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HIGH-TEMPERATURE PULPING--ISOTHERMAL DIGESTER

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INTRODUCTION

Previous work has demonstrated the utility of the isothermal digester for pulping aspen (Populus tremuloides) sapwood cut into pieces 0.023-inch thick, by the neutral sulfite process.[1] It was decided to redesign the electrical system of the isothermal digester in the interests of safety, ease of operation, and to increase the precision and accuracy of the measurements.

This report presents a description of the isothermal digester in its present form, and lists the changes which were made. A detailed explanation of operational procedures is included, along with data concerning experimental cooks performed, using the kraft process with conventional spruce chips.

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[1] Wally Z. Walters, Doctoral thesis, The Institute of Paper Chemistry, 1959, in publication.

EQUIPMENT DESIGN AND CHANGES

A schematic flow diagram of the isothermal digester is shown in Figure 1. A major change from the original equipment was the introduction of a permanent single-point Electronik Strip Chart temperature recorder with an eight-contact rotary switch which instantly and accurately measures temperatures (± 0.5°C.) at any point throughout the system. Another change was the connection in parallel of the 12 strip heaters located on the sides of the isothermal digester, with the introduction of a variac in the circuit to control the heat requirements. A Pulse Pyr-O-Vane Controller was put into the circuit by connecting a thermocouple inside the digester, through the Pyr-O-Vane, to the variac. This instrumentation and electrical setup makes it possible for one operator to handle the unit with the assurance of ease of operation with maximum electrical safety to obtain accurate results.

The strip recorder is a Minneapolis-Honeywell Type 153 "Electronik" recorder. The instrument is a potentiometer incorporating a continuous balancing system. In the Minneapolis-Honeywell self-balancing potentiometer, the continuous balance system provides both the detecting and balancing means. The electronic amplifier detects any unbalanced e.m.f. in the measuring circuit, amplifies it, and applies it as power to drive the balancing motor. The drive motor is connected to the contact by a cable to which the recording pen is attached, thereby eliminating any mechanical drive in the system. The recording pen has a complete span travel time of 1 second.

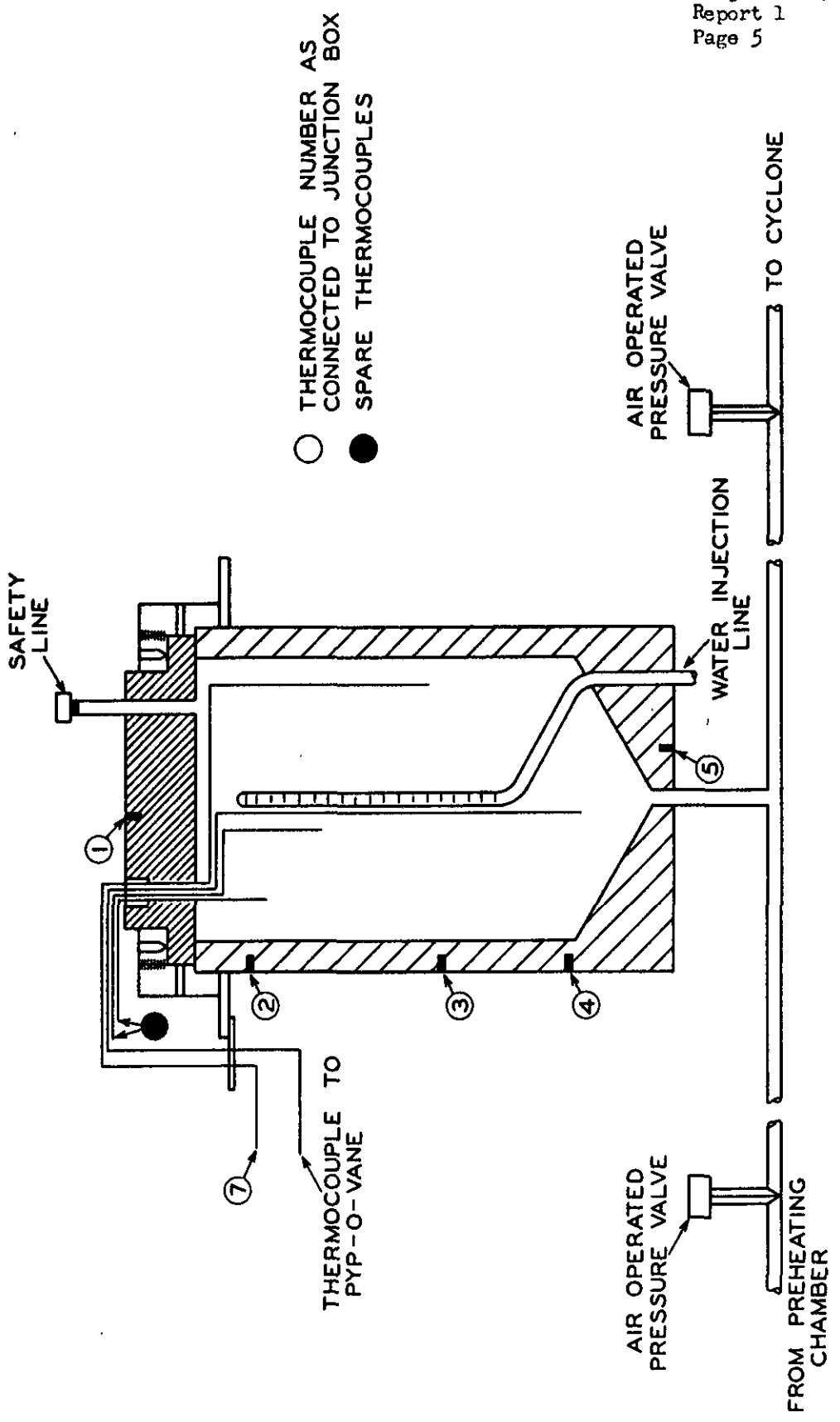


Fig. 1. Isothermal Digester

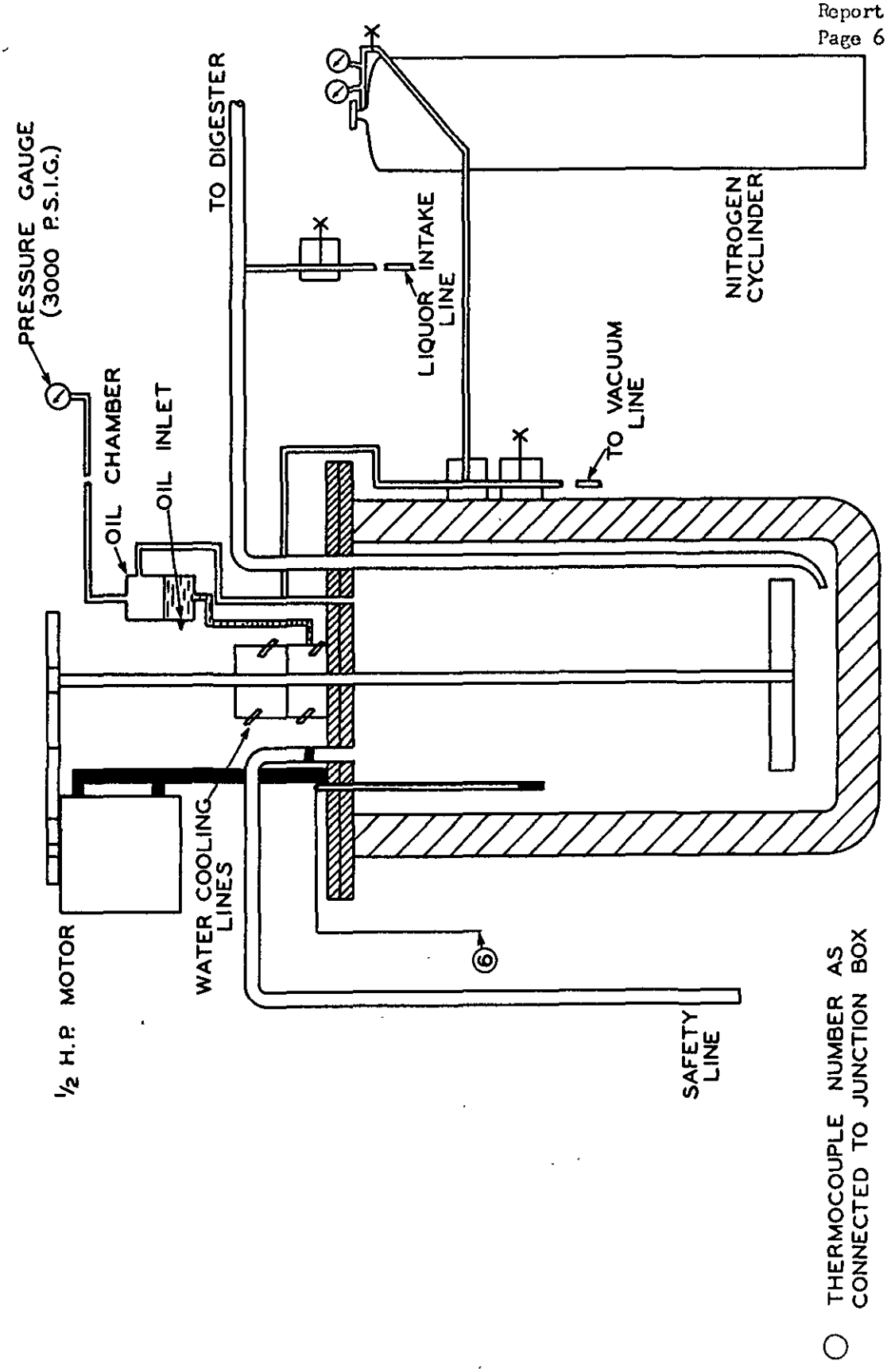


Fig. 1 (continued) Wright-Patterson Preheating Chamber

The instrument is automatically switched to a standard cell to standardize the battery current at fixed time intervals. In addition, a push button on the instrument chassis permits manual standardization.

The strip recorded is calibrated for iron constantan thermocouples to cover a temperature range of 0-250°C. The chart is 12" wide with line divisions for one degree centigrade.

The power for the chart drive is supplied by an A.C. motor. The chart speed can be varied to two positions by merely turning a toggle switch. The chart speeds used now are 6 inches/hour and 180 inches/hour. Thus, it is possible to change the chart speed, in about one second, from a low speed during the initial heat-up period to a relatively high speed during liquor transfer.

An 8-point junction box was installed to receive the e.m.f. signals from the 7 thermocouples located in the digester system. A pointer on the face of the junction box is used to indicate which thermocouple signal is being received by the potentiometer. All the temperatures throughout the system can be recorded on the chart in a few seconds. This set-up has given the operator the ability to apply heat, when necessary, at a particular spot during the cooking cycle to keep the temperature at a set point, thus increasing the precision of temperature control.

OPERATING PROCEDURES FOR ISOTHERMAL DIGESTER

PREPARATION FOR OPERATION

(1) The first step in preparing for operation is to check the equipment and establish that the entire system is closed. That is, the lid of the isothermal digester should be bolted in place and the air valves, cold water lines, vacuum lines, and vent lines should be closed. The recording potentiometer should be on. The only time the recording potentiometer should be turned off is when the operator does not plan to use the potentiometer for one week or more. This helps in prolonging the life of the tubes.

(2) The nitrogen cylinder is now turned on and between 100 and 150 p.s.i.g. of nitrogen gas can now be added to the preheating chamber. With the preheater under pressure, the air valve connecting the two digesters should be opened momentarily, and closed, followed by opening the air valve between the isothermal digester and the blow tank. This procedure will cause any condensate in the preheating chamber or digester to be blown from the system. After the pressure in the digester decreases, the blow line should be closed and additional relief of the preheating chamber accomplished through repetition of opening the transfer line and the blow line. Upon complete relief of the preheater, additional nitrogen should be added and the entire procedure repeated until no water discharges from the blow tank upon venting. The entire system at this point will be sufficiently dry to cause a negligible effect upon the subsequent steps.

(3) The air valves should then be closed and a very small amount of nitrogen (equivalent to approximately 5 p.s.i.g.) should be added to the preheater. The self-closing check vent on the oil reservoir of the preheater should then be depressed and vented until either gas or oil escapes. The preheater should then be relieved of all pressure by opening the transfer and blow line. The special grease gun should be attached to the check valve and 600-weight oil added to the reservoir by taking 5-10 strokes on the grease pump. The number of strokes should be varied to keep the oil reservoir about 1/2 full. The valve between the oil reservoir and the preheater should now be closed to prevent the oil from going into the preheater when it is under vacuum in Step 4. It should not be opened until the preheater temperature is 100°C. The nitrogen cylinder should then be turned completely off by closing the main cylinder line. With the transfer line closed, the preheater is ready to receive its charge of liquor.

(4) The prepared liquor charge should be added to the preheater through use of the 1/4-inch feeder and vacuum lines. It requires 14 liters of liquor to accomplish a perfect transfer, but it is recommended that at least 2 additional liters of liquor be used. The preheater has a total capacity of 5 gallons, and to prevent hydrostatic rupture on heating, liquor addition should never exceed 17 liters. After addition of the liquor, all lines leading to and from the preheater should be closed.

(5) The heaters to the preheater may now be turned on, but care must be taken in the adjustment of the rheostat so that the amperage never

exceeds 27 amps. Depending upon the final temperature desired, it will require from 2-4 hours to preheat the liquor. It is necessary to have cooling water running through the jackets surrounding the packing of the stirrer at all times when the temperature exceeds 100°C. The stirrer in the preheater should be turned on for 5 seconds every 15 minutes to prevent spot heating. The temperature of the preheater is recorded on the potentiometer by turning the junction box pointer to position No. 6.

(6) The isothermal digester can now be opened by removing the lid. The inside of the digester and lid should be wiped dry with a clean white cloth or paper towel. The transite plate should now be placed on the floorplate of the digester with care being taken to line up the holes in the two plates. The chip charge, which has been previously placed in the specially designed basket, should now be added to the digester with care taken so as not to disturb the lineup of the bottom plates. The circular asbestos plate and pressure gasket should be placed and the cover secured. The blow line should be closed and the vacuum pump turned on with the vacuum line open to the digester. The digester should be under vacuum at least 45 minutes before any heat is applied to it.

COOKING

(1) It requires between an hour and an hour and one half to preheat the shell of the digester. In the interest of saving time, it is suggested that the heating of the digester shell be started about 45 minutes before the desired temperature is reached in the preheater. Heating

of the shell of the digester is accomplished in the following manner.

(a) The top heater of the digester has the greatest lag. Hence, the top heating mantle should be turned on prior to any other heating of the digester shell. No other heat should be applied to the shell of the digester until a temperature of 75°C. is reached on the lid of the digester. The temperature of the preheater is recorded on the potentiometer by turning the junction box pointer to No. 1 position.

(b) When the temperature of the lid of the digester reaches 100°C., full power is applied to the side and bottom of the shell of the digester. These temperatures are recorded on the potentiometer by turning the junction box pointer to numbers 2 and 5.

Position 2 reads temperature at the top of the side of the shell.
Position 3 reads temperature at the middle of the side.
Position 4 reads temperature at the bottom of the side.
Position 5 reads temperature at the bottom of the shell of the digester.

(c) The side of the digester will heat up faster than the bottom, and should be turned off when the temperature at position 3 is 40° below the proposed cooking temperature. The residual heat will bring the side to the desired temperature.

(d) The bottom heater should be turned off when the temperature at position 5 reads 25° below the desired bottom temperature.

The desired bottom, side and top temperatures should be achieved simultaneously. This particular cooking schedule has given the necessary reproducibility to hit a given cooking temperature. The relative heating conditions stated above were used to hit 200°C. and should be increased or decreased depending upon what temperature you desire. The proper conditions can only be achieved at the present time by experience. It should be noted at this point that the top heater is kept on until the transfer temperatures

are reached on the appropriate thermocouples.

(3) When both the shell of the digester and the preheater are at the proper temperatures, the final adjustments before transfer can be made. The preheater should be on a low power output (variac setting between 40 and 50). The side heaters variac at a setting of 12 to 20. The vacuum line to the digester should now be closed.

(4) At this time the following items should be checked again, both for operational and safety reasons, before the liquor transfer:

(a) The air valve from the digester to the blow tank should be closed.

(b) The valve controlling the cold water addition to the digester should be checked and tightened by hand.

(c) The vacuum line should be closed.

(d) The recording potentiometer should be running and the chart speed set on high.

(e) The temperature levels should be checked again to see that they are as desired.

(5) Transfer of the liquor can now be accomplished. This is done by opening the air valve connecting the preheater and the digester. Cooking time can be considered to start 2 seconds after turning the air valve handle. Under no conditions, after the cook has been started, should the air valve controlling transfer be closed until the blow is completed. TO REPEAT, UNDER NO CONDITIONS SHOULD THE AIR VALVE CONNECTING THE PREHEATER AND THE DIGESTER BE CLOSED UNTIL AFTER BLOWDOWN. Closure of this air valve would isolate the liquor charge in the digester at a time when there is no room

available for expansion of liquor due to small temperature changes. If this valve were closed, it is conceivable that the digester could explode under a temperature change of only one or two degrees.

(6) The temperature of the digester can be controlled through the judicious use of the side and bottom heaters. Temperature control within ± 1°C. is possible with careful operation. The heat requirements of the bottom and side heaters can be anticipated by turning the junction box pointer to the appropriate thermocouples and adding heat to those points that are at a lower temperature than the cooking temperature. It is important that the side and bottom heaters be left on only for a few seconds, due to the heat lag, when their temperatures are below the cooking temperature.

COMPLETION OF THE COOK

(1) Completion of the cook is accomplished in the following way:

(a) Five to ten seconds before blowdown, the water line entering the blow tank should be opened.

Great care must be exercised to see that the following steps proceed in the proper sequence:

(b) Blowdown is accomplished by opening the air valve in the blow line.

(c) After opening the air valve in the blow line, the pressure cycle in the digester can be followed through the pressure gauge and when this pressure reaches a value less than 50 p.s.i.g., the air valve between the pre-heater and the digester must be closed. This pressure drop usually occurs from

5 to 10 seconds after opening the blow line.

(d) Immediately after closing the transfer valve, the cold water line leading into the digester should be open. This completes the quenching of the contents in the digester.

(e) The water line entering the blow tank should now be closed.

(2) The top heating mantle should be removed and the thermocouple leads disconnected. All but three evenly spaced studs in the lid of the digester should be loosened. At this point, the cold water entering the digester should be closed, and then as quickly as possible the lid of the digester should be removed and the basket containing the pulp removed. The pulp will be cool enough that it can be placed aside until equipment shutdown is completed.

EQUIPMENT SHUTDOWN

(1) Equipment shutdown is accomplished by simply shutting off the electrical supply to the preheater and to the digester and shutting off the cooling water to the preheater.

(2) It is important to note the following points:

(a) The transfer line is closed by the air valve and this valve should remain closed until the equipment is completely cooled. The reason for this is that following the blow there is a slight (50 p.s.i.g.) pressure buildup in the preheater. This pressure is created by superheated vapor and will relieve itself upon cooling. Serious injury could result if the transfer line were opened with the digester being open.

(b) The potentiometer power should be left on if a cook is to be made within a week as it will prolong the life of the tubes and the instrument. The potentiometer should only be shut off when no additional cooks are planned.

DISCUSSION OF RESULTS

COOKING

A series of 6 kraft cooks was made using nominal 3/4-in. chips. These cooks served as a means of establishing the utility of the newly installed equipment and the ability of the electrical changes to improve the precision of temperature control. In addition, the use of conventional chips instead of veneer chips was an innovation.

Spruce chips, prepared in the Institute's Carthage chipper, were used in this study. The chemicals used to prepare the kraft liquor were commercial grade sodium hydroxide and sodium sulfide prepared according to Pulping Group Procedure 4.

The cooking conditions are presented in Table I. In all of the cooks in this series, the pulped chips were treated in the same manner. After the cooking cycle was completed, the pulped chips--partially washed from the spray system in the digester--were dumped on a muslin-covered washbox and washed with hot water until all of the black liquor was removed. During this washing stage, the water pressure was sufficient to cause the greater percentage of the

TABLE I

KRAFT COOKING CONDITIONS

Cook	1	2	3	4	5	6
Chip charge (ovendry basis), g.	--	--	--	922	922	922
Liquor concentration (as NaOH), g./l.	50	50	50	50	50	50
Active alkali (as NaOH), %	--	--	--	75.8	75.8	75.8
Sulfidity, %	20	20	20	20	20	20
Liquor:wood ratio (oven-dry basis), cc./g.	--	--	--	15.2	15.2	15.2
Maximum temperature, °C.	200	208	205	205	205	210
Time at max. temp., min.	40	35	35	20	16	10
Unscreened yield, %	--	--	--	48.2	48.2	47.1
Screened yield, %	--	--	--	42.3	41.0	38.6
Screening rejects, %	--	--	--	14.1	17.7	21.9
Permanganate number (25-ml. basis)	9.3	12.3	13.5	21.2	20.0	16.0

pulped chips to disintegrate into individual fibers. The pulp was then screened on a Valley flat screen using a 0.010-inch cut plate. The pulp which passed through the screens was thickened in a stainless steel tank equipped with a perforated false bottom. Pulp from the tank was further dewatered to about 30% consistency in a laundry-type centrifuge. Samples of the dewatered, screened pulp were removed for determination of moisture content and permanganate number. The screened yield was calculated from the wet weight of accepted pulp and the ovendry content. The screening rejects were oven dried, weighed, and discarded. The weight of screenings was recorded as a percentage of the unscreened pulp. A permanganate number test was run on the screened pulp following Institute Method 410 (25-ml. basis).

The first three cooks in this series were made primarily for this operator to become acquainted with equipment changes and electrical setup. Several leaks were also apparent during these cooks. They appeared in the cover of the preheating chamber, in the air-operated valve between the preheater and digester, and in the digester cover. An error also occurred in the recording of the temperature of the cook due to a faulty connection at the thermocouple junction point. No chip charge or yield measurements were made until the equipment was in good working order. The first successful cook in the series was Cook 3, and no equipment failures were experienced in the cooks that followed.

TEMPERATURE CONTROL

The temperature control for Cooks 3 through 6 was fairly good with a variation of ± 4°C. The temperature-pressure cycles for these cooks are presented graphically in the Appendix of this report, Figures A-D. Cook 3 was the most effective, control-wise, with the desired temperature achieved in a 10-min. period following injection of the liquor. Good control of the temperature was maintained for the next 25 minutes, indicating that the digester has good isothermal properties. The temperature variation was greater in Cooks 4, 5, and 6 due principally to the short cooking times. The temperature-pressure data for Cooks 4 through 6 showed a trend in the preheating conditions. Upon transfer of the liquor, a desired temperature would be achieved and then would decrease a few degrees and hold steady. This could be attributed in part to insufficient heating of the digester shell. The temperature cycle is still better than that achieved by Walters in previous work with this equipment. Walters has demonstrated that corrections for cooking time can be made with a temperature variation of ± 4°C. with sufficient data.. As it was not in the scope of this report to pin down cooking conditions or accurate cooking times, no attempt was made to correct for cooking time.

A pulse Pyr-O-Vane was inserted in the circuit in one effort to improve temperature control for longer cooks. Because its use in circuit was limited to the side strip heaters, the results were spot heating and lack of heat on the top and bottom of the digester. It is felt by the writer that good temperature control can be obtained by measuring

temperatures of the shell at different points during the cook and applying heat to that section when the temperature is lower than the desired temperature. This can be accomplished with ease by manual operation.

STRENGTH RESULTS

The pulps obtained from all of the cooks were evaluated in a 1.5-lb. Valley beater. The physical properties obtained are presented in Table II and graphically in Figures E through J in the Appendix. Comparison of the data was made at three freeness levels in Table III. The data showed that an extraordinarily sharp increase in strength properties occurred from the low permanganate number of 9.3 to the high permanganate number of 20. The change in strength properties was accompanied by a noticable increase in the beating time required to reach a given freeness. It should be noted at this time that the only means of comparing the cooks is by permanganate number, as yield data were not available. The permanganate numbers were run on the screened portion of the final pulp and in some cases, the screening rejects were 22% of the total final pulp, indicating that these permanganate numbers may not present the true picture of the degree of cooking.

Table IV makes a comparison of physical properties of pulps prepared in the isothermal digester and pulps made in a conventional vertical stationary autoclave. Since the wood source was identical, the major difference in the preparation of the pulps was in maximum temperature which was 205°C. in the isothermal digester and 176°C. in the conventional digester. Pulps having a permanganate number of 12 showed marked superiority in favor of the pulp made at 176°C. The cooks having a permanganate number

of 20 were much more similar in strength properties. The high temperature cooks appeared to be slightly lower in bursting, tearing and zero-span tensile strengths, and higher in tensile strength. This would indicate that the higher temperature may have slightly degraded the pulp fiber, but it had not inhibited its bonding potential. It is interesting to note that the tear factor in both of the high temperature cooks was lower than was the case with cooks made at 176°C. This differs from Walters' findings that tear increased with increasing cooking temperature. The data are insufficient at this time to indicate whether or not the conditions maintained in the isothermal digester contributed to this finding of Walters.

TABLE II

PHYSICAL PROPERTIES OF UNBLEACHED SPRUCE KRAFT PULPS

Cook		1		2		3		4		5	6
Permanganate No.		9.3		12.3		13.5		21.2		20.0	16.0
Yield, %		--		--		--		48.2		48.2	47.1
Schopper-Riegler freeness, cc.	0[a]	830	5[a]	840	0[a]	845	0[a]	850	0[a]	840	845
	5	780	10	830	10	820	10	840	20	830	825
	10	660	20	750	20	775	20	820	40	770	740
	15	425	30	615	30	720	40	760	60	620	550
	20	270	40	460	40	595	60	580	80	475	385
	--	--	--	--	60	410	80	405	100	340	--
Apparent density	0	12.0	5	12.6	0	10.9	0	10.1	0	10.3	10.0
	5	13.8	10	13.6	10	12.9	10	12.3	20	13.3	13.2
	10	15.2	20	14.5	20	14.3	20	13.1	40	14.4	14.4
	15	16.4	30	15.5	30	14.8	40	14.5	60	15.1	15.3
	20	17.4	40	16.5	40	15.9	60	15.4	80	16.1	16.4
	--	--	--	--	60	16.5	80	16.3	100	16.9	--
Bursting strength, pt./100 lb.	0	98	5	133	0	96	0	93	0	85	91
	5	110	10	141	10	144	10	142	20	151	148
	10	116	20	147	20	153	20	168	40	166	159
	15	114	30	134	30	153	40	167	60	166	160
	20	115	40	129	40	149	60	170	80	154	156
	--	--	--	--	60	145	80	159	100	161	--
Tear factor	0	1.13	5	1.28	0	1.88	0	2.25	0	2.12	2.14
	5	0.81	10	1.13	10	1.38	10	1.65	20	1.38	1.36
	10	0.73	20	1.03	20	1.14	20	1.44	40	1.19	1.17
	15	0.61	30	0.92	30	1.09	40	1.25	60	1.15	1.09
	20	0.55	40	0.82	40	1.00	60	1.15	80	0.99	0.98
	--	--	--	--	60	0.89	80	0.95	100	0.93	--
Tensile strength, lb./in.	0	29.3	5	30.6	0	29.7	0	25.3	0	26.5	24.5
	5	32.9	10	34.7	10	35.2	10	36.0	20	40.7	40.8
	10	31.9	20	37.0	20	39.1	20	38.4	40	42.3	41.7
	15	32.5	30	36.5	30	37.2	40	42.6	60	44.1	41.5
	20	31.2	40	40.7	40	38.7	60	43.5	80	43.0	42.6
	--	--	--	--	60	38.7	80	42.2	100	43.4	--
Zero-span tensile strength, lb./in.	0	37.4	5	49.1	0	52.2	0	58.7	0	52.9	54.2
	5	41.3	10	51.6	10	56.7	10	62.9	20	55.6	55.2
	10	40.8	20	51.0	20	58.3	20	61.3	40	58.5	53.3
	15	43.0	30	50.1	30	55.0	40	58.5	60	56.0	55.7
	20	40.8	40	47.5	40	53.4	60	56.4	80	55.5	52.1
	--	--	--	--	60	55.4	80	56.1	100	56.7	--

[a]Beating time, min.

TABLE III

COMPARISON OF PHYSICAL PROPERTIES OF UNBLEACHED SPRUCE KRAFT PULPS

Cook	1	2	3	6	5	4
Permanganate number	9.3	12.3	13.5	16.0	20.0	21.2
Maximum temp., °C.	200	208	205	210	205	205
Properties at 800-cc. Schopper-Riegler Freeness						
Beating time, min.	4.5	14.5	15.0	29.0	32.0	30.0
Apparent density	13.3	13.8	13.6	13.7	13.9	13.9
Bursting strength, pt./100 lb.	106	145	149	156	162	170
Tear factor	0.86	1.11	1.29	1.28	1.26	1.35
Tensile strength, lb./in.	31.7	35.8	36.2	41.3	42.5	41.0
Zero-span tensile strength, lb./in.	40.0	51.7	58.2	54.2	57.2	59.7
Properties at 600-cc. Schopper-Riegler Freeness						
Beating time, min.	11.0	31.0	40.0	55.0	63.0	58.0
Apparent density	15.5	15.7	15.8	15.7	15.5	15.4
Bursting strength, pt./100 lb.	118	140	152	160	166	168
Tear factor	0.67	0.91	1.00	1.10	1.08	1.12
Tensile strength, lb./in.	32.8	38.2	39.0	42.5	44.0	43.7
Zero-span tensile strength, lb./in.	42.8	50.0	53.3	55.2	56.0	56.7
Properties at 450-cc. Schopper-Riegler Freeness						
Beating time, min.	14.5	40.0	55.0	72.0	82.0	75.0
Apparent density	16.3	16.5	16.4	16.3	16.2	16.1
Bursting strength, pt./100 lb.	119	128	147	158	164	162
Tear factor	0.62	0.82	0.90	1.03	1.00	1.01
Tensile strength, lb./in.	32.3	38.8	38.7	42.5	43.8	43.0
Zero-span tensile strength, lb./in.	42.8	47.5	54.5	54.0	56.0	56.2

TABLE IV

COMPARISON OF PHYSICAL PROPERTIES OF SPRUCE COOKED AT 176 AND 205°C.

Cook	2	2017-C11	4	2017-28
Maximum temperature, °C.	205	176	205	176
Permanganate number	12.3	--	20.0	--
Yield, %	--	--	48.2	--
Properties at 750-cc. Schopper-Riegler Freeness				
Beating time, min.	20.0	52.0	41.0	57.0
Apparent density	14.5	14.9	14.6	14.7
Bursting strength, pt./100 lb.	147	182	171	187
Tear factor	1.03	1.30	1.24	1.37
Tensile strength, lb./in.	37.0	41.0	42.8	41.8
Zero-span tensile, lb./in.	51.0	66.0	58.4	63.4
Properties at 500-cc. Schopper-Riegler Freeness				
Beating time, min.	37.5	78.0	69.0	94.0
Apparent density	16.2	15.7	15.8	15.7
Bursting strength, pt./100 lb.	131	175	164	180
Tear factor	0.84	1.18	1.05	1.23
Tensile strength, lb./in.	38.5	41.0	43.5	42.3
Zero-span tensile, lb./in.	48.2	65.0	56.1	59.0

CONCLUSIONS

The following conclusions or trends were found in pulping spruce chips using the kraft process in the isothermal digester:

(1) The use of a variac to regulate the amount of heat applied to the sides of the isothermal digester is a great improvement over the previous manual manipulation of the wires.

(2) The installation of a permanent, single point, strip chart temperature recorder and an eight-point junction box has given the operator greater control over cooking temperature by providing him with a continuous check upon the digester contents at a given heating point.

(3) Conventional wood chips can be pulped in the isothermal digester using instantaneous rises to temperatures quite in excess of those used commercially in the kraft process. This is accomplished without evidence of burning. High screenings may be attributed to the practice of dumping the cooked chips instead of blowing them.

(4) Pulps made at 205°C. maximum temperature, achieved instantaneously in the isothermal digester, proved to be surprisingly similar in strength properties to pulps made in a conventional manner in laboratory equipment. Pulp strength suffered, however, when the pulping was continued beyond the degree usually considered normal for a bleachable grade of kraft pulp.

(5) The tendency for pulp tearing strength to increase with increasing maximum cooking temperature, noted by Walters, was not borne

out in this comparison. It should be pointed out, however, that the low temperature cooks used in the present comparison were made in conventional equipment and not in the isothermal digester.

APPENDIX

FIGURES A THROUGH D	TEMPERATURE-PRESSURE CYCLE FOR COOKS 4-6
FIGURES E THROUGH J	PHYSICAL PROPERTIES OF UNBLEACHED PULP OF COOKS 1-6

Figure A. Temperature-Pressure Cycle (Cook 3)

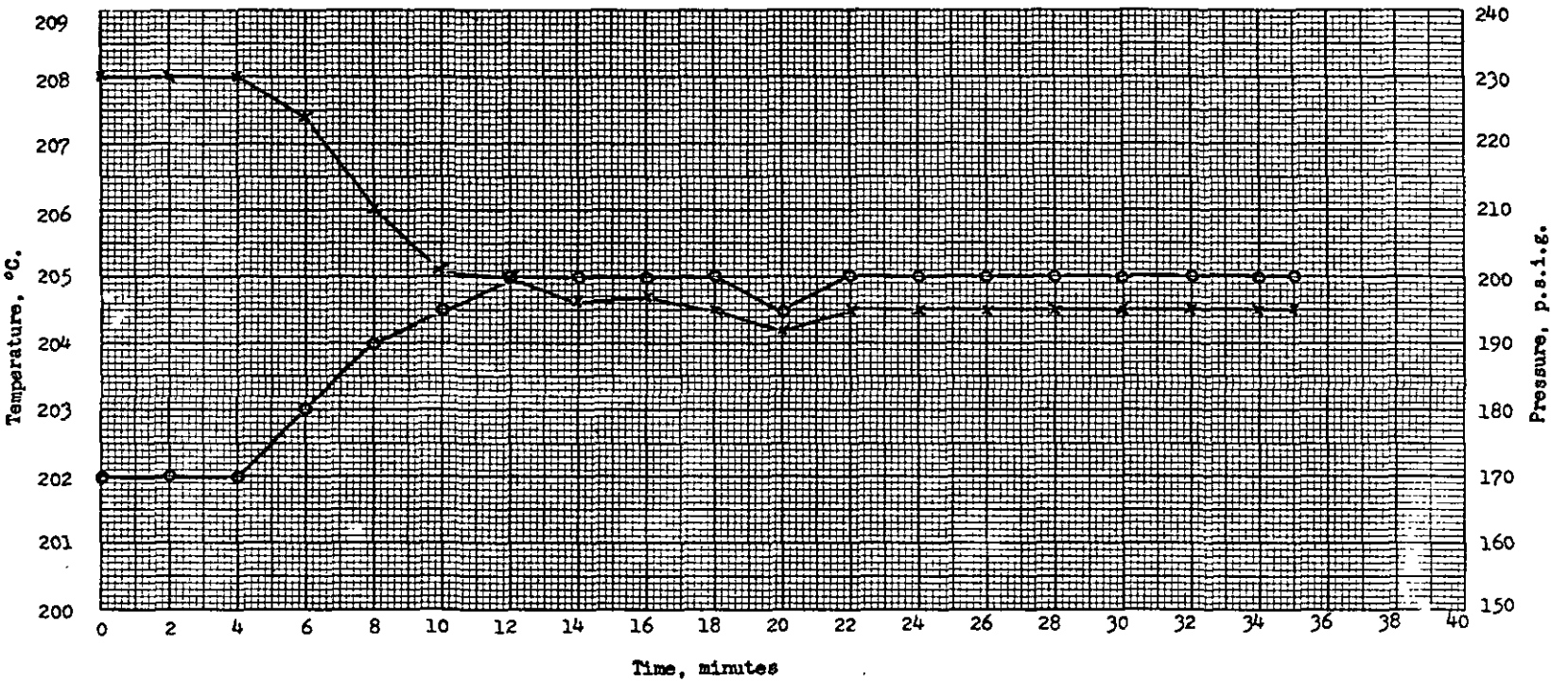


Figure B. Temperature-Pressure Cycle (Cook 4)

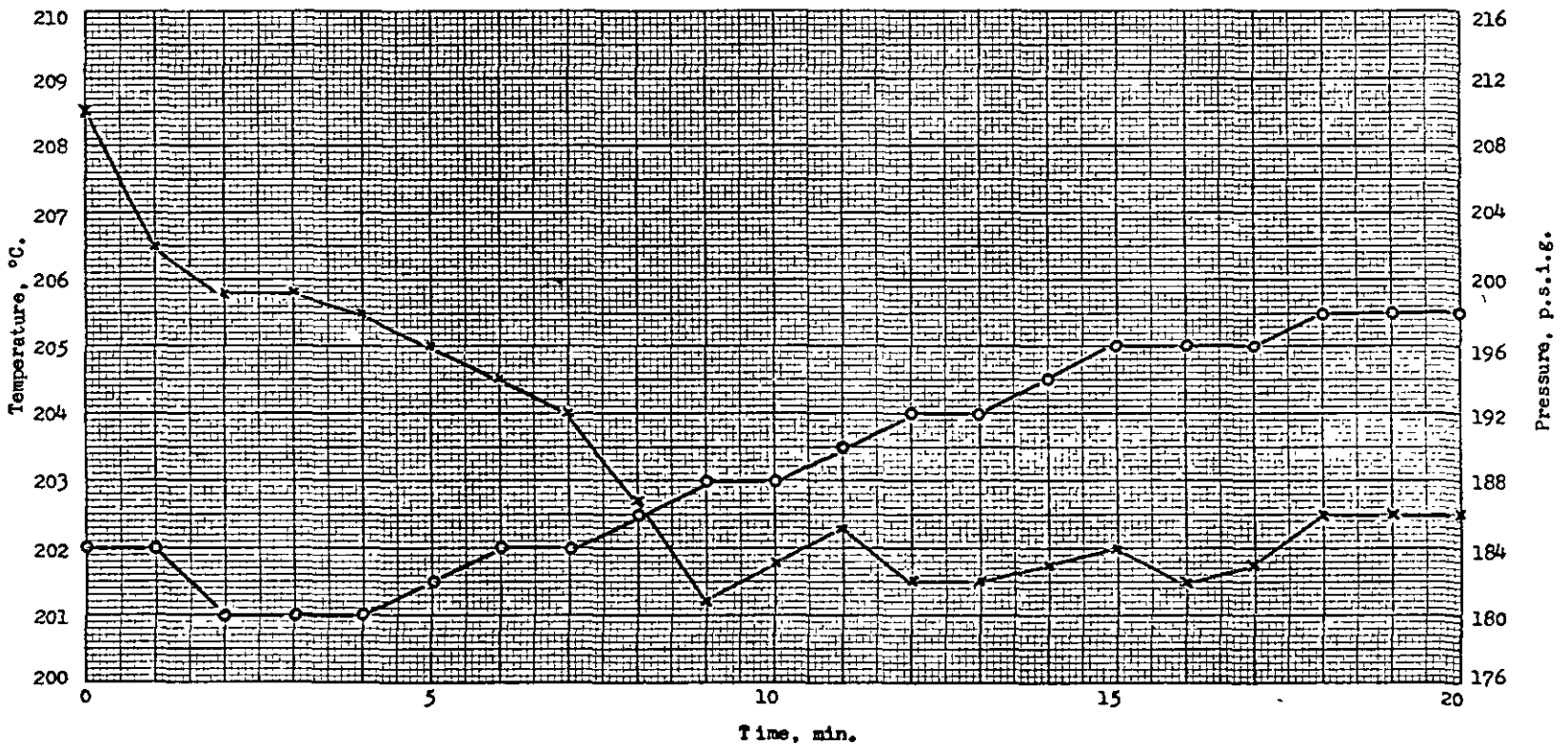


Figure C. Temperature-Pressure Cycle (Cook 5)

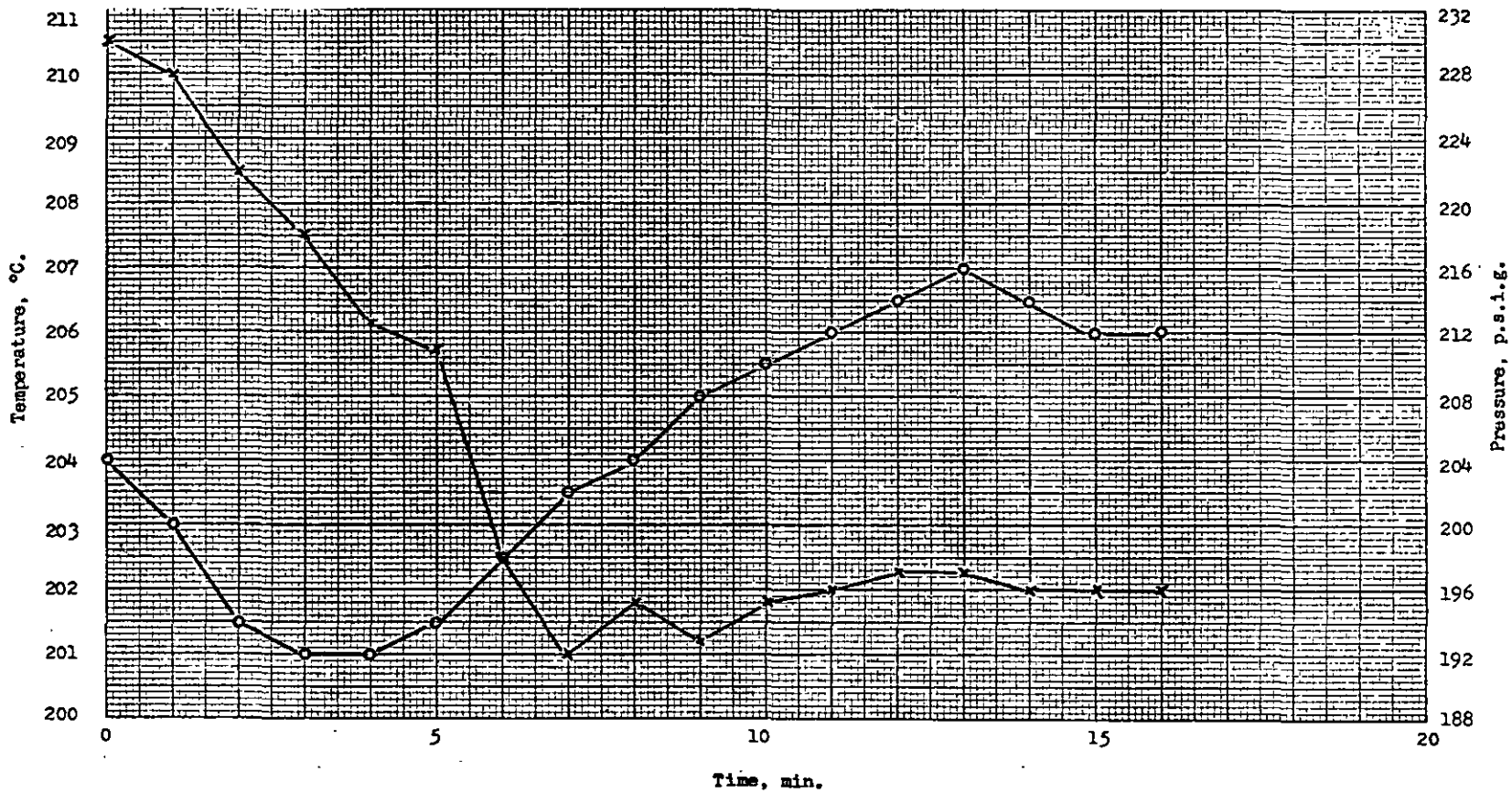
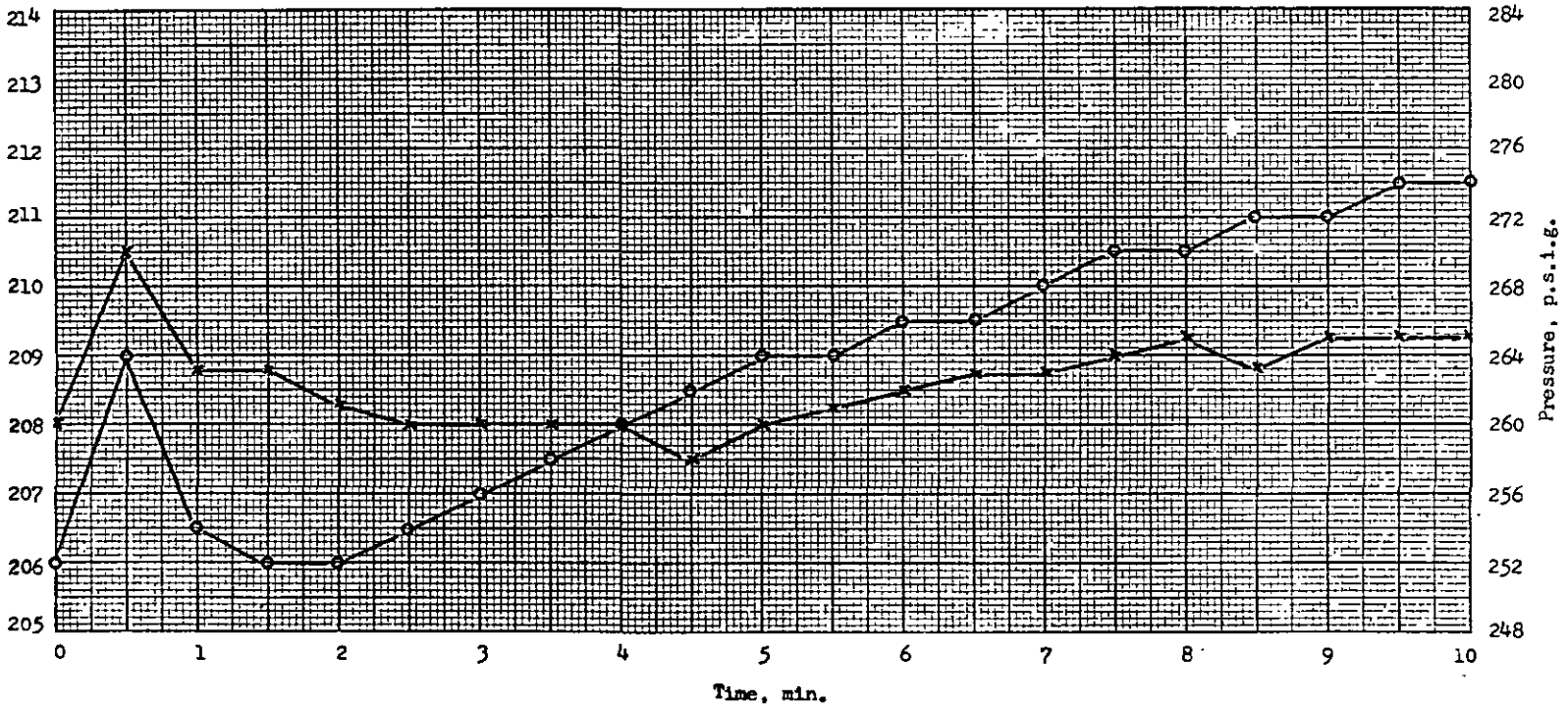


Figure D. Temperature-Pressure Cycle (Cook 6)



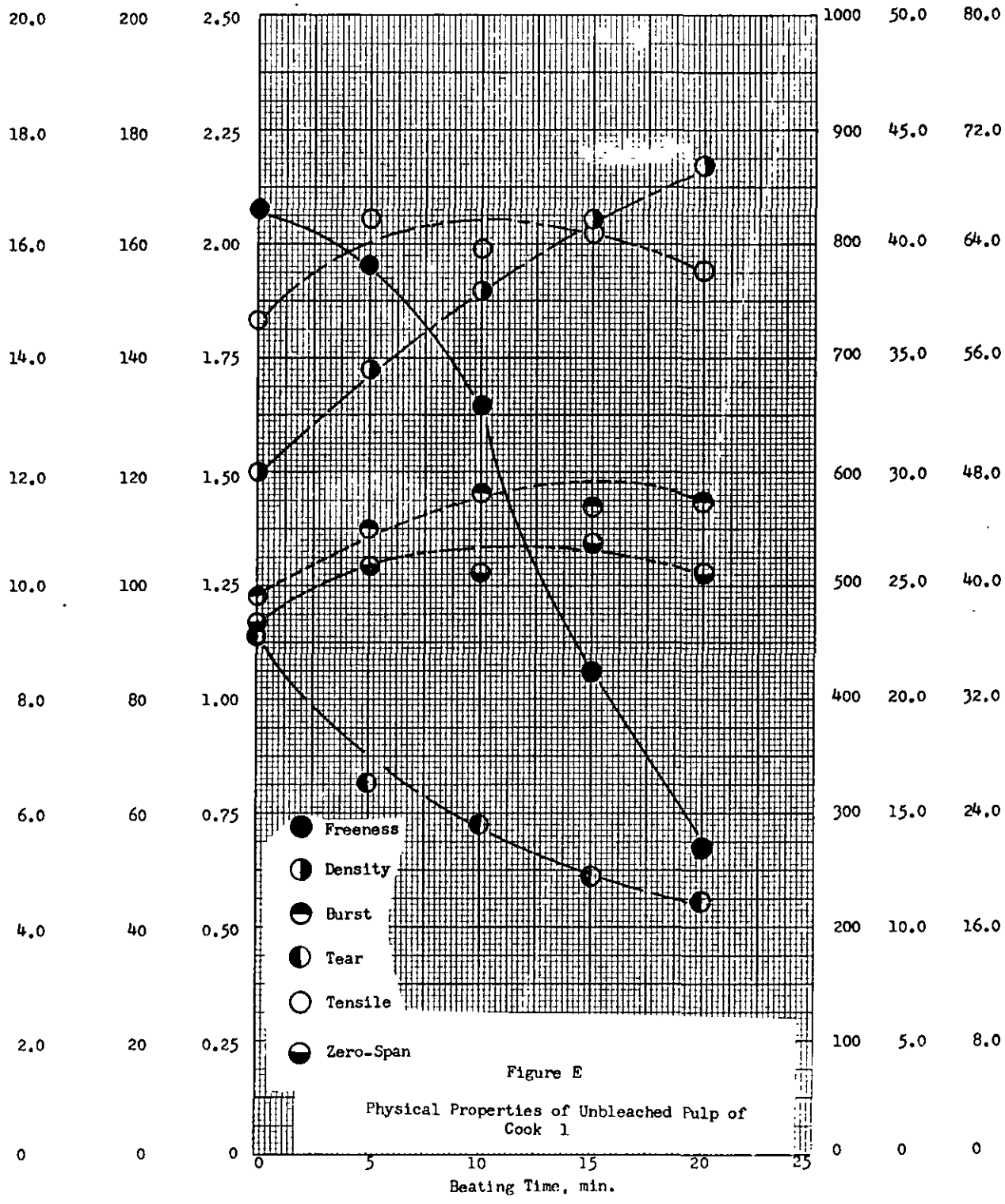


Figure E

Physical Properties of Unbleached Pulp of Cook 1

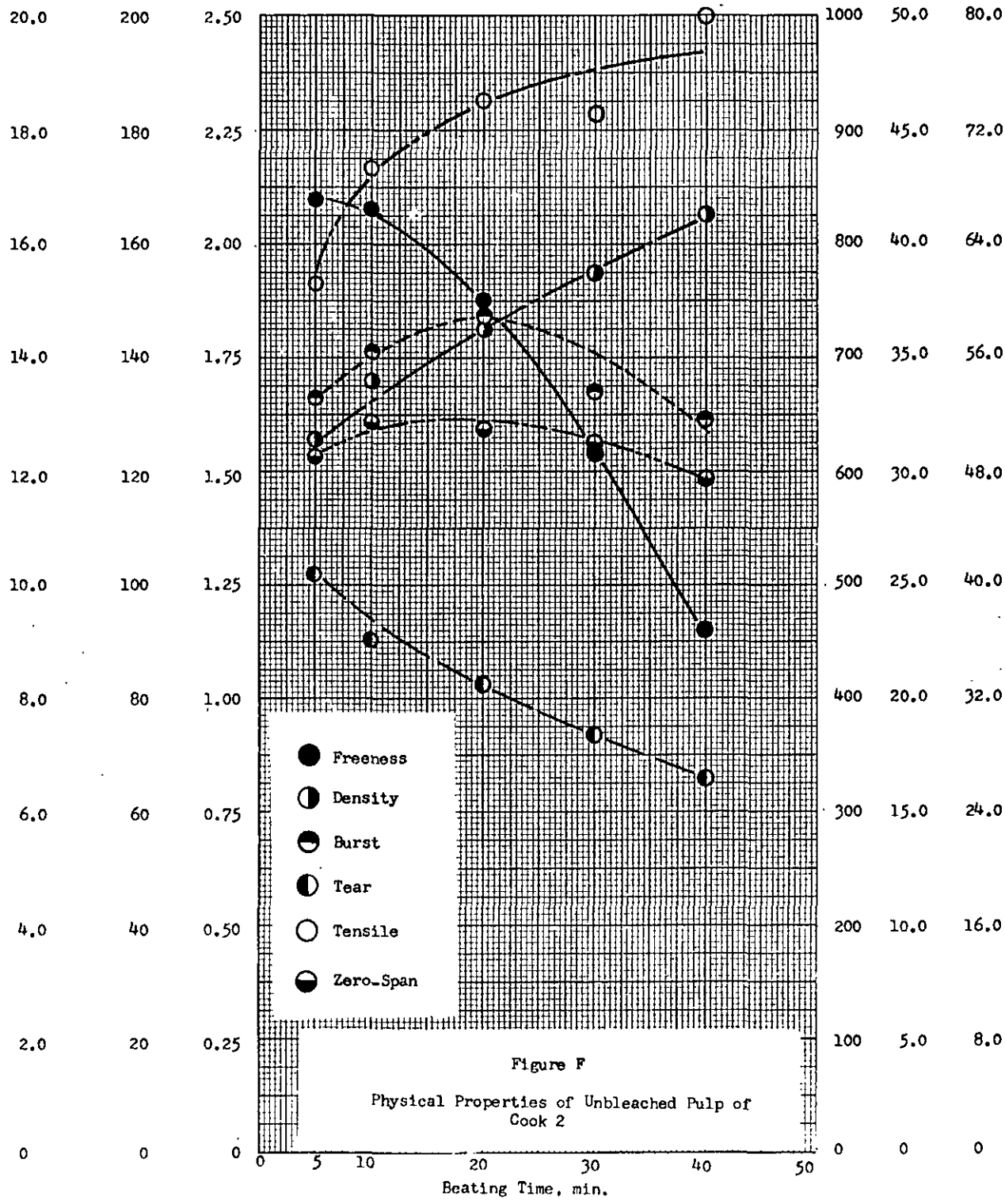


Figure F

Physical Properties of Unbleached Pulp of Cook 2

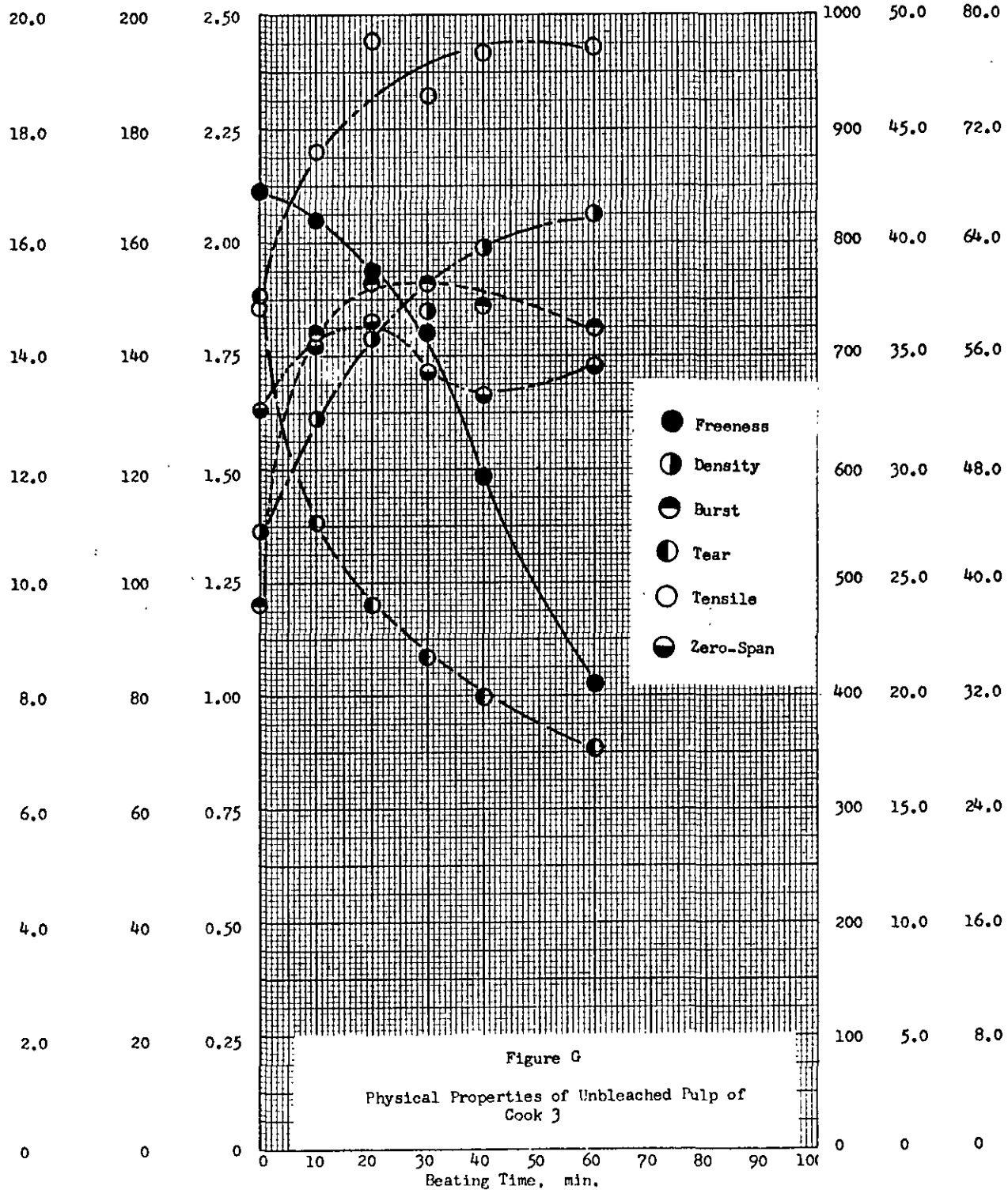


Figure G

Physical Properties of Unbleached Pulp of Cook 3

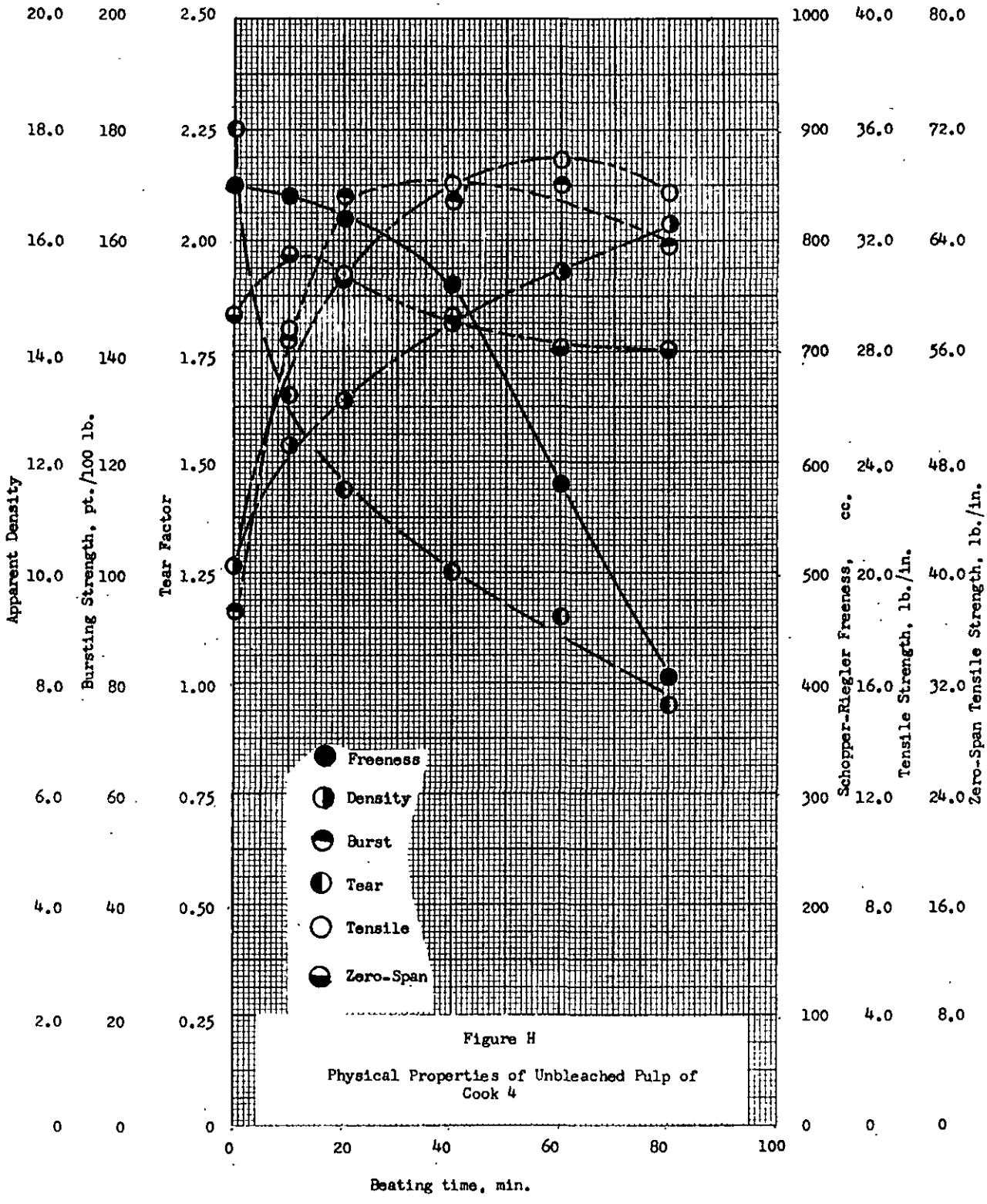


Figure H

Physical Properties of Unbleached Pulp of Cook 4

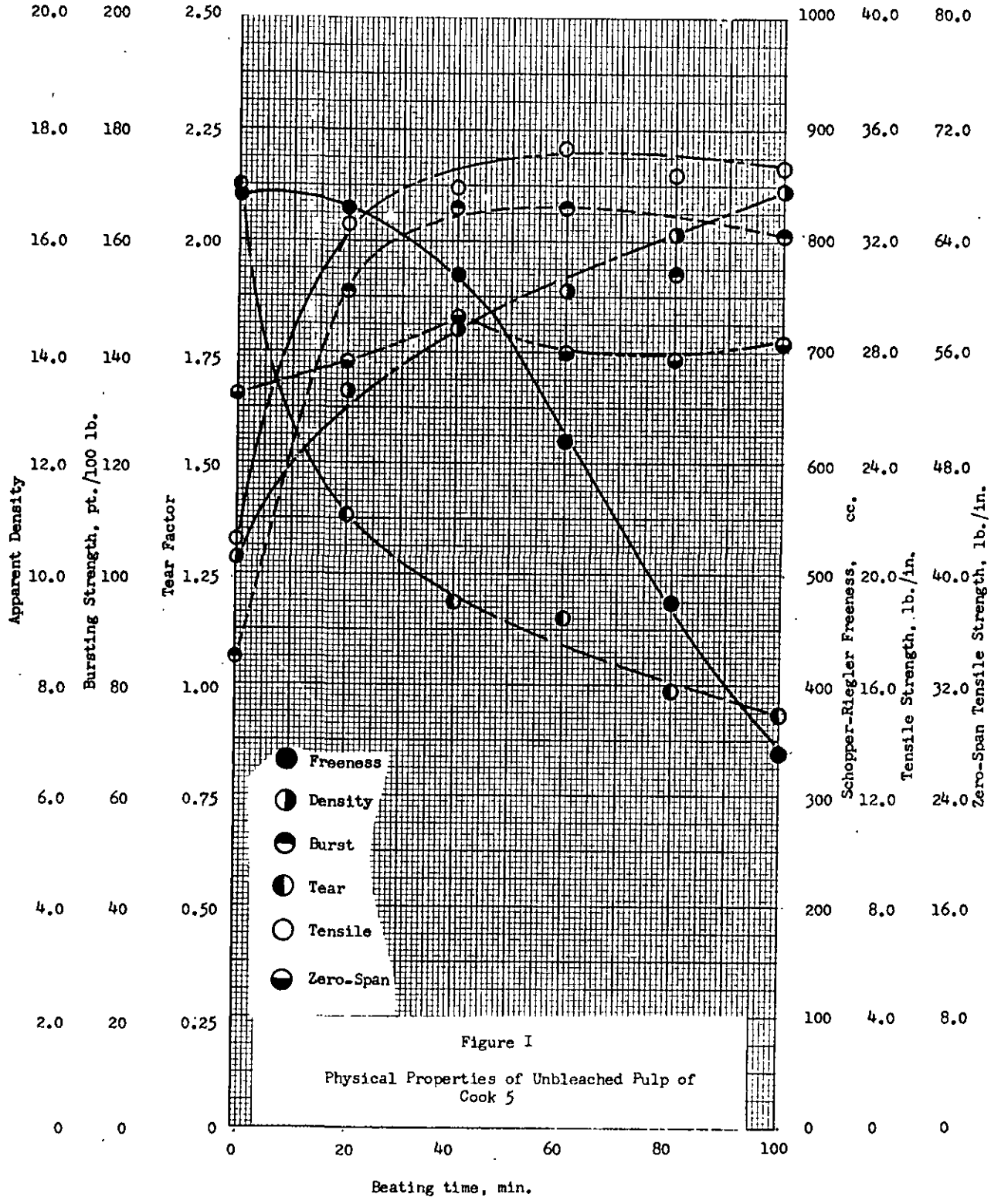


Figure I

Physical Properties of Unbleached Pulp of Cook 5

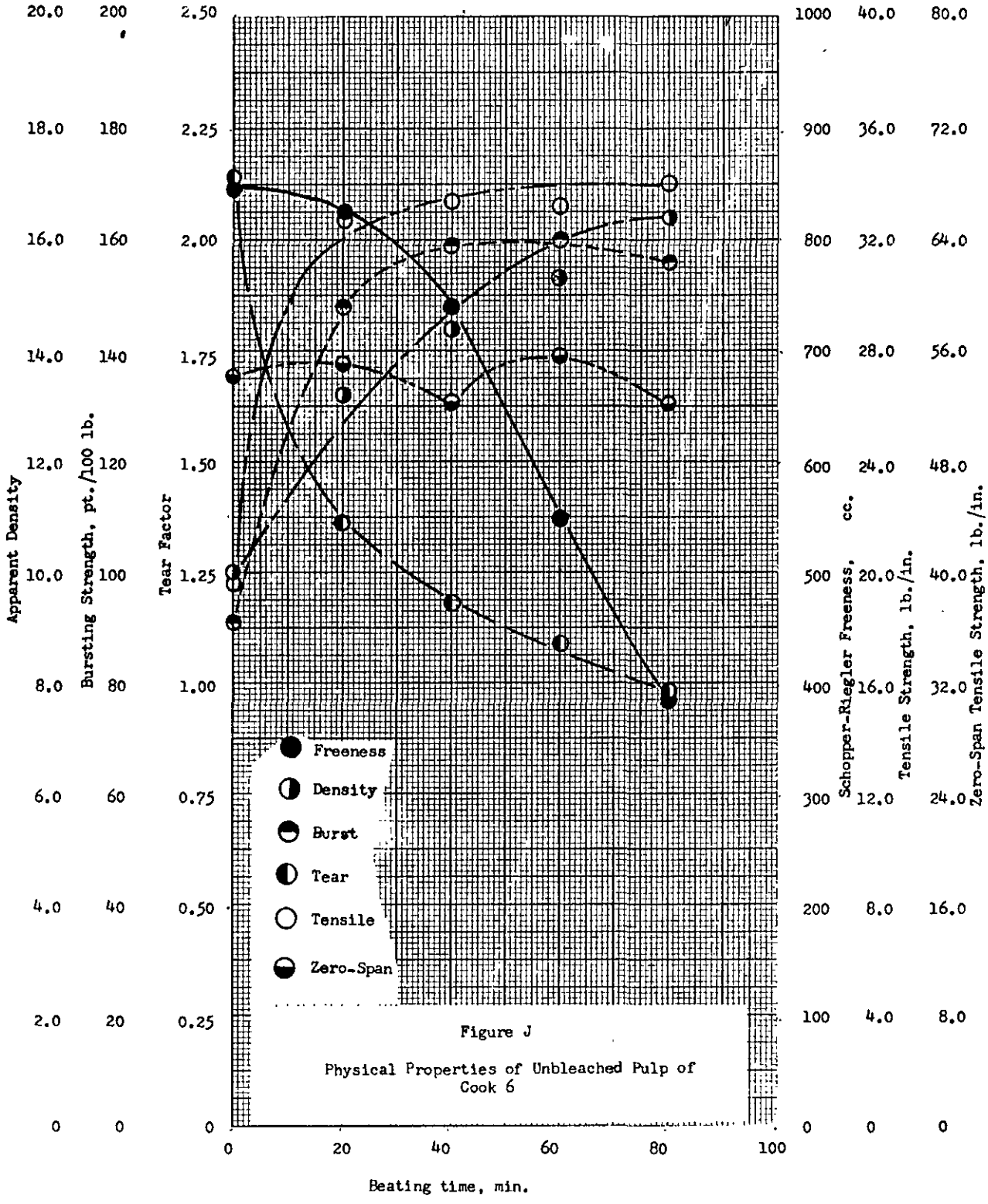


Figure J

Physical Properties of Unbleached Pulp of Cook 6