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Forest Products Lab.
Unnumbered Bull.

Issued June 11, 1912.

U. S. DEPARTMENT OF AGRICULTURE,

FOREST SERVICE.

HENRY S. GRAVES, Forester.

FOREST PRODUCTS LABORATORY SERIES.

EXPERIMENTS WITH JACK PINE AND HEMLOCK FOR MECHANICAL PULP.

BY

J. H. THICKENS,
Chemical Engineer in Forest Products.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

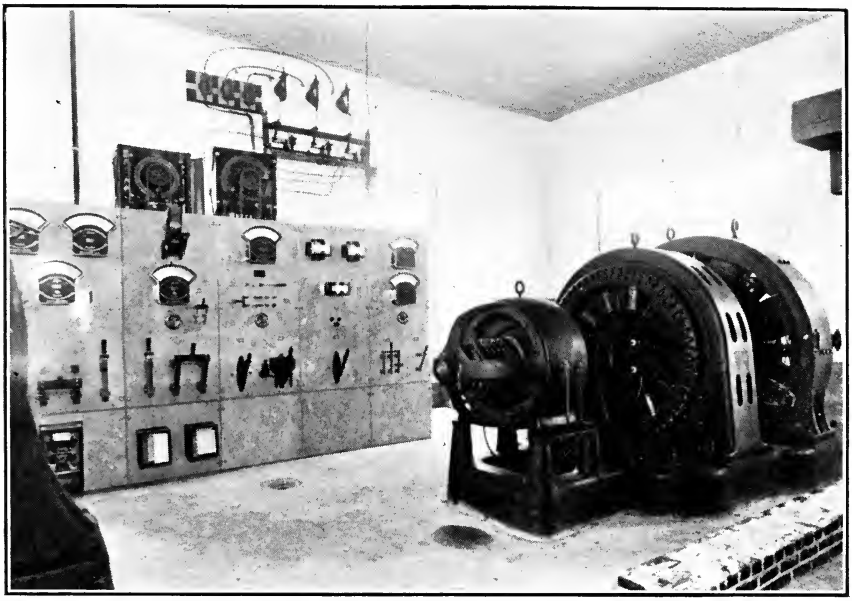

FIG. 1.—MOTOR GENERATOR SET AND SWITCHBOARD.

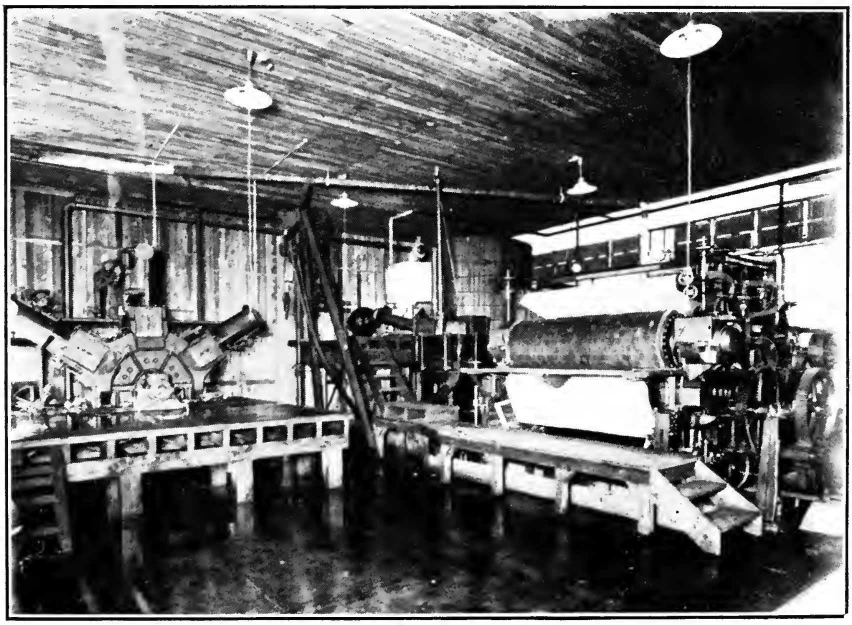

FIG. 2.—GRINDER AND WET-MACHINE ROOM.

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LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
FOREST SERVICE,
Washington, D. C., December 13, 1911.

SIR: I have the honor to transmit herewith a manuscript entitled "Experiments with Jack Pine and Hemlock for Mechanical Pulp," by J. H. Thickens, chemical engineer in forest products, and to recommend its publication.

Respectfully,

HENRY S. GRAVES,
Forester.

Hon. JAMES WILSON,
Secretary of Agriculture.

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EXPERIMENTS WITH JACK PINE AND HEMLOCK FOR MECHANICAL PULP.

NEED OF A SUBSTITUTE FOR SPRUCE PULPWOOD.

Few well-established industries have expanded as rapidly as has the pulp and paper industry. In less than a decade the amount of raw material used annually has more than doubled. During 1900[1] there were consumed in the United States 1,986,310 cords of pulpwood. The ground-wood process used 598,229 cords of domestic spruce, 120,820 cords of imported spruce, and 67,791 cords of other woods, such as hemlock, jack pine, poplar, and balsam, or a total of 786,840 cords. During 1909[2] the amount of wood used in all processes was 4,001,607 cords, the ground-wood process using a total of 1,246,121 cords, which consisted of 806,282 cords of domestic spruce, 317,289 cords of imported spruce, and 122,550 cords of other miscellaneous woods.

Thus the increase in the total amount of pulpwood used during this period was 101 per cent, while the amount of pulpwood of all kinds used for ground wood increased 58½ per cent. The domestic spruce consumption for this purpose increased 35 per cent and the consumption of miscellaneous woods 80.5 per cent. But the largest increase was in the use of imported spruce, the consumption of which increased 162 per cent.

The price of spruce has increased at a very rapid rate. In 1900 the average cost of spruce used in all processes in the United States was $4.83 per cord for domestic spruce and $6.50 for imported, while in 1909 the average price of domestic spruce was $9.32 and of imported $11.34 per cord.

This increase has been reflected in the cost of ground-wood pulp. The manufacturing cost of pulp, as determined by the Tariff Board,[3] increased from $10.84 per ton in 1900 to $16.58 in 1909, 93 per cent of this increase being accounted for by the greater cost of the wood used. Manifestly, therefore, it is almost essential, if the ground-wood

[1] Twelfth Census of the United States.

[2] "Pulpwood consumption, 1909," Bureau of the Census.

[3] Report by the Tariff Board relative to pulp and news print paper industry, Senate Document No. 31, Sixty-second Congress, first session.

industry is to continue, that substitutes be found for spruce pulp, especially in the manufacture of news, wrapping, and other of the cheaper grades of paper. To determine whether there are not other domestic species which will produce a commercial grade of ground wood suitable for the purpose, etc., the Forest Service, in cooperation with the American Pulp and Paper Association, began an extensive series of tests on several of the woods which occur in large quantities in the United States, particularly in the Lake States. The woods which have been tried up to the present are hemlock and jack pine, together with a small amount of spruce, for the purpose of comparison.

The experiments were conducted at Wausau, Wis., under the general supervision of the director and assistant director of the Forest Products Laboratory, and an advisory committee of the American Pulp and Paper Association, composed of Messrs. G. F. Steele, chairman Nekoosa-Edwards Paper Co.; W. G. McNaughton, secretary Nekoosa-Edwards Paper Co.; D. C. Everest, Marathon Paper Mills Co.; W. L. Edmonds, Wausau Paper Mills Co.; A. M. Pride, Tomahawk Paper Co.; and Wm. Eibel, Rhinelander Paper Co.

RESULTS OF EXPERIMENTS.

Not only have very promising sheets of pulp been obtained from both the hemlock and jack pine, but paper has been made from them on commercial machines, operating at high speed, and under all other conditions of actual commercial practice, which has the strength, finish, and appearance of standard news paper. The production per grinder, the horsepower consumption per ton, and the yield per cord approximate the averages which obtain in the grinding of spruce. Again, pulps composed of mixtures of hemlock, spruce, and jack pine in different proportions have been obtained, which compare very favorably with the ordinary spruce ground wood.

Hemlock ground wood has a decided reddish tinge, though this is not very noticeable, even in an all-hemlock sheet of news paper. Jack pine pulp is also slightly off in color, but is not nearly as dark as hemlock pulp. Careful study by experts should make it possible to bring the color of the paper produced from these pulps more nearly to the usual white. As it is, the sheets of news paper which have been secured are only slightly off color, though they are the result in each case of but a single attempt to secure the standard degree of whiteness.

Since the experiments on hemlock have brought out a number of points in favor of the grinding of that wood, two paper-mill companies have signified their intention of using it in their cheaper grades of paper. One of these mills has already begun to do so, and is well satisfied with the pulp obtained.

WHY JACK PINE AND HEMLOCK HAVE NOT BEEN USED.

There is much doubt as to exactly why the pulp industry has neglected to use hemlock and jack pine for the cheaper grades of paper. It seems to be the general impression that hemlock grinds so fine and short that there is a great loss in conversion. It has been said that the yield obtained is in many instances only three-fifths of that from an equal amount of spruce. This loss in grinding hemlock has not been in evidence during the tests.

The pitch in jack pine is undoubtedly responsible for the lack of attention paid to that wood. This, however, can be removed by steaming or soaking, and such treatments will be taken up in future experiments.

In all the experiments the yields secured from the different woods were in direct proportion to their bone-dry weight per cubic foot. It is therefore to be expected that the yields from jack pine and hemlock will be less per unit of volume than those from spruce, since the two first woods are considerably lighter in weight. On the basis of weight, however, there appears to be relatively little more loss in converting hemlock or jack pine into pulp than in converting spruce.

The fiber obtained from the ground hemlock and jack pine has been considered unsatisfactory on account of its shortness. Yet it has been found long enough for use in cheap papers.

One who is accustomed to handling spruce ground wood will not be favorably impressed with the appearance of either hemlock or jack pine pulp. This is particularly true of the hemlock sheet. Both pulps are somewhat softer in texture than spruce, and, altogether, are not as pleasing in appearance as the present commercial product.

Another point which may account for the lack of attention paid to hemlock and jack pine is the care which must be exercised in grinding them. It is possible to obtain a grade of pulp from spruce which is suitable for most purposes without using a great deal of care in the preparation of the surface of the pulp stones. In the grinding of jack pine and hemlock, especially hemlock, on the other hand, great care must be exercised in bringing the stone to the correct degree of sharpness, since these woods will grind to powder if the surface is as sharp as the one ordinarily employed in grinding spruce.

Yet notwithstanding certain shortcomings the fact remains that it is possible to obtain hemlock and jack pine pulps commercially which are suitable for the cheaper grades of paper.

EQUIPMENT USED IN THE EXPERIMENTS.

ELECTRICAL EQUIPMENT.

To study accurately the fundamental variables of grinding it was necessary to install an elaborate electrical drive and apparatus for control and manipulation. There has also been provided a system of recording instruments for the determination of speed, pressure, and load fluctuation. The electrical apparatus consists of a motor-generator set and a direct-current variable-speed motor. The variable-speed motor, direct connected to the pulp grinder, is rated at 225 horsepower at 100 revolutions per minute and 500 horsepower at 300 revolutions per minute, with a 50 per cent overload capacity at all speeds. However, it is possible to obtain about 25 per cent more capacity than the rating. Variation in speed is obtained by variation of voltage applied to the motor armature, and by means of a rheostat in the field circuit of the generator it is possible to maintain this voltage at any point desired, thus giving a very constant speed.

The efficiency of the grinder motor has been determined for all values of speed and load throughout the range of usage. Consequently, the power applied to the grinder at any value of peripheral speed or at any pressure on the cylinders can be calculated.

Individual motor drives have also been installed for the various other pieces of pulp-making machinery and their auxiliary apparatus. The machines for wood preparation and the wet-machine vacuum pump are the only ones which are not direct connected to individual motors. In several cases variable-speed motors have been installed to permit adjustment of speed to the most effective value.

PULP MACHINERY AND AUXILIARY EQUIPMENT.

The pulp-making machinery, machines for wood preparation, and the auxiliary pieces of apparatus are all of standard commercial types and were loaned by the following manufacturers or others interested in the work of the laboratory:

Grinder	Friction Pulley and Machine Works.
Wet machine	Improved Paper Machinery Co.
Flat screen	Harmon Machine Co.
Ruth centrifugal screen	H. L. Orrman & Co.
5 by 8 inch triplex pump	Goulds Manufacturing Co.
4 by 6 inch triplex pump	Do.
5-inch centrifugal pump	Do.
4-inch centrifugal pump	Do.
Storage tank	Valley Iron Works.
Barker	Green Bay Foundry and Machine Works.

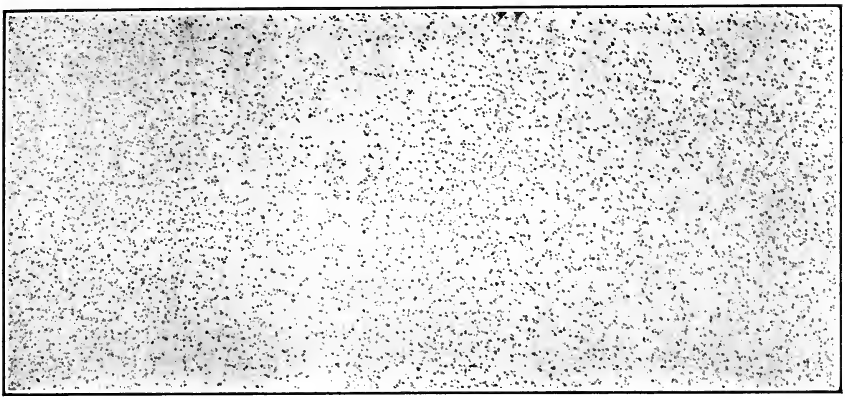

FIG. 1.—NATURAL SURFACE OF STONE. (JACK PINE RUN NO. 2.)

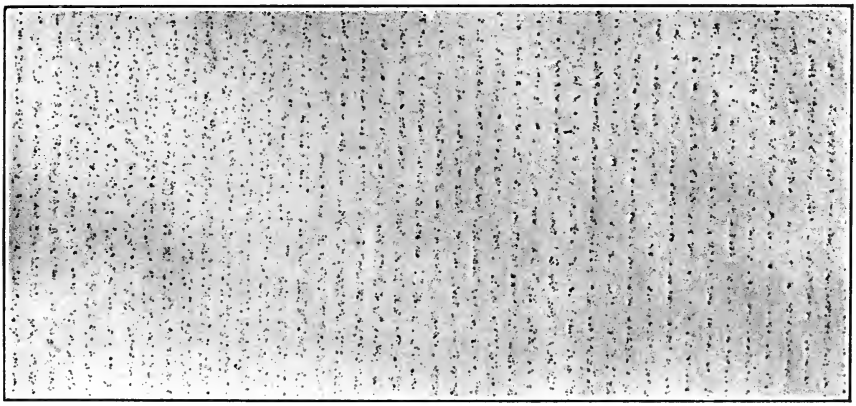

FIG. 2.—TEN TO THE INCH SOLID; STRAIGHT-CUT BURR. (HEMLOCK RUN NO. 0.)

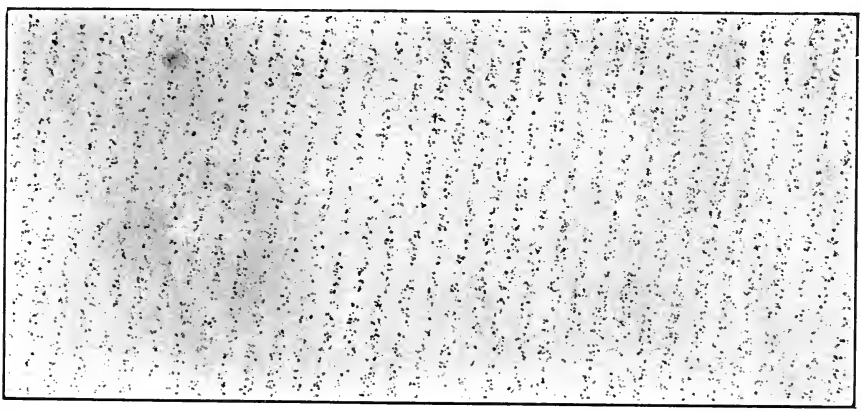

FIG. 3.—EIGHT TO THE INCH SOLID; SPIRAL BURR. (HEMLOCK RUN NO. 43.)

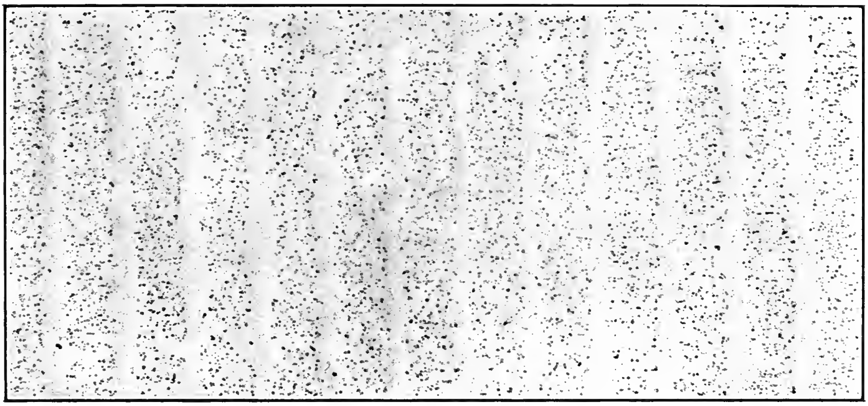

FIG. 1.—THREE TO THE INCH SOLID; STRAIGHT-CUT BURR. (HEMLOCK RUN NO. 46.)

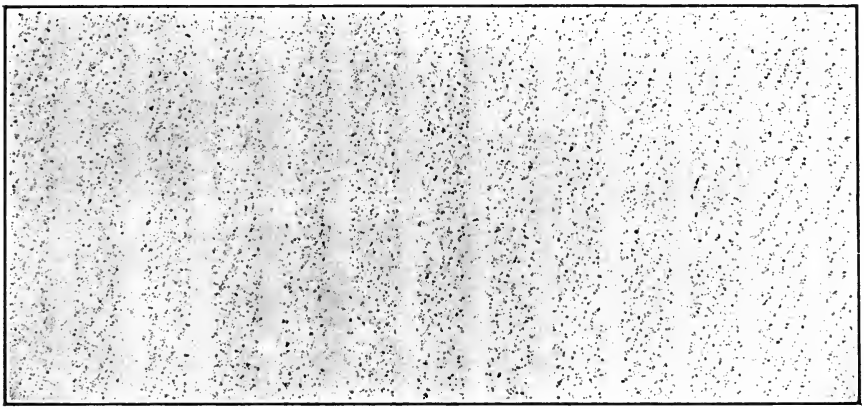

FIG. 2.—THREE TO THE INCH SOLID; STRAIGHT-CUT BURR. CUT OVER WITH TWELVE TO THE INCH SOLID; SPIRAL BURR. (HEMLOCK RUN NO. 51.)

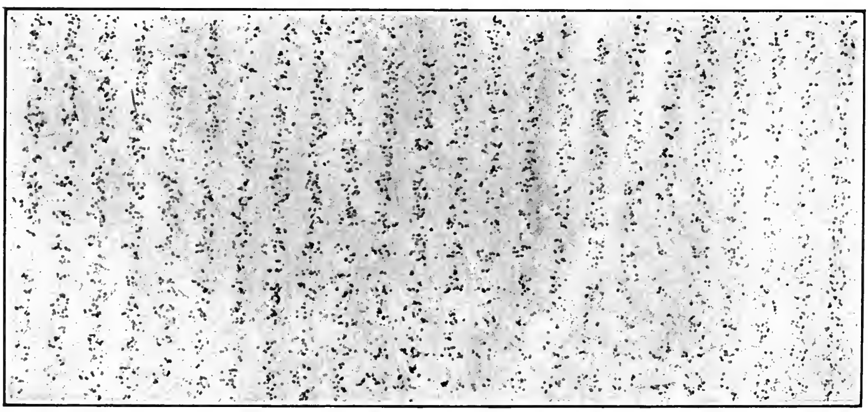

FIG. 3.—SIX TO THE INCH DIAMOND POINT BURR. (JACK PINE RUN NO. 17-1.)

Swing cut-off saw	American Pulp and Paper Association.
3-ton scale	Paper (Inc.).
2 Ashton relief valves	Do.
1 pulp truck	W. A. Lounsberry & Co.
1 wood truck	Do.
1 54 by 27 inch pulp stone	Manufacturers' Paper Co.
12 42-inch screen plates	Union Screen Plate Co.
1 wet-machine felt	Albany Felt Co.
1 wet-machine felt	Appleton Woolen Mills.
1 set barker knives	Dowd Knife Works.
1 set sectional and solid burrs	Ticonderoga Machine Works.

Plate I shows a portion of the pulp-making equipment. The grinder (Pl. I, fig. 2) has three pockets, the cylinders are 14 inches in diameter, and it is designed for a 54 by 27 inch pulp stone. Each of the grinder cylinders is equipped with a pressure gauge, and the pressure line between the triplex pumps and the grinder is provided with Ashton relief valves, which make it possible to obtain very uniform pressures up to 100 pounds per square inch.

A recording thermometer gives a record of the temperature in the grinder pit. From the grinder pit the pulp is passed through a mechanically agitated sliver screen, then pumped to a storage tank by means of a 6-inch centrifugal pump, and from there pumped to a centrifugal screen. A variable-speed motor direct connected to the screen makes it possible to obtain speeds of rotation from 400 to 600 revolutions per minute. Throughout the tests, however, the speed was maintained at 500 revolutions per minute. The plate in the centrifugal screen is perforated with holes 0.065 inch in diameter. The tailings from it are led by gravity to a 12-plate horizontal diaphragm screen, the plates of which are the Union Screen Plate Co's. type B, cut with 0.012-inch slots.

The good pulps from the centrifugal and the plate screens are united in the vat of the wet machine, which is direct connected to a variable-speed motor giving felt speeds ranging from 75 to 115 feet per minute. The wet machine is provided with a small triplex pump by which the cylinders connected to the press rolls are operated, the dryness of the pulp being determined by the pressure applied to the cylinders. A vacuum of from 10 to 15 inches, produced by a rotary suction pump, is maintained on the felt, and this, too, assists in obtaining the desired dryness of the pulp. The white water from the wet-machine vat is pumped back to the grinder sliver screen by a 4-inch centrifugal pump. White water from the felts is run directly to the sewer, as is also the white water from the felt suction. Plate I, figure 2, gives an idea of the general arrangement of the pulp-making machinery. A 40-inch swing cut-off saw and a Green Bay wood barker are used to prepare the wood.

METHODS EMPLOYED.

QUALITATIVE AND QUANTITATIVE TESTS.

In order to cover the field in a reasonable length of time, short tests ranging up to two hours in length were run. In these tests no attempt was made to cover every point, the object being to touch only such as were thought to have a marked effect on the quality of the product. The surface of the stone, the pressure on the grinder cylinder, and the peripheral speed of the stone were the variables which received most attention. No especial attention was given to economic considerations.

Tests were made with pressures of from 20 to 75 pounds per square inch on the cylinder, corresponding to from 8.2 to 30.8 pounds per square inch of pocket area. The speed of rotation of the stone was varied from 84 to 225 revolutions per minute, corresponding to a range in peripheral speed of from 1,173 to 3,150 feet per minute.

In studying the effect of the surface condition of the stone it was necessary to utilize burrs of many different types and designs. These ranged in fineness of cut from 12 to the inch to 3 to the inch. The style of cut differed also, spiral cut, diamond points, and straight cut being employed. The power applied to the grinder ranged from 87.3 to 520 horsepower, while the rate of production of bone-dry pulp varied from 1 ton to 7.3 tons in 24 hours. It should be understood that neither the two minimum nor the two maximum values were necessarily obtained from the same test. When the power applied to the grinder was 87.3 horsepower, for instance, it does not necessarily follow that the production was 1 ton per day. The horsepower consumption per ton under the given conditions was found to vary from 68.3 to 196 in 24 hours.

The samples of pulp obtained during the qualitative and quantitative tests were examined and commented upon by members of the advisory committee of the American Pulp and Paper Association, and those runs considered most promising were duplicated later in commercial tests.

COMMERCIAL TESTS.

TREATMENT OF THE WOOD BEFORE GRINDING.

All of the wood used in the tests was cut either in Wisconsin or Michigan and was representative of the species. In some cases the wood was secured directly from the forest, while in others it was shipped to the laboratory from near-by mills. Upon arrival at the laboratory the logs were closely piled on skids. An attempt was made to keep the material green by painting the ends with paraffin, but this proved unsatisfactory, because the paraffin peeled off. The wood tested was taken directly from the piles for all tests up to and including run No. 52 of the hemlock series, with the exception of runs Nos. 49, 50, and 51, the wood for which was soaked in the pond for approximately two months before being used. The only jack pine soaked was that used in the commercial test on seasoned wood of that species—run 14. The jack pine and spruce used in tests on mixed pulps were in all cases dry before grinding. The wood for the tests was prepared approximately 2 cords at a time, sawed into 2-foot lengths, barked, weighed, and piled up for the grinding process.

To determine accurately the yield, the bone-dry weight per cubic foot of wood, as well as the percentage of moisture present, was determined in each commercial test. All weighings were made in 500 or 1,000 pound lots, and the wood was used as soon as ground.

No attempt was made to remove knots or punky portions of the wood. In fact, all of the tests were carried on in accordance with the usual commercial practice.

GRINDING.

Before commencing the grinding tests an impression of the surface of the stone which had been selected was taken by means of a piece of carbon paper and a sheet of coated paper. This impression was later photographed, as shown in Plates II and III. In these the black dots represent projecting points and the white portions between them depressions in the stone. The surface shown in Plate III, figure 2, is particularly interesting, since it is the result of dressing with two different kinds of burrs.

Before starting the tests the recording thermometer and all of the other recording instruments were placed in operation. The pockets of the grinder were filled, the pressure adjusted to the proper value, and the grinder started.

For the purpose of check and control, regular readings were taken of the various switchboard instruments, the indicating tachometer, the pressure gauges, and the recording thermometer. On short tests up to 2 hours in length these readings were recorded at 5-minute intervals, but on longer tests the interval was increased to 15 minutes. The speed, pressure, and other variables were maintained as nearly constant as possible. For instance, when one of the grinder pistons was raised the speed was brought back to the desired value by manipulation of the rheostat controlling the motor armature voltage.

During the qualitative and quantitative tests the pulp stone did not have an opportunity to heat up, and, in consequence, some of the data on power consumption and production may be more or less questionable. In the commercial tests, however, all of which were made under the hot-grinding process, the stone was brought up to a high temperature, which was maintained throughout the run; consequently these more nearly approximate commercial conditions.

LOSSES IN GRINDING.

To determine approximately the losses occurring in the conversion of wood to pulp, the bone-dry weight of screenings obtained from a known amount of bone-dry wood was determined. The loss in the white water was then taken as the difference between the bone-dry weight of the wood ground and the bone-dry weight of the pulp secured plus the screenings.

FIBER STUDY.

During each test the character of fiber obtained was examined by means of an apparatus for microscopic study. This consists of an ordinary stereopticon provided with a specially constructed carrier for microscopic slides. Samples of wet pulp were taken from the wet-machine vat and slides were made by first removing the water by drying, then staining with Bismarck brown, and moistening with glycerine. The mixture of glycerine and fiber was teased out to cover the area of an ordinary microscopic cover glass, which was placed over the mixture. Evaporation or leakage was prevented by means of a thin strip of shellac around the edge of the cover glass.

With this apparatus it was also possible to compare different samples of pulp with the commercial standards used, the latter being selected from a large number of samples submitted by American manufacturers of ground-wood pulp.

CALCULATION OF RESULTS.

To give a clear understanding of the method employed in calculating the various items in connection with a test, all the calculations for a representative run, No. 50, Table 4, are given here. Considerable data taken during the tests have been eliminated from the compilation, since they have no direct bearing on the study.

The test mentioned required 3.42 hours to complete, and during that time 3,388 pounds of hemlock wood were ground. For comparison all of the figures on weight of wood were brought to a bone-dry basis. The bone-dry weight of wood was secured by drying a known volume of wood to constant weight and calculating the weight per cubic foot. By calculating the bone-dry weight of a log of measured volume and subtracting this amount from the actual weight of the log, the moisture content of the wood was determined. The bone-dry weight of this wood, per cubic foot, was 24.84 pounds, and the moisture content was 46.5 per cent; consequently the amount of bone-dry wood ground was 53.5 per cent of 3,388, or 1,810 pounds. This is equivalent to 72.9 cubic feet of solid wood ground during the given period; or, in other words, the grinding was carried on at the rate of 512 cubic feet of solid wood in 24 hours.

The amount of wet pulp obtained during the test was 3,795 pounds, and this upon analysis was found to have a moisture content of 60.22 per cent. Consequently, 1,507 pounds of bone-dry pulp were obtained during the period of test, corresponding to a production of $\frac{24}{3.42} \times \frac{1507}{2000}$ or 5.3 tons in 24 hours. To grind the wood and produce this pulp it was necessary to apply to the grinder motor power which averaged 338 kilowatts. This value was obtained by dividing the total number of kilowatt hours used, as given by a watt-hour meter, by the length of the test in hours. Figure 1 shows a section of a wattmeter record obtained during this test, and illustrates how the power used by the grinder varied upon the removal of the load from one of the grinder pockets. The entire recording wattmeter curve was averaged by means of a planimeter, in order to check the value of power consumed as given by the watt-hour meter.

By using curves which show the losses in the motor it was found that 15.3 kilowatts were required to supply the heat losses in the grinder-motor armature and 7.1 kilowatts to supply the stray power losses, making a total of 22.4 kilowatts lost in converting the power from electrical to mechanical. This amount subtracted from 338 kilowatts gives 315.6 kilowatts which were furnished to the grinder pulpstone, and 315.6 divided by 0.746 [1] gives the value of 422½ horsepower applied to the grinder. In order, then, to obtain 5.3 tons of bone-dry pulp in 24 hours it was necessary to apply to the grinder over that period 422½ horsepower, or the horsepower consumption per ton was 422½ divided by 5.3, or 79.7 horsepower per ton in 24 hours.

The yield from 100 cubic feet of solid wood was obtained by dividing the amount of pulp produced during 24 hours, 5.3 tons or 10,600 pounds, by the number of hundreds of cubic feet of wood ground in 24 hours, viz, 5.12. The result is 2,070 pounds.

The average temperature of grinding was determined by reading the recording thermometer every five minutes, adding these values, and dividing by the total number of readings.

COMPARISON OF YIELDS.

Much importance is attached to the amount of pulp obtained from a cord of wood, because this represents the efficiency of conversion. Commercial practice in the manufacture of spruce ground wood requires a yield of approximately 2,300 pounds per cord of

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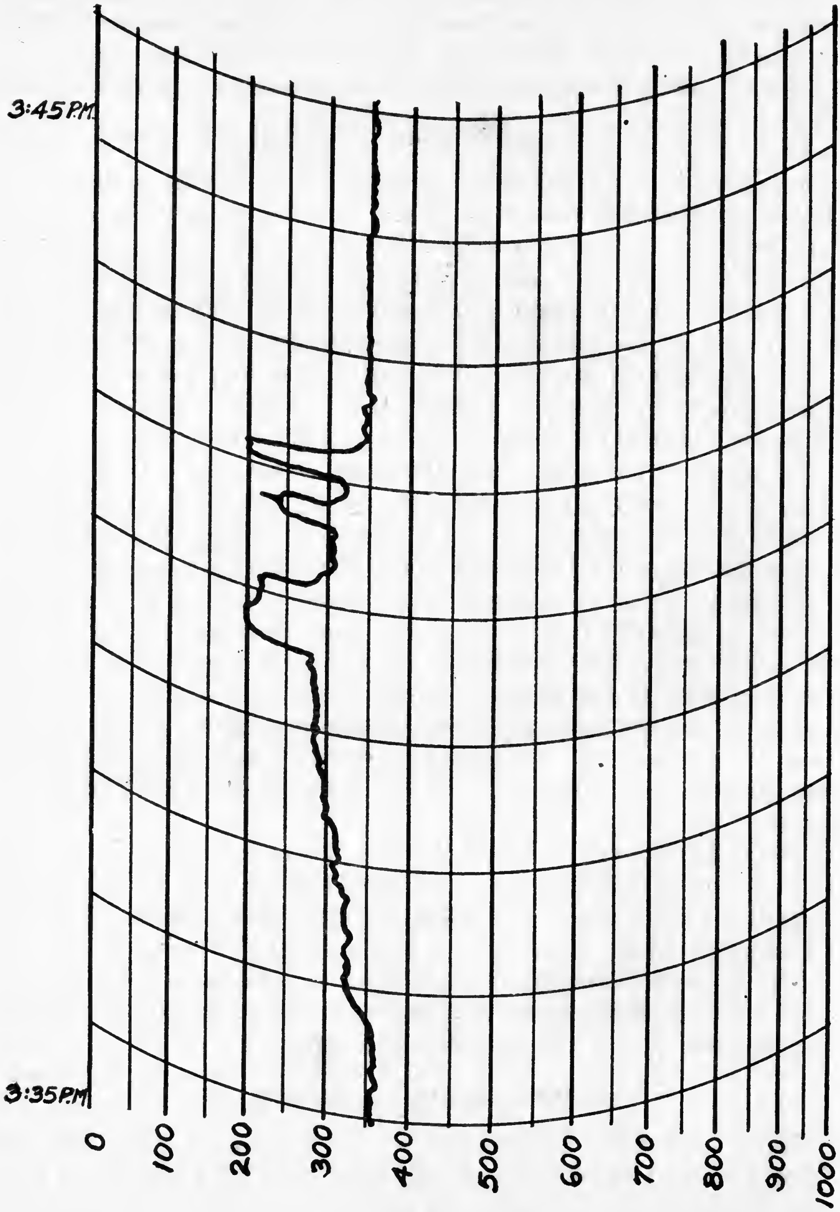
[1] A horsepower is equivalent to 0.746 kilowatt.

rossed wood, or 1,800 pounds per cord of rough wood. The average yields which have been obtained for hemlock and jack pine, together



KILOWATTS.

FIG. 1.—Portion of chart from recording wattmeter, showing decreased power consumption after removal of load from pocket and pocket binding.

with those obtained for two different shipments of spruce, are given in Table 1.

TABLE 1.—*Average yields from spruce, hemlock, and jack pine.*

Species.	Weight per 100 cu. ft. bone-dry.	Yield per 100 cu. ft. of solid wood.	Efficiency of conversion.
	Pounds.	*Pounds.*	*Per cent.*
Spruce	2,840	2,480	87.3
Do	2,270	2,000	88.2
Hemlock	2,480	2,100	84.8
Jack pine	2,540	2,200	86.7

One hundred cubic feet of solid wood was selected as the basis of yield, since it eliminates the variable loss in barking, and represents fairly well the amount of solid wood in a rossed cord. The yield, as will be seen, is directly proportional to the bone-dry weight of the wood. The loss in conversion has been found to range between 12 and 15 per cent of the original weight of the bone-dry wood. Approximately 6 per cent can be accounted for in the white water and 1 per cent in screenings. The manner in which the remaining losses occur has not been determined, but will be studied in future tests.

The storage capacity for white water in the laboratory was very limited, and this may to some extent account for the low yields. The continuous use of the white water and the use of save-alls would undoubtedly tend to increase the yields and result in saving a great deal of fine pulp.

The loss in barking jack pine and hemlock, so far as has been determined up to the present time, is practically the same as the loss in the barking of spruce. There are a great many knots in both hemlock and jack pine, and it is possible that this may cause a somewhat greater loss in barking these species. However, on account of the small amounts of the various woods used, no reliable data on loss were obtained.

FACTORS WHICH INFLUENCE QUALITY AND PRODUCTION.

SPEED AND PRESSURE.

The effect of speed on the quality of pulp can best be illustrated by the magnified fibers shown in Plates VII and VIII. In grinding these pulps the pressure and surface of the stone were maintained constant, and the speeds were, respectively, 100, 150, and 200 revolutions per minute for the hemlock, and 152 and 205 revolutions for the jack pine. There is little difference in the fibers ground under these different conditions of speed; especially those run at 150 and 200 revolutions per minute. Speed probably has very little effect on the quality of pulp. With satisfactory pressure and surface of stone, it is possible to obtain good grades of pulp at any speeds within reasonable limits. Commercially, it is practically impossible to maintain the speed constant at all times. When the pressure on a pocket is removed the speed is bound to rise considerably, especially when the water wheels or turbines are operated without a governor.

When hemlock wood was ground at low speed and low pressure it was impossible to obtain anything more than a powder. Also when this wood was ground at low pressure and high speed the product was extremely short, but the pressures at which these results were obtained are considerably lower than those ordinarily employed commercially, and the results have little significance. If the stone is what is ordinarily called sharp, it is necessary to use a lower pressure, and when dull, a higher one, but it is impossible to obtain the same quality of pulp under both conditions. Speed and pressure affect quantity rather than quality, and by the proper adjustment of both the maximum efficiency of grinding is attained. If a certain speed is selected there must be a corresponding pressure which will yield the greatest amount of pulp in 24 hours with the least consumption of power.

By the term "constant pressure," wherever used in this report, is meant constant pressure on the grinder cylinders. The pressure per square inch of wood in contact with the grinding surface varies considerably, chiefly with the size of wood ground and the area of the pocket. Again, the length of the wood is not at all a constant quantity, and this, too, can only result in a variable pressure per square inch of wood. The pressure of the wood on the stone varies throughout certain limits with any pressure on the grinder cylinder, and the ranges of pressure of the wood on the stone are raised or lowered by raising or lowering the cylinder pressure. This pressure variation, however, can hardly be controlled commercially, and therefore has not been considered in the tests discussed in this report. There is also more or less pressure variation due to binding of wood in the pockets, and this, too, is difficult, if not impossible, to control. Figure 1 shows a measure of the power applied to the grinder. The effect of pocket binding and the withdrawal of pressure from one of the pockets will be noted. At one end of this chart the power consumed is approximately 360 kilowatts, falling off gradually to 280 kilowatts, due to pocket binding. After raising the pistons and readjusting the wood in the different pockets, the power to the grinder motor had to be increased to 350 kilowatts on account of the added load produced by eliminating the pocket binding.

SURFACE OF STONE.

The most efficient grinding condition is one where there is a maximum amount of grinding surface, and still a sufficient amount of depression in the stone to allow for the carrying away of the ground wood, or, as this is commonly called, for the clearing of the stone.

FIG. 1.—SPRUCE SULPHITE STANDARD.

FIG. 2.—SPRUCE GROUND WOOD, NO. 1 STANDARD.

FIG. 1.—SPRUCE GROUND WOOD, NO. 2 STANDARD.

FIG. 2.—SPRUCE GROUND WOOD, NO. 3 STANDARD, COARSE GROUND.

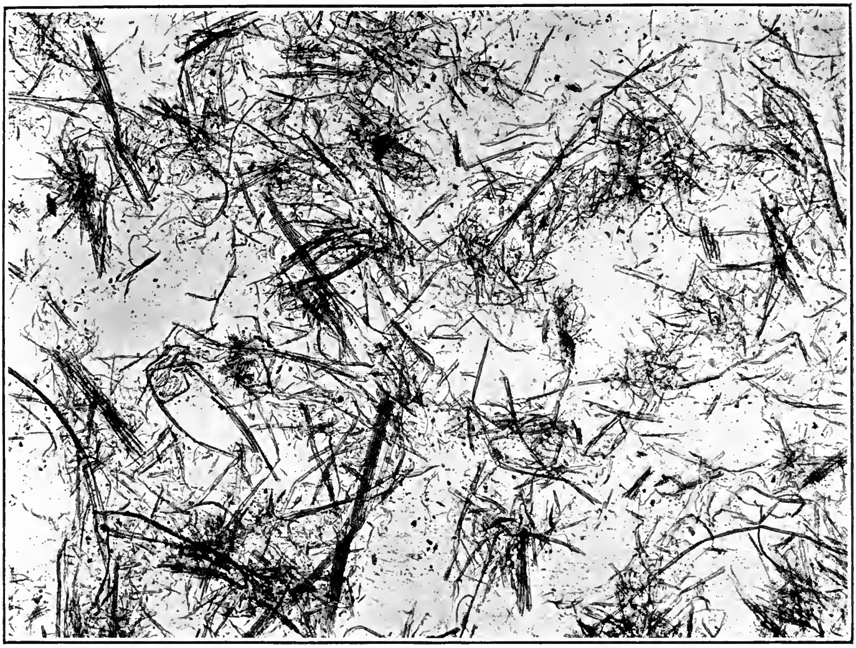


FIG. 1.—SPRUCE GROUND WOOD, NO. 4 STANDARD, MEDIUM GROUND.

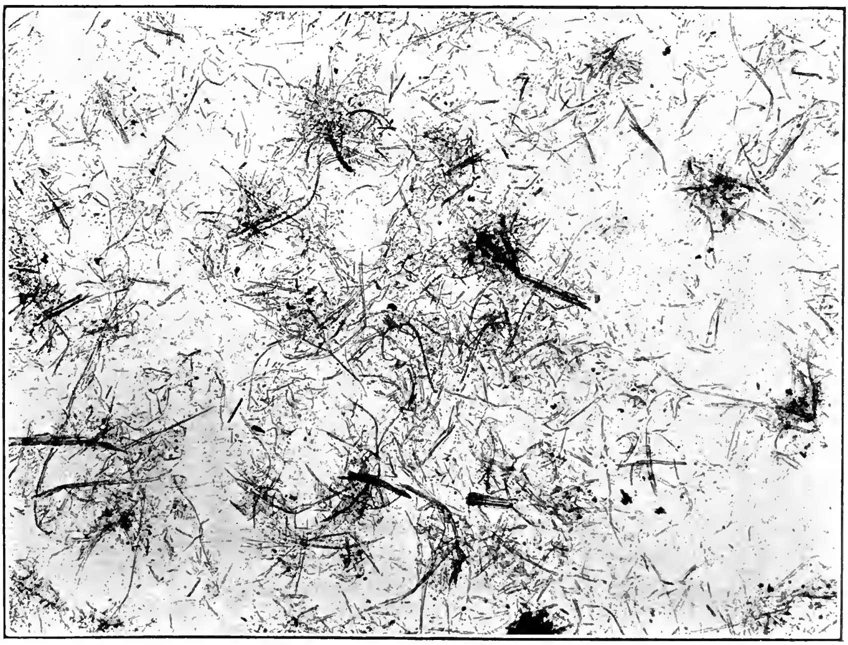


FIG. 2.—SPRUCE GROUND WOOD, NO. 5 STANDARD, FINE GROUND.

FIG. 1.—100 R. P. M. (RUN NO. 35.)

FIG. 2.—150 R. P. M. (RUN NO. 36.)

FIG. 3.—200 R. P. M. (RUN NO. 37.)

COMPARISON OF HEMLOCK PULPS GROUND AT DIFFERENT SPEEDS.

FIG. 1.—152 R. P. M. (RUN NO. 19.)

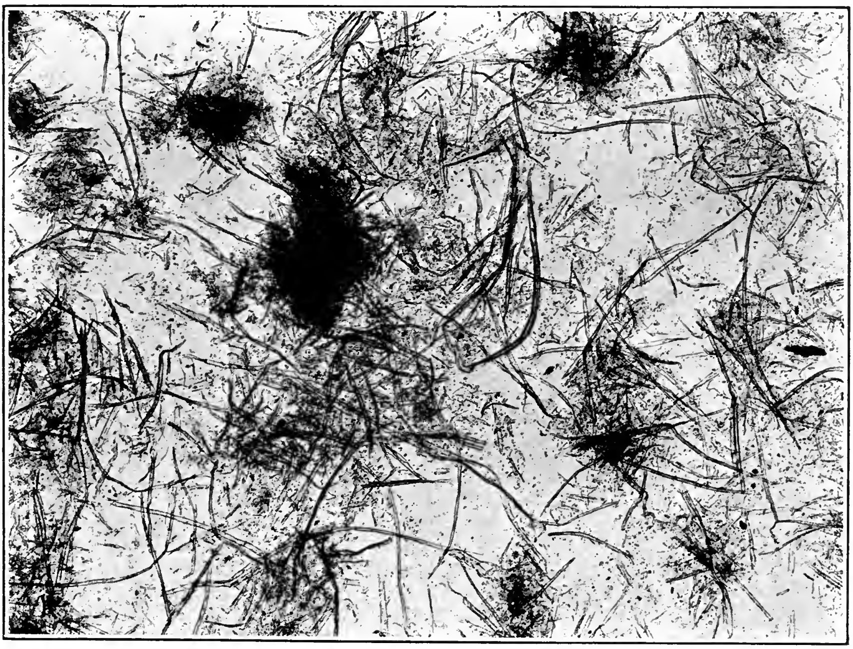


FIG. 2.—205 R. P. M. (RUN NO. 20-1.)

COMPARISON OF JACK PINE PULPS GROUND AT DIFFERENT SPEEDS.

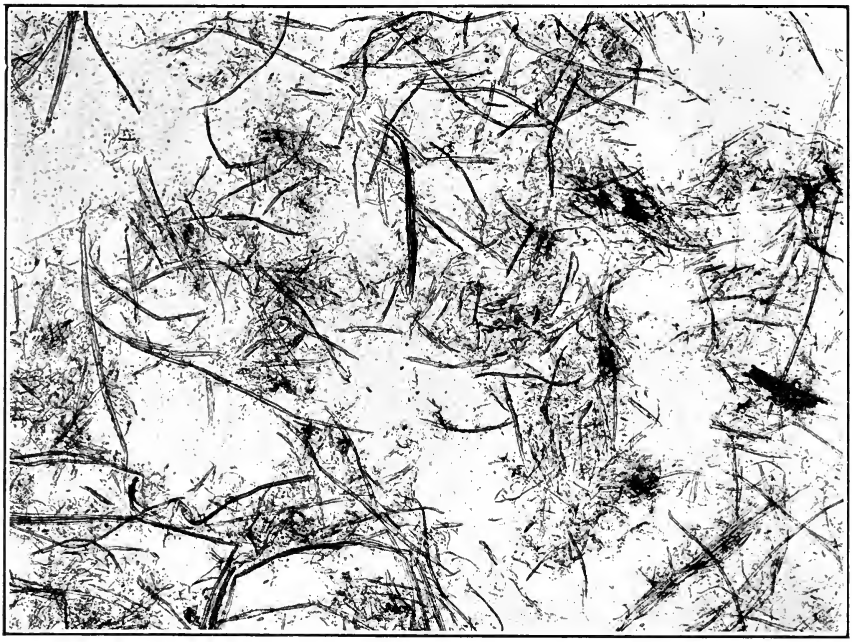


FIG. 1.—JACK PINE GROUND WOOD. (RUN NO. 14-1.)

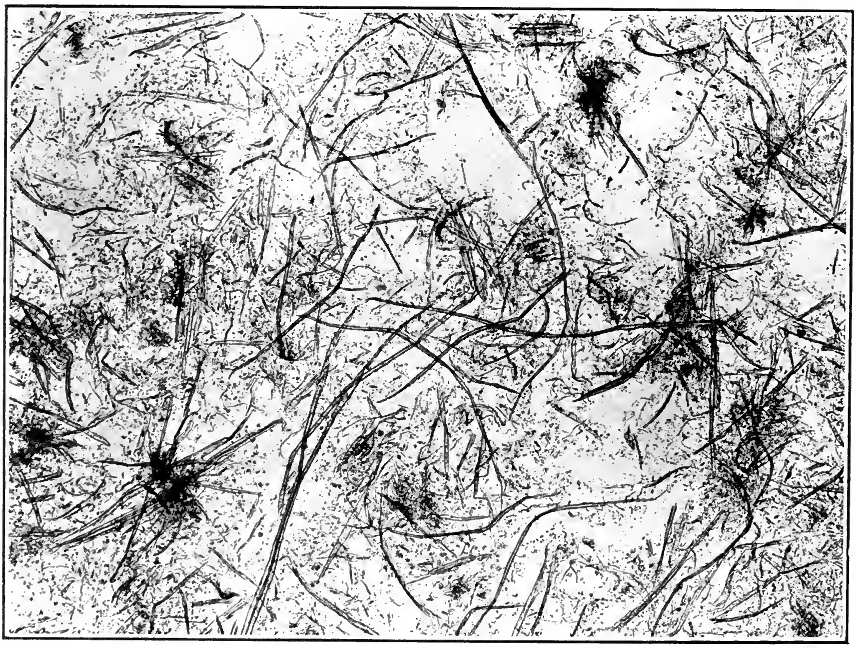


FIG. 2.—JACK PINE GROUND WOOD. (RUN NO. 13-1.)

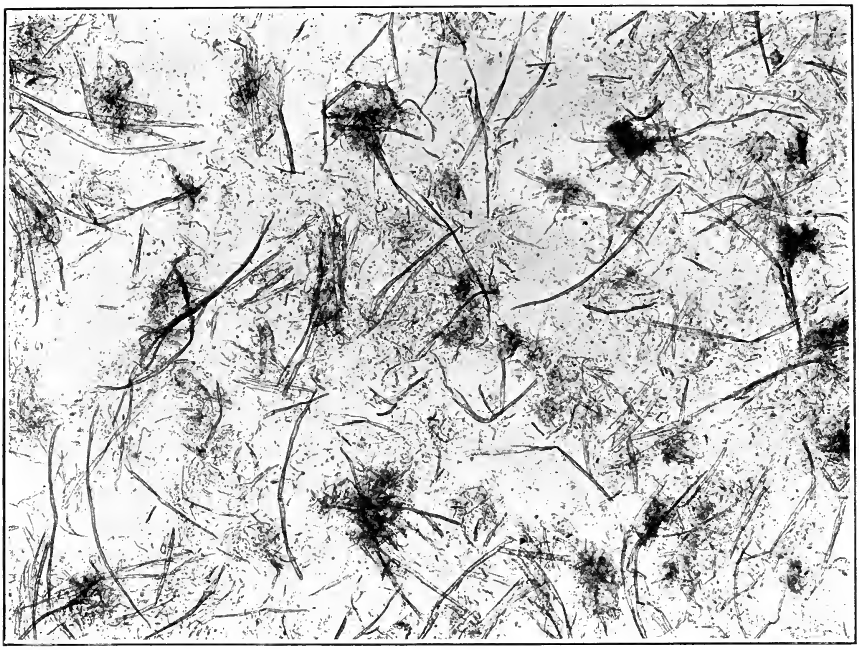


FIG. 1.—JACK PINE GROUND WOOD. (RUN NO. 7-1.)

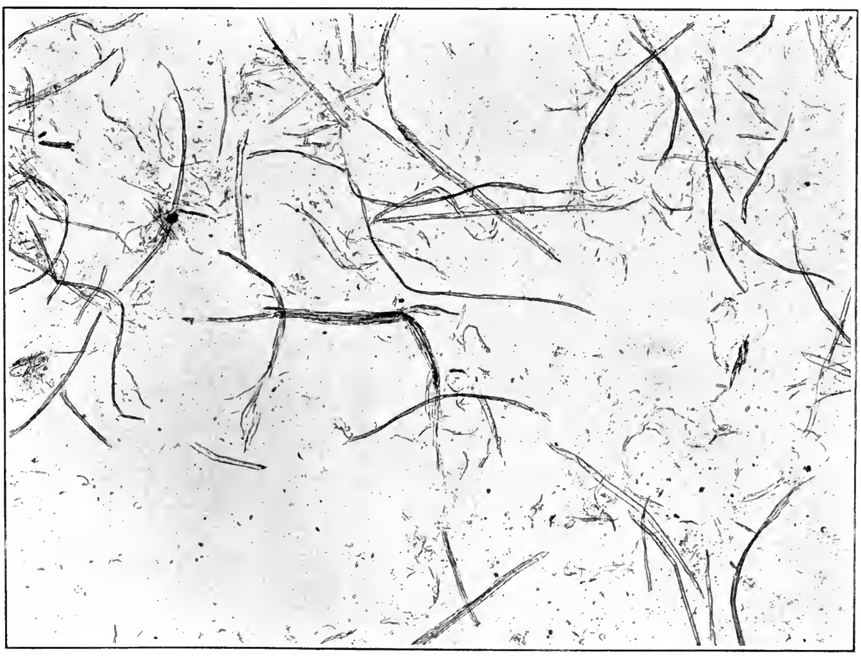


FIG. 2.—JACK PINE GROUND WOOD. (COMMERCIAL RUN NO. 24.)

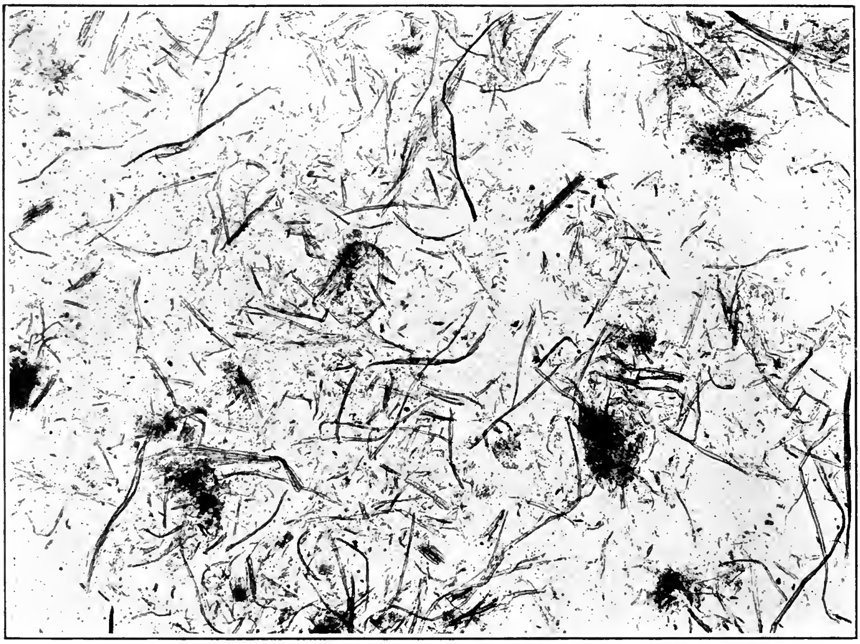


FIG. 1.—HEMLOCK GROUND WOOD. (RUN NO. 41.)

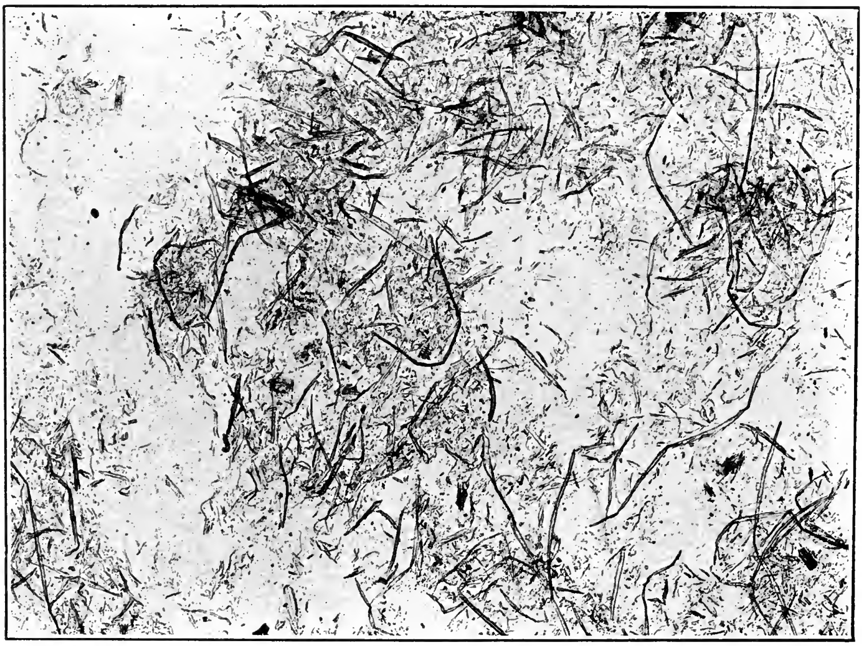


FIG. 2.—HEMLOCK GROUND WOOD. (COMMERCIAL RUN NO. 14-1.)

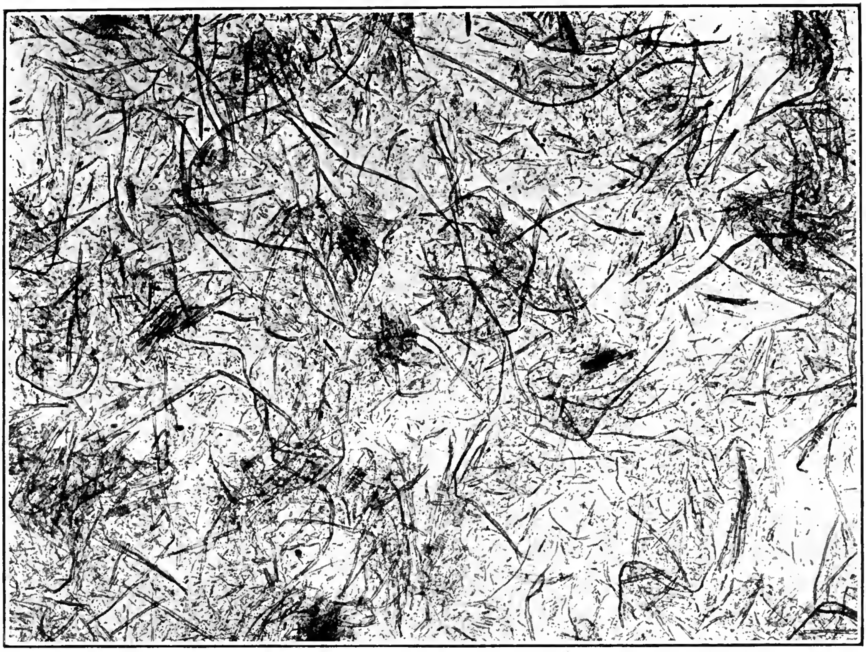


FIG. 1.—HEMLOCK GROUND WOOD. (COMMERCIAL RUN NO. 8.)

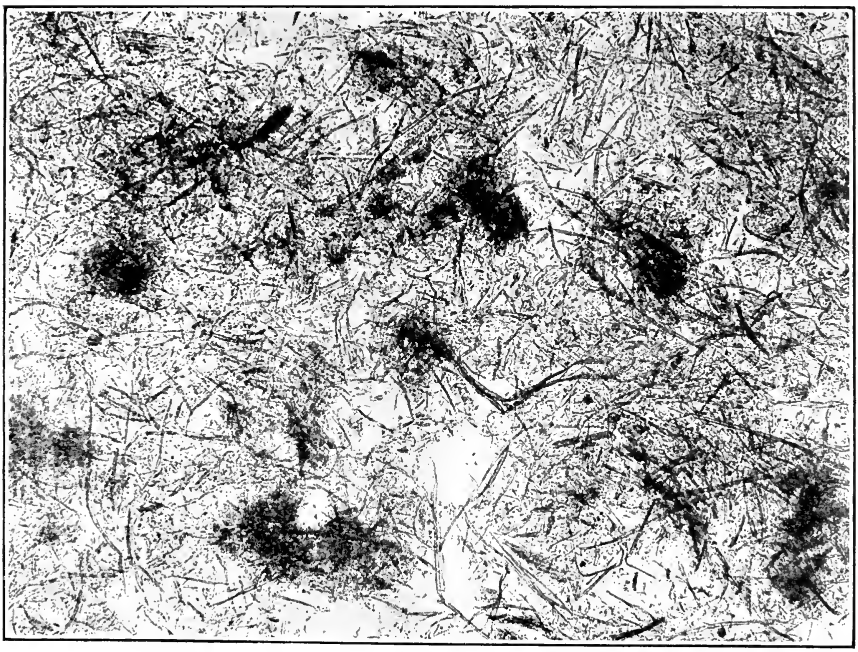


FIG. 2.—HEMLOCK GROUND WOOD. (RUN NO. 2.)

FIG. 1.—HEMLOCK GROUND WOOD. (COMMERCIAL RUN NO. 30)

FIG. 2.—HEMLOCK GROUND WOOD. (COMMERCIAL RUN NO. 50.) USED IN ACCOMPANYING PAPER SAMPLE.

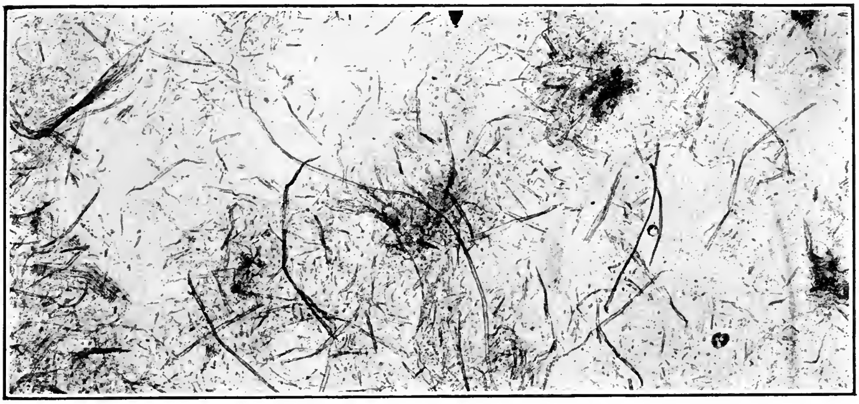


FIG. 1.—GROUND-WOOD PULP, ONE-THIRD SPRUCE, TWO-THIRDS HEMLOCK. (RUN NO. 46A.)

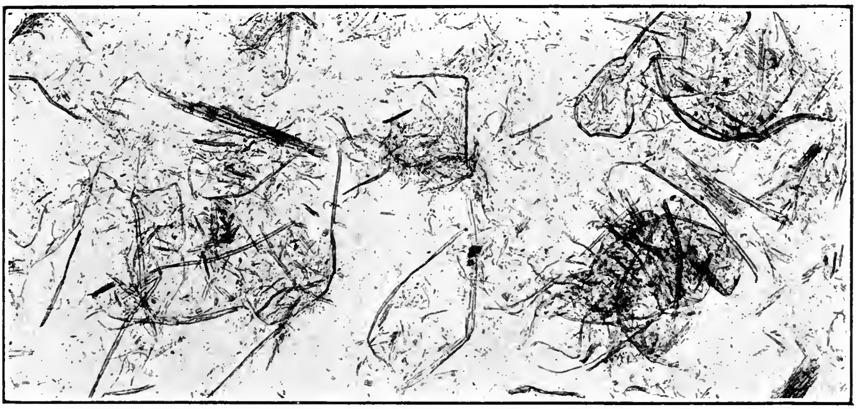


FIG. 2.—GROUND-WOOD PULP, ALL HEMLOCK. (RUN NO. 46B.)

FIG. 3.—GROUND-WOOD PULP, ALL SPRUCE. (RUN NO. 46C.)

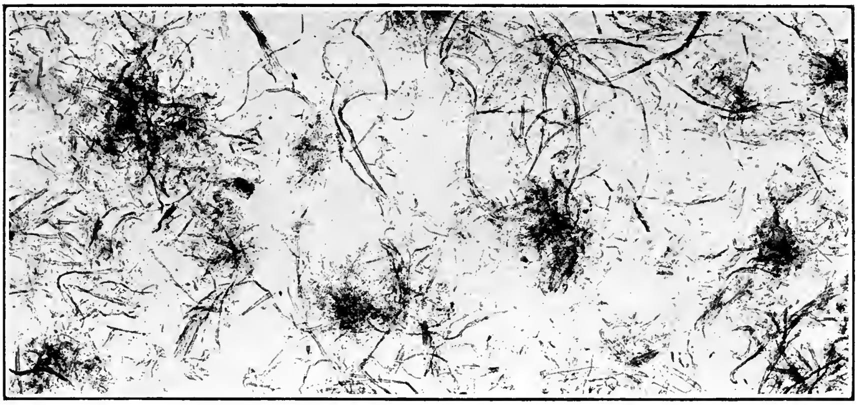


FIG. 1.—ONE-THIRD SPRUCE, TWO-THIRDS HEMLOCK. (COMMERCIAL RUN NO. 46A.)

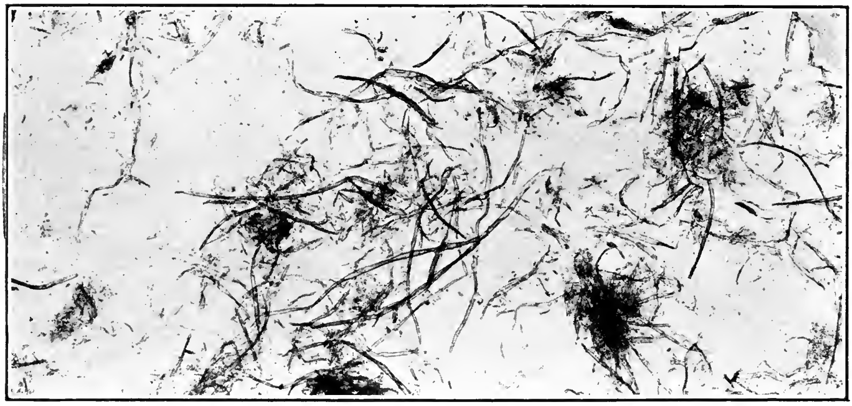


FIG. 2.—ONE-THIRD HEMLOCK, ONE-THIRD JACK PINE, ONE-THIRD SPRUCE. (COMMERCIAL RUN NO. 51.)

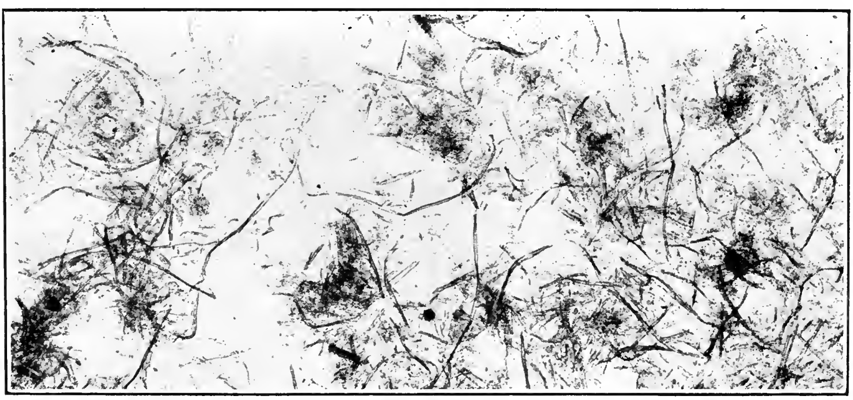


FIG. 3.—ONE-THIRD JACK PINE, TWO-THIRDS HEMLOCK. (COMMERCIAL RUN NO. 52.)

MIXED GROUND-WOOD PULPS USED IN ACCOMPANYING PAPER SAMPLES.

Throughout the experiments, particularly the commercial tests, it was found that the pulp of same appearance as regards fiber and of the same apparent strength can be obtained by using burrs of [illegible] different design and fineness of cut, provided the grit of the st[illegible] is in each case the same. For example, during the commercial tests the stone was burred at different times with different types of burrs, and the grinding in each case was found to require the consumption of the same amount of power. The production per day was the same also, provided the grit was brought to the same condition of sharpness and the other variables were kept constant.

During some of the preliminary tests the surface of stone was dulled with a fire brick, as is often done in mills. This appears to have been unnecessary; in fact, the result is detrimental rather than beneficial.

Better pulp was obtained and the production was increased slightly by crushing the tops of the ridges formed in burring by means of a solid, smooth bush roll. This method does not smooth off the individual particles of sand on the stone as dulling with the brick does, but rather sharpens them. During the tests conducted on mixed woods a surface obtained by the use of a three-to-the-inch straight-cut solid burr and a 12-cut spiral burr was used. The stone was first dressed with a three-to-the-inch burr, forming grooves in the stone approximately one thirty-second inch deep; then the portion of the stone between these depressions was roughed with a 12-cut spiral burr. This caused the grit to stand out and gave a maximum of useful grinding surface. The pulp obtained with this surface was almost entirely free from shives, and the fibers were long and fine. The surface of stone used during these tests is shown in Plate III, figure 2.

A great deal of experimentation still remains to be done, not only with burrs of different cut and design, but more especially with stones of different grits, since it appears that the grit is more responsible for the quality of pulp obtained than any other variable feature in its production.

Where the pulp stone is deep burred, however, the grit is not so important a factor of quality. When the power consumed in making a ton of bone-dry pulp is as low as 50 to 60 horsepower, the added production which must be secured to bring the power to this low value is obtained through the action of the ridges on the stone and not through the grit. When it is desired to manufacture a pulp of high quality, however, it is the grit of the stone and the manner of raising it which must be considered. The type of burr used and the depth of dressing both influence production, but it is only the latter that influences the quality. When the pulp stone has been dressed so as to provide just sufficient depression to carry away the ground wood a high-grade pulp will be produced, providing the grit of the stone is suitable, irrespective of the style of the burr and within reasonable limits of the pressure used. It is not impossible to conceive of an artificial stone which could be used continually without burring, which would clear itself without having depressions or ridges, and which would have the correct size and kind of grit to give the maximum production and best quality.

TEMPERATURE.

The temperature of grinding, it is said, has much to do with the quality and quantity of pulp obtained, and many manufacturers insist that it is impossible to secure a tough, strong fiber with anything but the hot grinding process. It was noted in the experiments that the rate of production was not nearly as great at a low temperature as it was after a high one was reached. However, it was impossible to detect microscopically any difference in the fibers themselves. As has been said, the only observations made on cold grinding were while the stone was warming up, and on this account it is impossible to say definitely what particular advantages or disadvantages, if any, lie in the hot grinding process.

UNDETERMINED FACTORS.

Since the experimental work on hemlock, jack pine, and spruce was started a number of factors which more or less influence the quality and the rate of production of pulp have made themselves evident. These are the rate of growth of the wood, moisture content of the wood, size of wood ground, temperature of grinding, the thickness of stock in the grinder pit, and the grit of the pulp stone, the last undoubtedly being the most important. All of these variables will be studied in future experiments, though the grit of the pulp stone is the one which will probably receive the greatest attention. It is doubtful whether this very important item in the production of ground wood has been given sufficient consideration by manufacturers.

MICROSCOPIC COMPARISON OF EXPERIMENTAL PULPS AND COMMERCIAL STANDARDS.

STANDARD PULPS.

Since it was necessary to have some means of comparing the experimental pulps produced with commercial products, portions of the samples obtained from manufacturers were photographed, in an endeavor to classify the fibers according to their quality. It was found that there is a more or less regular grading of the material from long, fine fiber to pulp which is almost a powder. It is probable that each of the various grades of pulp has its particular use in certain qualities of paper, though no attempt has been made to classify them according to uses. The standards selected are shown in Plates IV, V, and VI; in each case the fibers are enlarged 15 times. For the purpose of comparison the spruce sulphite standard fiber is shown in Plate IV, figure 1, and the No. 1 spruce ground-wood standard in figure 2. It is indeed very seldom that a sample of pulp is obtained which corresponds to the No. 1 spruce ground-wood standard. As will be noted, the fibers are very similar to the sulphite fibers, although there is a certain amount of short material and coarse fiber present which does not occur in the sulphite pulp.

Plate V shows the No. 2 ground-wood standard and No. 3 coarse ground-wood standard. The No. 2 differs from the No. 1 standard only in the amount of short fiber and coarse fiber present, the No. 2 having larger amounts of these two kinds. The coarse standard needs no description. It is a kind of fiber often made by mills during their low-water periods in order to maintain production with less power consumption.

The No. 4, medium ground-wood standard, and the No. 5, fine ground-wood standard, seem to follow in logical sequence those previously given. The No. 4 standard has the appearance of being a mixture of No. 3 and No. 5. The No. 5, as will be noted, contains an extremely small amount of fiber and is composed largely of dust and short-fiber particles.

Table 2 gives the data furnished by the manufacturers of the various pulp samples selected as standards. These data, for the most part, are only approximate, but they will serve to give some idea of the conditions under which the material was produced.

TABLE 2.—*Conditions of manufacture of spruce ground-wood standards.*

Number of standard.	Make of grinder.	Number of pockets.	Size of cylinders.	Pressure on cylinders.	Equivalent pressure on 14-inch cylinder.	Kind of stone.	Kind of burr.	Size of stone.	
								Diameter.	Face.
1	Friction Pulley & Machine Works.	3	16	35	45.7	Lombard	Washers	54	27
2	Carthage Machine Co	3	16	40	52.2	Lombard and Manufacturers'	Solid spiral cut 8 to 1 inch.	54	26
3	Dayton Globe Iron Works	3	18	45	74.4	Lombard	Diamond point cut 6 to 1 inch.	54	27
4	Carthage Machine Co	3	14	60	60.0	Empire	Straight cut 7 to 1-inch.	54	25½
5	Friction Pulley & Machine Works.	3	10	90	45.9	Greeley, New Castle.	Diamond point 7 to 1-inch and 5 to 1-inch.	54	18½

TABLE 2.—*Conditions of manufacture of spruce ground-wood standards*—Continued.

Number of standard	Make of grinder.	Revolutions per minute of stone.	Peripheral speed of stone.	Horsepower per ton.	Temperature of grinding.	Size of screen slots.	Grade of paper.
					°*F.*		
1	Friction Pulley & Machine Works	180	2,545	90	160	.012	Do not make paper.
2	Carthage Machine Co	190 to 200	2,686 to 2,827	75	175	.012	Poster.
3	Dayton Globe Iron Works	145	2,050	[1] 300	....	.010	News.
4	Carthage Machine Co	270	3,817	100	....	.075	Do.
5	Friction Pulley & Machine Works	220	3,110	70	Cold.	.011	Specialties. Some coated, requiring a soft and fine pulp.

[1] To grinder.

JACK PINE PULP.

Plates VIII, IX, and X show six samples of ground-wood fiber obtained from jack pine. The data taken during these tests are given in Table 4. There is a very striking likeness between the fiber obtained from jack pine and that from spruce. Especially is this true of the fiber secured by using the natural grit of the pulp stone without any burring. Tests Nos. 7–1, 19, and 13–1 were run by using an excessive amount of power and by sacrificing the rate of production. This wood was ground, however, in the dry state, and unquestionably the same quality of fiber could be obtained with increased production and lower horsepower consumption per ton if it was soaked or steamed. The fibers obtained in tests Nos. 20–1, commercial run No. 14–1, and commercial run No. 24 compare favorably with the No. 4 standard, and the production and power consumption are more nearly those obtained commercially. There is more short material than is found in the No. 1 or No. 2 standards, but still the fiber is long and fine, and appears to have considerable strength. The illustrations show some of the better fibers obtained. Of course pulp has been made in the laboratory which was fully as fine as that shown as the No. 5 standard. Some has been made also which is fully as coarse as the No. 3. However, this is rather the exception than the rule.

The jack pine fiber shown in Plate X (run No. 7–1) was the most pleasing in appearance when in the pulp lap, and was generally considered to possess the best quality. The rate of production, however, was so very low, and the horsepower consumption so high, that it has no commercial importance.

HEMLOCK PULP.

Plates XI, XII, and XIII show hemlock fibers which were obtained during the tests. Undoubtedly the most notable feature is the large amount of fine material present as compared with the jack pine samples. Hemlock grinds short and fine to a far greater extent than either spruce or jack pine. While there are a great many long fibers present, they are not sufficient in number to give a strong and tough pulp. A certain amount of short material is necessary, however, for news paper, and it is this material which gives a good finish. The finish on the paper made from the hemlock pulp, commercial run No. 8, was exceedingly good; in fact, the superintendent of the mill where the sample was run pronounced it better than the standard news. It will be seen that there is a regular gradation in the length of fibers from the long to the almost powder form. On certain of the illustrations of hemlock fiber black spots composed of a great deal of fine fiber will be noticed. These are the result of drying the pulp before making slides, it being impossible entirely to beat out the fiber after drying. When the material was in the form of pulp laps there was no marked difference in the pulps. However, as with the jack-pine samples, only the better grades of pulp obtained are shown. The sample of pulp illustrated in Plate XIII, figure 2 (commercial run No. 50), is fairly representative of the pulp which it is possible to make from hemlock under the conditions described.

MIXED PULPS.

Plate XIV shows three photomicrographs of fibers obtained under exactly the same conditions of pressure, speed, and surface of stone. The temperature and other minor variables were also kept as nearly alike as possible.

Figure 1 shows fibers obtained by grinding hemlock in two of the grinder pockets and spruce in the third (run 46*a*). Upon determination it was found that the pulp contained 34 per cent spruce and 66 per cent hemlock. Figure 2 shows hemlock fiber obtained under the same conditions (run 46*b*) as the first test, and figure 3 shows a number of spruce fibers (run No. 46*c*). The hemlock fiber is considerably shorter than the spruce and there are more shives present. In the composite sample the hemlock is decidedly in evidence.

Plate XV shows three fibers obtained by grinding different woods in different pockets of the pulp grinder. Commercial run No. 46*a* is composed of a mixture one-third spruce and two-thirds hemlock; commercial run No. 51 is composed of one-third jack pine, one-third spruce, and one-third hemlock; commercial run No. 52 of one-third jack pine and two-thirds hemlock. All of these pulps when in the lap appeared to be a very good quality; in fact, it will be seen that the fiber of which they are composed is of good length and that there is not nearly as much short material present as there is in the samples of hemlock pulp.

Commercially it would be possible to obtain better mixed pulps by grinding the different woods in separate grinders and preparing the stones so as to obtain the best quality of pulp from each wood.

It has been found, by comparing the samples submitted by American manufacturers with the standards chosen, that 5 per cent can be classed as No. 1 pulp, 12 per cent as No. 2 pulp, 12 per cent as No. 3 pulp, 61 per cent as No. 4, and 10 per cent as No. 5. Comparison of the experimental pulps with the commercial standards shows that mixed pulps particularly compare well with the No. 4 standard, for which there is evidently the greatest demand.

SAMPLES OF PAPER PRODUCED.

In order to determine the adaptability of the pulps obtained in the experiments to the manufacture of paper, a number of test paper runs were made with the pulps which gave greatest promise. Samples of the paper obtained accompany this report. All of the sheets of news paper were made on a machine in the Port Edwards mill of the Nekoosa-Edwards Paper Co. This machine is 116 inches wide, and the sheet produced, trimmed, was 109 inches. The machine was operated at a speed of 465 feet per minute, and no changes were made in weight of sheet or speed after the beginning of the test; in fact, throughout the runs the conditions were maintained as nearly constant as possible. The finish on the paper was obtained by passing the sheet nine times through a 12-roll calender stack. In each case three 1,500-pound beaters of stock were run into sheet in order to have the test continuous over sufficient time to give an idea of its operation on the paper machine. It was intended to by-pass the Jordan engine, but this being impossible, the stock was passed through the engine and the roll set up only slightly.

Running changes were made in each test, and no difference was found with any of the sheets excepting jack pine. This material was somewhat pitchy, and after an hour's run it was necessary to remove the dandy, since it began to pick up stock. All of the papers were free on the wire and caused no trouble whatever.

The samples of paper containing spruce were made up for the purpose of comparison. It will be seen that, with the exception of color, the sheets differ little, and it is reasonable to suppose that the color could be improved. Allowance should be made for the appearance of the sheets as regards brown shives, these being due to the hemlock sulphite used, and not to the ground wood. Data on the beater "furnish" for the various papers are given in Table 10. Table 3 gives a comparison of strength of the various sheets.

The samples of butcher's manila and No. 2 white manila given were made by the Nekoosa-Edwards Paper Co., the furnish being shown in Table 10. These samples are meant merely to give an idea of [illegible] can be obtained when mixtures of hemlock and spruce are used.

The strength of all of the sheets, with the exception of the one made up of hemlock sulphite and jack-pine ground wood, compares well with standard news paper. The paper from run No. 24 has another decidedly objectionable feature, and that is the loss of finish occasioned by rubbing the sheet with the hand. The fibers under this treatment fuzz up, and considerable powder and short fiber fall off. Several of the other sheets have this same peculiarity, but if more size were added this trouble would probably be eliminated.

The experimental papers have not yet been tested on high-speed presses, and this must be done before accurate knowledge of the value of the several sheets can be had.

However, after having obtained news paper of the quality of the attached samples from hemlock, jack pine, and mixtures of these woods without changing in any way present commercial practice, it seems beyond doubt that these woods may be advantageously used either singly or in various combinations, at least in the cheaper grades of paper.

TABLE 3.—*Strength, weight, and thickness tests on experimental papers.*

Commercial run No.	Hemlock sulphite.	Spruce ground wood.	Hemlock ground wood.	Jack pine ground wood.	Weight per ream of 500 sheets 24 by 36 inches.	Average thickness.	Mullen test. Bursting strength per square inch.	Mullen test. Strength factor.	Schopper test. Lengthwise. Average stretch.	Schopper test. Lengthwise. Average load on strip 18 by 1.65 cm.	Schopper test. Lengthwise. Average breaking length.	Schopper test. Crosswise. Average stretch.	Schopper test. Crosswise. Average load on strips 18 by 1.65 cm.	Schopper test. Crosswise. Average breaking length.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*Lbs.*	*Inches.*	*Lbs.*		*P. ct.*	*Kilos.*	*Meters.*	*P. ct.*	*Kilos.*	*Met's.*
1a	5	95	......	......	32	0.0033	11	0.344	0.8	2.95	3,687	1.4	1.765	2,254
1	25	75	......	......	33	.0035	13.2	.400	.95	3.49	4,043	1.22	1.780	2,150
24	25	......	......	75	33	.0038	8.2	.249	.95	2.53	3,251	1.08	1.305	1,690
46	25	25	50	......	33	.0037	11.4	.345	1.05	3.495	3,907	1.42	1.755	1,987
50	25	......	75	......	34	.0035	10.2	.300	1.11	3.615	4,111	1.17	1.555	1,819
51	25	25	25	25	32	.0035	9.7	.303	.95	2.855	3,495	1.24	1.410	1,692
52	25	......	50	25	33	.004	9.9	.300	.98	3.005	3,606	1.43	1.330	1,640

All of the above are averages of 10 determinations.

SUMMARY OF DATA.

Tables 4, 5, 6, 7, 8, and 9 show compilations of the data secured during tests on hemlock, jack pine, and mixtures of these two woods with spruce. The results of tests under many different conditions of speed, pressure, and surface of stone are given. In a number of cases the data on production and power consumption do not agree with that taken at another time and under the same conditions of pressure, speed, and type of burr. In all of these instances the differing values can be accounted for by the fact that although the same kind of burr [illegible]d, the stones were of different sharpness.

It has been found difficult to duplicate in one test the surface of stones used in another under the same conditions and obtain the same production with the same power consumption. In fact, the production factors vary greatly over short periods as a result of the varying attention given by the grinder man. On this account the power and production data in the tables can be applied to commercial plants only approximately. If a grinder is operating under the conditions of any of the commercial tests shown in Tables 5, 6, and 7, however, the data given will closely approximate the actual working conditions.

TABLE 4.—*Qualitative and quantitative tests on jack pine—Power consumption and production.*

Kind of stone.	Run number.	Kind of burr.	Pressure on 14-inch cylinder.	Pressure per square inch, pocket area.	Revolutions per minute.	Peripheral speed per minute.	Average horsepower to grinder.	Bone-dry pulp in 24 hours.	Horsepower per ton bone-dry pulp in 24 hours.	Bone-dry pulp per 100 cubic feet bone-dry wood.	Weight per cubic foot bone-dry wood.	Average temperature of grinding.	Size of screen slots.
			Lbs.	*Lbs.*		*Feet.*		*Tons.*		*Lbs*	*Lbs.*	°F.	*Inch.*
Manufacturers'.	1	Natural surface.	20.0	8.20	151.0	2,100	......	......	......	......	......	140.0	(1)
Do......	2	.....do.........	30.0	12.30	151.0	2,100	......	......	......	......	......	147.0	(1)
Do......	3	.....do.........	39.0	16.00	150.0	2,090	......	......	......	......	......	176.0	(1)
Do......	3-1	.....do.........	39.3	16.10	151.0	2,100	......	......	......	......	......	176.0	(1)
Do......	4	.....do.........	50.0	20.50	150.6	2,100	......	......	......	......	......	196.0	(1)
Do......	5	.....do.........	60.0	24.65	151.0	2,100	......	......	......	......	......	199.0	(1)
Do......	6	.....do.........	60.0	24.65	171.0	2,380	......	......	......	......	......	196.0	(1)
Do......	6-1	.....do.........	60.0	24.65	171.0	2,370	......	......	......	......	......	201.0	(1)
Do......	7	.....do.........	50.0	20.50	171.0	2,370	......	......	......	......	......	199.0	(1)
Do......	7-1	.....do.........	50.0	20.50	172.0	2,380	256.0	1.305	196.2	1,820	25.27	197.0	0.012
Do......	7-2	.....do.........	50.0	20.50	172.0	2,380	245.0	1.263	193.6	2,150	25.57	183.0	.012
Do......	8	.....do.........	60.0	24.65	203.0	2,810	......	......	......	......	......	198.0	(1)
Do......	8-1	.....do.........	60.0	24.65	203.0	2,810	......	......	......	......	......	191.0	(1)
Do......	9	.....do.........	50.0	20.50	202.0	2,800	......	......	......	......	......	205.0	(1)
Do......	10	.....do.........	75.0	30.80	202.0	2,800	......	......	......	......	......	185.0	(1)
Do......	11	Diamond point, 6 to the inch.	60.0	24.65	152.5	2,100	380.5	......	......	......	......	148.0	.012
Do......	11-1	.....do.........	60.0	24.65	154.0	2,100	360.5	6.075	59.3	......	......	146.0	.012
Do......	12	.....do.........	50.0	20.50	152.5	2,100	350.0	5.225	67.0	......	......	145.0	.012
Do......	12-1	.....do.........	50.0	20.50	154.0	2,100	359.0	7.030	51.0	......	......	179.0	.012
Do......	13	.....do.........	40.0	16.40	152.5	2,100	260.0	3.028	85.9	......	......	138.2	.012
Do......	13-1	.....do.........	40.0	16.40	153.5	2,100	299.0	2.670	112.0	......	......	195.0	.012
Do......	14	.....do.........	50.0	20.50	173.0	2,380	324.0	4.716	68.8	......	......	154.0	.012
Do......	14-1	.....do.........	50.0	20.50	174.0	2,380	398.0	5.046	78.8	......	......	166.0	.012
Do......	15	.....do.........	60.0	24.65	173.0	2,380	395.5	6.390	61.8	......	......	138.0	.012
Do......	15-1	.....do.........	60.0	24.65	174.0	2,380	461.0	5.500	83.8	......	......	158.0	.012
Do......	16	.....do.........	40.0	16.40	203.5	2,800	362.5	5.450	66.4	......	......	147.0	.012
Do......	16-1	.....do.........	40.0	16.40	205.0	2,800	375.0	5.360	70.0	......	......	200.0	.012
Do......	17	.....do.........	40.0	16.40	173.0	2,380	289.0	3.834	75.5	......	......	143.0	.012
Do......	17-1	.....do.........	40.0	16.40	174.0	2,380	332.0	4.350	76.3	......	......	178.0	.012
Do......	18	.....do.........	50.0	20.50	204.0	2,800	407.5	6.910	59.0	......	......	143.0	.012
Do......	18-1	.....do.........	50.0	20.50	205.0	2,800	414.0	6.360	65.0	......	......	193.0	.012
Do......	19	.....do.........	30.0	12.30	152.5	2,100	201.0	2.045	98.3	......	......	149.0	.012
Do......	20	.....do.........	30.0	12.30	205.0	2,800	313.0	5.320	58.8	......	......	178.0	.012
Do......	20-1	.....do.........	30.0	12.30	205.0	2,800	304.0	3.620	83.8	2,370	24.90	198.0	.012
Do......	21	.....do.........	30.0	12.30	174.0	2,380	269.5	4.810	56.0	......	......	172.0	.012
Do......	22	.....do.........	60.0	24.64	205.0	2,800	481.0	7.320	65.8	......	......	185.0	.012
Do......	23	.....do.........	40.0	16.40	205.0	2,800	249.0	4.110	84.9	......	......	206.0	.012
Lombard..	24	....	{40.0 45.0	16.40 18.46}	175.0	2,445	395.0	4.305	91.8	2,220	25.60	176.3	.012

[1] Unscreened.

TABLE 5.—*Qualitative and quantitative tests on hemlock—Power consumption and production.*

Kind of stone.	Run number.	Kind of burr.	Pressure on 14-inch cylinder.	Pressure per square inch, pocket area.	Revolutions per minute.	Peripheral speed per minute.	Average horsepower to grinder.	Bone-dry pulp in 24 hours.	Horsepower per ton bone-dry pulp in 24 hours.	Bone-dry pulp per 100 cubic feet bone-dry wood.	Weight per cubic foot bone-dry wood.	Average [illegible]ture of g[illegible]	Size of screen slot[illegible]
			Lbs.	*Lbs.*		*Feet.*		*Tons.*		*Lbs.*	*Lbs.*	*°F.*	*Inch.*
Manufacturers'.	0	Straight cut, 10 to the inch.	50	20.50	170.0	2,380	288.0	......	......	......	......	131.0	(1)
Do	1	do	30	12.30	100.0	1,400	154.0	......	......	......	......	126.0	(1)
Do	2	do	30	12.30	150.0	2,100	202.0	......	......	......	......	143.0	(2)
Do	3	do	30	12.30	200.0	2,800	275.0	......	......	......	......	150.0	(2)
Do	4	do	30	12.30	225.0	3,150	301.0	......	......	......	......	155.0	(2)
Do	5	do	20	8.20	150.0	2,100	169.5	1.011	167.7	......	......	159.0	(2)
Do	6	do	20	8.20	175.0	2,450	210.0	1.380	152.0	......	......	170.0	(2)
Do	7	do	20	8.20	225.0	3,150	223.0	1.295	172.0	......	......	169.0	(2)
Do	2-1	do	30	12.30	150.0	2,100	254.0	1.965	129.0	......	......	167.0	(2)
Do	8	do	40	16.40	175.0	2,450	328.0	3.055	107.3	......	......	166.0	(2)
Do	9	do	60	24.65	175.0	2,450	430.0	4.730	91.0	......	......	168.0	(2)
Do	10	Spiral cut, 10 to the inch.	20	8.20	100.0	1,393	87.3	......	......	......	......	129.0	(1)
Do	11	do	40	16.40	175.0	2,440	259.0	1.430	181.6	......	......	170.0	(2)
Do	12	do	50	20.50	225.0	3,150	368.0	2.475	149.0	......	......	178.0	(2)
Do	13	do	60	24.65	225.0	3,150	475.0	3.595	132.0	......	......	171.0	(2)
Do	14	do	50	20.50	175.0	2,440	358.0	3.395	105.6	......	......	166.0	(2)
Do	15	do	60	24.65	175.0	2,440	397.0	4.044	98.4	......	......	161.5	(2)
Do	16	do	30	12.30	175.0	2,440	243.0	......	......	......	......	148.5	(2)
Do	17	do	30	12.30	200.0	2,790	297.0	......	......	......	......	146.0	(2)
Do	18	do	30	12.30	100.0	1,390	162.8	......	......	......	......	158.0	(2)
Do	19	do	50	20.50	100.0	1,390	261.0	2.470	105.7	......	......	157.0	(2)
Do	20	do	40	16.40	200.0	2,790	377.0	3.780	99.7	......	......	162.0	(2)
Do	21	do	60	24.65	100.6	1,400	281.0	2.810	100.0	......	......	160.0	(2)
Do	22	do	50	20.50	150.0	2,090	366.0	3.815	96.0	......	......	161.5	(2)
Do	23	Diamond-point cut, 10 to the inch.	40	16.40	175.0	2,440	347.0	3.360	103.2	......	......	159.0	(2)
Do	24	do	50	20.50	175.0	2,440	394.0	5.065	77.7	......	......	157.0	(2)
Do	25	do	60	24.65	100.0	1,390	291.5	3.212	88.0	......	......	156.0	(2)
Do	26	do	30	12.30	200.0	2,782	315.0	2.945	107.0	......	......	163.0	(2)
Do	27	do	50	20.50	200.0	2,782	432.0	5.400	80.0	......	......	160.5	(2)
Do	28	do	60	24.65	101.0	1,408	290.0	......	......	......	......	168.0	(2)
Do	29	do	50	20.50	175.0	2,435	372.0	......	......	......	......	187.0	(1)
Do	30	Straight cut: 4 to the inch. 10 to the inch	40	16.40	175.0	2,435	319.0	3.900	81.8	......	......	145.0	(2)
Do	31	do	60	24.65	100.0	1,390	269.0	3.330	80.9	......	......	145.0	(2)
Do	32	do	60	24.65	100.0	1,390	298.0	3.120	95.5	......	......	155.0	(2)
Do	33	do	50	20.50	175.0	2,435	376.0	4.000	94.0	......	......	163.0	(2)
Do	34	Spiral cut, 8 to the inch.	60	24.65	100.0	1,390	297.0	4.350	68.3	......	......	135.0	(2)
Do	35	do	60	24.65	100.0	1,390	284.0	2.915	97.5	......	......	147.0	(2)
Do	36	do	60	24.65	150.0	2,090	417.0	5.130	81.4	......	......	152.0	(2)
Do	37	do	60	24.65	200.0	2,782	520.0	6.890	75.5	......	......	154.0	(2)
Do	38	do	50	20.50	84.3	1,173	212.0	2.660	79.7	......	......	154.0	(2)
Do	39	do	60	24.65	85.0	1,183	271.0	2.955	91.8	......	......	150.0	(2)
Do	40	do	50	20.50	100.0	1,390	285.0	3.025	94.3	......	......	156.0	(2)
Do	41	do	50	20.50	150.0	2,090	379.0	4.450	85.2	......	......	155.0	(2)
Do	42	do	50	20.50	175.0	2,435	429.0	5.295	81.1	......	......	155.0	(2)
Do	43	do	50	20.50	200.0	2,782	439.0	5.425	80.9	......	......	145.0	(2)
Do	44	do	40	16.40	175.0	2,435	359.0	4.225	85.0	......	......	158.0	(2)
Lombard	45	Straight cut, 3 to the inch.	40	16.40	200.0	2,800	340.0	2.915	116.5	......	......	159.0	(2)
Do	47	do	55	22.60	200.0	2,800	516.0	5.370	96.2	......	......	161.0	(2)
Do	48	do	50	20.50	225.0	3,145	510.0	6.235	81.8	......	......	164.0	(2)
Do	50	Straight cut, 3 to the inch; spiral cut, 12 to the inch.	50	20.50	175.0	2,445	422.5	5.300	79.7	2,070	24.84	170.6	(2)

[1] Unscreened.
[2] Size of screen slots, 0.065 and 0.012.

Table 6.—*Commercial tests on jack pine—Power consumption and production.*

GREEN MATERIAL.

Kind of stone.	Commercial number.	Kind of burr.	Pressure on 14-inch cylinder.	Pressure per square inch, pocket area.	Revolutions per minute.	Peripheral speed per minute.	Average horsepower to grinder.	Bone-dry pulp in 24 hours.	Horsepower per ton bone-dry pulp in 24 hours.	Bone-dry pulp per 100 cubic feet bone-dry wood.	Weight per cubic foot bone-dry wood.	Average temperature of grinding.	Screenings per 100 cubic feet bone-dry wood.	Size of screen slots.
			Lbs.	*Lbs.*		*Feet.*		*Tons.*		*Lbs.*	*Lbs.*	*° F.*	*Lbs.*	*Inch.*
Manufacturers'.	14	Diamond-point cut, 6 to the inch.	50	20.5	169	2,380	435	5.380	80.9	2,200	24.9	153	......	(1)
Do.....	14	.....do.........	50	20.5	171	2,400	458	6.650	68.9	2,070	24.9	150	......	(1)
Do.....	14	.....do.........	50	20.5	171	2,400	430	6.850	62.7	2,130	24.9	145	......	(1)
Do.....	14	.....do.........	50	20.5	171	2,400	416	7.040	59.1	......	24.9	149	......	(1)
Do.....	14	.....do.........	50	20.5	171	2,400	430	6.610	65.0	......	24.9	149	......	(1)
Do.....	14	.....do.........	50	20.5	171	2,400	427	7.070	60.4	2,190	25.8	150	......	(1)
Do.....	14	.....do.........	50	20.5	171	2,400	447	7.550	59.2	......	25.8	150	......	(1)
Do.....	14	.....do.........	50	20.5	171	2,400	459	8.300	55.3	......	25.8	147	......	(1)
Do.....	14	.....do.........	50	20.5	171	2,400	441	7.700	57.3	2,190	25.1	147	......	(1)
Do.....	14	.....do.........	50	20.5	171	2,400	430	7.420	58.0	2,075	25.1	151	......	(1)
Do.....	14	.....do.........	50	20.5	171	2,400	421	4.960	85.0	2,025	25.1	154	......	(1)
Do.....	14	.....do.........	50	20.5	171	2,400	459	6.035	76.0	2,180	25.1	162	......	(1)
Do.....	14	.....do.........	50	20 5	171	2,400	446	6.635	67.3	2,200	25.1	150	......	(1)
Do.....	14	.....do.........	50	20.5	171	2,400	445	7.135	62.5	2,190	25.1	147	......	(1)
Do.....	14	.....do.........	50	20.5	171	2,400	462	7.440	62.2	2,160	25.4	143	......	(1)
Do.....	14	.....do.........	50	20.5	171	2,400	452	6,860	66.0	2,153	25.4	148	......	(1)
Do.....	14	.....do.........	50	20.5	171	2,400	484	7.560	64.0	2,155	25.4	142	......	(1)
Do.....	14	.....do.........	50	20.5	171	2,400	467	7.335	63.7	2,235	25.4	137	......	(1)
		Weighted averages.	......	......	....	......	436	7.030	......	2,170	......	148	......	......

[1] Size of screen slots, 0.065 and 0.012.

SEASONED MATERIAL.

Kind of stone.	Commercial number.	Kind of burr.	Pressure on 14-inch cylinder.	Pressure per square inch, pocket area.	Revolutions per minute.	Peripheral speed per minute.	Average horsepower to grinder.	Bone-dry pulp in 24 hours.	Horsepower per ton bone-dry pulp in 24 hours.	Bone-dry pulp per 100 cubic feet bone-dry wood.	Weight per cubic foot bone-dry wood.	Average temperature of grinding.	Screenings per 100 cubic feet bone-dry wood.	Size of screen slots.
Manufacturers'.	14	Diamond point, cut 6 to the inch.	50	20.5	171	2,400	457	5.140	89.0	2,125	25.4	147	......	{0.065 .012
Do.....	14	.....do.........	50	20.5	171	2,400	451	5.570	81.0	2,170	25.6	142	......	{.065 .012
Do.....	14	.....do.........	50	20.5	171	2,400	468	6.780	69.0	2,210	25.6	140	......	{.065 .012
Do.....	14	.....do.........	50	20.5	171	2,400	455	7.050	64.5	2,260	25.6	136	......	{.065 .012
Do.....	14	.....do.........	50	20.5	171	2,400	460	7.365	62.4	2,233	25.6	142	......	{.065 .012
Do.....	14	.....do.........	50	20.5	171	2,400	490	6.160	79.5	2,150	25.6	154	......	{.065 .012
Do.....	14	.....do.........	50	20.5	171	2,400	386	3.995	96.6	2,095	25.6	152	.....	{.065 .012
Do.....	14	.....do.........	50	20.5	171	2,400	421	6.240	67.6	2,225	25.6	144	......	{.065 .012
Do.....	14	.....do.........	50	20.5	171	2,400	444	6.340	70.0	2,320	25.6	152	......	{.065 .012
Do.....	14	.....do.........	50	20.5	171	2,400	417	5,990	69.7	......	25.6	146	......	{.065 .012
		Weighted averages.	......	......	......	......	447	6.250	72.7	2,210	......	145	......	......

SEASONED MATERIAL.

Kind of stone.	Commercial number.	Kind of burr.	Pressure on 14-inch cylinder.	Pressure per square inch, pocket area.	Revolutions per minute.	Peripheral speed per minute.	Average horsepower to grinder.	Bone-dry pulp in 24 hours.	Horsepower per ton bone-dry pulp in 24 hours.	Bone-dry pulp per 100 cubic feet bone-dry wood.	Weight per cubic foot bone-dry wood.	Average temperature of grinding.	Screenings per 100 cubic feet bone-dry wood.	Size of screen slots.
Lombard.	24	Straight cut, 3 to the inch; spiral cut, 12 to the inch.	40	16.4	175	2,445	385	4.190	91.9	2,220	25.6	169.4	......	{0.065 .012
Do.....	24	.....do.........	45	18.46	175	2,445	404	4.400	91.8	2,220	25.6	182.0	......	{.065 .012
		Weighted averages.	......	......	....	......	395	4.305	91.8	2,220	25.6	176.3	14.9	......

TABLE 7.—*Quantitative and commercial test on mixtures of spruce, jack pine, and hemlock—Power consumption and production.*

Kind of stone.	Commercial run number.	Kind of burr.	Pressure on 14-inch cylinder.	Pressure per square inch, pocket area.	Revolutions per minute.	Peripheral speed per minute.	Average horsepower to grinder.	Bone-dry pulp in 24 hours.	Horsepower per ton bone-dry pulp in 24 hours.	Bone-dry pulp per 100 cubic feet bone-dry wood.	Weight per cubic foot bone-dry wood.	Average temperature of grinding.	Screenings per 100 cubic feet bone-dry wood.	Size of screen slots.
			Lbs.	*Lbs.*		*Ft.*		*Tons.*		*Lbs.*	*Lbs.*	*° F.*	*Lbs.*	*In.*
⅓ spruce; ⅔ hemlock:														
Lombard......	46A	Straight cut, 3 to the inch.	50	20.5	175	2,450	392.0	4.275	91.7	.....	....	152.5	....	0.065 / .012
Hemlock:														
Lombard......	46B	.....do.......	50	20.5	175	2,450	413.0	4.885	84.6	.....	....	175.5	....	.065 / .012
Spruce:														
Lombard......	46C	.....do.......	50	20.5	175	2,450	407.0	4.878	83.5	.....	....	160.0	....	.065 / .012
⅓ spruce; ⅔ hemlock:														
Lombard......	49A	Straight cut, 3 to the inch; spiral cut, 12 to the inch.	40	16.4	175	2,445	360.4	4.880	73.8	.....	....	155.0	....	.065 / .012
Hemlock:														
Lombard......	49B	.....do.......	40	16.4	175	2,445	370.0	4.885	75.7	.....	....	168.3	....	.065 / .012
COMMERCIAL RUNS.														
⅓ spruce; ⅔ hemlock:														
Lombard......	46A	Straight cut, 3 to the inch; spiral cut, 12 to the inch.	50	20.5	175	2,445	426.0	5.660	75.3	.....	....	149.0	....	0.065 / .012
Do.........	46A	.....do.......	50	20.5	175	2,445	425.0	5.135	82.7	.....	....	173.0	....	.065 / .012
Do.........	46A	.....do.......	50	20.5	175	2,445	432.0	4.905	88.0	.....	....	176.3	....	.065 / .012
		Weighted averages.	...	......	....	.....	427.2	5.175	83.0	2,030	24.8 / 23.76	169.0	16.3	......
⅓ jack pine; ⅓ spruce; ⅓ hemlock:														
Lombard......	51	Straight cut, 3 to the inch; spiral cut, 12 to the inch.	50	20.5	175	2,445	442.0	5.705	77.5	.....	....	167.6	....	.065 / .012
Do.........	51	.....do.......	50	20.5	175	2,445	444.0	5.420	81.9	.....	....	175.0	....	.065 / .012
		Weighted averages.	...	......	....	.....	443.0	5.575	79.4	2,232	25.6 / 24.7 / 29.11	171.0	17.4	......
⅓ jack pine; ⅔ hemlock:														
Lombard......	52	Straight cut, 3 to the inch; spiral cut, 12 to the inch.	50	20.5	175	2,445	398.0	4.550	87.5	.....	....	160.0	....	.065 / .012
Do.........	52	.....do.......	50	20.5	175	2,445	425.0	4.350	97.7	.....	....	185.4	....	.065 / .012
Do.........	52	.....do.......	50	20.5	175	2,445	406.5	3.950	103.0	.....	....	179.4	....	.065 / .012
		Weighted averages.	...	......	....	.....	414.0	4.310	96.3	2,230	25.2 / 26.75	177.7	17.6	......

TABLE 8.—*Commercial tests on hemlock—Power consumption and production.*

Kind of stone.	Commercial run number.	Kind of burr.	Pressure on 14-inch cylinder.	Pressure per square inch, pocket area.	Revolutions per minute.	Peripheral speed per minute.	Average horsepower to grinder.	Bone-dry pulp in 24 hours.	Horsepower per ton bone-dry pulp in 24 hours.	Bone-dry pulp per 100 cubic feet bone-dry wood.	Weight per cubic foot bone-dry wood.	Average temperature of grinding.	Screenings per 100 cubic feet bone-dry wood.	Size of screen slots.
			Lbs.	*Lbs.*		*Ft.*		*Tons.*		*Lbs.*	*Lbs.*	° *F.*	*Lbs.*	*In.*
Manufacturers'	14	Spiral cut, 10 to the inch.	50	20.5	175	2,435	331.0	2.855	116.0	1,955	24.8	173.5	......	0.065 / .012
Do	14	do	50	20.5	175	2,435	356.0	3.795	94.0	2,030	24.8	168.0	......	.065 / .012
Do	14	do	50	20.5	175	2,435	353.0	3.425	103.0	2,122	24.8	173.0	10.6	.065 / .012
		Weighted averages.	....	.....	....	.....	349.0	3.417	103.1	2,048	24.8	171.4	......	......
Manufacturers'	14-1	Spiral cut, 10 to the inch.	50	20.5	175	2,432	363.0	4.195	86.5	2,070	24.8	165.5	18.6	.065 / .012
Do	14-1	do	50	20.5	175	2,432	371.5	4.068	91.4	2,080	24.8	168.0	18.5	.065 / .012
		Weighted averages.	....	.....	....	.....	368.2	4.115	89.5	2,077	24.8	167.0	......	......
Manufacturers'	8	Straight cut, 10 to the inch.	40	16.4	176	2,450	346.0	3.945	87.7	2,118	24.8	165.5	24.8	.065 / .012
Do	8	do	40	16.4	176	2,450	287.0	3.410	84.2	2,085	24.8	159.0	15.5	.065 / .012
Do	8	do	40	16.4	176	2,450	270.0	2.772	97.5	2,038	24.8	177.6	18.6	.065 / .012
		Weighted averages.	....	.....	....	.....	306.0	3.435	89.7	2,083	24.8	168.4	......	......
Manufacturers'	23	Diamond point, cut 10 to the inch.	40	16.4	176	2,440	300.0	2.740	109.5	2,040	24.8	186.5	13.7	.065 / .012
Do	23	do	40	16.4	176	2,440	318.0	3.635	87.5	2,125	24.8	172.0	32.7	.065 / .012
Do	23	do	40	16.4	176	2,432	281.0	3.350	83.9	2,130	24.8	162.0	20.3	.065 / .012
		Weighted averages.	....	.....	....	.....	301.0	3.300	92.4	2,105	24.8	172.8	......	......
Lombard	30	Straight cut, 4 to the inch; spiral cut, 10 to the inch.	40	16.4	176	2,432	340.0	4.075	83.5	2,080	24.8	176.0	16.5	.065 / .012
Do	30	do	40	16.4	176	2,432	315.0	3.170	99.4	2,140	24.8	179.5	17.8	.065 / .012
		Weighted averages.	....	.....	....	.....	331.0	3.725	89.5	2,102	24.8	177.0	......	......
Lombard	50	Straight cut, 3 to the inch; spiral cut, 12 to the inch.	50	20.5	175	2,445	417.0	4.05	103.0	2,195	25.2	184.5	11.2	.065 / .012
Do	50	do	50	20.5	175	2,445	417.0	3.815	109.2	2,195	25.2	185.0	11.2	.065 / .012
Do	50	do	50	20.5	175	2,445	422.5	5.300	79.7	2,070	24.84	170.6	......	.065 / .012
		Weighted averages.	....	.....	....	.....	418.0	4.370	97.5	2,160	25.1	180.3	......	......

TABLE 9.—*Quantitative and commercial tests on spruce—Power consumption and production.*

Kind of stone.	Run number.	Kind of burr.	Pressure on 14-inch cylinder.	Pressure per square inch pocket area.	Revolutions per minute.	Peripheral speed per minute.	Average horsepower to grinder.	Bone-dry pulp in 24 hours.	Horsepower per ton bone-dry pulp in 24 hours.	Bone-dry pulp per 100 cubic feet bone-dry wood.	Weight per cubic foot bone-dry wood.	Average temperature of grinding.	Screenings per 100 cubic feet bone-dry wood.	Size of screen slots.
			Lbs.	*Lbs.*		*Ft.*		*Tons.*		*Lbs.*	*Lbs.*	*°F.*	*Lbs.*	*In.*
Lombard ..	1	Straight cut, 3 to the inch; spiral cut, 12 to the inch.	40 50	16.4 20.5	175	2,445	403	4.988	80.8	......	......	171.0	......	0.065 0.012
Do......	1	.....do	40 50	16.4 20.5	175	2,445	399	4.525	88.1	......	......	175.5	......	0.065 0.012
		Weighted averages.	......	......	....	......	401	4.810	83.5	2,480	28.4	172.6	17.2	......
Do......	2	Straight cut, 3 to the inch; spiral cut, 12 to the inch.	40	16.4	200	2,795	398	4.245	93.8	......	......	164.3	......	......
Do......	2	.....do......	40	16.4	200	2,795	408	3.995	102.0	......	......	171.3	......	......
Do......	2	.....do......	40	16.4	200	2,795	394	4.175	94.4	......	......	166.7	......	......
		Weighted averages.	......	......	....	......	402	4.120	97.5	2,012	22.72	168.0	13.75	......
	3	Straight cut, 3 to the inch; spiral cut, 12 to the inch.	20	8.2	175	2,445	191	1.215	157.0	2,300	27.66	163.0	9.82	......
	4	.....do......	40	16.4	175	2,445	333	3.025	110.0	2,408	27.66	166.5	17.8	......
	5	.....do......	60	24.65	175	2,445	454	5.255	86.4	2,415	27.66	152.2	18.6	......

TABLE 10.—*Furnish to beater on basis of 1,000 pounds of stock—Experimental and commercial papers.*

EXPERIMENTAL PAPER.

Run.	Number.	Hemlock sulphite.	Spruce ground wood.	Hemlock ground wood.	Jack pine ground wood.	Size.	Alum.	Clay.	Rhodamine B. extra.	Soluble blue H. A.	Diamond green C.N.	Auromine O. O. D.	Orange R. O.
		Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Oz.*	*Oz.*	*Oz.*	*Oz.*	*Oz.*
Commercial..................	1A	50	950	......	......	8	8	20	0.067	3.33	......	......	......
Do..................	1	250	750	......	......	8	8	20	.067	3.33	......	......	......
Do..................	24	250	......	......	750	8	8	20	......	3.6	0.15	......	......
Do..................	46	250	250	500	......	8	8	20	......	4.0	.15	......	......
Do..................	50	250	......	750	......	8	8	20	......	3.7	.20	......	......
Do..................	51	250	250	250	250	8	8	20	......	4.1	.15	......	......
Do..................	52	250	......	500	250	8	8	20	......	4.3	.15	......	......

COMMERCIAL PAPER.

No. 2 white manila..........	....	210	395	395	......	8	8	......	......	2.8	......	......	......
Butchers manila............	....	210	263	527	......	20	20	26.7	......	......	......	2.75	0.83