BARK-PEELING MACHINES
ANDMETHODS

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BARK-PEELING MACHINES AND METHODS

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Abstract

Methods of removing bark, factors affecting bark removal, and principles of machine operations are discussed and illustrated. Performance data of peeling equipment by product and machine type are tabulated.

Introduction

Rapid progress in the development and use of bark-peeling machines has been made in recent years. Increasing use of these machines, particularly by sawmills, has expanded the market and resulted in a number of new machines as well as improvements of earlier types. This revised report presents a summary of recent developments in the field.

Interest in efficient bark-peeling machines is directed especially at machines, other than the heavy-duty types used at pulp mills, to peel such primary wood products as pulpwood, sawlogs, fence posts, and poles. Particular interest centers about the peeling of sawlogs and pulpwood at or near the place of logging, instead of only at the mill.

Three basic factors are stimulating this interest. One is the rather obvious fact that hand peeling has, with few exceptions, become very costly. Another is the need to reduce shipping volume and charges on rough materials not debarked, because bark retards the drying of wood, occupies space, and increases weight to raise transportation cost. The third factor applies particularly to such products as sawlogs and veneer logs, because salvaged slabs and edgings have greater value for pulping, particle board manufacture, and chemical conversion if free from bark (40).

To ascertain what types of equipment are now available and what progress is being made in solving this bark-peeling problem, the U.S. Forest Products Laboratory maintains at Madison, Wis., in cooperation with the University of Wisconsin. Underlined numbers in parentheses refer to Literature Cited at end of this report.

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Laboratory surveyed and analyzed the machines in use and under development. Considerable development was found, and the need for more efficient peeling devices was generally acknowledged. Of special interest are machines for use in the woods. These must either be portable or mobile (mounted on wheels) for easy hauling from one cutting operation to another. Also of special interest are practical machines for use at sawmills. These peel sawlogs before they are sawed. Slabs and edgings can also be peeled to leave them free of bark.

When this report was first published in 1949, it stated that "No completely satisfactory device or method for bark removal has been found." Tremendous progress since that time has been made, and a number of satisfactory debarking machines are now available. No one machine is best for all conditions, but the range of choice for specific purposes is increasing (38). Although the roundwood machines are highly developed, machines for slabs and edgings are not so far advanced. Efforts are continuing to develop better machines of both types at lower costs.

In addition to machines for removing bark from logs, the survey considered other methods and aids, among them chemical pretreatment of logs, water-soaking and steaming treatments, and devices for separating bark from chipped wood. Many of these methods are still in the experimental stage, but some give definite promise.

One purpose of this report is to present the results of the survey for use as a general guide in selecting machines for specific needs. Another is to provide basic data on various designs, operational characteristics, and other important aspects of devices now in use or under test, so that further development can proceed to best advantage.

This report consists of two parts. The first part discusses bark-peeling machines as to design principles, performance, and factors that affect their output. Peak efficiency is seldom attained with any type of peeling machine. Factors that affect efficient operation are discussed and ways to improve efficiency pointed out.

The second part describes in detail the mechanisms and operating characteristics of various machines.
PART I

TYPES OF MACHINES AND PERFORMANCE FACTORS

Mechanical bark-peelers may be broadly classified according to two basic principles used to remove bark (17). Machines based on one of these principles are designed to separate bark and wood at their natural point of cleavage, known technically as the cambium layer, by destroying a thin layer of cells between the wood and the bark. The cambium cells, while fragile and easily broken in fresh, spring-cut wood, become relatively tough and hard to break in the dormant season. Machines based on the other principle use knives or cutting edges, which operate much the same whether in bark or wood. Such machines thus leave some of the bark or remove some of the wood, depending on depth of cut, variations in bark thickness, and irregularities in the form of the piece.

For specific purposes the machines in one class may have distinct advantages over those in the other. Where uniformity of size or shape is important, as in posts and poles, the knife machines are preferable. Where wood loss is important, however, as with high-quality pulpwood, cambium-separation machines are preferred. This difference in basic principle of operation makes possible a logical separation of types of machines for individual products. Selection on this basis alone, however, is not always followed as shown by table 1, which lists various products commonly peeled and the types of equipment used. A wide variation in machines used for individual products is shown. This variation is partly due to the fact that none of the methods is wholly satisfactory for a given product or entirely adaptable to circumstances peculiar to individual operations.

Operational Data

Of the various peeling machines available, only a limited number are suitable for small sawmills or for peeling in the woods. For some operations, in fact, hand peeling remains the most economical method.

Machines that fill this need must be portable, so that they can be moved with little or no dismantling. Portable machines can, of course, be bolted to permanent concrete foundations, temporary timber foundations, or skids. Machines mounted on wheels, which are considered mobile units, are most desired for use in the woods. Generally, however, mobile units are not stable enough unless braced when set up for operation.

Mounting a portable peeling machine on a war-surplus bomb-carrying trailer is an example of how both mobility and stability can be obtained. The frame of the trailer, serving as a base for the machine, can be lowered and raised with a hydraulic mechanism. During peeling operations the frame rests solidly on the ground, yet it is easily raised and held in place during transit. Figure 1 shows such a unit with one end of the frame lowered and the other raised.

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In selecting a machine for a specific purpose, a number of factors need to be considered, among them: (1) weight and portability of machines; (2) initial cost in relation to feed rate; (3) wood loss; (4) operator skill required and class of labor available; (5) crookedness of material to be peeled; (6) diameter and length of material to be peeled; (7) machine output in relation to crew size; and (8) mechanical feeding equipment, such as hoppers, feed rolls, and mechanical loaders. The quality of product and rate of production obtained with peeling machines depend upon these factors. In general, with knife-cutting machines the skill of the operator is one of the more important factors; with machines that rupture the cambium the condition of the log and bark is most important.

Table 2 shows some of the operational characteristics of various types of peeling equipment. The wide variation in wood loss with knife-cutting machines is attributable largely to the operator's skill or lack of it.

Important items of operating costs with all types of equipment include crew organization, machine investment, installation costs, and horsepower requirements. Mechanical equipment available for handling wood to and from a machine is a determining factor in crew size, and is reflected by the difference between minimum and normal crew requirements shown in Table 2. Handling equipment and installation costs for permanently installed machines were found to add 50 to 200 percent to the original machine cost. For portable machines, installation costs would be less. While auxiliary handling equipment, if used exclusively for this purpose, would bring the total cost up close to that for permanent installations, logging equipment suitable for this work is often available without additional investment.

Comparative horsepower consumption of various types of machines is shown in Table 3. The maximum production shown is that claimed for ideal operating conditions, seldom obtained. The minimum is that actually experienced under the most difficult circumstances. Average operating conditions fall somewhere between the two extremes. By multiplying the horsepower shown in Table 2 by the lineal feet per horsepower in Table 3, the capacities of the various types of machines can be determined in lineal feet per minute. A method for determining barking machine capacity per hour according to the log diameter and rate of feed per minute is shown in Figure 2. Table 5 shows the relationship of cords per hour to lineal feet per minute. Table 4 shows some of the basic data used to compile Table 5. It includes thick-bark Douglas-fir and hardwoods as well as thin-bark spruce.

To assist those familiar with cords to evaluate the new machines being developed for sawlogs, Figures 3 and 4 were prepared from Tables 4 and 5. The data in Table 4 are primarily from the Lake States, but include other data to show the very close relationship existing in other areas and species. At 10 inches, variation between species is slight; but with a decrease in diameters, the effect of bark thickness and the crookedness of hardwoods become apparent. Variation at 18 and 20 inches is more apparent than real because the reference data did not show fractions of a bolt except in Douglas-fir.
The above data are the basis for the computed data of table 5 and figure 4. These data make it possible to compare machines like debarking drums, rated in cords per hour, with machines rated in lineal feet per minute.

Causes of Variation in Machine Output

Considerable variation in production is recorded in tables 2 and 3 for the same machines used under different conditions and on different material. Some of the causes for this variation are subject to control, the degree varying with the particular circumstances surrounding each operation. Some control measures apply to both major classes of machines, while others apply to only one.

Some of the causes of varying production and corresponding measures of control are as follows:

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<th>Cause of variation</th>
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<td>Supervision, mechanical handling, use of long lengths</td>
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<td>Irregularity of pieces</td>
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<td>Character and condition of bark and cambium layer</td>
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Discontinuities in Input

One of the most important causes of inefficient operation is the method of delivering wood to the machines. This alone often determines success or failure, especially with portable equipment.

When an operator has to pick up a stick or roll it to a machine the resulting spaces between pieces passing through the peeler constitute nonproductive time as far as the machine is concerned. It is poor economy to purchase a machine with a feed rate of 100 feet per minute and then deliver material to it at a rate of only 80 feet per minute. Yet this is what happens when a 12-inch space, or 0.01-minute time lapse, occurs between successive bolts 4 feet long. Under the same circumstances, with bolts 16 feet long the net feed rate is 94 feet per minute.

Figure 5 shows graphically the effect on efficiency of gaps between commonly used lengths of forest products.
Even at permanent installations with synchronized conveyor systems, machines were observed operating at efficiencies as low as 50 percent. With portable machines more difficult conditions usually exist, and handling methods become nearly as important as the machine itself, accounting in part for the wide variations in feed rates and size of crews shown in tables 2 and 3.

Some control can be exercised over this cause of inefficiency by better crew organization, mechanical handling methods, and peeling material in the longest length possible.

**Irregularity of Pieces**

Protruding knots, limb stubs, and crookedness of the wood are important causes of inferior production and quality of peeling. Crooked material slows up production with all machines, but causes greatest difficulty in those that rotate the log. Small material, such as pulpwood, has shorter and more abrupt crooks and is, therefore, more troublesome than sawlogs; hardwoods are more likely to be crooked than softwoods.

Limb stubs can be eliminated by supervision that insists on smooth trimming. Some crooks can be removed by proper bucking, which calls for adequately trained and supervised cutting crews. It is easiest to do this when tree lengths are bucked at landings.

In some cases it has proved economical to segregate material at the landing, peeling straight material and disposing of crooked or knotty material as a rough product. At times it will prove more economical to peel crooked material by hand.

A segregation test made on spruce by the Northeast Pulpwood Research Center and sponsored by a number of pulpmills at Gorham, N.H., showed that, when 60 percent of the total wood was selected for peeling, 97.42 percent of the bark on the selected material was removed with a portable peeler. It was estimated that, with proper woods supervision and trained peeler-crews, 75 percent of the wood could be selected for machine peeling. Whether or not such a practice is justified depends a great deal on the particular machine being used.

**Frozen Wood**

Only knife or cutterhead machines peel frozen wood easily. Although cambium-separation machines can peel such wood, production rate or quality of product is generally reduced. As much as 75 percent of the wood run through a peeler may be rejected and rerun through the machine. Rejected bolts or logs are sometimes put through the peeler as often as six times. In very cold weather hydraulic peelers may build up ice on logs instead of peeling them. Machines using adjustable pressure scrapers or abraders to tangentially shear the cambium are superior to other types of cambium machines used on frozen wood.

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In frozen wood, resistance of the cambium layer to crushing is directly related to the moisture content of, and resulting ice-crystal formation in, the cells. The resistance increases as the temperature drops to about \(-17^\circ F\), below which the cambium again crushes more easily \(39\). This phenomenon accounts for some reports of better peeling at extremely low temperatures.

Heating will affect the cambium in such a way that peeling is greatly facilitated \(39\). For example, hydraulic machine peeling has been successful on frozen wood that was immersed for only 20 minutes in a pond heated to \(70^\circ F\). This heating time and temperature is not sufficient, however, for hand peeling. A new application of this heating method is a chain conveyor that submerges pulpwood bolts and carries them through a "hot" pond at a controlled rate. Variations in time and temperature will be required according to the machine or method used. Another heating device, used with a hydraulic peeler, is a steam hood over the incoming conveyor. Although bolts are in the steaming section only about a minute, peeling is measurably improved, especially if the hood is built so condensed steam drips on the bolts.

An early barking machine \(18\) was designed for use with hot water, much as present-day hydraulic barkers.

**Condition of Bark and Cambium**

The energy required to remove bark depends upon bark thickness and density, or hardness. This is true of all machines, and there is little that can be done to control this factor beyond the design of the machine. It does, however, cause a variation in peeling rates. With cambium-separation machines, the condition of the cambium is also important. Various means can be used to control cambium condition. More and better peeling can be done in the early growing season than at other times.

Another bark characteristic affecting the production rate of machines that separate bark at the cambium is the condition and strength of the cells in the cambial region. This varies tremendously in green wood from the rapidly growing state in the spring to the frozen state in mid-winter. (Quantity and quality of machine peeling varies directly with the season.)

The fragility of cambium cells during the growing season can be used to advantage by cutting all or as much as possible of the wood during the growing season. This is done in some cases, especially in the pulpwood industry. Hot ponds, pretreatment, controlled storage, and the like will increase machine efficiency.

**Effect of storage on bark removal.** After trees are cut the two factors that have the greatest influence on the tightness of bark are the length of time since cutting and storage conditions. The bond between wood and bark becomes stronger for a time after cutting, and then weakens gradually until the bark is entirely free. The length of time required to complete this cycle depends upon the species of timber, storage conditions, and climate, all of which help bring about certain changes in the cambium layer. A run of green, fresh,
summer-cut aspen, for example, was peeled by a machine at the rate of 1-1/2 cords per hour; yet aspen that was cut in the early spring, stored for a time in the woods, then shipped and stored again, was peeled in November at a greatly increased rate.

Water storage (25) retards the rate of change and may even soften the cambium layer. It is well-known that water-stored wood peels more easily than wood stored otherwise, and this fact offers a means of control. For example, although poor results were obtained with a hydraulic peeler on green spruce, the same machine averaged 10 cords per hour with water-driven and water-stored spruce.

Humid storage appears to accelerate the cyclic changes in, and resultant deterioration of, the cambium. When wood is stored under these conditions, however, stain and decay occur. While experiments with preventive chemicals indicate that it may be possible to overcome these difficulties, further research is needed to establish adequate control measures before such storage conditions can be recommended.

New Methods and Aids for Bark Removal

Chemical Treatment

A well-developed process of applying chemicals to living trees can lengthen the hand peeling season and increase the efficiency of cambium-separation machines. When cambium cell growth slows down gradually, internal cell activity strengthens the cell walls. If cell growth is stopped abruptly with chemicals or otherwise, the cell walls tend to remain arrested. In addition, some chemicals stimulate growth and cause abnormal cell activity (26).

Experiments at the Canadian Forest Products Laboratories (26) and several paper concerns in the United States indicate that trees treated with suitable chemicals during the growing season, when the cells are weak, remain easily peelable for an indefinite period. A thorough investigation of all aspects of chemical treatment showed that "all arsenic compounds were found to be highly effective, unless diluted below 10 percent concentration of arsenic" (48).

Chemicals are applied to the sapwood exposed by girdling and removing the bark completely around the tree. Width of the removed band of bark should be approximately equal to the diameter of the tree. Regular paint brushes or especially designed equipment are used to apply the chemical to the freshly exposed wood. It is important that the trees be treated during the growing season.

A recent development uses chemicals without girdling (43). Experimental trials on aspen have been successful, and full-scale field trials appear promising. The results of this particular chemical mixture and method of application on other species remain to be determined. Past results with all chemicals have shown variations in effects on different species. Some chemicals cause stains
in certain species but not in others. Such stains may or may not be objection-
able, depending upon the end product or manufacturing process.

Chemical treatment with subsequent hand peeling may be of value at small saw-
mills that have a market for slabs and edgings to be used for pulp chips. Enough
trees can be treated during the spring slack season to run the mill for the
coming year. Although chemical pretreatment increases the effectiveness of
cambium-separation peeling machines, no reports have been received on the
extent of increased production.

Caution must be exercised in the use of arsenic or other poisonous compounds
where animals or human beings are likely to come in contact with them.

Separation and segregation of bark from chips.--In view of the limited selection
of peeling machines for small forest products or portable operation, attention
has been given to other possibilities of eliminating bark or recovering it for
new uses (10). One step in manufacture where bark might be removed is after
chipping. Observations show that bark is broken up and knocked loose from the
wood during the chipping process. Segregation of this free bark from the chips
is possible if the two materials differ sufficiently in apparent specific gravity.

The first machines experimented with (22) were originally designed for segre-
gating crushed ore, but have since been adapted for other uses. Chipped material
is fed onto a vibrating screen with a mesh small enough to restrict the flow of
air forced through from the under side. Air pressure is controlled so that it
just floats the material on the screen. Vibration of the screen causes the
chips to work toward one end while bark works toward the other.

Extensive experiments have been made with three other processes designed for
bark removal. In one (23), the chips are first processed to loosen and separate
the bark from the wood and then passed over a shaker to even out the flow. The
evened chips then pass under a vacuum hood where lighter particles are vacuumed
off. The second process (30) uses centrifugal action in a double-walled cyclone.
The third process (20) presses the chips between pairs of rollers, one of metal,
the other of rubber, and the milling action loosens and pulverizes the bark for
removal by screening.

Freeness or separation of the bark depends upon action of the chipper, season
of the year, length of storage, species, and other factors. A trial experiment,
chipping aspen at -20° F., resulted in nearly 100 percent separation. In the
chipping process, bark tends to break up, depending upon its dryness and species,
so that a high percentage passes through the fine reject screens. Experiments
with liquid flotation show that red oak bark sinks very quickly in water con-
taining detergent, but results on other hardwoods were not satisfactory. Con-
siderable work remains to be done to determine the economic possibilities of
separation and segregation processes.

Bark has been removed experimentally after pulping (23,41). This was done by
centrifugal action in a bank or series of cyclones especially designed for the
process. Economic factors involved, however, have limited use of this equip-
ment to cleaning pulp and improving paper quality rather than elimination of
bark-peeling equipment.
Machines and Methods That Rupture the Cambium

The effectiveness of cambium-separation machines and methods depends upon the strength of the cambium layer and the thickness and hardness of the bark. Three methods of breaking the cambium—tension, crushing, and shear—are employed. The tension method is usually used with hand tools; there are no machines that employ this method exclusively. Most machines employ crushing methods, either direct or indirect. Direct-crushing types include hammer, chain, and wheel or roller peelers. Indirect-crushing types of machines include drum, semidrum, hydraulic, and abrasive-wheel machines, as well as combinations of cutting and crushing devices in a single machine. Shear machines rupture the cambium by exerting tangential forces against the bark to shear the bond between bark and wood. This is generally accomplished with scrapers.

Tension Methods

Tension methods pull the cells of the cambium layer apart. The cambium has less resistance to tension than to compression forces. Less power is required, therefore, with tension methods of bark removal, making it possible to use hand tools and methods.

These methods are most effective during the season of rapid growth, and immediately after trees are felled. The bark of spruce and aspen is, in fact, so tough that with pulpwood in this condition, long strips can be pulled loose by hand. With species having brittle or heavy bark, however, hand tools are needed to pry the bark loose around the log. This is usually done on large logs, such as redwood, or to recover tanbark from eastern hemlock and other species.

Crushing Methods

Crushing is the predominant method used with cambium-rupturing peelers. Direct-crushing types exert pressure to loosen the cambium and permit direct removal of bark. Indirect-crushing types apply an eroding or abrasive action that removes some of the bark before the cambium is crushed. For species with very thick bark, knives may be used to slice off part of the bark before crushing force is applied to loosen the cambium.

Hammer peelers.—Four hammer-type bark-peeling machines were examined, a mobile machine, two portable ones, and a nonportable type. The mobile wood peeler, a wheel-mounted unit (fig. 6), was designed originally for pulpwood, but has also been used for mine props, fence posts, and similar round products. The log passes between three powered rollers. One supports the log from below while
hammers fitted into another alongside the log loosen the bark as the third roller, set at an angle above and on the side of the log opposite the hammer roller, advances the log spirally. Feed rate is controlled by adjusting the angle of the third roller, which is also adjustable up and down to hold logs of various diameters against the hammer roller.

Pivoted hammers suspended in the hammer roller are swung out by centrifugal force and strike the bark on the side of the log. Intensity of the hammer blow is adjustable. This is accomplished with a mechanism that in effect moves the hammers in or out from 1/16 to 10/16 inch according to the thickness of the bark.

This machine works best on thick-bark species, such as aspen. Although frozen wood can be peeled, production rates are lower and wood loss higher than during other seasons. Straight wood peels better than crooked wood, which often requires additional hand cleaning.

A recently developed hammer machine is designed to remove bark from slabs and edgings (29). Unlike the preceding machine, the head that contains the hammer is at right angles to the long axis of the wood (fig. 7). The head is mounted on a rocking frame so balanced and held by weights and springs that its height is automatically adjusted for varying slab thicknesses. Independent narrow hold-down rollers on the infeed end keep edgings from turning and keep the bark edge turned up as it passes under the hammers. Slabs and edgings are moved under the debarking hammer head by a conveyor belt. Near the output end of the machine, slabs and edgings move under a wire brush that removes loosened bark and cleans them.

This machine is manufactured as a self-contained unit, and is portable. It requires no auxiliary equipment, and could be made mobile by mounting it on a trailer of the type shown in figure 1.

Another hammer machine in use is the stationary hammer peeler. This is a permanent installation consisting of two machines operated by one man. Their weight and size are such, however, that they could be made portable. Their vibration when in use makes mobile mounting questionable. The machines take 4-foot bolts, but could be made larger.

Unlike those of the mobile peeler, the hammers strike a solid blow. Their faces are rounded, exerting a high pressure per square inch causing a squeeze-out pressure on the sides.

Bolts are dropped onto a grating of steel bars. The drum that contains the hammers is below the grating, and as it rotates the extended hammers come up between the grating bars. Rotation of the drum is slow and the hammers heavy. Each blow causes the bolt to jump and rotate.

Best performance is on hardwoods, and the machine works well on seasoned beech. Because of the severe pounding, the operator must take care not to damage green softwoods.
One of the earliest commercially manufactured portable hammer machines rotated material of uniform length in front of hammers similar to, but lighter and more numerous than, those of the machine just discussed \(^{(47)}\). Toothed hammers have also been tried as a means of improving production on these machines.

Chain peelers. -- Two portable machines for post peeling use chains to beat off the bark. The principal difference between the two chain-beating machines is the use of tight chains on one, with the post peeled under the chains, whereas slack chains on the other strike the post from underneath.

Action of the chains removes the bark as the post is drawn back and forth and rotated. After peeling one-half the length, the post is turned end for end to do the other half. Heavier chains are used for hardwoods than for softwoods, and the speed of the head is varied.

Material is picked up, fed to these machines, and rotated by hand during the peeling process. For this reason, use of the machines is limited to fence posts and lightweight material. Likewise, peeling capacity is limited as much by the weight of the material handled as by the mechanical functioning of the machines.

Crooked material is not so troublesome on these machines as is generally the case with other peelers.

One chain-type machine in operation uses two heads. Mechanical feeding, however, has not been applied.

Early debarking experiments resulted in the development of three successful types of chain-flail machines, two for round logs and the other for slabs and edgings. Short lengths of chain, three or four links, are attached at one end to a revolving head. Improvement in methods of attaching the chain, as well as in the quality of the chain used, has overcome previous faults.

On the round log machines (fig. 8), the debarking head rotates parallel to the axis of the log. The head extends over the conveyor on a movable arm, and when a log is in position for debarking, the head is lowered. Shoes rest on the log to keep the rotating head at a constant distance as the log rotates. The debarking assembly, including motor, on one machine is mounted on a carriage that travels parallel to the log. Speed is controlled according to tightness of bark and other variables.

The log conveyor on this machine is unique in that log movement is controlled by pairs of spherical rollers, which can be rotated on two axes that are independently controlled \(^{(1)}\). During debarking, the spheres are rotated on the horizontal axis parallel to the log causing the log to rotate. Rotation of the spheres on the vertical axis changes the angle of the horizontal axis with respect to the log and causes the log to move lengthwise. The direction in which the sphere is turned determines whether the log moves forward or backward. This conveyor provides for complete control of the log being debarked. This machine is designed for use at medium-sized sawmills. It is a self-contained unit that can be moved without dismantling and is considered portable.
The other machine using the same debarking principle has a sawmill carriage frame with trunions mounted on it to rotate the log (3). As the log rotates, the carriage moves the log lengthwise under the chain-flail debarking head.

The chain-flail slab-and-edging debarker (2) has a rotating head with the axis at right angles to the slab. Head design and chain attachment are such that the chain ends approximate the curvature of the average slab. A balanced frame, similar to that of the hammer-type, slab debarker, supports the head above the slabs and edgings.

Material to be debarked is conveyed under the debarking head either by powered roller or belt conveyors. The infeed and outfeed conveyors are separate and terminate at a steel plate under the debarking head. The machine is a self-contained portable unit suitable for mobile mounting.

Roller peelers.—Directly crushing the bark and underlying cambium layer with rollers is an old method employed by several of the early willow-stripping machines. Its most recent application is embodied in a veneer bolt peeler (2), that employs recently developed hydraulic equipment.

Bolts are held in lathe chucks and rotated. A roller is held against the bolt by hydraulic pressure as the bolt is turned, thus squeezing the bark off ahead of it. Because of the high pressures available with present-day hydraulic equipment, this method is no longer limited to trees with thin bark.

Although the particular machine observed is not portable and is used only on veneer bolts, the principles involved may be useful in developing other machines.

Drums.—Drums are cylinders in which material is rolled or tumbled at slow speeds (25). Friction and pounding between bolts and the drum erodes away the outer bark. When a sufficient amount is removed, the pounding action, combined with the weight of the wood, crushes the cambium and the inner bark comes off in strips and patches (13, 45).

Drums are manufactured in a variety of sizes according to the users' specifications and vary from 5 to 20 feet in diameter and from 9 to 70 feet in length. Smaller sizes used for fence posts or pulpwood (31) are portable (fig. 9). Larger-sized pulpwood drums are sometimes set up at semipermanent installations.

As a rule, small drums are operated as batch machines (16) while large ones are operated continuously. They can be operated dry or wet. Although more power is required for those operated wet, the water helps wash bark out of the drum.

Fabricating material is either boiler plate (fig. 10) or channel iron (fig. 9) held together with rivets, bolts, or welds. Advantages are claimed for all joining methods, but the basic consideration is that all internal projections should be rounded and smooth to prevent damage and wood loss.

Properly designed internal projections and other features can increase efficiency. One such feature is the U-bar, which reduces the area of contact between the drum and wood thus increasing the pressure per square inch. A similar feature,
used on small drums, is a rod welded spirally around the inside (fig. 11) that also strengthens the drum. Another feature is the use of eccentric axles on small drums. Small volumes and weights in these drums make design features important.

Conifers, or species with flaky bark, peel better in drums than smooth, hard-barked species such as aspen.

Semidrums.—Several machines are classed as semidrums because the action and process of removing bark is essentially that employed by drums. The major difference is in machine design. Material is rolled, not tumbled end for end, and the top is open.

The oldest type is a multiple-pocket peeler (42,46). It consists of several adjacent semicircular pockets with an opening in the bottom. A shaft below the opening has cams that swing up through the opening into the pockets as the shaft is rotated. The cams roll the bolts or logs in the pockets around and boost them into the next pocket (fig. 12). Each log is rotated in and boosted from pocket to pocket until it is finally ejected. The pressure exerted between the bolts and against the cam is determined by the weight of logs.

Water is sprayed in over the pockets to carry away the bark. If this is not done bark accumulates between the logs and acts as a cushion, thus reducing the pressure exerted on the cambium and the effectiveness of peeling.

Machines of this type are built to accommodate pulpwood or small logs in lengths of 4, 8, and 12 feet. For effective operation, especially on long lengths, the logs must be reasonably straight. An advantage of this machine over the full drum is the reduced brooming loss, or damage to log ends.

For small sawmills using short logs a semidrum machine (12) was built at one time with a single pocket having a gate at the outlet. When a fully barked log worked up to the outlet the gate was raised and the log allowed to pass out of the machine onto the sawmill deck.

Another semidrum type is a single-pocket sawlog peeler (32). It is designed for sawlogs of varying length. The machine observed in operation was built to handle 16-foot logs. Although shorter logs can be handled together with the long ones, if too many or too short logs are put in at one time, they tend to upend or jackstraw and cause trouble.

This machine consists of a pocket with solid sheet-steel ends. The inlet side is also of sheet steel, but the bottom and outlet side are formed by four steel channels. Heavy endless chains with projections and dogs operate in these channels and over powered sprockets at the top of the outlet side. Rounded projections on the chains agitate the logs. The dogs pull logs from the bottom of the pocket and carry them up the discharge side (fig. 13). If logs are peeled they are allowed to pass; if not, they are kicked off the chain and fall back into the pocket.
The first bark removed is from the portion of the logs struck by the agitators and dogs. Best results are obtained when the pocket is full, which indicates the importance of the pressure on the bottom logs exerted by the weight of logs above.

One machine of this type uses water jets to wash away the loose bark. (37)

Hydraulic peelers.--Peeling by hydraulic pressure is employed with several commercial machines (6,19,27). Most of these are uneconomical for small timber. One machine of this type is available for small logs (28,36).

A stream of water under pressure is turned on the log. The stream can be directed by moving either the nozzles or the log. Small machines have fixed nozzles, and the log is moved. One method of doing this is to move the log endwise without rotation through a ring having many nozzles arranged to impinge water on all sides of the log at once. In another the log is rotated spirally under three nozzles. The assemblies are mounted in watertight compartments.

Analysis of hydraulic peeling action is difficult because sharpness of the spiral roll, water pressure, and wire brushes all influence the quality of peeling. Examination of bark removed, however, indicates that crushing forces predominate. Wood loss amounts to 2 and 3 percent on sound spruce.

As in all machines depending upon rotation of the log, straight material is required for best operation. Some crookedness and irregularity can be tolerated, but where it is too great the log may have to be sent through the machine several times or—perhaps more economically—cleaned by other methods.

Hydraulic peelers are not portable, but are suited for semipermanent locations. Cost of installation ranges from 50 to 200 percent of the machine, depending upon auxiliary equipment installed. Such equipment includes conveyors, water filters, and bark screens.

Hydraulic slab peelers.—The peeling of slabs by hydraulic machines has proved successful (11,29). Conveyors carry the slabs bark up under either fixed or oscillating nozzles. Cost of machines, power, and water requirements, however, limit their use to pulp mills or other locations where large concentrations of slabs are available.

Cambium-Shearing Machines

Machines of this type depend upon tangential forces that shear the bark from the wood at the weak cambium layer. The action is similar to that of machines used for testing the shear strength of glue lines.

Some machines apply force against the bark by rotating the log past fixed tools, and others apply it by rotating the tools around the log. In all cases, the tools resemble blunt-edged scrapers forced against the log so they will not climb up over the bark when shearing force is applied. Total power required is a combination of shearing force, tool pressure, and power required to rotate
either the log or the tool-holding assembly. In the tool-holding assembly, power required is constant for a given machine but in the log assembly, requirements vary considerably according to log size and weight. Most saw-log machines using this principle rotate the tool ring, but veneer-log machines rotate the log \(4, 7, 29, 44\).

Several methods are employed to apply pressure to the tools in order to hold them against the log during debarking. This is done with springs, heavy rubber tension belts (fig. 14), or hydraulic or air pressure (fig. 15). Pressure can be controlled by the operator on hydraulic or air operated machines, but it is controlled by adjustments on the machine in the other two types. Normally pressure adjustments are only required to compensate for seasonal changes, although machines regularly used on hardwoods use higher pressure than those regularly debarking pine.

Opening and closing of the tools on hydraulic or air operated machines is controlled by the operator but tool design in such that this is automatic on other machines that use springs or tension belts. Although these latter machines do not require a skilled operator, an attendant is necessary to control conveyors and prevent oversized logs, excessively long limb stubs, or other irregularities from causing stoppages or damage.

A slab-debarking machine of the cambium-shearing type \(2\) has tools or scrapers welded to roller chains (fig. 16). These chains travel across the slab, each alternate one in the opposite direction. Spring tensioning of the chains permits them to follow the configuration of the curved surface when pressure is applied to force the tools against the slab.

**Knife-cutting Machines and Methods**

Knife-cutting machines use cutting edges exclusively to remove bark from wood. They range from the simple lathe, now used only to cut veneer, to machines with cutterheads susceptible to considerable control. With most, the log is moved past the cutterheads and simultaneously rotated; a few however, have cutting mechanisms that rotate around the log. Relatively high skill is required to operate these machines without excessive wood loss. Most knife-cutting machines are used in the wood-treating and other industries where wood loss is not so serious as in the pulpwood industry.

Factors such as season of the year, which are important when operating cambiumrupturing machines, cause relatively little variation in production rates in this class. Because these machines process pieces individually, however, the length of the material and the method of handling it have important effects in production.

**Hand Methods**

Draw knives are among the oldest peeling tools and are suitable for practically all products, including slabs. Capital outlay is low, but labor costs are high, and considerable working space is required.
This method is used extensively for peeling fence posts. Although a worker can easily peel a 7-foot pine post in winter in 2-1/4 minutes or at the rate of 27 per hour, the average day's production is only about 100 posts. Without doubt, production could be increased with a conveyor system similar to those of assembly lines.

Limited efforts to use powered hand tools of knife types have been made, but this field has not been fully explored.

Knife Machines

Revolving disks with knives.---Among early peeling machines still in limited use are "disks" or "wheel barkers." Knives, usually four or more, are attached to the face of the disk in a radial position. Large slabs and both split and round bolts are held against the rotating face while the passing knives remove the bark or excess material. Although in declining use for peeling pulpwood because of the large amount of wood lost, these machines are still favored by the stave-bolt and similar industries where it is desirable to remove the sapwood.

Bolts 12 to 48 inches long and up to 30 inches in diameter are rotated against the knives. Peeling of double-length bolts is accomplished by doing one end at a time. Generally material is rotated by hand, but a mechanical attachment is used on some machines, especially for round material. It reduces wood loss and hazards to safety, and has other advantages.

Fixed-cutterhead machines.---Machines with fixed-position cutterheads are operated much as jointers and planers. The material to be peeled is moved past the rotating knives (6, 15, 19).

Multiple-cutterhead peelers.---The multiple-head or lathe type of cutter has a series of heads mounted on a shaft that must equal in length the longest material to be peeled (fig. 17). Material such as fence posts is mechanically centered, chucked, and rotated against the cutters.

Although considerable wood is removed, especially from crooked or irregular-shaped material, the resulting product has a uniform diameter. Advantages claimed are savings in shipping weight, storage space, and use of preservative fluids (31). The large amount of sapwood removed is a disadvantage with some species which have little sapwood, if they are to be treated with preservatives.

Single-cutterhead peelers.---Two types of single-cutterhead peeler machines are built. The rotating cutterheads are of the jointer type, and material is moved over them. One machine is designed for round material and the other for slabs.

In pulpwood machines (fig. 18) the material to be peeled rests on the cutterhead and an idling roller. A powered feed wheel is pressed down on the log, causing it to rotate against the knives. The angle of the roller controls the endwise speed of the material as it rotates spirally over the cutterhead.
Machines for slabs are generally dual units (37) with cutterheads on each end of a horizontal shaft (fig. 19). Centered between the cutterheads is either a pulley or an electric motor. Each cutterhead is enclosed except for an opening on top. Slabs, with the bark side down, are drawn across the opening as the protruding knives plane off the bark. Sometimes auxiliary cleaning of pulpwood is done with this machine.

Two operators, one for each head on the machine, can peel the slabs from about 10,000 to 12,000 feet of logs in a day. Thus, one machine could handle the slab output of a small sawmill.

Floating-cutterhead machines.—Machines in this classification have cutterheads that are lowered on the round material to be peeled, and are used extensively in the wood-treating industry for peeling such products as poles, posts, and piling. The material is placed on rollers called "bull wheels" one or more of which are power-driven. These wheels are steel and either have toothed rims (fig. 20) or are faced with solid or pneumatic rubber tires. The angle of the rollers is adjustable so that the material can be rotated spirally under the cutterheads at varying rates according to its diameter.

Some machines have two cutterheads (fig. 21), one for roughing and the other for finishing. Each head is equipped with adjustable guide shoes to control the depth of cut. The leading end of the knives is rounded and the shoe set for heavy cutting, while the opposite shoe is set for a very light cut. The depth of cut can thus be regulated according to bark thickness, so that little wood need be removed.

Although the mechanism is designed so that the heads are flexible, bark may be left on the inside of short crooks and excessive wood removed from the opposite side. The skill of the operator is an important factor in controlling wood loss. On pulpwood peelers (21, 47) of this type the loss has been held below 10 percent, and has also exceeded 20 percent.

Diameter of material that can be handled ranges from 3 to 34 inches. It is common practice to peel poles and piling up to 40 feet in length with these machines. Two commercially available machines of this type are portable.

Although most cutterhead machines contain sharp-edged knives, some do not. Some use dull-edged tools similar to those used in the shearing machines, but generally narrower and more numerous (fig. 22). Veneer-bolt debarkers, especially those for thick-barked Douglas-fir, were among the first of this type. As the bolt rotated in a lathe, the cutterhead traveled lengthwise removing the bark spirally (6).

A log debarker using these blunt-edged cutterheads rotates the log on trunions as the carriage moves the head along the top of the log (29). Action of the tools is a combination of cutting and shearing that has some advantage on very thick, hard, or stringy bark. Wood loss is much less than with sharp knives and can be negligible with proper tool design and adjustment.
Rotating-cutterhead peelers.—All the previously described knife machines rotate the logs, but there are two that do not. These pass the logs endwise through a revolving drum that has flexible mountings. These enable the drum to follow the contour of the pole (fig. 23). Inside the drum are guide rollers and cutterheads.

One type of pole-shaping machine is designed to trim off not only the bark, but enough of the wood to give the pole a uniform taper from top to bottom. As a result the four cutting heads, two for roughing and two for finishing, do not float freely, but are moved in or out at a fixed rate. The movement is controlled by a motor synchronized with the feed rate.

A similar machine (8) has two floating cutterheads, arm-mounted inside the drum on separate shafts on opposite sides of the pole. As with other dual-head machines, one head is mounted to make rough cuts, and the other head makes the finish cuts. The roughing head of this machine has a series of teeth set in alternate rows that tear up the bark and take off knots and other defects. The finishing head has blades set at right angles, rather than at an acute angle to the pole, as on planer heads. The resulting action is more like scraping than cutting, and probably accounts for the owners' claim that wood loss is low. This machine appears suitable for small sawlogs.

Fixed knives.—Several early patents covered machines with single fixed-position knives, but the only ones now in use are veneer lathes. A machine using multiple knives has been under development for several years, and is now ready for the market (fig. 24). The knives score the bark into narrow strips lengthwise of the bolt or log as the nonrotating logs are pushed through the rings of spring-loaded knives. Staggered setting of the knives permits effective use of side thrust against the bark. This side thrust shears the cambium under the narrow strips. Compression force of the springs is adjustable to compensate for different species or seasons of the year.

Following the head containing the knives is a rotary head with scrapers to direct the bark to the conveyor and clean off any remaining bark. The maximum wood diameter of the first production machine is 14 inches. The feed rate is variable over a wide range, and the total horsepower required is 17.
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(32) Murray, Alex

(33) Paul, Benson H.

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(35) Range, E. W.

(36) Shaw, E. C.

(37) Smith, Irvine W.

(38) Sterns, R. W.

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(45) West, P. H.

(46) Wharton, W. H.

(47) Whitney, R. L.

(48) Wilcox, Hugh
Table 1.—Classification of peeling equipment based on principle of operation

<table>
<thead>
<tr>
<th>Products commonly peeled</th>
<th>Cambium rupturing machines</th>
<th>Knives for cutting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tan bark : X : : :</td>
<td>: :</td>
<td>:</td>
</tr>
</tbody>
</table>
Table 2.--Operational data for various types of bark-peeling machines

<table>
<thead>
<tr>
<th>Machine</th>
<th>Price class</th>
<th>Approximate weight</th>
<th>Horsepower required</th>
<th>Normal Operation skill required</th>
<th>Wood loss</th>
<th>Maximum size of wood handled</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pounds</td>
<td>Percent inches</td>
<td>Feet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cambium rupturing machines</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mobile hammer peelers</td>
<td>5</td>
<td>Mobile</td>
<td>30-1/2</td>
<td>2</td>
<td>4-8</td>
<td>0-8</td>
</tr>
<tr>
<td>Hammer slab peeler</td>
<td>5</td>
<td>7,000</td>
<td>20</td>
<td>1</td>
<td>1-2</td>
<td>Low</td>
</tr>
<tr>
<td>Chain post peeler</td>
<td>1</td>
<td>300</td>
<td>4-6</td>
<td>1</td>
<td>1-2</td>
<td>Low</td>
</tr>
<tr>
<td>Chain-pulwood peeler</td>
<td>7</td>
<td>16,000</td>
<td>80</td>
<td>1</td>
<td>3-6</td>
<td>Moderate</td>
</tr>
<tr>
<td>Chain-flail slab peeler</td>
<td>4-5</td>
<td>3,500</td>
<td>15</td>
<td>1</td>
<td>1-2</td>
<td>Low</td>
</tr>
<tr>
<td>Chain-flail log peeler</td>
<td>6</td>
<td>12,000</td>
<td>25</td>
<td>1</td>
<td>1-3</td>
<td>Low</td>
</tr>
<tr>
<td>Multiple pocket semidrum</td>
<td>8</td>
<td>300</td>
<td>3</td>
<td>2</td>
<td>9</td>
<td>Low</td>
</tr>
<tr>
<td>Single pocket semidrum</td>
<td>8</td>
<td>125</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>Moderate</td>
</tr>
<tr>
<td>Small hydraulic peeler</td>
<td>7-8</td>
<td>350 to 450</td>
<td>3</td>
<td>3</td>
<td>2-5</td>
<td>Moderate</td>
</tr>
<tr>
<td>Portable drum</td>
<td>2-4</td>
<td>4,500</td>
<td>5-30</td>
<td>1</td>
<td>1-5</td>
<td>Low</td>
</tr>
<tr>
<td>Large drum</td>
<td>8</td>
<td>150</td>
<td>1-4</td>
<td>1</td>
<td>1-4</td>
<td>Low</td>
</tr>
<tr>
<td>Cambium-shearing log peeler</td>
<td>6</td>
<td>3,500</td>
<td>30</td>
<td>1</td>
<td>1-2</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>3,000</td>
<td>40</td>
<td>1</td>
<td>1-2</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>16,000</td>
<td>50</td>
<td>1</td>
<td>1-2</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>28,000</td>
<td>70</td>
<td>1</td>
<td>1-2</td>
<td>Moderate</td>
</tr>
<tr>
<td>Cambium-shearing slab peeler</td>
<td>7-8</td>
<td>30,000</td>
<td>75</td>
<td>1</td>
<td>1-2</td>
<td>Moderate</td>
</tr>
<tr>
<td>Knife machines</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed single-head peeler</td>
<td>3</td>
<td>400</td>
<td>6</td>
<td>2</td>
<td>2-4</td>
<td>Moderate</td>
</tr>
<tr>
<td>Lathe peeler</td>
<td>4</td>
<td>3,500</td>
<td>17-1/2</td>
<td>1</td>
<td>3</td>
<td>Moderate: Very high</td>
</tr>
<tr>
<td>Floating-head post peeler</td>
<td>4</td>
<td>3,300</td>
<td>14</td>
<td>3</td>
<td>5-8</td>
<td>Moderate</td>
</tr>
<tr>
<td>Floating-head pulwood peeler</td>
<td>4</td>
<td>2,500</td>
<td>10-15</td>
<td>3</td>
<td>5-8</td>
<td>Moderate</td>
</tr>
<tr>
<td>Floating-head log peeler</td>
<td>5</td>
<td>2,000</td>
<td>18</td>
<td>1</td>
<td>1-2</td>
<td>Moderate</td>
</tr>
<tr>
<td>Floating-head pole peeler</td>
<td>5-6</td>
<td>25-45</td>
<td>3</td>
<td>1</td>
<td>4-9</td>
<td>Moderate</td>
</tr>
<tr>
<td>Rotating-head pole peeler</td>
<td>6</td>
<td>40</td>
<td>1</td>
<td>5</td>
<td>5</td>
<td>Moderate</td>
</tr>
<tr>
<td>Pole shaper</td>
<td>6</td>
<td>100</td>
<td>3</td>
<td>3</td>
<td>3-5</td>
<td>Moderate</td>
</tr>
<tr>
<td>Disks shaper with radial knives</td>
<td>5</td>
<td>4,000</td>
<td>5</td>
<td>1</td>
<td>1-2</td>
<td>High</td>
</tr>
<tr>
<td>Jointer head</td>
<td>1</td>
<td>800</td>
<td>5</td>
<td>1</td>
<td>1-2</td>
<td>High</td>
</tr>
</tbody>
</table>

1 = under $500; 2 = $500 to $1,000; 3 = $1,000 to $2,000; 4 = $2,000 to $5,000; 5 = $5,000 to $10,000; 6 = $10,000 to $20,000; 7 = $20,000 to $50,000; 8 = $50,000 to $100,000.

2Data are for a machine with three rows of pockets.
Table 3.--Relationship of horsepower to feed rate with various types of bark-peeling machines

<table>
<thead>
<tr>
<th>Machine</th>
<th>Horsepower: per lineal foot</th>
<th>Lineal feet: per minute per horsepower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cambium rupturing machines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mobile hammer peeler</td>
<td>0.54 : 1.39</td>
<td>0.72 : 1.86</td>
</tr>
<tr>
<td>Hammer slab peeler</td>
<td>.19 : .57</td>
<td>1.75 : 5.25</td>
</tr>
<tr>
<td>Stationary hammer peeler</td>
<td>.75 : 6.25</td>
<td>.16 : 1.33</td>
</tr>
<tr>
<td>Chain post peeler</td>
<td>.60 : 1.50</td>
<td>.67 : 1.67</td>
</tr>
<tr>
<td>Chain pulpwod peeler</td>
<td>.71 : 2.68</td>
<td>.39 : 1.41</td>
</tr>
<tr>
<td>Chain-flail slab peeler</td>
<td>.13</td>
<td></td>
</tr>
<tr>
<td>Chain-flail log peeler</td>
<td>.83 : 1.67</td>
<td>.60 : 1.20</td>
</tr>
<tr>
<td>Multiple pocket semidrum</td>
<td>2.27 : 3.60</td>
<td>.03 : .44</td>
</tr>
<tr>
<td>Single pocket semidrum</td>
<td>3.79 : 5.22</td>
<td>.19 : .26</td>
</tr>
<tr>
<td>Single pocket semidrum (wet)</td>
<td>1.87 : 2.56</td>
<td>0.53</td>
</tr>
<tr>
<td>Small hydraulic peeler</td>
<td>2.64 : 21.1</td>
<td>.05 : .28</td>
</tr>
<tr>
<td>Rotating-head post peeler</td>
<td>.93 : 2.78</td>
<td>.36 : 1.08</td>
</tr>
<tr>
<td>Portable drums</td>
<td>.21 : 1.60</td>
<td>.62 : 4.74</td>
</tr>
<tr>
<td>Large drums (wet)</td>
<td>2.56 : 0.39</td>
<td></td>
</tr>
<tr>
<td>Large drums (dry)</td>
<td>.52 : 1.04</td>
<td>.96 : 1.92</td>
</tr>
<tr>
<td>Cambium-shearing log peelers</td>
<td>.20 : 1.2</td>
<td>.80 : 5.00</td>
</tr>
<tr>
<td>Cambium-shearing slab peelers</td>
<td>.19 : .43</td>
<td>2.31 : 5.38</td>
</tr>
</tbody>
</table>

| Knife machines                 |                             |                                       |
|--------------------------------|-----------------------------|                                       |
| Fixed single-head peeler       | 0.80 : 1.25                |                                       |
| Lathe peeler                   | .81 : 1.00                 | 1.00 : 1.24                           |
| Floating-head post peeler      | .47 : 2.41                 | .41 : 2.14                            |
| Floating-head pulpwood peeler  | .48 : 2.77                 | .375 : 2.10                           |
| Floating-head log peeler       | .60 : 1.20                 | .84 : 1.67                            |
| Rotating-head pole peeler      | 2.00 : 2.67                | .37 : .50                             |
| Pole shaper                    | 5.0 : 0.20                 |                                       |

1 Where production data were obtained in cords per hour they were converted to feet per minute by considering a cord to have 90 sticks, or 360 lineal feet. In the case of the single-pocket semidrum peeler, the number of 16-foot logs per hour was the base used. Where larger or smaller wood is used, there will be some variation on a volume basis. It is generally necessary, however, to vary the feet rate as the size of material changes, therefore, the net result does not vary a great deal.

2 A study, "Size, Volume, and Weight of Pine Slabs and Edgings in the South Carolina Piedmont," by Arthur S. Todd, Jr., and Walter C. Anderson shows that 76 percent of pine slabs have from 0.011 to 0.045 cubic feet per lineal foot, and 78 percent of pine edgings have 0.001 to 0.010 cubic foot per lineal foot.

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Table 4.—Relationship of cords of pulpwood to lineal feet

<table>
<thead>
<tr>
<th>Report No. 1730 (Revised)</th>
<th>Average diameter of 8-foot bolts per cord</th>
<th>4-foot bolts per cord</th>
<th>Lineal feet per cord of pulpwood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inside</td>
<td>35 inches</td>
<td>41 inches</td>
<td>1,240</td>
</tr>
<tr>
<td>Hemlock</td>
<td>1: Spruce</td>
<td>2: Hard maple</td>
<td>1:320</td>
</tr>
<tr>
<td>Red oak</td>
<td>3: Yellow birch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outside</td>
<td>20 inches</td>
<td>24 inches</td>
<td>1,068</td>
</tr>
<tr>
<td>Hemlock</td>
<td>1: Spruce</td>
<td>2: Hard maple</td>
<td>692</td>
</tr>
<tr>
<td>Douglas-fir</td>
<td>3: Red oak</td>
<td>4: Yellow birch</td>
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1Lake States Forest Experiment Station, U.S. Forest Service. "How Many Bolts Per Cord?" Tech. Note No. 197, Feb. 1943. (Jack pine and aspen values are between the two shown.)


5Northeastern Forest Experiment Station, U.S. Forest Service. C. Edward Behre. Occasional Paper No. 9, Apr. 5, 1940.
Table 5.--Relationship of cords per hour to lineal feet per minute

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<th>Rate</th>
<th>Pulpwood diameter in inches</th>
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<table>
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<tr>
<th>Cords per hour:</th>
<th>Lineal feet per minute</th>
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</table>

Report No. 1730 (Revised)
Figure 1.—Mobile trailer unit consisting of portable peeling machine mounted on war-surplus bomb-carrying trailer. Frame of trailer shown lowered at one end.
Figure 2.—Method of determining bark machine capacity per hour, according to log diameter and rate of feed per minute. Example: To bark 5,000 board-feet of 22-inch logs per hour, a machine must have a production rate of 4 lineal feet per minute.
Figure 3. --Relationship of pulpwood cords to lineal feet of bolts.
EXAMPLE:
A MACHINE BARKING 20 CORDS PER HOUR OF 6" PLYWOOD HAS THE SAME PRODUCTION RATE AS A MACHINE BARKING 119 LINEAL FEET PER MINUTE.

Figure 4.--Relationship of cords per hour to lineal feet per minute.
Figure 6. --Mobile cambium-rupturing wood peeler of hammer type.

Figure 7. --Hammer-type slab debarker.
Figure 8. -- Chain-flail log debarker.
Figure 9. --Mobile mounted drum.

Figure 10. --Portable drum made of boiler plate and mounted on eccentric.

Figure 11. --Portable drum showing spiral reinforcing rods.
Figure 12. --Sketch of multiple-pocket peeler.

Figure 13. --Single-pocket semidrum peeler.
Figure 14. --Shear-type log debarker using heavy rubber tension belts to force tools against log.

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Figure 15. Bark-shearing machine that uses air to force tools against the log.
Figure 19. - Double-head slab peeler. Slab is held against cutterhead, A, and bark and shavings are removed through conveyor, B.
Figure 20. --Portable peeler with single floating cutterhead.

Figure 21. --Peeler with double cutterheads of floating type.
Figure 22. --Cutterhead on veneer-bolt peeler, equipped with cutters resembling edger saws.

Figure 23. --Input end of rotating-cutterhead type of pole-shaping machine.
Figure 24. --Machine using multiple spring loaded, fixed knives followed by a rotary cleaner.

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