Technical Bulletin No. 262 September, 1931

IMPROVEMENT IN THE PRODUCTION OF OLEORESIN THROUGH LOWER CHIPPING

BY

ELOISE GERRY
Senior Microscopist
Forest Products Laboratory, Branch of Research
Forest Service

United States Department of Agriculture, Washington, D. C.

For sale by the Superintendent of Documents, Washington, D. C. - - - - - - - - - - Price 15 cents

TECHNICAL BULLETIN No. 262 — SEPTEMBER, 1931

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

IMPROVEMENT IN THE PRODUCTION OF OLEORESIN THROUGH LOWER CHIPPING

By ELOISE GERRY,[1] *Senior Microscopist, Forest Products Laboratory*[2] *Branch of Research, Forest Service*

CONTENTS

INTRODUCTION

A highly significant, though peaceful, revolution is taking place in the American naval-stores industry. The raw material involved is the oleoresin, or "gum," which exudes from wounds cut in the wood of the living longleaf pine (*Pinus palustris* Miller) and slash pine (*P. caribaea* Morelet), which grow in the coastal plain region of the southeastern United States. From these living trees, and from the stumps of their predecessors in the virgin forest, is obtained more than 65 per cent of the world's supply of turpentine

[1] The author wishes to express her appreciation of the generous cooperation given by various members of the Forest Service and of the naval stores industry, as well as by others interested in better operating methods. Special acknowledgment is made to Austin Cary, logging engineer, and to E. R. McKee, principal forest ranger, who selected and matched the trees and made this study possible. The turpentining was conducted as a part of the Graham naval stores demonstration project, instituted by Region 7 of the Forest Service and supervised by E. R. McKee with the able assistance of J. T. Wright and his helpers who were responsible for chipping the trees and for collecting and weighing the oleoresin obtained.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

and rosin as well as other compounds, such as pine oil and tar. Wholly unfounded to-day appears to be the belief, which has been rather widespread, that this great American industry is to disappear. No longer do the well informed believe that the production of naval stores will cease with the passing of the virgin pine forests of the South, or that it is in danger of becoming as out of date as the wooden ships whose use of pine tar and pitch in early days led to these pine products being called naval stores.

"Pine tree chemicals" is the collective name now applied to the already increasing number of the more highly refined products that are manufactured from the crude exudate from the living trees and from the products distilled and extracted from the stump wood of the virgin stands. A further expansion of the list of products promises to result from continued scientific research on these compounds. To maintain the production of oleoresin it is necessary to perpetuate the forests of living pines, which are its major source. At the present time there is throughout the region where the longleaf and slash pines grow, an increasing realization and appreciation of the value of the great number of young trees, often somewhat scattered and unkempt it is true, but for the most part made up of sturdy volunteers which have risen up and successfully occupied considerable areas of cut-over land.

The vigor of these young trees in favorable situations, their capacity for maintaining the yield of oleoresin, and their hardihood in resisting fire have been a source of amazement, but are also recognized as very potent assets. Moreover, even the somewhat sporadic attempts at forest management thus far applied to such stands, in the form of fire protection and early thinning to relieve the stunting effect of too dense growth, have made more apparent the value of this crop of potentially multi-product trees which produce oleoresin, pulpwood, poles, ties, and lumber. These trees are justly held to be an important factor in solving the problem of the best land use for a large proportion of the 50,000,000 or 60,000,000 acres included in the coastal plain area of the Southeastern States.

Once the trees are large enough to yield a profitable amount of oleoresin, it follows that the methods used for their exploitation are of paramount importance. Growth in height and in diameter and also crown development should not be unduly reduced by turpentining nor should the vigor of the trees, as manifested in one way by the increase in resin flow as a result of wounding, be seriously impaired by a wasteful and needless depletion through excessive removal of wood. To this end a number of experiments and tests have been and are being conducted in the southern forests by various Forest Service units.

The study here reported was conducted by the Forest Products Laboratory of the Forest Service on material from trees that were turpentined on the Choctawhatchee National Forest in Florida. No radical changes in methods already in practice in the woods were involved. The only modification was the making of a slight reduction in the height (vertical length) of the chip of wood removed each time the wound was freshened. The results obtained in this test demonstrate that the low chipping (chips one-fourth inch in vertical height) described successfully keeps ahead of the lightwood, that is, the darkened part of the wood near the surface of the wound, where resin has soaked into the woody tissues. Moreover, this conservative chipping can be applied safely and profitably. It is especially desirable for use on young trees that are to be cupped repeatedly over a prolonged period.

PREVIOUS ATTEMPTS TO REDUCE THE HEIGHT OF CHIPPING

In theory at least, the idea of removing only a thin chip each time the wound is freshened is by no means new. Thin chipping was recommended in 1851 by DeBow (*3*)[3] and a partially successful effort to determine its advantages was made in 1911 by Herty (*7*, *8*).

The introduction on a commercial scale of distinctly lower chipping than was generally practiced, followed the first sale of Government turpentine leases on the Choctawhatchee National Forest in Florida, where turpentine work under Government regulation began in 1910. With reference to the height of the faces, the leases stipulated that not more than one-half inch of new wood was to be taken from the upper side of each streak, whereas the common practice was to remove three-fourths to 1 inch. Moreover, the faces chipped or " pulled " were to be restricted to not more than 16 inches increase in height each season. A No. 0 or smaller chipping tool was required (*10*). These regulations have been enforced with such success that it is not uncommon to find a full season's chipping that produced faces only 13.5, 14, or 15 inches in height instead of the 16 inches allowed. This practical work, done on a crop basis of 10,000 trees, positively demonstrated the fact that with only ordinary labor, but with the smaller tools, thinner chips could be cut. Moreover, the yields secured far surpassed those obtained by the surrounding operators who practiced the old-fashioned high and deep chipping together with the cutting of wide faces, and who killed a large number of trees. (Figs. 1 and 2.)

An attempt to gain experimental evidence on the effects of still further reducing the height of the chip was made by the Forest Products Laboratory in tests on virgin longleaf pine in Mississippi during 1916 and 1917 (*4*). The results obtained on two roughly matched tree groups of about 5,000 trees each, served to indicate the relative effectiveness of the methods used. During the first year the low faces yielded about 18 per cent less turpentine and rosin than the customary high faces. During the second year the yield of turpentine was only about 3 per cent less and there was no reduction in the amount of rosin obtained. Though the high faces fell off the second year more than 18 per cent in the yield of turpentine and 15 per cent in the yield of rosin, the low faces maintained practically the same productivity as during the first year. The low faces also ran exceptionally well at the end of the second season, even after a long dry period.

With the aid of the microscope a detailed study was made (*4*) each month during the test of specimens of wood taken from five matched representative trees from each of the groups. These studies, supplemented by an annual checking from an examination of an additional 50 trees from each group and of 20 unturpentined trees which grew in the immediate vicinity of the turpentined trees, showed that tree

[3] Italic numbers in parenthesis refer to Literature Cited, p. 23.

vitality, responsive power, and total amount of resiniferous tissue (parenchyma), as observed just above the face at midstreak, were best in the trees with low faces. Forty to fifty per cent higher yields per inch of face used were obtained from low chipping during the two years of this test. The apparent advantages which existed in the low-chipped trees and the sustained yield obtained from them seemed to indicate that in later years they might surpass the early higher yield of the high-chipped faces, in spite of the fact that considerable inequality probably existed in the matching of the groups. Unfortunately, however, the trees had to be cut at the end of the second year, and nothing beyond the results just presented is available from that source.

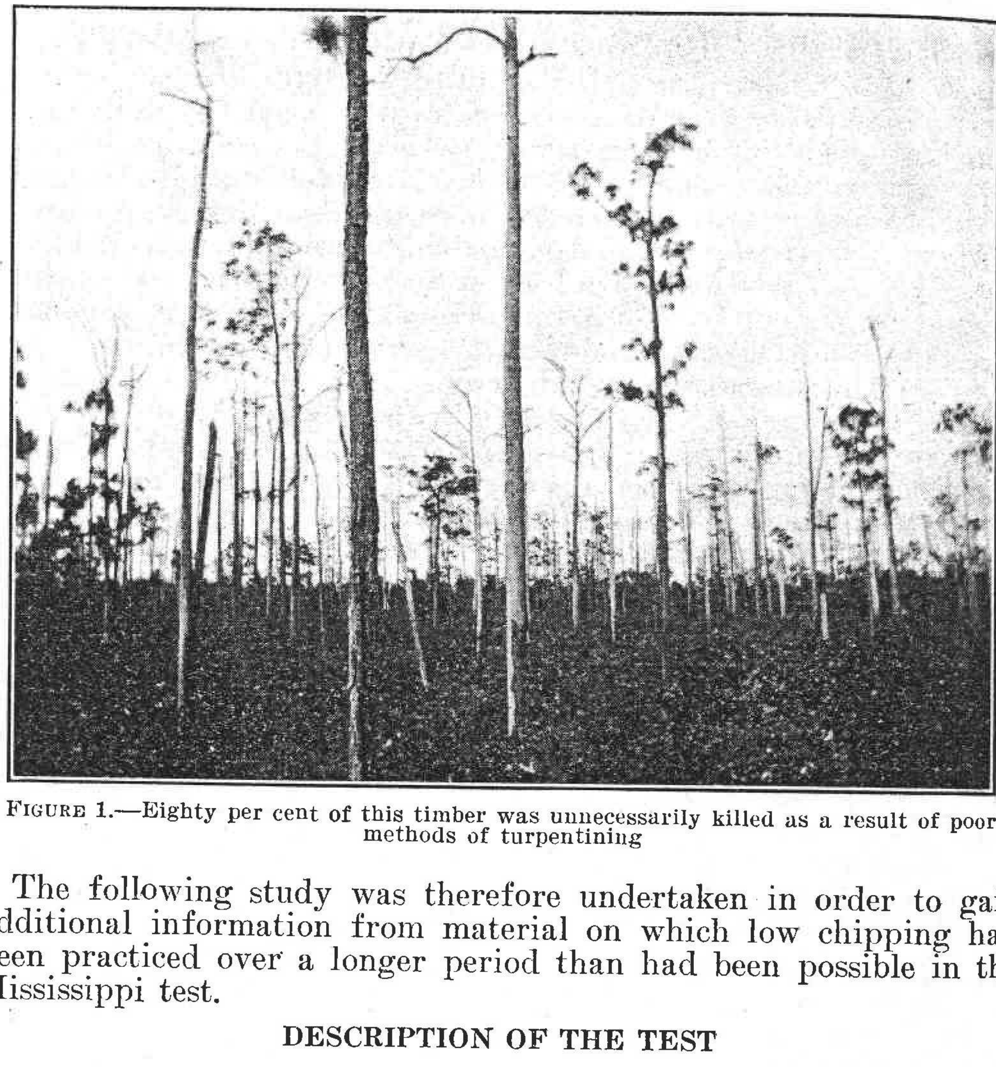


FIGURE 1.—Eighty per cent of this timber was unnecessarily killed as a result of poor methods of turpentining

The following study was therefore undertaken in order to gain additional information from material on which low chipping had been practiced over a longer period than had been possible in the Mississippi test.

DESCRIPTION OF THE TEST

LOCATION AND TYPE OF TREES

The test, which covered a period of five years (1923–1927), was located on the Choctawhatchee National Forest in Florida, about 2 miles northeast of Camp Pinchot, where the soil is very sandy, contains little humus, and ranks very low as a longleaf pine site. The trees used in the test were middle-aged longleaf pine. (Fig. 3.) The trees ranged from 9 to 14 inches in diameter at 4½ feet above the ground, and averaged about 11.5 inches for each group. They were selected and matched, tree by tree, for spacing, diameter, appearance of bark, crown development, and rings per inch in the outer inch of wood. The matched trees were arranged in three groups of 20 trees each. The excellent matching of the trees to

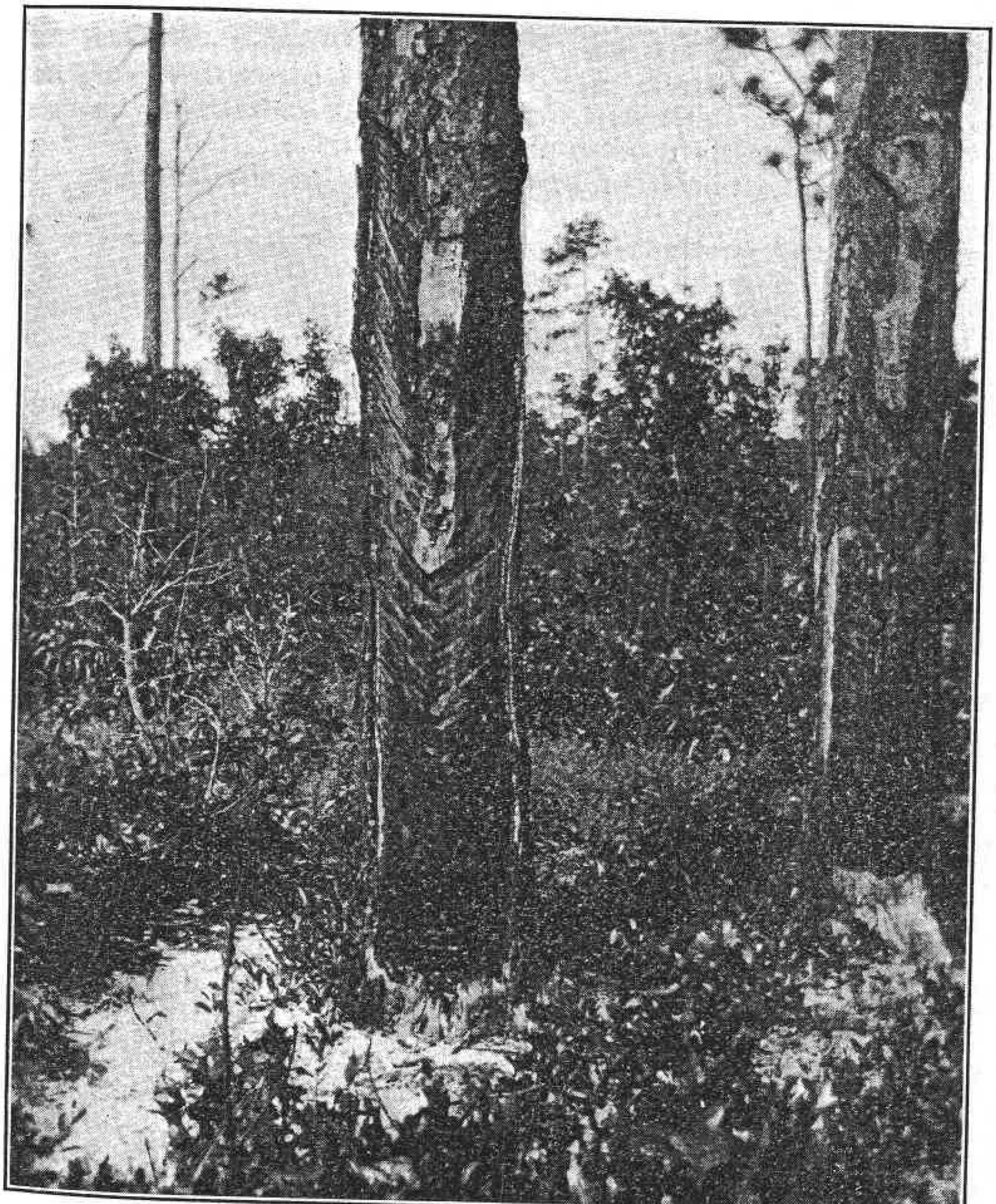


FIGURE 2.—Deep and high chipping resulted in the dry facing and death of the timber illustrated

some extent offset the fact that the number of trees used in the test was small.

THE GROUPS OF TEST TREES

GROUP 1. LOW CHIPPING

The 20 trees of Group 1 were the trees selected for the lowest chipping. They were marked on the bark with one spot of white paint. The specification for this group was that the weekly chipping should remove only one-fourth inch of wood from the upper edge of the wound. This should make a face 8 inches in height by the end of a regular 32-streak season.

GROUP 2. PRESENT FOREST SERVICE CHIPPING

The 20 trees in Group 2 were to have one-half inch of wood removed each week. They were marked with two spots of white paint on the bark of each tree. The faces on the trees in this group were not to be raised more than 16 inches in height each season. The negro chippers, however, became so proficient at low chipping, as a result of being required to chip only one-half inch instead of higher as had

FIGURE 3.—Middle-aged longleaf pine on the Choctawatchee National Forest in Florida where the height-of-chipping test was conducted

been the common practice, that they often removed even less wood than was allowed.

Group 2, which was chipped according to the existing Forest Service method, was representative of more than 31,000 trees in the stand in which it stood, and of other crops adjacent.

GROUP 3. ORDINARY COMMERCIAL PRACTICE

A chip three-fourths inch in height was to be removed each week from the 20 trees in Group 3. They bore the identifying mark of three spots of white paint. It was intended that the faces on the trees in the group should be 24 inches high each year. It is of interest to note that one of the most frequently advanced objections to light chipping has been the difficulty of getting laborers to do it. In this test, however, a chipper who was accustomed to light chipping, at first found it difficult to adjust himself to remove the desired three-fourths inch high chip even with a large, or No. 2, hack. It would seem from this and other instances that the habit of light chipping may probably be as successfully instilled into the worker as that of heavy chipping.

METHODS OF WORKING

Oblong galvanized-iron cups and saw-toothed aprons of the same material were used on all trees. (Pl. 1.) Only one face per tree was permitted. The faces were started low down on the trees, within 7 inches of the ground, and there was a minimum of butt scarring. No. 0 hacks and pullers were used for Groups 1 and 2, and No. 2 tools, which are larger, were used for Group 3. The depth of chipping was as nearly the same as possible, and averaged one-half inch in depth beyond the bark. The width of the faces averaged practically the same in all groups, being governed by the diameter of the tree and by the depth of chipping. A straight cut from shoulder to peak (not "wrapped" or "rainbowed") was used. The variable under test was the height of the chip removed each week.

Except for the first two dippings the weight of the dip, that is, the more liquid oleoresin which collects in the cups, was not recorded for the individual trees, nor were individual trees given identifying numbers. The oleoresin from each group of 20 trees was collected at each dipping and weighed separately (p. 8). The scrape, or hardened gum adhering to the face was also collected for each group and weighed at the end of each season.

DATA OBTAINED IN THE TEST

From 1923 to 1927, inclusive, the test was conducted according to the regular working schedule applied to the commercial operation surrounding it. The operating season extended from February or March to November or early December. The number of streaks cut each year was 31 to 33. No trees were killed by the turpentining. All the trees were chipped to the safe depth of one-half inch. The Group 3 trees, all of which were high chipped, suffered slightly more than the other groups from the tendency to become dry faced. Only one tree, however, became entirely unproductive. Some tendency to form resin blisters in the inner bark (phloem), a condition not commonly observed up to that time was noted in the Group 3 trees during the later years of the test.

DIMENSIONS OF FACES

Careful measurements of the faces were made each year. They included the height, depth, and width of face obtained in the three groups. The measurements obtained on the height of the faces are summarized in Table 1 and are strikingly apparent in Plate 1. The depth of chipping was very uniform. There was a slight tendency on the part of the chipper to cut a somewhat shallower streak in the Group 1 trees with the low faces; which probably reduced the yield by a small amount. The Group 1 faces, however, averaged about one-half inch wider during parts of the test than the faces on the trees in Groups 2 and 3. This may have given the Group 1 trees a small advantage, thus helping partially to offset the reduction which may have resulted from slightly lessening the depth of chipping. The faces on the Group 3 trees were notably widened during the latter part of 1927, the last year of the work when the faces were over 9 feet above the ground.

TABLE 1.—*Summary of measurements of height of faces,[1] in the height-of-chipping test, Choctawhatchee National Forest, 1923 to 1927*

Date	Streaks each year	Group 1, ¼-inch chipping			Group 2, ½-inch chipping			Group 3, ¾-inch chipping		
		Total (cumulative)	Rate per year	Average per streak	Total (cumulative)	Rate per year	Average per streak	Total (cumulative)	Rate per year	Average per streak
	Number	*Inches*	*Inches*	*Inch*	*Inches*	*Inches*	*Inch*	*Inches*	*Inches*	*Inch*
Nov. 24, 1923	32	9.00	9.00	0.28	14.50	14.50	0.45	23.00	23.00	0.72
Nov. 17, 1924	32	17.75	8.75	.27	29.00	14.50	.45	47.00	24.00	.75
Nov. 11, 1925	32	27.50	9.75	.30	43.50	14.50	.45	70.00	23.00	.72
Dec. 28, 1926	31	36.25	8.75	.28	56.00	12.50	.40	91.50	21.50	.69
Nov. 10, 1927	31	44.75	8.50	.27	69.25	13.25	.43	114.25	22.75	.73
Average height			8.95	.28		13.85	.44		22.85	.72
Specified height		40.00	8.00	.25	80.00	16.00	.50	120.00	24.00	.75

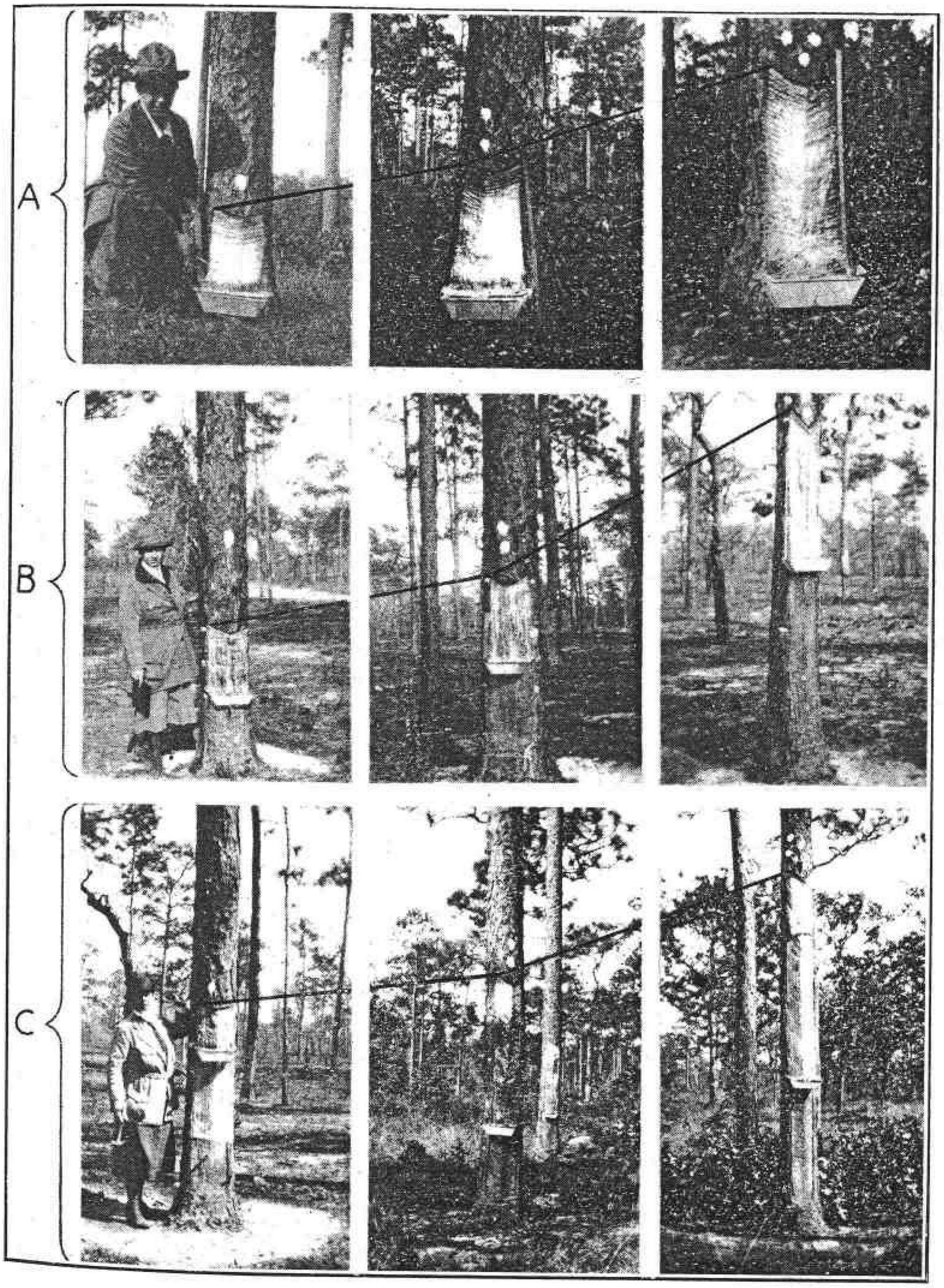
[1] The figures given represent the height of faces resulting from the weekly rate of chipping practiced in the test. They have been corrected for 1 slight error in chipping made during the first month of the test, which made the low faces about 1.5 inches too high and the high faces about 1.5 inches too low. The height of the extra streaks cut to obtain specimens for microscopical study at the end of the season, after chipping had stopped, has also been subtracted.

LOWEST CHIPPING OBTAINED

As far as is known the chipping of the Group 1 trees is the lowest recorded chipping thus far obtained with a hack. (Table 1.) The chipping during the first, or virgin, year was at the average rate of about 0.28 inch per streak. That is, faces about 9 inches high with 32 streaks were obtained. Moreover the faces were begun within 7 inches of the ground. The total height of the faces chipped the second year was still less, the rate being about 0.27 inch per streak. The average rate was 0.28 inch per streak and this was easily maintained during the fourth and fifth years, when a puller was used in place of the hack.

TOTAL PRODUCTION

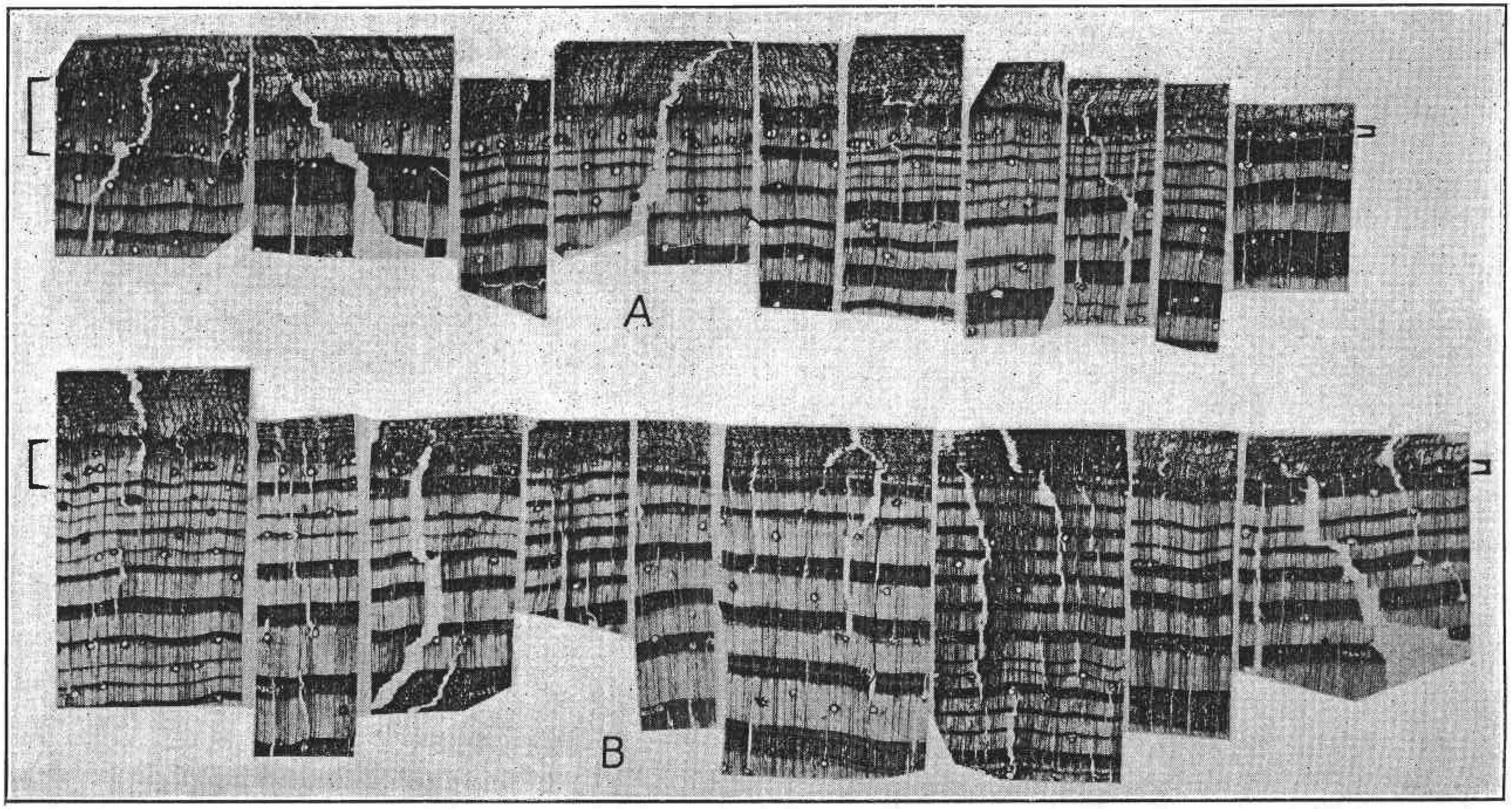
The variations that were obtained when the yields from each tree in the test were weighed separately at two different dippings at the beginning of the test indicated a fairly satisfactory matching of the groups. The weights of oleoresin obtained from the three groups of test trees are given in Table 2. The number of streaks cut varied a little from year to year. Also, in the weighing of the gum, accidents happened twice, so that the weights were incomplete in the case of the first dipping in 1923 and again in 1924. The yields were therefore reduced to a basis of the yield from the last 26 streaks cut each season in order to have comparable data for each year. These data are presented in Table 3 and are also given for ready comparison in Figures 4 and 5.



M15754F

EXTERNAL APPEARANCE OF TREES FROM THE THREE TEST GROUPS

A, After one year; B, three years; and C, five years of turpentining. The low faces in Group 1, which are marked with one spot of paint, were chipped about one-fourth inch high each week. The total height of the face after five years' work was 45 inches. The current Forest Service faces in Group 2, which are marked with two spots of paint, were chipped about one-half inch high each week. The total height of face after five years' work was 70 inches. The ordinary commercial type of faces in Group 3, which are marked with three spots of paint, were chipped about three-fourths inch high each week. The total height of face after five years' work was 114 inches.



M15753F

STRUCTURAL RESPONSES AFTER ONE YEAR OF TURPENTINING, 1923, IN SPECIMENS CUT MIDWAY OF THE STREAK

A, Thin magnified cross sections from typical (Group 1) one-fourth inch chipped trees; B, cross sections from typical (Group 3) three-fourths inch chipped trees. The wider growth rings, more summer wood, and more resin passages, especially in the spring wood, shown in the bracketed areas which embrace the 1923 annual growth ring, are particularly noticeable in the A specimens when compared with those in B. The sections are arranged with the widest ringed specimens at the left and the narrowest at the right to show the range of variation among the trees in the contrasted groups. The beginning of the 1923 ring in each specimen is used as the horizontal base line, the years' growth during turpentining being shown in their varying widths above it.

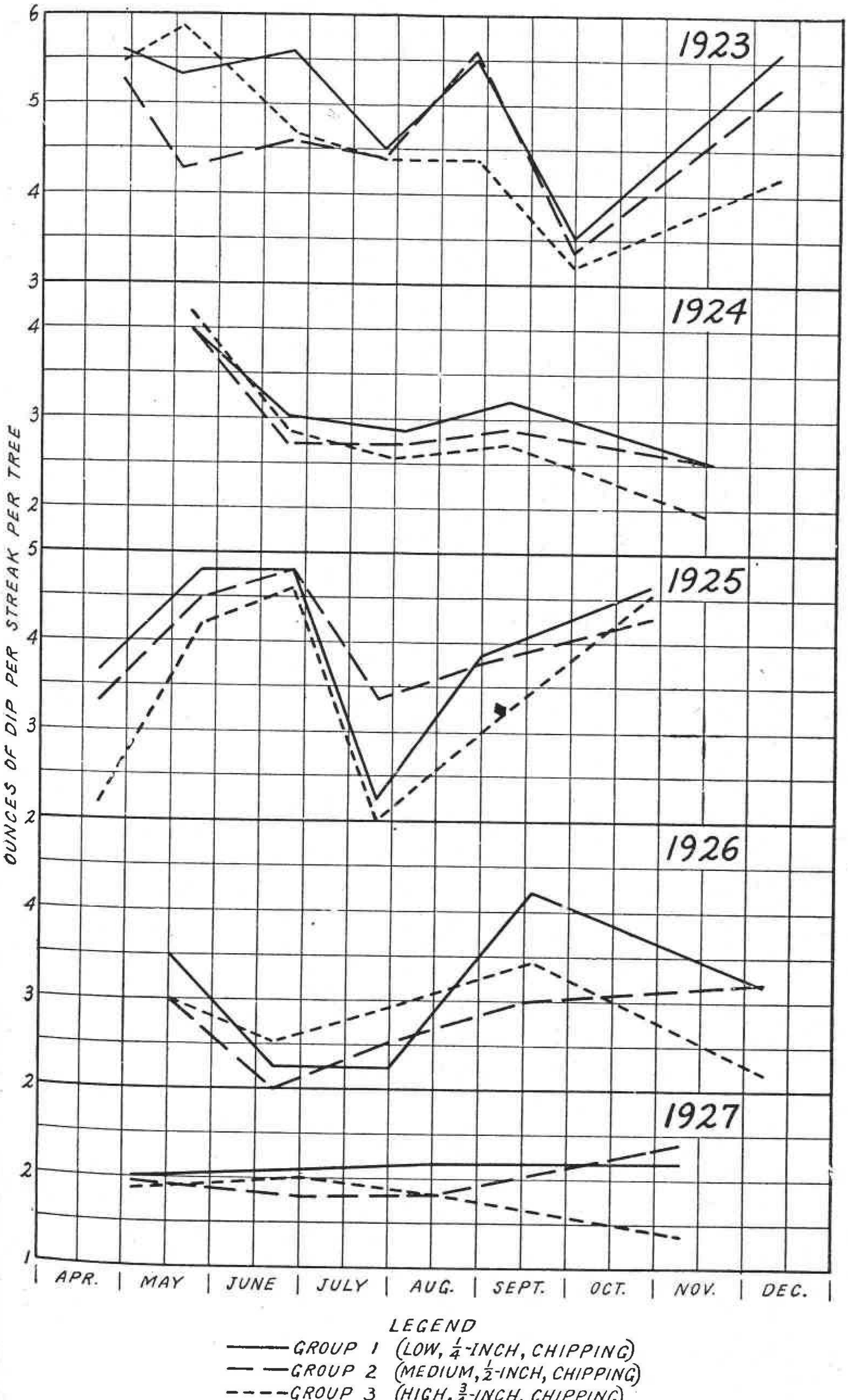


FIGURE 4.—Periodic yield, by years, of oleoresin in the form of dip. A streak was cut each week during the 26-streak season used but the number of streaks included in a given dipping varies from 3 to 9, consequently each point represents the average of the yield of a varying number of streaks

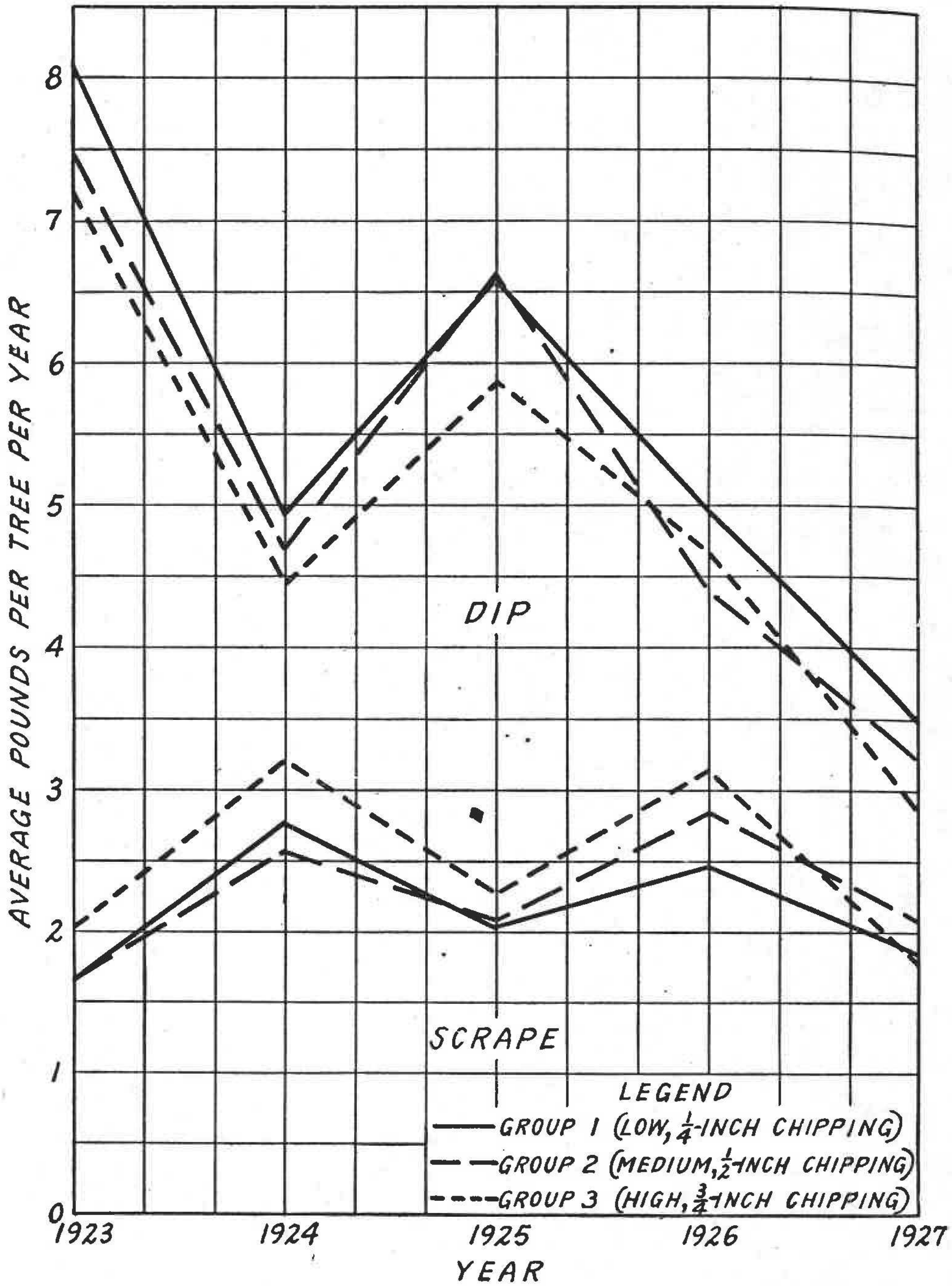


FIGURE 5.—Average yield of dip and scrape per tree per year, based on 26-streak seasons

TABLE 2.—*Original yields of oleoresin in the height-of-chipping test, Choctawhatchee National Forest, 1923 to 1927*

Year	Streaks	Collections	Product	Group 1, ¼-inch chipping		Group 2, ½-inch chipping		Group 3, ¾-inch chipping	
				Yield of 20 trees	Average yield per streak per tree	Yield of 20 trees	Average yield per streak per tree	Yield of 20 trees	Average yield per streak per tree
	Number	*Number*		*Pounds*	*Ounces*	*Pounds*	*Ounces*	*Pounds*	*Ounces*
1923	33	8	Dip	194.00	4.70	172.50	4.18	[1] 151.00	[1] 4.47
1923	33	1	Scrape	43.00	1.04	42.00	1.02	51.00	1.24
			Total	237.00	5.74	214.50	5.20	202.00	5.71
1924	[2] 26	6	Dip	98.89	3.04	94.00	2.89	89.00	2.74
1924	32	1	Scrape	68.00	1.70	63.00	1.58	79.00	1.98
			Total	166.89	4.74	157.00	4.47	168.00	4.72
1925	32	6	Dip	158.95	3.97	157.50	3.94	134.00	3.35
1925	32	1	Scrape	50.00	1.25	51.00	1.28	56.00	1.40
			Total	208.95	5.22	208.50	5.22	190.00	4.75
1926	31	5	Dip	121.31	3.13	107.00	2.76	112.00	2.89
1926	31	1	Scrape	58.95	1.52	68.00	1.75	75.00	1.94
			Total	180.26	4.65	175.00	4.51	187.00	4.83
1927	31	4	Dip	82.11	2.12	77.00	1.99	69.00	1.78
1927	31	1	Scrape	44.21	1.14	50.00	1.29	42.00	1.08
			Total	126.32	3.26	127.00	3.28	111.00	2.86

[1] The dip from the first 6 streaks on the Group 3 trees was not weighed.
[2] The dip from the first 6 streaks on all trees—a small amount that year—was not weighed.

YIELDS FROM DIFFERENT HEIGHTS OF CHIPPING

Throughout the test the Group 1 trees gave good yields as is shown in Tables 2 and 3. When the annual yields from the five years are combined on a percentage basis (Table 3), Group 1 is shown to have given slightly more than either the Forest Service chipping of Group 2, or the ordinary high clipping of Group 3. In most cases a large scrape yield (fig. 5) was obtained from the higher faces, but this was not sufficient in amount to make the total products over the 5-year test period exceed those obtained from the low faces where the total dip yield, rich in turpentine, usually exceeded that from the high clipping. The gum had to travel a decidedly greater distance on the high faces than on the low faces before reaching the cup and had a larger area on which to collect as scrape and lose value through the evaporation of the volatile turpentine.

TABLE 3.—*Comparable yields*[1] *of oleoresin in the height-of-chipping test, Choctawhatchee National Forest, 1923 to 1927*

Year	Collections	Product	Group 1, ¼-inch chipping				Group 2, ½-inch chipping				Group 3, ¾-inch chipping			
			Yield of 20 trees	Average yield per tree	Average yield per streak per tree	Group 1 [2]	Yield of 20 trees	Average yield per tree	Average yield per streak per tree	Group 2 compared with Group 1	Yield of 20 trees	Average yield per tree	Average yield per streak per tree	Group 3 compared with Group 1
	Number		*Pounds*	*Pounds*	*Ounces*	*Per cent*	*Pounds*	*Pounds*	*Ounces*	*Per cent*	*Pounds*	*Pounds*	*Ounces*	*Per cent*
1923	7	Dip	162.00	8.10	4.98	100	149.17	7.46	4.59	92.1	144.17	7.21	4.44	89.0
1923	1	Scrape	33.88	1.69	1.04	100	33.09	1.65	1.02	97.6	40.18	2.01	1.24	118.9
		Total	195.88	9.79	6.02	100	182.26	9.11	5.61	93.1	184.35	9.22	5.68	94.2
1924	5	Dip	98.89	4.94	3.04	100	94.00	4.70	2.89	95.1	89.00	4.45	2.74	90.1
1924	1	Scrape	55.25	2.76	1.70	100	51.19	2.56	1.58	92.8	64.19	3.21	1.98	116.3
		Total	154.14	7.70	4.74	100	145.19	7.26	4.47	94.3	153.19	7.66	4.72	99.5
1925	6	Dip	131.52	6.58	4.05	100	132.64	6.63	4.08	100.8	117.71	5.89	3.62	89.5
1925	1	Scrape	40.62	2.03	1.25	100	41.44	2.07	1.28	102.0	45.50	2.28	1.40	112.3
		Total	172.14	8.61	5.30	100	174.08	8.70	5.36	101.0	163.21	8.17	5.02	94.9
1926	5	Dip	99.43	4.97	3.06	100	88.25	4.41	2.72	88.7	93.25	4.66	2.87	93.7
1926	1	Scrape	49.44	2.47	1.52	100	57.03	2.85	1.75	115.4	62.90	3.14	1.94	127.1
		Total	148.87	7.44	4.58	100	145.28	7.26	4.47	97.6	156.15	7.80	4.81	104.8
1927	4	Dip	69.24	3.46	2.13	100	64.77	3.24	1.99	93.6	57.33	2.87	1.76	82.9
1927	1	Scrape	37.08	1.85	1.14	100	41.94	2.10	1.29	113.5	35.23	1.76	1.08	95.1
		Total	106.32	5.31	3.27	100	106.71	5.34	3.28	100.6	92.56	4.63	2.84	87.2
1923 to 1927	27	Dip	561.08	28.05	3.45	100	528.83	26.44	3.25	94.3	501.46	25.07	3.09	89.4
	5	Scrape	216.27	10.80	1.33	100	224.69	11.23	1.38	104.0	248.00	12.40	1.53	114.8
		Total	777.35	38.85	4.78	100	753.52	37.67	4.63	97.0	749.46	37.47	4.62	96.4

[1] The number of streaks each season varied from 26 to 33. Therefore the dip from the last 26 streaks each season was used to give a uniform basis for comparison. To this was added the calculated amount of scrape assignable to 26 streaks.

[2] Group 1 is rated as 100 per cent and is the standard for comparison.

The yields of oleoresin from the Group 1 trees, all of which were low chipped, were probably slightly reduced below normal by a number of minor accidents, most of which were not due in any way to the process of turpentining. For example, one of the original 20 trees in Group 1 was killed by lightning in August, 1924. Another tree, one of a few extra unmarked trees that had been chipped with low faces like the Group 1 trees, was substituted for it. Also in the same storm a second tree was struck by lightning. It was expected that this tree too would die, but it recovered later in the season. Normal yields, however, were not obtained from it during this period. In 1925 another tree of Group 1 was struck by lightning. It also recovered, but two dippings were entirely lost, for there was no cup on the tree during this period (about 10 weeks). The yields in Tables 2 and 3 are computed for these trees from the average obtained from the other trees. The 1925 lightning injury came at a very dry period during which all trees suffered in vigor and the death of much round timber occurred in the stand. Undoubtedly these dry conditions tended further to reduce the yields of enfeebled trees such as this one. In 1926 still another Group 1 tree, an excellent one, was eliminated from the test because it had to be cut in order to clear a right of way. From that date, calculated yields, based on the average production of the other trees, were regularly used in the place of those from the missing tree and appear in Table 2. In view of the accidents mentioned, therefore, it does not seem that any natural advantages were responsible for the excellent production of the low-chipped trees (Group 1). No accidents befell the trees in Groups 2 and 3.

HIGHER YIELDS SECURED THROUGH RAISING CUPS

In Figures 4 and 5 and Table 3 the higher yields of dip shown for the years 1923 and 1925 are largely due to the fact that the cups were closest to the current chipping during those years. In 1923, the first year of the test, all faces were relatively low, so that the gum easily reached the cups. In 1925 the cups were raised so that the gum again had a comparatively short distance to travel to reach the cups, and consequently there was less waste of turpentine during both these years. A relative increase in the amount of scrape, which is the less desirable product, because it usually gives a lower grade of rosin, is apparent especially in 1924 and 1926 when the cups were not raised. The high chipping fosters scrape production. With low chipping the cups do not need to be raised so often to secure results comparable with those obtained at present with high chipping. On the other hand, raising cups each year will give still higher yields (*2*).

VALUE OF PRODUCTS

The returns that might have been obtained at the 1923 to 1927 market prices from the turpentine and rosin yields obtained with the three heights of chipping have been calculated in Table 4, after converting the actual yields obtained to a crop basis of 10,000 cups. The values for comparative purposes are conservatively estimated on the basis of a 26-streak season instead of the usual 32 or more streaks (p. 8), which constitute a full season's work. The addition of about one-fourth—that is, the yield of six streaks to the reported yield—would show a very fair return considering the class of timber worked and the weather conditions existing during the test years.

TABLE 4.—*Summary of yields and value of products based on 26-streak seasons for 3 groups of 20 trees each in the height-of-chipping test, Choctawhatchee National Forest, 1923 to 1927*

Year	Estimated turpentine per crop [1]	Estimated rosin per crop [1]	Calculated value [2] of turpentine and rosin per crop
LOW CHIPPING, GROUP 1 (1/4 INCH)			
	Barrels	*Barrels*	*Dollars*
1923	53.0	168.2	4,561.58
1924 [3]	37.7	137.2	3,509.37
1925	45.0	149.6	3,977.51
1926 [3]	37.0	131.8	3,399.73
1927 [3]	26.2	94.4	2,422.62
Total	198.9	681.2	17,870.81
MEDIUM CHIPPING, GROUP 2 (1/2 INCH)			
1923	49.0	156.8	4,240.50
1924 [3]	35.7	129.0	3,306.68
1925	45.4	151.4	4,022.13
1926 [3]	34.9	130.0	3,291.42
1927 [3]	25.6	95.5	2,417.56
Total	190.6	662.7	17,278.29
HIGH CHIPPING, GROUP 3 (3/4 INCH)			
1923	48.6	159.6	4,268.26
1924 [3]	36.2	137.8	3,459.86
1925	41.7	143.0	3,751.30
1926 [3]	37.2	140.1	3,534.70
1927 [3]	22.4	82.7	2,101.05
Total	186.1	663.2	17,115.17

[1] A crop is made up of 10,000 cups. Yields of dip computed as composed of 21.2 per cent turpentine, 9.1 per cent waste, and 69.7 per cent of rosin. Yields for scrape computed as composed of 11.2 per cent turpentine, 5.1 per cent waste, and 83.7 per cent rosin. The weight of turpentine is taken as 7.2027 pounds for a gallon. A barrel of turpentine contains 50 gallons. In the computations a round barrel of rosin was considered to weigh 420 pounds, net.

[2] The average prices, during 1923 to 1927, the years of the test, are taken as 77 cents a gallon for turpentine and $15 a round barrel for rosin. Considerably lower prices now prevail.

[3] The lower yields in 1924, 1926, and 1927 are partly because the cups were not raised.

The advantage of obtaining the major part of the yields in the form of dip instead of scrape is shown when the yields in barrels of turpentine from the three groups are compared in Table 4. Finally, even when figured on the conservative 26-streak season, it appears from the calculations presented in Table 4 that the value of the products from the low chipping (Group 1) under the conditions existing at the time was about $17,900 compared with $17,300 from the current Forest Service work (Group 2) and $17,100 from the highest faces (Group 3). This presents a margin worthy of consideration, but of far greater importance is the fact that the work on the Group 1 faces could be continued for another 5-year period, whereas the Group 3 faces were exhausted because they were out of reach.

MICROSCOPIC STRUCTURE AND PHYSIOLOGICAL RESPONSES AFFECTED BY HEIGHT OF CHIPPING

SELECTION OF THE TREES

The trees that were used in the study of the effect of different heights of chipping were matched tree by tree in pairs not only by external appearance but also on the basis of the character of the annual rings in the outer sapwood as observed under a lens on increment borings made at the time of the selection.

SPECIMENS USED FOR STUDY

At the beginning of the test (November, 1922) increment borings and small chips were used to determine the condition of the trees before chipping began. Later hack and puller chips, which were collected as a rule immediately after they had been cut, although somewhat shattered and split, were used. The chips were always taken from a point midway between the peak and the shoulder of the streak, for this had been found in previous investigations (*4*) to serve well as an indicator of the tree's response to wounding. Conclusions based on the structures observed in this area are conservative, for the area represents a mean between the more vigorous growth at the shoulder (at the side of the face) and the less vigorous growth characteristic of the peak region (over the middle of the face). The newly formed annual rings above the streak tend to be somewhat narrower and have less summer wood than elsewhere on the circumference of the tree.

The specimens were sectioned without treatment except for soaking in water. Cross sections 10 to 30 micromillimeters in thickness were most frequently the material studied. The sections were prepared with the aid of a Jung-Thomson wood-cutting microtome. At the end of the test some blocks were cut from the trees with hammer and chisel. These blocks offered the best material for study since they had the proper dimensions and were in unshattered condition.

STANDARDS FOR ESTIMATING TREE RESPONSES AND VITALITY

Structural and physiological features, particularly the width of annual rings, amount of summer wood, amount and character of resiniferous tissue and its location were the chief characteristics used for comparing the results obtained from the different heights of chipping. Additional observations were made at the beginning of the test of the spring-wood and summer-wood formation, the thickness of the walls of the summer wood (*5*), and the activities of the phloem, or inner bark. It is believed that the activities of the phloem have an important relation to the wound responses resulting from turpentining. Exceedingly abnormal conditions in the phloem have been found associated with many cases of dry facing.

RESULTS OF MICROSCOPICAL STUDY

By midseason (July 26, 1923) the trees with the low faces (Group 1) had the largest number of cells for that year, the Group 3 trees having the smallest. (Table 5.) The specific observations were made for the 1923 growth ring midway along the streak in the region above the face. In more than half of the Group 1 trees, as many wood cells were present on July 26, 1923, as existed in the entire ring of the preceding year, when the trees were unturpentined; whereas this was true of only about one-third of the Group 3 trees. In the Group 1 trees there were also nearly three times as many summer-wood cells, on the average, and about twice as many resin passages as in the Group 3 trees. Beginning about July 26, the yield of oleoresin from the Group 1 trees also showed a notable rise as compared with the high chipping. (Fig. 4.) The difference in the amount of summer wood and the time at which it began to form (Table 5) appeared to be closely correlated with the different types of chipping (*5*).

TABLE 5.—*Measurements on the structure of the wood formed in longleaf pine*

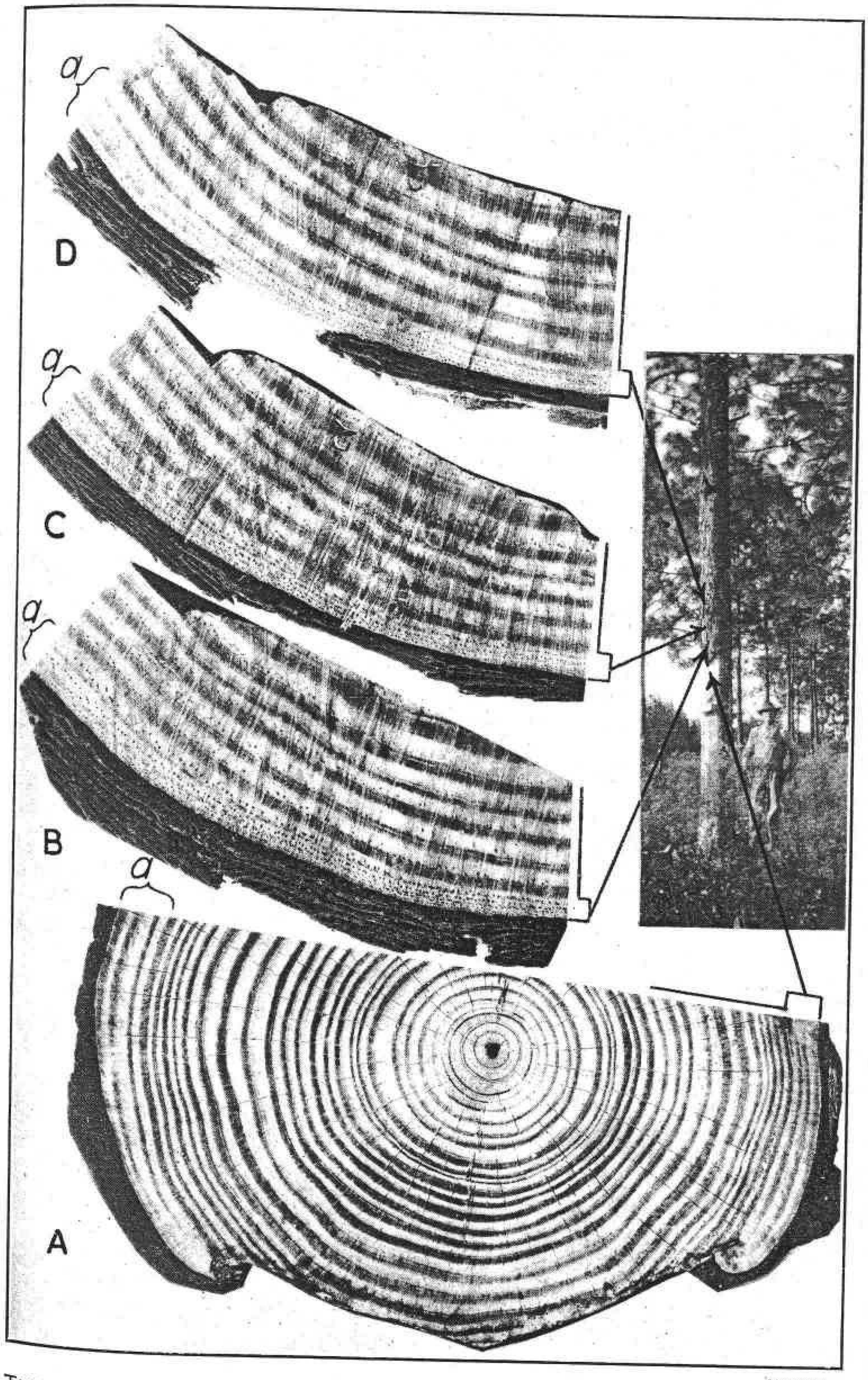
[Specimens[1] from the test of the effect of the height of chipping, Choctawhatchee National Forest, 1923]

Height of chip, group, and date of removal	Cells in the 1923 growth ring			Resin passages in unit area[2]		Observations in which width of 1923 ring was found equal to, less than, or greater than width of 1922 ring		
	Spring-wood cells	Summer-wood cells	Total cells	1923	Average for 3 years before turpentining	Equal	Less	Greater
	Number	*Number*	*Number*	*Number*	*Number*	*Per cent*	*Per cent*	*Per cent*
Chips taken July 26, 1923:								
Group 1 (¼-inch chipping)	7.8	18.3	26.1	12.0	1.1	31.8	31.8	36.4
Group 2 (½-inch chipping)	11.0	12.9	23.9	9.0	1.1	5.0	40.0	55.0
Group 3 (¾-inch chipping)	7.8	6.4	14.2	6.5	1.1	25.0	62.5	12.5
Chips taken Nov. 24, 1923:								
Group 1 (¼-inch chipping)	[3] 12.6	19.2	31.8	11.4	1.1	2.7	32.4	64.9
Group 3 (¾-inch chipping)	8.3	14.0	22.3	7.3	1.2	11.6	46.5	41.9

[1] Specimens taken from midway of the current streak at the top of the face.
[2] The "unit area" in this case was the full length of a microscopic field, about 4 millimeters (0.16 inch) in diameter measured along the middle of the annual ring, and the full width of the given annual ring.
[3] The greater number of spring-wood cells in November as compared with July is partly due to the fact that the November chips were cut higher up in the tree where the wound effect is relatively reduced.

CONDITIONS AT THE END OF THE FIRST YEAR

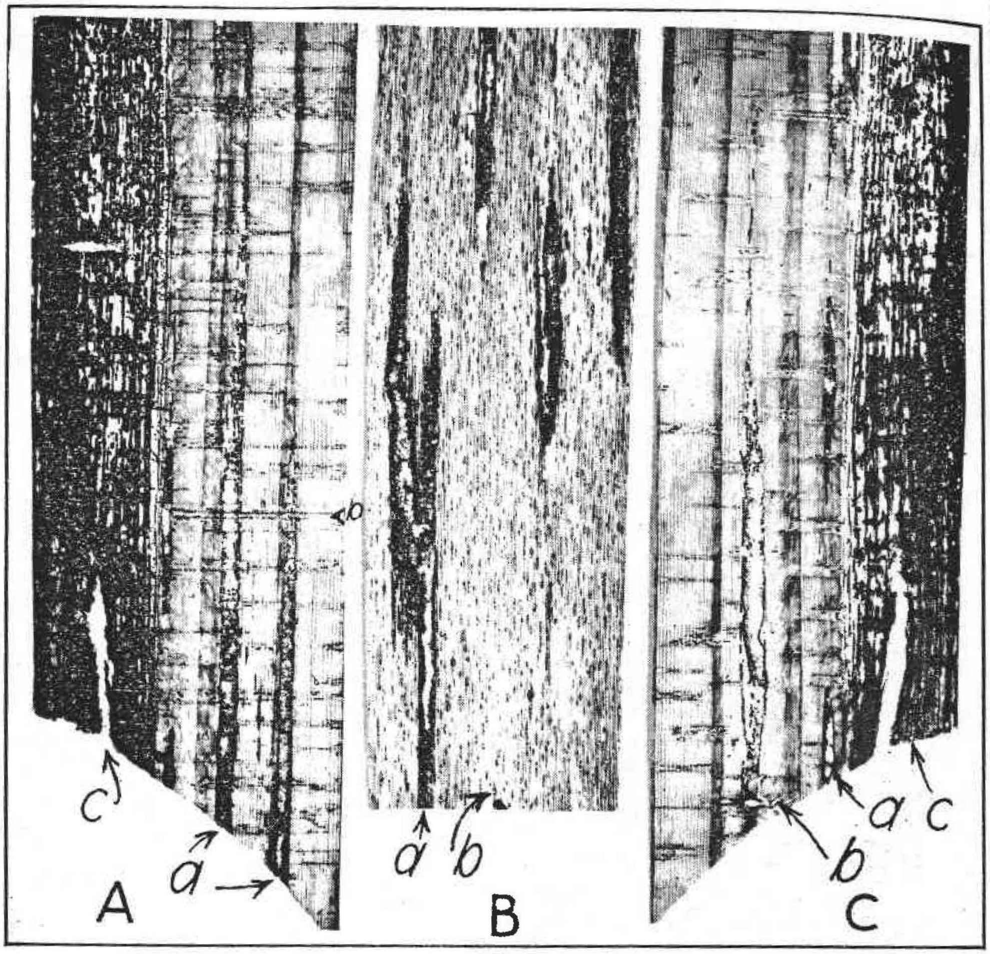
By November 24, 1923, the differences in the amount of wood tissue were not so marked between the Group 1 and Group 3 trees as they had been at midseason. However, in the completed 1923 ring of wood, the average width of the ring, the amount of summer wood, and the number of resin passages were still distinctly greatest in the Group 1 trees. Group 2 came next in order, and Group 3 showed the poorest development during this first year of turpentining (*5*). The development of the 1923 annual ring in Groups 1 and 3, as well as the approximately 50 per cent more resin passages in the low faced tree specimens constituting Group 1, are shown in Plate 2. By the end of the first year there was also a marked tendency in the high-chipped trees for many of the resin passages to be lacking in the early spring wood of the 1923 annual ring. Apparently some of the resin passages that formed in the early spring wood as a result of wounding were comparatively short. In high chipping the short



M15755F

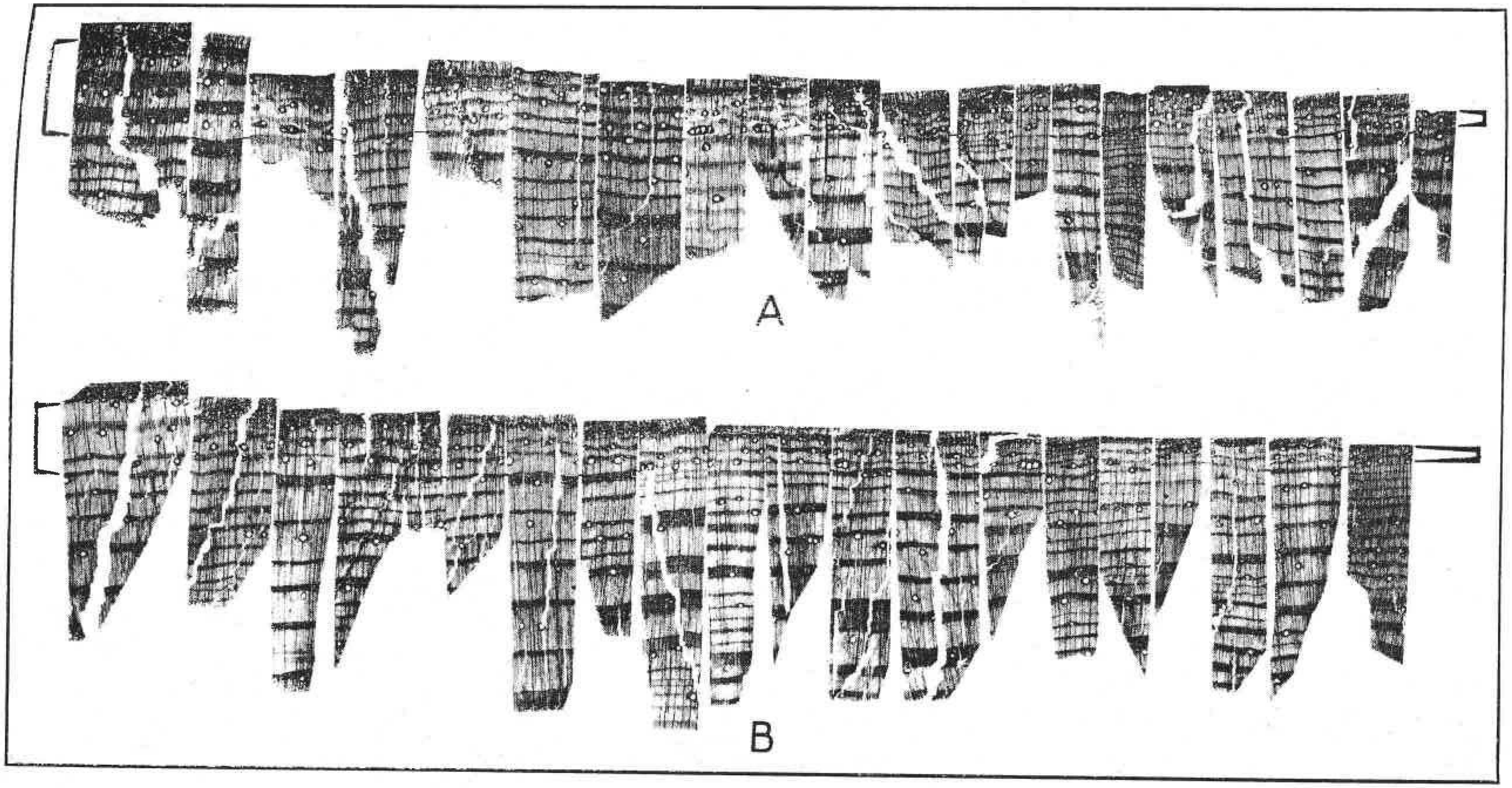
THERE IS A DECREASE IN THE NUMBER OF RESIN PASSAGES WITH INCREASE IN DISTANCE ABOVE THE FACE. (YOUNG LONGLEAF PINE FROM GEORGIA)

A, Disk cut at the top of the face, considerably reduced in size; B, block cut 3 inches above and to the left of the peak and extending toward the shoulder or side of the face. The resin passages present appear as conspicuous black dots and are very numerous in wood formed after turpentining began, *a*; C, block cut 1 foot above B. Only about one-half as many resin passages were present at this height in a given portion of the rings of the area *a* as were found in the B block; D, block cut 1½ feet above B. Only about one-third as many resin passages were present as in B in the rings in a similar portion of *a*. About one-fourth as many resin passages were found in a similar portion of the normal wood as in the rings of the area selected in block B.



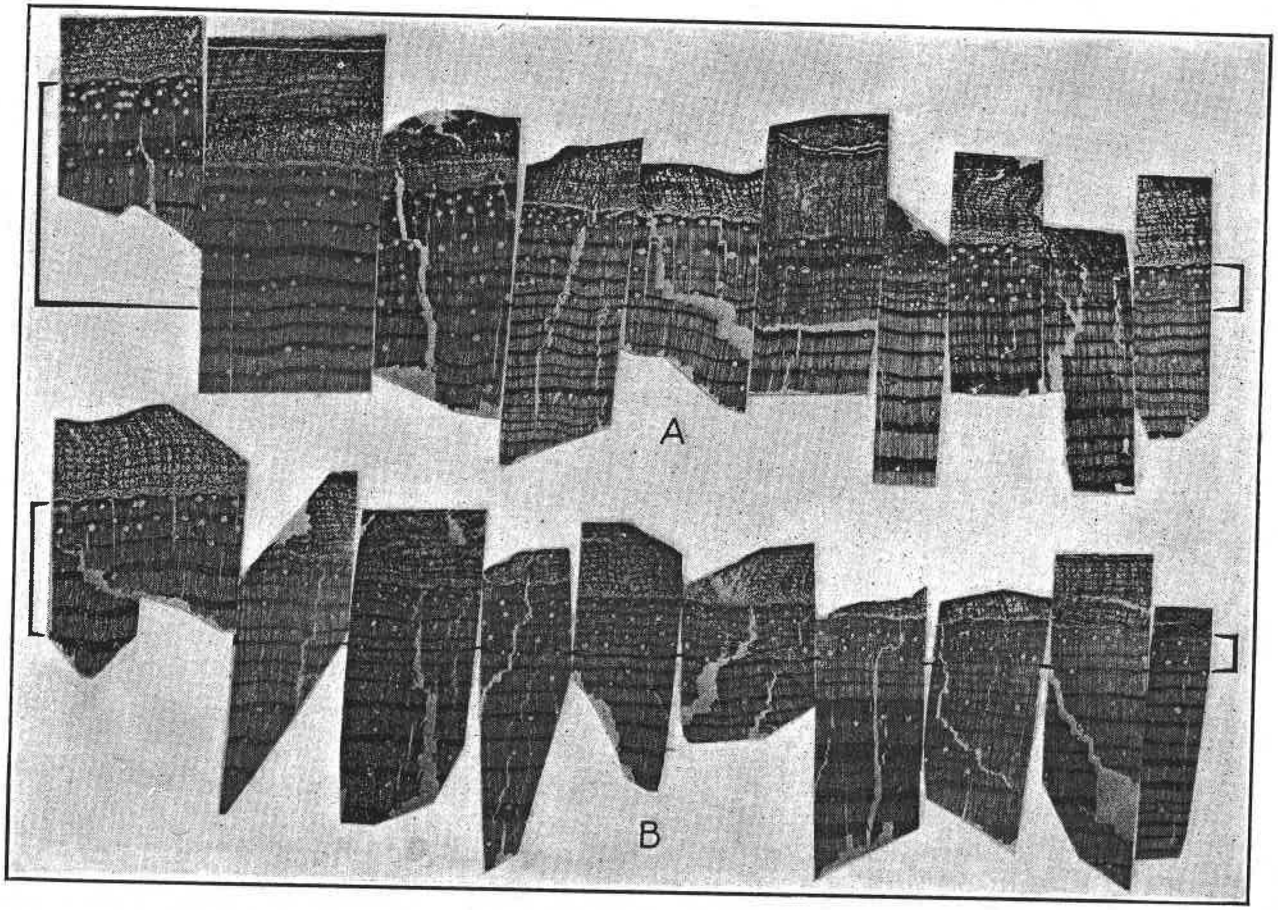
M15757F

A, B, and C, Longitudinal sections removed from a longleaf pine; *a* shows the large vertical, and *b* the small horizontal resin passages at and above the streak. The curved surface at the bottom of the radial sections A and C is the actual streak surface (in profile) as cut by the puller. The phloem, or inner bark, with its darkly stained stored reserves is shown at *c*. B is a tangential section cut just under the bark and approximately parallel with the outer surface of the tree



STRUCTURAL RESPONSES AFTER THREE YEARS OF TURPENTINING, 1923–1925, IN SPECIMENS CUT MIDWAY OF THE STREAK

A, Sections from typical (Group 1), one-fourth inch chipped trees; B, sections from typical (Group 3), three-fourths inch chipped trees. The wider growth rings, more summer wood, and more resin passages (about 50 per cent), especially those in the spring wood, shown in the bracketed areas, which embrace the 1923 to 1925 annual rings, are particularly noticeable in the A specimens when compared with those in B. The sections are arranged with the widest ringed specimens at the left and the narrowest at the right to show the range of variation among the trees in the contrasted groups. The beginning of the 1923 ring in each specimen is used as the horizontal base line, the years' growth during turpentining being shown in their varying widths above it.



M15751F

STRUCTURAL RESPONSES AFTER FIVE YEARS OF TURPENTINING, 1923–1927, IN SPECIMENS CUT FROM MIDWAY OF THE STREAK

A, Sections from typical (Group 1), one-fourth inch chipped trees; B, sections from typical (Group 3), three-fourths inch chipped trees. The greater summer wood formation and wider annual rings with about 50 per cent more resin passages, shown in the bracketed areas, which embrace the 1923 to 1927 annual rings, are noticeable in the A specimens when compared with those in B. The sections are arranged with the widest ringed specimens at the left and the narrowest at the right to show the range of variation among the trees in the contrasted groups. *The beginning of the 1923 ring in each specimen is used as the horizontal base line, the years' growth during turpentining being shown in their varying widths above it.*

resin passages were entirely chipped away, whereas in low chipping many remained to function for more than one year.

DISTRIBUTION OF RESIN PASSAGES IN RELATION TO HEIGHT ABOVE THE FACE

A further illustration of the distribution of resin passages in a young longleaf pine is presented in Plate 3. The decrease in the number of resin passages in relation to the increase in distance above the face is apparent from the three blocks cut at varying distances above the face. Many of the resin passages in the spring wood and in the summer wood near the butt of the tree are formed at the same time as those in the corresponding positions higher up; but more and shorter ones are also formed in the immediate vicinity of the face. Some of the resin passages formed, say in midseason, together with those intimately connected with them, may extend for a distance of more than 20 or 30 feet, but others are short. The short resin passages may be entirely cut away and wasted by one season's heavy chipping. Plate 3 illustrates in block B the general increase in number of resin passages formed after turpentining has begun. The resin passages appear as black dots. They are particularly abundant in the three annual growth rings next the bark, a condition which is very apparent if these rings are compared with the inner rings which were formed before the tree was turpentined. (Pl. 3, B, *a*, compared with the other rings in B.)

When block B, cut 3 inches above and to the left of the peak, is compared with block C, cut 12 inches above it, and with block D, cut 18 inches above B, the decrease in the number of these resin passages corresponding to the increase in height above the chipping is also apparent. In definite numbers counted on the surface of 1 inch of wood measured along the circumference of the tree about midstreak, 108 vertical resin passages were counted in the growth ring just completed next the bark in block B. (Pl. 3, B, *a*.) In block C, which was taken 1 foot higher in this same tree, only 54 resin passages were present in a similar area of the same annual ring directly above that measured in the B block. One and one-half feet above the B block and on a similar area only about 33 resin passages were present in the ring. The average number of resin passages per ring in similar areas from five rings formed before turpentining began was about 25. The number of resin passages prior to turpentining was practically the same at all three heights. Both the resin passages present in the outer rings of the round timber and those produced in the rings formed during turpentining contribute to the yield of oleoresin. The location and number of resin passages as related to height of chipping is shown for the test trees in Plates 2, 5, and 6. The greater number present in the trees with low faces is obvious.

The appearance of the resin passages as seen along the grain extending vertically in the tree is shown in Plate 4, A, B, and C at *a*. A is a view of a split or radial surface extending from the bark inward across the streak. The curved surface of the streak cut by the puller, which evidently was sharp and made a clean, smooth cut, is seen in profile at the bottom of the picture. The lines of resin-yielding tissue, or resin passages, are also shown cut across at *a* as they are at each chipping. It is apparent that these are not perfectly straight vertically, since they do not appear to be entirely continuous but bend slightly and sometimes fuse together. (Pl. 4, B, *a*.) That the resin passages are in contact with the horizontal lines of cells, the rays, is apparent in Plate 4, A, following from *b* to the bark at the left and in C at *b*. Many of these rays contain small resin passages, as is shown in Plate 4 in B, *b*, and in C, *b*. Plate 4, B, represents a slice of wood cut just under the bark and approximately parallel with the outer surface of the tree—that is, at right angles to the sections shown in A and C in Plate 4. The large vertical resin passages are shown at *a*, and may be contrasted with the small horizontal resin passages in the rays shown at *b*.

COMPARISON OF THE RESULTS OBTAINED IN THE LATER YEARS OF THE TEST WITH THOSE OBTAINED THE FIRST YEAR

Specimens were collected and studied microscopically each year. Typical groups of sections are presented for comparison in Plates 2, 5, and 6. Plate 5 shows the condition existing in the Group 1, the low, ¼-inch chipping, and in the Group 3, the high, ¾-inch chipping, after three years of turpentining. The superior development of wood, wider ringed with denser summer wood, as well as the more abundant resiniferous tissue in the Group 1 specimens is apparent in the respective bracketed areas. In Plates 2, 5, and 6 the sections are arranged with the widest ringed specimens at the left and the narrowest at the right to show the range of variation among the trees in the contrasted groups. The beginning of the 1923 ring in each specimen is used as the horizontal base line, that year's growth during turpentining being shown in varying widths above it. The external appearance of the trees is shown in Plate 1.

Again at the end of the 1927 season comprehensive comparisons were made of the specimens from the three groups. Illustrations of the microscopic structure of typical specimens from Group 1, the low chipping, and Group 3, the high faces, have been assembled in Plate 6 and give cumulative evidence as found at midstreak at the top of the face on the relative effects of low and high chipping for the entire 5-year period. The Group 2 material, the ½-inch chipping, was, in general characteristics, intermediate between the Groups 1 and 3.

After five years of turpentining the trees making up Group 1 on which low chipping was used appeared to be in excellent condition. They had healthy appearing tops and showed notably good wood formation. (Pl. 6.) Repeatedly it has been found that in the new growth directly above the face (not markedly in the other parts of the tree's circumference) resiniferous tissue is produced at the expense of summer wood. This is especially true in less conservative commercial work and particularly in young, fast-growing trees. Therefore, the fact that the low-faced trees, all things considered, produced not only at the beginning of the test but also in later years, the best summer wood, appears to be highly significant. Indeed in some of the Group 1 trees there was by the fifth year practically no reduction below normal apparent in the amount of wood formed, even in the area directly above the face. The trees had apparently successfully adjusted themselves to the exploitation for oleoresin.

SIGNIFICANCE OF RESULTS

LOW CHIPPING GENERALLY PRACTICABLE AND ADVANTAGEOUS

The conclusions to be drawn on the basis of the results secured in the 5-year height-of-chipping test here described are definitely in favor of the practice of lower chipping than is now commonly used in the exploitation of southern pines for their oleoresin.

The results of this test have also been sufficiently confirmed by other Government tests [4] (*1*, *11*, *12*, *13*, *14*, *16*, *17*) and in several instances in commercial practice, so that the method of reducing the height of the chip, periodically cut, below one-half inch should now be considered in the plans of every operator as a means of eliminating waste and conserving tree energy and producing power.

Indeed this improvement has been deemed so significant that the administrators of the national forests in Florida are making plans to incorporate the requirement for low chipping (less than one-half inch high) in leases for commercial turpentining where Government-owned timber is worked. Several private operators with large holdings are also modifying their practice with this objective. The reduction in scar thus made possible, or, if preferred, the increased length of operation combined with sustained tree health and growth, are factors of basic importance where carefully thought out forest-management plans are in operation.

It seems obvious, therefore, that faces about 10 inches in height per year could undoubtedly be obtained under ordinary conditions, and that 12 inches should be a maximum height during hack chipping in operations where conservation of the timber is a consideration. The only additional effort in obtaining a nearly double operating period or else half as much scar for each face is a little more rigid supervision conscientiously practiced until the chippers thoroughly understand the type of work that is expected of them. It has been demonstrated that they can and will do this work when it is definitely required.

Under the present system of facing, low chipping will permit the maximum width of face to be maintained longer than is possible with the other methods. The face frequently must be narrowed as it increases in height because of the taper of the tree trunk above the butt region. The period of hack chipping with the face at a convenient height is also prolonged by using a ¼-inch high streak. In this way the time when the puller must be used is consequently delayed.

The long exposed surface of the high-chipped, Group 3, trees caused them to suffer somewhat more than the other groups from becoming dry faced, and possibly from insect infestation. One tree in Group 3 became entirely unproductive, and over one-third of the streak surface of another ceased to exude. A tendency of some of the trees to form resin blisters in the phloem was also noted exclusively in Group 3, apparently indicating very abnormal and not desirable conditions in the trees. The undue exposure to drying, which reduces the vitality of the living wood in the vicinity of the face, is undoubtedly one of the chief reasons why wood formation

[4] WYMAN, L. RESULTS OF EXPERIMENTAL TURPENTINING SLASH AND LONGLEAF PINES. (Unpublished manuscript.)

was so noticeably reduced above the faces in these trees. (Pls. 2, 5, and 6.) The length of the face is a great mechanical hindrance to oleoresin collection in the cups. This area of exposed wood also tends to crack and check. The fissures thus formed invite the turpentine borer, *Buprestis apricans* Herbst, which lays its eggs in the cracks. The larvae of these beetles may then tunnel out the interior of the butts of the turpentined trees. The partial destruction of the wood which results also degrades the butt lumber from the trees. The holes from which the beetles emerge after several years' sojourn inside the butts of the trees and their tunnels within the bole favor the growth of fungi, which may bring about further deterioration through decay. Even without decay the tunneling brings about a weakening of the tree so that it may be more easily blown over. Low chipping, which keeps the wood near the face healthy and vigorous, also keeps a good coating of gum on the face and tends, provided the face is not burned, to minimize the danger of damage from attack of this borer.

LOW CHIPPING IMPORTANT IN YOUNG TIMBER

In a forest-management plan (*9*), which involves several workings of a stand of timber, it is especially important that conservative chipping be practiced, particularly during the first working. Turpentining trees 10 inches in diameter at breast height with an American face considerably weakens the tree mechanically so that it is less able to withstand strong winds. This is especially true where deep ax cuts are used for inserting aprons when the cups are raised. Therefore, the low-faced trees are less subject to windfall damage than the high-faced trees since in the latter the stems may be very slender 6 or 8 feet above the ground due to natural taper.

Furthermore, the healthier the tree is the more rapidly the exposed area will be healed over by new wood formed at the sides of the face, and the sooner it will be ready for a second careful working.

Severe chipping has been found often to reduce growth in height and diameter as much as one-third or one-half in young stands (*2*). The fact that in the low-chipped trees only a relatively small reduction in width of growth rings, even above the face where growth is most affected, was found (pl. 6) shows how this type of exploitation tends to conserve tree vigor and insure better healing over of the scar.

Low chipping as applied by the use of the so-called split faces offers still greater promise of good yields, conservation of tree energy, and rapid healing. The principal characteristic of the split face is that it has a 4 to 6 inch bar of bark between the two halves of the face, that is, it has four shoulders and no peak. The half faces may be clipped either American style[5] (*4, p. 39*) or French style with the gutters so arranged that the gum exuded flows into one cup. (Fig. 6.) The results from low chipping with the French faces, as cut with the new tool developed by the Southern Forest Experiment Station, offer exceedingly good promise (*6, 15*). Moreover, these faces are smoother than the American faces and hence do

[5] The American style split face was demonstrated in 1927 by W. K. and H. D. Cook of Spring Hill, Fla.

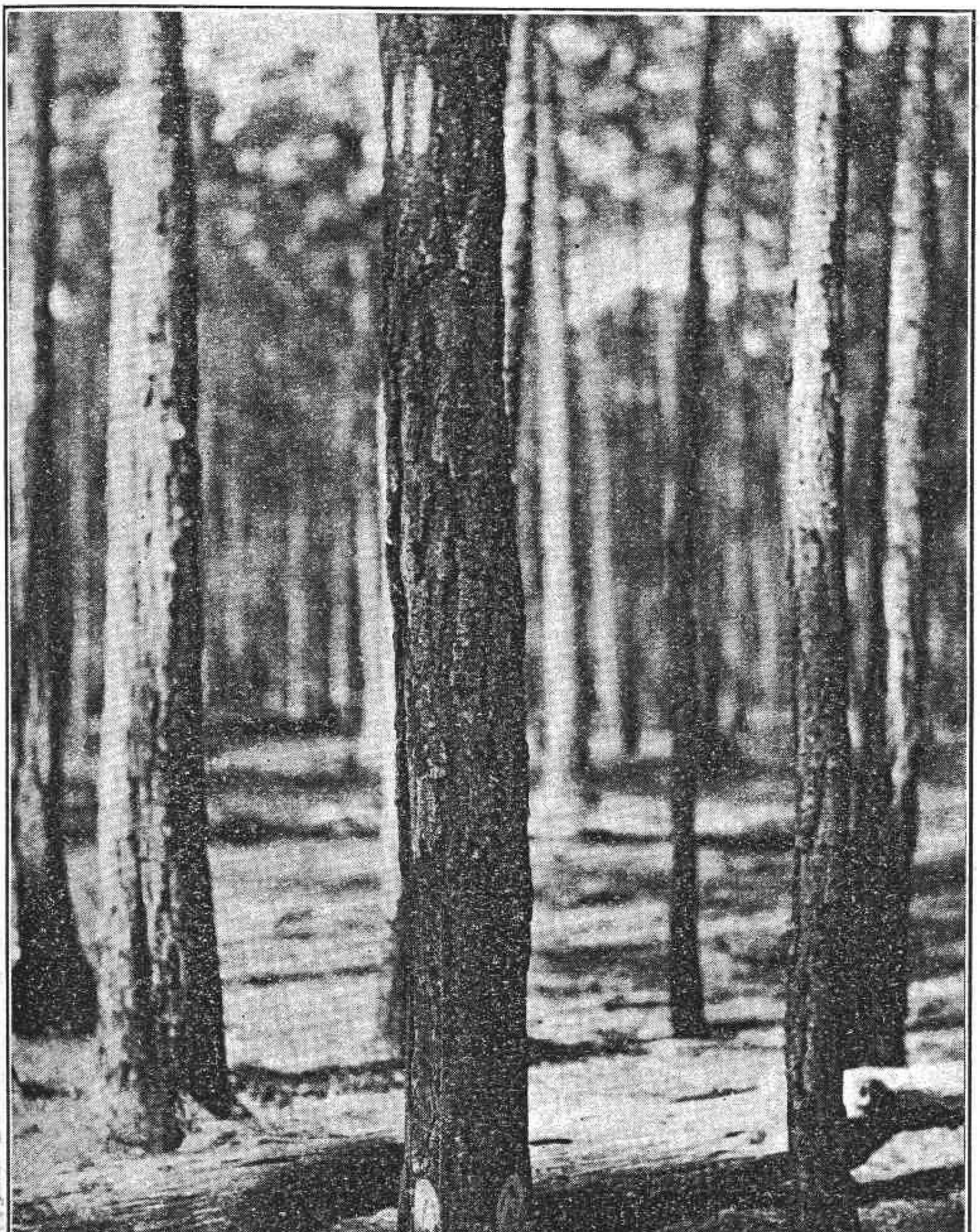


FIGURE 6.—The results from low chipping with a split face of the French type, as cut with the new tool developed by the Southern Forest Experiment Station, offer exceedingly good yields combined with a minimum depletion of tree vigor

not encourage scrape formation while at the same time they favor good circulation of sap and the best opportunity known for rapid healing.

PROFITABLE YIELDS OF OLEORESIN FROM LOW CHIPPING

The Group 1 trees chipped slightly more than one-fourth inch high each week (average 0.28 inch) produced in this test at least as much oleoresin as the trees chipped more than twice as high. Excellent yields from low chipping have also been obtained in other larger Government tests[6] and in commercial chipping. Nevertheless, there are some records where especially during the early years of operation higher yields were obtained from moderately high chipping as compared with low chipping. Whether this may be characteristic of certain classes of timber or of environments, or whether it is due to faulty matching of the groups for comparison or to some other unknown factor, remains to be determined. There is, however, no exception whatever to the fact that, inch for inch of height, the low faces have always produced the largest amount of oleoresin.

An operator, therefore, in deciding whether to practice low chipping, must weigh future considerations in the balance with immediate gains. When he is to work his own timber and intends to make the most profit through several rotations of working, his decision for low chipping may be considered almost a foregone conclusion. If, on the other hand, he is leasing timber that is to be turpentined for only a brief period before it goes to the sawmill, he may choose high chipping, which may be carried out faster and with less care, since in this case the potential value of the trees for further working is not involved.

MICROSCOPE REVEALS ADVANTAGES OF LOW CHIPPING

General confirmation of the earlier observations on the maintenance of better vigor in the low-chipped trees was obtained from the comparison of the wood formed during turpentining by the trees in the present test. The very thorough study of the test trees during the first year of turpentining (*5*) brought out the facts that earlier and more abundant summer-wood formation and wider annual rings, as well as greater development of resiniferous tissues, occurred in the low-chipped group. These responses were even more marked in the later years of the test, as is shown in Plates 5 and 6. In some of the low-chipped trees, wood formation, even above the face, does not appear to be materially reduced as a result of turpentining. (Pl. 6.) This is of particular interest since such apparent adjustment to wounding has never before been observed even in young trees growing on far better sites than that where this test was located. The power to build abundant wood cells and also more resiniferous tissue than normal, together with the tendency to store reserve food materials in both the wood and the phloem, appeared highly significant in the case of the Group 1 trees.

The needless waste of otherwise productive resiniferous tissue through high chipping, which removes the shorter resin passages

---

[6] See footnote 4.

before they can fully function, is a matter that appears to be of fundamental importance in conserving the energy of the tree's living cells. In this connection, however, it should not be disregarded that, although resin passages are decidedly more abundant in the Group 1 trees, nevertheless, number alone is not an invariable indicator of productive power. Indeed, exceptional cases have been found in a recent study of high and low yielding trees in which a large number of resin passages did not always accompany high exudation of oleoresin. The machinery was there but it was not functioning, except as manifested in the formation of the various cells.

The characteristics of the phloem, or inner bark, its storage capacity, and its bearing on productive power are being studied in connection with this test and also in a study directed toward determining the characteristics of high and low yielding trees.

SUMMARY

Low chipping of approximately one-fourth inch showed distinct improvements upon the higher chipping of approximately one-half to three-fourths inch now generally used in turpentining. Low chipping, using the smaller-sized hacks (Nos. 00, 0, 1), can be practiced without appreciable increase in operating costs and is capable of keeping ahead of the lightwood under ordinary conditions. During the 5-year test (1923–1927) on the Choctawhatchee National Forest in Florida as high a yield of oleoresin was obtained from the low faces as from faces more than twice as high, thus almost doubling the potential yields per face as well as the leasing value of the timber, or, if preferred, reducing the butt scar by half. Moreover, the low faces gave yields of higher quality because they contained a greater proportion of dip, as compared with the relatively large yield of scrape collected from the high faces. Possible degrade of butt lumber because of excessive pitch soaking or because of drying of the exposed surface accompanied by attacks of insects and fungi was also reduced to a minimum by the use of low faces.

A microscopical study of the wood and bark from the test trees obtained at different heights showed that the low-chipped trees when compared with the high-chipped trees had wider rings of annual growth, better-developed summer wood (strength giving) and markedly more abundant oleoresin-giving tissues immediately above the faces. In short, the low chipping reduced the waste of productive wood and in addition maintained the potential oleoresin and wood producing powers of the tree, matters of great significance in the turpentining of second-growth timber, where rapid healing following low chipping, especially of the French split-face type, will hasten the next working of the trees for oleoresin.

LITERATURE CITED

(1) ANONYMOUS.
1924. VISIT FORESTRY STATION AT STARKE. FIRST YEAR'S EXPERIMENTS HAVE PROVED IMPORTANCE OF LIGHT CHIPPING AND NARROW STREAK. South. Lumber Jour. 50(3): 18.

(2) CARY, A.
1921–31. STUDIES ON FLOW OF GUM IN RELATION TO PROFIT IN THE NAVAL STORES INDUSTRY. Naval Stores Rev. v. 31–40.

(3) DeBow, J. D. B.
1851. MAKING TURPENTINE AND ROSINS IN THE SOUTH SEVENTY-EIGHT YEARS AGO. DeBow's South. and Western Rev., Sept. 1851. [Reprinted in Gamble's Naval Stores Yearbook. p. 11-13. 1929-30. Original not seen.]

(4) Gerry, E.
1922. OLEORESIN PRODUCTION. A MICROSCOPIC STUDY OF THE EFFECT PRODUCED ON THE WOODY TISSUES OF SOUTHERN PINES BY DIFFERENT METHODS OF TURPENTINING. U. S. Dept. Agr. Bul. 1064, 46 p., illus.

(5) ———
1925. EFFECT OF HEIGHT OF CHIPPING ON OLEORESIN PRODUCTION. Jour. Agr. Research 30: 81-93, illus.

(6) Harper, V. L.
1931. FRENCH FACE EXPERIMENTS IN TURPENTINING. Jour. Forestry 29: 225-232, illus.

(7) Herty, C. H.
1911. RELATION OF LIGHT CHIPPING TO THE COMMERCIAL YIELD OF NAVAL STORES. U. S. Dept. Agr., Forest Serv. Bul. 90, 36 p., illus.

(8) ———
1916. THE TURPENTINE INDUSTRY IN THE SOUTHERN STATES. Jour. Franklin Inst. 181: 339-367, illus.

(9) Mattoon, W. R.
1931. SLASH PINE. U. S. Dept. Agr. Farmers' Bul. 1256, 53 p., illus.

(10) McKee, E. R.
1923. NAVAL STORES PRODUCTION ON THE FLORIDA NATIONAL FOREST. Naval Stores Rev. 33(6): 16-17.

(11) Wyman, L.
1924. HOW FAST SHOULD A FACE BE RAISED IN CHIPPING TIMBER? Southern Lumber Jour. 50(20): 17-18, illus. Naval Stores Rev. 34(32): 16-17, illus.

(12) ———
1928. NAVAL STORES YIELD MUCH AFFECTED BY METHODS OF CHIPPING. U. S. Dept. Agr. Yearbook 1927: 473-475.

(13) ———
1929. FACTORS WHICH INFLUENCE YIELD OF GUM. *In* Pine Institute of America (Inc.), Jacksonville, Fla. Pine Tree Chemical Industries Year Book 1929: 31-33.

(14) ———
1929. FLORIDA NAVAL STORES. Florida Dept. Agr. Bul. 25 (n. s.), 42 p., illus.

(15) ———
1929. FRENCH FACES MADE QUICKLY WITH NEW TURPENTINING TOOL. U. S. Dept. Agr., Forest Serv. Forest Worker 5: 13.

(16) ———
1929. NARROW CHIPPING IN END SHOWN TO INCREASE THE YIELD OF GUM. Naval Stores Rev. 39(38): 25.

(17) ———
1930. HIGHER RETURNS FROM TURPENTINE FORESTS. Naval Stores Rev. 40(12): 15-16.

U. S. GOVERNMENT PRINTING OFFICE: 1931