch, Mr. Jason L. Merrill, furnished the writer with details of the plant used in his researches. He mentioned the following firms of manufacturers of experimental plant :—

Rotary for soda cooking—4′ (*d*) × 5½′ (*l*) Manitowock Engineering Company, Manitowock, Wisc.

" Giant " Rag Cutters. Taylor Styles and Company, Riegelsville, N. J.

Chippers. Carthage Machine Company, Carthage, N. J.

All equipment. Ernest Scott and Company, England.

Messrs. Scott and Company have given the writer plans and estimates for a complete installation.

Solvent Process for Oil Seeds.

255. Messrs. Scott and Company also gave the writer details of a small experimental plant for the extraction of oil from seeds by means of solvents, such as Benzoin, Petrol, etc. A visit was paid to a factory at Hammersmith to see a small plant of the same size and design at work extracting oil from a consignment of Saf flower seeds sent home for experiment by the Government of India.

Section 6.—DESTRUCTIVE DISTILLATION.

Distillation of Wood.

256. The following is a list of publications that have come to the notice of the writer on the subject of the *Destructive Distillation* of *Wood* :—

1. The Utilization of Wood Waste by Distillation by W. J. Harper.
2. A Statistical Study of the Growth of the Hardwood Distillation Industry (1914) by R. C. Palmer, F. P. Lab : Madison, U. S. A.
3. Chemical Utilization of Southern Pine Waste (1914) by Dr. J. S. Bates F. P. Lab. Montreal.

4. Yield from the Destructive Distillation of certain Hardwoods (1914) U. S. Department of Agriculture Bulletin No. 129.
5. The Hardwood Distillation Industry in New York. Technical publication No. 5, Syracuse University.
6. U. S. Department of Agriculture Bulletin No. 508.
7. Canadian Wood Oils for Ore Flotation (1917) by R. E. Gilmore and C. S. Parsons, F. P. Lab. Montreal.
8. Present and Possible Products from Canadian Woods (1917) by Dr. J. S. Bates, F. P. Lab. Montreal.
9. The Utilization of Wood Waste by E. Hubbard. (Translation from German.)
10. Wood Products, Distillates and Extracts by P. Dumesny and J. Noyer (Translation from French.)

In spite of its origin " The Utilization of Wood Waste " is a very useful little book which might well be brought to general notice.

The following are details of the experimental plant at Madison for the *Destructive Distillation of Wood.* The retort has a double jacket, the intervening space forming an oil bath, heated along one side by a row of coal-gas jets. Circulation of the oil is thereby set up The boiling point of the oil is not less than 400° C.

The retort takes a charge of 90 lbs. of wood. Mr. Sherrard, the officer in charge, took the same line as Mr. Kress. He thought a half-ton retort much too large. On the other hand Mr. A. Chisholme Woods, Manager of the Standard Chemical, Iron and Lumber Company, Toronto, Ont., the owners of practically all the distillation plant in Canada, informed the writer that he would prefer a capacity of not less than $\frac{1}{8}$th of a cord (450 lbs) for experimental purposes.

257. The writer spent a few hours at the works of the Standard Chemical, Iron and Lumber Company at Longford, Ont. A little Birch and Alder are used but fully 90 per cent. of the wood is Maple. The wood is air-dried for two years before being cooked. There are 14 retorts, each holding 6 cords (9 to 12 tons). Cooking takes one day and it takes another six days to cool down and unload the charcoal. The condensers are cleaned out once a week. There are 5 successive distillations, *viz.*—

1st—from wood in retorts.

2nd—to separate out the tar.

3rd—to reclaim alcohol from acetate liquor.

4th—to raise alcohol from 10 to 90 per cent.

5th—to raise alcohol from 90 to 100 per cent.

The method is the same in all the stages. At current prices the yield from a cord of wood is as follows :—

	Rs.
50 Bushels of charcoal at 20 cents	=30
9 Gallons of alcohol at $ 1·50	=20
200 lbs of acetate of lime at 5 cents	=30

16 Gallons of tar—which is not sold but is used as fuel to heat the retorts and boilers.

253. For many years it has been the desire of experimenters to discover some form of continuous process for destructive distillation of wood. There are indications that a satisfactory solution of the problem has been arrived at in what is known as the *Seaman Process*, the patent rights in which are held by the Seamans Wastewood Chemical Company, 17 Battery Place, New York. The writer saw a representative of the firm at New York. The notes given below are taken from a report in 1917 by Dr. Bates, Superintendent of the Montreal Laboratory.

Continuous Method of Distillation.

The process is of special interest as its raw material is in the form of sawdust and chips. It can therefore be looked upon as an adjunct to a lumber mill for the utilization of waste. The raw material is fed continuously into a rotary drier from which it passes steadily into a rotary retort for rapid and continuous distillation. At Gauley Falls W. Va., plant of commercial size has been in operation for the past two years in connection with the lumber mills of the Cherry River Boom and Lumber Company.

Results on a Laboratory scale are stated to be approximately as follows :—

Acetic Acid (or the equivalent of acetate of lime or acetone) 50 per cent. higher than in ordinary hardwood distillation.

Methyl Alcohol 25 per cent. less than in ordinary hardwood distillation.

Charcoal about the same as in the ordinary method but in a finely divided form.

Tar and Oils about 3 times as much as in the ordinary method.

Dr. Bates sums up his conclusions by stating that he considers the Seaman Process to be technically sound and commercially feasible.

259. THE PRINCIPAL MAKERS OF APPARATUS ARE :—

Struthers Wells Company, Warren, Pa.

Walter Lummus Company, Boston, Mass.

E. B. Badger and Sons Company, Boston, Mass.

Ernest Scott and Company, Glasgow, England.

The two first named American firms, and also the Standard Chemical, Iron and Lumber Company, Toronto, kindly supplied a good deal of useful information on the subject. The British firm has given a detailed estimate for experimental plant.

SECTION 7.—BRIQUETTING.

260. The writer came into contact with the following firms in America interested in *Briquetting Machinery* :—

Briquetting.

(1) *The Watson-Stillman Company, New York.*—The firm manufactures a press specially designed for experimental work in briquetting granulated material.

(2) *General Briquetting Company, New York.*—This firm makes several machines designed for continuous production on a commercial scale.

There are two chief types, horizontal and vertical, respectively, in various sizes and with pressures from 10 to 15 tons per sq. inch. The briquettes are about 3″ long and circular in section (4″ to 8″ in diameter). At the office of the firm the writer was shown some softwood sawdust briquettes which had been made solely by pressure, *i.e.*, without the addition of any binding material. They were certainly quite hard, although the edges were rather friable.

If prices are not prohibitive there would seem to be a field for these machines for charcoal, sawdust and possibly paddy husks.

(3) *Robert Hamilton and Company, Vancouver, B. C.*—This firm was experimenting with a plant at Victoria but, owing to the War, operations were stopped. No details were given.

261. In the *Popular Mechanics Magazine* for August 1918 (Chicago) the following article appeared :—

" *Smokeless Fuel Bricks made from Sawdust.*—A synthetic hard coal is now being made from sawdust by a process that has been developed in Canada to utilize sawdust which is now wasted estimated at several thousand tons daily in British Columbia alone. While this man-made coal is not being produced commercially as yet, it is estimated that the cost of manufacture is about $ 3 per ton, three tons of sawdust being required for one ton of fuel."

" The sawdust is delivered into a charging device ; thence into a revolving horizontal retort, heated by gas jets. The retort is slightly lower at one end than at the other and by the time its contents reach the other end it is made into charcoal. Whilst this change is taking place considerable moisture and gas are given off, which are condensed into a distillate consisting of tar, turpentine, rosin, etc. From the retort the charcoal passes into a container to cool."

" The next step is to convey it to a mill that grinds it, mixing in crude oil or some of the products condensed from the gases referred to. The plastic charcoal is now pressed into bricks that are baked so as to be made into a smokeless fuel. This is done in a portable retort into which hot gas is pumped. Much of the gas drawn off during the baking is condensed, leaving fixed gas which is heated and forced back into the retort to help continue the process. The fuel obtained by this means is said to contain 90 per cent of fixed carbon, seven per cent of volatile gases, and three per cent. ash."

262. Messrs. Briquette Machinery, Limited, Leeds, England, are makers of machinery (presses and driers) suitable for briquetting sawdust, charcoal, etc., as well as stone, metal, etc. The firm would be glad to submit detailed estimates on receipt of the requisite data.

CHAPTER XIV.

WATER HYACINTH.

Section 1.—INTRODUCTION.

263. Whilst the writer was at New Haven discussing details of his proposed tour in the United States with Professor Bryant, Yale Forest School, a more or less casual reference to the Water Hyacinth served as a reminder of the existence of this obnoxious pest; and arrangements were accordingly made to see something of it. At the time the writer was not aware of the fact that information as to operations in Florida was supplied to the Forest Department, Burma, in 1913.

The operations for dealing with the weed are under the control of the United States Corps of Engineers. A call on the Chief of Engineers at Washington D. C. met with a cordial response. All information available at headquarters was given, together with letters of introduction to the District Engineers at New Orleans, La., and Jacksonville, Fla.

Historical Notes.

264. A good deal of information as to the earlier history of the plant in the United States of America is contained in the enclosures to a letter dated 15th December 1898 from the Secretary of War to the Speaker of the House of Representatives, and printed as Document No. 91 of the 3rd Session, 55th Congress.

So far as is known the plant first came to notice in the State of Louisiana in 1884 and in Florida in 1890. On the supposition that it was not indigenous the manner of its introduction into the States has given rise to endless discussion and much divergence of opinion. According to one story the first plants brought into Florida came from Europe and were placed in a small pond near Palatka. Before very long they began to lose their charm owing to the overpowering luxuriance of their growth. To get rid of them the plants were thrown into the nearest stream. There may be some truth in the story but it is now generally recognised that the plant is a native of South America—Venezuela and Columbia—and that it has spread from there to all parts of the world.

The topography of the States of Florida and Louisiana lent itself only too readily to the spread of the plant with remarkable rapidity. The St. Johns River in Florida may be looked upon as the connecting link to a vast series of lakes, swamps and lagoons, and the Delta of the Mississippi in Louisiana is of much the same character. Not only did this network of waterways provide a ready means for natural extension, but another contributing cause appears to have been that cattlemen carried the plant upstream in many places for propagation as food for their cattle.

The Board of Engineer Officers constituted to investigate the Water Hyacinth question in 1897 recommended that systematic operations should be undertaken to keep waterways open for navigation. Operations on a large scale commenced in both States about 1899. Although they began on similar lines subsequent developments have been in different directions.

The agitation of cattle owners against the use of chemicals in Florida culminated in 1906 in the absolute prohibition in the State of the use of any chemical process likely to be injurious to cattle. Since then attention has been confined to mechanical methods. In Louisiana, on the contrary, grazing interests have evidently not had such powerful political backing because spraying with chemicals is (next to drifting) still relied upon as the chief method of clearing streams and is practised on an extensive scale in the State.

In a period of 18 years—from 1899 to 1917—expenditure was as follows :—

Louisiana	$244,115	
Florida	$158,265	
Total.. ..	$402,380	=Rs. 12,07,140.

265. There is every indication that operations will have to be continued indefinitely, as no practicable method is known for the complete eradication of the weed from such a huge and confused system of waterways as exists in these States. Nothing short of absolute extermination will suffice to do away with the necessity for repeating operations, at relatively short intervals, and expenditure on a scale similar to that in the past is therefore likely to have to be continued indefinitely in the future.

The Irrawaddy River system in Lower Burma is comparable in character and size with the Mississippi system in Louisiana, so that it is only reasonable to suppose that if operations against the Water Hyacinth are to be as efficacious in Burma as they are in Louisiana they will have to be on a scale of similar magnitude, in other words, Burma must be prepared to face an annually recurring expenditure of about a quarter of a lakh of rupees.

Although complete extermination seems to be hopeless in Louisiana and Florida, it is interesting to note that this consummation is hoped for in the Gatun Lake, Panama, by means of spraying. Reports of ultimate success are said to be promising.

Section 2.—GENERAL NATURE OF OPERATIONS.

Nature of operations.

266. The methods that have been tried for dealing with the plant are summarized below :—

1. Drifting and towing to salt water.
2. Log Booms.
3. Mechanical crushing.
4. Spraying (Louisiana only).
5. Mechanical piling (Florida only).

The fact that the plant cannot live in salt water was observed long ago. Systematic drifting towards the sea soon began to be practised and still continues to be the cheapest way of getting rid of vast quantities of the weed wherever a suitable current exists. As the rise and fall of the tide in the Gulf of Mexico is not nearly so great as it is in the Bay of Bengal the problem of encouraging drifting is not so difficult in the States as it is in Burma.

In another respect (Frost) Nature assists in the States more than it does in Burma. The winter 1917-18 was very severe and cut back the hyacinth very severely. Plate CXXX taken in Haw Creek, Crescent City in March 1918 shows a mass of weed badly cut back by frost. The decayed matter under water was however so thick that it was found to be impossible to force a boat into the pack.

267. The following extract from a report, dated 18th July 1898, by Mr. (now General) J. W. Sackett shows that the idea of towing masses of the plant soon came to nothing :—

> " On January 25th, 1898, experiments were undertaken to ascertain whether any appreciable mass of the plants could be surrounded with a net and towed, the object being, in case the plants could be handled in this way, to tow them to the lower portion of the river, where the water was sufficiently salt to kill them. The net was made of three-sixteenth-inch cotton line with a lead and cork line one-half inch in diameter. The net was 200 yards long. A tow boat with an engine of about 150 H. P. was used. It was found that by towing very slowly the plants which could be enclosed by the net could be moved about. It was necessary to have both wind and current favourable. When a heavy strain was put upon the net the plants began crowding over it, sinking the cork line, and the plants could no longer be retained Various devices to remedy this were experimented with and although better results could be obtained than at first, after two days' trial it was decided that that method would not answer the purpose desired."

268. Good examples of the use of Booms confining the plant to or keeping it out of backwaters and side-channels were seen by the writer in his visit to the Pull-Boat logging operations in the Cypress Swamps at Donner, La. At intervals along the sides of any of the canals dredged for rafting logs booms could be seen holding back dense masses of the weed. The booms are not, however, sufficient and a certain amount of attention has to be paid from time to time to the removal of stray plants that find their way into the canals.

Crushing.

269. In addition to towing the only suggestion the Board of Engineers in 1897 thought to be of practical value was mechanical crushing between rollers mounted on a suitable vessel. An expenditure of $36,000 was sanctioned for construction and operation for one year. The writer is uncertain as to whether such a machine was actually built or not, but, in any case, the idea was soon given up as impracticable.

Spraying.

270. Although the report of the Board in 1897 on the subject of experiments with chemicals was chiefly of a negative character this method appears to have become general, because it aroused such active opposition on the part of cattle owners in Florida that the Government of the State took the matter up and ordered a special enquiry in 1906. An exhaustive series of experiments was

(1). Water Hyacinth badly cut back by frost; still however so thick under water that a boat could not travel far into it: — Crescent City, Florida.

(2). S. S. Hyacinth spraying densely packed Water Hyacinth.

(para 279).

tried. The following is a summary of the chief points in the report dated 23rd April 1906 by Major Francis R. Shunk, United States Corps of Engineers.

The objects aimed at in the experiments were to find :—

(1) A solution or mixture fatal to the plant.

(2) Whether cattle would eat the plants, after spraying, with injurious effects.

(3) Whether anything could be added to make the sprayed plants obnoxious to cattle.

A small pasture was fenced off in which to confine the cattle during the experiments and a space of water stocked with hyacinth was enclosed and divided into compartments by means of booms. If a solution proved to be effective as a plant killer cattle were put into the compartment and kept under observation. Subsequently a number of evil-smelling and ill-tasting compounds were tried with a view to finding something which cattle would refuse to eat.

No less than 23 different substances were tried. The only ones which were effective in killing the plant were :—

(1) Fowler's Solution.

(2) Sulphate of Copper.

(3) Bi-Carbonate of Potassium.

(4) London Purple.

(5) Arsenite of Lime.

(6) Arsenite of Soda.

The three first named chemicals were too costly to be worth further consideration and the choice finally narrowed itself down to the arsenical compounds, owing to their cheapness.

All the six chemicals above mentioned proved to be injurious to cattle, *vide* the following extract :—

"The experiments in connection with a long series of observations previously made in the course of the work indicate that most cattle are not very likely to eat the sprayed hyacinth when they can get anything else. In summer, when grass is plentiful, there is little danger to be apprehended from the eating of sprayed plants; in winter, when, in many districts, there is nothing but hyacinths to feed upon, they will eat them even if sprayed. It must be observed, however, that, in the words of Dr. Dawson, some cattle will eat anything and there will always be a certain amount of danger. It also appears to be the fact that cattle in poor condition are much more readily affected by the poison than those in good condition. This probably accounts for the fact that, in the past, several cows have been watched after eating the sprayed plant and no ill-effects have been noted."

A considerable number of substances were tried to see if cattle could be kept from eating plants after spraying. Results were negative. Plants sprayed with aloes were eaten without hesitation. Assafœtida "appeared to be an appetizer." The addition of whale oil soap cattle did not seem to notice. Tobacco had no effect. Quinine was readily eaten. Iod. form was effective but its cost made it prohibitive. Rotten egg also proved to be effective but could not be used on a large scale. Other forms of decomposed albumen were tried but it was found that plant killers were also germ killers.

The conclusion arrived at was that spraying could not be continued in the State and the only alternative seemed to be to rely on systematic drifting to salt water.

Section 3.—SPRAYING IN LOUISIANA.

Spraying in Louisiana.

271. The inference that the injurious effect on cattle of eating plants sprayed with arsenic is after all not so very bad may be judged from the fact that spraying has gone on interruptedly in the State of Louisiana. The writer has no statistics with regard to grazing to refer to but it is probably correct to say that it is quite as extensive in Louisiana as it is in Florida.

Before spraying operations in any locality are commenced care is taken to notify the fact and to warn people concerned. Occasionally a stray animal is killed but this is not by any means a common occurrence. People with "an axe to grind" are said to jump sometimes at a chance of putting the loss of an animal down to the spraying operations, but subsequent enquiry has more than once proved the charge to have been without foundation. In any case there appears to be no likelihood of Louisiana following the example of Florida by putting a stop to the use of chemicals.

The outfit in use in Louisiana consists of :—

(1) The *S.S. Hyacinth*, a double-decked stern-wheeler, which cost about $40,000.

(2) The "*Chene*," a Government barge—not self-propelling—equipped with spraying apparatus.

(3) A barge on hire, similar to the "*Chene*."

272. The *S.S. Hyacinth* measures 106′×17′, and has accommodation for the officer in command and a crew of five men.

The main boiler is 125 H. P., driven by an 85 H. P. engine burning crude oil. An auxiliary boiler is provided for use when the main boiler is being cleaned out, which usually takes place once a month.

Behind the boiler on the lower deck are the tanks—two in number—for the spraying solution. The tanks hold 1,122 and 2,244 gallons respectively. The smaller tank rests on the top of the larger one. From the lower tank a pipe leads to a double-

Two views taken at same place as the actual spraying in Plate CXXX (2) 10 days later, the creek not having been disturbed in the interval.

(para 274).

acting force pump and thence to the spraying apparatus, which is fixed in front of the cabin and has two lengths of flexible hose attached to it, so that spraying can be done simultaneously on both sides (*vide* Plate CXXX). The nozzle is of the *Fuller type* and gives a very fine spray. The pressure on the hose is usually about 50 lbs. A relief valve into the tank is provided so that the pump need not be stopped every time the nozzle is closed. This is a detail of importance as spraying has to be frequently interrupted in order to economize the amount of the solution used.

The small upper tank is used for mixing purposes. A full charge of arsenic and soda is put into it with water and then steam is blown through.

The barge "*Chene*" measures 60′×16′ and has a draught of 2′ 6″. If living accommodation for the crew were not provided the length could be reduced to about 45 feet.

273. The chemicals used are white arsenic (arsenious oxide) and soda (sodium carbonate), which are usually purchased and stored on board in barrels containing 625 lbs. A full barrel of each is put into the mixing tank—the soda coming first—and enough water is added to dissolve this quantity—usually about 625 gallons. Steam is then blown through (gradually at first, to guard against overflow) until the water boils and is continued for another two hours to thoroughly dissolve the chemicals. When hot, the solution takes up more room than when cold.

The depth of the liquid in the tank is measured with a graduated stick. After running a known amount (measured by the depth) into the lower tank, water is pumped into the latter to give any desired strength. To simplify matters for the operators a chart of volumes corresponding to various depths is at hand.

The usual strength is 1 in 10, *i.e.*, one pound of arsenic and one pound of soda in 10 gallons of solution. The full charge of 1,250 lbs. of chemicals would be sufficient for 12,500 gallons or say 5 times the volume of the lower tank.

The lower tank holds enough for 1 to 1½ hours with both nozzles open. Six hours' spraying would be a full day's work and the average for several days' running is usually not more than 7,000 gallons. The *S.S. Hyacinth* has storage space for 1½ tons each of soda and arsenic and this quantiy usually lasts for 10 days or more.

274. The spraying is more effective in the heat of the day in bright sunshine—the drier the leaves the quicker the chemicals take effect. Spraying is useless in wet weather and has no effect on leaves covered with dew owing to the excessive dilution which at once takes place. Spraying therefore does not begin until the sun is well up and, on very cloudy or wet days, may be out of the question altogether.

With a 9 or 10-per cent. solution the effect of the spraying is visible in a couple of hours. Within 24 hours the ends of the leaves turn black, and within three or four days all signs of greenness disappear and it becomes possible to send a boat through a place which was absolutely impassable before spraying. Within 16 to 18 days—

in a place where there is no traffic to cause any disturbance of the water—all traces of the previous existence of the weed disappear (Plate CXXXI).

On warm sunshiny days one gallon of solution is usually enough to destroy 10 square yards of closely packed hyacinth. On cloudy or cool days a larger quantity is necessary and a stronger solution may be advisable. Where the plants are very tall and dense the spray has difficulty in reaching the shorter stems and a second operation, some days later, may be called for.

The spray can reach to a distance of 40 feet on either side of the boat, *i.e.*, the steamer can clear a track 80 feet wide. On a broad stream the usual plan is to go up one side, then down the other side, and lastly up the middle.

In badly packed localities the rate of progress may be as slow as only 3½ to 5 miles a day cleared for a width of 80 to 100 feet. Under easier conditions a length of 8 to 10 miles is not unusual.

275. The writer paid a visit to the *S.S. Hyacinth* at Donner La, but was unable to see any actual operations as it was too early in the year. In 1917 spraying went on from April to September, inclusive, but in 1918 a start was not made until the beginning of May because the abnormally severe frosts in the preceding winter had killed off the weed very considerably.

The excellent photographs of spraying operations (Plates CXXX and CXXXI) attached to this report were obtained through the courtesy of Captain Kenny, the Officer in charge. The pictures were specially taken for the purpose and reached the writer after his return to England.

276. Spraying operations are looked upon as a permanency in Louisiana. With three boats—*Hyacinth*, *Chene* and a hired one—the District Engineer is just about able to keep pace with the growth of the plant. Complete eradication is looked upon as impossible. Owing to shallows, sharp bends and overhanging jungle there are many places which cannot be reached by spraying and act as centres of infection. It entirely depends on the density of the growth and on the amount of traffic in a particular stream as to whether spraying is done once or twice, or not at all, in any given season. The outfit is not large enough to make it possible to attend annually to every area known to be infected. In practice the three boats are kept fully occupied in creeks that are reported to be badly infested. Sometimes nothing at all is done in a given creek until private firms or individuals concerned make complaints and ask for assistance from Government.

The Water Hyacinth is to be found all over the State, and distances are great. Half the time is taken up with going backwards and forwards. In one instance mentioned to the writer, the *S.S. Hyacinth* had to travel 381 miles from one place of working to the next one and the journey took six and a half days owing to bad weather. In 1917 a total length of over 400 miles of stream was cleared, and more than half of the total was done twice over. Six weeks were spent in one stretch which was very badly infested.

277. *Summary of Expenditure on Spraying and other operations in Louisiana in 1917.*

U. S. S.S. Hyacinth—

	$		
Pay of crew for whole year	6,261		
Fuel, oil and miscellaneous charges for whole year	3,194		
Total cost of operating		9,455	
Installation of new boiler ; cost $ 2,250 ; Fixing, $ 338 ..		2,588	
Minor repairs		130	
Chemicals..		1,599	
			13,772

U. S. Barge Chene.—

Pay of crew	662	
Fuel and miscellaneous charges	162	
Repairs	150	
Chemicals	910	
		1,884

Hired Boat—

Hire	481	
Chemicals	145	
		626
Supervision and Office Expenses		1,538
Miscellaneous charges		2,245
Total ..		$ 20,065 (Rs. 60,195)

The greater part of the miscellaneous charges were in connection with the fixing of log booms, pulling out of snags, etc. The purchase of a new boiler was also an extraordinary item. Recurring expenditure on spraying may therefore be put at about $16,000 (Rs. 48,000).

The area sprayed is reported to have been—

	S. yds.
By *S. S. Hyacinth*	3,946,500
By Barge *Chene*	1,762,000
By hired boat	366,000
Total ..	6,074,500 = 5,021 ac.

SECTION 4.—MECHANICAL PILING IN FLORIDA.

Mechanical Piling.

278. The prohibition of spraying which came into effect in the State of Florida in 1906 led to close study of mechanical methods of getting rid of the Water Hyacinth. In 1909 piling by means of an *Elevator* was started. The experiment was such a great success that the method has been continued up to date.

In 1916 piling by means of a simpler contrivance, called a *Grappler*, was tried and the experience already gained points to this method as also being very successful and practical.

Elevator.

279. Up to date two *Elevators* have been built. The first one was built on the St. John River in 1909. It worked very successfully for seven years but was then found to be more or less worn-out. In 1916 it was dismantled and a second machine was built on the Withlachoochee River on an improved design, the engine being the only part retained in the new boat. The cost was $3,800, to which the original price of the engine, $1,500, should be added : total $5,300 (Rs. 15,900).

The Withlacoochee River only began to give trouble after the Florida Power Company built a dam right across the stream about 12 miles below Dunellon. The effect of this dam was to back up the water for a distance of 10 miles above Dunellon. As drifting over the dam could not be done the hyacinth brought down from upstream had no means of escape and became such a nuisance that measures had to be undertaken to get rid of it. The only feasible plan for clearing the 20 mile stretch of dead water above the dam appeared to be to pull the weed out of the water and pile it on the banks to die.

At the time of the writer's visit to Dunellon the machine was temporarily out of work through no fault of its own. A short time before a bad setback occurred to the Power Company in the bursting of the dam. The water level for miles upstream promptly fell [as shown by the mud marks on the piers of the bridge in Plate CXXXII (1)] and the old-time current was restored with free flow to the sea. The hyacinth could be drifted away and the Elevator will not be required again until the dam is rebuilt—a matter of some months.

The general idea of the Elevator is to lift the weed out of the water by means of an inclined conveyer, one end of which dips into the water and the other end stands up towards the bank, or wherever it is desired to do the piling.

The barge on which the machine is built is not self-propelling. It has to be towed about. The method of feeding the hyacinth to the conveyer depends on circumstances. If there is any current at all it is sufficient to throw a rope or place a boom obliquely across the stream. Failing a current, the usual plan is to pass a long rope (300 feet) round a mass of the plant and to haul it in gradually by means of hand capstans or winches on either side of the conveyer. Across the foot of the conveyer runs a board on which men can operate long rakes and feed the weed to the ladder.

280. When the level of a pile of weed reaches up to the top of the conveyer a move has to be made to a new site. It may only be necessary to move a few yards at a time as the pile may be practically a continuous one for any length, sometimes several hundred yards.

(1). Withlachoochee River, showing flood marks on piers of bridge after the fall of the water level due to the bursting of the dam in February 1918.—Dunellon, Florida.

(2). Water Hyacinth piled by Elevator; 8 feet high when piled; only 4 feet high two months later, when photo taken :—Dunellon, Florida.

(para 280).

Piling on the actual banks is not obligatory. It can be done in three or four feet of water. All that is required is some means of holding the weed together until a solid mass standing on the bed of the stream has been built up. A snag or root will do, or the site can be encircled by a rope or by a number of stakes, etc.

The part under water quickly begins to rot. On this account, and also because it begins to dry up, the part above water soon begins to settle down. It may eventually disappear altogether or it may float away if conditions are favourable. In the latter case it floats away as a solid mass, *i.e.* it does not rapidly disintegrate. Piles on the banks practically disappear in twelve months. The pile shown in Plate CXXXII (2) stood under 4 feet high at the time the picture was taken. When built about a couple of months earlier it was twice as high. Five to ten such piles a day were made.

281. The crew required to work the elevator consists of 7 men, *viz.*, foreman in charge, gas engineer, two men at the foot of the conveyer, three men in boats to handle ropes, etc., for moving the weed close into the machine.

The gasoline engine which drives the conveyer uses two gallons of gasoline per hour when at work. The average in 1917 was 4½ hours actual working of the engine in an 8-hour day. The rest of the time was taken up with moving into position, etc.

The following is a summary of work done in 1916-17. The elevator started work in August 1916. In the 10 months between then and the end of the fiscal year (30th June) it kept the channel clear for a width of 100 to 150 feet from the Power Co's dam for a distance upstream of 3½ miles. The channel kept closing again and again as the weed drifted down. In addition to the water hyacinth the elevator removed considerable quantities of drift timber and logs, and 800 feet of log-booms to keep the weed out of side-channels were placed in position in the course of the operations.

It is however not correct to estimate the area of weed removed by the Elevator simply by the length of channel kept open to traffic in the part of the river concerned. Fresh supplies of the plant kept coming down continually. The District Engineer estimates that the work done represented 86 acres of pack of average density cleared per month, *i.e.*, 3½ acres a day.

282. The following estimate of recurring expenditure for working the Elevator was given to the writer :—

	$
Pay of Foreman, gas engineer and 5 boatmen	400
Hire of gasoline launch for towing	50
Gasoline :—2 gallons per hour, 4½ hours per day, for 6 days per week, at 26 cents.	56
Miscellaneous items	94
Total per month ..	$600 (Rs. 1,800)

The actual expenditure in 1917 in a working season of 10 months was $ 6,933.

283. The photographs (Plates CXXXIII and CXXXIV) give a good idea of the general appearance and design of the Elevator. The chief points about the design to be noted are as follows :—

(1) In the first machine the upper end of the conveyer was flush with the end of the boat so that when the elevator was at work a man had to be stationed on the bank all the time to haul the weed out of the way. It may be seen in the photographs that in the second machine the upper end of the ladder projects beyond the end of the boat. Higher piles can therefore be built and the services of the man on the bank can be dispensed with.

(2) The slats of the conveyer are 7 feet wide. This limit was imposed by the necessity for keeping the over-all width of the machine down to 24 feet to enable it to pass under existing bridges. With wider bridges a wider ladder can be used.

(3) The conveyer engine is 25 H. P. It is possibly a little more powerful than required solely for the hyacinth, but it should not be forgotten that a good many submerged snags, etc., are met with and the machine should be equal to getting rid of them without loss of time.

(4) The boat has hutting and feeding accommodation for a crew of 7 white men. If desired, the accommodation could be on a separate boat or raft. The size and cost of the elevator itself would thereby be considerably reduced.

(5) The elevator is built up on the catamaran principle; with a clear space between the two sides. To allow for the extra weight at one end the keel is sloping. At first it was thought that an even keel could be obtained by uniting the two halves of the catamaran at one end. Although this idea was subsequently abandoned there appears to be something to be said for it, and it would be as well to give further study to this detail if the matter is taken up in Burma or Bengal.

(6) There is not much point in trying to make the elevator self-propelling. It would add considerably to the cost. A separate launch for towing purposes is preferable. When not required to move the elevator the launch could be kept fully occupied in fetching supplies, towing in masses of weed, etc.

Grappler.

284. On the St. John's River experiments with another kind of piling machine were started in 1916. For some years the power boat "Captain Macguire" had been used for removing snags. etc. For this purpose a 25-feet jib crane was mounted at one end of the boat with a special engine to haul the rope. The experiment with the hyacinth consisted in using the crane to lift a grappler made up of a pair of large wooden toothed jaws. The original apparatus is still in use and the success of the experiment is obvious.

The writer saw the machine at work in Haw Creek on 23rd March 1918. This Creek flows into the large lake near Crescent City. After crossing the lake by

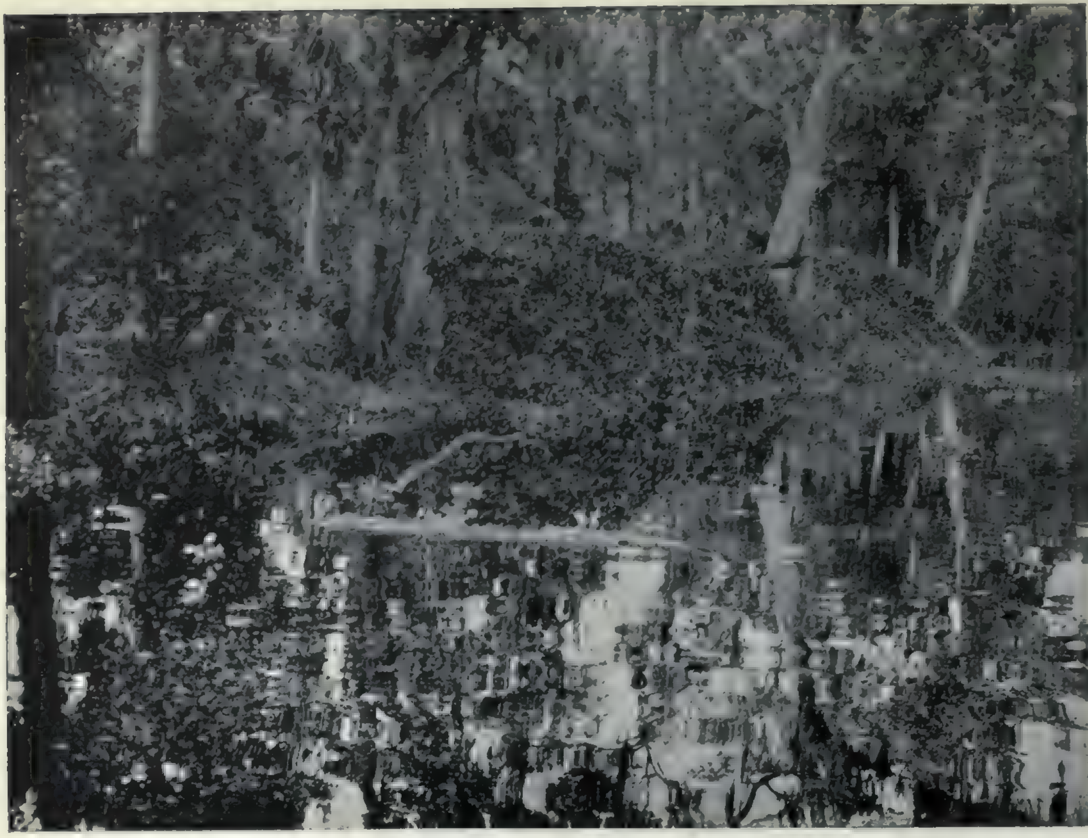
Front View of Elevator, Dunellon, Florida

(para 283).

Plate CXXXIV

Views of Elevator on Withlachoochee River :— Dunellon, Florida.

(para 283).



(1). Near view of Water Hyacinth piled in heaps by Grappler in Haw Creek :—Crescent City, Florida.

(2). Distant view of long heap of Water Hyacinth piled by Grappler in Haw Creek :—
Crescent City, Florida.

(1). Grappler at work, grapple being lowered ;—
Haw Creek, Crescent City, Florida.

(2). Grappler at work, grapple being raised ;—

motor boat (9 miles in one hour) the writer proceeded up the Creek. The latter is from 60 to 100 feet wide with dense jungle of the Swamp Cypress type on either side.

Half a mile upstream the hyacinth began to get plentiful, but only loosely disposed and the motor boat had no difficulty in getting along. On the banks from here onwards fresh piles of hyacinth were noticed. In a length of a mile there must have been a dozen piles which were anything up to 5 feet high and anything up to 100 feet long. The upper picture in Plate CXXXV gives a near view of a pile and the lower picture shows a distant view. The latter picture was taken at a bend where the stream broadens out. The smell was obvious! A mile further on the Grappler was found at work. It appears that it began operations in the Creek a fortnight earlier. The Creek was then quite impassible. In 14 days a length of 3 miles had been opened out.

285. The method of operation was to pass a long rope round a mass of the plant and draw it in gradually. The man hauling at the rope can be seen sitting on the side of the boat in Plate CXXXVI. The engine driver attended to the raising and lowering of the Grapple. Two men, one on either side, managed the ropes by which the jaws were held open. One man on the bank pulled the jib over to the piling place. It took about half a minute to lower the Grapple, lift it, and swing it round, release it and swing it back into position for another mouthful. In less than half an hour a mass rather loosely covering a fifth of an acre was completely disposed of. The piles were said to practically disappear in the course of a year—to rot away to nothing. Each pile represented from one to two acres of weed.

286. As already stated, the existing Grappler outfit is merely an experimental one obtained by adapting a power boat already in existence. The "Captain Macguire" is 67′ × 18′ and draws 3 feet of water. There is housing accommodation for a white crew of 7 men, and the boat engine is 40 H. P. The jib crane is much heavier than would be necessary solely for hyacinth work. It is equal to lifting 4 or 5 tons, whereas a load of weed is not more than half a ton.

Points to be noticed about an apparatus specially designed for hyacinth work are :—

(1) The jib could with advantage be longer than the present 24-feet one : say 30 feet, in order to pile the weed further away from the boat.

(2) For quick operation the existing grapple is quite large enough.

(3) The 6 H. P. engine used for hoisting the grapple is not quite strong enough. It is inclined to pull up with a full load ; 10 to 15 H. P. would be better. The existing engine uses about half a gallon of gasoline per hour.

(4) The general design of the boat is immaterial.

(5) For reasons discussed below it would be preferable to make the boat self-propelling.

The greater part of the above suggestions were made to the writer by Mr. Richards, the Foreman in charge.

287. Under favourable conditions the Elevator can probably work faster than the Grappler, although Mr. Richards said that the latter had actually cleared 4 to 5 acres a day. A self-propelling Grappler would be a more suitable outfit for narrow channels. It is advisable to make the boat self-propelling as it is desirable to be able to move at short intervals. Moreover the grappling outfit is so simple, and takes up so little room, that the boat can very well be used for other purposes.

SECTION 5.—COMPARISON BETWEEN SPRAYING AND PILING.

Comparison between Spraying and Piling.

288. In 1917 the expenditure on the Elevator amounted to $ 6,933 and it was reported to have cleared the equivalent of 621½ acres of packed hyacinth. This works out at Rs. 33 per acre.

In the same year the *S.S. Hyacinth* cleared 815 acres in 5½ months (say 6 months). For the rest of the year the boat was fully occupied with other duties so that against the spraying only half the cost of upkeep ($ 9,455) need be charged. This would put the total cost of the spraying at $ 4,727 + 1,599 + 65 = $ 6,391, which works out at Rs. 24 per acre.

It is to be noted that the average of the *S.S. Hyacinth* was only 5 acres a day. When actually at work all day in thick packs the boat can travel from 3½ to 5 miles, spraying a width of 80 to 100 feet. Taking the lower limits in both cases the total comes to 34 acres in a single day. This shows how much actual operations were interfered with by either or all of the following causes :—

(*a*) Wet weather.

(*b*) Moving long distances from one infected area to another.

(*c*) Other work.

In the dry season in Burma, and operating on big rivers where distances from one centre to the next are not likely to be very great, the actual average for short periods might be expected to approach much nearer to the figure of 34 acres a day than the *S.S. Hyacinth* succeeded in doing in 1917. On the other hand the average for the Elevator could not under any circumstances be expected to exceed 3½ to 5 acres a day.

The two methods may be summarized as follows :—

Mechanical piling can be done all the year round, but only in shallow water, and a single machine cannot be expected to clear more than 5 acres a day.

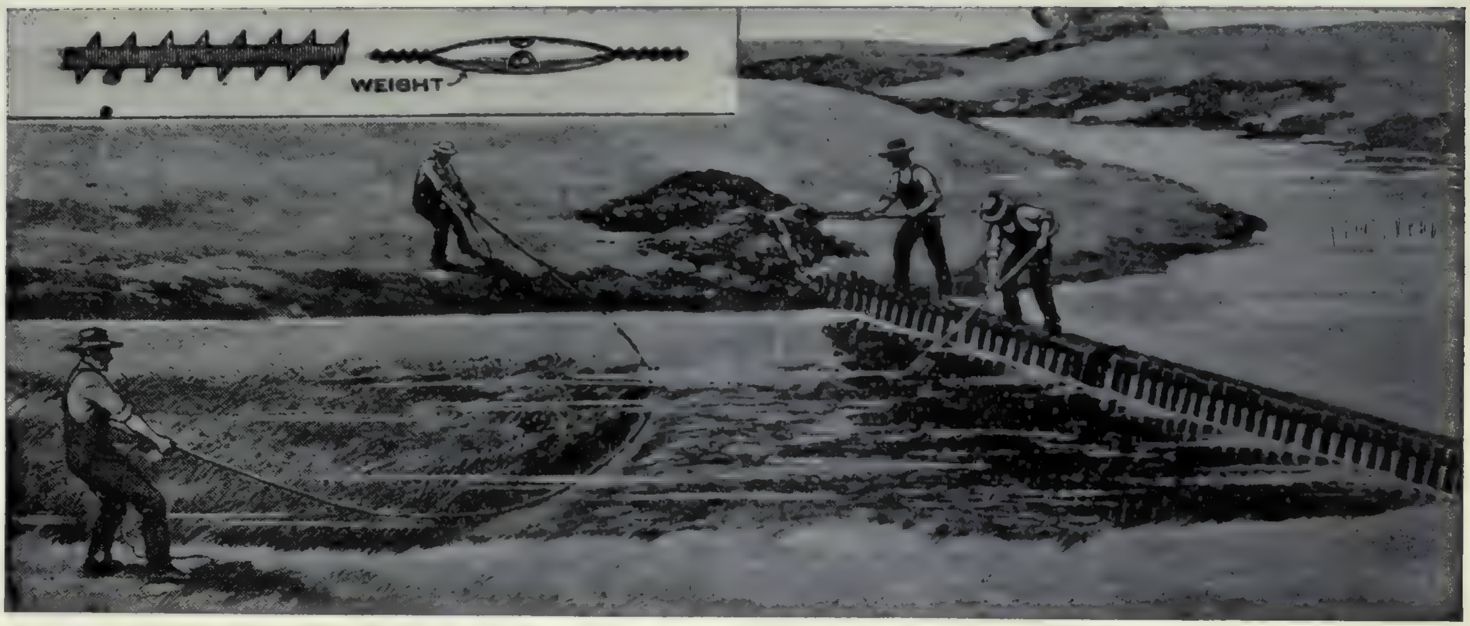
Spraying can only be done in fine weather, and preferably only when the sun is shining, but the depth of water is quite immaterial and under favourable circumstances a single machine can clear from 20 to 40 acres a day.

Submarine Saw.

289. The following extract and the accompanying illustration (Plate CXXXVII) are taken from the *Popular Mechanics Magazine* (Chicago) for August 1918. The apparatus is evidently intended for cutting off the tops of aquatic plants :—

"For clearing weeds from irrigation canals in California the Reclamation Service has found an underwater saw most efficient and economical.

Plate CXXXVII.



Under water saw for removing aquatic plants—
(Popular Mechanics Magazine).

(para 289).

It consists of a flexible tempered steel tape 1-50th″ thick with serrated edges (base and height 1-16th″) to which small iron weights are attached at 3-feet intervals. The saw, with ropes tied at each of its ends, is drawn back and forth by two men stationed on opposite banks of a canal. The cutters proceed upstream. As they do so the mowed weeds are carried by the current to an inclined grating placed against a plank spanning the stream. As they collect there, the weeds are removed with pitchforks. The per mile cost of this work varies from $ 20 to $ 50 according to conditions."

Recommendations for Burma. *

290. When all is said and done, drifting to salt water still remains the cheapest way of getting rid of immense quantities of the Water Hyacinth wherever the necessary current exists. Unfortunately the weed has spread over large areas of tanks, lakes, swamps and backwaters, where there is no outlet or steady current. For use under such conditions the writer recommends that Spraying be given the first place, and that mechanical piling be limited to localities that cannot be dealt with otherwise. Spraying does not affect the water for drinking purposes and it is not anticipated that it would be a difficult matter to give adequate protection to cattle and so there would be little to fear from friction with villagers. For getting rid of the weed in tanks, borrow pits, etc., a portable form of apparatus could be designed.

Mechanical piling may be required in the Prome and Tharrawaddy Districts in the interests of departmental teak operations in the Myitmaka and its branches. The *Grappler* type of apparatus is recommended in preference to the more elaborate and expensive *Elevator* type. As already remarked, the Grappler described in these notes was only an experimental adaptation of a machine built for another purpose. The design can obviously be improved upon.

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*According to a recent article in the "Pioneer," the Hyacinth has already become a pest in Bengal.—F. A L.—28th August 1919.

G. M. Press, Simla.—No. 206R&A—15-12-19—2,200—E. A., etc.