Forest Utilization.

TO THE READER.

The Biltmore Forest School has offered annually, since 1898, a course of lectures on Forest Utilization—a vast topic comprising every art, every industry, all activity connected with the utilization of our woods.

If forestry is and means a business, then it is safe to say that forest utilization comprises the major—the by far major—part of the American forester's activity, provided that the term "forester" describes a man placed in charge of a forest and of its administration.

There cannot be any doubt that American forest utilization is conducted on the grandest, most ingenious scale which the world ever knew. The conditions surrounding and bearing it are entirely at variance from those now confronting the European forester. It is not to be wondered at, consequently, that little knowledge of American forest utilization can be gathered from European handbooks on European forest utilization or from European travels.

Like all disciplines of forestry, forest utilization had best be studied in and near the woods. Lectures delivered at a forest school, unless they be continuously illustrated by object lessons in the forest and in the workshop, can merely lay a bare foundation of the topic in the mind, or rather in the memory of the student.

The pages herewith submitted are printed primarily for the use of the students attending the Biltmore Forest School; they comprise the dictation given by the teacher during and after lectures; they are a skeleton of lectures merely, and it is the teacher's task to clothe the skeleton with flesh, obtained from his practical experience in the American woods.

There is ample reason to believe that one-sided and local experience has allowed a number of mistakes to creep into the following paragraphs. The Biltmore Forest School begs to be corrected by the reader, and any suggestions relative to errors and erroneous statements contained in this little publication will be most thankfully received.

Aside from the entire literature on forest utilization available in America and abroad, liberal use has been made of communications appearing in all of the leading trade papers; of the catalogues issued by the leading firms manufacturing implements for forest utilization; of the experience of the rangers and foremen of the Biltmore Estate; of information privately obtained through correspondence.

Most truly,

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BILTMORE, N. C., Sept. 1, 1904.

Forest Utilization.

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FOREST UTILIZATION.

§ I. DEFINITION.

The term "forest utilization" comprises all acts by which forests—the immobile produce of nature—are converted into movable goods or commodities. Considered as a science or as an art, forest utilization constitutes the major part of forestry now practiced in our new country, abounding in forests.

As a discipline, forest utilization may be divided into two main parts, namely: "logging operations" and "manufacture," arranged in the following five chapters:

Chapter I. Labor employed in the forest.
Chapter II. Cutting operations.
Chapter III. Transportation.
Chapter IV. Foundations of manufacture.
Chapter V. Manufacturing industries.

§ II. LITERATURE.

There exists, unfortunately, no handbook on American forest utilization, although forest utilization shows a higher development in the United States than in any other country.

Among the foreign literature on forest utilization, publications of the following authors are particularly worthy of note:

Carl Gayer, Richard Hess, William Schlich, Hermann Stoetzer, Carl Grebe, Wilhelm Franz Exner, Carl Schuberg, Heinrich Semler, H. von Noerdlinger, Carl Dotzel, E. E. Fernandez, L. Boppe, M. Powis Bale.

Part I. Logging Operations.

CHAPTER I. LABOR EMPLOYED IN THE FOREST.

§ III. MANUAL LABOR.

A. Duration of employment.

I. Determining factors are:

(a) Climatic conditions;

(b) Economic conditions;

(c) Local custom.

In the South, work lasts all the year round.

In the Lake States and in New England, late fall, winter and early spring (from four to eight months) comprise the usual period of activity.

In the European mountains, logging is restricted to the summer months; in the European lowlands, to the winter months.

II. Advisability of continuous employment in conservative forestry, especially in the case of foremen and sub-foremen, leads to the adoption of means tending to attach the laborer to his job and to his employer.

Such means are:

(a) Advances for tools.

(b) Rent of cabins and farms at reduced rates.

(c) Help in case of sickness and accidents.

(d) Wholesale purchase of victuals so as to give the workmen the benefit of a reduced price.

(e) Firewood, forest pasture and forest litter free of charge.

(f) Permission of agricultural use, for a number of years, of clear cut areas. (This last system is called in India "tongya.")

(g) Employment during the season when cutting is stopped, in road building, fire patrol, planting, weeding, nursery work etc.

(h) Possibility for hands to rise to a foreman's position.

(i) Encouragement of home industries so as to keep the workmen busy on rainy or cold days, i. e., basket weaving, shingle making, wood carving, sieve making.

It seems most important to supply the family of the woodworker with a comfortable home and school and church advantages.

B. Remuneration.

I. Means of remuneration.

(a) Money. Wages in the South are from 50 to 75 cents a day. At Biltmore, now $1 per day, even in the mountains. On the Pacific coast, $2 to $3 per day. In Lake States, $18 to $32 per month, plus board; dry days only included.

(b) Commissary bills. This method of payment is used in the South only, in connection with colored labor.

(c) Privileges (house, farm, pasture).

(d) Board. Expense at Biltmore, per capita, 25c to 30c; in Lake States, 40c to 50c per day. Wages of camp cooks in Lake States, $50 and over per month: at Biltmore, $15 to $30 per month.

Victuals required per capita, see "Lumber and Log Book," page 144.

II. Scale of remuneration.

Wages depend on the effect of labor or on the values created by labor.

Influencing factors are:

(a) Density of population.

(b) Human strength and technical skill required.

(c) Silvicultural understanding required.

(d) Hardships endured and risks taken.

(e) Prices of the necessary victuals.

(f) Length of day during cutting season. Compare page 162, "Lumber and Log Book."

Where contract work prevails, the following additional factors come into play:

(g) Tools supplied by employer or employee.

(h) Softwoods or hardwoods.

(i) Amount to be cut per acre.

(j) Configuration of ground and remoteness from roads.

(k) Distance from home village.

(l) Possibility of continuing work during rain.

Experiments have shown that workmen paid under contract per one thousand feet b. m. earn more money in big timber than in small timber, and that a system of payment according to the diameter of the log is far more just.

C. Method of employment.

In France the woodworkers are employed by the purchaser of stumpage; in Germany, invariably by the owner of the forest. In America, both systems are found, the former prevailing. Whether the German or French system is preferable is an open question.

I. Hands are usually recruited from farm laborers, hence advisability of locally combining agriculture and forestry. In addition, the employees of the building trades, unoccupied during winter, supply help for the lumber camp.

II. Day work is advisable in preference to contract work

(a) Where quality (effect) of labor cannot be controlled, notably in nursery work;

(b) Where experienced hands must be trained;

(c) Where contract labor cannot be obtained (Pacific coast);

(d) Where contract legislation is bad. (Lien laws in Minnesota; $1,500 exemption clause in North Carolina.)

III. Contract work is generally preferable to day work because it is cheaper. Contract work is doubly advisable where employer's liability laws work against the employer. Contracts should always be in writing. The specification sheet should be kept apart from the paragraphs of agreement, so as not to encumber the contract.

The main clauses of a contract cover:

(a) Time allowed to complete work;
(b) Installments and payments;
(c) Building of snaking roads, sleigh roads and skidways;
(d) Scaling of defective logs and of sound logs;
(e) Employer's liability;
(f) Fines for fire, stock at large, fishing, hunting and drunkenness, and demand for discharge of culprits;
(g) Shanties and log houses and commissary bills;
(h) Supply of tools; deduction for loss and spoliation of tools;
(i) Fines for cutting trees not marked or of too small a diameter;
(j) Fines for leaving marked trees uncut;
(k) Fines for poor work and unnecessary damage;
(l) Possibility of speedy termination of contract in emergency cases;
(m) Nomination of umpire to avoid suits in case of discrepancies.

The specifications cover the following points:

Height of stumps; peeling of bark; separating product according to quality; length, diameter, weight of product; nosing logs; cutting defects out (unsound knots etc.); placing the product on sticks (so as to allow it to dry) or on skidways; method of carrying or moving products; swamping (removal of branches); use of road poles (breast works); skidways; road building.

D. Subdivision of labor.

The leading principle is that one division gang must push the other.

I. Lumbering.

(a) Cutting or felling crews, consisting usually of two hands; sometimes a third man to drive wedges and to make the axe cut.
(b) Log makers, dissecting the bole into logs. A foreman should be an ex-sawyer or an ex-lumber inspector.
(c) Swamping crew, to clear trees of branches and to open suspicious knots.
(d) Snaking crew—at Biltmore five hands for a three-yoke team; three men to get the logs ready and to remove brush (debris) and two men to accompany the load.
(e) Skidway crew—two hands rolling logs onto skidways.

(f) Road crew—meant to prepare snaking or sleigh roads; to sprinkle and sand ice roads.

II. Firewood or cordwood making (for pulp, distillation, cooperage etc.).

a, b, and c are the same as in "I.—a, b and c."

(d) Carriers or carrying crew—often with hand sleighs or rollers or grapple hooks.

(e) Splitters—with heavy axes which have broader, thicker cheeks than cutting axes.

(f) Piling crew—a very careful, honest man is required for piling the wood.

§ IV. ANIMAL LABOR.

A. Countries.

In Europe, even in virgin forests, practically none is required. In India and possibly in the Philippines, elephants are used.

In the United States, in the Southern and Pacific States, as also in the Appalachians, oxen are used. In the Lake States, Pacific States and New England States, horses are preferred. In the South, mules are used for small logs and especially on tram roads.

B. Horses.

I. The numerical ratio between hands and horses in Northern camps varies from 2 to 1 to 6 to 1.

The standard amount of work for one horse is:

(a) A haul of 1,600 lbs. inclusive of wagon, on a level road over 23 miles per day.

(b) An output of 2/3 horsepower per minute, equal to 320 horsepower per day of eight hours.

II. Horses are employed for

(a) Skidding or snaking.

(b) Rolling logs on skidways.

(c) Sleighing, trucking (two wheels) and wagoning (four wheels).

(d) Go-deviling.

(e) Loading on railroad cars.

(f) Supplying power for portable mills.

III. Food for horses.

(a) Interdependence between feed and effect in foot pounds per 1,000 lbs. horse flesh during a day's work is:

Straw	2 lbs.	2 lbs.	2 lbs.
Hay	19 lbs.	15 lbs.	11 lbs.
Oats	2 lbs.	6 lbs.	10 lbs.
Effect	3,000,000	9,000,000	15,000,000

(b) Food required.

After Thaer, per 1,000 lbs. of horse flesh, 25 lbs. of good hay and oats.

After the "Lumber and Log Book," 50 lbs. of oats and 40 lbs. of hay per team per day.

(c) Feed values equivalent to 100 lbs. of good hay, after Haswell, are

= 54 lbs. of barley.
= 57 lbs. of oats.
= 59 lbs. of corn.
= 275 lbs. of green corn.
= 374 lbs. of wheat straw.
= 400 lbs. of cornstalks.

C. Mules.

I. They are employed for:

(a) Light logs on good ground and for long distances.
(b) For wagoning lumber and provisions.
(c) For hauling on rail tracks (wooden and iron rails).
(d) For hoisting logs on inclines.
(e) For plowing and scraping in road and railroad building.

II. Food for 1,000 lbs. mule flesh, as for horses.

Mules require less care than horses, taking care of themselves and resisting overwork. They are frequently not fed at noon. (Price per team at Biltmore, $200.)

D. Oxen.

I. Price per yoke is from $80 to $120, weight from 2,000 to 2,500 lbs.

Ox yokes form the rule, although efficiency of oxen in harness is superior. Shoeing for each claw separately—difficult and risky, but necessary on hard ground.

Special training takes place from second year on. Fitness for hard work begins in the fifth year, when ossification of bones is completed.

Special training for leaders.

II. Employment.

In the South for snaking heavy logs—or log trains in Oregon; for hauling logs suspended underneath high two-wheel trucks in the pineries; rarely for loading cars or wagons.

III. Standard work.

An ox walks 14 miles per day with load. An ox yields in eight hours of work 270 horsepower, hence he produces only four-fifths of the effect of a horse.

After Thaer, an ox produces only one-half as much power as a horse of the same weight.

IV. Feed.

(a) It is much cheaper to feed oxen per 1,000 lbs. living weight than to feed horses of same weight.

Ruminants have four stomachs and thus digest their food better. No feed is given in the middle of the day, and no expense is incurred during idle periods, where pasture is available.

(b) Careful treatment and good stables required. Oxen must not be hurried. Soft yokes, proper salting and regular watering.

(c) In the South, at the present time, cottonseed meal and hulls form the cheapest food. Food requirements per yoke per day are 25 lbs. of meal and 40 lbs. of hulls. Present prices of meal $25 per ton and hulls $8 per ton, delivered at Brevard, N. C.

CHAPTER II. CUTTING OPERATIONS.

§ V. WOODSMEN'S TOOLS AND IMPLEMENTS.

A. Axe. It consists of a handle, 32 inches to 42 inches long, made of hickory, ash, locust or mulberry, either straight or "S" curved, and of a blade or head forming a steel wedge of particular temper. The cheeks of the wedge are slightly curved in the midst, falling down gradually towards the upper and lower line. The weight lies either close to the bit or close to the handle, according to local predilection.

The best make is the Kelly axe.

Double bit axes, requiring straight handles, are largely used in the Northeast. Special splitting axes, of greater weight and broader cheeks, are rarely used (for sugar barrel bolts and retort wood).

For hardwood, a thin and light axe (a cutting axe) is preferred, while for softwood a broad and heavy axe is used (a tearing axe).

A box of axes contains an assortment of various weights. In Europe the bit is relaid with steel, after wearing off.

The axe is used

I. For cutting trees entirely or partly.
II. For swamping (axe to be 1½ lb. heavier).
III. For splitting.
IV. For nosing logs.
V. For driving wedges.

Price of axes from $6 to $8 a dozen. Handles are $1 a dozen.

B. Adz and broadaxe.

The adz and broadaxe are used for trimming and barking export logs, squares, ties and construction timber. The blade of the adz stands at right angles to the plane of the sweep and has such curvature as corresponds to the curve of the sweep through the air. The cutting edge is ground concave on the inner side.

The broadaxe is either right or left sided, the plane of the blade forming an angle of 5° to 10° with the plane of the handle. The handle is usually short, the blade very heavy and wide.

C. Peavies.

The peavy is a typical American tool, not used elsewhere. The best make is Morley Bros.' line of blue tools.

The hooks are distinguished as round bill, duck bill and chisel bill hooks, made of hammered steel. The socket is either solid or consists of rings. The square pick (point) is driven cold into the round bored point of the handle. The handle is 4 to 6 ft. long, straight, 2½ inches to 3 inches through and is made of hickory, ash, or usually hard maple. Price per dozen is $10 to $22.

A peavy must answer the following requirements:

I. Hook adapted to any size log.

II. Bill to be so constructed as to catch securely through any layer of bark.

III. Proper length, greatest strength and low weight.

D. Cant hooks.

The cant hook is a peavy, lacking the pick (point).

The socket consists of two rings only joined by a narrow bar.

Cant hooks are used more in the mill and yard, peavies more in the woods.

E. Cross-cut saws.

I. Radius experiments show a radius of 5 feet 2 inches to be best. The straight drag saws require excessive strength and are deficient in dust chambers.

II. Width of blade.

It is at the widest point about 8½ inches. The hollow back saws, a very recent invention, have only about 4 inches width all through.

III. Thickness of blade.

The back of the saw is always somewhat thinner than the gauge of the teeth. Henry Disston gives the saw backs 4 or 5 gauges less thickness than the saw teeth. Atkins gives the teeth "14 gauge," the back at the handles "16 gauge" and at the center of the back "19 gauge."

IV. Uniformity of temper and proper temper are obtained by special processes. No hammering of blades. Cheeks are perfectly smooth.

V. Construction of teeth is very variable. Dust room between the teeth should be twice as large as the teeth.

For hardwoods more teeth are necessary than for softwoods. There are two kinds of teeth, namely:

(a) The cutting teeth, a couple or trio of which might be arranged on a common stock, to form "Tuttle or Wolf Teeth." Only the points of the cutters actually cut into the fibre.

(b) The raker or cleaner teeth, meant to plane off the fibre severed by the cutters and to shift the sawdust out of the kerf. European experiments prove the uselessness of cleaners. They simply occupy valuable dust room. The point of the rakers should recede by 1/32 of an inch from the cutting line of the cutting points.

VI. Length of saw is from 4 ft. to 8 ft. At Biltmore 6½ ft. and at Pisgah 7 ft. is preferred.

Local crews use the "diamond cross-cut," the "champion teeth" and the "hollow back" saw.

VII. Saw handles should be easily detachable. The material of the handle is maple, birch and hickory. Handles are fixed (usually) vertically to back of saw. Sometimes, however, they are in the direction of the radius of the saw.

Large "bow" saws allow of a very thin blade and have a bow instead of handles. They are not used in America.

VIII. The effect of a saw is equal to the number of square inches cut by one man per minute. The effect is small in pole-woods, increasing gradually up to a diameter of 1¾ ft. and decreasing thereafter owing to increasing friction.

In cutting longleaf pine, the saw is continuously sprinkled with turpentine.

The effect of curved saws is from 40 % to 50 % higher than the effect of straight saws.

The saw overcomes

(a) The resistance of the fibre by the sharp points acting as knives and planes;

(b) The friction at both cheeks of the blade by smooth cheeks and by a gauge narrowing toward the back;

(c) The friction of sawdust by deep teeth, curved line of teeth, perforation, large dust chambers and possibly by "cleaning teeth."

IX. Dressing of cross-cut saws.

(a) "Jointing" means filing all cutting teeth down to exactly the same circumference.

The tool used is called a jointer. A file is placed in the joints and by a screw pressed into the proper curvature.

(b) "Fixing the rakers" means filing them down with the help of a raker gauge. The rakers act as brakes if they project into the cutting line. Outside and forks of rakers are slightly filed to remove case hardening, and the point is sharpened to a planer edge.

A raker swage is being introduced to spread the points of the rakers and to give them a hook-like point, which is said to tear out long slivers instead of tearing out dust.

(c) "Setting the cutter teeth" is done under the control of a "set gauge" with the help of a "set block and hammer," giving 3 to 4 taps (the best method when done by experienced men) or with the help of a "saw set." "Saw sets" are constructed either wrench-like or after the hammer and block principle.

Rules of setting are:

1. Setting should never go lower than half the length of the tooth.
2. It should never exceed twice the gauge of the teeth.

3. More set is required for long saws and for soft woods than for short saws and hard woods.
4. When hammering, strike tooth fully ¼ inch from point of tooth.
5. If teeth are badly set, take, to begin with, all set out of the teeth.
6. Apply side file inside file holder, to take away slight irregularities of set (after filing the teeth).

(d) "Filing." Filing usually follows setting except in the case of saws spanned in a vise, when the set is afterward given by holding the set block on one side of the spanned saw and hammering from the other.

Rules of filing are:

1. File inside of tooth only.
2. File to a bevel or fleam of 45°.
3. Push the file away and do not draw it toward you.
4. Do not file point to a feather edge.
5. It is useless to sharpen tooth below the cutting point.

(e) "Gumming." Gumming is usually done with the file; the lever (punch) gummer may be used for the purpose, however.

(f) Remarks: A good, well-tempered saw holds sharpening and filing for six work days.

In California one man "cross-cut saws" up to six feet long are used in dissecting the bole into logs.

The cross-cut saw file shows, on the cross section, a narrow triangle with curved back.

In Europe flat and triangular files are used for cross-cut saws.

The "spread set" of the cutting teeth has been tried and was found impracticable.

F. Wedges.

Wedges are used:

I. To split wood. The "axe wedge" is usually made of iron and should have straight and not convex cheeks, which are often grooved to prevent wedge from jumping the cleft.

Wedges are sold by the pound.

Iron wedges are prevented from jumping by heating them, by putting dirt in the cleft, or else a rag (wet) over the wedge.

Wooden wedges are made of the butts of hard maple, hornbeam, black gum, dogwood and beech.

Iron wedges with wooden backs are frequently used abroad.

II. To prevent saw from pinching in the kerf.

Special saw wedges of oil-tempered steel are made by Morley Bros.

Frequently saw wedges and axe wedges are used alike.

Wooden wedges must be driven with the axe or hammer.

Iron and steel wedges must be driven with a wooden maul.

G. Mauls and maul bands.

Mauls are made of the butts of dogwood, beech, hornbeam, hard maple, gum and locust, and are held together by two iron hoops made of 1/2-inch by 3/4-inch flat iron.

H. Pickaxe and mattock.

They are used where the stumps are used together with the bole and in the preparation of forest roads. The points of both are relaid with steel after wearing out.

I. Brush hooks.

They are used in cleaning boles and in making fagots or fascines; further in clearing snaking roads in dense underbrush.

J. The krempe.

The krempe is used largely abroad and in India and resembles the picaroon or hookaroon used in America for handling ties, telegraph poles and pulp wood. It is used in rolling and moving logs down hill, the pick acting as a lever, the fulcrum of which lies at the heel.

K. Pike poles.

Pike poles are used with pike and hook or with pike only; are 12 ft. to 20 ft. long, made of selected white ash, the points consisting of cast steel. The points are either screwed into the wood or driven without heating. Pike poles cost $10 to $25 a dozen. They are indispensable in driving and rafting operations and at mill ponds.

L. Screws for blasting stumps. Such screws are used abroad, not to shoot stumps out of the ground but solely to split stumps where prices of firewood are high. The hollow screw loaded with blasting powder is inserted into an auger-made hole.

M. Grindstones.

Grindstones should not be exposed to the sun, should be kept equally round and even and should always be kept wet while in use. A water trough underneath the stone should be rejected, as the submerged side softens unduly and unevenly. Stones are sold by the pound.

A 70-lb. grindstone costs about $4. The extra fixtures, consisting of hubs, shafts with nuts, crank etc. cost about a dollar.

N. Machine saws.

For cutting trees such saws have proven a failure. Similar was the fate of the "electric cutting machine" recently patented by Bayer. The expense of carrying machines from tree to tree is greater than the expense of cutting by hand.

O. Tree-felling machines.

They are largely used abroad to obtain the stump of a tree together with the bole.

I. One of them is the "Nassau machine," consisting of a 4-inch board 10 inches wide into which regular steps are hewn, and of a pole about 25 ft. long, with a crooked pike at the small end and squarely bound in iron at the big end. Half a foot above the big end the pole is perforated so as to receive a 1½-inch round steel spike. The square base of the pole is placed on a step of the board, fixed flat on the ground, some 12 feet from the tree. The pole then forms an angle of about 50° against the board, while the spike is securely placed into the bole of the tree. By means of two crowbars the base of the pole is moved step by step toward the tree. This machine must be used in Hesse Darmstadt, under the employer's liability law.

II. The "wood devil" has been used for centuries in Switzerland. A rope or cable is fixed in the top of the tree to be felled and a chain is fastened around a stump in the falling direction, which chain ends in two hooks. The lower end of the rope is secured to a chain, the links of which receive the hooks. By moving a long lever to and fro, the hooks are inserted alternatingly in the chain end of the rope, advancing two or three links at a time.

The instrument is very cheap, simple and powerful; at an angle of 45° the rope has the maximum of power.

III. To remove stumps alone the stump lifter might be used.

IV. "Weston's differential hoist" lifts the maximum of weight with a minimum of its own weight.

A Weston hoist capable of lifting 1½ tons 8½ ft. high weighs only 81 lbs. and costs $25.

§ VI. FELLING THE TREES.

Under "A" and "B" are described the chief methods of felling.

A. Obtaining bole without stump and roots:

I. By exclusive use of the axe, handled from one side only in cutting small trees, in thinnings and in coppice woods.

II. By exclusive use of the axe, cutting two kerfs on opposite sides. The first notch, on side toward which tree is intended to fall, made from 4 inches to 6 inches lower, must penetrate the center of the tree. Avoid felling toward the direction in which the tree leans.

Advantages of this method are the facts that one tool and one man only are required; that the bole is easily directed; that the logs obtain proper noses.

Disadvantages are loss of bole, amounting to from 4% to 8% and loss of time and labor in large timber. This method of felling is universally used in Maine.

III. By hewing "out of the pan," a method used for valuable heavy boles. Uncertainty of fall is counterbalanced by a gain in the length of the bole. The bole thus obtained is said to show less heart shakes.

IV. By using the two-handed cross-cut saw alone, without the help of the axe, a method not advisable for the reason that the fall of the bole cannot be directed.

V. By joint use of cross-cut saw and axe. The axe cuts a kerf on the falling side, the depth of which is 1/4 to 1/5 of the diameter, and the innermost point of which lies on a level with the saw kerf. When the saw begins to pinch, drive wedges behind the back of the saw. Withdraw the saw when the tree begins to shake heavily and force it to fall by wedging.

Advantages of this method are: the trees are easily directed at a small loss of timber.

Disadvantages are: several tools and several men are required. In very thick woods and on very rocky, steep slopes, the use of the saw is not advisable or possible. Careless wedging may cause the bole to split at the butt. The saw and the wedge are said to be responsible for heart shakes.

B. Obtaining bole with stump and roots:

It is essential to thoroughly sever the main roots with axe, mattock and pick. The tree is then forced over by a tree-felling machine, or with a rope fastened to a high limb.

Advantages are: longer bole; gain of lumber 8 % to 10 %. Possibility of obtaining knees for ship building (tamarack and white oak). The tree falls gently, its fall being checked by the roots so that the bole shows less splits, cracks and wind shakes. The bole is less apt to break and can be allowed to dry out gradually. Further, root-breeding insects don't find any incubators and agricultural use is facilitated.

Disadvantages are: greater expense, more tools, axes ruined in cutting roots, extra saw cut required to sever the butt log from the roots and, above all, the delay in finishing the logging job.

C. Criteria of a good method:

I. Danger to workmen.
II. Total net value obtained.
III. Wastefulness.
IV. Possibility of throwing the tree in the desired direction.

D. Pollarding before felling:

The branches or the tree tops in European logging are frequently lopped off before felling, for the following reasons:

I. The younger generation of trees surrounding the tree to be cut receives less injury.

II. Lopped trees touch the ground all along the bole at one and the same time. Hence no danger of the boles breaking or splitting. In addition, a reduced crown causes the tree to fall with decreased force.

E. Felling rules:
  I. The trees must be thrown in such a way as to do least damage to themselves, to surrounding trees and to undergrowth.
  II. The felled tree should lie in a position allowing of easy dissection of bole and of easy removal of logs.
  III. Operations must be stopped during storms and blizzards.
  IV. Trees over 6 inches in diameter should be sawn down, coppice woods excepted.
  V. No more trees should be felled than can be worked up within reasonable time after felling.
  VI. The stumps should not be higher than the tree's diameter.
  VII. All trees marked for cutting, and none else, must be cut.
  VIII. The tops should be swamped so that they may come in contact with the ground.

§ VII. DISSECTING THE BOLE OF THE TREE.

A. Purpose of dissection.
  I. Reduction of freightage.
  II. Better adaptation to different methods of transportation required for different assortments.
  III. Better accommodation of buyers requiring different assortments.
  IV. Obtaining manageable size of logs and wood.
    As much net value should be obtained from the bole as possible. Waste is advisable wherever it pays to waste.
    In no forest on earth is all the woody substance produced marketable. The amount of offal (waste, debris) depends merely on the expense of transportation to markets within nearest reach. It is better to waste wood than to waste money. The modern lumberman gathering logs of 4 inches diameter and the modern forester objecting to any waste frequently neglect this rule.

B. Factors influencing the dissection:
  I. Requirements of the market governed by custom.
  II. Distance from market: the longer the distance, the better must be the quality of the product.
  III. Locality (f. i. steepness of slope; swampiness).
  IV. Local laws (f. i. in North Carolina relative to 8-foot firewood).
  V. Available means of transportation and their construction.
  VI. Freight rates varying with the degree of conversion.
  VII. Size of cars and wagons.
  VIII. Length of mill carriage and of feedworks.

C. The main divisions of woody produce obtained from dissected boles are:
  I. Piece stuff, i. e. logs, blocks, construction timber, sold by the foot, the standard, the pound.
  II. Numbered stuff, i. e. poles, posts, mine props, scaffolding poles and shingles, boards and staves, sold by the dozen, by the hundred, by the thousand etc.

III. Space stuff, i. e. industrial cordwood (for insulator pins, bobbins, pulp, tannin etc.), tanbark and fuel, sold by the cord. In the case of bark, 2,240 lbs. are usually considered the equivalent of one cord.

D. The specifications governing the dissection describe:

I. The dimensions, i. e., the range of length and diameter desired for each section obtainable.

II. The quality of each section and the defects allowed and prohibited therein.

(a) Saw logs for lumber.

1. Dimensions. Douglas fir on the Pacific coast used to be cut in logs 24 ft. long. The minimum diameter permissible was 30 inches.

Spruce in New England is often cut 13 ft. 4 inches long with a diameter of 6 inches and up.

For yellow pine logs, any length and any diameter over 8 inches are permissible.

Hardwood logs have a length ranging from 6 ft. 4 inches to 18 ft. 4 inches, arranged in intervals of 2 ft. Odd lengths are scaled down. A deficiency of ¼ ft. in length of board or less is, however, often disregarded.

Export logs of yellow poplar are 8 ft. and 16 ft. long.

Jack pine logs for cheap box lumber are often cut 6 feet 6 inches long, the diameters ranging from 4 inches upward.

2. Treatment. Saw kerfs at either end of log should be made perpendicular. Branches should be swamped off, knots cut level and laid open. Bark in the case of conifers is frequently peeled off in Maine and in Europe. Bark rings are sometimes left at the ends. Defects of bole must be concentrated in one log, or must be sawn out. Nosing is required for loose driving and for snaking. Painting of end faces with red lead is prescribed for export logs. Very heavy logs are sometimes split in two. Putting logs on sticks to prevent spoliation of sap and to reduce specific gravity is often advised.

(b) Blocks for woodenware.

Poplar, for large bowls, must be entirely free from defects. White pine blocks are often cut between the whirls of branches.

(c) Hub blocks must be butt logs, the length allowing to cut either two or four out of the block.

(d) Construction timber is hewn according to local requirements. Minimum diameter at small end most important. Construction timber abroad is sometimes whip sawn.

(e) Poplar and walnut squares run from 4" x 4" to 10" x 10". They are whip sawn in the backwoods of western North Carolina.

(f) Telegraph poles. The smallest diameter, the diameter at or close to the big end, the length, crooks and treatment of bark must be considered. Sometimes pointing of the small end is specified.

(g) Fence posts. Species, length, smallest diameter, straightness, method of manufacture etc. must be considered. Usual length is 6½ feet.

(h) Railroad ties. Specifications are very variable. Face is usually from 6" x 6" to 7" x 9". Sawed railroad ties are used, especially in the yellow pine section. Great waste in hewing ties from trees just too small to yield two ties. Specifications cover allowance of sap, wind shakes, wany edge and dote.

(i) Shingle bolts. Lengths are multiples of 16" and 18", usually.

(j) Mine props. Middle diameter from 3" to 8".

(k) Stave and heading bolts. Basswood heading bolts used in Michigan. Length 18" or 37" and diameter not less than 8". If from 12" to 18", split into halves. If over 18", split into quarters. White oak bolts used at Wilmington measure 36" for stave bolts and 24" for heading bolts; core must be hewn out; minimum face at inner edge 4".

Heading bolts for sugar barrels in the Adirondacks consist of spruce cut in lengths forming multiples of 22" with a diameter minimum of 6".

Stave logs for sugar barrels consist of birch, beech and maple, the lengths forming multiples of 32", with a diameter minimum of 8".

(l) Bolts for carriage spokes. Material is black or shellbark hickory, white oak, white ash and post oak strictly free from imperfections. Minimum diameter 12"; length 6½ feet, 7½ feet, 8½ feet and so on.

(m) Paper pulp. Logs scale 6" and upwards; no dead timber. In the State of Maine pulp logs are peeled in the woods.

(n) Veneering blocks. Hardwoods preferred, of the biggest possible diameter, but certainly over 18" diameter. Blocks from 2 to 6 feet long.

(o) Tannin extract wood. Length of wood 5 feet, split from logs 10 inches and over in diameter. Wormholes allowed. Fibre must be absolutely sound. A cord consists of 160 cubic feet.

Higher price for peeled wood. Butt logs preferred. Cutting of saw logs out of same tree forbidden.

(p) Fuel cordwood. Advisability for piles to contain one cord. Weight of pieces should be such that one man can lift them easily. Splitting facilitates the process of drying; in pine wood it also prevents rotting.

CHAPTER III. TRANSPORTATION.

§ VIII. TRANSPORTATION WITHOUT VEHICLES ON LAND.

The following methods of such transportation are en vogue:

A. Carrying stove wood, pulp wood, extract wood etc. on men's shoulders, a method of transportation very largely used abroad and in India. Carrying distances abroad range up to one-eighth of a mile. In India railroad ties are carried by the Hindoos over much longer distances.

"Stretchers" are sometimes used where slope is not steep, or "timber carriers." Morley Bros.' lughooks are used in America.

At Biltmore firewood is carried to the roads over an average distance of 150 feet on men's shoulders.

B. Dragging logs by human force where vehicles or water is near and where produce does not weigh over a ton. The front end of a log is placed on a tray (lizard) to prevent it from boring into the ground.

Barked or peeled and well trimmed logs are easily dragged. Silviculturally, dragging is, of course, inferior to carrying of wood products.

C. Rolling logs by human labor is necessary almost everywhere. Peavy, cant hook and "krempe" are used for the purpose.

On a slope of about 15 %, after removing obstacles, logs will roll easily.

Shingle blocks, stovewood blocks and other short round wood may be spanned in a frame. This method of transportation badly damages young growth and trees left standing.

D. Shooting logs down chutes.

A dell in the slope of 30 % or more is often filled with (peeled) logs; then the top logs are shot down the dell over the other logs below.

Three kinds of chutes proper may be distinguished:

I. Pole chutes;

II. Board chutes;

III. Earth chutes.

I. Pole chutes have been largely used in the United States, costing about $300 a mile. They are said to last from seven to ten years and should have the following grades:

	For long logs.	For short logs.	For railroad ties.
Dry chute	15-20%	25-35%	26%
Iced chute	4- 8%	8-12%	6%
Watered chute	3- 6%	5- 8%	

Heavy curves must be avoided and the outside of light curves fixed with a number of "saddle logs."

Pole chutes consist of a trough made of four to six poles. The pole chute is about three feet wide and requires cribs or yokes for a foundation where it is not laid on the ground.

Water, ice and soap are used for lubrication. Chutes made of hardwoods are said to run smoother than those made of conifers, owing to the greater elasticity of conifers. Where the grade is light, poles should be peeled and hewn on the inside. The grade of inlet must be very steep; the outlet should open into a pond. Frequently, when the job of chuting is finished, the poles or ties composing the chute are shot down themselves, thus dissolving the chute.

II. Board chutes, which are frequently movable, consist of 1-inch or 2-inch boards. They are used in carrying firewood and other short stuff down slopes of 25% to 35%. The rougher the produce, the steeper must be the grade and the wider and smoother must be the trough. Sprinkling is required during dry weather, sanding during wet spells.

III. Earth chutes. These resemble snaking roads of a steady grade, which grade must be:

(a) Where snow or ice crust is available, 8 to 10%.

(b) Where split cross ties are used, laid about 5 feet apart; for logs 16 feet long or longer, from 10½ to 18%.

(c) Where dry earth is used, 25% and over.

Road poles must be used on the valley side, especially so in curves, and bridges must cross all the gullies.

E. "Roping" is a method employed for moving long and heavy logs in the "Black Forest." A rope is fastened at the small end of the log to a ring dog and swung once or twice around the stump of a tree nearby. The log is started by the "krempe," and its speed is controlled by loosening or tightening the loop around the tree. When the rope is run out it is fastened anew, after stopping the log, to a tree lower down on the slope. The best slope is about 35%.

F. Snaking logs or skidding logs.

I. Attachment by chains 12 to 16 feet long and 1/3 inch to ½ inch thick ending in dogs. When a chain link breaks, a "cold shut" is put in its place (cost $3 per 100 for ½-inch chain). For smaller logs skidding tongs are used in place of dogs, attached to main chain by three rings, swivel and hook, and costing, per dozen, about $50.

In the case of horses, stretchers are used to prevent the traces from hurting their legs.

On muddy soil, the nose of the log is frequently placed on a tray, or a lizard, or a triangle.

Snaking dogs are usually hand made and should be driven by a maul. Plain points on dogs seem to be preferred. Logging dogs 10 inches to 12 inches long are quoted at $15 per dozen.

II. Animals. For long distance hauling, mules or horses are preferred to oxen. Ox harness is rarely used. In the South three yokes form a "team" usually, the chains running from yoke to yoke. Leaders (oxen) require special training. The teamster manages the yokes of oxen by shouting, applying the whip as little as possible.

III. Roads for skidding or snaking.

(a) Uphill grades must be strictly avoided; even level stretches are disastrous. The grade depends on the season of usage. Where ice and snow are available 1% or 2% are ample. On dry rocky ground 50% is the maximum. On the average, for "Biltmore" conditions, 20% seems best.

(b) Curves must be strictly avoided, especially "inside curves" skirting a gully. Herein lies the greatest difficulty of snaking road building in sections where the mountain slopes are deeply gullied.

(c) In the Appalachians the surface of the road is 2½ to 3½ feet wide and road poles laid on the valley side prevent the logs from jumping the road.

Swampy and moist places are corduroyed lengthwise with the road. Creeks must be bridged. It must be kept in mind that one bad spot in a snaking road requires the use of additional teams over the entire length of road.

Regular troughs made of two strong poles resting on cross ties are used in Pennsylvania, where grade is deficient and distance long. Out West cross ties 7 feet apart are placed on the road. In both cases long log trains are formed. It is claimed for such trains that the pull or strain on the animals is evened or equalized, some logs sliding down hill while other logs of the same train overcome impediments.

(d) Means of lubrication are: Sprinkling with water; laying cross ties or length ties; peeling of logs; greasing the ties.

Means of braking the logs are: Sprinkling earth, sand, hay and branches on the road; throwing chains on the road, or tying chains around the logs.

(e) Snaking distance. Snaking distances range up to one mile (usually), averaging about one-third of a mile. Where many logs, say 30,000 board feet of logs or more, must be transported on the same road over an average distance greater than one-third of a mile, other means of transportation are usually preferable to snaking.

In the Appalachian hardwoods the expense for 1,000 board feet snaked over ½-mile amounts to about $4. In the Adirondacks skidding costs 40c to 50c per 1,000 board feet, the distances being short, since the logs are merely skidded to the skidways arranged alongside the sleigh roads.

G. Drums.

I. Hand drums or winches are used for yarding logs and especially for hoisting logs up hill on steep inclines, the distances not exceeding 300 feet. G. B. Carpenter quotes single "drum grabs," weighing 275 pounds and having 2 tons power, placed in strong oak frames, at $27. Power capstans might be used for the same purpose.

II. Drums with horses as motive power are used in eastern Tennessee for hoisting logs up to the rim of the sandstone plateaus.

III. Steam power is now universally used out West in connection with drums known as "Bull Donkey" and "Donkey" engines. Skidding or snaking roads are usually dispensed with. Steel cable (¾-inch plow steel) is used on the drums. The distance of haulage should not exceed 1,200 feet. The main cable is pulled out by a

½-inch endless cable ("tripline") running into the district to be logged over a number of tackle blocks. Zigzags can be made by using tackle blocks on the hauling line as well. One engineer and one fireman are all the crew required in addition to two loaders. Frequently the engine loads logs on railroad cars at the same time.

The engine's cylinders are about 8 inches by 10 inches. Engines are moved from place to place by their own power. Price for an engine f. o. b. Biltmore is $1,400. Boilers are of the upright type. The wire cable is usually made of 6 strands, each containing 19 wires, wound around a hemp center. Running cables should never be galvanized. The proper load of a cable is only one-fifth of the breaking strain in tons. Steel ropes (cables) have twice the strength of charcoal iron ropes. One-inch steel wire cable costs 19c a foot, weighs about 1½ pounds per foot and has a breaking strain of 33 tons. Its proper load is 6 tons only. Silviculturally this method of steam logging is objectionable.

§ IX. WATER TRANSPORTATION.

Logs or lumber are driven loosely or floated in rafts.

A. Loose driving is a method used in eastern America for short logs, pulp wood and firewood.

Specific gravity of material driven must be reduced below 1.00. Heavy species might be deadened a year before driving, like teak in India, to attain this end, provided that attacks from fungi or insects, on the deadened trees, are not to be feared.

Under favorable conditions, where the creeks are narrow and well watered, no special arrangements for driving are required.

I. Splash dams. The proper site for a splash dam is the rocky narrows of a water course below a broad bottom of little fall, or else at the outlet of a natural lake.

Large splash dams must be placed on rock foundations. The expense of building increases at a cubic ratio with the height of the dam.

Splash dams built in tributaries are preferable to dams in the main creek, provided that they can be filled quickly enough.

A system of dams of first, second and third importance is frequently formed.

The distance of effectiveness of a dam depends on the size of the water reservoir, the width of the water course below the dam, and the rapidity of its fall. On "Big Creek" in Pisgah Forest the distance of effectiveness was four miles.

Splash dams meant to be permanent must be built of stone and are exceedingly expensive.

The usual splash dam consists of timber cribs filled with rock and joined by logs laid crosswise. The front of the dam must be slanting and is covered with a double layer of boards. The gateway of the dam must allow of rapid drawing (or opening) of the basin. The gates are either constructed barn door fashion, held in place by a strong key and lever, or consist of (vertical) piling, the individual piles to be lifted by a crowbar or drum. Half-moon-shaped gates are used in the Lake States and in the Adirondacks.

The smaller the water supply and the greater the pressure the tighter must be the gate.

The expense of a splash dam of the first order is from \$1,000 to \$2,000. A timber splash dam lasts from six to ten years.

Frequently additional small gates are made to give a "fore-water," meant to loosen the logs in the creek below the dam. The actual splash rather presses the logs down the creek, instead of floating the logs.

II. Dams in the creek bed itself are sometimes required to raise the water in a shallow section.

III. Before driving begins, the creek bed must be cleaned out by removing old log jams, leaning trees and huge boulders. Sharp bends of the creek must be cut through, so as to straighten the creek bed.

IV. Fixtures along the bank of the creek are required to prevent logs from getting smashed when striking a bluff; from being thrown on the bank in a curve of the creek; from destroying the banks, and further to prevent the spread of water and loss of force, where a splash is expected to overrun adjoining flats.

Such bank fixtures consist of:

Pole cribs filled with rock, the poles lying solid, pole to pole, toward the creek, or of inclines of poles laid horizontally, supported by strong uprights from behind, or of alternating layers of fascines and stone, joined together by strong piling driven into the ground; or, finally, of brush laid on the sloping bank and irregularly covered with rock.

V. The bottom of the creek is sometimes paved with stone or poles laid lengthwise, where the bottom consists of clay. This is especially necessary in artificial channels or canals dug through sharp curves of the creek, or dug close to the connecting booms.

VI. Booms.

(a) European booms are rake booms, the teeth of the rake formed by strong palings.

The tops of the teeth are connected by strong timber bars, which are held in place by stone cribs.

These booms are stretched diagonally across the river. The logs or wood are merely diverted by the boom and forced into an artificial side canal ending in a reservoir near the mill or depot.

A gridiron or sieve, filtering the river at a waterfall and retaining the wood on the gridiron, has been used in the Tyrol by the Bavarian Government for many decades.

(b) The American boom consists of two sections, an upper shear boom spanning diagonally across the stream and a lower storage boom stretching for miles along the river bank, where the water is quiet and the current slow. Both booms are floating booms consisting of one or two strings of prime logs, the logs joined by anchor chain. The booms are kept in place either by wire cables ¾-inch to an inch in diameter or by stone filled cribs. It is advisable to have the storage boom consist of independent sections so that the breakage of the boom empties one section only.

Frequently several mill concerns form boom companies.

The logs are lifted out of the booms by "jack works" or "log hoists."

VII. Driving and splashing must be considered a backwoods method, applicable to very cheap stumpage. It is not practiced on the Pacific coast, where we have very cheap stumpage, owing to the size of the logs and poor water facilities. Where there are plenty of natural lakes, in a coniferous country as in the Adirondacks, Michigan and Minnesota, the method continues to be practiced.

Splashing is the more advisable:

(a) The smaller the specific gravity of timber.

(b) The shorter the logs.

(c) The lower the stumpage price.

(d) The more reliable the rainy season and the gauge of the river.

(e) The better the natural conditions are at the dam sites, in creek bed and at boom site.

(f) The poorer the natural conditions are for railroad building and wagon road building.

(g) The less land owned by other parties is traversed by splashed logs.

(h) The more saw timber improves while being bathed in running water.
(i) The longer the distance.
(j) The more inclined the log owner is toward taking risks and the less affected he is by reduced fertility along the river bank.

Remarks: In the pine woods of the South in olden times ditches were dug about three feet wide, connecting stumpage with swamps and rivers.

The outlay per 1,000 board feet in splashing and driving is from 50c to $1 (for manual labor only).

River driving of cord wood at Biltmore from the upper end of the estate to Asheville, inclusive of piling at the boom, costs 50c per cord.

B. Rafting.

Loose logs are tied into rafts at a place where the flow of the creeks and rivers begins to be more gentle.

Only rarely are rafts used in connection with splash dams on very rapid streams. (Black Forest.)

According to the size and species of logs, rafts are formed either with the logs lying with the stream (longleaf pine rafts etc.), or with the logs lying square to the stream. In this latter case the length of the logs should not exceed eighteen feet. Square rafts consist usually of hardwood logs.

I. Logs with the stream.

(a) The logs are joined into raft sections, each section one log long; the narrow end of the log points down stream; joining usually by rope, cable or chain; ring dogs or eye dogs are used, or wooden pins in connection with auger holes.
(b) At the tail section the rear ends of the logs are allowed to spread fan shaped.
(c) The raft is directed by long rudders (sweeps), by brakes (poles which are pressed against the bottom of the river) and pike poles.
(d) The width of the raft and the tightness of binding depend on rapidity of the stream, span of bridges to be passed, sharpness of bends of river and width of river bed.

Remarks: Ring dogs for rafting weigh about 1½ pounds, are four inches long and have a 2½-inch ring, through which rope is run. Price 10c apiece.

Eye dogs are made of ½-inch round iron, are six inches long and cost 6c per pound.

II. Logs square to stream.

(a) The ends are joined by cross poles, sometimes imbedded in the logs and held in place by pins driven into auger holes, or by chain rafting dogs, consisting of two small wedges joined by two rings and five links of chain. Weight 2½ pounds. Price 12c.

(b) The logs must have about equal length. Species not floatable otherwise are tied up with floaters of pine, yellow poplar, cottonwood and linden.

In the Mississippi two oak logs are floated by three cottonwood logs.

(c) Such rafts are naturally stiff and cannot be used on rapid streams. The narrow and wide ends of the logs should alternate so as to keep the sections straight.

C. Flumes.

Flumes resemble chutes made of boards. They must be water tight. They are largely used on the Pacific coast.

I. A V-shaped cross section has proven best. Side boards are equally long, about 16 feet, in double layers. Angle of the V = 110°. Top width is 3 feet to 4 feet.

II. An even constant grade of from 1% to 3% is necessary, also slight curves and large water supply, which is often obtained from artificial reservoirs. High trestle bridges are sometimes required.

III. The main flume has a number of tributaries. A crew is stationed along the flume; special attention is given to the inlets of tributaries. Patrol trails along the flume.

IV. The fluming of logs is said to be unsuccessful. In the West, anyhow, the size and weight of the logs would prevent fluming. Nowadays either planks or heavy dimension stuff, to be resawn at the outlet of the flume, are sent down. Only coniferous lumber is flumed.

The lumber in the flume forms one continuous chain; this arrangement prevents the lumber from sticking and catching at the side walls of the flume.

V. Famous flumes are those at Chico—Sierra Nevada range (40 miles of flume), the flume of the Bridal Veil Lumber Company and the Great Madeira flume, all in California. The last is 54 miles long and has a daily carrying capacity of 400,000 feet of lumber. It cost only $5,000 per mile.

The scarcity of water in California is the greatest obstacle to the continuous use of flumes.

D. Water transportation over lakes and sea is effected in the following way:

I. In the "fiords" of the Pacific coast, logs standing upright are chained together so as to form a stockade in which the other logs are similarly placed, filling it tightly. Such stockades hold about half a million board feet of lumber at a time and form a seaproof raft, pulled to the mill by tugboats.

II. Logs chained together in the form of a cigar-shaped raft after various patterns have proven a failure. These rafts were taken from the Oregon and Washington coast to San Francisco, being launched like a steamboat and towed by tugboats. To judge from newspaper reports cigar-shaped rafts of boards have proven a success.

The steamship companies consider cigar-shaped rafts a great danger to navigation.

III. In carrying logs across the lakes in the Adirondacks and Lake States, light ring booms are used. The logs are placed in such booms at "the landing" and are rafted (driven) to the outlet of the lake either by wind, current or tugboat.

§ X. TRANSPORTATION ON LAND WITH VEHICLES.

A. Sleighs and sleds.

I. Hand sleighs, home made, very light, are frequently used abroad at grades of 10% and more. Man sits in front of load and directs with legs and side brake. On steep slopes such sleighs are used in summer as well. Fifty cubic feet is an average load for one man. The workman carries his sleigh back uphill on his shoulders for the next load.

Sleighing roads for summer sleighing frequently have cross ties at short intervals to be kept greased at slight grades.

II. The American sled has nothing in common with the European sled. A team of horses is always used for motive power.

The sleigh, or sled, consists of two sets:

The front set has a tongue of rock elm or oak and a front roller in which the tongue is set. Runners are 7 feet to 9 feet long, 3 inches to 4 inches wide, shod with ½-inch steel shoes or cast iron shoes either below only or both above and below; they are either slightly convex or flat. The front of the runner should be of a natural curve or crook, not hewn. Material is white oak. The cross beams, either ironed or plain, rest in saddles or nose plates with knees.

The "back roll" of the hind set is coupled to the front set by chains attached to the center of the front cross beam. There is no tongue to the hind set.

III. Log binders are used on loading chains to take about half a foot of slack out of the chain, unless the same end is secured by poles and the twisting of the binding chain.

IV. The usual load of a sleigh is five tons, while a wagon carries only two tons on an average.

The actual load depends on distance, grade and condition of road. In the Adirondacks about 2,000 board feet form a load; in Ontario 1,500 feet of white pine or spruce.

V. Sledding roads are constructed in the Adirondacks at an expense of $25 to $150 per mile. The sledding distance is said not to exceed three miles, usually. The teaming expense is about 10c per 1,000 board feet per mile.

The relative distance of snaking and sledding depends on configuration and density of stand. Sledding roads are preferably built on swampy soil. Heavy grades require a heavy outlay for sanding; insufficient grades a heavy outlay for icing. Carelessness in surveying sleigh roads is extremely expensive in short, mild, snowless winters. The modern lumberman surveys his roads with instrument in hand, completing them before snowfall.

To begin with, an empty or lightly loaded sleigh is run over the road to mark and set the track.

B. Transportation on two-wheelers.

I. High wheelers, wheels 7 feet to 10 feet high, are used in the pineries of the South, in California, and to a certain extent in the Lake States for hauling coniferous logs of 1½ feet average diameter and of extra long length.

Logs are loaded underneath the axle, either by using the tongue as a lever or with the help of a second axle having the form of a winch (Southern method).

Logging distance in the South not to exceed half a mile, average one-quarter of a mile. Expense $1 per 1,000 board feet.

The best makes are:

Bodley Wagon Co., Staunton, Va.; Snyder Wagon Co., Shreveport, La.

Prices from $100 to $150.

II. Low wheelers, usually called "Bummers," the wheels consisting of a solid tree section held by iron rims 1½ feet in diameter. The top of the axle is even with the top of the wheels. The tongue is only six feet long and merely used as a lever in loading. The bummer is pulled by chain attached to point of tongue and is loaded by placing axle parallel to log close to center of log, with the tongue standing perpendicular, the log being fastened to the axle by short chains and dogs.

High and low wheelers are used on undulating ground for downhill pull on soil free from rock, swampy places, debris and brush.

C. Log wagons. Log wagons are entirely used for transportation in the old country, where the forests are traversed by a network of well graded stone roads. Wagons are always handmade, of light weight and carry up to 17 tons of logs.

In carrying long boles, the front and hind trucks are separated. Steep curves can be made if the rear ends of the logs are fastened underneath the axle of the hind truck.

The American wagon has a track width, from center to center of tire, of 4 feet 6 inches or 5 feet.

Wheels are usually made entirely of white oak. The wood is well seasoned. The tire is 3 inches, 5 inches and over. Front and hind wheels usually equally high—2 feet to 3½ feet. Eight wheelers are now widely advertised.

Skeins are preferably made of welded steel instead of cast, 3 inches to 5 inches in diameter.

Steel axles have not proven a success, owing to difficulty of repairs in the backwoods. Bolsters should reach to or over the top of the wheels.

The reach should allow of changing distance between front and rear set.

Main requirements are:

I. Strength.
II. Possibility of repairs in the woods.
III. Low point of gravitation.
IV. Ease of loading.
V. Ease in turning.
VI. Light weight of wagon itself.

Prices for log wagons range from $80 to $200 according to carrying capacity. Weight from 800 to 1,800 pounds. Carrying capacity 1½ to 5 tons.

D. Traction engines. Traction engines are largely used abroad and have proven very successful recently in the South African war. In freighting lumber from mill to city or depot they are used in the United States on a small scale, since stone roads seem to be a prerequisite; loose sand, deep mud or swamp are impracticable for traction engines. In Pennsylvania four-wheelers costing $1,500 for a 16-horsepower compound engine and able to climb 12% grades and to turn 30 feet curves have proven a failure, since the use of traction engines plows the roads during rain.

In the California mountains, where drouth prevails during six months of the year, the three-wheelers manufactured by the Best Company, of San Leandro, Cal., have been largely and successfully introduced. Very high wheels and broad tread cause little injury to the route traveled. The boiler is a combination of upright and horizontal, concentrating weight on the driving wheels and preventing water and fuel from dropping back from the pipes on steep grades. Engines are said to be able to climb 30% grades and to climb over logs, brush, stone etc. Front wheel is for steering only, with front drum for skidding logs by wire cable.

E. Pole roads. A statistic of 1886 finds in the United States over 2,000 miles of pole roads, using over 400 locomotives and over 5,000 trucks.

I. The rails are made of straight, preferably coniferous poles, sufficiently trimmed to fit the double flange of the truck wheels. On suitable soil no ties are required, the rail being gradually pressed into the ground.

Sawn rails, preferably consisting of several layers of boards, must be used in curves of the pole road and are still largely used near mills on steep and short grades.

II. Trucks. The wheels should not turn with the axle. An oval concave rim said to be inferior to a flat rim with heavy flanges.

Each wheel has about 2 inches room for side play. The reach should turn like a swivel in hind and front set, allowing all wheels to stay on the track.

III. All lumbermen now agree that pole roads are impracticable for locomotives. On sawn rails locomotives are still used, however, when prices of steel are high, grade steep, distance short and use intended for a short while only. Sawn wooden rails do not allow of heavy loads and, consequently, seem unadvisable just for logging by steam engines.

F. Forest railroads.

I. Portable forest railroads.

In American lumbering portable railroads are little used. The sections of which portable railroads consist are necessarily light and, consequently, unfit for the heavy traffic of American lumbering. In Europe the sections are usually 6½ feet long, have 2½ feet gauge and weigh 80 pounds. Steel ties are preferable at the ends so as to have the joints supported by ties. The sections are joined by a hook arrangement without being bolted together.

Usually the sections are merely laid on wood roads. Motive power is supplied by gravity, men or horses. Wheel flanges usually on both sides of the rail. Rail sections of trapeze form are sometimes used in building curves. Bridge switches are preferable to split switches.

In the wood yard at Biltmore sections of wooden rails were used, the ties being replaced by iron rods. The top of the rail was shod with a strip of ¼-inch iron, the ends joined by hook and pin, and by hole and pin.

Steel sectional tracks of 2½-inch gauge are manufactured by the C. W. Hunt Co., New York. The trucks used have the wheel flange outside. Curves and switches are ready made. Straight sections are 6 feet to 20 feet long.

II. Stationary track.

(a) Grade. A proper survey is very essential. For steep grades (over 7%) a soft rail is required. Grades of 11% are feasible on straight track for locomotives having eight drivers.

High percentage for very short distance is, however, permissible.

Logging roads in the South have grades running up to 15% for uphill traffic, obtaining the necessary impetus by a corresponding downhill grade. The expense of maintaining the track and the frequency of accidents render steep grades highly expensive.

The standard railroads have never over 4% grade.

(b) Curves. The minimum radius of curves depends on gauge of track; distance between axles of front and hind trucks; length of timber to be carried and grade in the curve. Curvature is measured by the subtended angle, the (secant) chord of which is 100 feet. Standard railroads do not allow of an angle exceeding 10%.

In curves, to relieve the increased friction, and, further, to prevent the trucks from jumping the track, owing to centrifugal force, three remedies are required:

1. Lessened speed and reduced grade.

   In practice for standard gauge of 56½ inches, for each degree of curvature the grade is released by 0.02%; for narrow gauge by 0.03%.

2. The outer rail is elevated for standard track by ½-inch for every degree of curvature: for 36-inch gauge (usual narrow gauge) by 1-3 inch for each degree of curvature.

3. The track is widened in curves by 1-16 inch for every 2½ degrees of curvature.

(c) Rails. The form is usually the T rail. Grooved rails, flat rails, rails inclined toward center of track etc. are freaks merely. In logging railroads the rails are often fastened lengthwise on sawn or hewn stringers, which arrangement allows of light rail. The gauge is measured inside the tops of the rails if the flange is inside, and outside the rails if the flange is outside. If the wheel has a double flange, measure from center to center of rails.

In lumbering operations, the standard gauge (56½ inches) is generally preferred, since heavier loads can be taken and since the rolling stock can be disposed of more readily at the end of operations. Of the narrow gauges 36 inches is best, since the odd gauges prevent ready exchange of addition to and sale of rolling material.

In mountainous sections narrow gauge is preferred. Here the expense of wide gauge track is too high, since it requires flatter curves, smaller grades and largely increased outlay for roadbed.

In standard lumbering operations a heavy (56 pounds) rail is now preferred, the up-keep of track being cheaper, the bed for the track being less expensive and fewer ties being required for the heavy rail. Light rails are so twisted, after short use, that they cannot be sold at second hand. For 36-inch gauge a rail weighing 16 pounds to 20 pounds is best.

Rule for number of tons of rail required per mile:

1. Tons of 2,000 pounds.

   Multiply the weight of the rail by 7/4 and you obtain the number of tons required per mile. For example, 20-pound rail x 7/4 = 35 tons.

2. Tons of 2,240 pounds (after which rails are usually sold).

   Multiply weight of rail by 11/7 instead of by 7/4.

   The price per ton of rail (steel) varies from $25 to $35.

   The interdependence between locomotive's weight and minimum weight of rail permissible is given by the following equation:

$$\frac{w}{n} \times 8 = r$$

wherein *w* stands for weight of locomotive in tons; *n* stands for number of drivers; r stands for minimum weight of rail in pounds.

Estimates of cost of track, exclusive of rolling stock and bridge arrangements, vary from $1,300 to $4,300 per mile for easy grading. One-half of the expense in this case is for rails, spikes and splice joints (fish plates).

The grading and laying of track costs from $300 to $1.000 per mile for easy grading; and cross ties cost about as much.

Estimate of cost per mile for

1. Sixteen-pound steel rail, requiring

25 tons of rail @ $32 per ton.	$ 800.00
1,780 pounds of 3½x⅜ in. spikes at 2c per pound	35.60
357 splice joints at 20c	71.40
2,640 cross ties at 15c	396.00
Grading and track laying	500.00
Total	$1,803.00

2. 40-pound steel rail, requiring 63

tons of rail at $30 per ton	$1,890.00
4,690 pounds of 4x½ in. spikes at 2c a pound	93.80
357 splice joints at 40c each	142.80
2,640 cross ties at 25c each	660.00
Grading and laying track	1,000.00
Total	$3,786.60

(d) Cars.

Cars consisting of two trucks, of two axles each, form the rule.

The trucks should be very low and should have short distance between axles where curves are heavy. For narrow gauge tracks, special trucks are constructed costing from $50 to $80. While steel trucks are more satisfactory in the old country, in America trucks with wooden framing and wooden bolsters are usually preferred, owing to greater ease of repair far from factory.

The bearings are frequently outside as well as inside the wheels, so as to have the frame supported at eight instead of at four points of the two axles. The bolsters, swiveled on the frame, are very frequently much longer (wider) than the axles.

The weight and capacity of logging cars should be as follows:

	Weight in lbs.	Capacity in board feet.
4 wheel cars	3,000 lbs.	1,000 b. ft.
4 wheel cars	4,000 lbs.	1,500 b. ft.
4 wheel cars	5,000 lbs.	2,000 b. ft.
4 wheel cars	6,000 lbs.	2,500 b. ft.
8 wheel cars	6,900 lbs.	2,000 b. ft.
8 wheel cars	8,400 lbs.	3,000 b. ft.
8 wheel cars	9,600 lbs.	4,000 b. ft.
8 wheel cars	11,000 lbs.	5,000 b. ft.

(e) Locomotives.

Logging locomotives are manufactured by the Baldwin Locomotive Works, Philadelphia;
H. K. Porter, Pittsburg, Pa.;
Climax Mfg. Co., Corry, Pa.;
Stearns Locomotive Co., Erie, Pa. (for Heissler geared locomotives).

The price is practically independent of the gauge, being influenced more by horsepower.

Four driving wheels are usually sufficient. On steep grades, six wheels and, on very steep grades, eight wheels are used.

The resistance to be overcome by the tractive force is:

1. Gravity, which increases in exact proportion to steepness of grade expressed in per cent. Thus it is always 20 pounds per ton for each per cent.
2. Friction of the journals and of the wheel flanges against the rails, which depends, aside from curvatures, on quality of the track and of rolling stock. It is at least 5 pounds per ton; it amounts to 6½ pounds for first class equipment; to 20 pounds to 40 pounds for bad equipment, and in extreme cases it rises to 100 pounds.

Tractive force is understood to be one-fifth of the weight, in pounds, on the driving wheels, expressed in tons.

For instance:

Weight on driving wheels 25,000 pounds, divided by 5=5,000 pounds; and 5,000 tons is therefore the tractive force of the engine.

The hauling capacity of an engine is: tractive force divided by the sum of the frictional and gravity resistance, both expressed in pounds, deducting the weight of the locomotive from the quotient. For example:

Weight of locomotive on 4 driving wheels = 20,000 pounds. Tractive force is 4,000 tons.

First case—Frictional resistance 8 pounds per ton, grade level. Then the hauling capacity equals 4,000 tons over 8 (friction) plus 0 (gravity) minus 10 = 490 tons.

$$\frac{4000}{8+0} \text{ minus } 10 = 490 \text{ tons.}$$

Second case—Frictional resistance same as above, grade 1%.

$$\frac{4000}{8+20} \text{ minus } 10 = 133 \text{ tons.}$$

Third case—Frictional resistance 8 pounds, grade 2%.

$$\frac{4000}{8+40} \text{ minus } 10 = 73 \text{ tons.}$$

The cost of hauling logs on a standard railroad, per carload of 40,000 pounds, amounts to $5 for distances of one to fifty miles, and to $6 for distances of fifty to one hundred miles.

Porter's catalogue gives the cost of hauling as ranging from 30c to 60c per 1,000 b. ft. for a logging distance of from five to ten miles. At Chicora, Ala., two standard trains provide daily, together, 100,000 b. ft., coming from a distance of about eight miles.

Small (narrow gauge) locomotives haul from 60,000 to 120,000 b. ft. per week over distances of from five to ten miles.

Where grades are not excessive, a locomotive should cover daily 60 to 80 miles, the hauling distance varying from 2 to 10 miles.

G. Mono rail.

The mono rail portable railway is a French invention (Caillet) and has been tried to a limited extent in India.

It consists of one rail only, resting on steel sole plates at intervals of a few feet, and is laid down direct on the surface of the ground. Rails are joined together by scabbard fish plates. The trucks have two low wheels, grooved at the rim, the carriage hanging between the wheels a few inches above the rail. Cars are balanced by a telescopic rod and kept in balance, like a bicycle, by the motive power itself, which consists of an animal hitched in a frame alongside of the carriage.

The mono rail system might be applicable in the transportation of bark, cordwood and minerals.

H. Cable way logging.

The logs are suspended from a cable and are not dragged on the ground.

I. On steep slopes, the grade being 35% to 50%, the logs slide down by gravity, being suspended from two trolley blocks held apart by a strong rod or pole, about 15 feet long. At the upper end of the cable, curved iron rails lead, like a bridge switch, onto the cable. The cable is kept tight by heavy drums, over which the cable runs at the ends. It is said to wear out in about eight years.

The speed of the block carriage is regulated by manila rope, wire or light wire cable, and the empty block carriage is carried backward by the same rope without any motive power other than that of a loaded block carriage going down hill. Proper switches allow the empty block carriage to pass the loaded one at a half-way point. The price of 1-inch wire cable is about 19c per foot.

In Switzerland lines two miles long are found, without any supports. In the Hartz Mountains supports are given every 700 feet and the expense is $800 per mile for entire equipment.

In Oregon and western North Carolina short cable conduits of this character are in successful use, and in India (in the Himalayas) the most extensive plants of this character are said to exist.

II. In swamps of the Atlantic coast, where railroading is difficult, the system of the Trenton Iron Co. and of the Lidgerwood Manufacturing Co. have been tried which move the block carriage holding the logs in suspense over a cable either by steam power or by electricity.

(a) In case of steam power, the engine is placed either on a scow swimming in the swamp, in the river, in the logging canal cut by powerful dredges, or on a railroad car, the logging outfit costing about $7,500 per mile (including lateral rig), consisting of:

One-inch carrying cable and double traction rope;

Double block carriage with differential hoist and log grip;
Brackets, supporting the cable;
Steam engine with hoisting drum;
Lateral hauling-in rig, by which logs are dragged to the main carrying line over distances running up to 1,000 feet.

(b) In case of electric power, the outfit, costing $6,200 per mile, consists of:
One-inch carrying cable and ½-inch single current rope, which is swung thrice over a grooved sheave;
Generating machines and 20-horsepower steam engine;
Carriage, including the log support and the motor with sheave, which has a speed of six miles an hour.

I. Loading arrangements are required, wherever vehicles are used, except for bummers.

I. Loading on wagons.

(a) Sliding logs from a higher bank onto vehicles. Only one layer can thus be loaded conveniently.
(b) Rolling logs up an incline, either with peavies or rope, the top of the incline resting on the tops of the wheels.
(c) A (drum) winch in front of wagon, incline behind wagon, pulling logs up by rope.
(d) Tackle block attached to a tree, the wagon standing between the tree and log; the end of rope attached to outside wheel and the free end pulled by animals.
(e) The skidway scheme. Trained horses running on prepared track opposite the skidway. Two poles leading from skidway to wagon; rope running from outer wheel of wagon under and around the log and back over the wagon to the horses.
(f) A jack, consisting of a gear wheel and a toothed iron rod.
(g) German lever arrangement.

II. Loading on railroad cars.

Additional methods.

(a) A huge tripod and Weston's differential hoist.
(b) A drum and wire cable rig, the loading cable running over a tackle block suspended over track.
(c) Cranes or derricks as used on the harbor docks, a special make of which is known as the

"Decker log loader." There is some mechanical difficulty in constructing loaders of a sufficient angle of leverage.

§ XI. CHOICE BETWEEN THE VARIOUS SYSTEMS OF TRANSPORTATION.

Conditions governing the selection of means of transportation are:

A. Topography. Steep grades make it advisable to send products down by their own weight, so that animals and vehicles need not reascend the grade.

B. Periodicity of rain and snow fall (West Virginia for spring rains, Lake States for snow fall, California for spring drouth) invite the use of means relying on water supply, on layers of snow, on dry soil.

C. Rocky soil entails blasting expenses and thus bars railroading and road building. Wet or swampy soil requires an artificial surface on which means of transportation are placed.

D. Existence of drivable creeks and rivers, their grade, rockiness, curves, steadiness of flow, the spans and number of bridges crossing them, the danger or help expected from freshets are factors bearing on the advisability of water courses used as means of transportation. Electric power derivable from water falls might be used as motive power in days to come.

E. Availability of building material in the forest, especially the price of rails and ties and quality of stone etc.

F. Total amount of stumpage, and stumpage per acre to be carried away from a given locality annually, periodically or once only.

G. Maximum weight and size, also average weight and size of pieces to be handled.

H. Price and effect of day labor and prospects of changing prices under the influence of labor laws and socialistic legislation.

I. Relative price of team labor and of manual labor. The ratio between price of hand labor and team labor abroad is 1 to 8. In this country it is 1 to $2\frac{1}{2}$; in Lake States even less, viz., 1 to 2.

J. Condition of existing public means of transportation; roads, railroads and navigable rivers.

K. Laws relative to rights of way and relative to damage inflicted on outsiders in the course of transportation, i. e., by splashing logs; raising water level of lakes and thus destroying trees etc.

L. Mileage of the various links forming the chain of transportation and speculation as to the building of additional public links of transportation.

M. Silvicultural considerations, or choice between conservative and destructive lumbering.

Donkey engines are the destroyers of any second growth left on the ground and should be used only in clear cutting.

High two wheel logging carts are used abroad to save young growth.

N. Possibility and amount of damage to logs and loss of logs in course of transportation. Loss of bark. Loss of sap-wood. Deterioration by fungi and insects. Theft. Loss of interest on value of logs.
O. Regularity and reliability of means of transportation.
P. Possibility of using the means of transportation for purposes other than carrying forest products (access to mines and farms; passenger traffic; supplies for lumber camps; use of snaking roads as fire lanes, patrol trails, sport trails).
Q. The general political and economic condition of the country (settled or unsettled); the possibility of financial surprises.

Part III. Manufacture of Wood Products.

CHAPTER IV. FOUNDATIONS OF MANUFACTURE.

§ XII. THE AMERICAN FORESTER AS A LUMBERMAN.

In the old country, a large portion of the products grown in the forest go to the holders of prescriptive rights (easements). The balance is sold either under private contract or at public auction or under sealed bids.

In France, standing stumpage is sold, while in Germany the trees are dissected, at the owner's expense, into assortments required by the local manufacturing trades.

Usually, in the old country, the raw products of the forest are not refined by the forest owner. The forest industries are in the hands of parties who do not own or control an acre of woodland.

In Canada, timber leases or timber limits are sold at public auction. The purchaser pays, aside from the auction price, an annual rental (so called ground rent) and, further, for every 1,000 feet b. m. cut, a specified royalty. Neither ground rent nor royalty is object of the auction sale.

On the forest reserves of the United States auction sales are meant to form the main method of disposal of forest products, exceptions being made only in the interest of local residents.

The private owner of woodlands in the United States, and his forester, is and will be compelled to be a wood manufacturer for many a year to come.

The lumberman need not be a forester; but the forester must be a full fledged and experienced lumberman. Woe to conservative forestry in the United States if the forester, satisfied to give theoretical advice, fails to devote to lumbering and manufacture the larger part of his energy!

§ XIII. MOTIVE POWER.

Motive power is supplied by:

A. Actual animal power said to be used in Texas for running portable saw mills.

B. Wind-mills, which furnish an insufficient and unreliable power.

C. Water-mills. The horse power of falling water is:

$$\frac{v \cdot h \cdot 62.5}{33000},$$

wherein stands: v for volume of discharge in cubic feet per minute;
and h for height of fall in feet; and
wherein 62.5 represents the weight of a cubic foot of water and 33,000 equals one horsepower per minute.

For example, if cross section of a race is = 2 sq. ft., water velocity = 660 ft. per minute, height of water fall 30 ft., then the power is:

$$\frac{2 \cdot 30 \cdot 600 \cdot 62.5}{33000} = 75 \text{ H. P.}$$

Water wheels are either vertical, i. e., overshot, breast or undershot wheels, or horizontal wheels, i. e., turbines.

I. Overshot wheel. Effective power is 60% to 70% of possible power. The proper velocity at the circumference is 5 feet per second and at best if it is equal to 0.55 of velocity of water.

In falls of 20 feet to 40 feet and over, overshot wheels are more effective than turbines.

The buckets, framed by the shrouding, should be curved or elbowed and not radial. They should have a capacity three times as large as the volume of water actually carried, a depth of 10 inches to 12 inches and a distance apart, from center to center, of 12 inches.

Ventilated buckets, having holes in the bottom and allowing air to escape, are said to have a better effect.

It is difficult to transform the slow speed of an overshot into the rapid speed required for a circular saw. Transformation is either by countershaft or by cog wheel.

II. The breast wheel has an effective power of from 45% to 65%, is best applied to falls of from 5 feet to 15 feet and to a discharge of from 5 to 80 cubic feet per second. While in the overshot the water works by weight only, it works in the breast wheel largely by impact.

The velocity of wheel should be such as to fill the buckets to 0.5 or 0.6 of their volume. The buckets here are usually called blades and must be ventilated.

The wheel runs in a curb or mantle, formed by the inclined and cased end of the sluiceway.

The distance of the blades, from center to center, should equal the depth of the shrouding, both being from 10 inches to 15 inches. The clearance between the curb and the shrouding must be at least half an inch.

"High breast" wheels are semiovershot and "low breast" wheels are semiundershot wheels.

The "flutter" wheel is a low breast wheel of small diameter and high speed. It is largely used in western North Carolina for saw-mill purposes where water is plentiful and fall about 12 feet.

III. Undershot or current wheels have an efficiency of from 27% to 45% only and are usually kept anchored in rapid streams, so as to be independent of water gauge. No buckets, but long blades instead.

The diameter of the wheel is from 13 feet to 16½ feet; usually 12 blades, the depth of which is 3 feet to 4 feet. The blades should be completely submerged when passing underneath the axle.

IV. Turbines have an efficiency of 60% to 80%. The water does not work by weight, but by impact, pressure, reaction and suction.

The speed is much higher than in vertical wheels and hence is well adapted for circular saw mills.

A turbine, however, is badly affected by variations of water supply and suffers from debris and sand and ice. The effect of the water is greatest when the turbine is entirely under water, the flow of water filling the curved channel completely.

Turbines are:

(a) Outward flow turbines, water fed from near the center.

(b) Downward flow turbines, water fed and pressing from above.

(c) Inward flow turbines, water fed from the perimeter.

(d) Reaction turbines, working after the principle of a lawn sprinkler.

(e) Impulse turbines, principle of flutter wheels.

Modern turbines are worked both by impact and reaction and, if possible, by suction.

A 9-inch turbine, furnishing 14 horsepower, costs $250, plus $100 for setting it in masonry.

The advantages of water mills are: no fuel, no fireman, no engineer, no explosion, less insurance, possibility of using dust and slabs for stable bedding, laths etc.

Disadvantages are: usually small power, small speed and small capacity. Power less controllable, less reliable than steam power and not portable.

Small capacity does not justify a large outlay for good sawmill machinery.

D. Steam mills.

For circular saws, the number of horsepower required is about = 1/3 the diameter of the saw. For example, a 48-inch circular saw requires 16 horsepower. Ten horsepower are said to manufacture 5,000 b. feet daily in circular sawmills, and 30 horsepower will cut 30,000 b. feet daily. Every additional horsepower should increase the capacity by 1,000 b. feet.

In large mills each horsepower ought to manufacture 1,000 b. feet; in small mills only 500 b. feet.

Boilers in common use are designated as:

I. Internally fired boilers, when firebox and waterbox are comprised by one and the same steel shell; so all portable boilers and all locomotive boilers.

(a) Cornish boiler: large flues below and return flue above water through entire length of boiler.

(b) Lancashire boiler: divided flue below and divided flue above water through entire length of boiler, so as to even the draft when firing, and so as to strengthen the broad heating surface.

(c) Galloway boiler: like Cornish but V-shaped tubes beset the boiler proper, thus increasing the heating surface and strengthening the flue.

(d) Locomotive boiler: firebox surrounded by a waterleg on all sides, excepting at the grate below. A bank of small tubes carries gases to an "extension" or "smoke box" in front of smoke stack.

II. Externally fired boilers: masonry firebox underneath boiler which is traversed by a large number of tubes. Gases pass first to combustion chamber at rear end and then through tubes back to front.

To II belongs the water tube boiler, with inclined tubes, a horizontal top vessel and vertical tail tubes, creating a continuous circuit of water.

(a) Pointers about boilers.

1. Twelve square feet of heating surface of boiler furnish one horsepower.
2. Each nominal horsepower requires one cubic foot or 7½ gallons of water per hour.
3. Mud drum at base of boiler to receive impurities deposited by water. Where no mud drum exists, boiler should be blown off weekly through a bottom valve (mud cock).
4. Steam and water capacity must be sufficient to prevent any fluctuation in pressure or water level.
5. A large water surface (horizontal versus upright boilers) prevents steam from bearing water particles along. Usefulness of dome is doubtful as a means to secure the return of watery particles to the boiler.
6. Water should occupy three-quarters of boiler space.

Water space should be divided into sections, an arrangement improving the circulation of water and reducing the severity of any explosion.

7. Modern boilers are tubular boilers, which have the largest heating surface. Diameter of tubes is measured outside, including metal.

8. Combustion chamber should allow of full combustion of fuel and gases. Draft area should be one-eighth of grate area. Return flues pass the gases to the entrance of the combustion chamber.

   Heating surface should be as nearly as possible at right angles to the current of escaping gases.

9. Very best water gauges, safety valves, injectors and steam gauges are prerequisites. All boiler fixtures should be readily accessible.

10. Safety valves must be tried once daily. The water level should be controlled by gauge cocks, glass gauges alone being unreliable.

11. Cold water should not be fed directly into boiler and should never come in direct contact with the boiler metal. Steam injectors will not lift hot water as well as cold water.

12. Steam pressure gauge must stand at zero when pressure is off.

13. In case of low water and danger of explosion, cover fire with wet earth.

14. If fire is fed from mill refuse, steady heat can be retained only with boilers of large water capacity. The larger the boiler the greater the fuel economy.

(b) Pointers about engines.

1. Horsepower of engines is:

   Sectional area of piston in square inches times pressure times velocity in feet over 550.

   Deduct 10% to 20% for friction.

   Pressure on the piston is not much over one-half of pressure in the boiler (60%).

2. Interdependence between size of cylinder and horsepower actually developed is approximately:

Diameter, inches	8	9	10	12	12	12	14	16
Length, inches	15	15	15	15	20	24	24	30
Horsepower	12	15	20	25	30	35	50	85

These figures hold good for single cylinder engines and are much lower than the usual catalogue figures. A new engine develops more power than an old one.

3. The flywheel should weigh 600 pounds for every inch of cylinder diameter.
4. Double cylinders are more effective than single cylinders, especially if not hitched tandem fashion, which arrangement, however, allows of using one piston rod.
5. Center crank engines are preferable for small portable saw-mills, since they allow of exchange of flywheel and main driving pulley.
6. Machines cannot get along any better, without care, than horses. Repair and watch the smallest defects. Have the firmest possible foundations. Saw-mill engines are put to the severest possible tests owing to frequent and rapid change of strain.

§ XIV. TRANSMISSION OF POWER.

A. Belts.

Belts in woodworking establishments are always dry and dusty and are kept at a high and often irregular rate of speed. Dust materially decreases the transmitting power of belts.

The heavier the belt the more powerful; use light belt on small pulleys, however, for high speeds.

I. Pointers about belts.

(a) Belt tighteners are required where a belt itself is not heavy and not long enough to cause sufficient sag.

(b) The sag should always be on top and not on the bottom.

(c) The angle of belt against the horizon should not exceed 45°.

(d) Placing one pulley above another requires tight belt, which causes heating in the bearings and destruction to the belt.

(e) Belts should run off a shaft in opposite directions to relieve one sided friction of shaft in bearings.

(f) The pulley must be wider than the belt.

(g) The larger the pulley the greater the tractive power of the belt.

(h) Be sure that the belt does not rub against any beam or other solid object.

(i) Long belts have greater adhesion than short belts because they have more weight.

(j) Belt dressing, to prevent slipping off of belt, is objectionable, because it gathers dust and dirt, except perhaps linseed oil used on rubber belts.

(k) Belts will slip if:

1. The pulleys do not run in one and the same plane.
2. The shaftings are not parallel.
3. The pulley is not as wide as the belt.
4. The belt ends are improperly joined.
5. The speed is too high for the weight of the belt.

II. Kinds of belts:

(a) Leather belts.

Leather belts are either single or double. They come in rolls of from 200 feet to 300 feet, are run with the grain side in and are preferably joined with studs—not by leather laces requiring holes; belt cement is now largely used, laps being joined to a fine edge.

Leather belts must be very well protected from moisture, grease, lubricating oil etc.

Transmitting power of a single belt is only 70% of that of a double belt.

The price of a 7-inch single belt per running foot is $1. For double belt $2.

(b) Rubber belts.

Rubber belts withstand moisture better than leather belts. They are cut from ⅛ inch to ¼ inch shorter per foot than the circuit on which they run and are run with seam side out.

They are sold as 2, 4, 6 or 8 ply rubber belt, the 4 ply being equivalent to single leather belting and the 6-ply to double leather belting.

The price of 4-ply 7-inch rubber belting is 70c per running foot; of 6-ply, $1.

The ends are joined either by belt cement or by lace leather. The laps are strengthened by a strip of leather on the outside.

Never use metal studs in rubber belts.

B. Pulleys.

Pulleys are made either of iron or of wood.

The adhesion of leather to wood is much greater than to iron, hence greater transmitting power of wooden pulleys.

Split wood pulleys are preferable. The best make is the Dodge split wood pulley, costing for 24-inch diameter and 10-inch face $11.20.

The so called clutch pulleys consist of two wheels wedged one into the other, the inner one loose, the outer one fastened onto the shaft.

Iron pulleys must be absolutely symmetrical

Pulleys for stationary belts are slightly crowning, while those for shifting belts are straight faced.

Pulleys for heavy work should be placed close to bearings of shaft. The main driving pulley must stand between bearings not over four or five feet apart.

The ratio between the speed of driving and driven pulley is inverse to the ratio of the diameter.

Remarks relative to starting and stopping machinery:

I. Machinery is started by belt tighteners, the belt running over flanged pulleys, by clutch pulley, by tight and loose pulley with shifting belt, by eccentric boxes and by friction pulleys.

II. A rotation is reversed by crossed belts (belt turning 180°) or by paper friction pulleys or by forcing the belt against a driven pulley remaining outside the belt circuit.

III. A rotation is turned at right angles by giving the belt a quarter-twist (90°), or by gear and pinion or by beveled friction.

C. Shafting.

Cold rolled shafting is said to have a torsional strength 30% greater than that of hot rolled shafting.

The usual diameters of shafting in saw mills are from 1½ inch to 3½ inch. The proper speed for shafting is 300 to 400 revolutions and its transmitting power is given as $\frac{D^3 \times R}{80}$ = horsepower.

Herein stands: D for diameter of shafting;
R for revolutions of shafting per minute;
80 for a constant factor.

Couplings by which the sections of shafting are joined should be close to a hanger or a support. They should be easily detachable without driving keys.

Shafting comes in sections usually 12, 14, 16 or 18 feet long.

The section closest to the main driven pulley is often stronger than the other sections.

The bearings should be long, say four times as long as the shafting is thick, and should have self-lubricating devices.

Hangers for 3-inch shafting and of 3-ft. drop cost about $20.

Bearing-boxes are lined with an anti-friction alloy melting easily and offering little friction even under severe pressure. A space of $\frac{1}{8}$ inch to $\frac{1}{2}$ inch is left between the cast-iron box and the shafting (journal) to be supported. The box is held in a "babbitting jig" while the melted alloy is poured from a ladle. Babbitt metal (invented by Isaac Babbitt) consists of about 96 parts tin, 4 parts copper and 8 parts antimony.

Rules for shafting are:

I. Be sure that line of shafting is parallel to axis of driver.

II. Place all heavy work on the main shaft and close to the main driver.

III. Oil freely and watch bearings constantly. Oil after stopping work, while bearings are still warm.

IV. Drive only minor machinery from gear wheels.

Price of shafting is about 5c or 6c per lb.

§ XV. TECHNICAL USE MADE OF THE TREES, BY SPECIES.

A. Hardwoods.

Cucumber tree: Ox yokes; pump logs; water troughs; cabinet making; ceiling; flooring; invariably mixed with and substituted for yellow poplar.

Tulip tree or yellow poplar: Panels; flooring; molding; clapboarding; sheathing; shingles; siding on railroad cars; interior finish of Pullman cars; coffins; cheap furniture; bodies of carriages and sleighs; sides and bottoms of farm wagon beds; woodenware; bungs; slack barrels and tobacco hogsheads (staves and heading); backing for pianos and for veneers; boxes, especially biscuit boxes and cigar boxes; scroll saw work; wood carving; wood burning; matches; excelsior; paper pulp.

Linden or basswood: Mirror and picture backs; drawers and backs of furniture; molding; woodenware; panels and bodies of carriages; ceiling; wooden shoes abroad; inner soles of shoes; cooperage heading; slack barrel staves; butter churns; laths; boxes; grape baskets; excelsior; parts of pianos and organs; fine carving; papier mache; paper pulp. The flowers are used for tea; the inner bark for coarse cordage and matting.

Holly or ilex: Mallets; edging and engraving blocks; fine cabinet work; painting on wood; tool handles; mathematical instruments.

Buckeye: Artificial limbs; woodenware; paper pulp; wooden hats; fine wood carving.

Maple (western): Furniture; axe handles; frames of snowshoes.

Maple (eastern): Furniture (curly and birdseye); flooring; sugar barrels; mantels; runners of sleighs; peavy handles; ox yokes; axe handles; sides and bridges of violins; woodenware; wooden shovels; shoe pegs and lasts; gun stocks; saddle trees; teeth of wooden gear wheels; piano keys and hammers; wood split pulleys; framework of machinery; ship building; maple sugar; surveyor's implements; plane stocks; wooden types; faucets; clothespins; charcoal; acetate of lime; wood alcohol.

Sumach: Tanning; dyeing and dressing skins; Japanese lacquer work.

Black locust: Police clubs; fence posts; insulator pins; construction work (bridge); turnery; wheelwright work; tree nails (pins); ship building (ribs); hubs of wheels; house foundation.

Mesquit: Fence posts and rails; used extensively for fuel (destructive to boilers).

Black cherry: Fine furniture; cabinet work; interior finish; tool handles; surveyor's implements.

Crabapple: Pipes, mallets; wooden measure rules; tool handles.

Witch hazel: Pond's extract.

Dogwood: Tool handles; spools; bobbins; shuttles; mauls; wheel hubs; machinery bearings; engraving blocks.

Black gum: Heavy (wagon) hubs; rollers in glass factories; mangles; ox yokes; stock of sledge hammers in steam forges; veneers for berry baskets and butter dishes; slack barrels; in cheap furniture, for backing and drawers; barn flooring.

Tupelo gum: Chemical paper fibre; slack barrel staves (rotary veneer cut); wooden shoes and woodenware; the corky root is used under the name of corkwood for bicycle handles and floaters of fishing nets.

Sweet gum: Known in Europe as satin walnut and used for fine furniture and cabinet work, in America for cheap furniture; cheap building lumber; flooring; plug tobacco and cigar boxes; wagon beds; slack barrels; strawberry boxes; veneer cut dishes; coiled hoops; street paving.

Sourwood: Tool handles; machinery bearings; sled runners.

Rhododendron: Bruyere pipes; tool handles; turnery; toys; rustic furniture.

Persimmon: Bobbins; spools; shuttles; tools; golf club heads; plane stocks; shoe lasts; wood engraving. The black heart is cut into veneers and used for ebony.

White ash: Wagons and carriages (poles, shafts, frames); interior woodwork; inner parts of furniture; mantelpieces; sporting goods (bats etc.), oars and gymnastic bars; lances; agricultural implements; tennis racquets; snowshoes; skis; wooden pulleys; barrel hoops; pork barrel staves; baskets; dairy packings (firkins tubs etc.); tool handles.

Catalpa: Fence posts; railroad ties; telegraph poles.

Sassafras: Light skiffs; fence posts; rails; cooperage; insect-proof boxes; ox yokes. Roots used to make sarsaparilla.

California laurel: Ship building; cabinet work and interior finish.

Elms: Wheel stock, especially hubs; fence posts; ribs of small boats; top spans in covered railroad cars; railroad ties; tongues for sleighs and sleigh runners; saddle trees; flooring; exported for inner lining of boats; butcher blocks and churns (butter); cheese boxes; imitation oak furniture; sugar and flour barrel staves; patent coiled hoops for slack cooperage; agricultural implements; bicycle rims; basket making; gun stocks; frame timber of piano cases; wheelbarrows; hockey sticks.

Hackberry: Fencing; occasionally for cheap furniture; hames.

Mulberry: Fencing; cooperage; in the South for boat building; axe handles.

Osage orange: Fencing; paving blocks; railroad ties; wheel stock; toothpicks; fine mallets.

Sycamore: Furniture; plug tobacco boxes; butchers' blocks; interior finish; beehives (hollow log sections); butter and lard trays; wooden bowls.

Walnuts: Interior finish; furniture; gun stocks; tool handles; cabinet work; boat building.

Hickories: Axe handles; wagon stock, especially whiffletrees; neck yokes; spokes; tongues; felloes; skeins; buckboards; rustic furniture; barrel hoops; screws; mallets; parts of textile machinery; farm implements; wooden rails (top); baskets; bows of ox yokes; boat building; hickory bark for flavoring sugar (to imitate maple syrup).

Oaks (white and burr): Furniture; wagon and carriage stock, especially spokes, felloes, hubs, tongues, hounds, bolsters, sandboards, reaches, brake bars, axletrees, whiffletrees; railroad ties; freight car building (framework); ship building; house building and interior finish; shingles; agricultural implements; bridge building; mining timber; wine, beer and whisky barrels; parquet flooring; staircases; split wood baskets; hogshead and barrel hoops.

Post oak: Fencing; railroad ties; construction; staves; carriage and wagon work; farm implements.

Basket oak: Baskets; cooperage; wheel stock; fencing; agricultural implements; construction.

Chestnut oak: Bark used for tanning; fencing; bridges; railroad ties; substitute for white oak, but objectionable in tight cooperage.

Live oak: Ship building; furniture.

Red oak: Shingles; furniture; interior finish; tight and slack cooperage.

Texas oak: Same as red oak. Said to check less than red oak.

Black oak: Plow beams; furniture; lumber; bark for tanning and quercitrin.

Tanbark oak: In California bark used for tanning.

Chestnut: Tannin extract; coffins; furniture; interior finish; shingles; fencing; railroad ties; sheathing; jacob staff for compasses; bridge building (trestles); telephone poles; backing of piano veneers; slack barrel hoops and sawn staves.

Beech: Wood alcohol; wood ashes; charcoal; shoe lasts; plane stocks; clothespins; handles; wooden bowls; horse collars (hames); parquet strips; flooring; street paving; railroad ties; sugar barrels. Beech furniture made out of veneers of three or four thicknesses, or bent after steaming.

Hop hornbeam: Posts; levers; tool handles; wagon brake; shoes; wedges.

Hornbeam: Used for same purposes as above, and teeth of gear wheels.

White birch: Toothpicks; shoe pegs and lasts; wood pulp; spools; clothespins; screws; flooring; veneers; furniture; bobbins and spindles; wooden skewers; hand-made barrel hoops.

Gray birch (yellow): Furniture (usually mahogany finish); match boxes; wheel hubs; tool handles; buttons; brush backs; shoe pegs; clothespins; sugar barrels; dry distillation for wood vinegar; wood alcohol; charcoal etc.

River birch: Furniture; woodenware; wooden shoes; ox yokes.

Cherry birch (sweet birch): Imitation cherry furniture; ship building; bark distilled for oil of wintergreen.

Oregon alder: Furniture; cigar boxes; mining props and water conduits; charcoal in gunpowder.

Black willows: Osier culture (imported species); pollarded for fascines; the Missouri species for fence posts after thorough seasoning; bats for baseball; a drug, salicylic acid, made from the bark; charcoal for smokeless powder.

Cottonwoods: Boxes; wood pulp and fibre; slack barrels; woodenware; flooring; excelsior; backing for veneers in organs and pianos; matches; cheap building lumber; cheap furniture; wagon beds; turnery; woodenware; fence boards.

B. Conifers.

Incense cedar: Water flumes; fencing; furniture; interior finish; laths and shingles.

White cedar (northern): Posts; fencing; telegraph poles; railroad ties; tanks and buckets; shingles; street paving; boat lining.

White cedar (Southern): Woodenware; tanks; buckets; barrels; telegraph poles and fence posts; shingles; railroad ties; boats; lampblack.

Red cedar (Pacific): Canoes of Indians; interior finish; fencing; shingles; cooperage; tanks; buckets.

Port Orford cedar (Lawson's cypress): Lumber; inside finishing; flooring; railroad ties; fence posts; matches; ship building. The rosin is a powerful insecticide.

Western juniper: Fences.

Red cedar (of the East): Tanks, posts, buckets; telephone poles; cigar boxes; chests; pencils; interior finish.

Bald cypress: Tanks; shingles; doors; house building; interior finish; sashes; blinds; molasses barrels; railroad ties; posts; car siding; flooring and covering; wharf piles.

Big tree: Lumber; fencing; shingles; construction; water conduits.

Redwood: House building and finishing; shingles; fencing; telegraph poles; vineyard stakes; railroad ties; car lining; tanks; coffins.

Yew. In Oregon for bows and fishing rods.

White pine: House building and finishing; boxes and crates; sash, doors and blinds; shingles; backing of fine veneers; excelsior; matches; laths; woodenware; slack barrels; framing of machinery; furniture; patterns for casting metals; ship masts; baled shavings for filtering gas, bedding for horses, packing for crockery.

Sugar pine: Same uses as white pine; cooperage; shakes (large board shingles).

Lodge-pole pine: Cheap lumber; mining timbers; railroad ties; used where other timber is not available.

Loblolly pine: Common lumber and cheap veneers, usually mixed with "echinata"; shingles; house building purposes altogether; mining timber; boxes; rice and potato barrels; laths.

Shortleaf pine (echinata): Same use as above; boxes for naval stores.

Table mountain pine: In Pennsylvania used for charcoal.

Longleaf and Cuban pine: House building; dimension stuff; shingles; tanks; flooring; interior finish; railroad ties; railroad bridges; car sills and framework of cars; furniture; sash, doors and blinds; framework of machinery; mining timber; ship building; masts; wagon tongues and beds; naval stores.

Scrub pine (Virginiana): In Kentucky, for lumber.

Jeffrey's pine: Coarse lumber; mining timber.

Bull pine (ponderosa): Lumber; railroad ties; mine props; shingles; boxes; slack barrels.

Jack pine (divaricata): Ties and piling; cheap lumber; boxes; laths.

Norway pine: Lumber generally; ship building; construction; flooring; masts; piles of wharves; covering; lining; siding; flooring and sills of railroad cars; railroad ties.

Eastern spruce: Chemical fibre and paper pulp (down to 5"-diameter); matches; excelsior; construction; posts; railroad ties; fresh-water ship building; clapboards; flooring; ceiling; stepladders; sounding boards (from butt logs); oars; spars; wharf piles; telegraph poles; toys; wood type; butter buckets; slack cooperage; wooden thread (for mattings); chewing gum; vanillin. In Europe spruce bark is used for tanning.

Engelmann's spruce: Used in Colorado for common lumber.

Tideland spruce: Lumber; construction; outer finish; woodenware; paper pulp.

Hemlock: Coarse rat-proof lumber; dimension stuff and construction; shingles; railroad ties; fencing; paper pulp; bark for tanning.

Douglas fir: All building lumber; construction; railroad ties; trestle bridges; piles; car sills; ship building; masts; mining timber; bark sometimes used for tanning.

Firs: Paper pulp. In the East for corduroying. In the West for local lumber; packing cases; cooperage; interior finish; mine props.

Tamarack (Eastern): Fence posts; telegraph poles; ship's knees; railroad ties.

Tamarack (Western): Posts; railroad ties; car construction; dimension stuff.

C. Tropical and subtropical timber.

Yucca: Paper pulp and fibre for ropes; pincushions.

Eucalyptus: Street paving; railroad ties; mine props; piles; ship building; wagon making; orchard paling.

Mangrove: Bark very rich in tannin.

Palmetto: Wharf piles; pincushions; brushes.

Lignumvitae: Bowling balls; blocks for pulleys; fine interior finish and furniture; railroad ties in Panama.

Teak: Ship building and flooring; railroad cars; street paving.

West India cedar: Racing boats; cigar boxes.

Olivewood: Turnery; inlaying; furniture; backs of hair brushes; wood carving. The fruit yields the best oil for table use.

Quebracho: Tanning; paving; railroad ties.

Lancewood: Fishing rods.

Mahogany: Furniture; ship building; pianos; fine interior finish.

§ XIV. TECHNICAL QUALITIES OF THE TREES.

A. Botanical structure of the trees.

I. Botanical structure of hardwoods.

The cells forming the woody tissue are:

(a) Ducts (pores, vessels) formed by the resorption of the partition walls in a vertically running string of cells. Such ducts are characteristic of hardwoods.

(b) Sclerenchyma, cells of heavy walls and small lumina, usually forming long fibres.

(c) Parenchyma, cells of thin walls and large lumina, frequently containing grains of starch.

Medulla or pith is found in the central column, in the primary, secondary, tertiary rays and (rarely) in medullary spots (birch). The central pith is:
Heavy in ash, maple, elder, catalpa;
Triangular in birch, alder;
Quinquangular in hornbeam.

Broad leaved species are called "ring porous," if the spring wood of the annual ring contains strikingly large pores, or else "diffuse porous," if the ducts are evenly distributed over the entire ring. Sapwood and heartwood are merely distinguished by a difference of color, caused by incrustations of pigments, lignin, tannin etc., in the walls of rings formed a number of years before. The number of years elapsing before incrustation takes place is small in catalpa, chestnut, locust; and larger in yellow poplar, white oak, walnut where it is about thirty or forty years old. Beech, maple, basswood etc. do not form any heartwood.

GENERIC STRUCTURE OF HARDWOODS.

Medullary Rays.	Ringporous always with heart.	Diffuse porous. Inner pores more numerous, always with heart.	Pores absolutely even With heart.	Pores absolutely even Without heart.
Scarcely visible.	Castanea Robinia Fraxinus Hicoria	Rhamnus Rhus Syriuga	Juglans Pyrus malus Sorbus Salix Liriodendron Populus	Alnus Pyrus communis Crataegus Betula Aesculus Populus
Visible.	Ulmus Morus Ailanthus	Prunus		Tilia Acer Corylus Carpinus Ilex
Broad.	Quercus Vitis Rosa	Sambucus		Platanus Fagus

II. Botanical structure of softwoods.

(a) The tissue of softwoods is more homogeneous than that of hardwoods. It is mainly formed by tracheae.

The cell walls formed in early spring are thinner and the lumina formed in early spring are larger than those formed in summer.

(b) Parenchyma is found in the medullary rays and around the rosin ducts.

(c) Ducts of the form found in hardwoods exist only close to the central pith column.

(d) The medullary rays are very fine (microscopic), usually only one cell wide and about a dozen cells high. The lowest string of cells in the ray is usually formed by tracheae (exception—red cedar).

(e) Rosin ducts are not cells merely, but, unlike the ducts of hardwoods, hollow tubes, the walls of which are formed by parenchymatic cells. These ducts are running horizontally as well as vertically in picea, pinus, larix, pseudotsuga.

The tissue of the genera abies, taxus, juniperus, thuja, tsuga, chamaecyparis etc. lacks the ducts.

(f) Heartwood and sapwood of conifers are distinguished merely by a difference in color, due to incrustations of rosin in the inner heartwood rings. Pinus echinata has, usually, about thirty sapwood rings. Spruces, firs and hemlocks have no heartwood. Heartwood is conspicuous in the pines, red and white cedars, lawson cypress, yew, larches and douglas fir.

B. Chemical qualities of wood.

I. The walls of the tissue are formed by cellulose ($C_{12}H_{20}O_{10}$) and by lignin ($C_5H_{12}O_5$).

Cellulose transforms, entirely or partially, in the very year in which the cell is built, by incrustation and reduction into lignin. If a branch or a seedling does not enjoy enough light during summer to allow of thorough lignification, then that branch or seedling is necessarily killed by the winter frost.

II. Wood and bark contain on an average 45% (weight) of water. Conifers contain less water than broad-leafed species. The percentage varies irregularly with the seasons and with the precipitations.

III. Other substances found in the woody tissue are:

(a) In the sap and medulla—albumen, starch, sugar, oils.

(b) In the cell walls—tannin, rosin and pigments.

IV. The specific gravity of pure wood fibre is 1.56.

C. Outer qualities, or qualities discernible by eye, touch or scent.

I. Texture. The texture is fine or rough according to the ease with which parts composing the tissue can be distinguished.

The texture is:

(a) Very fine—yew, box, holly, persimmon.

(b) Fine—pear tree, hornbeam, black gum.

(c) Pretty rough—spruce, fir, magnolia, cottonwoods.

(d) Rough—cherry, sycamore, maple.

(e) Very rough—oak, elm, locust, beech.

II Color. Color is an advantage in the furniture trade and a disadvantage in the manufacture of paper. The heart of seasoned wood is always darker than the sapwood.

Tropical species are particularly rich in color.

Wood exposed to air changes its color more or less visibly. The heart of yellow poplar changes to a dark brown. Alder changes from white to red. Ash from white to light violet. Mahogany from brown to black. Walnut similarly.

III. Gloss. Gloss is due to evenness, number and size of medullary rays.

Shining species are maple, ash, elm, beech.

Medium shining are oak, alder, hornbeam.

Dull are peach, pear, conifers.

Quarter sawing increases the gloss.

IV. Odor. Odor is important for the use of wood in the package industry. The strong odor of wood is usually lost in the course of seasoning. The following species retain, however, a characteristic odor: Cherry, birch, sassafras, red cedar.

D. Inner qualities, or qualities discernible by mechanical tests.

I. Specific gravity.

(a) Pure wood fibre forms in fresh wood, with broad leafed species of temperate climates, about 35 % of the entire weight, while conifers show an average of about 25 %.

(b) Air dried wood still retains from 10 % to 15 % of water. If the dry kiln reduces the percentage of water below that figure, the hygroscopicity of the wood will speedily cause it to return.

(c) Factors influencing specific gravity of air-dried wood within the same species are:

1. The width of the rings, in ring porous hardwoods and in conifers forming heartwood.
2. The incrustations of rosin, tannin and pigments in the heart.
3. The age of the tree.
4. The decay of the fibre.
5. The section of the tree, since roots are very light, butt logs heavy, bole fairly light and branches fairly heavy.

In the case of the diffuse porous hardwoods and of conifers destitute of heart, no rule can be given relative to specific gravity of inner and outer layers, of wide and narrow rings.

(d) Air dried lumber has, on an average, the following weights:

Species—	Specific gravity.	Weight of 1,000 ft. b.m.
Turkey oak, hickory, service-bush.	over 0.75	over 4,000 lbs.
Ash, white and red oak, locust, beech, hornbeam, hard maple, pear tree	0.70-0.75	about 3,750 lbs.
Elm, soft maple, apple tree, sycamore, birch	0.60-0.70	about 3,400 lbs.
Horse chestnut, chestnut, tulip tree, alder, larch, longleaf pine	0.55-0.60	about 3,000 lbs.
Yellow pine, douglas fir, spruce, fir, willow, cottonwood	0.45-0.55	about 2,600 lbs.
White and sugar pine	under 0.45	about 2,200 lbs.

(e) Rules.

1. Specific gravity times 5,200 equals the weight of 1,000 feet b. m. of sawn lumber. Reason—1,000 superficial feet of water one inch deep weigh 5,200 lbs.

2. Specific gravity times 8,000 times cordwood reducing factor equals the weight of a cord of wood. Reason—128 cubic feet of water weigh 8,000 lbs.; a cord of wood contains from 20 % to 85 % of wood, the balance being air.
3. Specific gravity air dry times 5.200 times 23 equals the weight of 1.000 feet b. m. in the log. Reason—a green log has about 10 % bark, about 27 % of water, to be removed by drying, and loses 33 % for slabs and kerf in band sawing. Hence the weight in 1.000 feet b. m. air dried and band sawed lumber is only 0.9 times 0.73 times 0.67 of the weight of a log scaling 1,000 feet b. m. Doyle. The weight of a green log is 2.3 times the weight of air dried lumber obtainable from it by the band saw. For broad-leafed species and for circular saws the figure is higher than for conifers and band saws.

(f) Heavy planks do not dry as thoroughly as thin boards.

(g) Weight determines freight and customs charges. Also adaptability to packages, floatability in flumes and rafts and possibility of loose driving.

Lumber freight rates from Asheville, N. C., are:

29c per 100 lbs. to New York.
23½c per 100 lbs. to Philadelphia.
12½c per 100 lbs. to Atlanta.
18c per 100 lbs. to Washington.
14c per 100 lbs. to Norfolk.

Lumber freight rate from Portland, Ore., to Chicago is about 50c per 100 lbs.

Steamer rate to Europe from Norfolk is 14c per 100 lbs. of lumber.

The freight rate on logs for 50 miles is at least $5 per carload; for 100 miles at least $6.

II. Hardness.

By hardness is understood the resistance of the fibre to axe and saw worked vertically to the fibre.

Factors of hardness are:

(a) Density; wide rings in oak and narrow rings in pine increase the hardness.

(b) Incrustation; heartwood is harder than sapwood.

(c) Moisture contents; dry wood is, on the whole, harder than green wood. With some broad-leafed species of loose tissue (willows and cottonwoods), however, moist wood is tougher and therefore harder as well.

(d) Frost increases the hardness.

SCHEDULE OF HARDNESS.

Hard.	Medium.	Soft.	Very soft.
Hickory	Ash	Chestnut	White pine
Dogwood	Oak	Tulip tree	Sugar pine
Sugar maple	Elm	Sweet gum	Sequoia
Sycamore	Beech	Douglas fir	Paulownia
Locust	Cherry	Fir	Willow
Hornbeam	Mulberry	Yellow pine	
Persimmon	Birch	Larch	
	Sour gum	Linden	
	Longleaf pine	Horse chestnut	
		Hemlock	
		Cottonwoods	
		Spruce	

III. Cleavability or fissibility.

Cleavability is the resistance of fibre to axe, saw and wedge, worked lengthwise in the direction of the fibre. Radial cleavage is usually by 50 % to 100 % easier than tangential cleavage (except in black gum).

Factors of cleavability are:

(a) A straight, long, elastic fibre.

(b) Heavy and high medullary rays.

(c) Straightness of growth.

(d) Branchiness.

(e) Moisture (very green and very dry wood splits best).

(f) Frost (reduces the cleavability).

(g) Hardness and softness (extremely hard and extremely soft wood splits badly. This rule holds good only in hardwoods).

SCHEDULE OF CLEAVABILITY.

Hard to split.	Medium to split.	Easy to split.
Black gum	Oak	Chestnut
Elm	Ash	Pines
Sycamore	Larch	Spruce
Dogwood	Cottonwood	Fir
Beech	Linden	Cedar
Holly	Yellow poplar	
Maple	Hickory	
Birch		
Hornbeam		

IV. Pliability.

Under pliability we combine flexibility and elasticity.

(a) Flexibility: wood which is easily bent without breaking is flexile (flexible). Softwoods are naturally less flexile than hardwoods.

Flexibility depends on:

1. Toughness and cohesive force of fibre.
2. Moisture, which increases it very much.
3. Heat, which increases it.
4. Age of tree, inasmuch as young shoots are tougher than old wood.
5. Impregnation, natural as well as artificial,

checks flexibility. (Heartwood less flexible than sapwood.)

6. Root wood more flexible than stem wood.

Remarks: Heat and moisture as a means to increase flexibility are applied in these industries:

Cooperage; for bending staves and hoop poles.

Carriage works; for bending poles, shafts, felloes, top frames, seats etc.

Furniture; bent wood furniture.

Ship building.

Veneer peeling.

Basket work.

Manufacture of musical instruments.

(b) Elasticity and flexibility are not always found in the same piece of wood. On the contrary, qualities which increase flexibility frequently reduce elasticity, and vice versa. Elasticity is the force with which an object resumes its old shape when pressed out of shape and released.

The factors of elasticity are:

1. Long and straight fibre.
2. Narrow rings in conifers.
3. Dryness (moisture reduces elasticity).
4. Frost (which destroys elasticity).
5. Excessive contents of rosin (which increases the elasticity).

SCHEDULE OF ELASTICITY.

Very elastic are:	Less elastic are:
Yew	Cottonwood
Larch	Birch
Fir	Maple
Locust	Elm
Chestnut	Alder
Hickory	Walnut
Osage orange	Yellow pine
Red cedar	Yellow poplar
Lancewood	Beech
Spruce	
White pine	
Ash	
Oak	

V. Strength.

Strength is resistance to:

(a) Tension; to which timber is usually not exposed. (Yoke of oxen pulling the cart by the pole.)

(b) Compression (arches, pillars, scantling).

(c) Torsion (shafts, screws, axles).

(d) Shearing.

(e) Transverse straining (beams, girders, joists).

Factors of strength are:

1. Specific gravity.
2. Soundness of tissue.
3. Freedom from branches.

Timber, like any other material, should never be loaded to over one-fourth of its indicated strength.

Transverse strength is always proportioned to length of girder; to width of girder; and to the square of the depth of girder. It is *the* quality of timber which is most required in timber used for building purposes.

VI. Hygroscopical qualities.

(a) Timber changes form, coherence and volume with greater or lesser ease under the influence of moisture, applied in gaseous or liquid form. Hence shrinking, swelling, warping, checking, cracking, casehardening and working.

(b) Water invariably saturates the cell walls; in addition, it may or may only partially fill the lumina.

(c) Sapwood invariably contains more water than heartwood.

(d) Rate of dryness depends on the species, looseness of tissue, dimensions of object to be dried, presence or absence of bark cover in logs, preceding treatment by floating, deadening, steaming, prevalence of sapwood or heartwood, season of year, exposure to wind, climate etc.

(e) Boiling and steaming reduce the hygroscopicity and produce, consequently, a more even shrinkage.

(f) The evaporation from the cross section bears to that of the tangential and to that of the radial section the ratio of 8 to 1 to 2.

(g) In the dry kiln, temperatures of 160 degrees to 180 degrees Fahrenheit are gradually produced. Drying is accomplished by hot air, steam and moving air.

Conifers stand the dry kiln process much better than hardwoods. The better qualities of hardwoods undergo air drying before being kiln dried, especially so in wagon, furniture and barrel factories.

The dry kiln saves insurance and interest on large stocks of lumber and allows the lumberman to rapidly fill pressing orders for lumber.

(h) Wood is least permeable for water in the direction of the tangent or vertically to the medullary rays —a fact important for tight cooperage.

1. Shrinkage.

It is least along the fibre; it is up to 5 % along the radius and is up to 10 % along the tangent.

Shrinkage of over 5 % of green volume

occurs in walnut, linden, beech, elm, chestnut, birch.

Shrinkage of 3 % to 5 % occurs in oak, maple, sycamore, ash, cottonwood, yellow pine.

Shrinkage of 2 % to 3 % occurs in spruce, larch, fir and white pine.

A large percentage of rosin, narrow annual rings and light specific gravity reduce shrinkage within the same species.

2. Checking.

It depends on the rapidity of the drying process; on size and dimension of object; on peeling of logs; on homogeneity of tissue.

Checks are often of a temporary nature, disappearing when the inner layers are as dry as the outer layers.

Hardwoods check much worse than softwoods; and rift sawed or quarter sawed lumber checks less than bastard sawed lumber.

Remedies against checking of logs are: Winter cutting; strips of bark left near the end of peeled logs; felling with the roots and leaving the crown on the undissected bole; deadening; "S" shaped iron clamps driven into logs; boards nailed onto the ends of the logs; earth cover at the ends of the logs; red lead painting for export logs.

Remedies against checking of lumber are: Quarter sawing; slow air drying under sheds; veneer sawing; steaming or boiling; sticks placed close to the ends of tiers in lumber piles.

Checks are radial since the tangential shrinkage is greatest. The so-called wind (or ring) shakes are not caused by the hygroscopicity of the timber; they are merely a form of disease of timber, due to frost, heat, fire or insect plagues interfering with the radial cohesion of adjoining rings.

3. Swelling, warping and working.

These phenomena are due to reabsorption of water after drying. The swelling is greatest tangentially. Heartwood warps

less than sapwood, and conifers warp less than hardwoods. Boards obtained from close to the slab warp worst of all.
Remedies against working are steaming; varnishing; forming boards by gluing fine veneers one upon another; allowing framework of doors to be sufficiently grooved for receiving the panels.

VII. Duration of wood.

(a) Duration of wood depends on:

1. The surrounding conditions; i. e., tropics or arid deserts; presence of insects (ants and fungi); contact with clay, limestone or sandy soil; immersion in water (toredo); exposure to atmosphere; moisture conditions; presence of preserving matter (salt water, copper mine water).

2. The natural qualities of wood, especially the presence or absence of rosin, tannin and other preservatives; the specific gravity; the percentage of sapwood; the susceptibility to fungus and insect diseases. Locust, red cedar, sequoia, bald cypress, are less subject to such diseases when dead than when alive.

(b) Remedies against destruction are: Impregnation or painting; charring the part imbedded in the soil; winter cutting; change of species when replacing ties; kiln drying and steaming and smoking; raising buildings high above ground.

(c) Bulletin No. 10 gives the following data for the average "life" of ties:

White and chestnut oak,	8	years
Chestnut,	8	"
Tamarack,	7—8	"
Cherry and walnut,	7	"
Elm,	6—7	"
Longleaf pine,	6	"
Hemlock,	4—6	"
Spruce,	5	"
Red and black oaks,	4—5	"
Ash, beech, maple,	4	"
Locust, cypress,	10	"
Red cedar,	10	"
Redwood,	12	"

(d) Schedule for lumber:

Very durable.	*Durable.*	*Short lived.*
Walnut	Ash	Beech
Locust	Larch	Sycamore
Sequoia	Yellow pine	Birch
Cedar	Spruce	Linden
White oak	Fir	Cottonwood
Catalpa	Yellow poplar	White pine
Sassafras	Douglas fir	
Chestnut		
Longleaf pine		

VII. Heating power.

Heating power or fuel value bears a direct ratio to specific gravity air dry. All wood fibre having the specific gravity 1.56, equal air dry weights of our common species furnish equal heat. On the other hand, light weight means greater inflammability and a quicker heat, which naturally lasts for a short time only. The heating power of hard coal is to that of lignite and to that of wood as 5.2 : 4.3 : 1. In other words, 5.2 lbs. of dry wood yield as much heat as 4.3 lbs. of lignite or as 1 lb. of coal.

Influencing factors are found in the following moments:

(a) Presence of rosin increases the heating power by about 12%.

(b) A cord of wood containing 45% moisture has, after German experiments, the heating power of half a cord of air dried wood. After Sargent, the discrepancy is not as great. One cord of green wood contains 250 gallons of water, and the calories of heat required to convert this large amount of water into steam are lost for heating purposes.

(c) Unsound wood has a reduced heating power, the cell walls being decayed.

(d) Chestnut, and to a certain extent larch and spruce, are despised in open fires owing to crackling and emission of sparks. Black gum is despised because it is difficult to split and therefore difficult to season. Hornbeam, birch and alder are said to furnish a particularly quiet flame.

(e) Schedule of the heating power of wood per cord:

Best.	*Good.*	*Moderate.*	*Bad.*
Hickory	Oak	Spruce	White pine
Beech	Ash	Fir	Alder
Hornbeam	Birch	Chestnut	Linden
Locust	Maple	Hemlock	Cottonwood
Heart pine		Sap pine	

IX. Miscellaneous technical qualities of wood.

(a) Adaptability to planing and molding; varnishing and polishing; painting and gluing.

(b) Nail holding power, which is said to be excellent in chestnut, white pine and hemlock.

(c) Twisted growth, which is frequent in chestnut, Italian poplar and horse chestnut. Certain twists are due to a hypertrophical growth of the tissue and are highly prized by the trade under the names of birdseye maple, curly poplar, curly walnut, curly cherry and curly ash etc. It is impossible to say whether a standing tree is "curly" or not. Sap-sucking woodpeckers may start the "freak."

(d) Knots check the value of lumber. A standard knot is a sound knot, the diameter of which varies according to local inspection from 1¼" to 1¾". Dry, dead and unsound knots throw a board into the mill cull pile. Usually, the knotty part of a log is sawn into dimension stuff. The core of a log, even in yellow poplar, necessarily shows knots, since there is no height growth without simultaneous formation of side branches.

(e) The discoloration of the inner layers of certain species which are not classed as heartwoods (beech and maple) is a disease often found in old trees and causes rejection for certain applications in the trades (impregnation).

CHAPTER V. MANUFACTURING INDUSTRIES.

§ XVII. THE SAW MILL.

A. The saw.

Three kinds of log saws are used:

I. Straight saws, viz:
- Vertical straight saw;
- Gang saws;
- Horizontal frame saw.

II. Circular saws, viz.:
- Solid tooth single saw;
- Solid tooth double saw;
- Inserted tooth saw.

III. Band saws, viz.:
- Single cutting band saw;
- Double cutting band saw.

I. Straight saws.

(a) Single vertical straight saw. At the toothed edge this saw has a thickness of from 5 to 10 gauges. Its blade is 8 inches wide and at least twice as long as the log diameter.

A short blade yields the finest work, since it can be spanned more tightly.

The gauge along the back should be finer than the gauge along the cutting line.

The saw can cut any thickness of trees.

The saw cuts only by the down stroke while the log is moved against the saw during the up stroke.

The saw is spanned in a guide frame and is given as many inches inclination toward the log as the feed of the carriage per stroke amounts to. If the saw were not inclined all the work would be done by the lowest teeth.

The usual set is still the spring set and not the swage set, although the latter is sure to be superior.

Usually the ends of the boards are not sawn through but are held together by the "comb," which is finally split with the axe.

In filing mill saws, obtain sufficient pitch of teeth to prevent saw from kicking out of the cut. Too much pitch, however, causes chattering.

Gullets must be kept carefully rounded.

(b) Gang saws. They are used in large mills for inferior logs.

The best make is Wickes Bros.,' Saginaw, Mich. Enormous stone foundations are required.

The saw frame has an oscillating motion which presents the saw to the cut in an easy raking sweep, forcing each tooth to do its full share of the work.

Gang saws are not fed from a carriage. The logs are run through feed rolls, feeding the logs into the saws.

Blades are 6 to 10 inches wide and of 8 to 16 gauge.

Horsepower required is said to be for friction, 3 horsepower; for first blade 4 horsepower, and for every additional blade ½ horsepower more.

Where log heaps (up to 12 logs) are run through the gang saw, the logs are slabbed by a "rosser" or "log siding machine," so that the logs can be placed one upon another.

(c) Horizontal frame saw. It is used to cut fine veneers and valuable timber. Its advantage lies in the fact that very little weight rests on the saw, that the saw can cut on both trips (to and fro), that high speed may be applied and that a thin gauge can be used.

The best make is Kirschner's, Leipzig, Germany.

II. Circular saws.

(a) Power.

Ten horsepower should manufacture 5,000 b. feet per day; 20 horsepower should manufacture 10,000 b. feet per day; 30 horsepower should manufacture 30,000 b. feet per day, and each additional horsepower should add 1,000 b. feet to amount cut. This amount depends on size of logs.

Five horsepower is required for a 20-inch to 30-inch saw; 12 horsepower for a 30-inch to 40-inch saw; 15 horsepower for a 48-inch to 50-inch saw; 25 horsepower for a 50-inch to 62-inch saw.

(b) Right hand and left hand mills.

If the carriage is to the left of the observer while the saw runs towards him, the mill is a left hand mill, and vice versa. A right hand saw is screwed to the arbor by a left hand nut and is usually driven by a left hand steam engine.

Center crank engines can be used for either right or left hand mills.

(c) Speed.

The proper speed at the rim of any circular saw is 9,000 feet per minute.

There should be a speed indicator to control the saw's speed. It costs 75c.

If the power is too light to run the mill at standard speed, portable mill men usually increase the speed of the engine, putting a larger receiving pulley on the saw mandrel.

(d) Proper qualities of a saw.

1. The usual thickness is 7, 8 or 9 gauge. Frequently the center is one gauge heavier than the rim.

2. There should be a sufficient number of teeth for the amount of feed.

   Each tooth should cut as much as is offered to it at a revolution.

   To cut one inch of lumber one may use either:

   Eight teeth, cutting 1/8 inch each at a revolution, or

   Sixteen teeth, cutting 1-16 inch each at a revolution, or

Thirty-two teeth, cutting 1-32 inch each at a revolution.

The number of teeth for one inch of feed should be, in hard timber, 16 teeth; in medium timber, 12 teeth, and in soft timber, 8 teeth.

The usual feed is from 1 to 6 inches per revolution. The quicker the feed the more teeth are required to do the work.

3. The saw must be perpendicularly hung; must slip on the mandrel against the fast collar easily, so as not to twist the saw out of true, thus causing it to buckle when the loose collar is tightened up.

The loose collar is hollow at the center (small saws excepted) and has about 6 inches diameter and ¾ inch rim.

By pressing a layer of writing paper between the collar and the saw the saw may be slightly bent toward or away from the carriage.

4. The saw must be evenly set (either spring or swage set). The teeth, filed square (not to a point but to a cutting edge), must form an exact circle and must retain that form in the course of operation.

5. The teeth must have the proper pitch. A shallow tooth cuts the smoothest lumber, but forbids of rapid feeding.

The modern shape of teeth is such as will facilitate filing and as will preserve the original pitch.

A tooth gets dull over as much of an inch as it cuts.

The gullet of the tooth must be larger for soft wood than for hard wood. Large gullets weaken the saw, small ones increase the friction very badly.

A tooth should be filed two to four times a day. The backs of the teeth must never protrude beyond the point.

Gullets must be kept circular carefully. Any sharp edge in a gullet is sure to cause a crack.

6. The mandrel must not heat in the journals. The boxes require frequent rebabbitting. The stem of the mandrel must be exactly level and perfectly straight.

Mandrels run hot owing to excessive friction in bearings, to excessive tightness of belts, insufficient lubrication or heating of the saw in the center.

A hot mandrel expands the saw in the center, causing crooked sawing.

(e) Lining of the saw with the carriage into the log.

The saw must "lead into the cut" just sufficiently to keep the saw in the cut. The proper lead is 1/8 inch in 20 feet. Too much lead into the cut causes the saw to heat at the rim. A lead out of the cut causes the saw to heat at the center.

The 1/8 inch lead in 20 feet is obtained by sighting over the saw and fixing the saw plane for a radius of 10 feet. This may be done by putting two staffs vertically into the ground 10 feet from the saw center behind and in front of the saw; that done, a horizontal stick is fastened to a head block so as to just touch the forward staff. Then the carriage is gigged backward to the other vertical staff where the horizontal stick must lack exactly 1/8 inch from touching.

(f) Filing room.

Automatic sharpeners and gummers are required for mills having over 15,000 feet daily capacity.

Setting instruments for spring set are similar to those used with cross cut saws, constructed either after the wrench principle or after the block and hammer principle.

The spring set is gradually discarded for the swage set.

In swaging use oil on the point of the tooth, after filing to a sharp point. Swaging should draw the tooth out and should not shove it back.

The set or swage of teeth should increase the gauge at the rim by at least 3-32 of an inch.

The pitch of the tooth might be controlled by a so-called trammel.

Gumming is required to preserve the original hook or rake of the tooth as well as the original roundness of the gullet.

Gumming as well as sharpening are usually done with emery wheels.

Emery wheel rules are as follows:

1. Do not put too much pressure on emery wheel so as not to change the temper of the tooth (bluing and casehardening and consequently crumbling of the tooth).

2. Do not try to fix a tooth fully at one time. Treat it gradually at five or six revolutions of the saw.
3. Proper speed for emery wheels at the rim is 4,500 feet per minute.
4. After gumming remove the irregularities at the edges with a side file, since cracks in saw are apt to start from them.
5. Hammering becomes necessary when the use of emery wheels has caused the saw to expand ("let down") at the rim.

   For small mills gumming with a file or a butt gummer is preferable to the use of emery wheel.

   Soft wood requires more set or spread and less pitch than hard wood.

   Swaging is also called upsetting or spread setting.

(g) Inserted tooth circular saws.

1. The insertion into each socket of the rim consists of a holder and of a chisel point. These points are extremely hard; still they can be filed and swaged with the help of specially constructed files. It does not pay, however, to spend much time in filing since new points are cheap, and since they are readily inserted with the help of a special wrench.

   Points are oiled before being inserted.

   When renewing one individual point be sure to have it dressed down to correspond to the line of old points.

   If the saw guide is not properly adjusted it may touch the holder and smash the saw.

2. Advantages of inserted tooth saw are:

   Less experience is required for dressing a saw.

   Less filing and gumming.

   Less saw repairs in backwoods.

   Diameter of saw remains unchanged during its use.

3. Disadvantages of inserted tooth saw are:

   The saw kerf is very heavy.

   The teeth are large and hence few, so that feed must be comparatively slow.

   The price of the inserted tooth saw is higher than that of the solid tooth saw.

The best makes are the Atkins and Disston saws.

(h) The double circular saw.

For big logs and high speed a double circular saw must be used.

The width of the widest board which a single circular saw may cut equals radius minus three inches. Hence much valuable material is wasted in the common circular saw mill sawing heavy logs.

The double circular saw shows an under or lower saw of 56 inches or 60 inches and an upper saw of 30 inches or 36 inches diameter. The top saw should have a reversed motion (so as not to throw sawdust into the lower saw), an arrangement which it is difficult to secure.

A hanger top saw can be added readily to any single saw. Both saws should have the same speed at rim.

The top saw should remain inactive so as not to use up power when small logs are sawn.

Inserted teeth are not used at the double mills.

The advantages of the double saw mill are:

1. Less chattering and truer cut than would be possible for one big saw.
2. Thinner kerf.
3. Faster feed.
4. Less expense for saws.
5. Less repairs.

(i) Remarks relative to "putting up" portable circular saw mills:

The minimum yard required is 50,000 board feet.

The expense of tearing down and putting up again is about $50.

For foundation timbers, place two pieces 8 x 10 inches x 11 feet long on either side of the saw pit (3 feet deep) and underneath the "husk." One piece 4 x 6 inches x 7½ feet long is saddled into the two big pieces, spanning the saw pit underneath the far rail of the track.

Construct the carriage track absolutely straight and level on the track ties (16 to 25 in number) and on the saw pit span.

Place carriage with rack shaft, feed and gig works in place and fasten the track by cleats and nails solidly to the foundation timbers. Then place the husk on them at a distance of about 6 inches from the track, putting wedge blocks between the husk and track. Then spike the husk to its foundation—to begin with in two places only, viz.: at the sawyer's corner and at the middle of the opposite side, so as to enable the sawyer to change the lead by wedging the blocks. Then fix or hang the saw, set the saw guide and fire away.

III. Band saws.

(a) The blade.

The blade material is steel. The width of the blade for log band saws is from 10 inches to 16 inches—14 inches being usual.

Gauge of blade is from 19 gauge to 13 gauge.

Under tension of blade is understood the curvature across the width, which is increased or decreased by hammering at center or at edge. The tension gauge with curved edge guides the filer.

(b) The tooth.

Its width is from 1¼ inch to 2¼ inch.

The hook or pitch is from 40° to 65°.

The depth should be as shallow as possible, with gullets kept round, since cracks usually start from a corner in the gullet.

For sharpening the tooth, a medium soft emery wheel should be used and should not be crowded too hard against the saw, so as to prevent case-hardening.

The teeth are swaged—never spring set—like gang saws. The full amount of set should not exceed 9 gauge in a 14 inch saw.

Side filing or side dressing, after swaging, is usually practiced, although objected to by the saw makers.

For gumming, either a gumming press or the emery wheel is used.

(c) The filing room.

Every band saw mill has a separate filing room equipped with automatic dressing machines, i. e., automatic sharpener, automatic swage, automatic swage shaper, saw stretcher etc.

In the band saw mill, the filer is considered more important than the sawyer for the success of the mill.

Saws are changed three or four times a day.

"Brazing" of a band saw means joining the loose ends, uniformly beveled or ground to a feather edge ¾ inch long. A strip of silver solder is placed between the cleaned laps, which are then taken between the cheeks of the brazing clamps heated to a bright red heat. After pressing the clamps together for several minutes and allowing them to cool, the braze is dressed down with a file to the proper thickness.

The filer arrests cracks by punching a small pin hole or dot at extremity of crack.

(d) The wheels.

The band saw runs, belt like, over two wheels weighing from 1,500 to 3,000 pounds (the lower heavier than the upper) ; the lower wheel driving the upper by the band saw.

The strain on the saw, which should not exceed 5,000 pounds and by which slipping off is prevented, is obtained by raising the upper wheel.

The diameters of the wheels are 8 to 10 feet, the face about 11 inches, the teeth overlapping the wheel.

The crown of the tire is up to 1-64 inch.

The entire length of the log band saw varies from 30 feet to 70 feet.

The saw guides, lined with wood or babbit metal, prevent the cutting part of the blade from bending toward the carriage or toward the wheels, while the guard rolls, standing about 2 inches back of the saw, prevent it from slipping backward at the approach of the log.

The maximum diameter of logs that can be handled by band saws is about 90 inches.

The weight of a band saw mill complete is 20,000 to 40,000 pounds.

(e) The "Allis" double cutting telescopic band saw.

The saw blade has teeth on both edges, so that a board is obtained at each trip of the carriage.

The entire mill is raised or lowered by hydraulic pressure with a view to bringing the top of the logs immediately underneath the upper wheel.

IV. Conclusions.

(a) The superiority of the band over the circular saw lies in a saving of 1,000 board feet in every 16,000 feet of 4/4 inch boards obtained. In heavier planks the saving is less, in lighter boards more. The boards obtained have a better width. Logs over four feet through cannot be handled by circular saws. Further, the band saw allows of a more rapid feed. Hence it is used preëminently for valuable logs, for big logs and for high output.

Frequently mills of large output employ simultaneously band, circular and gang saws, allotting the logs according to their quality, the best to the band saw and the poorest to the gang saw.

Two edgers and one trimmer can take care of such a combined output.

(b) Mammoth mills are now considered uneconomical, since it is difficult to take care of the output of boards at the outlet from the mill floor.

The output per mill hand in big concerns is up to 7,500 board feet daily.

Four acres of mill pond hold up to 1,000,000 board feet.

Two standard gauge trains supply an output of 100,000 board feet from an average distance of 10 miles, daily.

B. The carriage.

I. The composing parts are:

The truck with head blocks, knees, dogs, set works, and the driving machinery.

The carriage is subject to the roughest treatment. Still, its proper alignment is as essential as that of the saw.

(a) The truck is made of timber at least 6 inches square, thoroughly seasoned and strongly braced and bolted.

Construction material is:

Up North—Norway pine, birch and maple.

Down South—Yellow pine and white oak.

The length should correspond with the maximum size of logs.

So called screw block trailers may be added, increasing the length (in longleaf pine mills) up to 72 feet.

(b) The head blocks, iron with steel face, are let into the timbers of the truck and form a groove for the tongue of the knee, which slides on the head blocks, being moved forward and backward by the set works.

The head block and knee form a right angle into which the log is firmly pressed.

(c) The knee is either solid or hollow and carries the dogs.

The dogs are hooks or clamps or teeth, meant to grasp the log. They are fastened either inside or outside of the knee.

Two tooth bars, playing inside the hollow knee and pressed by a powerful lever, replace the original dogs in modern mills.

"Underdogs" are used in quarter sawing.

The number of head blocks, knees and dogs is variable. The minimum is two of each.

(d) The set works consist of:

The set beam, a shaft running underneath the carriage from head block to head block, with a pinion at each head block. This pinion corresponds with a rack forming the tongue or basis of each knee.

The index disc and ratchet.

The set lever, handled either by the sawyer, in small saw mills, or by the setter, in larger mills.

The set works are usually double acting, so that the knees advance with the to and fro motion of the set lever.

In addition, each knee can be moved individually on its rack by the so-called taper movement.

The knees, before a new log is loaded, are receded either by a spring device or, on the gig motion of the carriage, by a friction device.

The brake wheel on the setshaft acts as a buffer when logs are loaded on the car.

(e) The wheels.

The wheels are attached either to the carriage or to the floor. The near wheels are flat on the tire and the far wheels, called guide wheels, are grooved on the tire.

In band saws, an automatic off-set is required to prevent the face of the log from striking the saw on the gig motion.

The steel rails are invariably placed on stringers.

II. Driving machinery.

The to and fro trips of the carriage are known as feeding and gigging.

In small mills the motive power is derived from the saw arbor by:

(a) Rack and pinion device.

(b) Chain, rope or cable running over one or several sheave drums.

The speed is regulated either by so-called cone pulleys (two, three or four on the same shaft) or by a paper friction device.

The so-called Reamy Disc Friction allows of freely varying the speed.

The usual feed, with the cone pulley, is from ¼ inch to 3 inches per revolution of saw.

In large saw mills the piston of a steam cylinder pushes the carriage to and fro (so-called shotgun feed). In that case the carriage usually runs on three rails (center guide rail).

C. Additional parts of high grade saw mills:

I. "The log haul up" (elevator) consists of a flanged foot wheel and an inclined trough, on the bottom of which runs a strong endless chain driven by sprocket wheels. The chain has steps (called welds) at intervals of about 6 feet.

The haul up is driven by a separate engine or from the main shaft by double gear wheels. It consumes a great deal of power.

At the upper end of the haul up, a log flipper "boxes" the logs out of the trough onto the log deck, which is usually inclined toward the carriage.

On the log deck, the logs are freed from dirt and bark by hand.

II. "The nigger," handled by the sawyer, throws the logs on the carriage and turns them by a boxing movement.

III. "The hog" is a steel box within which the edgings and trimmings are cut into small slices by very strong knives rapidly rotating.

IV. "Dust conveyors" convey the output of the hog and the sawdust automatically to the boilers.

D. The edger.

The boards, falling from the log, are conveyed automatically or by hand to the edger.

I. Parts of the edger are:

(a) One or several circular saws of 12 inches to 28 inches diameter.

(b) Feed works, either power or hand driven, consisting either of a carriage or of feed rolls or of barbed chains by which the boards are fed into the saws.

(c) Edger table.

II. Task of the edger is:

(a) Removal of defects, knots, bark edge at the side of a board.

(b) Splitting boards into pieces of different quality.

(c) Rapid sawing to proper width required for special purposes.

III. Kinds of edgers.

(a) Hand feed edger, with one or two saws.

(b) Power feed edger, usually with a single saw.

(c) Gang edger.

IV. Pointers.

(a) The distance between the various saws in gang edgers is regulated by overhead levers or by hand wheels.

(b) Several boards can be fed at one time.

(c) The attendant of the edger must be a lumber inspector at the same time, so as to turn out the maximum value of edged product.

(d) The boards are taken to the edger from the live rolls onto which the board drops from the log, either by hand or automatically, by chain conveyors.

(e) The boards are conveyed from the edger to the trimmer by hand.

E. The trimmer.

In large mills, trimming follows edging. In small mills, edging follows trimming.

I. Parts of the trimmer are:

(a) One or several circular saws about 18 inches in diameter. A one saw trimmer is called a "cut-off."

(b) Feed works, viz.: live rolls or carriage or barbed chains running over sprocket wheels.

(c) Table.

II. Task of the trimmer is:

(a) The shortening of boards to standard lengths of 6, 8, 10, 12 and up to 20 feet, allowing 2 inches extra for shrinkage.

(b) The removal of defects at either end, so as to raise a board into a higher grade.

(c) The cutting of straight ends.

III. Pointers.

(a) Where two saws are used, the distance between them is changed by a lever or by a screw wheel, shifting one of the saws, while it is in motion, along the shaft.

(b) Chain power fed trimmers are used in all large mills. The saws are either jump saws, easily pushed from below the table in pairs, or swing saws, hanging above the table and, similarly, pressed down by the attendant in pairs by a touch on hand or foot levers.

F. Yard work. (Sorting and piling.)

I. Sorting.

The board after leaving the trimmer is taken up by a chain or cable conveyor and passes by the lumber inspector, who pencil-marks its quality.

The various qualities are either at once thrown into parallel gutter conveyors, leading to separate chutes, below which a wagon or truck is in waiting, or are transferred to the piles by endless chain conveyors, by hand trucks and wagons. Frequently elevated roads traverse the yard on which and below which such conveyance takes place.

II. Piling.

Strong, high, horizontal ground sills are of the utmost importance. The front sill should be higher than the middle and back sills, except in shed drying.

In some yards the front of the piles is given an overhanging "batter," to protect it from rain, an arrangement feasible only in low piles. The usual pitch of the pile is 1 foot in 10 feet or more.

The tiers of boards are kept apart by three or four well seasoned cross pieces called sticks—sawn 1 inch square and placed directly one over the other.

The usual width of the piles is from 6 feet to 10 feet.

The distance between the piles is at least one foot and should be three feet.

In order to prevent end cracks, the sticking should be placed exactly at the ends, slightly projecting over the ends.

Each pile must contain equal lengths, as "overlaps" are sure to get spoiled.

Valuable wide boards are often painted at the ends.

Oak, ash, hickory and elm require at least four months for air drying; lynn, poplar and pine about two and a half months.

Slow drying involves a loss of interest, large yard room, large insurance and slow filling of orders. Still in the case of high grade hardwoods, the use of the dry kiln is disastrous to the lumber.

Thin lumber does not check as badly as thick lumber. Squares check worst of all.

A fermentation and incidentally a discoloration takes place where two fresh sawn surfaces touch one another.

Each pile should have a roof 12 inches high in front and 6 inches high in back, projecting in all four directions over the pile.

Proper curing of lumber is as important as proper sawing of lumber.

III. Dry kiln.

A dry kiln consists of
- shed with gates closing tightly;
- lumber conduit;
- heating apparatus.

The heat is supplied—slowly—
- either by a hot air fan;
- or by a system of steam pipes;
- or by steam admitted into drying room.

The air in the dry kiln must be kept in constant movement, so as to prevent unequal drying of the lumber in the piles.

Lumber can be more evenly dried by steam than by hot air.

Sapwater heated to boiling point expands 600 times. Consequently, wood at 212° F. contains only 1/600 of the water originally found therein.

Before building a mill be sure to consult insurance companies, submitting mill plans.

The insurance company prescribes the distance between the yard, boiler house, engine house, mill and dry kiln. The rate of insurance on a mill is 5% and over.

§ XVIII. WOODWORKING PLANT.

A. Planing (surfacing, dressing or sizing).

The planer consists of cylindrical cutter heads carrying two to four knives and making 3,000 to 5,000 revolutions per minute. It is preferably belted at both sides.

The smaller the diameter of the cylinder with its knives, the smoother is the planing.

The feeding is done either by two to four feed rolls (above) and friction rolls (below) or by a traveling bed. The entire cutting length of the knives should be uniformly used.

The top cutter should do the heavier work in double surfacers.

The knives are usually sharpened automatically.

Lumber is fed into the machine at the rate of 20 feet to 150 feet per minute. Hardwoods more slowly than the soft woods.

The chip breaker is merely a front pressure bar preventing long splinters from being torn off.

Price of single planers is $100 to $400; of double planers $400 to $800.

No machine should have wood in its construction.

B. Flooring.

The flooring machine is a surfacer having an additional outfit of two side cutters revolving on ratchet spindles, cutting tongues and grooves.

The machines weigh 5 tons and more.

The usual flooring made is hard maple.

Planers and flooring machines must be provided with a folding hood connected with an exhaust fan, so as to prevent the shavings from clogging up the machinery or from pressing themselves into the planed surface.

C. Resawing.

Resaws are either circular or band resaws.

The use of a resaw involves a great saving, since it takes a very fine kerf and at the same time relieves the work of the main saw.

The feed is automatic and consists of four rolls.

Circular resaws have as low as 19 gauge at the rim and are frequently built as segment saws.

D. Ripping.

The rip saw is a circular saw running on a bench and allowing, by a gauge arrangement, to cut any desired width of board or strips. It is usually hand fed.

A power fed gang rip saw is merely an edger.

E. Cut off saws.

Cut off saws are either swing saws, jump saws, stationary saws with carriage moved by hand or automatically, or traveling railway cut off saws when the saw is moved horizontally against the timber.

F. Sand papering.

I. Belt sand papering, for carriage spokes, axe handles, buggy poles etc.

II. Disc sand papering, notably for boxes.

III. Spindle sand papering, for small tool handles.

IV. Cylinder drum sand papering.

The object to be sand papered is always fed onto the machine by hand.

G. Scraping.

Under "scraping" is understood the removal of an extremely thin (not over 1/64 inch) layer of tissue from a planed surface. It is meant to replace and to cheapen the process of sand papering, and is not intended to reduce the thickness. The scraper consists of power driven, smooth feed rolls and of one stationary knife, over which the boards are passed. Corky or stringy lumber cannot be scraped.

H. Mitering.

In mitering the stock is run along the so-called "fence" against a circular saw, the plane of which forms a variable angle with the plane of the saw table.

I. Moulding.

Mouldings are either one, two or four sided.

Cutter heads, into which cutters of variable size and form are inserted, secure any variety of patterns of moulding. Moulders are often called "stickers."

J. Miscellaneous.

Under "matching" is understood the cutting of a tongue and groove into the edge of box boards, flooring boards etc. The work is done by a knife and cutter head.

Under "gaining" is understood the ditching across a piece.

Under "plowing" is understood the ditching along a piece.

"Tenoning" is especially required for doors and blind slats—single and double tenons being distinguished.

Door panels go through a "panel raising" machine.

Sash and door "relishing" means the biting or sawing of large teeth into the tenon.

§ XIX. VENEERING PLANT.

Veneers are either sawn or peeled (sliced). The furniture factory and the package trade use veneers, with entirely different ends in view, on a daily increasing scale.

The thickness of sliced veneers ranges down to 1/120 inch; veneers less than 1/40 inch thick, however, are rarely used.

Sawn veneers are 1/20 inch thick or thicker.

A. Veneer saws.

Any saw of a fine gauge is a veneering saw. Largely used are the:

I. Horizontal mill saw;

II. Fine band saw;

III. Circular saw ground to a fine gauge (19 gauge) at rim, strong (5 to 10 gauge) at center; there is only one collar, to which saw is screwed. Veneer saws consisting of sections screwed to a common centerpiece are common.

B. Veneer cutting machines.

Logs are boiled or steamed (in exhaust) for several hours beforehand. Usually, logs 3 to 5 feet long are used, the length of the log almost equaling the length of the knife.

I. The rotary machine peels any log of, say, over 18 inches diameter, notably poplar, lynn, gum and cottonwood, into thin layers by revolving the log slowly against a sharp stationary knife. A clipper cuts the roll into pieces of proper size for strawberry boxes, staves, potato barrels, box boards, furniture backing etc. The core of the log, some 6 inches in diameter, does not allow of peeling.

II. The stationary log cutter consists of a knife set in a sash frame removing at each stroke a thin slice or board.

C. Advantages of veneering.

I. There is little or no loss of timber for kerf and sawdust. Valuable logs (for furniture, cigar boxes) are invariably veneered nowadays. Logs too short for lumber are fit for peeling.

II. Veneers show little shrinkage and little checking. Hence they allow of rapid seasoning. For that purpose, the veneers are frequently passed between heated rollers.

III. The rotary machine yields very large veneers often entirely free from knots which are merely contained in the core left unpeeled.

§ XX. BOX FACTORY.

A. Kinds of boxes.

(a) Planed or unplaned.

(b) Knocked down or set up.

(c) Nailed, lock-cornered or dovetailed.

B. Material.

Wood as light as possible—readily planed, nailed and treated.

The best is white pine; next are spruce, basswood, poplar and, more recently, yellow pine, hemlock, gum, cottonwood. Elm and sycamore are used for special purposes.

C. Machinery.

A well equipped plant contains planers, resaws, rip saws, cut off saws, box board matchers (which tongue and groove composite sides), lock corner machine (or nailing machine or dovetailing machine), sand paper machine and printing machine (drum pattern).

D. Business side.

The skill of the box maker is shown by working up, without waste, the proper proportions of widths and thicknesses. Careful piling of lumber in the yard, separating according to width and thickness, is very essential.

The interdependence between crop prospects and box prices is easily felt by the box makers.

For large boxes the nailed pattern is preferred, being the strongest. Box shook fasteners and box strapping increase the strength.

The lock cornered box is preferred for starch, plug tobacco and small boxes. Lock cornered boxes are required either by the bad qualities of the lumber or by the quality of the stuff packed. Locked corners demand gluing. "Bevel locked" corners and "inclined locked" corners are scarcely used. The dovetailed box does not require gluing. The mechanical process for stamp locked corners (dovetails stamped into thin boards) is not yet perfected.

E. Expense of manufacture.

I. The manufacture of 1,000 feet of lumber into shooks involves a bill of $4 for labor and $1 for wear and tear.

II. One thousand small lock cornered boxes—9x6x3 inches, ¼ inch thick for frame and 3/16 inch for top and bottom—require 700 board feet of lumber worth $8.50 in case of white pine; $5.10 for labor; $2.72 for glue, wear and tear; $2.50 for ten packing crates.

§ XXI. BASKETS.

A. Willow baskets.

They are hand made, mostly from cultivated shoots of Salix viminalis, amygdalina and caspica. Shoots 1 to 2 years old are used, being cut either in fall or in spring. In the first case, the bundles of shoots are kept in water over winter. The shoots are peeled after the rising of the sap by being passed through an iron or wooden fork; then rapidly dried to retain the white color. In this condition the material may be stored away for years. The shoots are bathed in water before weaving to restore flexibility and toughness. The bottom of the basket is made first, and then, frequently with the help of a model, the standards or uprights of the wall are fixed. The manufacture has been introduced into New Jersey and New York.

B. Wooden baskets.

They are used for picking and transportation of bulky farm produces. Sizes ½ bushel to 2 bushels.

I. The hand made basket, from thin strips split and shaved from basket oak and white oak (sapwood).

II. The Briggs stave basket consists of radial ribs cut from 2¾ inch oak planks; cross cut into lengths varying from 12⅝ inch for ½ bushel to 18 inches for 2 bushel baskets. The ribs are jointed and pointed to an exact fit for a round center plate and then bent over a model form having grooves indicating the proper position for each rib and for the strong elm hoop clasped around the rim.

III. The common wood basket is made of straight long ribs up to ¼ inch thick, cut on a rotary veneer machine. No center piece, no pointing and no jointing are required. The ribs are bent over a model form. A workman is said to make about 300 baskets in a day.

§ XXII. COOPERAGE.

A. Terminology.

I. "Slack" cooperage turns out barrels for packing lime, vegetables, cement, salt, nails, crockery, sugar, flour, etc.

II. "Tight" cooperage deals with barrels for liquids and for meat (pork).

B. Material used:

Any species may be used for slack cooperage. Alcoholic liquors must be cased in white oak (Quercus alba, michauxii, prinus, macrocarpa, minor etc.). Red oak will not hold whisky, but is used for other staves, flour barrel heading, sawn and coiled hoops.

White ash is used for pork staves and butter tubs.

Elm yields the best coiled hoops and the best slack staves.

Cottonwood and gum are cut for staves on a large scale.

Chestnut is used for cheap slack barrel hoops; yellow poplar for tobacco hogsheads; basswood for flour barrel headings; beech and maple for sugar barrels; second growth of hickory, birch and ash for hoops.

For buckets, red and white cedar; for tanks, cypress and redwood are preferred.

C. Specifications:

I. Flour barrels contain 196 pounds, or 3.57 bushels, or 32 gallons of flour.

The diameter of the head is 17 inches; the length of the staves 28 inches.

The forms preferred in slack cooperage, either locally or for given goods, vary to such a degree that figures descriptive of the forms cannot be recorded.

II. The "Tight Coopers' Union" specifies:

(a) Whisky barrel staves—length 34 inches to 35 inches, thickness 7/8 inch, width 4¼ inch after jointing, measured across bilge on the outside.

(b) Wine barrel staves—length 34 inches, thickness 11/16 inch after drying and planing, width 4½ inches.

(c) Oil, tierce and pork staves have similar dimensions, allowing, however, of sap, one or two sound worm holes and knots showing on one side only.

Variations of 1/8 inch in length and 1/16 inch in thickness are permitted in all staves (so called equalized staves).

Pipes, butts and puncheons contain over 100 gallons and are used for port, rum etc.

A hogshead of claret is 46 gallons.

D. Statistical notes:

I. One thousand feet board measure in logs—Doyle's rule—yield 2,500 sawed flour staves, 3,200 veneered staves, 4,000 cut hoops or 3,000 sawn hoops.

II. One cord of bolts, with the bark, will make 1,000, or, without bark, 1,200 slack staves.

III. In Tennessee, eight white oaks (of over 18 inches diameter) are said to average 1,000 half barrel beer staves.

E. Prices and their tendency:

	Apr. 1, 1901.	Feb. 10, 1904.
Staves—		
No. 1, flour barrel, per 1,000	$ 9.00	$11.00 to $13.50
No. 1, cottonwood, per 1,000	6.00	....
No. 1, gum, per 1,000	....	10.00 to 12.00
Memphis white oak, without sap	26.00	44.00
Heading—		
No. 1, flour barrel, per set	.05½	.08 to .08½
No. 1, gum, per set	.04	.07½ to .08
Hoops—		
Coiled elm hoops, per 1,000	7.00	9.00 to 10.00
Hickory hoops, per 1,000	6.00	6.25 to 6.75
Barrels—		
Flour, 12 hickory hoop barrel	.41	.45 to .48½
Flour, 8 patent hoop barrel	.39	.46
Flour mugwump (10 hickory hoops)	.39	.45
Oil (52 gallon)	....	1.45

The price of white oak material has risen rapidly and must continue to rise indefinitely, substitutes for white oak being impossible.

In slack cooperage, on the other hand, raw material continues to be plentiful, and new, cheaper forms of packages enter into daily competition with the barrel.

The cost of making tierces at Chicago is: Staves ($21 per 1,000), 39 cents; heading, 16 cents; hoops, 20 cents; wages, 25 cents; total, $1.

F. Manufacture of heading, staves, hoops and barrels.

1. Heading.

Heading for tight cooperage is sawn from split bolts. These bolts are obtained in the woods by halving, quartering and splitting (by hand and always with the grain) round blocks which slightly exceed in length the diameter of the heading. The heart of the bolt is not removed. The bolts are wagoned or sledded to the heading plant, where they are inspected, sorted, piled and air dried.

Twenty-five horsepower are said to be required at a heading plant. The output at a "setting" of the plant averages 200,000 sets of heading.

The tight heading plant usually contains a sawing machine, an equalizer and jointer.

(a) The heading sawing machine consists of a vertical circular saw (44 inches diameter) screwed to the arbor without a loose collar; a pendulum swing with "grate" and "dogs" to receive the bolt; a slide guiding the swing; a gauge, adjusted by screws; a separator throwing the sawed slats to the side. Price $300.

(b) The equalizer contains a tilting table or a carriage, which is forced against a pair of circular saws.

(c) The jointer edges the slats. It consists of a strong wheel carrying on its side 4 to 6 straight knives. The wheel is covered by a hood. Price $140.

For tight cooperage the joints are made secure by blind wooden nails and by coopers' flag (Typha latifolia) glued into the joints.

Two more machines are required to finish the heading prepared by the apparatus mentioned under a, b, and c, viz.:

(d) The heading planer carries knives 16 inches to 24 inches wide and has a capacity of 8,500 headings a day.

(e) The heading turner cuts the heading circularly and carves the required bevel edge. It usually carries a concave saw, to cut through the boards, and on the same mandrel a small, thick circular saw which gives the bevel.

The heading, held in clamps, rotates obliquely against these saws. Price $235. Capacity 5,000 a day. Heading is usually kiln dried.

For slack heading, quarter sawing is usually not required. Ordinary lumber can be used. The slack heading plant may or may not contain all of the machines enumerated under a, b, c, d and e.

The tight heading plant of the woods contains the machines a, b and c, while the machines d and e are usually combined with the cooper works, unless they form a separate establishment.

II. Staves.

(a) Staves for barrels containing the more valuable beverages are hand made (rived staves). The riving of staves wastes timber. Proper bilge and curvature are obtained either by hewing (Germany) or in the finishing plant (America).

The white oak timber used must come from straight trees of over 18 inches diameter. Such trees are found in clumps only. Hence the necessity of a portable finishing plant, using from 15 to 35 horsepower. At each set or site—now usually 15 miles from the railroad—at least 100,000 staves are manufactured. Six hundred rough staves have the weight of 1,000 finished staves. Hence it is wise to bring the plant close to the timber.

The felled tree is sawed (by hand) into blocks of two inches more than stave length, which are placed on their larger ends. Then the sap line is demarked with a pencil, and inside the sap line, with the help of a pattern showing the cross section of a stave, as many staves are pencil-marked as possible.

By axe, wedges and wooden mauls the block is then halved and quartered (and rehalved and requartered in case of heavy blocks), the clefts following the pencil marks. The sectors are then split, along the annual rings, into rough staves—always following the pencil marks.

The core of at least four inches diameter, containing the small limb-stubs, is thrown away.

The rough staves are inspected and sorted and piled hogpen-fashion for air drying, either before or after sledding or wagoning to the finishing plant. It might be added here that this finishing plant is—contrary to expectation—never combined with a heading plant.

(b) The "stave bucker," by which three-fourths of all rived staves made in the United States are refined, dresses and planes both sides of the staves to proper curvature and bilge. A rack forces the rough staves through the narrow passage left between two knives (either straight knives, or curved to correspond with the periphery of the finished barrel) which are fastened in a rocking frame.

(c) The "stave dresser" frequently takes the place of the bucker. It carries knives on two cutter-heads, dressing and hollowing the stave on both sides to proper thickness and leaving either an abrupt or a gradual shoulder

(d) The stave saw yields staves of equal form, but greater permeability, more economically than the hand. Stave bolts must have the following minimum dimensions: thickness with grain 5 inches; width close to heart 3 inches.

The bolts are barked and hearted in the woods, being split from logs having at least a diameter of 15 inches inside the bark.

The stave saw consists of:

1. A hollow steel cylinder, having the diameter of the barrels to be made and carrying saw teeth at one end.
2. A carriage with clamps passing the saw cylinder.
3. A stave holder running into the cylinder and removing the sawed staves. Capacity 12,000 staves per day.

(e) In slack cooperage, a stave cutter is often used, consisting of a circle (20 inches for fruit barrels) with one knife attached, making 150 revolutions per minute. The stave bolts are steamed beforehand. The knife separates at each revolution of the circle, or by each single stroke, a stave from the bolt.

Capacity 140,000 per day. Price $130. Horse-power, 4.

(f) The rotary veneer machine is now also used to cut 4 inch or 4½ inch gum staves.

(g) The stave equalizer trims the ends and gives the staves the proper length. It consists of two circular saws and a tilting bed or a carriage.

(h) Stave listers or jointers edge the staves in such a way that the edges coincide with a plane through the axis of the barrel.

Staves for export are straight listed and without bilge.

The stave jointer is either a circular swing saw or it consists of two circular saws; or of a number of inclined knives held by cutterheads; or of one knife running in a sash frame; or it resembles a heading jointer (starjointer).

(i) In the "stave planer," a steel pattern passing through the machine with the stave lifts the cutters in such a way as to allow the shoulders of the staves to retain a greater thickness than the middle of the staves.

III. Hoops.

In tight cooperage, steel or iron hoops are used, driven over the barrel by hoop drivers or trussing machines and sometimes fastened by hoop fasteners.

In slack cooperage, wooden hoops are still preferred and wire hoops are only occasionally used. Wooden hoops are either hand made, especially the long white oak hoops used on tobacco hogsheads, or sawed from plank by a hoop machine, or finally knife-cut on a rotary machine or a sash frame machine.

A machine by which sawed hoops are obtained directly from logs does not seem to be much used. By special machinery hoops are planed, pointed, lapped and punched.

A hoop coiler rolls the hoops into bundles; usually the outfit of a "sawed hoop" plant consists of a saw bench, a saw machine and a coiler.

IV. Barrels.

Putting up a barrel requires:

(a) Heating, in order to increase the flexibility of the staves held together by an iron form and by one or two hoops.

(b) Bending in an apparatus consisting of screw and rope, windlass and rope, or of a funnel press.

(c) Crozing, i. e., making a groove for the insertion of the heading, either by a hand planer or by a power groover.

The finished barrel is automatically planed on the outside; if it does not assume the exact form of a doubly truncated parabolloid, it is pressed into shape by a barrel leveler.

§ XXIII. WAGON WORKS.

A. The raw material must be tough and strong and, above all, air dry. The dry kiln often follows after two or three years of air drying.

Second growth of black or shell bark hickory is used for tongues, shafts, spokes, rims, axles, neck yokes, whiffletrees and eveners.

White oak or burr oak is used for spokes, tongues, bolsters, hounds, reaches and axles.

Black birch, rock elm, white oak and locust are used for hubs.

Wagon beds are made of yellow poplar, pines, cottonwoods, the composing boards being either ship lapped or tongued and grooved.

White ash, bending easiest and best of all woods, is used for rims, bent seats, bent bows, shafts etc.

B. The manufacturing machinery is usually supplied by the Defiance Machine Works, Defiance, Ohio.

I. Hubs are cut direct from log to proper length by double equalizing saws and are turned on outside automatically on a lathe; bored for boxes (thimbles); chisel mortised for spokes; and set with two to four iron rings.

II. Spokes are obtained from bolts by rip sawing into squares which are turned on a lathe; tenoned at the big end; equalized in length; sandpapered and polished; and driven into hubs by automatic hammers.

III. Rims and felloes are either bent to proper form or sawn from straight bolts. In the first case, the bolts are steamed or boiled; then bent and pressed in an iron pattern when hot; then cased up and dried; then bored to receive the spokes; rounded on the inside with a slight elevation left around the hole; planed and finally sandpaper polished.

Very wide plank is required for sawn felloes, which are obtained either by a set of concave saws, having the required curvature, or by a narrow band or scroll saw which follows the pencil marks of a pattern made for each piece on the plank.

IV. Axles are turned on a lathe according to a steel pattern spanned in the lathe; are gained to receive bolsters and hounds; and have the thimble skeins driven on by hydraulic pressure.

V. Shafts and poles are sawn from plank 1½ inch to 2½ inch thick and 8½ to 12 feet long; are heated and bent, cased, dried, rounded and belt polished.

C. Few establishments make entire wagons. Usually shafts, spokes, rims, axles etc. are made in factories close to the woods, while other factories closer to the cities or to railroad centers put the wagons together after buying their component parts.

§ XXIV. SHINGLE MILLS.

A. Material.

Breasted, shaved, rived or rifted shingles (meaning hand made) are used in the backwoods only. At Biltmore, shaved shingles made of chestnut cost $2 per M., while so called boards, two feet long and six inches wide, split from white oak, cost $3 per M.

Shaved shingles cannot be laid so neatly as sawn shingles.

For machine made shingles are used:

On the Pacific coast, red cedar;

In the Lake States, white pine, white cedar, spruce, norway pine and hemlock;

In the South, cypress, longleaf pine and shortleaf pine.

B. Durability.

The durability is said to be for:

White pine rived, 20 to 35 years.
White pine sawn, 16 to 22 years.
White pine (sappy) sawn, 4 to 17 years.
Chestnut rived, 20 to 25 years.
Cedar sawn, 12 to 18 years.
Spruce sawn, 7 to 11 years.

C. Specifications.

The usual size of sawn shingles is: 16 inches or 18 inches long; 4 inches wide; 1-16 inch thick at small end; ½ inch thick at butt end. A bundle of shingles contains 250 pieces, is 20 inches long and has 24 tiers.

A carload of white pine shingles, weighing 22,000 pounds, contains 70,000 16-inch shingles; a large car of red cedar shingles contains 170,000 pieces.

One thousand shingles cover 100 square feet of roof, each showing 14.4 square inches to the weather.

A rule for the number of shingles required for a roof is: ascertain number of square inches in one side of roof; cut off the last figure, and the result is the number of shingles required for both sides of the roof. In this case, each shingle shows 20 square inches to the weather.

Shingles are usually laid to show 4 inches of their length, which arrangement yields, in 16-inch shingles, a quadruple layer of shingles on the roof. The higher the grade of the shingles, the larger is the weather face permissible.

D. Machinery.

The machinery used in a shingle plant consists of:

I. Drag saw, either driven from a countershaft or acting directly from the piston, cutting the logs into shingle lengths.

II. Bolter, a circular saw cutting the round blocks into bolts, the thickness of which equals the width of the shingle. Bolts split with an axe yield a better grade of shingles but cause a large waste of timber. A knot saw may be used after bolting to remove knots, rot, sap etc.

III. Shingle machine, constructed in a variety of forms:

(a) A knife is spanned in a sash frame moving up and down and severing a shingle at each stroke from steamed bolts. This system, furnishing "cut shingles," is not much used.

(b) The shingle saw machine uses a circular saw lacking the loose collar and screwed onto the fast collar. The gauge at the center of the saw may be very heavy while the gauge at the rim is from 15 to 20 only.

The shingle blocks are fastened into either a sliding frame or a rotating frame and are tilted continuously, so as to alternate edge and butt cuts. The sliding frame is either hand fed or power fed. A machine takes from one to ten blocks at a time.

IV. The jointer is meant to give a rectangular shape to the shingle. It is either a single or a double rip saw (two saws 4 inches apart) or a wheel jointer consisting of a steel wheel carrying, close to the circumference, 4 to 8 knives radially or almost radially set and of a hood covering the machine and connected with a blowpipe to remove shavings. The shingles are placed opposite an opening in the hood and pressed by hand against the knives, which make about 500 to 800 revolutions per minute.

V. The shingle packer, used for 16 inch and 18 inch shingles, consists of a bench and two slotted and overhanging steel rods. The attendant pressing the rods down by hand or foot packs the shingles tightly with their fine ends overlapping.

VI. Shingle planers, fancy butt shapers and dry kilns are found in up to date plants. After dry kilning, bundles require tightening up.

§ XXV. LATH MILL.

The usual length of laths is 4 feet; the weight per 1,000 is 500 pounds. One thousand laths cover 70 square yards, and a cord of slabs yields 3,000 laths.

All softwoods, further yellow poplar, cottonwood and linden form the raw material for lath.

The machinery used consists of:

A. Slab resaw, by which the last board is cut out of the slab. It contains a circular saw and feed works pressing the slab in to the saw.

B. Lath bolter, consisting of a single or double cutoff.

C. Lath machine, which is either an ordinary rip saw having up to six small circular saws and an automatic feed, or a cutter-head and knife machine. The latter machine makes the so called "grooved" lath.

D. Lath bundling machine, which presses the laths together by a foot or hand lever and facilitates binding.

§ XXVI. CLAPBOARD MILL.

The cross section of clapboards is either square or, more usually, beveled, with the big edge from 3/8 inch to 5/8 inch thick

They are manufactured either from boards 1 inch thick fed through a resaw, the feed rolls of which are inclined toward the saw, or by special clapboard machinery directly from the log. Logs, in the latter case, are cut in pieces of proper lengths (4 feet to 6 feet) by a drag saw;

are turned on a lathe and then spanned into a sliding frame (between pins). Frame and log pass a circular saw with and not against the rotation of the saw. After passing, the log is automatically turned by an angle corresponding with the bevel of the clapboard.

This process leaves a four inch core unused.

A planer, molder or jointer dresses the sides and a butter or trimmer dresses the ends.

§ XXVII. NOVELTY MILL.

Novelty mills have sprung up, in recent years, all over the Northeast, manufacturing trays, wooden dishes, wooden wire, rules, pen-holders, flasks, skewers, toys and thousands of playthings of the hour.

The variety of the raw material used is as great as the variety of the goods manufactured. Still, birch seems to be the acknowledged leader for novelty makes.

Wooden dishes and wooden wire may deserve particular mention.

A. Wooden dishes.

I. Material.

Yellow poplar is used for large wooden trays. Second growth white pine (cuts taken between whirls) is said to be used in New England. Maple is preferred for small oval wood dishes, turned out by a special machine automatically.

II. Manufacture of oval dishes.

These oval dishes are obtained from sawn blocks, scaling from 6 inches by 8 inches to 7¼ inches by 9½ inches.

The dishes are cut with the grain from the side face. Blocks are thoroughly boiled. The cutting knife, revolving circularly, makes 25 dishes to the inch and 75,000 per day.

Two facing knives shave the block clean between every two cuts, carving out true edges.

A screw fed carriage automatically feeds the block into the knives. No skilled labor is required. The attendant merely removes the remnants of a spanned block and places a new block in the carriage.

B. Wooden wire.

Wooden wire is used for mattings, screens, inner rack of ladies' hats etc.

The raw material consists of willow, basswood and poplar plank.

A series of planing knives, in the form of sharp rimmed, fine steel cylinders, plies in a sliding frame over the plank, severing at each stroke a series of wires having the length of the plank.

A straight planer knife follows in the wake of the fine cylinders, removing the irregularities left on the plank.

§ XXVIII. MATCHES AND THEIR MANUFACTURE.

Wooden matches are either round or square.

A. Round matches are made on a machine resembling the wooden wire machine described in Section XXVII.

B. Square matches are made from blocks 16 inches to 24 inches long which, after steaming or boiling, are peeled on a rotary veneer machine into layers having the thickness of a match.

I. The veneers are automatically clipped into sheets having a length of 6 feet and width equaling 5 to 12 match lengths. These sheets are heaped up in packs containing 50 to 60 tiers.

II. A knife system, with vertical spur-knives, plays in a vertical sash and cuts from each tier, at each stroke, 5 to 12 matches. The pack, after each stroke, is moved forward the thickness of a match. The machine has a daily capacity of 25,000,000 matches.

III. The matches are then dried and cleaned by sifting.

C. The treatment thereafter is identical for round and square matches, consisting of the following operations:

I. Causing the match pegs to lie parallel, by rocking them in an oscillating drawer.

II. Fixing about 2,250 matches at a time in a clasp or frame.

III. Dipping the clasp (for fine matches) wholly into paraffine and the tips thereafter into a chemical compound (mastic) which forms the inflammable head. The mastic consists of one or more oxidizing substances (chlorate or bichromate of potash), often mixed with a particle of some explosive, so as to allow of ignition by friction on any rough surface.

D. The raw material for matches is derived from cottonwoods, linden, sapwood of yellow poplar, white pine, spruce. A white, soft and long fibre is required.

§ XXIX. SHOE PEGS AND THEIR MANUFACTURE.

A. Wooden shoe pegs are used to fix the "uppers" to the shoe sole and to construct the heel. The pegs are automatically fed from a pegging machine.

Pegs are ⅜ inch to ⅞ inch long, square with a prismatic head.

The raw material consists of birch and hard maple.

B. Manufacture.

I. The blocks are cut into discs, ⅜ to ⅞ inch thick, by a circular saw.

II. The discs are pointed in a pointing machine, which plows parallel grooves, lengthwise and crosswise, into the discs. The distance between two furrows equals the width of the peg.

III. The splitting machine severs, by the gradual strokes of a knife (first stroke down to ½, second stroke down to ¾ of thickness of disc), the disc into strips of pegs and, playing crosswise, into individual pegs. After each stroke of the knife the disc is moved toward it by the width of one furrow. During the operation the disc is held in a leather frame.

IV. The wet, red pegs are then bleached by applying sulphuric acid; then dried in heated drums; then cleaned from splinters and irregularities by sifting.

§ XXX. EXCELSIOR MILL.

A. Grades of product.

First Grade—Fine wood wool, thickness from 1/500 inch to 1/64 inch.

Second Grade—Common fine wood wool.

Third Grade—Mattress stock.

The greatest demand is for stock 1/100 inch thick and from 1/32 to 1/8 inch wide.

B. Usage. Excelsior is used for upholstering and for packing (glassware, furniture, confectionery etc.). It is preferred to straw owing to its greater elasticity and to its lack of dust. It is easily colored. A limited amount of excelsior is woven into mattings and rugs.

C. Kinds of wood.

Basswood is best; balm of gilead, cottonwood and yellow poplar come next. Pine and spruce also are used. One cord of wood will yield 1,500 pounds of excelsior.

D. Process of preparation.

The wood is peeled, cut into 38-inch blocks, and the blocks split into slabs 5 inches to 6 inches thick. These slabs are thoroughly air seasoned under cover, and finally cut into two lengths of 18 inches each.

Frequently the core of blocks peeled on the rotary veneer machine is used for excelsior.

E. Machinery.

Excelsior machines are small, upright knife machines, or carry the knives on a disc set in rapid rotation. The modern machine, however, is an eight block horizontal machine consisting of:

I. Two sliding steel frames carrying eight tool heads into which the knives and the comb-like spurs are spanned. The sliding frames are moved by powerful cranks and pitmans on maple slides.

II. Two stationary frames, above the sliding frames, each having four sets of rolls, each set pressing a block by its rotation downward against the knives.

III. The shavings, falling through the sliding frame, are carried out by broad belts.

IV. The daily capacity of an eight block machine is 4,000 pounds of fine wood wool, or 10,000 pounds of mattress stock.

V. Additional machinery consists of automatic knife grinders, baling presses, cut off saws etc.

VI. The price of the machinery for a modern plant is about $2,000. About 30 horsepower are required.

§ XXXI. GROUND WOOD PULP AND CHEMICAL FIBRE AND THEIR MANUFACTURE.

A. Historical remarks.

Up to 1854 paper was made from cotton, linen and hemp fibre, precipitated from a mush in the shape of a matting.

Wood grinding was invented in 1854. Since 1867 the ground wood is refined by chemical processes which separate the wood into thinner strings of cells and free it from rosin, tannin, albumen, gums etc.

In the United States there were, in 1890, 82 mills producing $4,600,000 worth of wood paper, while the value of the output in 1900 approximated $20,000,000.

Rags, manila, straw and waste paper used as raw material for paper still outrank in value (in 1900) the wood used as raw material.

In 1900, close to 2,000,000 cords of wood were consumed, worth nearly $10,000,000; three-fourths being spruce and one-fourth poplar and miscellaneous.

If the United States shall conquer the Swedish and German export and supply the entire consumption of wood paper at home, 6,000,000 acres of well managed wood lands will be required to produce the raw material.

B. Statistical remarks.

One cord of wood yields one ton of ground pulp wood (mechanical fibre) or ½ ton of chemical fibre. In the so called "news grade" 80% of pulp is mixed with 20% of chemical fibre.

Japanese paper is made of the inner bark of a mulberry tree (Brussonetia).

For highest grades of writing paper, cotton and linen are used.

An average mill produces 25 tons a day.

A modern pulp plant requires annually, at least, 6,000 cords of wood; a modern fibre plant at least 25,000 cords.

The price of the product loco factory is about:

For ground wood pulp, $13 per cord;

For soda fibre, $20 per cord;

For sulphite fibre, $25 per cord.

C. The plant.

The plant requires an outlay of about $10,000 per ton of daily production. Unlike a saw mill, a paper mill cannot be shifted when the nearby supply of raw material is exhausted.

A plant must be located:

I. Close to water; water is not so much used for motive power as for the dissolution of the fibre in the washing process.

II. Close to cheap wood supply; wood must be plentiful and uniform, of a long, straight fibre, readily interlacing and white. Spruce is considered best, the price at river fronts being about $3.50 per cord and at mill from $4.50 to $5.50. Cottonwoods and poplar are next in importance. Price at river fronts $2. Hemlock and balsam are mixed with spruce in a daily growing proportion. Birch, beech and maple can be used only for wrapping paper and cardboard, the fibre being short, brittle and unbleachable.

The use of pine is handicapped by the expense of the removal of the rosin.

The Pacific spruces and cottonwoods may have a great future.

III. Close to cheap coal, since the coal consumption per pound of paper amounts to 5/16 of a pound of coal. So much coal is required for heating, drying and bleaching, that all excepting 15% of the machinery can be driven free of charge.

D. Process of manufacture.

The manufacture is either purely mechanical (ground wood pulp) or also chemical. In the latter case, distinguish between the soda process, the sulphite process and the sulphate process. The electric process, though very promising, is still in early infancy.

The principle of manufacture is:

Grinding and beating of wood in water until it forms a fluid pulp; allowing water to run off leaving a matted stratum of wet fibre; bleaching; drying; pressing.

I. Ground wood fibre.

(a) The wood is cut into bolts one foot long and five inches thick. The bark is removed, and the knots are usually bored out.

(b) The bolts are pressed against stone mill-wheels which turn slowly under constant influx of water. Bolts must be ground in the direction of the fibre.

(c) The fluid pulp is carried through sieves retaining the long splinters, which are transferred to a pulp engine for mechanical refining.

(d) The fibre is ground a second time both in stampers and rotary mills.

(e) The fluid is separated according to fineness by sieves of different mesh which allow the water to run off. The filtered mass is taken up by endless belts of cloth which carry it as a thin matting through a series of heated rolls.

(f) The mattings are dried by superheated steam, by pressure or in the air. Pulp is shipped in rolls about 3 feet long and 1½ feet in diameter. It is not paper but merely the leading raw material for ordinary paper.

II. Soda process.

This process consists of:

(a) Sawing wood into discs about 1 inch thick.

(b) Grinding and dissecting the discs into fragments about 1/24 inch by 1 inch in size.

(c) Packing the material into perforated iron boxes which are placed in digestors containing a solution of caustic soda.

(d) Boiling the wood for four hours under a pressure of 125 pounds.

(e) Grinding between stones.

(f) Repeated washing and sifting.

(g) Bleaching with chlorate of lime and washing.

(h) Taking up mass by endless rolls of cloth and drying it between heated rollers.

(i) Reclaiming caustic soda by boiling and melting.

III. Sulphite process.

Same as the soda process, excepting points "c," "d" and "g."

The wood fibre is first cooked without chemicals and then boiled for 60 hours with calcium sulphite—a cheap chemical usually prepared at the mill itself.

No or only little bleaching is required, the fibre being free from color when leaving the digestor.

The expense of manufacture per ton of sulphite fibre is said to be as follows:

Two tons of spruce	$ 9.00
Coal	3.00
Sulphur	3.30
Lime	.70
Labor inclusive of office force	7.00
Wear and tear	2.50
Total	$25.50

These figures may seem to be unusually high.

The sulphite process offers the following advantages:

(a) It is cheaper (no bleaching, cheap chemicals).

(b) It does not interfere with the strength of the fibre.

(c) It yields a larger output of fibre per cord.

Hence the sulphite process is rapidly superseding the soda process. Exception in poplar.

IV. Sulphate process.

It is adopted in mills originally arranged for caustic soda process. The chemical used is sodium sulphate, the price of which is only one-third that of caustic soda. It is reclaimed out of its watery solution by evaporating and melting. This process gives the old soda mills a new lease of life which were about to be forced to the wall by the superiority of the sulphite process.

V. Electric process.

The electric current is used to obtain from an 8% solution of common salt (Na Ci) its composing parts, viz., caustic soda and hydrochloric acid.

These substances, alternatingly acting upon the wood prepared in the manner described under II, a, b, and c, dissolve the lignin and destroy the incrustations of the fibre, so that pure cellulose remains in the digestors.

Two digestors are used, connected with the positive and the negative electrode of the current respectively.

The process is said to be faster and cheaper than the sulphite process. No bleaching required.

§ XXXII. TANNING MATERIALS AND TANNERIES.

A. Tanning materials.

Tanning materials used in the United States were in 1900:

Hemlock bark, 1,170,000 cords.
Oak, 445,000 cords.
Gambier, 128,000 bales.
Hemlock bark extract, 13,000 barrels.
Oak bark extract, 54,000 barrels.
Quebracho bark extract, 20,000 barrels.
Sumac bark extract, 8,500 barrels.
Chemicals, $2,225,000 worth.

In the sole leather, belt leather and harness leather industries, vegetable tanning material is still preferred. Mineral or chemical tannage, however, has been developed during the last ten years to a degree threatening to entirely supplant the old methods.

Since 1900, extracts obtained from chestnut wood have gained both favor and importance.

B. Tanbark in particular.

I. Notes on tanbark.

(a) The corky layers of bark do not contain any tannin and are usually shaved off. In Europe, young oak bark not having any cork is preferably used.

(b) Fresh bark contains on an average 45% water and shrinks heavily during the drying process.

(c) While oak bark must be peeled in spring immediately when the sap begins to rise (April-May), hemlock bark may be peeled at any time from May to September.

(d) Bark peeling season for oak is from early April to the end of June. Trees in the bottoms peel earlier than those higher up.

The bark on the uphill side of a tree is thinner than the bark on the downhill side.

Trees exposed to the weather, isolated, on unprotected slopes, have short boles but a heavier bark than those growing under the reverse conditions.

Dying trees will not peel.

II. Peeling process.

(a) Girdle the tree about four feet above the ground; remove bark from stump and roots; fell the tree in such a way as to leave the bole well raised above the ground.

(b) Notch (with axe) a line along the tree and rings around the tree every four feet. Have two men with "spuds" peel the ringed sections, and see that the pieces peeled are as wide as possible and, as near as possible, four feet long. Large pieces will dry well and will save expense in handling. Handling costs more than peeling.

(c) Lean the peeled pieces against the felled bole, preferably flesh side out, as high above ground as possible, and see that the air circulates freely around them.

(d) See that the bark is as little shaded as possible. Peel before leaves are out. Never leave bark to dry in a moist gully.

(e) Toward evening, turn the flesh side of the bark toward the object supporting it so as to protect it from dew. The expense of "curing" is so high, however, and the danger of spoliation by rain so great, that bark is now usually placed at once "bark side out."

(f) Pile the bark after two to three days, provided it is not wetted, close to the tree in loose piles. These piles are left for weeks in the woods. Bark is sure to mold if a rainy season sets in. Free access of air greatly reduces the danger of damage.

(g) Finally sled the bark, by hand sleds, cattle or mules, over rough trails (best grade is about 20%) to the wagon roads, to be removed to tannery or railroad.

III. Remarks.

(a) The minimum diameter of trees and branches peeled depends on the price of bark and the price of stumpage. At the present time, far from the tannery, it does not pay to peel pieces of less than 10 inches diameter.

(b) The expense of the harvest of oak bark is per cord:

Roads, 45c; felling, 27c; peeling, 57c; piling, 72c.

On the average a man will peel per hour from 0.3 to 0.38 cord.

(c) Tannin percentages of dressed bark are, after Sargent:

Mangrove	30 %	Burr and red oak	4.6%
Sumac	18 %	Chestnut	6.7%
Sassafras root	58 %	Douglas fir	13.8%
German oak	14 %	Eastern hemlock	13.1%
Cal. Chest. oak	16.5%	Western hemlock	15.1%
Live oak	10.5%	Eastern spruce	7.2%
Chestnut oak	6.2%	German spruce	8 %
Spanish oak	8.6%	German fir	6 %
Black oak	5.9%	Larch	7 %
White oak	6 %	Birch	4 %

C. Wood extracts in particular.

I. Tannin extracts are manufactured from bark, chestnut wood, quebracho, mangrove and oak. Quebracho wood contains 24% of tannin; chestnut wood 14% (?) of tannin.

II. The wood is shredded in a chipper and the tannin extracted (not entirely) by steam or hot water under pressure. The liquid obtained is condensed.

III. While in France the sappy branches and young shoots of chestnut are preferred, in America the heart wood and especially the butt is preferred.

IV. The wood is cut 4 feet to 5 feet long. The leather trust uses a cord of 160 cubic feet = 1¼ cords of 128 cubic feet.

V. Clear water, cheap transportation and cheap fuel are required for successful manufacture.

Only sound wood is used; wormholes in chestnut, however, do not interfere with its value.

VI. Extracts exposed to air or exposed to heat spoil rapidly.

VII. Extracts are shipped in barrels of 56 gallons capacity or in tank cars.

VIII. The price of chestnut extract is 1½c to 2c per pound. At a price of 1½c, extract is cheaper than oak bark at $6 per cord.

IX. One cord of chestnut wood yields 500 pounds of extract containing about 25% tannin.

D. The methods of tannage employed nowadays are:

I. Tanning by means of aluminum salts.

II. Chamoying by means of certain oils or acids of oils.

III. Tanning by salts of chromium.

IV. Vegetable tanning, using the wood of quebracho, chestnut and oak; the bark of various oaks, hemlock, spruce, douglas fir, birch, larch, willows; fruits, cups and galls, i. e., divi-divi, catechu, myrobalans; further, the leaves of sumac. Instead of using these vegetable matters, their watery extracts frequently are applied.

E. Object of tanning.

Tannage tends to render the skin permanently supple and durable by impregnation with tannin. Aside of the mechanical imbedding of molecules by impregnation, a chemical action (fermentation) may take place in the case of bark tannage, due to the presence of microbes in the bark, chemically binding the tannin to the albumen and gelatine of the skin.

F. Criteria of a good method of manufacture are:

I. The weight of the leather produced. Since leather is sold by the pound, the tanner tries to press into the hide the maximum amount of tannin, tannin being much cheaper than hides.

Beyond a certain point, this extravagance of impregnation fails to increase the wearing qualities of leather and is therefore useless to the buyer.

II. The color of the leather produced and the adaptability of the leather for coloring.

III. The possibility of tannin being washed out through wear and tear. From chromium tanned leather even a boiling process will not remove the tannin.

IV. Quickness in filling orders and amount of capital required.

V. Cheapness of manufacture. The best leather is produced slowly only by use of materials rather poor in tannin.

G. Statistical notes.

I. One ton (2,240 pounds) of hemlock bark will tan 300 pounds of sole leather or 400 pounds of upper leather; 4 to 5 pounds of good oak bark are required to produce 1 pound of sole leather.

One acre of hemlock wood is said to yield about 7 cords of bark, and 1,500 board feet of timber are said to carry one cord of bark.

One acre of hardwoods will yield on the average not over one-half cord of chestnut oak bark.

One cord of chestnut wood yields one barrel of extract.

II. The price of bark at the tanneries ranges from $4 to $16 per cord. The cord of bark is not measured, but is weighed, 2,240 pounds being called a cord.

The price of a cord of chestnut wood f. o. b. cars is $2.50 to $3.

III. One hundred pounds of dry hides yield 150 to 185 pounds of leather; 100 pounds of green hides yield 60 to 80 pounds. The cost of the hide amounts to from 50% to 75% of the cost of production.

IV. The number of tanneries in the United States has greatly decreased from the year 1880 (5,628 plants) to 1900 (1,306 plants). The small tanneries using old fashioned and wasteful methods have been killed by the large and intelligently conducted modern plants. The leather trust controls over 100 of the largest plants.

The investment of capital has increased from $73,000,000 in 1880 to $174,000,000 in 1900.

The cost of raw material, $155,000,000, and the value of the product, $204,000,000, have remained almost unaltered during the same period.

V. "Hides" are obtained from oxen, cows and horses; "kips" from yearling cattle; "skins" from calves, sheep, goats and pigs.

Calf skin is used for upper leathers of shoes; sheep skin for cheap shoes, linings and gloves; goat skin for fine upper leathers and gloves.

Hides often are split and the so called grain and flesh splits are used in place of goat and calf skin.

H. Manufacture.

The old fashioned methods used from time immemorial consisted of rinsing skins; scraping off the flesh; treating the hair with lime; placing alternating layers of crushed oak bark and of skins in rough vats. The time consumed in this process of manufacture frequently exceeded a year. The best leather, however, is produced in this way.

The modern process in manufacturing sole, belt and harness leather is:

I. Soak in soft water (heated to less than 70° F.) to remove salt and blood and to restore the original softness and pliability of the skin.

II. Loosen hair by either liming green hide in milk of lime for three to six days or sweating dry hides at 70° in a close room, inviting a partial decomposition of the hair sheath. The sweating is preferred for acid hemlock tannage.

III. Remove on the "beam," by hand or machine, flesh, hair, blood, lime, dirt.

IV. Prepare the liquors in the leech house The liquors contain often from 5% to 6½% of tannin only. Cold water extracts only part of the tannin from either bark or wood. Very hot water may extract all, extracting with it, however, undesirable coloring matters and killing the fermenting microbes.

V. The tannage itself is either "Acid hemlock tannage" or "Non-acid hemlock, oak and union tannage."

(a) Acid hemlock tannage consists of:

1. Coloring in a dilute solution of tannin.
2. Placing skin for 2 to 4 days in a sulphuric bath (of 10% to 30%) by which the hide is swelled to a great thickness.
3. Placing the hide in a strong, concentrated solution of tannin.

(b) Non-acid hemlock, oak and union tannage (2-3 hemlock, 1-3 oak bark):

1. Treat the hide, to begin with, with very weak solutions of tannin.
2. Gradually increase thereafter the concentration of the liquors. If a hide is at once hung in a strong liquor, its outer layers only are tanned. The hide will not swell, and the inner layers will fail to be impregnated.

VI. The operations finishing the process of manufacture are: Washing; scouring off the so called bloom; stuffing (which means bathing in grease); drying; dampening and rolling under pressure; redrying; glossing on a brass bed by brass rollers.

§ XXXIII. CHARCOAL BURNING IN CHARCOAL KILNS.

A. Distillation of wood.

Destructive distillation of wood, under reduced admission of air, yields chemically the following proportion of substances:

I. 25 % of non-condensable gases, viz.:

carbon monoxide	acetylene
carbon dioxide	propene
marshgas	ethylene

II. 40% of condensable vapors, viz.:

acetone	formic acid
furfurol	butyric acid
methyl alcohol	crotonic acid
methylamine	capronic acid
acetic acid	propionic acid

III. 10% of tarry liquid, viz.:

tar	cresol
creosote	phlorol
toluol	naphtalene
xylol	pyrene
cumol	chrysene
methol	paraffin

IV. 25% of solid residue, viz.:

charcoal	inorganic salts

B. The kiln process.

In the kiln process of destructive distillation of wood, all of the above substances are allowed to escape unused, excepting the solid residue.

Modern technology succeeds in catching and utilizing several of the substances given under II and III, as appears from Section XXXV.

Still, the large majority of the charcoal commercially used is produced by the old and wasteful charcoal kiln.

C. Characteristic qualities of charcoal.

I. Charcoal has per cubic foot a larger heating power than wood.

II. Owing to its lesser weight, it is very cheaply transported.

III. Its freedom from sulphur and phosphates makes it valuable for metallurgic work (Swedish charcoal iron).

D. The work at the kiln.

I. For use in kilns, wood must be thoroughly seasoned, free from heavy knots. The billets must have equal length.

The kilns should be charged with one species and one assortment of wood only at a time.

II. The work consists of:

(a) Preparation of ground near water by leveling and hoeing the soil, by removing roots and stones, by raising the center of the circle to be occupied by the kiln about 10 inches over its circumference.

The diameter of the circle is from 15 feet to 30 feet usually. The best soil is loamy sand, which secures proper regulation of the draft.

The site should be protected from wind. Twigs are woven into a wind screen on the windward side, if necessary.

(b) Erecting the "chimney" by placing three or four poles of even height at one foot distance from a center pole, fastening them together to the central pole by withes.

The chimney is cylindrical if kiln is lighted from above, pyramidal if kiln is lighted from below.

The chimney is filled with inflammable substances (dried twigs etc.).

(c) Constructing the kiln proper.

The kiln should have a parabolic form. It consists of two or more tiers of billets placed almost vertically, the bark turned outward, the big end downward, the finest pieces near the chimney and near the circumference, the largest pieces half way between.

These tiers are topped by a cap, consisting of smaller billets placed almost horizontally. A cylindrical chimney extends through the cap A pyramidal chimney is closed by the cap.

In the latter case a lighting channel is left on the ground running radially on the leeward side from the bases of the pyramidal chimney to the circumference. This channel, too, like the chimney, is filled with easily inflammable material.

(d) Stuffing all irregularities, interstices, cracks etc. showing on the outside of the kiln with small kindling.

(e) Covering the kiln by two draft-proof layers so as to exclude or restrict the admission of air.

1. The green layer, ½ to ¾ feet thick, made of green branches, grass, weeds and moss.
2. The earth layer, 4 inches to 6 inches thick, consisting of wet loam, charcoal dust etc.

   If kiln is lighted from below, a belt about 1 foot high running around the circumference on the ground is left without earth cover until fire is well started.

   The earth layer and the green layer are thoroughly joined by beating with a paddle.

   In large kilns a wooden frame (the armor) consisting of T sections is used to prevent the cover from sliding down.

III. The kiln is lighted early in the morning on a quiet day. The cylindrical chimney is stuffed up with wood from above and then closed on top by heavy covering after the fire is well started in the cap.

The lighting channel, in the case of a pyramidal chimney, is similarly stuffed and closed.

IV. The regulation of the fire and of the draft are the most important functions of the attendant who guides the fire evenly and gradually from the cap down to the bottom.

The means of guidance are:

(a) To check draft, increased earth cover.

(b) To increase draft, holes of about 1½ inches diameter punctured through the cover with the paddle reversed.

If wind is strong, all holes are closed and earth cover increased.

Cracks forming in the cover must be closed at once.

In dry weather the kiln is continuously sprinkled.

The kiln may explode if cover is too heavy and draft too strong.

The color of the smoke escaping through the punctures indicates the completion of the charring process above the holes (transparent bluish color).

The holes are then closed, and another row of punctures is made about two feet below the closed holes.

V. Refilling is required where dells are forming irregularly, while the kiln gradually collapses to half of its original volume.

For refilling, the cover over the dell is quickly removed, all holes having been closed beforehand, and the dell is rapidly filled with fresh wood.

VI. When the bottom holes show the proper color of smoke, the charring process is completed. All holes are then closed and the kiln is allowed to cool.

The duration of the charring process is from six days to four weeks, according to size of kiln. The contents vary between four and sixty cords.

VII. The kiln is gradually, beginning at the leeward side, uncovered, and the crust of earth, after hoeing, is thrown on again. The earth, trickling down, quenches the fire. After another twelve to twenty-four hours, preferably at night, the coal is taken out in patches.

Water must be ready at hand, since fire usually breaks out when coal is drawn.

E. Statistical notes.

The loss of weight in the charring process is 75 %.

The loss of volume is 50 %.

In America charcoal is sold by the bushel, a bushel weighing about 25 lbs.

F. Appendix.

In Norway, Sweden and Russia kilns of trapezium form are built of peeled logs 15 to 30 feet long.

The lighting channel runs lengthwise on the ground.

The kiln is lighted at the narrow end and covered with green branches and earth in the usual manner.

The side walls being almost perpendicular, the cover is held in place by slabs spliced against the walls. No refilling is required.

Fire is conducted from the top of the kiln at the big end toward the bottom of the kiln at the little end.

The process lasts six to eight weeks.

The billets are placed horizontally, skidway fashion, the largest billets being put in the center and the smallest at the head and at the foot of the kiln.

§ XXXIV. LAMPBLACK AND BREWER'S PITCH, AND THEIR MANUFACTURE.

The former is used in the manufacture of patent leather; the latter for pitching beer barrels.

A. Raw material is spruce rosin.

B. The process consists in a combined melting and pressing of rosin. The brewer's pitch runs out through a pipe connecting the bases of the melting vats with a cooling vat.

C. The solid residue remaining in the vats is slowly burned in an oven. The smoke passes through a cool room and into a smoke room, the top opening of which is covered by a common bag. In this room pine soot or lampblack is deposited. The draft is regulated by the attendant according to the shape or bulge which the bag assumes under the influence of the smoke.

D. Some turpentine can be derived at the same time if the vats are closed air tight and if the escaping gases are condensed in a worm.

§ XXXV. PYROLIGNEOUS ACID, WOOD (METHYL) ALCOHOL, AND THEIR MANUFACTURE.

A. Raw materials: These are, preferably, broad leafed species—beech, birch, maple—which must be thoroughly seasoned.

Heavy stuff is preferable, it is said, to small stuff.

B. Distillation: The process consists in a dry distillation of the wood, differing from the charcoal kiln process merely by allowing the gases to condense.

The distillation takes place in large horizontal iron cylinders, usually about 10 feet long by 5 feet in diameter, into which the wood is run on steel trucks. After closing the cap of the cylinders (admission of air reduces the output of pyroligneous acid) the cylinders are slowly heated to a redhot. The gases forming are led through long worm pipes into a condenser.

Not all of the gases formed allow of condensation. The uncondensable gases are conducted to the fire room.

At the bottom of the cylinder, tar is forming and is let out by a system of pipes into a collecting basin. Conifers yield more wood tar than hardwoods.

C. Further treatment.

The gases, condensed to a liquid a large proportion of which is water, are then treated with lime. Lime neutralizes the pyroligneous acid, forming acetate of lime.

The liquid is then redistilled, wood alcohol going over first, water next. The residue is boiled down in open pans to the consistency of a sugar, the acetate of lime of commerce. From it acetic acid and its salts are derived in chemical works.

D. The output.

One hundred volumes of air dry wood furnish up to forty-eight volumes of pyroligneous acid.

One and three-quarters cords of beech yield 2,650 pounds of liquids, 25 gallons of tar and 700 pounds of charcoal.

The 2,650 pounds of liquids furnish 200 pounds of acetate of lime and 9 gallons of 82% wood alcohol.

E. Use: Acetate of lime is used by the chemical industry in the manufacture of acetic acid and of the salts of acetic acid.

Wood alcohol is used largely in the manufacture of varnishes, dyes, celluloid and especially for heating. It is poisonous.

§ XXXVI. TRUE OR AETHYL ALCOHOL AND ITS MANUFACTURE.

A. Principle underlying the process.

Wood boiled under pressure in the presence of acids yields sugar (dextrose). This sugar, freed from the acid admixed, is allowed to ferment under the influence of yeast and changed into aethyl alcohol.

B. Raw material:

Cottonwoods, linden, yellow poplar are said to be superior to the heavy hardwoods as well as to conifers. Possibly chestnut wood, from which the tannin is withdrawn in tannin extract factories, may answer as a raw material. Unless sawdust is available, the wood is prepared, sawed and pounded as if it were to be used in the manufacture of chemical fibre.

C. Process:

The acid used does not enter into any chemical combination with the wood. It merely acts by its presence and is said to be most efficient when in statu nascendi. Sulphuric acid, sulphurous acid, hydrochloric acid or a mixture of these and similar acids are used.

The temperature of the lead-coated vats containing acid and wood is gradually raised to about 250° F. Hydraulic pressure is also applied, either before or after the boiling process. As a matter of fact, the partial conversion of cellulose into starch seems to be due to pressure—not to boiling. The acid is then neutralized and the temperature reduced to about 85° F. By the addition of yeast (fed on phosphates of potash and of ammonia) a violent fermentation of the sugar is started, ending within thirty-six hours, when the yeast has dropped down to the bottom of the vat while the sugar has been converted into alcohol.

The liquid is distilled and redistilled, yielding alcohol of any desired concentration.

The wood remaining—only 20% of its weight seems convertible into sugar—might be used for paper manufacture or as fuel for the boilers. Classen claims, after his methods, to obtain at least 30% dextrose from absolutely dry wood.

D. Output.

One hundred pounds of dry wood are said to actually yield about 5 pounds of 96% alcohol. The process of manufacture is far from being perfect. A number of chemists, notably Classen, are hard at work to further improve and to cheapen the process. Cheap alcohol—a fuel, a source of light and a source of technical energy—manufactured from wood will be a boon for household, industries and forest.

§ XXXVII. ARTIFICIAL SILK MADE FROM CELLULOSE.

A. History.

Artificial silk was first prepared by Hilaire de Chardonet in 1884. Today many patents and numerous factories to exploit them exist in the old country.

B. Process.

There are two main processes in use, namely:

I. A solution of nitrocellulose, a compound of nitric acid and cellulose in ether or alcohol, is pressed through minute capillary pipes, appearing in long, silky threads. Additional chemicals (methods of Vivier, Lehner) reduce or entirely destroy the inflammability of the product.

II. Pure cellulose is readily dissolved in a few chemicals only,notably in concentrated copper oxide dissolved in ammonia. This solution forms a waxy mass which is pressed through minute capillary openings and appears in the form of supple, long, silky threads, immediately entering a bath of sulphuric acid. Here cellulose is set free, now a solid thread, while blue vitriol and sulphate of ammonia result at the same time. The threads are spun exactly like threads of natural silk.

C. Qualities of product.

Artificial silk has an exquisite shine and is easily colored before the pressing process. The tearing strength of silk obtained from nitrocellulose, however, is now only 33% of that of true silk, its toughness only 45%.

Artificial silk is used on a daily increasing scale in silk weavings. New methods and modifications of manufacture continuously increase its chances as a substitute for natural silk.

§ XXXVIII. MANUFACTURE OF OXALIC ACID FROM WOOD.

A. Principle.

Any wood heated to about 400° F. in the presence of caustic substances yields, among many other products of disintegration, a goodly percentage of oxalic acid.

B. Raw material.

Any wood finely ground or pulverized, and especially sawdust and mill refuse, is well adapted to the process—oak as well as beech, pine, chestnut etc. Cottonwood is said to be rather poor as a raw material.

C. Process.

A mixture of caustic soda, caustic potash and sawdust is heated, under continuous stirring, in open pans (½ foot deep and 6 feet square) by superheated steam or air. The temperature is gradually raised to 480° (not over) F., remaining at that figure for about 1½ hours. The melted mass, consisting of oxalate of sodium and of carbonate of potassium, is thrown into water and allowed to cool, when the oxalate forms a dough of minute crystals. This dough is freed from water by centrifugal power, then treated with lime and thereafter with sulphuric acid, with the result that gypsum is precipitated from a solution of oxalic acid.

D. Output.

One hundred parts of wood yield up to 80 parts of oxalic acid.

The quantity of output depends on proper mixture of caustic soda and potash, and on proper regulation of the temperature.

§ XXXIX. THE MAPLE SUGAR INDUSTRY.

In the sap of all broad leafed species considerable quantities of sugar are found. This quality is commercially important, however, only in the case of hard maple. In 1900 there were produced 51,000,000 pounds of maple sugar and about 3,000,000 gallons of maple syrup.

New York, Vermont and New Hampshire lead this industry. Seventeen percent of all granulated sugar made in the United States is obtained from the maple tree.

Vermont protects its maple sugar industry from counterfeits by State inspection and official stamp.

A. Tapping the trees.

I. Time. End of January and February is best.
Cold nights and hot days necessary for best results.

II. A hole is made, with an auger, ½ inch to ¾ inch in diameter, slightly slanting towards the entrance, to a depth of 2 inches to 8 inches, at a point 2 to 3 feet above ground. Holes on north side of tree said to be most productive. Holes 10 feet above ground do not yield any sap.

III. A wooden or galvanized iron spout (3 to 8 inches long with a hook at the end to suspend the bucket) is inserted into the hole.

IV. Buckets are emptied at least daily, as the sap ferments easily. The sap, poured into large tanks resting on sleds, is quickly taken to the sugar shed. Buckets must carefully be kept clean.

V. Production per tree is 4 lbs. of sugar per season. The season lasts not over a month. The trees are not affected by tapping, either in quality or vitality. A new hole is made every year.

B. Boiling process.

Immediately after gathering, the sap is boiled down in open pans.

I. Manufacture of sugar.

Syrup is boiled to the consistency of wax, poured into forms and stirred to prevent formation of large crystals. Crystalization takes about 12 hours. Fifty quarts of sap yield 2 lbs. of sugar.

II. Manufacture of syrup.

The sap is boiled down to a lesser consistency and at once canned or bottled.

§ XL. NAVAL STORES, THEIR PRODUCTION AND MANUFACTURE.

A. Statistics.

In 1902 the United States produced 600,000 bbls. of turpentine worth $13,200,000; 2,100,000 bbls. of rosin or colophany worth $4,200,000.

One acre of orchard yields in three years' tapping 25 gallons of spirits of turpentine, worth $8, and 800 pounds of rosin worth $4, at a labor expense and manufacturing expense of $10. Thus a profit of $2 per acre is left to the owner.

Orchards are leased actually at $1 to $2 per acre for three years.

B. Methods of orcharding.

I. Southern method (also Austrian method).

(a) Species used: Longleaf pine (used now down to 8 inches in diameter); Cuban pine; echinata (small trees preferred); after W. W. Ashe, also Taeda; in Austria, Pinus Austriaca.

(b) Operations of the first season:

1. Boxing: The tree is cut into, 8 inches above ground, with a narrow, thin-bladed "boxing axe." Usually two boxes to a tree, on opposite sides. Width of box is 14 inches; depth horizontally 4 inches, vertically 7 inches; height of the tip above the lip about 10 inches. Boxing takes place in January and February.

2. Cornering: Immediately after boxing the tree is "cornered." Cornering implies the removal of two triangular strips of bark and sapwood above the

box, running as high as the tip. The resulting grooves act as gutters for the rosin.

3. Hacking: Hacking or chipping begins in early March and is continued until October. The "hack" is a bent-bladed, sharp instrument which is used obliquely across the tree, producing a series of V shaped grooves in the outer layers of sapwood above the box and the corners. The points of the Vs stand in a vertical line over the tip. The surface thus scarified is called a face. The chipping removes ½ inch of sapwood. The face of the first season is from 18 inches to 24 inches high and always remains as wide as the box.

4. Collecting: The virgin dip accumulating in the box during the first season is dipped out seven or eight times; the rosin, hardened on the face, is scraped off.

(c) Operations of subsequent seasons:

In the following seasons, the face is gradually carried upward until the working becomes unprofitable.

The output of dip, now called yellow dip, decreases from year to year, with the increase of distance between freshly hacked face and box. The scrape preponderates over the dip.

Longleaf pine may be tapped for an indefinite number of years, if intermissions of a few years permit the trees to recuperate.

II. French method (Hugues system).

(a) Species used: Pinus maritima, which grows on the sand dunes fringing the western shore of France, is exclusively treated to this method.

(b) Operations:

1. Remove the rough bark around the tree to prevent pieces of bark from falling onto the face.

2. In early March make a scar close to the ground 4 inches wide and 1¼ feet high, removing 2/5 inch of sapwood. The instrument used is a bent-bladed, crooked-handled axe.

3. Insert a toothed collar, made of zinc or

iron, into an incision cut with a sharp curved knife at the bottom of the scar.

4. Hang a glazed earthen pot on a nail immediately under the lip of the collar. The pot is 5½ inches deep, 5½ inches wide at top and 3 inches wide at bottom.

5. Extend the 4-inch scar week by week upward until October, taking each time a thin layer of sapwood off the old face. The final length of the face reached in a number of years is up to 30 feet.

6. The collar and cup are moved each spring to the top of the preceding year's face.

The nailhole in the pot allows rainwater to run off, since water is lighter than crude rosin.

The pot is often covered with a wooden lid, the face itself by rough boards.

III. Dr. Charles H. Herty's gutter method.

(a) Applicability:

The method can be applied to bled or unbled trees. It has been tried by the Bureau since 1902 in the Southern pineries.

(b) Operations of the first season:

1. Use cornering axe to provide two flat faces 8 inches above the ground forming an angle of about 120°; each is half as high as long; total width about 14 inches. Two men, right and left handed, cut 3,000 faces per day.

2. Make incisions at base of faces, one at least an inch higher than the other. Tool used is a broad axe having a 12-inch straight blade.

3. Insert galvanized sheet iron gutters into the incisions. Gutters are 2 inches wide and 6 inches to 12 inches long, bent to proper form (angle 120°) by a tilting-bench contrivance. The lower gutter projects by 1½ inch over the mouth of the upper, the projection forming a spout.

4. Fasten an earthen cup of a capacity equaling that of a box (5½ in. x 3½ in. x 7 in.) on the side of the upper gutter in such a way that its rim stands ½ inch below the spout, and that the nailhole is as far as possible from the spout. The

naillhole should be two inches below the rim of the cup.

5. Chipping as in method I; cups emptied from time to time into collecting buckets.

(c) Operations of subsequent seasons:

Next season, the uppermost chipped channels are used for the insertion of the gutters. The cup is fastened at the upper end of the face made in the previous year.

(d) Equipment:

Equipment required for 10,000 boxes is: 10,500 cups (cost 1¼c each = $131.25); gutter strips made from 1,886 pounds of galvanized iron, 29 gauge (cost of material $103.27; cutting and shaping gutters cost $4); 10,000 six-penny nails (costing $1.05); freight charges are about $30; labor at the trees requires an outlay of $80.

(e) Results:

Dr. Herty justly claims financial superiority of this method over the old Southern method, due to an increased output of turpentine.

C. Manufacture of naval stores from pine products.

I. From rosin of longleaf pine etc.

(a) Melting crude rosin in order to separate from the liquid constituents pieces of bark, wood and a pitchy residue.

(b) Dry distillation of the latter in a copper distilling apparatus, heated usually from an open fire beneath the apparatus; but preferably from steam of high temperature.

(c) Cooling of gases in a worm and condenser where there are obtained:

1. An upper layer of turpentine which is redistilled.
2. A middle layer of rosin (colophany) of a light yellow color, which is sifted repeatedly into different qualities.
3. Water forming the lowest layer.

II. From roots, branches and stumps of pine, the stumps to be dug out a few years after the trees are cut.

(a) Cut the wood into kindling.

(b) Fill it (from above) into a gasproof brick still-room, 15 feet high and 6 feet through, holding from 5 to 6 cords of kindling. The top and bottom of the still are funnel shaped and provided with pipes. The still is surrounded by the fire room.

(c) After closing the upper funnel, apply heat very gradually. Within 24 hours turpentine begins to escape through the top pipe which leads through a worm into a condenser. When the gases appear dense and thick, the top pipe is closed and the gases (now largely containing pyroligneous acid) are forced through the bottom pipe to be condensed in another condenser. Light (at a later stage dark) tar is let out through this same pipe. The fires are checked when the tar begins to flow freely.

(d) The process takes, for heating, 3 days; for cooling, 8 days. Charcoal is left in the still room. Proper regulation of temperature is most essential.

(e) One cord of pine kindling yields about 25 gallons of tar, 1 to 1½ gallons of machine oil, ½ to 1 gallon of turpentine, some pyroligneous acid and ½ cord of charcoal.

III. Uses of naval stores:

(a) Spirits of turpentine are used for colors, paints, varnishes, asphalt laying, solvent for rubber.

(b) Colophany is used for glue in paper manufacture, varnishes, soap making, soldering, manufacture of sealing wax.

(c) Wood tar made of conifers is lighter than water (owing to spirits of turpentine therein contained); made of broadleafed is heavier than water. It contains tolnol, xylol, cumol, naphtalin, paraffin, phenol, kreosol, pyrogalol and many other carbohydrates.

Caustic soda causes the solution of the aromatic alcohols contained in wood tar. From this solution true creosote is derived.

Dry distillation of wood tar yields:

1. Light wood oil;
2. Heavy wood oil;
3. Shoemaker's pitch, a residue.

D. Conifers other than pines are used only to a limited degree in the manufacture of naval stores.

(a) The larch yields the so-called venetian turpentine, which is obtained by boring (with 1½ inch auger) a deep hole into the heart of the tree. The hole is closed by a plug. After a year the turpentine, entirely filling the hole, is extracted.

(b) Spruce was tapped for turpentine on a large scale in the old country before the orchards of the South were developed. Only scrape is obtained from long and narrow faces. The scar invites red rot, badly checking the value of the timber. The output in ten years is, per acre, 73 lbs. of crude spruce rosin.

(c) Fir has rosin ducts only in the bark. Blisters or bubbles of the bark filled with rosin yield the so-called "Canada balsam" and "Strassburg turpentine," collected in tin cans. The blisters are opened with the rim of the can.

§ XLI. VANILLIN.

Vanillin, a substitute for vanilla, which has caused the price of bean vanilla to decline rapidly and permanently, is obtained from spruce (fresh cut) by removing the bark and collecting the sap either with sponges or broad-bladed knives. The sap is then boiled, strained and condensed in the vacuum pan to one-fifth of its former volume.

In the cooling room, crystals of coniferine are formed from the syrup. Coniferine, when treated with potassium bichromate and sulphuric acid, is oxydized into vanillin. The syrup obtained as a by-product is distilled and used in the manufacture of alcoholic beverages.

Eighty gallons of sap yield one gallon of coniferine.

§ XLII. BEECHNUT OIL.

Mast years of beech occur, according to climate, every 3 to 8 years. The nuts are gradually dried, slightly roasted, peeled and cleaned of shells; then either ground, applying moderate heat, or pounded in mills by stampers. The oil oozing out is strained and placed in a cool room (in earthenware vessels), where the clean oil forms a top layer to be poured off gradually.

The residue is pressed into cakes and used as feed for stock.

Two hundred pounds of dry beechnuts yield 5 quarts of oil.

§ XLIII. PINE LEAF HAIR.

Pine leaf hair, or curled pine straw, is used as a substitute for wool and cotton in upholstering, carpets etc. The stuff is mothproof.

Three hundred to 400 pounds of needles yield 100 pounds of wool.

The price is $3 to $12 a cwt., according to the quality.

A by-product is known as pine needle extract, used by the perfumer.

The process of manufacture consists of:

Drying the freshly cut needles; steaming; fermentation; crushing and disfibreing in pounding mills; repeated washing of the feltlike mass; loosening on sets of oscillating sieves; drying and bleaching. The product has a greenish or yellowish color. It is called "pine hair" in North Carolina, where the industry, now extinct, promised a successful career twenty years ago.

§ XLIV. IMPREGNATION OF WOOD.

Impregnation tends to increase the durability of wood by injecting an antiseptic liquid and may mean a desirable or undesirable change of color, and in some cases fireproofing. Little is known about the latter.

Four principles may be applied:

A. Immersion:

I. The oldest method used was immersion in a strong solution of salt. European railroads place ties for eight days in large tanks filled with a light solution of corrosive sublimate. No other work required. The method is called "Kyanizing." Drawbacks are that the liquid is washed out on wet ground; that spikes do not hold well in the timber. Expense per cubic foot, 6½c.

II. "Metalized" wood is obtained as follows:

Immerse the wood in a solution of sulphate of iron; then smear the wood with chloride of calcium. In the outer layers of the wood gypsum (sulphate of lime) is formed together with chloride of iron. Such wood is impermeable to water and has a metallic shine.

B. Boiling:

I. Boiling in salt water or in a solution of borax seems to be a method rarely practiced. Boiling, however, with exhaust steam, when a black juice is forced out of the log, is frequently seen abroad.

In the latter case the log is practically steam dried.

II. "Franks" mixture consists of 95 % liquid manure and 5 % of lime. It is pumped into large vats, within which the wood is boiled for 3 to 8 days. The liquid enters to a depth of about 3 inches and darkens the wood to a mahogany tint.

III. A method called "siderizing" injects by a boiling process a solution of copperas. The wood is then dried, and liquid glass (a hot solution of silicate of aluminum) smeared on the surface. By a chemical reaction silicates of iron are formed in the outer layers, which are insoluble in water and resist decomposition. The wood at the same time obtains a beautiful gloss.

C. Use of hydrostatic pressure:

A solution of sulphate of copper (blue vitriol) is used after Boucherie. It is kept in a tank 30 ft. to 40 ft. above ground. The timber must be fresh cut with the bark on and is spread on a rough log-deck. At the big end of each stick a ring made of rope is held in place by a board or heading nailed to the log. A hose connected with the tank injects the liquid into the small cleft formed between log and heading. After a few hours, drops of vitriol appear at the small end, showing that the process is complete. The pressure being slight, only the outer sappy layers are impregnated. This method is largely used abroad, often in the woods themselves, for telegraph poles of pine, spruce, fir etc. Expense per cubic foot, 4c.

D. Use of steam pressure:

The wood is dried thoroughly, then placed on small steel cars running into long cylinders or boilers, closed by a strong head. A vacuum pump removes the sap water and causes a vacuum to form in the wood itself. Then an antiseptic liquid is pressed into the boilers; temperature of liquid is 150° to 200°.

The liquids used are:

(a) Chloride of zinc.

(b) Creosote or rather cheap coal tar oils.

(c) Gases of tar oils (so called thermo-carbolization).

The creosoting method is used for ties and paving blocks. Creosoted timber holds nails well; creosote is not washed out by rain; on the other hand, the darkened color of the wood is sometimes objectionable. It is claimed that creosoting in the United States has failed, probably because an extravagant amount of the liquid has been pressed into the timber. In Germany the expense per tie is only 63c as against $1.25 in the United States.

E. Results:

Heart wood is not as permeable and hence not as impregnable as sap wood. Maple, birch, beech, spruce, sappy pine etc. are more benefited by impregnation than white oak, longleaf pine etc. Generally the duration of life of impregnated ties is increased at the following ratio: Beech, 400%; yellow pine and oak, 200%; spruce, 50%.

Obviously, every additional pound of preservative pressed into the fibre has a lesser effect on the lastingness of the wood than the preceding pound. For every woody species the limit must be found at which additional impregnation proves unremunerative.