THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

SEGREGATION OF WOOD CHIP/BARK MIXTURES USING LIQUID FLOTATION PROCEDURES

Project 2977

Report Two

A Progress Report

to

MEMBERS OF GROUP PROJECT 2977

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SUMMARY

The work of Project 2977 during the second six-months' period involved investigations to solve the problems preventing segregation of wood chips from bark chips for white birch, sugar maple, and eastern cottonwood. These were the three species in which the basic work in the first project period indicated wood-bark chip mixtures could not be segregated using simple liquid flotation techniques.

In an effort to solve the segregation problems, modifications involving: air elutriation, chemical additives, dwell time, mechanical treatment, pressure-heat treatment, and sequence changes were studied. In addition, samples of chip mixtures from two of the Morbark Metro-Chiparvestor demonstrations were tested, using the flotation procedures developed.

The preliminary studies involving technique modifications revealed birch, cottonwood and maple, while different in many ways, had similar characteristics which hampered effective flotation segregation. For example, it was determined that the inner bark of all three species sank readily in water and the outer bark tended to float much longer than the wood of the same species. This factor was used in developing a multistage liquid flotation segregation system for each of the three species. Workable systems which recover more than 90% of the wood with less than 3% contamination were demonstrated and described for sugar maple and white birch. Results with eastern cottonwood indicate an "acceptable" system may be close at hand.

The preliminary studies involving technique modifications enabled priorities to be set regarding modifications to be tested in the work with the five new species. The work with chemical wetting and foaming agents was the least effective in influencing flotation, while the work with "pressure heating" was the most effective. Pressure heating the chips followed by a cold water quench caused the sinking of wood chips in an acceptable time (5 minutes) and still allowed the outer bark to float, effecting a segregation.

Characterization of wood and bark as to "flotation media dwell time" is another type of basic information useful in solving segregation problems. Mechanical treatments involving "beating" the chips with a pulp-cake breaker and compressing the chips with mechanically driven steel rolls were found to be effective treatments in both describing and solving flotation problems.

Not to be forgotten should be the effects of particle size, specific gravity, and moisture content of the chips, as described in Progress Report One. Specific gravity differences between the bark and wood of a species play an important role in the ease of segregation <u>via</u> liquid flotation. Small and wetter chips sink more readily than larger, drier chips.

The work with the Metro-Chiparvestor mixed species chip sample indicated a simple one-step flotation may be the best approach to wood-bark segregation using liquid flotation. Data collected also suggest that certain species, like oak and basswood, have different flotation characteristics which necessitate their being processed separately to obtain optimum segregation.

INTRODUCTION

The evaluation of the basic flotation work in the first report revealed two species which gave adequate segregation. "Adequate segregation" was arbitrarily described as recovery of about 90% or more of the wood with less than 3% bark in a theoretical mixture of wood-bark chips containing 25% bark and 75% wood. Populus tremuloides Michx., trembling aspen, and Quercus macrocarpa Michx., bur oak — a white oak, were classified as species for which a flotation system could be defined which would give adequate segregation. The two are not compatible in the same flotation. In the case of aspen the bark sinks and the wood floats while the oak bark floats and oak wood sinks. Aspen and oak were not studied further in this second project period. The remaining three species, sugar maple, white birch and eastern cottonwood, became the object of the investigation for this project period.

The methods investigated for improving wood-bark chip segregation by flotation for maple, birch, and cottonwood included the use of: wetting agents; air entrapment; changes in dwell times; changes in temperatures of the flotation media; changes in atmospheric pressure; and, for white birch, air classification. Obviously, any in-depth study into the variations possible with the few modifications listed above is beyond the scope of the time and budget available to this project. For this reason much of the work carried on during this second project period was empirical in nature. Nonetheless, it is felt that the progress made is well worth the efforts expended as reasonable solutions appear to be forthcoming for each of the species under study.

MATERIALS

SPECIES AND SOURCE

Four materials were investigated during the past project period:

1. White birch (Betula papyrifera March.),
2. Eastern cottonwood (Populus deltoides Bartr.),
3. Sugar maple (Acer saccharum March.),
4. Morbark Metro-Chiparvestor mixed species chip samples.

Chips from the first three species mentioned were to have been obtained by using the surplus chips from the previous report period. In spite of inclusion of formaldehyde-soaked cards in the chip bag and keeping the chips in cold storage, heavy amounts of mold in the chips necessitated their being discarded. New samples were collected from the local area in June and July so that fresh chips could be used. The physical description of the trees can be seen in Table I. No significant departures from the descriptions of the trees used in the first period of the project were found. The Morbark Metro-Chiparvestor chip samples came from the demonstration at Gaylord, Michigan in June of 1971, courtesy of U.S. Plywood-Champion Papers, Inc., and the demonstration near Tomahawk, Wisconsin in September of 1971, courtesy of Owens-Illinois, Inc. The data from the processing of these samples presented later in this report give additional information about the samples. Several descriptions of the Morbark system and the stands where the demonstration took place can be found in the literature. A feature article in Paper Trade Journal, July 26, 1971 (1) contains a description of some Morbark Metro-Chiparvestor demonstrations.

TABLE I

SAMPLE TREE DESCRIPTIONS

Material	Age, years	Height, feet	Diam. at 4.5 ft., inches	Av. Sp. Gr., g./cc. Wood	Bark
Sugar maple	40	60	9.0	0.633	0.503
White birch	37	62	7.9	0.501	0.531
Eastern cottonwood	18	60	8.0	0.374	0.316

PREPARATION OF SAMPLES

The newly cut wood for this period's work was obtained in the form of 4-ft. bolts. Some of these were too great in diameter to enter the chute of the chipper so they were split as necessary. Each species was handled separately and the chipper was carefully cleaned between uses. The chipper is a 41-inch knife machine made by Carthage Machine Company, and the newly sharpened knives were set to deliver chips of a nominal 3/4-inch length. All of the bolts constituting one sample were chipped together and the chips were well mixed before processing.

A representative sample of the chips for each wood species was screened on a 24-inch Sweco laboratory screen fitted with 3/4, 1/2, and 1/4-inch mesh screens. The chips were charged through the top (3/4-inch mesh) screen where the obviously oversize material was picked off manually. The screen delivers the sized material continuously so four streams were recovered, i.e.: (1) "on 3/4-inch," (2) through the 3/4-inch and on 1/2-inch mesh which from here on is known as "on 1/2-inch," (3) through 1/2-inch and on 1/4-inch mesh which from here on is known as "on 1/4-inch," and (4) through 1/4-inch or "fines."

After the chips were screened, representative samples were removed from each size class for determination of moisture content and bark percentage. Table II gives a description of the sample by size distribution, moisture content, and bark percentage. While the data are not representative of any particular "mill run" chips, it does describe the samples and, if properly interpreted, can suggest other possible utilization or processing schemes. For example, it is evident from the data in Table II that screening wood-bark chips to size can result in several different quality chip mixtures which might be used for different processes or products. The "on 3/4 inch" generally have less bark than the "on 1/4 inch."

TABLE II

WOOD-BARK CHIP DESCRIPTIONS

Species	Characteristic	Chip Size[a], % Oversize	On 3/4-inch	On 1/2-inch	On 1/4-inch	Fines
Betula papyerifera (white birch)	Moisture content[b]	26.6	43.4	44.1	42.8	43.6
	Distribution[c]	7.0	26.1	55.0	9.5	2.4
	Bark content[d]	23.3	1.9	7.8	28.8	ca. 80
Acer saccharum (sugar maple)	Moisture content	35.9	36.5	36.8	34.6	36.1
	Distribution	8.1	48.1	32.8	9.1	1.9
	Bark content	--	3.1	9.1	55.4	ca. 70
Populus deltoides (eastern cottonwood)	Moisture content	50.7	52.0	53.5	53.2	51.6
	Distribution	14.2	34.0	40.4	8.8	1.9
	Bark content	--	2.4	12.9	31.1	ca. 70

[a] Size indicates the mesh screen on which the chips were retained. Oversize chips were extracted manually.

[b] Moisture content based on ratio ovendry to fresh weight.

[c] Distribution based on ratio of ovendry weight of the size class to the ovendry weight of the whole wood-bark chip sample.

[d] Bark content based on ratio of ovendry weight of bark in that fraction to ovendry weight of the whole sample in the size class.

The "on 1/4-inch" and "on 3/4-inch" chips were then hand sorted to obtain an ovendry equivalent of 400 grams of pure bark and 800 grams pure wood. These pure fractions of wood and bark were then equally divided into four samples and placed in polyethylene bags. Half the samples were adjusted to a 45% moisture content and the other half to 20% moisture content and the samples stored in a 40°F. cold room to await use on the basic "pure fraction" study to be run using the most promising preliminary study modifications. The preliminary studies utilized charges made up of representative mixtures of the three chip size classes and/or samples taken at random from the "on 1/2-inch" chips. The portion of each sample not used was put in covered 50-gallon galvanized garbage cans with a dilute formaldehyde-soaked blotter paper enclosed as a preservative and stored in a 40°F. cold room.

PRELIMINARY STUDIES

The three wood species that were not amenable to satisfactory wood-bark segregation by water flotation at ambient temperature were white birch, eastern cottonwood, and sugar maple. Plans were made to study the above species, using several modifications to the basic flotation procedure described in the first report. The modifications included: air elutriation — with white birch, chemical additions — foaming and wetting agents, dwell time, mechanical pretreatment, compression — during flotation, and the addition of pressure and/or heat. The sequence planned involved working on the three species simultaneously but not necessarily with the same treatments. In this way a fair amount of knowledge could be gained about both the three species and the modifications.

The work reported in this "Preliminary Studies" section emphasizes the influence of various modifications. The best segregation via liquid flotation sequences are more thoroughly tested in the "Pure Fraction Studies" section. Care is advised in the interpretation of the preliminary study tests as the samples used were not standardized or duplicated and, to preclude erroneous assumptions, the reported data was not adjusted to a common level. This last is particularly true of the "Percent Bark in Fraction" data.

The tests in the "Pure Fraction Studies" on the other hand offer more solid evidence of the behavior of some of the more promising sequences derived from the information in the preliminary work. The pure fraction work was duplicated, run on more adequate amounts of wood and bark and are presented in the tables on common basis.

AIR ELUTRIATION

The air elutriation work was initiated with the reexamination of the data concerning the reaction of birch bark to water flotation. As shown in Table III, nearly 80% of the bark that floated was outer bark. The next largest fraction was unseparated bark fragments, which upon closer examination was found to be 60% outer bark. These data supported the conclusion that the main contaminant in the floating fraction of a water flotation of birch wood-bark chips would be outer bark.

TABLE III

PROPORTIONS OF INNER AND OUTER FRACTIONS OF BIRCH BARK WHICH FLOATED DURING WATER SEPARATION[a]

Sample Identity	Outer Bark, %			Inner Bark, %			Unseparated, %		
	1	2	Av.	1	2	Av.	1	2	Av.
3/4-In., 20% moisture	86.5	77.4	82.0	1.4	13.5	7.0	0	21.2	10.6
1/4-In., 20% moisture	76.1	50.0	63.0	8.7	7.1	7.9	15.2	42.9	29.0
3/4-In., 45% moisture	87.0	77.6	82.3	13.0	0	6.5	0	22.4	11.2
1/4-In., 45% moisture	90.7	82.5	86.6	9.3	5.5	7.4	0	12.0	6.0
Average			78.6			7.2			14.2

[a]Percentage based on ovendry weight with the total ovendry weight of the bark sample as a base.

Several trials were undertaken to remove the outer bark by air separation prior to water flotation. The observation that a substantial amount of the bark did not separate into the two fractions through chipper action led to the use of a pulp-cake breaker to complete the breakdown of the inner-outer bark interface. This device (Fig. 1) is simply a shaft suspended in a funnel-shaped housing and bearing four opposing steel arms on the lower end. When rotated at

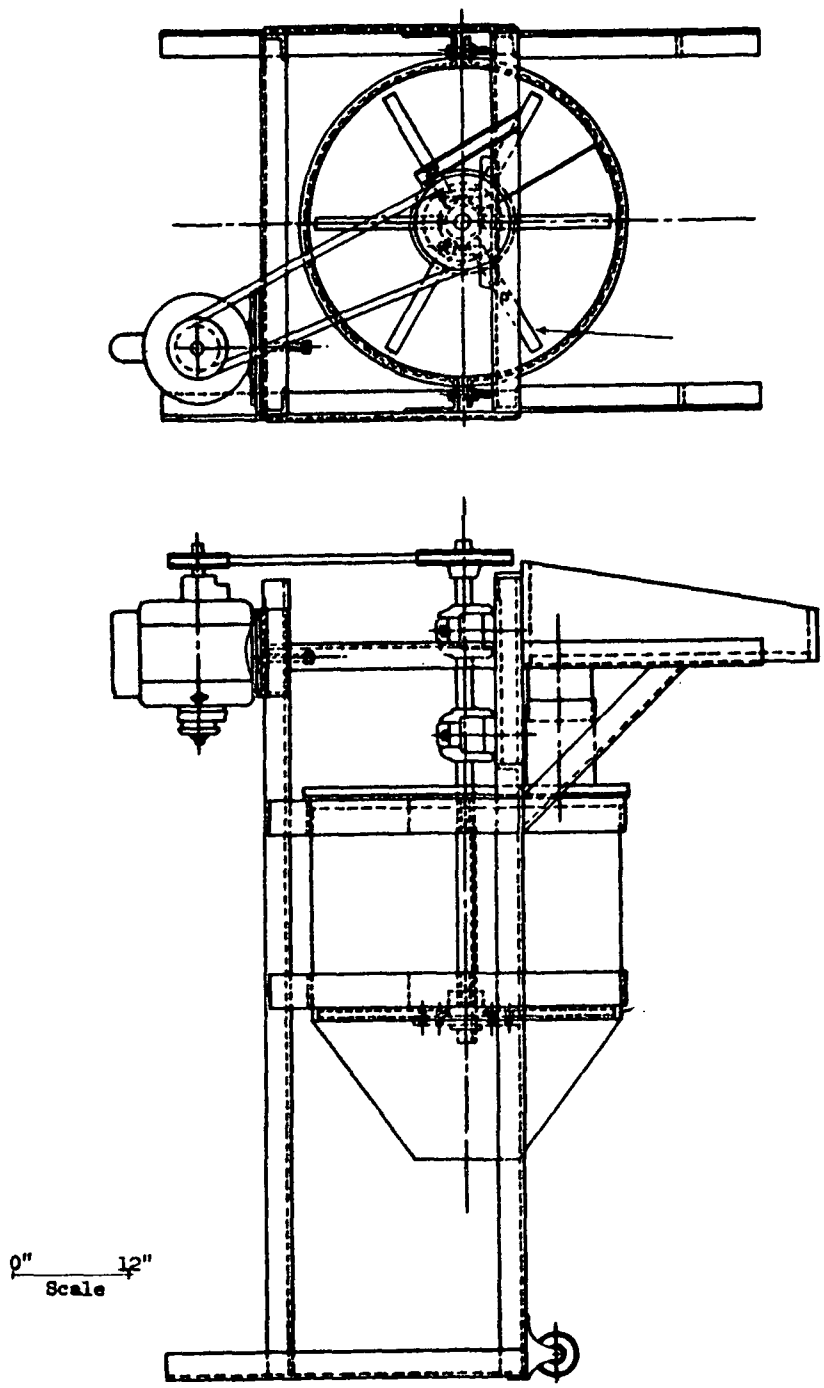

Figure 1. Drawings of the Pulp-Cake Breaker as Viewed from Above (Top) and Side View (Bottom). Arrows Show the Location of the Whirling Arms Inside the Funnel-Shaped Housing

1000 r.p.m., chips dropped into the whirling arms are battered quite vigorously — at least enough to fracture the friable inner bark while causing little damage to the more resilient wood and outer bark particles.

After the breaker treatment, the material was screened on the Sweco screen, with the fines, through 1/4-inch screen, being discarded. The other wood-bark streams from the Sweco screen were allowed to fall into containers, with air being moved across their paths with ordinary 12-in. cooling fans. This technique demonstrated that outer bark, separated from inner bark, could be segregated from wood and inner bark by air elutriation*. However, the method worked best with the coarse (on 3/4-in.) fraction since the wood and inner bark fragments were sufficiently heavy to resist the movement of the air. As the particle size decreased (on 1/2-in. and on 1/4-in.), more and more small wood chips were removed with the bark. No data were taken, but visual observations indicated that the removal of birch outer bark by air elutriation should be practical if reasonably complete separation from the inner bark can be achieved.

It was decided to forego further work with air elutriation and explore more fully means of improving the liquid flotation system because of: (1) the high cost of building the proper apparatus to test air elutriation, (2) the feasibility of developing a reasonably simple liquid flotation segregation system for white birch, and (3) verbal agreements previously made with the North Central Forest Experiment Station Engineering Laboratory to restrict work on wood-bark chip segregation via air flotation.

*The term separate has been adopted to indicate "free of adhesion" while segregate means "to set apart from."

CHEMICAL INFLUENCES

The investigation of chemicals that might improve the efficiency of the flotation system was limited to the use of wetting and foaming agents. Of the many other possible approaches with chemicals, only that of changing the flotation media density was given much consideration. In the end, this procedure was not investigated because the more practical approaches called for additions which would increase the density. The behavior of the tree species involved indicated a lower density media would be more desirable.

A list of several wetting and foaming agents was obtained. The claims for the chemicals were studied and a priority list set up to determine the order of study. The resulting work involved tests of only three of the chemicals before terminating the effort and looking to more fruitful methods. Preliminary studies were initiated on chips which remained in storage after the first block of work had been completed. The largest volume available was in the form of the "on 1/2-inch" fraction which had not been needed in the work reported earlier. This was used with reluctance because of the presence of substantial amounts of mold growth, particularly in the case of cottonwood. However, pending the procurement of freshly cut wood, the effect of the additions of the first two agents to be investigated were studied with the unseparated "on 1/2-inch" wood-bark chip mixture.

The wood-bark mixtures used weighed about 200 grams o.d. and were not adjusted to specific moisture contents but were used as removed from storage. The testing procedure consisted of a five-minute agitated flotation in water at room temperature to which the appropriate concentration of the chemical had been added. The sinking chips were then taken off and labeled "first sinkers." The

floating chips were run through a hand wringer* and processed through a second 5-minute agitated float. The sinking particles were then labeled "second sinkers" and the floating particles labeled "floaters." All labeled fractions were then hand picked to segregate wood and bark and determine the ovendry weights.

Besides a control test with tap water, two wetting agents were used at 1% concentration, and in one instance air was bubbled in the water bath. Table IV shows the results obtained with both maple and cottonwood. As can be seen by reference to the table, no particular improvement in segregation of bark from wood was obtained by adding wetting agents, Tergitol Anionic 08 (Carbide & Carbon Chemicals Co.) or Pluronic L-92 (Wyandotte Chemical Co.), to the water used to float the wood-bark mixtures. The same was true in the instance when air bubbles were introduced. For both cottonwood and maple, most of the bark sank and most of the wood floated. However, the floating wood was still substantially contaminated with bark and the percent-bark-in-fraction figure was little improved over the control. For example, for the eastern cottonwood control 84.3% of the wood originally introduced to the flotation and 12.0% of the bark introduced remained as floaters after the second flotation. This amounted to a percent bark contamination of 2.0%. For Tergitol Anionic 08 at 1% concentration, the floaters constituted 88.0% of the wood and 16.0% of the bark originally put into the flotation. That amounted to 2.5% bark in the floating fraction or no improvement over the control.

*The hand wringer, as described in Report One, was used to compress the material and thus increase the basic density of certain fractions and cause further segregation.

TABLE IV

PRELIMINARY FLOTATION TESTS
OF
"ON 1/2-INCH" WOOD-BARK CHIPS[a]
WITH
CHEMICAL ADDITIVES

Fractions	Control			Fine Bubbles (Air Stream Agitates Bath)			1% Tergitol Anionic 08			1% Pluronic L-92		
	% Recovery[b]		% Bark in Fraction	% Recovery[b]		% Bark in Fraction	% Recovery[b]		% Bark in Fraction	% Recovery[b]		% Bark in Fraction
	Wood	Bark		Wood	Bark		Wood	Bark		Wood	Bark	
Sugar Maple (38.8% Moisture Content)												
Original Sample	100.0	100.0	16.0	100.0	100.0	7.0	100.0	100.0	10.1	100.0	100.0	10.5
Floaters	65.1	24.5	6.7	64.2	42.9	4.8	66.9	19.8	3.2	58.1	23.8	4.6
2nd Sinkers	0.9	20.3	80.5	6.9	14.2	10.0	4.3	9.9	21.5	6.1	14.3	16.9
1st Sinkers	34.0	55.2	23.6	28.9	42.9	13.5	28.8	70.3	20.4	35.8	61.9	21.4
Eastern Cottonwood (52.6% Moisture Content)												
Original Sample	100.0	100.0	12.5	100.0	100.0	11.2	100.0	100.0	12.5	100.0	100.0	11.3
Floaters	84.3	12.0	2.0	86.2	13.4	1.9	88.0	16.0	2.5	87.3	13.3	1.9
2nd Sinkers	3.2	30.4	39.8	3.3	45.5	33.1	2.3	24.0	46.9	1.1	23.0	41.1
1st Sinkers	12.5	57.6	57.6	10.5	41.1	63.0	9.7	60.0	60.0	11.6	63.7	72.2

[a] Chips used were from old supply. All percentage figures are based on ovendry weights.

[b] "% Recovery" is the percentage of the material (wood or bark) taken off for a certain fraction using the amount of the material in the original sample as a base.

A third chemical that could be used as either a wetting or a wetting and foaming agent, Pluronic P-104 (Wyandotte Chemical Company), was tested with the freshly cut samples of sugar maple. The samples used were representative of the wood-bark chip mixture before screening. Several concentrations of the chemical and moisture contents of the chip samples were used. The conditions of the tests run can be seen in Table V, which also shows the results of the various flotation tests.

Two types of flotations were used, employing P-104 as a wetting agent. The first was a two-stage flotation identical to the previous tests. The second was a single flotation of five minutes with gentle stirring. The only two alternatives for this type flotation are labeled simply "sinkers" or "floaters." The test using the chemical as a foaming agent also used a test of this last type. The foam was generated by the inclusion of a fine gas dispersion tube in the bath through which air was bubbled.

As the data in Table V indicate, when maplewood is quite dry (20% moisture content or less), the majority of the normal wood and outer (corky) bark will float. The inner bark which sank was accompanied by knots and compression wood. The bark in the floating fraction was less when 1% P-104 was used as compared with the flotation in 0.1% of the same wetting agent. At 25% moisture content, more wood sank so that roughly 54.9% of the wood and 81.4% of the bark went to the bottom together as "first sinkers." Little difference could be seen when Pluronic P-104 was added to the water to a 0.5% concentration. As the moisture content increased, more of the bark and wood sank and segregation of the bark from the wood was not achieved. No particular advantage could be attributed to the addition of Pluronic P-104 as either a wetting or foaming agent. Further

TABLE V

PRELIMINARY FLOTATION TESTS
OF
SUGAR MAPLE WOOD-BARK CHIP MIXTURES[a]
WITH THE
ADDITION OF PLURONIC P-104

Fractions	Concentration: None			0.1%			0.5%			1.0%		
	% Recovery[b] Wood	% Recovery[b] Bark	% Bark in Fraction	% Recovery[b] Wood	% Recovery[b] Bark	% Bark in Fraction	% Recovery[b] Wood	% Recovery[b] Bark	% Bark in Fraction	% Recovery[b] Wood	% Recovery[b] Bark	% Bark in Fraction
20% Moisture Content												
Original Sample				100.0	100.0	11.3				100.0	100.0	9.2
Floaters				96.6	48.7	6.0				96.3	40.2	4.1
Sinkers				3.4	51.3	65.9				3.7	59.8	61.8
25% Moisture Content												
Original Sample	100.0	100.0	7.0				100.0	100.0	7.2			
Floaters	36.7	18.6	3.7				34.9	26.4	5.5			
1st Sinkers	54.9	81.4	10.0				61.4	73.6	8.5			
2nd Sinkers	8.4	--	--				3.7	--	--			
26.2% Moisture Content												
Original Sample										100.0	100.0	10.8
Floaters										54.9	63.0	12.2
Sinkers										45.1	37.0	9.1
37% Moisture Content												
Original Sample	100.0	100.0	12.2									
Floaters	60.5	42.6	8.9									
Sinkers	39.5	57.4	16.8									
45% Moisture Content												
Original Sample				100.0	100.0	7.4				100.0	100.0	13.3
Floaters				--	31.1	95.8				--	35.7	100.0
Sinkers				100.0	68.9	5.2				100.0	64.3	10.5
Foamed												
Original Sample										100.0	100.0	9.9
Floaters										--	30.3	96.8
Sinkers										100.0	69.7	7.1

[a] All percentages based on ovendry weights.

[b] "% Recovery" is the percentage of the original wood or bark in the "chip sample" found in the fraction indicated. Percentages are based on ovendry weights.

work with wetting and foaming agents was set aside at this point in favor of more promising areas of investigations.

Initial work on pure fractions of white birch, in Report One, indicated a decisive majority of the bark which contaminated the recovered wood after flotation was the papery outer bark. It seemed a reasonable solution might be a two-stage float where the inner bark would be taken off as the first sinking fraction and the wood recovered as a later sinking fraction, leaving the outer bark floating. A bench test of dwell time using wood-bark chip mixtures of approximately 35% moisture content indicated most of the inner bark could be removed as a sunken fraction during the first five minutes of the float. Up to three days soaking time was necessary to get a reasonable recovery of wood in the next sunken fraction. Means were then investigated to speed up the water uptake by the wood so that a quicker segregation could be implemented.

A dwell time bench test was also made on 1/2-inch eastern cottonwood chips. The chips were simply placed in a vessel of water and allowed to soak until most of the chips had sunk. A large percentage of the chips sinking in the first five minutes was inner bark. The chips sinking after five minutes were generally mixtures of wood and bark. At the end of five days a few wood chips remained floating and the bark floating was mostly particles of outer bark or particles with a larger portion of outer bark than inner bark.

Two important determinations were made in the bench tests for the above species. First of all, the flotation behavior of the wood and bark was determined, whether either wood or bark would sink and how long it took. Secondly, the reasons for the behavior were observed. The observations of all three species were quite similar in that all wood eventually sinks, the outer bark tended not to sink,

the inner bark sank before anything, and particles with both inner and outer bark tended to sink about the same time as the wood. Depending on moisture content, maplewood sank within a 24-hour period, white birch sank within 72 hours, and most of the cottonwood sank within a 5-day period. Work was directed from this point on toward finding means by which the inner and outer bark could be separated and methods which would speed up water uptake of wood chips and hasten sinking.

MECHANICAL TREATMENTS

The first treatment tried was one which could separate the inner from the outer bark. To accomplish this, the pulp-cake breaker, previously described in the "Air Elutriation" section, was utilized. It was found that the barks of all three species separated reasonably well into inner and outer bark. Eastern cottonwood bark was the most resistant to separation. It was also observed that bark chips were reduced in size more readily than the wood chips.

The first tests made with the pulp-cake breaker, after the air elutriation work, were done with sugar maple. The first test was run on a wood-bark chip blend (representative chips from the chipper with only the oversized and fines screened out) at 37% moisture content. Figure 2 is a flow chart showing the test sequence and the material distribution as a percentage of the ovendry weight of the original sample. As the flow chart shows, the test incorporated dwell time in the extended flotation, the concept of reflotation and the use of the pulp-cake breaker. The recovery and bark contamination percentages for the test are listed in Table VI. The data show that if the "reflotation" floaters are combined with the 4 and 24-hour sinkers from the "extended float," the wood recovery of the wood entering the system was 97.0%. The recovered material had a bark contamination of 0.4%.

FLOW CHART
SUGAR MAPLEWOOD-BARK MIXTURE

10.1% Bark
37.0% Moisture Content

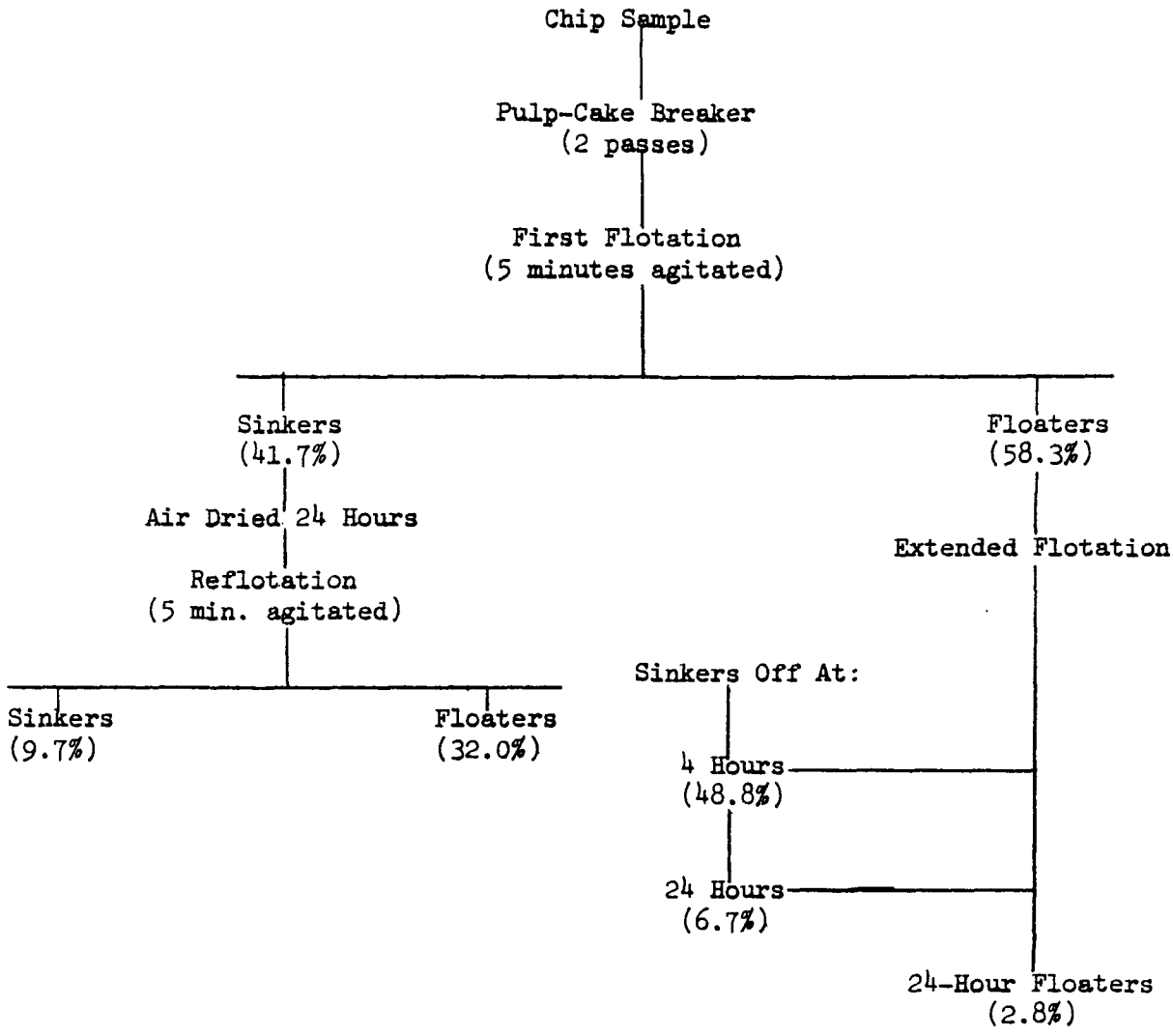

Figure 2. Presented Above is the Flow Chart Describing the Sequence Used in Testing the Effects of the Pulp-Cake Breaker, Reflotation, and Extended Flotations on the Flotation of Sugar Maple Chips. Percentages Listed are Ratios Based on the Ovendry Weight of the Fraction Involved to the Ovendry Weight of the Original Sample. The Sample Moisture Content was 37%

TABLE VI

SUGAR MAPLE
24-HOUR FLOTATION
37% MOISTURE CONTENT
10.1% BARK

WOOD RECOVERY AND BARK CONTAMINATION DATA

Fraction	% Recovery[a]		% Bark in Fraction	Combination[b]	
	Wood	Bark		% Wood Recovered	% Bark Contamination
1st Flotation					
Sinkers	38.5	69.7	71.8		
Floaters	61.5	30.3	5.2		
Reflotation					
Sinkers	3.0	69.0	71.8		
Floaters	35.5	0.	0.2		
Extended Flotation[c]					
Additional sinkers Taken at:				97.0	0.4
4 Hours	54.2	1.0	0.2		
24 Hours	7.3	1.8	2.7		
Floaters at:					
24 Hours	0	27.5	100.0		

[a] "% Recovery" is the percentage of the original wood or bark in the "chip sample" found in the fraction indicated. Percentages are based on ovendry weights.

[b] "Combination" data give the percentage of pure wood recoverable if a certain combination of "fractions" are used. The "% Bark Contamination" shows the amount of bark contaminating the combined recovered wood.

[c] The "Extended Flotation" data indicate what material has accumulated since the last data point. Values must be added to determine recovery for combined fractions.

A second test was run with a similar system but with the chips at 20% moisture content and the data taken in a different sequence in the "Extended Flotation" (see Fig. 3). The reason for a further test was to determine whether chips at 20 and 45% moisture content are still reasonable parameters for the pure fraction tests. The data taken from the test, Table VII, show similar results — 92.0% wood recovery with only 0.3% bark contamination.

With the results of these two tests as successful as they were, further preliminary testing of sugar maple was stopped and the above flotation sequence was tested using sugar maple pure fractions.

Two tests involving the white birch wood-bark chip blends used the pulp-cake breaker and the compression of the hand wringer. The schemes used are shown in Fig. 4 and 5.

The first test used 44.3% moisture content chips. After the chips were processed through the pulp-cake breaker and first flotation, the sinkers were discarded. The extended flotation of the floaters was started by compressing the chips using the hand wringer. After five minutes of flotation the sinkers were taken off and the remaining chips kept in the flotation for 48 hours. The results, Table VIII, indicate the wood recovery was less than desirable and that more inner-bark was left, after the first five minutes of extended flotation, than desirable.

The second test was implemented to demonstrate the segregation possibilities without the compression. The second test differed from the first test in that the extended flotation was started with no compression, had sinkers taken out at 5 minutes, 20 minutes and 24 hours with the test terminating at 24

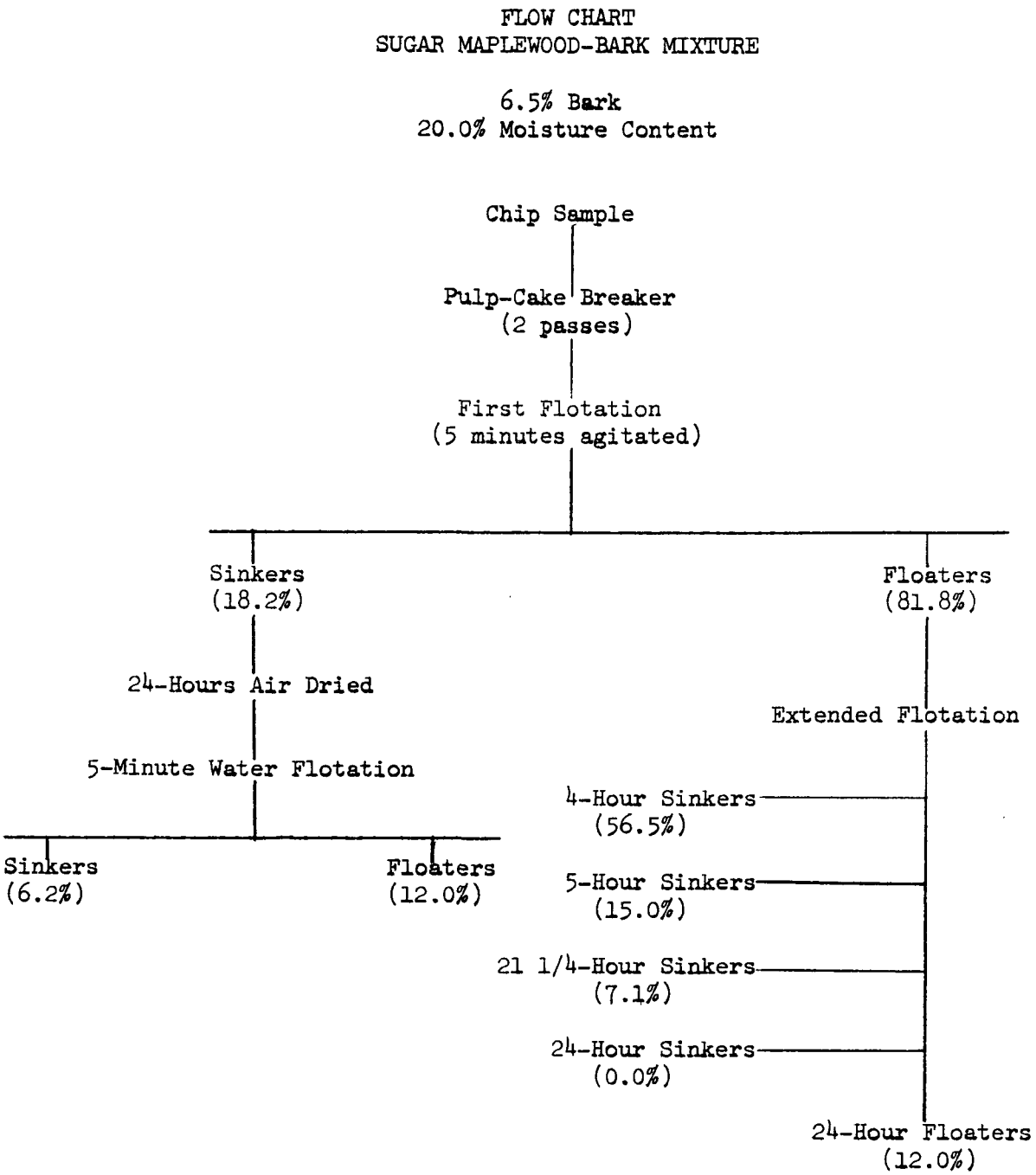

Figure 3. The Flow Chart Above Shows the Material Distribution of Sugar Maple Wood-Bark Chips of 20% Moisture Content Through the Flotation Sequence. The Percentages Listed are Based on the Ovendry Weight Ratios of the Fraction Involved to the Original Sample

TABLE VII

SUGAR MAPLE
24-HOUR FLOTATION
20% MOISTURE CONTENT
6.5% BARK

WOOD RECOVERY AND BARK CONTAMINATION DATA

Fraction	% Recovery[a]		% Bark in Fraction	Combination[b]	
	Wood	Bark		% Wood Recovered	% Bark Contamination
1st Flotation					
Sinkers	15.1	50.1	18.8		
Floaters	79.9	49.9			
2nd Flotation					
Sinkers	3.0	48.5	53.2		
Floaters	12.1	1.6	1.0		
Extended Flotation[c]					
Sinkers					
4 Hours	57.4	2.7	0.3	92.0	0.3
5 Hours	15.3	0	0		
21 1/4 Hours	7.2	<0.1	0.1		
24 Hours	0	0	0		
Floaters at:					
24 Hours	0	47.2	100.0		

[a] "% Recovery" is the percentage of the original wood or bark in the "chip sample" found in the fraction indicated. Percentages are based on ovendry weights.

[b] "Combination" data give the percentage of pure wood recoverable if a certain combination of "fractions" are used. The "% Bark Contamination" shows the amount of bark contaminating the combined recoverable wood.

[c] The "Extended Flotation" data indicate what material has accumulated since the last data point. Values must be added to determine recovery for combined fractions.

FLOW CHART
WHITE BIRCHWOOD-BARK MIXTURE

6.3% Bark
44.3% Moisture Content

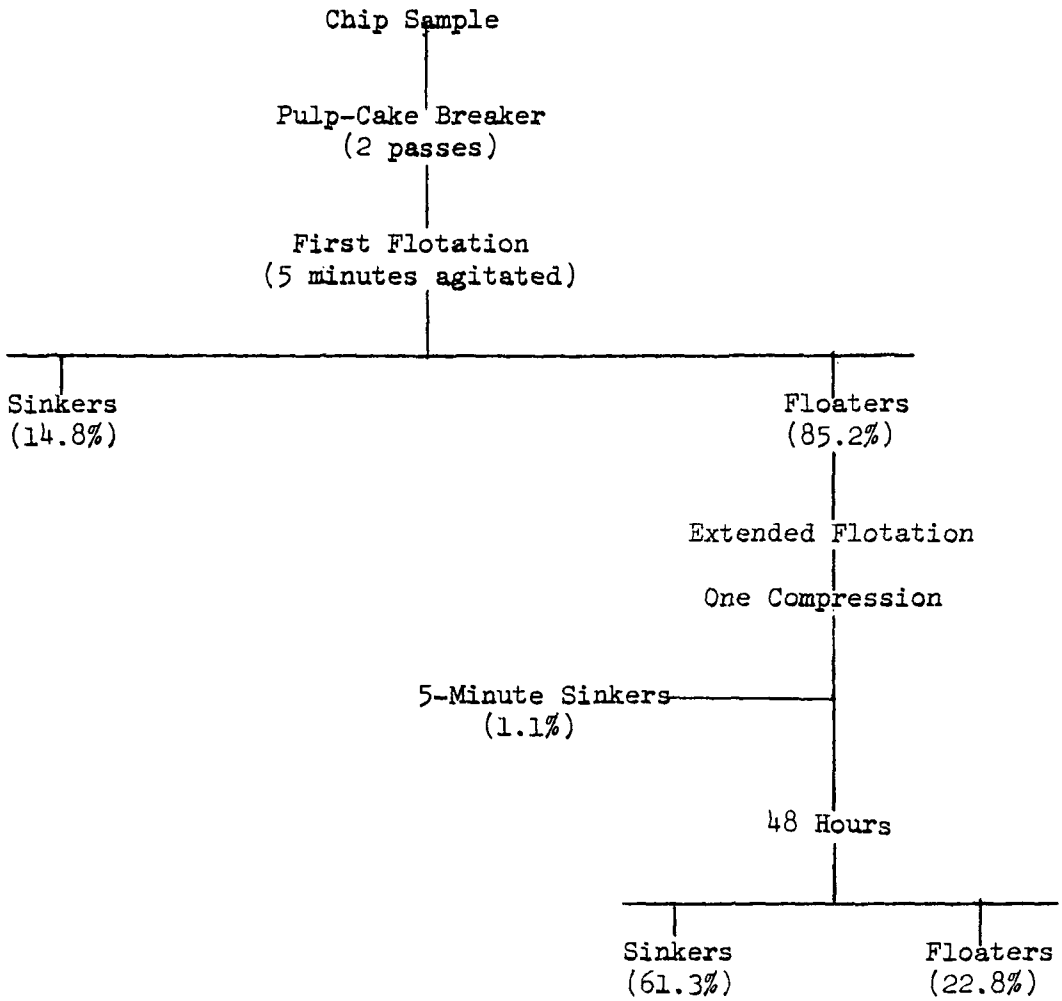

Figure 4. The Flow Chart Above is for the Pulp-Cake Breaker and Compression Tests of White Birch. The Percentages Listed are Ratios Based on the Ovendry Weight of the Fraction Involved to the Ovendry Weight of the Original Sample

FLOW CHART
WHITE BIRCHWOOD-BARK MIXTURE

7.2% Bark
42.8% Moisture Content

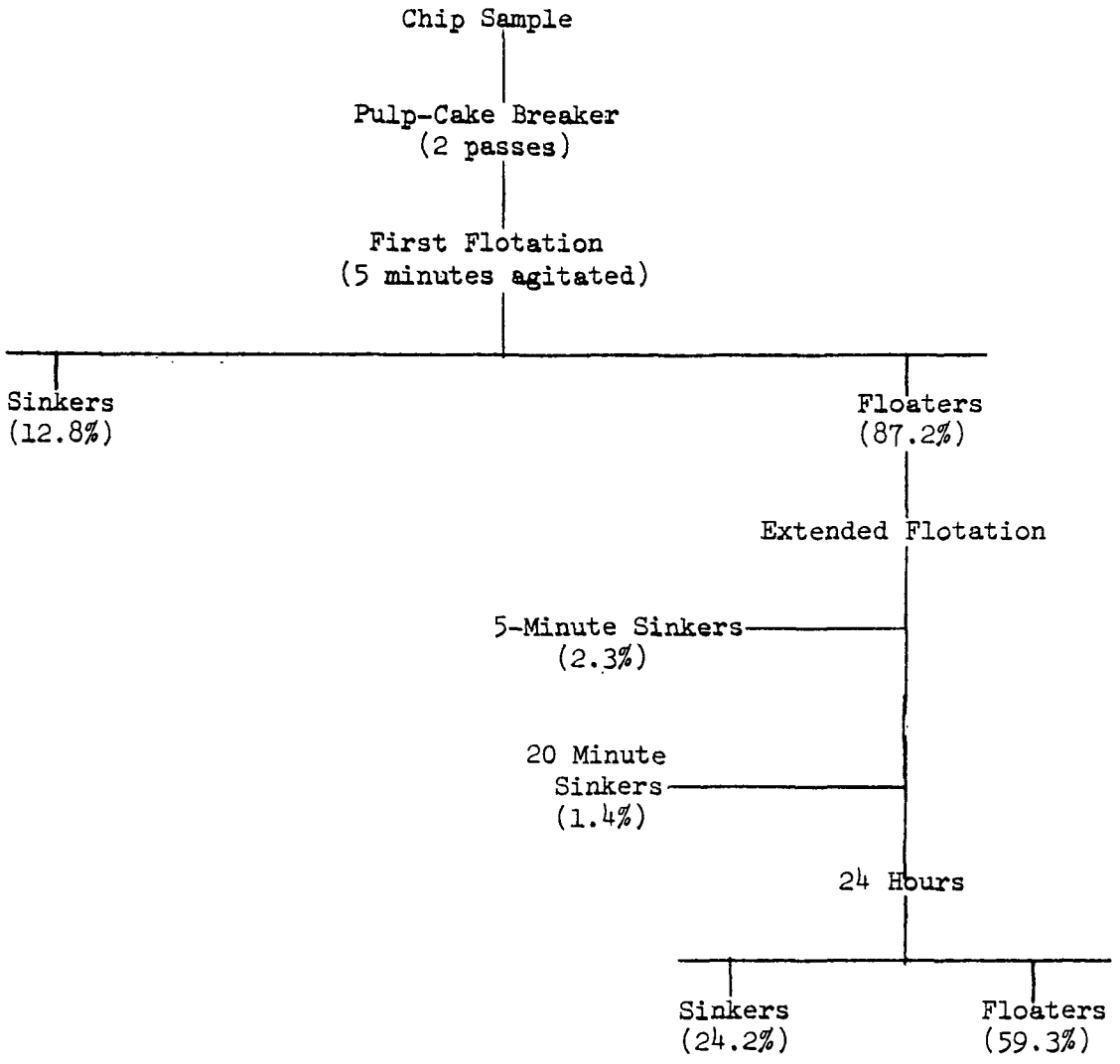

Figure 5. This Flow Chart is for the Test of the Influences of the Pulp-Cake Breaker Without Compression. Percentages Listed are Ratios Based on the Ovendry Weight of the Fraction Involved to the Ovendry Weight of the Original Sample

TABLE VIII

BIRCH
48-HOUR FLOTATION
44.3% MOISTURE CONTENT
6.3% BARK

WOOD RECOVERY AND BARK CONTAMINATION DATA

Fraction	% Recovery[a] Wood	% Recovery[a] Bark	% Bark in Fraction	Combination[b] % Wood Recovered	Combination[b] % Bark Contamination
1st Flotation					
Sinkers	10.0	69.9	31.8		
Floaters	90.0	30.1	2.2		
Extended Flotation[c] (Floaters) After compression					
5-Minute sinkers	7.8	0.4	0.3		
48-Hour sinkers	60.9	6.6	0.7	68.7	0.7
48-Hour floaters	21.3	23.1	6.7	82.2	2.4

[a] "% Recovery" is the percentage of the original wood or bark in the "chip sample" found in the fraction indicated. Percentages are based on ovendry weights.

[b] "Combination" data give the percentage of pure wood recoverable if a certain combination of "fractions" are used. The "% Bark Contamination" shows the amount of bark contaminating the combined recovered wood.

[c] The "Extended Flotation" data indicate what material has accumulated since the last data point. Values must be added to determine recovery for combined fractions.

hours. The results, listed in Table IX, are inconclusive as to the influence of the compression because of the variation in the bark behavior of the inner bark in the first flotation. Too little inner bark was left for the test of compression in the first test. The data do show that sinkers taken off during the first 20 minutes of the extended flotation are predominantly inner bark and that this procedure could result in a cleaner segregation. A speed-up of the sinking of the wood during the extended flotation did not appear to be feasible with the mechanical compression devices at hand because of the resistance of birchwood to compression.

The pulp-cake breaker treatment and flotation sequence were also tried for eastern cottonwood. The flow chart for this test is presented in Fig. 6. The results, given in Table X, indicated further treatment to encourage the sinking of wood chips was necessary. From an original mixture with 7.0% bark the best segregation occurred on the first flotation where 95.3% of the wood was recovered as floating material with 4.4% bark contamination.

Compression, using a hand wringer, was incorporated into the sequence of the extended flotation. This modification is shown in the flow chart (Fig. 7). The data collected from the test, summarized in Table XI, demonstrated little or no improvement in wood recovery or reduced bark contamination.

The use of the hand wringer as a device for compressing the wood and bark chips was terminated in favor of a mechanically driven glue spreader which has a steel roll opposed by a roll with a grooved rubber cover. It was felt that this device would give greater compression and/or encourage more water uptake by the wood. Figure 8 shows the flow chart of the exploratory compression flotations using the device. The flotation test covered a span of 72 hours with

TABLE IX

BIRCH
24-HOUR FLOTATION
42.8% MOISTURE CONTENT
7.2% BARK

WOOD RECOVERY AND BARK CONTAMINATION DATA

Fraction	% Recovery[a]		% Bark in Fraction	Combination[b]	
	Wood	Bark		% Wood Recovered	% Bark Contamination
1st Flotation					
Sinkers	10.0	52.0	28.6		
Floaters	90.0	48.0	4.0		
Extended Flotation (Floaters)					
Sinkers					
5 Minutes	2.5	0.1	0.3		
20 Minutes	0.4	13.6	71.0		
24 Hours	23.8	28.2	8.4	87.1	3.0
Floaters at:					
24 Hours	63.3	6.1	0.4		

[a]"% Recovery" is the percentage of the original wood or bark in the "chip sample" found in the fraction indicated. Percentages are based on ovendry weights.

[b]"Combination" data give the percentage of pure wood recoverable if a certain combination of "fractions" are combined. The "% Bark Contamination" shows the amount of bark contaminating the combined recovered wood.

[c]The "Extended Flotation" data indicate what material has accumulated since the last data point. Values must be added to determine recovery for combined fractions.

FLOW CHART
COTTONWOOD WOOD-BARK MIXTURE

7.0% Bark
49.1% Moisture Content

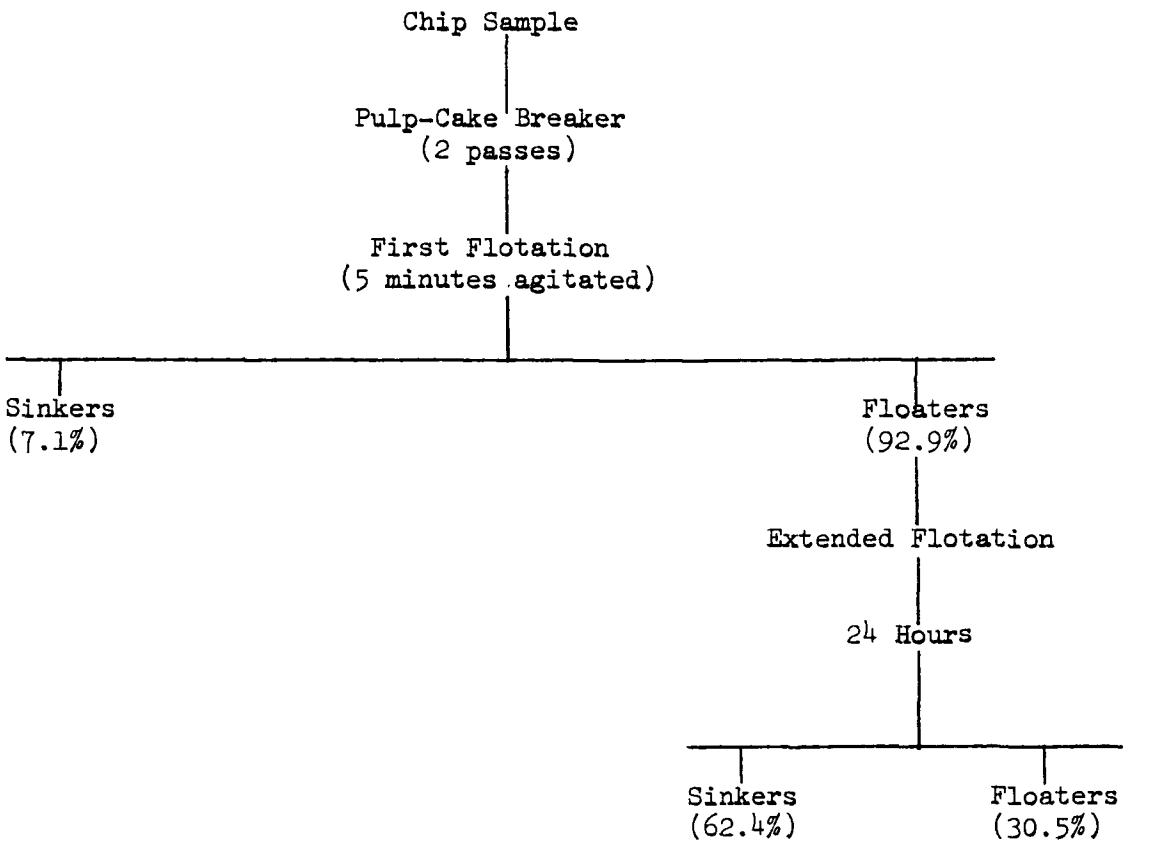

Figure 6. Flow Chart for the Flotation of Eastern Cottonwood Chips Passed Through the Pulp-Cake Breaker. Percentages Listed are Ratios Based on the Ovendry Weight of the Fraction Involved to the Ovendry Weight of the Original Sample

TABLE X

COTTONWOOD
24-HOUR FLOTATION
49.1% MOISTURE CONTENT
7.0% BARK

WOOD RECOVERY AND BARK CONTAMINATION DATA

Fraction	% Recovery[a]		% Bark in Fraction
	Wood	Bark	
1st Flotation			
Sinkers	4.7	40.9	38.7
Floaters	95.3	59.1	4.4
Extended Flotation[b] (24-Hour float)			
Sinkers	65.5	20.3	2.3
Floaters	29.8	38.8	8.9

[a] "% Recovery" is the percentage of the original wood or bark in the "chip sample" found in the fraction indicated. Percentages are based on ovendry weights.

[b] The "Extended Flotation" data indicate what material has accumulated since the last data point. Values must be added to determine recovery for combined fractions.

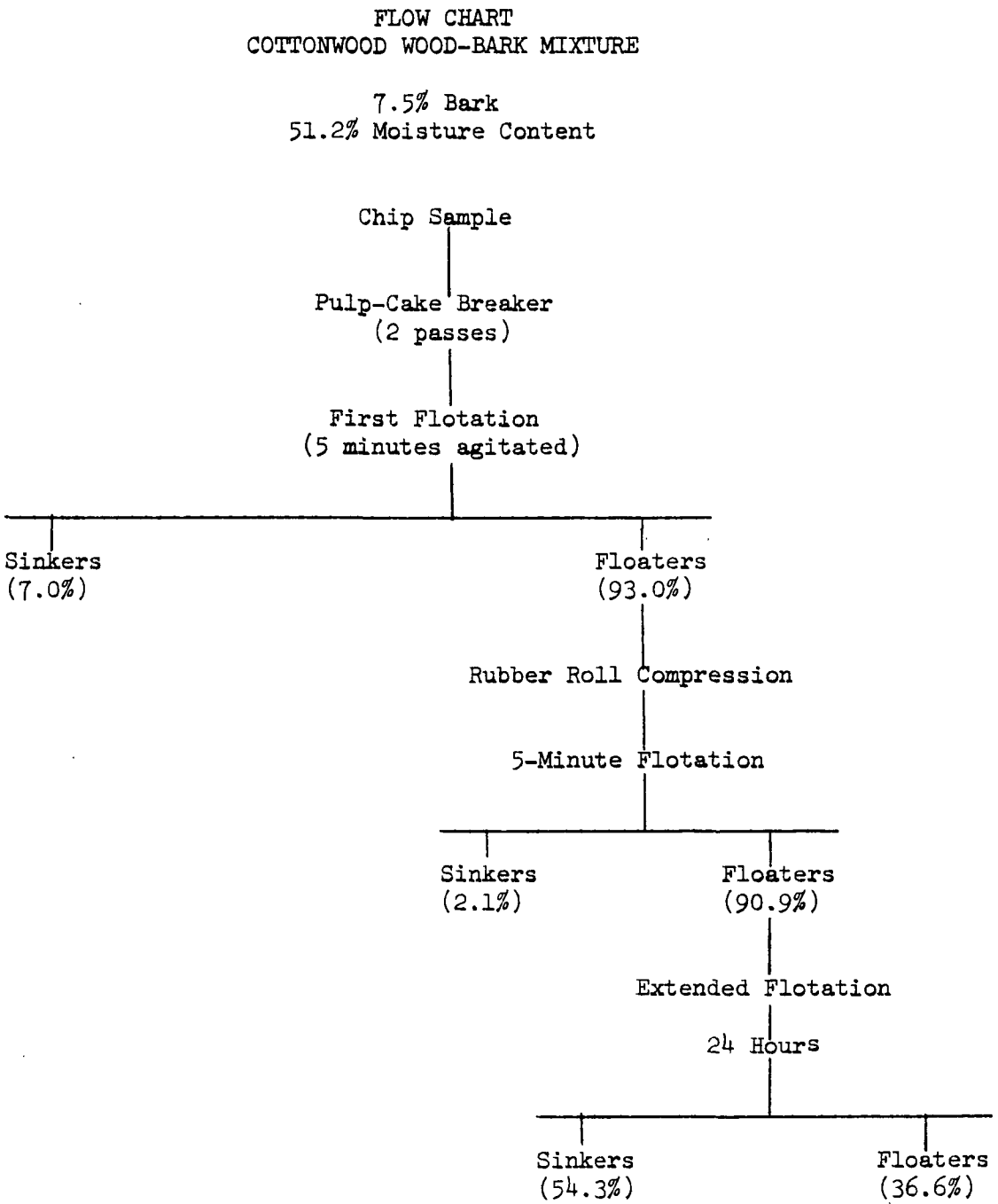

Figure 7. This Flow Chart Shows the Flotation of Cottonwood Chips Processed Through the Pulp-Cake Breaker and Incorporating Compression in the Extended Flotation. Percentages Listed are Ratios Based on the Ovendry Weights of the Fraction Involved to the Ovendry Weight of the Original Sample

TABLE XI

COTTONWOOD
24-HOUR FLOTATION
51.2% MOISTURE CONTENT
7.5% BARK

WOOD RECOVERY AND BARK CONTAMINATION DATA

Fraction	% Recovery[a]		% Bark in Fraction	Combination[b]	
	Wood	Bark		% Wood Recovered	% Bark Contamination
1st Flotation					
Sinkers	4.0	44.9	47.3		
Floaters	96.0	55.1	4.4		
Extended Flotation[c]					
Additional sinkers Taken at:					
5 Minutes	1.1	13.0	48.1	59.3	2.5
24 Hours	58.2	6.0	0.8		
Floaters at:				94.9	3.5
24 Hours	36.7	36.1	7.4		

[a] "% Recovery" is the percentage of the original wood or bark in the "chip sample" found in the fraction indicated. Percentages are based on ovendry weights.

[b] "Combination" data give the percentage of pure wood recoverable if a certain combination of "fractions" are used. The "% Bark Contamination" shows the amount of bark contaminating the combined recovered wood.

[c] The "Extended Flotation" data indicate what material has accumulated since the last data point. Values must be added to determine recovery for combined fractions.

FLOW CHART
COTTONWOOD WOOD-BARK MIXTURE

8.6% Bark
33.1% Moisture Content

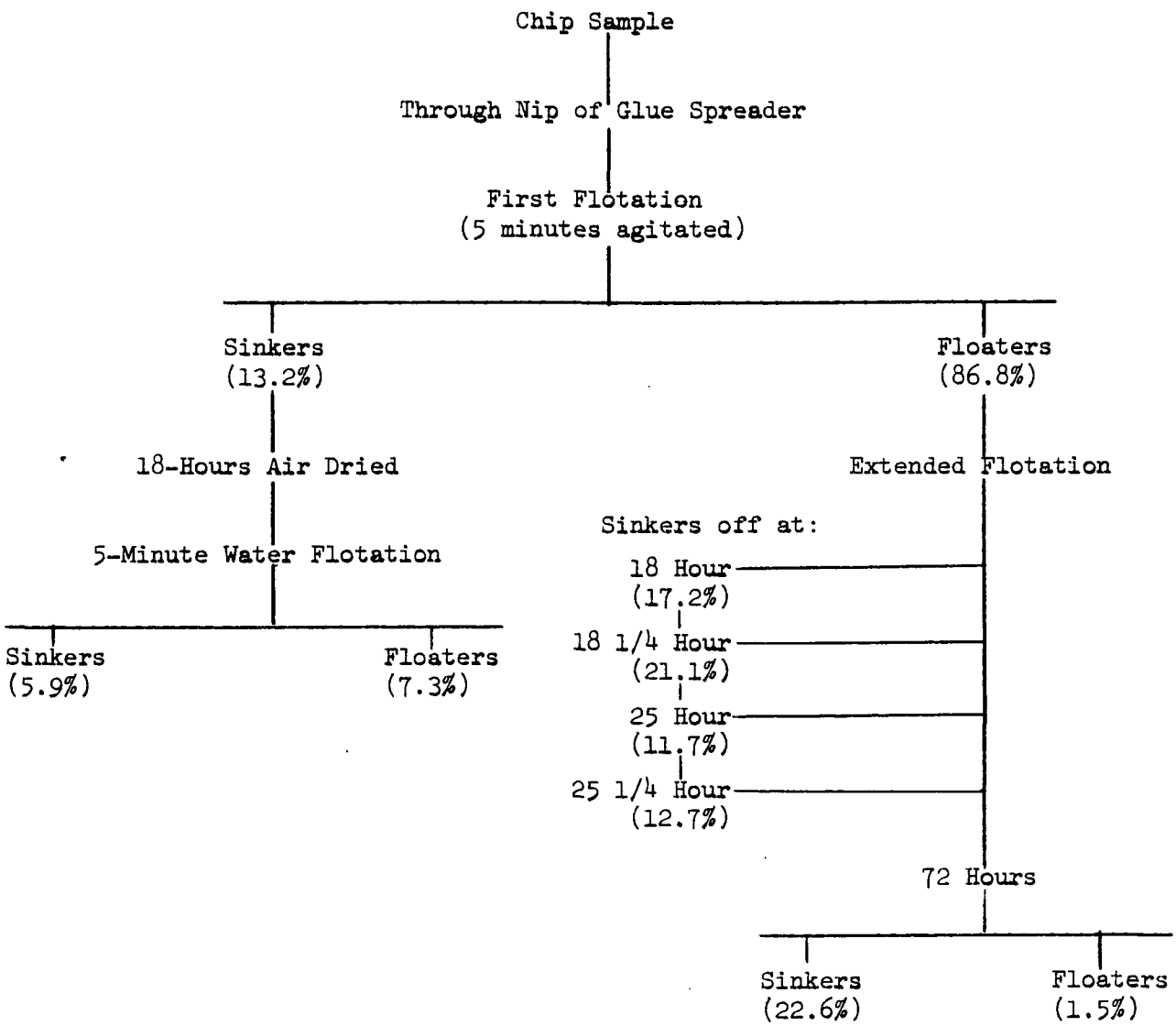

Figure 8. Flow Chart Showing the Use of the Glue Spreader in Compressing Chips and the Following Flotation Sequence. The Percentages Listed are Ratios Based on the Ovendry Weights of the Fraction Involved to the Ovendry Weight of the Original Sample

a sample of 1/2-inch cottonwood chips. The data, summarized from the test and presented in Table XII, indicate that a reasonable segregation can be obtained with a recovery of more than 90% wood at under 2.0% bark contamination. While the pulp-cake breaker was not used, the drag of the rollers tended to separate the inner from the outer bark.

The time interval of 72 hours is impractical so an additional test was run using more compression. The flow chart of the test is shown in Fig. 9. The data collected from the test, Table XIII, indicated two possible segregations for the 24-hour flotation. The first possibility showed a 91.3% wood recovery with 1.7% bark contamination. The alternative segregation gives a wood recovery of 88.8% with 0.5% bark contamination. The levels are very near the limits considered as acceptable for this test.

STEAM AND PRESSURE TREATMENTS

As evident from the compression tests, there was still a need to develop a treatment which would accelerate the water absorption by the wood chips and cause them to sink. It was felt a steam pressure treatment would accomplish this. Earlier work, done in another project, indicated aspenwood treated with steam and pressure would sink immediately when put in a cold water quench. It was theorized during that work that the heat and pressure forced air from the wood and the cold water quench caused the wood to suck in water, thus causing the wood to sink.

To proceed with this test a 10-gallon resin kettle was obtained. The kettle was fitted with a pressure top and a jacket which could be pressurized and heated to create pressure indirectly. A steam valve allowing steam to

TABLE XII

COTTONWOOD WOOD-BARK MIXTURE
72-HOUR FLOTATION
33.1% MOISTURE CONTENT
8.6% BARK

WOOD RECOVERY AND BARK CONTAMINATION DATA

Fraction	% Recovery[a]		% Bark in Fraction	Combination[b]	
	Wood	Bark		% Wood Recovered	% Bark Contamination
1st Flotation					
Sinkers	8.7	67.2	39.9		
Floaters	91.3	32.8	3.5		
Reflotation of 1st Sinkers					
Sinkers	1.4	59.4	79.3		
Floaters	7.3	7.8	8.4		
Extended Flotation[c]					
Additional sinkers Taken at:					
18 Hours compression	18.6	1.0	0.4	98.9	1.9
18 1/4 Hours	22.0	10.7	4.0		
25 Hours compression	12.6	0.6	0.4		
25 1/4 Hours	13.7	0.2	0.2	91.2	1.3
72 Hours	24.4	1.4	0.5		
Floaters at:					
72 Hours	0	18.9	100.0		

[a] "% Recovery" is the percentage of the original wood or bark in the "chip sample" found in the fraction indicated. Percentages are based on ovendry weights.

[b] "Combination" data give the percentage of pure wood recoverable if a certain combination of "fractions" are used. The "% Bark Contamination" shows the amount of bark contaminating the combined recovered wood.

[c] The "Extended Flotation" data indicate what material has accumulated since the last data point. Values must be added to determine recovery for combined fractions.

FLOW CHART
COTTONWOOD WOOD-BARK MIXTURE

11.9% Bark
55.5% Moisture Content

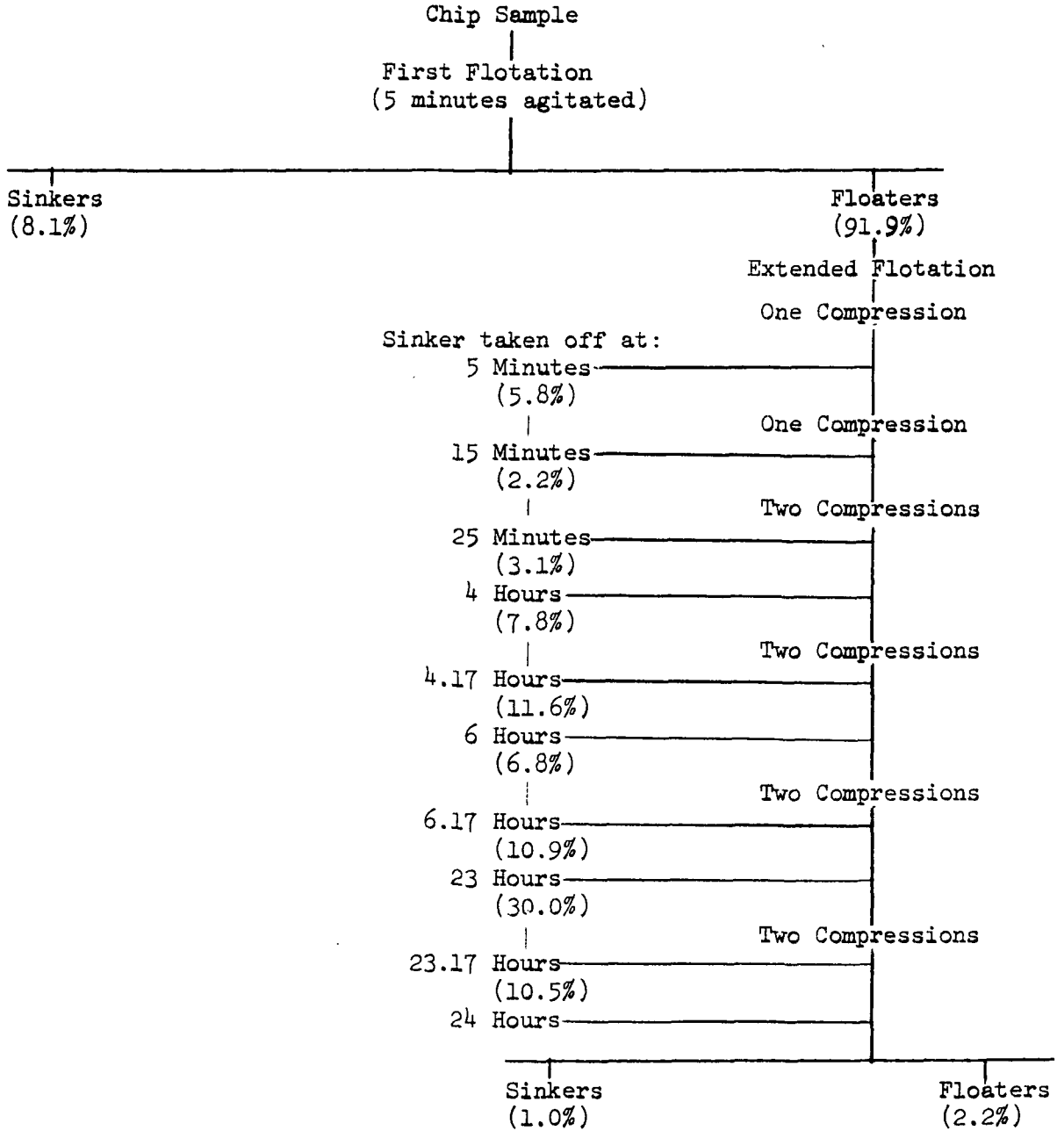

Figure 9. Flow Chart for Processing of Eastern Cottonwood with Compressions During an Extended Flotation to Encourage Segregation. Percentages Listed are Ratios Based on the Ovendry Weights of the Fraction Involved to the Ovendry Weight of the Original Sample

TABLE XIII

COTTONWOOD
24-HOUR FLOTATION
55.5% MOISTURE CONTENT
11.9% BARK

WOOD RECOVERY AND BARK CONTAMINATION DATA

Fraction	% Recovery[a]		% Bark in Fraction	Combination[b]	
	Wood	Bark		% Wood Recovered	% Bark Contamination
1st Flotation					
Sinkers	4.1	38.0	55.5		
Floaters	95.9	62.0	8.0		
Extended Flotation[c]					
Sinkers taken off at time lapsed:					
1 Compression 5 Minutes	1.6	36.7	75.2		
1 Compression 15 Minutes	2.1	2.4	13.3		
2 Compressions 25 Minutes	2.5	7.8	30.2		
4 Hours	8.6	1.3	2.0		
2 Compressions 4 Hours, 10 min.	13.1	0.6	0.6	91.3	1.7
6 Hours	7.7	0.3	0.5		
2 Compressions 6 Hours, 10 min.	12.4	<0.1	<0.1	88.8	0.5
23 Hours	34.0	0.7	0.3		
2 Compressions 23 Hours, 10 min.	11.8	0.6	0.7		
24 Hours	1.2	<0.1	0.7		
Floaters at: 24 Hours	0.9	11.5	63.8		

[a] "% Recovery" is the percentage of the original wood or bark in the "chip sample" found in the fraction indicated. Percentages are based on ovendry weights.

[b] "Combination" data give the percentage of pure wood recoverable if a certain combination of "fractions" are used. The "% Bark Contamination" shows the amount of bark contaminating the combined recovered wood.

[c] The "Extended Flotation" data indicate what material has accumulated since the last data point. Values must be added to determine recovery for combined fractions.

pressurize the kettle directly was also fitted to the kettle. For the purposes of this report the resin kettle will hereafter be referred to as a "pressure cooker."

One-half-inch wood-bark chip mixtures were tested for both cottonwood and birch in the pressure cooker. The chips had been pretreated by passing through the pulp-cake breaker and a 5-minute agitated float in 22°C. of water to remove the inner bark. The moisture content of the chips was about 50% for both the white birch and eastern cottonwood. Two baskets, one with birch, the other with cottonwood chips, were put in the cooker containing water. The water level came to one inch below the basket tops. The cooker was then closed and the jacket heated to bring the inner pressure up to 7 p.s.i. with indirect pressure. The pressure was held for five minutes after which the chips were taken from the kettle and immersed in tap water (approximately 17°C.) and the floating particles segregated from the sunken particles. The segregation was so good for the white birch that further evaluation was discontinued and the procedures scheduled for testing with pure fractions. More wood chips than desired were lost on the first flotation but it was felt that either less wood would be lost using a lower moisture content wood or the sunken wood could be recovered by air drying and re-floating the sunken chips.

The eastern cottonwood also showed much improved results but less wood was recovered than desired; i.e., too high a percentage of wood floated and would be discarded with the floating outer bark. Because the time and funds budgeted for this portion of the project were exhausted, the decision was made to run the eastern cottonwood pure fraction tests using the conditions appearing best at this point; i.e., a flotation to segregate the inner bark from the other chips, followed by a steam pressure treatment of the floating chips at 15 p.s.i. and

85°C., and a cold water quench to complete the segregation. No data, only observational information were collected on the preliminary work with the "pressure cooker."

PURE FRACTION STUDIES

During the "Preliminary Studies" each species was handled as an individual problem. The "pure fraction" approach was used because data interpretation was simplified and test sample sizes could be reduced and still obtain reliable estimates. If, during the course of the preliminary studies, a method was found to be satisfactory using wood-bark chip mixtures, the studies for that species were terminated and the method tested with pure fractions. This procedure allowed more time to be spent on the most difficult species.

The procedures used for the pure fraction studies are similar to those used for the basic flotation work described in the first report. Pure samples of wood or bark chips of a specified size and moisture content were tested in duplicate. The duplicate determinations were then evaluated for consistency by a visual check of the data. If no inconsistencies existed between the duplicate runs, the data were composited into a single expression (percentage). Chip moisture content and size were standardized as in the initial flotation work to test a range of conditions. The array tested is shown below:

	Moisture Content	
Chip Size	20%	45%
On 1/4-inch	x	x
On 3/4-inch	x	x

The "bark contamination factor" (hereafter BCF) was again used to evaluate the results. To review, the BCF is a percentage expression indicating the amount of bark contaminating the theoretically recovered wood from the wood-bark chip mixture of a presupposed bark content. The manner in which the BCF is calculated is given in Appendix Table I, Report One (page 38). The presupposed wood-bark chip mixture for the work described in Report One was 25% bark. The analysis of the Metro-Chiparvestor samples, given later in this report, indicate that bark content between 10-13% is a realistic figure to assume for "total stand" harvesting when the chips are screened prior to delivery to the mill. Because of the factors discussed, it was decided to compute BCF values for wood-bark chip mixtures of theoretical bark content of both 25 and 12.5%. BCF values were computed only for the procedures that had the best wood recovery potential.

SUGAR MAPLE

As was indicated in the preliminary studies, battering the chips to separate inner from outer bark and using a flotation sequence modification and an extension in flotation time gave satisfactory segregation in the maplewood-bark mixtures. The preliminary tests used chips of 20 and 35% moisture content with the 35% moisture content chips giving the best segregation.

The sequence used and depicted in Fig. 10 consisted of battering the chips in the pulp-cake breaker to knock off the outer bark from the inner bark, a five-minute agitated float, removal of the sinkers to air dry, a continued flotation of the floaters for 24 hours, and the removal of the sinkers as wood and the floaters as contaminants. The sinkers of the first five-minute float generally had a large percentage of bark but too much wood to waste. Air drying the chips for 24 hours and refloating them recovered much of the wood with only

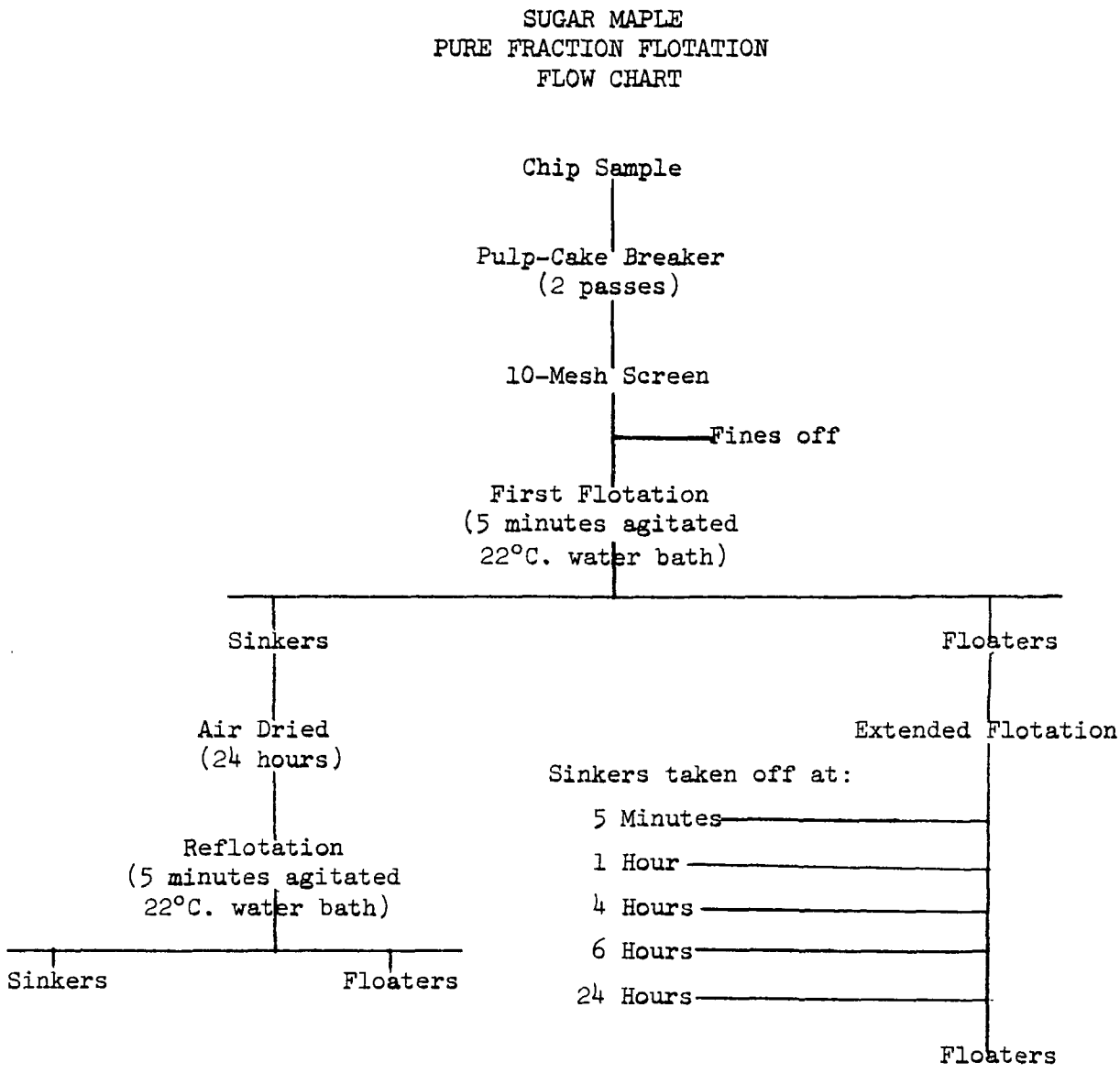

Figure 10. The Flotation Testing Scheme Used for Sugar Maple Pure Fractions

a small percentage of bark. The sinking chips from the extended 24-hours' float were taken off at 1, 4, 6, and 24 hours to allow evaluation of the recovered material as related to dwell time. A very high proportion of the material floating at the end of the 24-hours' soak was outer bark. The system works because the inner bark of the maple sinks in the first five-minute agitated flotation and the outer bark continues to float through the 24-hours' soak.

Since the flotation sequence described worked well with both 20 and 35% moisture content chips, it was decided to run the pure fractions at 20 and 45% moisture content. This allowed the studies to bracket the 35% moisture content which was believed to be the optimum for the tests run. The results of the flotation work with pure wood or bark fractions of maple are listed in Table XIV.

There are several concerns regarding the beating of chips in the pulp-cake breaker, such as how does it affect the wood and bark chip size, how much wood is lost, how does it affect the cook, etc. Little attempt was made to answer those questions in this study, but the percentage of wood or bark lost as fines (through 10-mesh screen) was determined and is presented in the table in the line "Fines Lost." Generally speaking, more bark than wood was removed as fines, 2.7% versus 0.4%.

The "% Recovery" columns indicate the percent of bark or wood taken from a given portion of the float at a given time ("periodic") and the "accumulated" percent of wood taken through a given time. The sequence of listing the recoveries was chosen to give a logical flow.

The two BCF values, which assume either 25 or 12.5% bark in the wood-bark mixture being processed, were computed for only the better wood recovery possibilities. As can be seen from the table, adequate recovery of wood (over

TABLE XIV

SUGAR MAPLE
PURE FRACTION
FLOTATION RESULTS[a]

Fraction	"On 1/4-Inch" % Recovery[b] Periodic Wood	Periodic Bark	Accum. Wood	BCF[c] 25%	BCF[c] 12.5%	"On 3/4-Inch" % Recovery[b] Periodic Wood	Periodic Bark	Accum. Wood	BCF[c] 25%	BCF[c] 12.5%
20% Moisture Content										
Fines Lost	5.5	0.5				0.1	1.4			
First Flotation:										
Sinkers	10.4	80.4				1.6	64.9			
Floaters	89.1	14.1	89.1	5.0	2.2	98.3	33.7	98.3	10.3	5.3
Reflotation:										
Sinkers	7.6	79.5				0.0	64.6			
Floaters	2.8	0.9				1.6	0.2			
Extended Flotation:			91.9	4.7	2.1			92.8	7.1	3.0
Sinkers taken at:			75.6	3.6	1.6			85.6	4.3	1.9
5 Minutes	16.3	5.2	89.1	4.5	2.0	7.2	8.5	91.2	6.7	3.0
1 Hour	11.3	5.2				6.7	1.3			
4 Hours	51.4	0.8	72.8	3.3	1.5	67.4	8.3	84.0	4.3	1.7
6 Hours	6.8	1.5				16.0	0.0			
24 Hours	3.3	0.0				1.1	1.7			
Floaters 24 hours	0.0	1.4				0.0	13.9			
45% Moisture Content										
Fines Lost	0.5	2.1				0.6	1.8			
First Flotation:										
Sinkers	96.8	69.2				91.3	74.0			
Floaters	2.7	28.7				8.1	24.2			
Reflotation:										
Sinkers	59.4	67.4				32.1	71.2			
Floaters	37.4	1.8				59.2	2.8			
Extended Flotation:										
Sinkers taken at:										
5 Minutes	1.6	0.6				3.4	1.7			
1 Hour	0.4	0.1	40.0	3.7	1.6	2.2	0.5	67.3	2.3	1.0
4 Hours	0.4	0.4				2.4	0.2			
6 Hours	0.0	0.0				0.1	<0.1			
24 Hours	0.2	1.7				0.0	0.6			
Floaters 24 hours	0.1	25.9				0.0	21.1			

[a] All percentages based on ovendry weights.

[b] "% Recovery — Periodic" is the percent of the material (wood or bark) originally entering the system that was recovered at a given data point (fraction). "Accum." is accumulated recovery of wood from the indicated data points.

[c] "BCF" is the % bark contamination in the recovered portion of a theoretical wood-bark chip mixture with an original bark content of 25 or 12.5%.

90% for the chips of 20% moisture content) was obtained with fair bark removal. More than one interpretation can be made of the data in Table XIV. For instance, if no effort was made to recover the wood from the sinkers of the first flotation, 72.8% of the on 1/4-inch wood and 91.2% of the on 3/4-inch wood could be recovered with BCF (25) values of 3.3% for on 1/4-inch, 3.9% for on 3/4-inch, and BCF (12.5) values of 1.4% for on 1/4-inch and 1.7% for on 3/4-inch.

The data obtained for the pure fraction tests of sugar maple chips show a marked improvement over the values of the basic flotation work. Depending on BCF values used and the allowable limits of bark contamination in the wood, the system tested may or may not be acceptable. Some improvement can be expected if wood-bark chips of 35% moisture content are used but the allowable conditions determine the quality of the recovery.

WHITE BIRCH

With the results of the "pressure cooker" treatment at hand, the flotation scheme, shown in Fig. 11, was designed to test the pure fractions of the white birch. The segregation procedure was basically a two-step process that segregates the inner bark from the other chips in the first flotation and the wood chips from the bark particles in a "hot chip" segregation. The latter step was performed by quenching the hot floating chips in a cold water quench.

The results, shown in Table XV, were different from the original observations on the 1/2-inch wood-bark chips (preliminary study) in that BCF values were generally higher than expected. The test for the on 3/4-inch chips showed fairly good BCF values only because of an originally small percentage of inner bark in that fraction. The apparent reason for the differences between the tests on pure fractions and the preliminary tests with the steam and

WHITE BIRCH AND EASTERN COTTONWOOD
PURE FRACTION FLOTATION
FLOW CHART

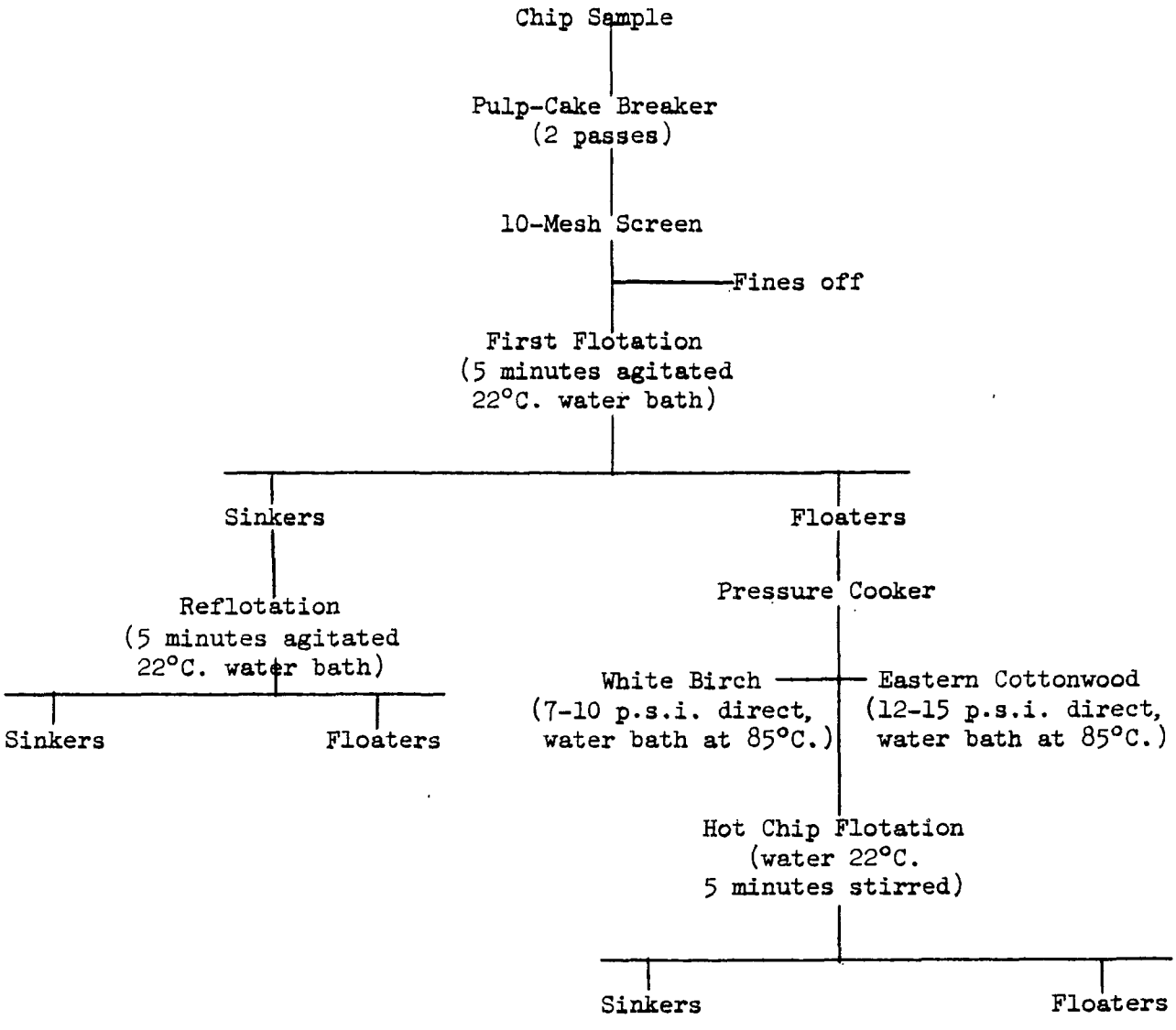

Figure 11. Diagram of the Flotation Test for White Birch and Eastern Cottonwood Pure Fractions

TABLE XV

WHITE BIRCH
PURE FRACTION
FLOTATION RESULTS[a]

Fraction	"On-1/4 Inch" % Recovery[b] Periodic Wood	Periodic Bark	Accum. Wood	BCP[c] 25%	BCP[c] 12.5%	"On 3/4-Inch" % Recovery[b] Periodic Wood	Periodic Bark	Accum. Wood	BCP[c] 25%	BCP[c] 12.5%
20% Moisture Content										
Fines Lost	0.6	3.5				0.8	1.8			
First Flotation:										
Sinkers	0	28.8				0	10.6			
Floaters	99.4	67.7				99.2	87.6			
Reflotation:										
Sinkers	0	10.8				0	6.2			
Floaters	0	18.0				0	4.4			
Hot Chip Flotation:										
Sinkers	86.5	61.9	86.5	19.3	9.3	81.2	11.0	81.2	4.3	1.9
Floaters	12.9	5.8				18.0	76.6			
45% Moisture Content										
Fines Lost	0.5	2.4				0.4	0.4			
First Flotation:										
Sinkers	4.1	23.3				1.4	22.2			
Floaters	95.4	74.3				98.2	77.4			
Reflotation:										
Sinkers	4.1	4.1				0	15.3			
Floaters	0	19.2				1.4	6.9			
Hot Chip Flotation:										
Sinkers	73.1	71.0	73.1	24.5	12.2	92.7	1.4	92.7	0.5	0.2
Floaters	22.3	3.3				5.5	76.0			

[a] All percentages based on ovendry weights.

[b] "% Recovery — Periodic" is the percent of the material (wood or bark) originally entering the system that was recovered at a given data point (fraction). "Accum." is accumulated recovery of wood from the indicated data points.

[c] "BCP" is the % bark contamination in the recovered portion of a theoretical wood-bark chip mixture with an original bark content of 25 or 12.5%.

pressure treatment appears to be due to the difference in the moisture content of the chips. Because of the higher moisture content in the chips used in the preliminary test, more inner bark and wood sank during the first flotation. Re-evaluation of the procedure used for the pure fraction tests revealed too little inner bark was segregated out as sinkers in the original flotation. The basic studies, reported in Progress Report One, indicated a reasonable segregation of inner bark from the remaining chips would take place if two flotations were used with a compression step between them.

Not enough time, budget, or chips remained to do another set of pure fraction tests which would incorporate the suggested second flotation and compression steps. However, confidence in the procedure was sufficient that it was felt the potential should be demonstrated. As a result, duplicate tests for both 20 and 45% moisture content using "on 1/2-inch" wood-bark chips, instead of pure fraction chips or pure wood chips of "on 1/4-inch" or "on 3/4-inch" classification, were performed under the new procedure (see Fig. 12). The results are listed in Table XVI. The samples used had an average bark content of 6.5 to 7.0%. For this reason the bark data has a narrower base than the pure fraction data. The BCF values listed in the table indicate wood-bark chips of 20% moisture content could be processed using the outlined procedure and recovering as high as 95% of the wood with as little as 0.7% bark. The bark contamination depends on the percentage of bark in the original sample.

The behavior of the 45% moisture content chips during the first flotation is different than expected. In the basic flotation work with white birch, 99% of the 45% moisture content wood chips sank in the first flotation. In the first flotation of the modified procedures for both the pure fractions and the test with on 1/2-inch chips, a much lower percentage sank (59%).

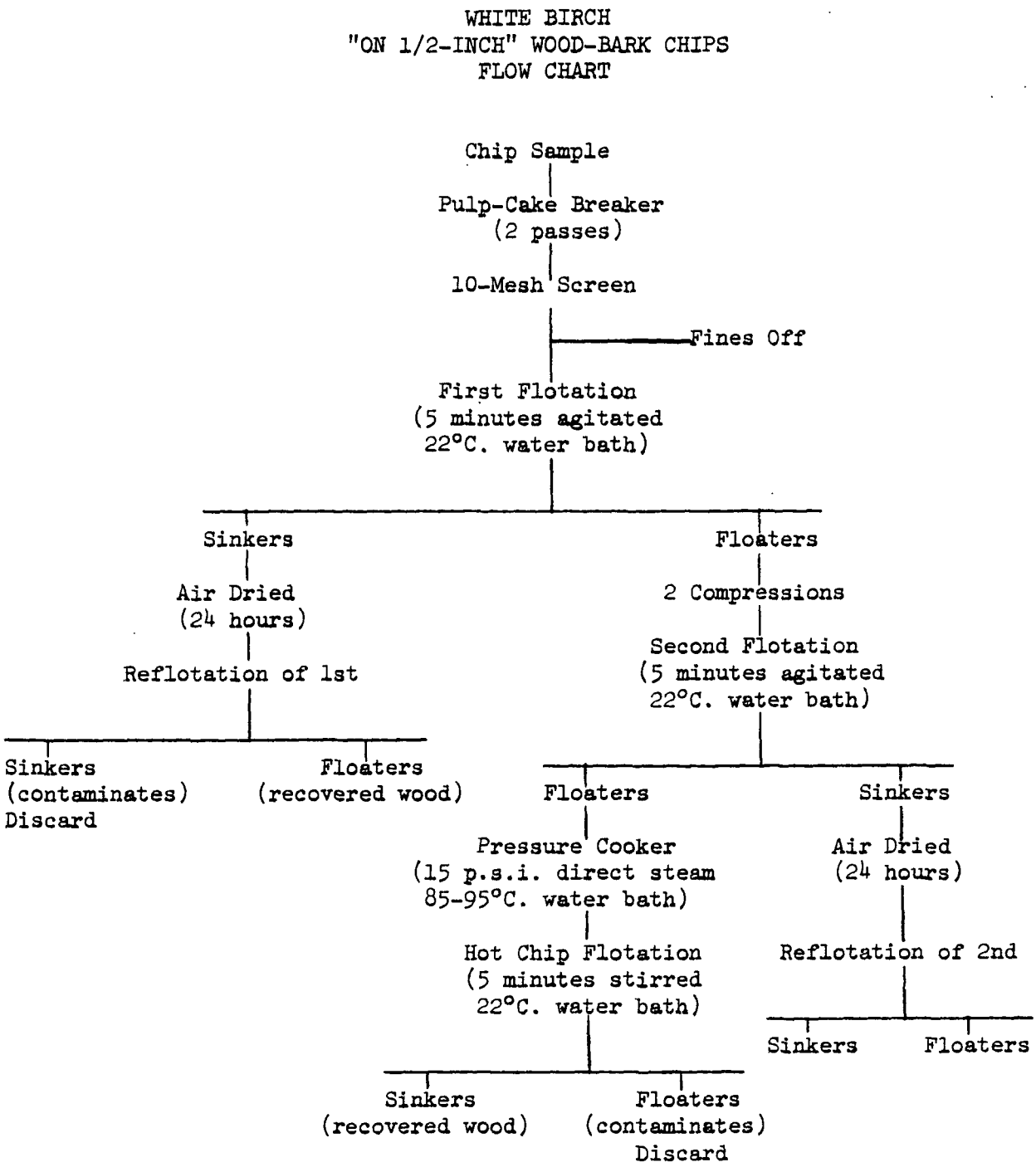

Figure 12. Revised Flotation Testing Sequence for White Birch

TABLE XVI

WHITE BIRCH
"ON 1/2-INCH" WOOD-BARK CHIPS
FLOTATION TEST RESULTS[a]

Fraction	% Recovery[b] Periodic Wood	Periodic Bark	Accum. Wood	BCF[c] 25%	BCF[c] 12.5%	% Recovery[b] Periodic Wood	Periodic Bark	Accum. Wood	BCF[c] 25%	BCF[c] 12.5%
	20% Moisture Content					45% Moisture Content				
First Flotation:										
Sinkers	0.1	32.1				59.2	58.2			
Floaters	99.9	67.9				40.8	41.8			
Reflotation of 1st Sinkers:										
Sinkers	<0.1	29.3				23.2	46.1			
Floaters	0.1	2.8				36.0	12.1			
Second Flotation:										
Sinkers	0.6	14.7				14.8	3.4			
Floaters	99.3	53.2				26.0	38.4			
								76.7	2.1	0.9
Reflotation of 2nd Sinkers:										
Sinkers	<0.1	10.3				<0.1	0.5			
Floaters	0.5	4.4				14.7	2.9			
Hot Chip Flotation:										
Sinkers	95.3	4.8	95.3	1.7	0.7	26.0	1.7			
Floaters	4.1	48.4				0	36.7			

[a] All percentages based on ovendry weights.

[b] "% Recovery — Periodic" is the percent of the material (wood or bark) originally entering the system that was recovered at a given data point (fraction). "Accum." is accumulated recovery of wood from the indicated data points.

[c] "BCF" is the % bark contamination in the recovered portion of a theoretical wood-bark chip mixture with an original bark content of 25 or 12.5%.

Whether this was due to the specific wood samples used or some error in the handling of the samples could not be determined. The logs used for the later work had some rot in them and this might have resulted in lower density wood.

It appears from the recovery data for the "Reflotation of First Sinkers" that less wood was recovered than expected for this reflotation. All other reflotations for this test averaged between 10-20% moisture content while the duplicate samples for the "Reflotation of First Sinkers" were both very close to 40% moisture content. Drying the samples more than 24 hours, i.e., to a lower moisture content, could have resulted in greater wood recovery.

EASTERN COTTONWOOD

Eastern cottonwood has been the most troublesome to work with of the five species investigated. The problem appears to result from the fact that the specific gravities of the bark and wood are so similar. The variation in the flotation behavior of the smooth green bark of the younger stems as contrasted to the corky bark of older stems is another problem.

When the allotted time for the eastern cottonwood investigation had run out, the best method for wood-bark segregation via liquid flotation was theorized and the procedure tested on pure fractions. In fact, a system similar to the white birch, with different temperatures and pressures, was used and run in sequence with the white birch. The system is described in the line diagram in Fig. 11.

The results for the pure fraction tests are listed in Table XVII. As can be seen from the data, no improvement over the basic results given in Progress Report One is evident. As with the white birch, it was felt an

TABLE XVII

EASTERN COTTONWOOD
PURE FRACTION
FLOTATION RESULTS[a]

Fraction	"On 1/4-Inch" % Recovery[b] Periodic Wood	Periodic Bark	Accum. Wood	BCF[c] 25%	BCF[c] 12.5%	"On 3/4-Inch" % Recovery[b] Periodic Wood	Periodic Bark	Accum. Wood	BCF[c] 25%	BCF[c] 12.5%
20% Moisture Content										
Fines Lost	0.7	2.9				0.2	1.2			
First Flotation:										
Sinkers	0.1	4.6				0	5.7			
Floaters	99.2	92.5	99.2	23.7	11.75	99.8	93.1	99.8	23.7	11.75
Reflotation of 1st Sinkers:										
Sinkers	<0.1	4.4				0	5.3			
Floaters	<0.1	0.2				0	0.4			
Hot Chip Flotation:										
Sinkers	73.2	52.1	73.2	19.2	9.2	33.7	65.9			
Floaters	26.1	40.4				66.1	27.2	66.1	12.0	5.5
45% Moisture Content										
Fines Lost	0.5	4.2				0.2	0.8			
First Flotation:										
Sinkers	3.2	14.9				1.5	43.0			
Floaters	96.3	80.9	96.3	21.9	10.73	98.3	56.2	98.3	16.0	7.6
Reflotation of 1st Sinkers:										
Sinkers	<0.1	10.9				0	35.5			
Floaters	3.1	4.0	79.2	17.4	8.3	1.5	7.5			
Hot Chip Flotation:										
Sinkers	76.1	46.1	76.1	16.8	8.0	39.5	37.3			
Floaters	20.2	34.9				58.7	18.9	58.7	9.7	4.4

[a] All percentages based on ovendry weights.

[b] "% Recovery – Periodic" is the percent of the material (wood or bark) originally entering the system that was recovered at a given data point (fraction). "Accum." is accumulated recovery of wood from the indicated data points.

[c] "BCF" is the % bark contamination in the recovered portion of a theoretical wood-bark chip mixture with an original bark content of 25 or 12.5%.

improvement would result if a compression and a second flotation were added after the first flotation.

The compression would accomplish further separation of inner from outer bark, further compression of the inner bark and greater water uptake by the inner bark. The result would be more inner bark sinking in the second flotation and thus more bark would be segregated from the wood. A certain amount of wood would also sink but, if necessary, could be reclaimed by air drying and refloating the sinkers. Time did not allow further checking of this theory but it is felt reasonable success would result, although not as good as desired because of the variability in bark characteristics.

CHIP MIXTURES (METRO-CHIPARVESTOR SAMPLES)

The introduction of the Morbark "Super-Beever" Metro-Chiparvestor (see Fig. 13) into the wood harvesting scene in the spring of 1971 confirmed one of the premises upon which this project was proposed, i.e., that wood harvesting in the future would take place by chipping whole trees in the woods and segregating the bark from the resulting wood-bark chip mixtures. The opportunity to process and analyze the chips from such a source was too timely to pass by. Since this was an addition to the project work as originally proposed and since the knowledge to be gained had sufficient impact on two other Institute of Paper Chemistry projects, the work was done under all three projects with joint support. The information obtained was classified into two categories, chip analysis and flotation analysis, with Project 2977 receiving both types of information and the other projects receiving only the chip analysis data.

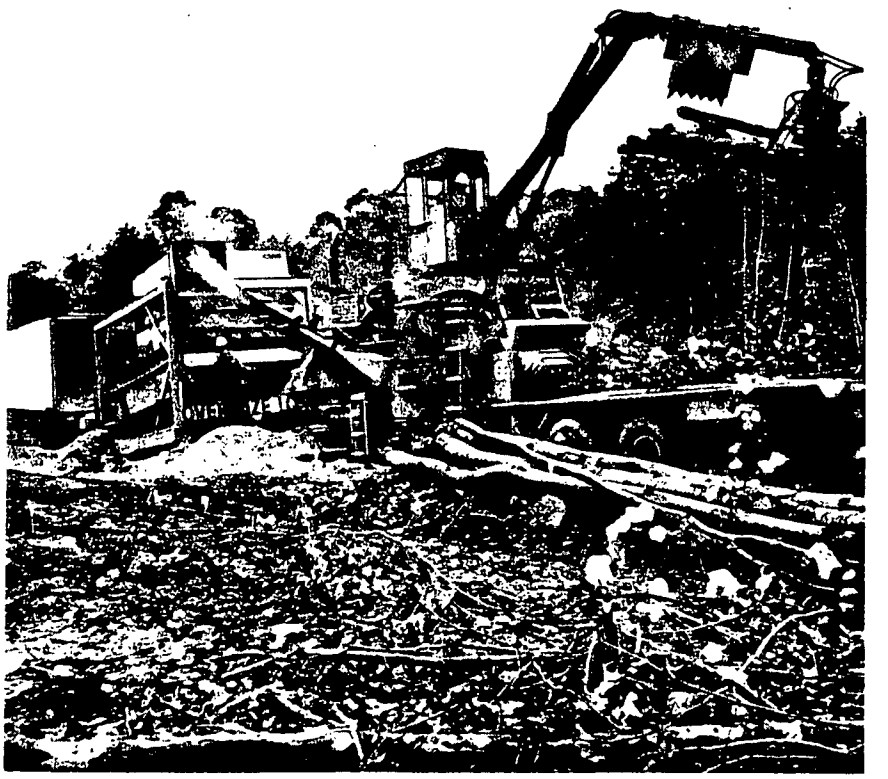

Figure 13. Pictured Above is the Morbark Super-Beever Metro-Chiparvestor

GAYLORD, MICHIGAN DEMONSTRATION

Methods

A bag of chips of approximately 20 lb. ovendry weight (35% moisture content) was received from U.S. Plywood-Champion Papers Inc. in early July. The chips were processed the same day using a one-stage flotation. The apparatus used was a 65-gallon stainless steel tank (30 inches in diameter) into which about 50 gallons of water (22°C.) was poured. The chip sample was dumped into the water and stirred with a Patterson Uni-power stirrer. The stirrer created a vortex so that the chips were continually immersed. At the end of five minutes the stirrer was shut off and removed from the tank. The floating chips were then removed by hand, the final particles taken out with a skimmer of window screen. The tank was drained over a washbox which caught the sunken particles. Both fractions, the sunken and floating particles, were set aside (separately), spread out and allowed to air dry for 20 hours. At the end of the 20-hour drying period the particles were dry enough to allow separate classification of the sunken particles ("sinkers") and floating particles ("floaters") by processing them through a 24-inch Sweco laboratory screen.

Results

The basic data for the single flotation and particle classification are too complicated for easy interpretation. Therefore, several different views of the data are presented in condensed form in the following discussion and tables.

The composition of the chip sample, size classes, and type of material, are presented in Table XVIII. As can be seen from the table, the sample is made up of 44.8% aspen, 26.4% maple, 11.5% oak, 10.7% bark, 0.2% leaves, 1.4% out-sized chips, 1.5% reaction wood and 3.5% twigs which were estimated to have 60% wood content.

TABLE XVIII

COMPOSITION OF CHIP SIZE CLASS BY MATERIAL
METRO-CHIPARVESTOR DEMONSTRATION
GAYLORD, MICHIGAN

Classification	Sample Composition[a], %	Composition, %[b]						
		Bark	Leaves	Twigs	Reaction Wood	Aspen	Maple	Oak
Oversize	0.6	--	--	--	--	--	--	--
"On 3/4-inch"	41.8	4.0	0.1	2.1	1.8	63.5	22.2	4.7
"On 1/2-inch"	36.4	14.9	0.2	5.7	1.6	46.9	10.9	19.8
"On 1/4-inch"	20.4	17.4	0.3	2.8	0.7	3.8	63.6	11.3
Through 1/4-inch	0.8	--	--	--	--	--	--	--
Gross	100.0	10.7	0.2	3.5	1.5	44.8	26.4	11.5

[a]Column shows composition of whole sample by chip size classes. Percentage data were figured from ratios of the ovendry weight of the chip size class to the ovendry weight of the whole sample.

[b]These columns show composition of the various chip sizes. Percentage data were figured from ratios of the ovendry weight of the specific material to the ovendry weight of the whole class.

A summary of the results of the single step water flotation segregation is listed in Table XIX. The second column titled "Floating Material" shows the composition of the floated materials, of which 95.1% was actual wood chips and 4.9% "Contaminants." The contaminants contained approximately 60% wood and thus from the most optimistic viewpoint 98.2% of the material recovered as floating can be considered as wood.

The last column lists the percentage of the various materials recovered by floating. The recovery of the aspen was 99.3%, the maple 92.6%, and the oak only 9.2%, most of which was sapwood. Total wood lost amounted to 12.7% but 82% of the lost wood was oak which past project experiments indicated should sink.

The floating bark contaminants were not identified but, in observing the floating bark, little was found that could be recognized as the corky outer bark of oak. It is speculated that the outer bark of oak, being very friable, broke up in small pieces and was screened out at the site.

TABLE XIX

SUMMARY FLOTATION DATA
METRO-CHIPARVESTOR DEMONSTRATION[a]
GAYLORD, MICHIGAN

	Composition, %		Original Material Recovered as Floating Particles, %
	Original Sample	Floating Material	
Outsized Chips			
Obvious oversized	0.6	--	--
Through 1/4 inch screen	0.8	--	--
Contaminates			
Bark	10.7	0.5	3.6
Leaves	0.2	>0.1	30.7
Twigs[b]	3.5	3.1	65.3
Reaction wood	1.5	1.2	55.7
Wood			
Aspen	44.8	60.5	99.3
Maple	26.4	33.2	92.6
Oak	11.5	1.4	9.2
Total	100	100	--

[a] Percentages are based on ovendry weight.

[b] "Twigs" are approximately 60-70% wood but were considered contaminates as a whole for this analysis.

The overall results of this first flotation segregation of Morbark Chiparvestor chips was very promising with 87.3% of the wood recovered and with only 0.5% "bark" contamination in the recovered wood.

TOMAHAWK, WISCONSIN DEMONSTRATION

The Metro-Chiparvestor demonstration at Tomahawk, Wisconsin took place in early September of 1971. The stand differed from the Gaylord area in species composition; the Tomahawk area being a northern hardwood stand. Several wood-bark chip samples were taken from the Tomahawk demonstration and returned to the Institute for analysis. The most striking observation of the samples was the variation in species composition from one sample to another.

The first sample processed was composed of aspen, basswood, white birch, maple, and red oak. It was decided to process the chips with a flotation followed by a compression of the floaters and an extended flotation with several compressions included. A schematic diagram of the flotation and the conditions relating to it are presented in Fig. 14. It should be pointed out the testing sequences diagrammed for the flotation work on the three samples indicate the procedure used to obtain experimental data and do not necessarily suggest a method for processing chip mixtures.

As the diagram shows, the test used a 144-hour extended flotation with reflotations of a series of sinkers taken off during the first five hours. The compressions used in the system utilized the glue spreader rolls and took place prior to the time the sinkers were taken off. The materials were classified as to size after processing so the chip size composition data should not be considered representative of the Metro-Chiparvestor chips.

Great difficulty arose in the liquid flotation segregation attempt. In order to more easily understand the problem, the size and species composition data, Tables XX and XXI are presented first. Table XX presents the "Material Composition by Chip Size" and Table XXI provides a different view by presenting

FLOTATION FLOW CHART
METRO-CHIPARVESTOR CHIPS
TOMAHAWK, WISCONSIN

SAMPLE ONE

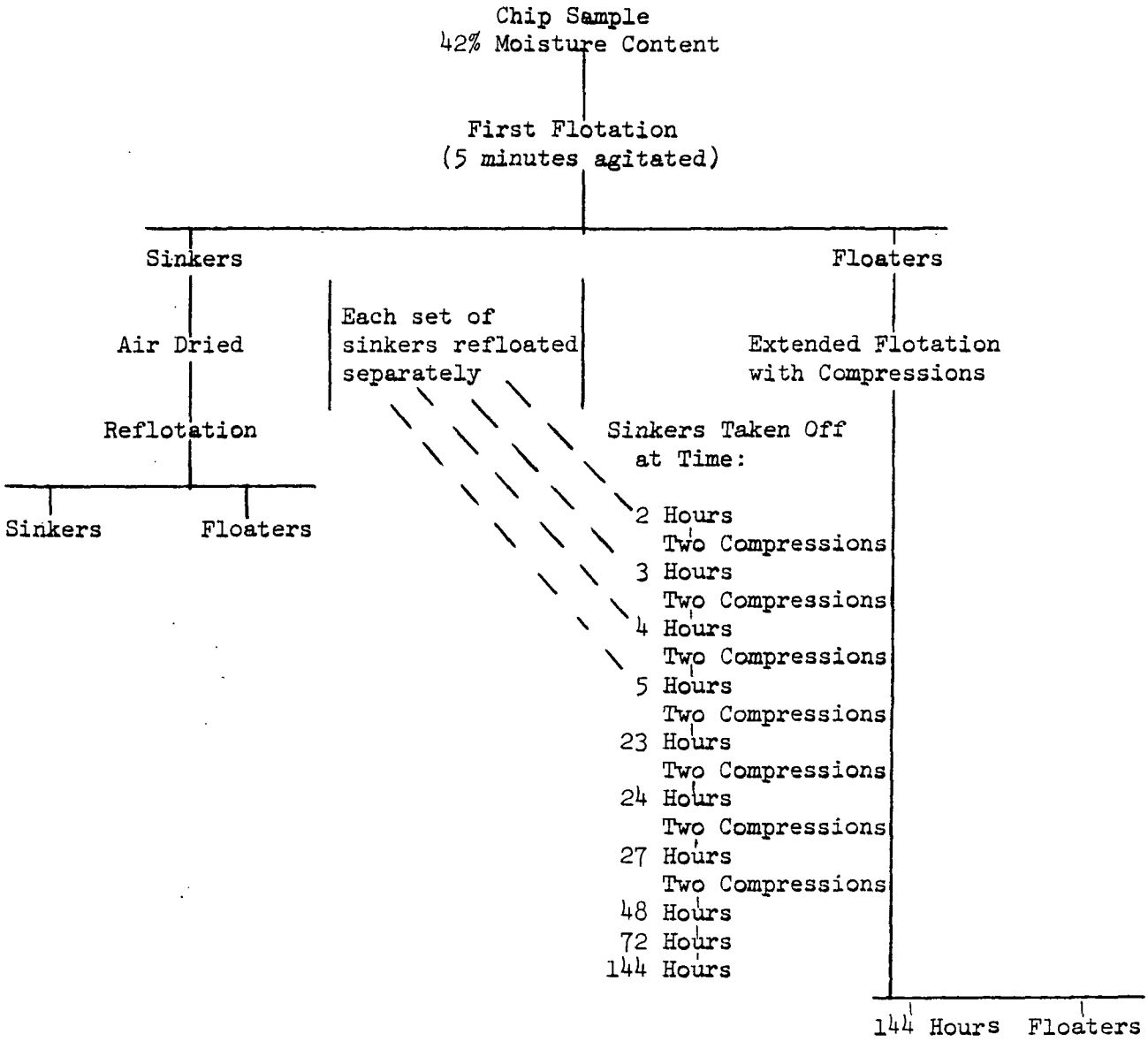

Figure 14. Testing Scheme for the First Wood-Bark Chip Sample Processed from the Metro-Chiparvestor Demonstration at Tomahawk, Wisconsin

TABLE XX

MATERIAL COMPOSITION BY CHIP SIZE
METRO-CHIPARVESTOR DEMONSTRATION[a]
TOMAHAWK, WISCONSIN

SAMPLE ONE

Classification[b]	Sample Composition, %	Out-Sized	Material Composition, %[c]						
			Bark	Leaves	Twigs	Wood & Bark	Aspen & Basswood	Birch & Maple	Oak
Oversize	1.3	22.8	--	--	--	--	--	--	--
"On 3/4 inch"	18.2	--	15.6	1.7	21.7	45.8	23.6	17.6	20.1
"On 1/2 inch"	39.2	--	22.9	1.1	34.4	38.0	42.9	45.2	54.4
"On 1/4 inch"	36.9	--	61.5	97.2	43.9	16.2	33.5	37.2	25.5
Through 1/4 inch	4.4	77.2	--	--	--	--	--	--	--
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[a] An analysis performed at The Institute of Paper Chemistry on a screened wood-bark chip sample, taken September 10, 1971 from the Metro-Chiparvestor demonstration at Tomahawk, Wisconsin. Weight of sample was 9.5 pounds ovendry.

[b] Classifications are not true values for the Metro-Chiparvestor chip sizes because the analysis process required for this particular sample used compression techniques which necessarily reduced the size of the chips.

[c] Percentages based on ratios of ovendry weight of material in size class to ovendry weight of the material.

TABLE XXI

CHIP SIZE COMPOSITION BY MATERIAL
METRO-CHIPARVESTOR DEMONSTRATION[a]
TOMAHAWK, WISCONSIN

SAMPLE ONE

		Chip Size Class Composition, %[c]							
Classification[b]	Out-Sized	Bark	Leaves	Twigs	Wood & Bark	Aspen & Basswood	Birch & Maple	Oak	Total
Oversize	100.0								100.0
"On 3/4-inch"	--	9.4	<0.1	3.8	11.1	10.7	64.9	0.1	100.0
"On 1/2-inch"	--	6.4	>0.0	2.7	4.3	9.0	77.4	0.2	100.0
"On 1/4-inch"	--	18.3	1.1	3.7	1.9	7.5	67.4	0.1	100.0
Under 1/4-inch	100.0								100.0
Gross	5.7	11.0	0.4	3.2	4.4	8.2	67.0	0.1	100.0

[a] An analysis performed at The Institute of Paper Chemistry on a screened wood-bark chip sample, taken September 10, 1971 from the Metro-Chiparvestor demonstration at Tomahawk, Wisconsin. Weight of sample was 9.5 pounds ovendry.

[b] Classifications are not true values for the Metro-Chiparvestor chip sizes because the analysis process required for this particular sample used compression techniques which necessarily reduced the size of the chips.

[c] Percentage based on ratios of ovendry weight of material in size class to the total ovendry weight of the size class.

the "Chip Size Class Composition by Material." As can be seen in the table, five major species were present in the sample. The chips were difficult to rapidly identify as to species macroscopically and it was necessary to group similar species. As a result, the chips were classified as aspen and basswood; white birch, sugar maple, and minor amounts of cherry, soft maple, and ironwood; and red oak. The material classified as "wood and bark" and "twigs" was primarily birch, as the compression with the glue spreader rolls debarked most of the other species. The "wood and bark" category was used when bark was adhering to the wood. The material in the category was about 75% wood. The material was later hand separated and the actual amount of wood or bark from this category was placed with the proper classification of either "birch and maple" or "bark" of either sinkers or floaters, whichever was appropriate.

The flotation summary is presented in Table XXII. To obtain this summary, some assumptions had to be made and it would be helpful to the reader to remember that the data in the left half of the table are reflotation data and the data on the right are for the extended flotation. It is assumed that a segregation system would process the chips as the flow diagram has shown but that the first sinkers would be taken out after the fifth-hour compression, i.e., the results through the fifth hour are composited. These sinkers would then be air dried and refloated. The resulting sinkers are then considered "discards," or contaminates, and the floaters are considered as "recovered." The floaters at five hours are continued on an extended flotation. The sinkers between 5 hours and 144 hours are considered as "recovered wood" and the 144-hour floaters as "discards" or outer bark material.

TABLE XXII

FLOTATION DATA SUMMARY[a]
METRO-CHIPARVESTOR DEMONSTRATION
WOOD-BARK CHIPS
TOMAHAWK, WISCONSIN

SAMPLE ONE

PERCENT OF MATERIAL FLOATING OR SINKING

Material	Flotation Number										
	R-0.1	R-2	R-3	R-4	R-5	23	24	27	48	72	144
	Reflotation					Extended Flotation					
Floaters											
Contaminates											
Bark	4.5	4.2	2.8	3.6	1.0	--	--	--	--	--	15.4
Leaves	17.1	21.8	4.4	0	0	--	--	--	--	--	0
Twigs	27.7	25.1	10.3	5.9	0.1	--	Not computed			--	3.2
Wood & bark	Segregated as described below					--	--	--	--	--	
Wood											
Aspen & basswood	0	0.8	0	4.2	1.7	--	--	--	--	--	28.7
Birch & maple	2.5	4.3	4.4	5.6	0.4	--	--	--	--	--	0.5
Oak	0	16.2	14.1	0	0	--	Not computed			--	0
Sinkers											
Contaminates											
Bark	36.7	0.4	12.0	4.3	1.5	4.6	3.7	2.7	0.7	0.1	1.7
Leaves	51.5	3.4	1.8	0	0.1	0	0	0	0	0	0
Twigs	10.3	0.5	3.3	1.0	1.2	1.1	7.6	2.3	0.3	0	3.2
Wood & bark	Segregated in the data as wood (birch & maple) or bark										
Wood											
Aspen & basswood	0	0	0	1.0	0	6.2	6.7	8.4	5.9	7.5	22.8
Birch & maple	3.4	0.3	3.9	1.2	1.6	14.3	13.2	8.9	13.4	6.8	15.5
Oak	0	0	20.1	0	17.3	32.3	0	0	0	0	0

Wood recovered (all species) — 85.8%

Contamination (all contaminates less wood) — 5.5%

[a]Percentages given are the ovendry weight ratios of the material in the fraction to the ovendry weight of the material in the original sample. For purposes of this test the data blocked in were considered discards, the other data recovered material. The flotation data number corresponds to the hour of the flotation. "R" means reflotation data. "Wood & bark" means wood with bark adhering.

The problems arising with the flotation are these:

1. Oakwood and bark behaves the reverse of the aspen, maple, and birch bark. The species shouldn't be processed together.

2. Basswood bark behaves similarly to aspenwood in flotation. A high portion of basswood bark constitutes the bark of the 5-144-hour sinkers.

3. Basswood wood wouldn't sink readily. A high proportion of the late sinking "aspen and basswood" was basswood.

In spite of these factors a relatively good segregation was performed. The recovery of the aspen and basswood wood was 64.2%, birch and maplewood was 88.3%, and red oak was 62.7% — mostly sapwood. A total of 85.8% of all the wood entering the system was recovered with 3.2% bark contamination and 5.5% total contamination.

The system could obviously be improved by segregating certain species for use with specific flotation systems and treating the chips at five hours to hasten the sinking of the remaining wood.

Two additional samples were processed from the Tomahawk demonstration. Sample Two was taken fresh (49% moisture content) in the field from a van and Sample Three was taken from the chip pile (34.7% moisture content) in the mill yard a week later. These samples had little or no basswood in them and were processed as shown in the flow diagram (Fig. 15), using the pulp-cake breaker and the pressure cooker. The original flotation data for these samples are presented in Tables XXVII and XXVIII of the Appendix. It was noticed during the processing of the samples that when the "floating" chips of the first flotation were put in the hot water of the pressure cooker, additional chips sank. These were set aside and data taken for all but the "on 1/2-inch" chips of Sample Two.

FLOW CHART
MORBARK METRO-CHIPARVESTOR DEMONSTRATION
WOOD-BARK CHIP SAMPLES
TOMAHAWK, WISCONSIN

SAMPLES TWO AND THREE

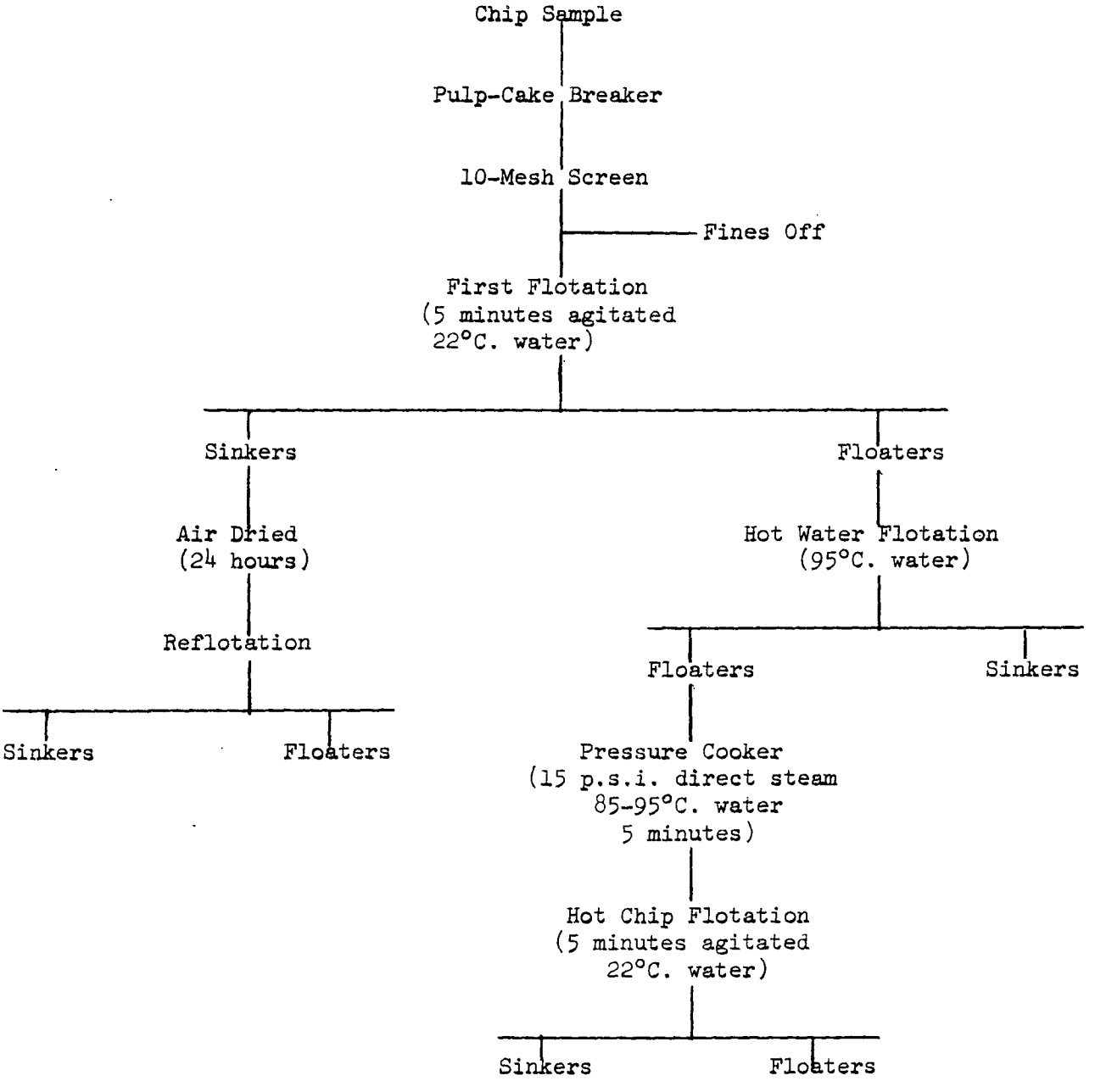

Figure 15. Schematic Diagram Showing Sequence and Conditions of Treatments for Chip Samples Two and Three from the Metro-Chiparvestor Demonstration at Tomahawk, Wisconsin

This was done to gain additional insight into wood-bark liquid flotations and no further description of the process is intended at this time. All were considered as part of the "Hot Chip Flotation — Sinkers" for the summary data.

Again, to facilitate interpretation, the data were broken down for presentation. The chips were screened to size on the Sweco laboratory screen and each size class processed separately. In addition, the fines (through 10-mesh screen) were kept track of for Sample Three in order to determine pulp-cake breaker influences. Most of the fines were contaminates. The material composition by size class of each of the two samples is given in Table XXIII. The data show that the field sample (Sample Two) has the greatest portion of chips in the "on 1/2-inch" class, while the chip pile sample (Sample Three) had the greatest portion in the "on 3/4-inch" class, e.g., Sample Two material was distributed 23.9% "on 3/4-inch," 52.2% "on 1/2-inch," and 20.6% "on 1/4-inch," while Sample Three was distributed 51.3% "on 3/4-inch," 30.0% "on 1/2-inch," and 14.3% "on 1/4-inch." The size class composition by type of material is presented in Table XXIV. As the data indicate, the two samples have about the same portion of contaminates, but the wood species differed. Sample two had 46.5% aspen, 31.2% birch and maple and 0.1% oak. Sample Three had more oak and less aspen, with 19.5% aspen, 30.3% birch and maple and 26.0% oak.

The flotation data for the two samples are presented in Table XXV. As indicated, three possible segregation systems are demonstrated with the data. The systems include: (1) Recover first flotation floaters only, discard sinkers; (2) Recover first flotation floaters and reflotation floaters, discard reflotation sinkers; and (3) Recover reflotation floaters and "hot chip" flotation sinkers, discard reflotation sinkers and "hot chip" flotation floaters.

TABLE XXIII

MATERIAL COMPOSITION[a]
MORBARK METRO-CHIPARVESTOR DEMONSTRATION
TOMAHAWK, WISCONSIN

Classification[b]	Sample Composition, %	Material Composition by Size, %									
		Out-Sized	Bark	Leaves	Wood & Bark	Aspen & Basswood	Birch & Maple	Twigs	Oak	Fines	Reaction Wood
Chip Sample Two											
Oversize	1.5	45.3	--	--	--	--	--	--	--	--	--
"On 3/4-inch"	23.9	--	12.8	8.2	37.6	22.3	29.1	26.7	--	--	75.4
"On 1/2-inch"	52.2	--	46.4	22.4	53.2	56.2	54.9	41.2	100.0	--	24.6
"On 1/4-inch"	20.6	--	40.8	69.4	9.2	21.5	16.0	32.1	--	--	--
Through 1/4-inch	1.8	54.7	--	--	--	--	--	--	--	--	--
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	--	100.0
Chip Sample Three											
Oversize	2.5	--	--	--	--	--	--	--	--	--	--
"On 3/4-inch"	51.3	--	31.5	39.6	68.3	58.2	55.2	44.5	54.1	42.1	--
"On 1/2-inch"	30.0	--	34.2	46.2	24.0	32.6	37.3	21.4	24.5	46.8	--
"On 1/4-inch"	14.3	--	34.3	14.2	7.7	9.2	7.5	34.1	21.4	11.1	--
Through 1/4-inch	1.9	--	--	--	--	--	--	--	--	--	--
Total	100.0	--	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	--

[a] Values based on ovendry weights.

[b] Sizes are the screen size the material was retained on. Oversize chips were extracted manually.

TABLE XXIV

SIZE CLASS COMPOSITION[a]
MORBARK METRO-CHIPARVESTOR DEMONSTRATION
TOMAHAWK, WISCONSIN

Classification[b]	Size Class Composition by Material, %										
	Out-Sized	Bark	Leaves	Wood & Bark	Aspen & Basswood	Birch & Maple	Twigs	Oak	Fines	Reaction Wood	Total
	Chip Sample Two (49.0% Moisture Content)[c]										
Oversize	100.0	--	--	--	--	--	--	--	--	--	100.0
"On 3/4-inch"		5.4	0.1	7.7	43.3	38.0	3.1	--	--	2.4	100.0
"On 1/2-inch"		9.1	0.1	5.0	50.1	32.9	2.2	0.2	--	0.4	100.0
"On 1/4-inch"		20.2	0.6	2.2	48.5	24.2	4.3	--	--	--	100.0
Through 1/4-inch	100.0	--	--	--	--	--	--	--	--	--	100.0
Gross	1.5	10.3	0.2	4.9	46.9	31.4	2.8	0.1	0.1	1.9	100.0
	Chip Sample Three (34.7% Moisture Content)[c]										
Oversize	100.0	--	--	--	--	--	--	--	--	--	100.0
"On 3/4-inch"		6.0	0.6	9.5	22.1	32.2	1.4	27.1	1.1	--	100.0
"On 1/2-inch"		11.1	0.2	5.7	21.1	37.6	1.1	21.2	2.0	--	100.0
"On 1/4-inch"		23.4	0.4	3.8	12.6	15.9	3.8	39.1	1.0	--	100.0
Through 1/4-inch	100.0	--	--	--	--	--	--	--	--	--	100.0
Gross	3.4	9.7	0.1	7.1	19.5	30.3	1.6	26.0	1.3	--	100.0

[a] Values based on ovendry weights.

[b] Sizes are the screen size the material was retained on. Oversize chips were extracted manually.

[c] Moisture contents are based on: ovendry weight/fresh weight.

TABLE XXV

FLOTATION DATA SUMMARY[a]
WOOD-BARK CHIPS
MORBARK CHIPARVESTOR DEMONSTRATION
TOMAHAWK, WISCONSIN

	Composition of Original Sample, %	1st Flotation		Reflotation of 1st Sinkers		Hot Chip Flotation of 1st Floaters		Recovery Possibilities		
		Sinkers	Floaters	Sinkers	Floaters	Sinkers	Floaters	1	2	3
Chip Sample Two (49.0% Moisture Content)[b]										
Contaminates										
Bark	10.3	78.6	21.4	72.5	6.1	10.9	10.5	21.4	26.5	17.0
Leaves	0.2	52.5	47.5	25.2	27.3	46.8	0.7	47.5	74.8	74.1
Twigs	2.8	20.2	79.8	13.2	17.0	66.3	3.5	79.8	86.8	83.3
Wood and bark	4.9	8.6	91.4	3.7	4.9	87.5	3.9	91.4	96.3	92.4
Reaction wood	1.9	100.0	0.0	24.5	75.5	0.0	0.0	0.0	75.5	75.5
Wood										
Aspen	46.9	2.4	97.6	1.4	1.0	86.3	11.3	97.6	98.6	87.3
Birch and maple	31.4	15.1	84.9	9.8	5.3	65.8	19.0	84.9	90.2	76.1
Oak	0.1	74.3	25.7	37.8	36.5	25.7	0.0	25.7	62.2	62.2
Chip Sample Three (34.7% Moisture Content)[b]										
Contaminates										
Bark	9.7	62.9	37.1	58.9	3.0	31.6	6.5	37.1	40.1	34.6
Leaves	0.1	5.4	94.6	5.4	<0.1	93.4	1.2	94.6	95.6	98.8
Twigs	1.6	25.8	74.2	9.0	16.8	67.2	7.0	74.2	91.0	84.0
Wood and bark	7.1	4.9	95.1	4.9	0.0	93.1	2.0	95.1	95.1	93.1
Wood										
Aspen	19.5	0.0	100.0	0.0	0.0	93.6	6.3	100.0	100.0	93.6
Birch and maple	30.3	2.6	97.4	1.9	0.7	88.4	9.0	97.4	98.1	89.1
Oak	26.0	41.9	58.1	28.5	13.4	58.1	0.0	58.1	71.5	71.5

[a]Composition percentages of the original samples are based on the ovendry weight of the sample. Flotation and recovery values are expressed as ovendry weight percentages based on the original weight of the material. Recovery possibilities are:

(1) Recover 1st flotation floaters only. Discard 1st sinkers.
(2) Recover 1st flotation floaters and reflotation floaters. Discard reflotation sinkers.
(3) Recover reflotation floaters and hot chip flotation sinkers. Discard reflotation sinkers and hot chip flotation floaters.

[b]Moisture contents are based on: moisture content divided by fresh weight.

The true results in terms of wood and contaminates are difficult to obtain from the flotation data presented, but by making a few assumptions and adjustments, the generalized data found in Table XXVI can be determined. If the "twigs" are considered to be 60% wood and 40% bark and the "wood and bark" is considered to be 25% bark, then the estimates of the table can be assumed to be correct.

TABLE XXVI

RECOVERY DATA
METRO-CHIPARVESTOR DEMONSTRATION
TOMAHAWK, WISCONSIN
SAMPLES TWO AND THREE[a]

System / Sample	Recover First Flotation Floaters Only, 1	Recover First Flotation Reflotation Floaters, 2	Recover Reflotation Floaters & Hot Chip Flotation Sinkers, 3
Sample Two			
Recovery wood %	92.3	96.5	84.7
with Contamination %[b]	4.3	6.4	5.3
Sample Three			
Recovery wood %	84.5	89.5	84.3
with Contamination %[b]	5.9	6.3	5.6

[a] Percentages are based on ovendry weights.

[b] The "Contamination %" includes all bark from "leaves," "bark," "twigs," and "wood and bark" and the material identified as "reaction wood."

The first system appears to be the best for both samples. The segregation of Sample Three could have been improved considerably if the oak had been processed separately. The bark contamination due to separate bark chips was under 3% for both the first and third systems of both samples, but the presence of leaves, reaction wood, and bark adhering to twigs and wood chips increased the contamination levels to 4-6%.

PLANS

The basic flotation work of the first project period characterized the flotation behavior of quaking aspen, bur oak, white birch, sugar maple, and eastern cottonwood. Work during this period was easily defined and readily implemented because of past experience. The results of the first period left some challenges including, "How to modify liquid flotation procedures to accomplish adequate wood recovery and wood-bark segregation of wood-bark chips of birch, cottonwood, and maple?"

Work during the second project period involved the use of an "empirical approach" and resulted in the descriptions of liquid flotation segregation sequences which were demonstrated to be "workable" for sugar maple and white birch. Also suggested was a "less satisfactory" liquid flotation approach for eastern cottonwood. Several flotation system modifications were tested, and it was determined that flotation media dwell time, mechanical treatments — beating and compression, and pressure heating all could be used effectively in developing liquid flotation segregation systems.

Plans for the third project period call for the characterization of three new species as to the specific gravity and physical characteristics of the bark and wood, and the influence of moisture content, chip size, flotation media dwell time, pressure heating and mechanical treatments on flotation behavior. Based on these characterizations, logical flotation sequences similar to those of the second project period will be developed and tested. The three species to be investigated are loblolly pine, shagbark hickory, and white spruce. Because of cooperator requests, slash pine was replaced by loblolly pine as the southern pine to study. Arrangements have been made for the collection of these materials and the basic tests will be well under way by the time this report is distributed.

The fourth period, beginning in April of 1972, will be used to investigate the flotation behavior of wood-bark chips of two western conifers, western hemlock and Douglas-fir.

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APPENDIX

TABLE XXVII

ORIGINAL FLOTATION DATA[a]
WOOD-BARK CHIPS
MORBARK METRO-CHIPARVESTOR DEMONSTRATION
TOMAHAWK, WISCONSIN

SAMPLE TWO

Material	Chip[b] Size	Flotation: Sinkers	Flotation: Floaters	Hot Water Flotation: Sinkers	Hot Chip Flotation: Sinkers	Hot Chip Flotation: Floaters	Total
		Reflotation: Sinkers	Reflotation: Floaters	Floaters	Floaters	Floaters	
Bark	3/4	49.6	11.7	0.5	27.4	10.8	5.4
	1/2	67.3	7.2	N	9.5	16.0	9.1
	1/4	85.4	3.1	3.1	4.2	4.2	20.2
	Total	72.5	6.1	1.3	9.6	10.5	10.2
Leaves	3/4	0	14.1	21.2	68.9	1.8	0.1
	1/2	28.9	29.0	N	41.5	0.6	0.1
	1/4	27.0	28.4	1.4	42.6	0.6	0.6
	Total	25.2	27.3	2.8	44.0	0.7	0.2
Twigs	3/4	0	19.6	36.7	38.4	5.2	3.1
	1/2	16.8	22.6	N	55.9	4.6	2.2
	1/4	19.7	7.7	46.8	25.2	0.6	4.3
	Total	13.2	17.0	24.8	41.5	3.5	2.8
Wood and bark	3/4	1.8	10.3	14.6	65.6	7.6	7.7
	1/2	3.2	0	N	95.0	1.9	5.0
	1/4	14.9	10.9	23.4	50.7	0	2.2
	Total	3.7	4.9	7.6	79.9	3.9	4.9
Reaction wood	3/4	32.5	67.5	0	0	0	2.4
	1/2	0	100.0	0	0	0	0.4
	1/4	0	0	0	0	0	0
	Total	24.5	75.5	0	0	0	0.8
Aspen	3/4	0	0.5	1.3	72.4	24.8	43.4
	1/2	1.9	1.3	N	87.2	9.6	50.2
	1/4	1.6	0.7	6.7	91.8	0.9	48.6
	Total	1.4	1.0	1.4	84.9	11.3	46.5
Birch and maple	3/4	0.7	4.5	27.7	64.9	2.3	38.0
	1/2	10.9	4.8	N	59.5	24.7	33.9
	1/4	22.7	8.2	30.5	8.6	30.0	24.2
	Total	9.8	5.3	12.9	52.9	19.0	31.2
Oak	3/4	0	0	0	0	0	0
	1/2	37.8	36.4	N	25.7	0	0.2
	1/4	0	0	0	0	0	0
	Total	37.8	36.4	0	25.7	0	0.1
Outsize	Overs						1.5
	Fines						0.8

[a] Data are percentages based on ovendry weight of the material in the size class. N = not performed.

[b] Sizes are the screen size the material was retained on. Oversize chips were extracted manually.

TABLE XXVIII

ORIGINAL FLOTATION DATA[a]
WOOD-BARK CHIPS
MORBARK METRO-CHIPARVESTOR DEMONSTRATION
TOMAHAWK, WISCONSIN

SAMPLE THREE
(MILL YARD CHIP PILE)

Material	Chip[b] Size	Flotation Sinkers Reflotation Sinkers	Flotation Sinkers Reflotation Floaters	Floaters Hot Water Flotation Sinkers	Floaters Hot Chip Flotation Sinkers	Floaters Hot Chip Flotation Floaters	Total
Bark	3/4	60.0	2.7	20.5	7.6	9.2	6.0
	1/2	59.5	2.7	22.1	12.2	3.6	11.1
	1/4	57.3	3.4	24.8	7.3	7.1	23.4
	Total	58.9	3.0	22.5	9.1	6.5	10.2
Leaves	3/4	18.2	<0.1	54.3	27.5	<0.1	0.1
	1/2	0	<0.1	0	97.0	3.0	0.2
	1/4	5.1	<0.1	28.8	66.1	<0.1	0.4
	Total	5.4	<0.1	21.6	71.8	1.2	0.1
Twigs	3/4	5.3	22.3	10.5	56.7	5.2	1.4
	1/2	13.7	9.5	44.4	18.7	13.7	1.1
	1/4	10.9	14.2	46.3	23.6	5.0	3.8
	Total	9.0	16.8	29.9	37.3	7.0	1.6
Wood and bark	3/4	3.6	0	54.7	38.8	2.9	9.5
	1/2	1.3	0	60.6	38.1	0	5.7
	1/4	27.7	0	64.6	7.7	0	3.8
	Total	4.9	0	56.9	36.2	2.0	7.1
Aspen	3/4	0	0	8.7	83.4	7.9	22.1
	1/2	0	0	2.8	94.9	2.2	21.1
	1/4	0	0	1.5	87.4	11.1	12.6
	Total	0	0	6.1	87.5	6.3	19.5
Birch and maple	3/4	2.8	0.9	51.8	34.1	10.4	32.6
	1/2	0.2	0.6	60.7	29.9	8.6	37.6
	1/4	3.5	0.6	71.9	23.5	0.5	15.9
	Total	1.9	0.7	56.6	31.8	9.0	30.3
Oak	3/4	30.6	11.3	49.3	8.8	0	27.4
	1/2	9.5	18.6	51.0	20.9	0	21.2
	1/4	45.2	12.7	35.5	6.6	0	39.0
	Total	28.5	13.4	46.8	11.3	0	26.0
Outsize	Overs						2.5
	Fines						1.9
Pulp-cake breaker fines	3/4						1.1
	1/2						2.0
	1/4						1.0
	Total						1.3

[a] Data are percentages based on ovendry weight of the material in the size class.

[b] Sizes are the screen size the material was retained on. Oversize chips were extracted manually.