#1102-3 THE INSTITUTE OF PAPER CHEMISTRY
(Pulping)
Project Reports (1)

PROJECT REPORT FORM

Copies to: Files
Mr. Steele
Dr. Glidden
Mr. Kottwitz

PROJECT NO. 1102-3
COOPERATOR Institute
REPORT NO. 1
DATE May 18, 1948
NOTE BOOK 606
PAGE 80 TO 81
SIGNED Frank Kottwitz
Bob Schmid

EFFECT OF BEATING ON THE BRIGHTNESS OF UNBLEACHED SULFITE PULP

(Using Distilled and Tap Water)

OBJECTIVE

The use of tap water in pulp evaluation studies introduces the possibility of another significant variable. Recent publications, of English and Australian origin, have established the influence of certain tap water ions on the physical characteristics of refined pulp. This work has not, however, been comprehensive. The objective of this work is twofold. First, to establish a quantitative relationship between degree of beating and brightness (General Electric reflectance) of a typical unbleached sulfite pulp. Second, to determine whether the use of Appleton city tap water in the beating process produces a deleterious effect on the pulp brightness. The pulp used was Kapuskasing unbleached sulfite.

PROCEDURE

A sample of the pulp was beater evaluated (3-29-48) following Institute Method 403 (No. 3 Beater - 5,500 g. bedplate loading). In this method tap water is used throughout the beating and subsequent sheet making operations. Regular British handsheets were prepared and dried according to Institute Method 411. Beater intervals were 0, 5, 10, 25, and 40 minutes.

A second sample of the pulp was evaluated and formed into handsheets employing the above procedures with the following deviations. Distilled water was used in the beating and handsheet preparation. Interval samples were 0, 5, 10, 25, 40, 55, and 70 minutes. When preparing handsheets with distilled water, tap water was used under the wire.

The handsheets from both evaluations were conditioned 48 hours at 73° F, 50% R.H. before the General Electric reflectance was determined. Reflectance was determined for both the rough (felt) and smooth (wire) side. Wire side, as used here, is a misnomer because during drying the wire side remains in contact with a metal disc which produces a glossy surface on that side.

RESULTS AND CONCLUSIONS

The data have been listed in tabular form. See Table I. Examination shows that significant differences in brightness were not obtained when the unbleached sulfite pulp was beaten and formed into handsheets using distilled water throughout as compared to the normal treatment using tap water. Critical examination of the data indicate a general trend of slightly higher brightness for the tap water treatment, but this is probably due to normal variations of the processing and testing procedures.

Figure 1 is a graphic representation obtained for the quantitative relationship of degree of beating and General Electric brightness. Here the distilled water run was chosen because of the more extensive coverage of the freeness range. In this instance, using distilled water, the reduction in brightness produced by beating is a result of changes in scattering power of the handsheet optical surface. This light scattering power is closely associated with the more general term "texture."

The results of this work should not be construed in a general manner. It should be realized that identical results, speaking qualitatively, may not be obtained with a "high white" pulp, and that the effect of tap water may be subject to seasonal variations in water supply.

TABLE I: BRIGHTNESS OF BEATER EVALUATED PULPS

Beating Time, min.	Tap Water			Distilled Water		
	S. R. Freeness cc.	G. E. Brightness, %		S. R. Freeness cc.	G. E. Brightness, %	
		Rough Side	Smooth Side		Rough Side	Smooth Side
0	865	61.6	61.0	870	61.2	60.6
5	855	59.9	59.2	855	59.2	58.5
10	850	59.4	58.4	845	58.3	57.3
25	745	56.3	55.3	745	55.3	54.7
40	590	53.1	51.9	580	53.4	53.0
55	--	--	--	400	51.4	51.5
70	--	--	--	240	48.2	48.1

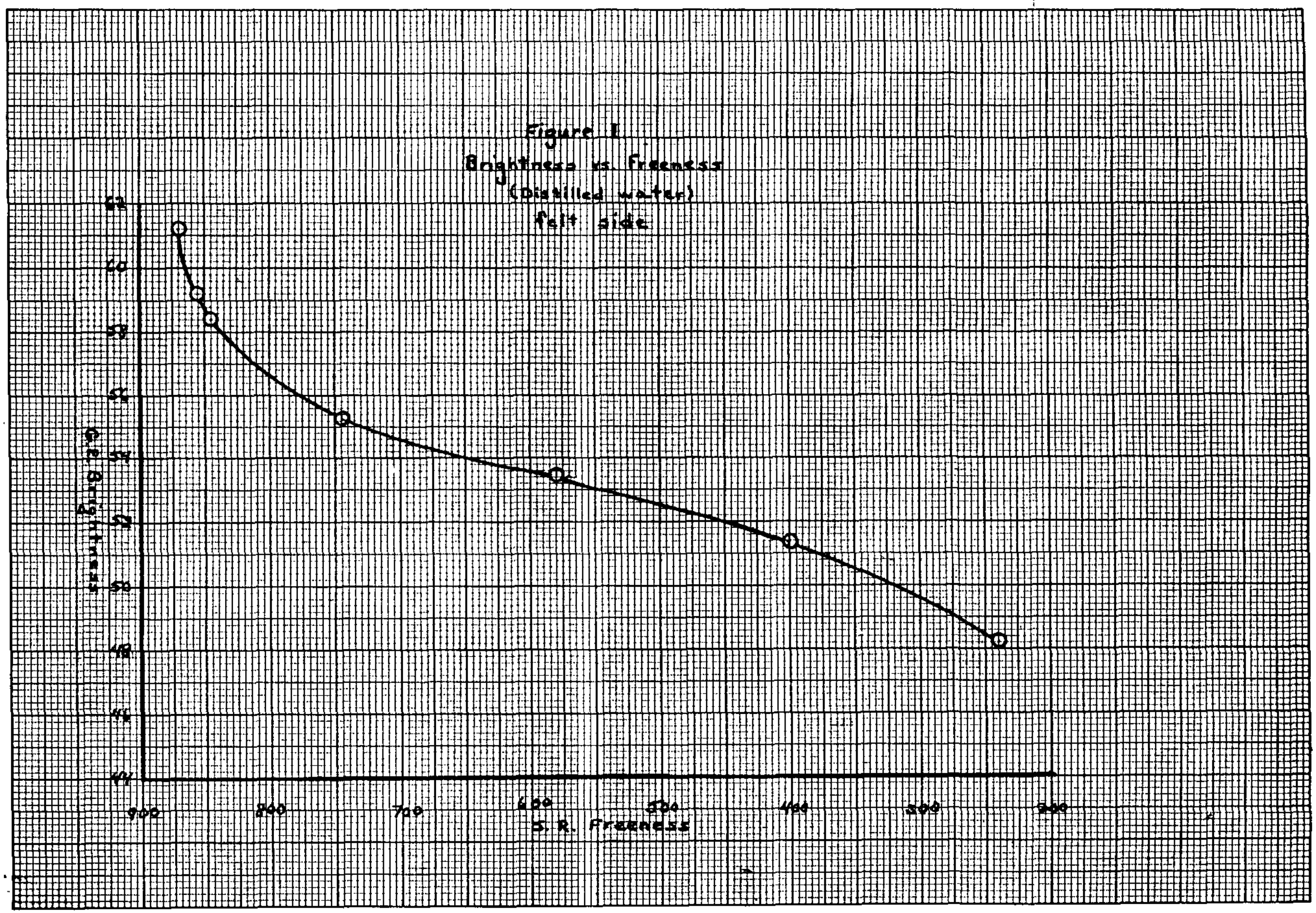
Figure 1
Brightness vs. Freeness
(Distilled water)
felt side
G.E. Brightness
62
60
58
56
54
52
50
48
46
44
900
800
700
600
500
400
300
200
S. R. Freeness

PROJECT REPORT FORM

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PROJECT NO. 1102-3
COOPERATOR Institute
REPORT NO. 2
DATE July 6, 1948
NOTE BOOK 606
PAGE 80 TO 81
SIGNED F. Kottwitz
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R. Schmid

EFFECT OF TAP WATER ON THE TENSILE STRENGTH OF UNBLEACHED SULPHITE PULP
(Distilled and Tap Water Comparison)

The use of tap water in pulp evaluation studies may effect pulp quality and paper physical characteristics. These effects, however, are specific with water supply. A study of the Appleton city water, its effect on brightness, was made.

Refer to May 18, 1948, report of Project 1102-3, the Effect of Beating on the Brightness of Unbleached Sulphite Pulp. This report covers an extension of that work wherein tensile strength determinations were made on samples taken from the brightness study.

Procedure

A sample of pulp was beater evaluated (3-29-48) following Institute Method 403 (No. 3 beater - 5,500 gm. bedplate loading). In this method tap water is used throughout the beating and subsequent sheet-making operations. Regular British handsheets were prepared and dried according to Institute Method 411. Beater intervals were 0, 5, 10, 25, and 40 minutes.

A second sample of the pulp was evaluated and formed into handsheets as described in the above procedure with the exception that distilled water was used in place of tap water and the intervals were extended to include 0, 5, 10, 25, 40, 55, and 70 minutes. When preparing the handsheets with distilled water, tap water was used under the wire.

The handsheets from both evaluations were conditioned for 48 hours at 73° F. 50% R. H. before General Electric reflectance was determined. These results have been reported. Data on Schopper tensile strength results were obtained from the specimens (1-1/2 by 2 inches) used for the brightness determinations in May 18, 1948, report. The length of the tensile strip was one inch.

Results and Conclusions

The data have been listed in Table I. Examination shows that significant differences in tensile strength were not obtained when the unbleached sulphite pulp was beaten and formed into handsheets using distilled water throughout as compared to using the normal treatment of tap water. It should be noted, however, that the tap water run was not carried to the lower freeness range of the distilled water evaluation.

Figure I is a graphic comparison of tensile strength versus freeness of both the tap water and distilled water evaluations.

These results should not be given general interpretation since identical results, speaking qualitatively, may not be obtained with all of the various type pulps, and tap water effects may be subject to seasonal variations in water supply.

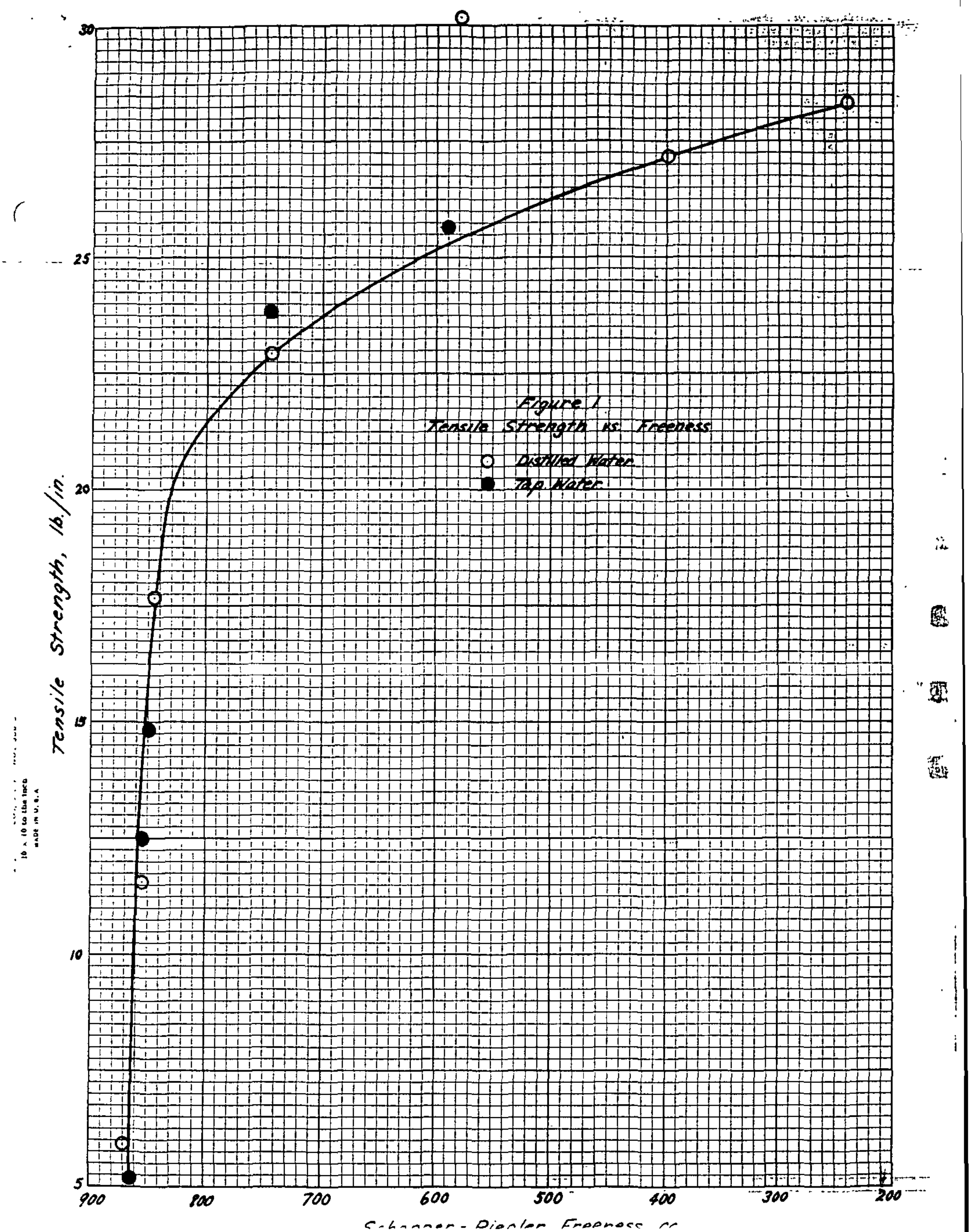
Figure 1
Tensile Strength vs. Freeness
Distilled Water
Tap Water
Tensile Strength, lb./in.
30
25
20
15
10
5
900
800
700
600
500
400
300
200
Schopper - Riegler Freeness, cc.
10 x 10 to the inch
MADE IN U.S.A.

TABLE I

TENSILE STRENGTH OF BEATER EVALUATED PULP

Beating Time, min.	Tap Water			Distilled Water		
	Schopper-Riegler Freeness, cc.	Basis Weight, lb. 25 x 40/500	Schopper Tensile, lb./inch	Schopper-Riegler Freeness, cc.	Basis Weight, lb. 25 x 40/500	Schopper Tensile, lb./inch
0	865	44.2	5.2	870	47.9	5.9
5	855	45.2	12.5	855	45.9	11.6
10	850	44.9	14.8	845	44.8	17.7
25	745	45.5	23.8	745	45.1	22.9
40	590	45.1	25.7	580	45.0	30.2
55	---	---	---	400	44.2	27.2
70	---	---	---	240	43.9	28.3

Institute File No.	Code No.	Beating Time, min.	Schopper-Riegler Freeness, cc.	Basis Weight, lb. 25x40/500	Schopper Tensile, lb./inch
					lb./15 mm.
131010	1102-3-A (Distilled Water):	0	870		3.6
					3.7
					3.2
					4.0
					3.0
				Av.: 47.9	3.50 =
					5.9 lb./in.
		5	855		7.1
					5.3
					7.2
					8.1
					6.7
				Av.: 45.9	6.88=
					11.6 lb./in.
		10	845		10.5
					10.3
					11.6
					9.4
					10.5
				Av.: 44.8	10.46=
					17.7 lb./in.
		25	745		13.2
					14.1
					13.7
					15.4
					11.3
				Av.: 45.1	13.54=
					22.9 lb./in.
		40	580		16.9
					18.5
					19.0
					17.4
					17.3
				Av.: 45.0	17.82=
					30.2 lb./in.
		55	400		14.9
					15.4
					16.5
					18.1
					15.3
				Av.: 44.2	16.04=
					27.2 lb./in.

Institute File No.	Code No.	Time, min.	Schopper-Riegler Freeness, cc.	Basis Weight, lb. 25x40/500	Schopper Tensile, lb./inch
					lb./15 mm.
131010 (continued)	1102-3-A (Distilled Water):	70	240		16.5
					15.9
					15.4
					18.2
					17.5
				Av.: 43.9	16.70= 28.3 lb./in.

Notes: The handsheets were conditioned and tested at 50% R.H., 73° F.
All the data in this report were obtained from the specimens (1-1/2 by 2 inches) used for the brightness determinations. The length of the tensile strip was one inch.
Weight on bedplate = 5500 grams.

Institute File No.	Code No.	Beating Time, min.	Schopper-Riegler Freeness, cc.	Basis Weight, lb. 25x40/500	Schopper Tensile lb./inch
					lb./15 mm.
130956	1102-3:	0	865	Av.: 44.2	3.1 3.1 3.2 2.8 3.2 3.08 = 5.2 lb./in.
		5	855	Av.: 45.2	6.4 7.7 7.5 7.8 7.5 7.38 = 12.5 lb./in.
		10	850	Av.: 44.9	7.8 8.6 9.0 9.2 9.0 8.72 = 14.8 lb./in.
		25	745	Av.: 45.5	13.9 14.1 14.7 13.7 13.9 14.06 = 23.8 lb./in.
		40	590	Av.: 45.1	12.6 16.8 15.4 15.2 16.0 15.20 = 25.7 lb./in.

Notes: The handsheets were conditioned and tested at 50% R.H., 73° F.
All the data in this report were obtained from the specimens (1-1/2 by 2 inches) used for the brightness determinations. The length of the tensile strip was one inch.
Weight on bedplate = 5500 grams.

PROJECT REPORT FORM

PROJECT NO. 1102-3
COOPERATOR Institute
REPORT NO. 3
DATE October 21, 1949
NOTE BOOK
PAGE TO
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CORRELATION OF PHYSICAL PROPERTIES OF VARIOUS PULPS

This work was done in an attempt to establish a correlation between strength data and caliper and apparent density on British handsheets. Most of the data was taken from work reported on earlier projects.

The projects investigated were as follows:

Project No.	Co-operator
1126	Crown Zellerbach Corporation
1274-C	Crown Zellerbach Corporation
1348	Howard Paper Mills, Inc.
1425	Kalamazoo Vegetable Parchment Co.
1457	Fibreboard Products Inc.
1481	Nekoosa-Edwards Paper Company

The majority of the data was taken from standard Valley beater evaluations of the various pulps. If the procedure was modified or if a different refiner was used, it is mentioned in this report. Most of the data was taken from Code Office reports. It is not tabulated, but the file numbers are shown to facilitate future reference. Any data not obtained from Code Office reports are tabulated in this report.

The graphs drawn for this study were merely rough sketches, and no copies were made. The original graphs are attached to the file copy of this report.

The data taken from Project 1126 were physical properties of Douglas fir, hemlock, and cedar kraft pulps. The Institute file numbers for these data are 121669, 121673, and 121696.

Figure 1 is a plot of bursting strength, tensile strength, and tear factor vs. caliper for the hemlock and Douglas fir pulps. From the appearance of these curves, it appears that the strength curves for hemlock pulp may be a continuation of the corresponding curves for Douglas fir pulp with some overlapping occurring at the end of the beating cycle for Douglas fir pulp and at the start of the beating cycle for hemlock pulp.

Figure 2 shows three plots of tensile strength vs. caliper. The bottom curve is the tensile strength in lb./in. vs. caliper as plotted in Figure 1. The next curve is the same except that a basis weight correction has been applied to the tensile strength values. These values were obtained by dividing the tensile strength in lb./in. by the basis weight in lb. and multiplying by 100. The top curve is the same except that a caliper correction has been applied to the tensile strength values. The original tensile strength was merely divided by the caliper.

Neither of the top two curves shows an improvement over the bottom curve as far as showing a continuous curve for the two pulps is concerned.

Figure 3 shows the same values of tensile strength plotted against apparent density. These curves show an improvement over those plotted against caliper. In the bottom curve the cedar pulp is also included, and it seems to fall fairly close to the same line.

Figure 4 is included to show the variation between the tensile strength of Douglas fir and hemlock pulps as indicated by a normal beating curve.

Figure 5 shows the bursting and tearing strength for the three pulps plotted against apparent density. These two properties for the hemlock and Douglas fir pulps do not seem to come any closer to being on a common curve than they did when plotted against caliper in Figure 1. It is noticed that the curves for the cedar pulp lie between those for the hemlock and Douglas fir pulps.

The only strength data obtained on hemlock and Douglas fir pulps in Project 1274-C were tensile strength. The file numbers for these data are 131351 to 131358 for the Douglas fir pulp and 131465 to 131472 for the hemlock pulp. The basis weight of the sheets made for this project was approximately one-half of the normal basis weight for British handsheets.

The tensile strength is plotted against caliper in Figure 6 and against apparent density in Figure 7. Both curves indicate that the tensile strengths of the two pulps fall on a common curve with Figure 7 showing the least variation of points from this curve.

Figure 8 is included to show the variation between the two pulps as indicated by normal beating curves.

The data from Project 1348 were then investigated to see what an analysis of this type would indicate when different refiners were used on the same pulp. The refiners used were the Valley beater, the Abbé pebble mill, the Lampén ball mill, and the Morden stock maker. The file numbers for these data are 131095 for the Valley beater, 131386 for the Lampén ball mill, 131331 for the Morden stock maker, and 133217 to 133222 for the pebble mill. Plotting bursting and tearing strength against caliper in Figure 9 does not show close agreement between any of the four refiners used except for tearing strength of stock refined in the Valley beater and the Morden stock maker. The tear curve for the stock refined in the Lampén mill is also fairly close to these curves.

Figure 10 shows the same properties plotted against apparent density. This method of plotting shows very close agreement between the Valley beater and the Morden stock maker in both bursting and tearing strength. No tensile strength data were obtained in this project.

Project 1425 was an investigation of four different pulps. The file numbers for these data are 134921, 134970, 134922, 134971, 134941, 134962, 134942, and 134963. In Figures 11 to 13, bursting, tearing, and tensile strength are plotted against caliper. No striking similarity can be seen between any of the four pulps from these curves. In Figure 14, the bursting strength is plotted against apparent density, and again no similarity can be noticed. In Figure 15, the tensile strength is corrected to be lb./in./100 lb. and plotted against apparent density, and no similarity is noticed.

Project 1457 investigated three species of western firs that were cooked to approximately the same permanganate number. Douglas fir, white fir, and red fir were cooked separately, and a blend consisting of 75% red fir and 25% white fir was also pulped. The file numbers for these data are 136008 for the red fir, 136009 for the white fir, 136010 for the Douglas fir, and 136153 for the blend. The bursting and tearing strength for these pulps are plotted against caliper in Figure 16. These curves show fairly close agreement for the red fir, white fir, and the blend in tearing strength and the red fir and the blend in bursting strength. It is interesting to note that the bursting strength of the Douglas fir and the white fir pulps fall on the same straight line except for the last two beating intervals when the maximum bursting strength has been developed.

In Figure 17, the same properties have been plotted against apparent density, and the curves follow the same trends without appreciable difference, except that the curves are not as straight.

In Project 1481, duplicate beater runs were made on the co-operator's pulp. The file numbers for these data are 137514 and 137515.

Figure 18 shows the normal beating curves for these two beater runs. This graph shows that all the data are in close agreement except for tensile strength.

Figure 19 shows the strength data plotted against caliper. The tearing strength agrees very well for the two beater runs, but the bursting strength shows more variation than in the normal beating curves. The tensile strength still shows a wide variation between the two runs.

In Figure 20, tensile strength is given both a basis weight correction and a caliper correction and plotted against caliper, but neither correction brings the two beater runs into close agreement on tensile strength.

In Figure 21, the strength data are plotted against apparent density with about the same results as shown in Figure 19.

The remainder of this study was confined to an analysis of some data obtained by Mr. Neimeyer in conjunction with setting up Project 1274-C. This work was a study of the effect of variable wet pressing of British handsheets. The Code Office report on this data could not be located so it is tabulated in Tables I and II.

TABLE I

EFFECT OF VARIABLE WET PRESSING ON NEKOOSA KRAFT BEATEN 2 MINUTES TO 850 cc. S.R. FREENESS

(Basis Weight - 47 lb., 24x36/480)

Moisture Content	61.7	55.2	36.5
Caliper, in. x 10^3	9.7	8.0	5.0
Density, g./cc.	0.32	0.41	0.61
Bursting Strength, pt./100 lb.	25	38	73
Tensile Strength, lb./in.	6.63	9.60	18.3
Tensile Strength, lb./in.^{2}	684	1200	3650

TABLE II

EFFECT OF VARIABLE WET PRESSING AT VARIOUS DEGREES OF BEATING, CROSSETT UNBLEACHED KRAFT

(Basis Weight - 40 lb., 24x36/480)

Freeness, cc.	875	855	820	805	720
Normal wet pressing, moisture content about 65%:					
Caliper, in. x 10^3	9.2	6.5	5.4	5.1	5.1
Density, g./cc.	0.29	0.41	0.48	0.52	0.52
Bursting Strength, pt./100 lb.	16	82	127	124	144
Tensile Strength, lb./in.	3.16	14.4	19.0	21.8	24.4
Tensile Strength, lb./in.^{2}	344	2220	3520	4290	4800
Excessive wet pressing, moisture content about 35%:					
Caliper, in. x 10^3	4.6	4.4	4.1	4.1	3.9
Density, g./cc.	0.56	0.65	0.67	0.66	0.68
Bursting Strength, pt./100 lb.	61	134	170	169	173
Tensile Strength, lb./in.	12.7	23.2	28.4	30.0	30.0
Tensile Strength, lb./in.^{2}	2770	5280	6930	7330	7690

Figure 22 shows a graph of the properties in Table I plotted against moisture content. This graph indicates that all the properties except caliper give a linear relationship with respect to moisture content.

Figure 23 is a graph of the data from Table II plotted against freeness. This graph shows a comparison of the properties at two degrees of wet pressing. It shows that the density, bursting strength, and tensile strength were increased and the caliper decreased by wet pressing to 35% moisture rather than the usual 65% moisture.

Figure 24 is a graph of the strength data vs. caliper, and Figure 25 is a graph of the same data vs. density. No correlation is evident in these graphs.

CONCLUSIONS

From this work, the following conclusions can be drawn:

1. It appears that caliper and apparent density are responsible for the differences in the strengths of hemlock and Douglas fir pulp. If the strength data are plotted vs. either caliper or apparent density, it seems that there may be a possibility of the corresponding data for the two pulps giving a common curve with the hemlock having more bursting and tensile strength and less tearing strength because of its higher apparent density. This could be investigated further by wet pressing Douglas fir handsheets to the same caliper and apparent density as hemlock handsheets and

obtaining strength data on these sheets.

2. When strength data for pulp refined in the Valley beater and the Morden stock maker are plotted vs. apparent density, the bursting strength and tearing strength data give common curves for the two refiners.

3. When plotting strength data for red fir, white fir, and Douglas fir pulps vs. caliper and apparent density, the tearing strength of the red and white fir pulps follow the same curve with the red fir having less tearing strength due to its higher apparent density. The bursting stength of the Douglas fir and white fir pulps follow a common curve up to the point where maximum bursting strength is developed. The white fir pulp has a higher apparent density and a higher bursting strength.

4. Wet pressing handsheets to three different moisture contents and plotting the physical properties vs. the moisture content shows that density, bursting strength, and tensile strength have a linear relationship with respect to moisture content while caliper does not.

5. The degree of wet pressing has a decided effect on the physical properties of the pulp. Wet pressing to a lower moisture content increases density, bursting strength, and tensile strength, and decreases caliper.

6. In a number of the curves plotted, it was noticed that there was a linear relationship for bursting, tearing, and tensile

strengths with respect to caliper for nearly all of the pulps in the middle range of the beating cycle. In some cases this linear relationship covered the entire beating range.

jfw/mc

THE INSTITUTE OF PAPER CHEMISTRY

BEATING CURVES

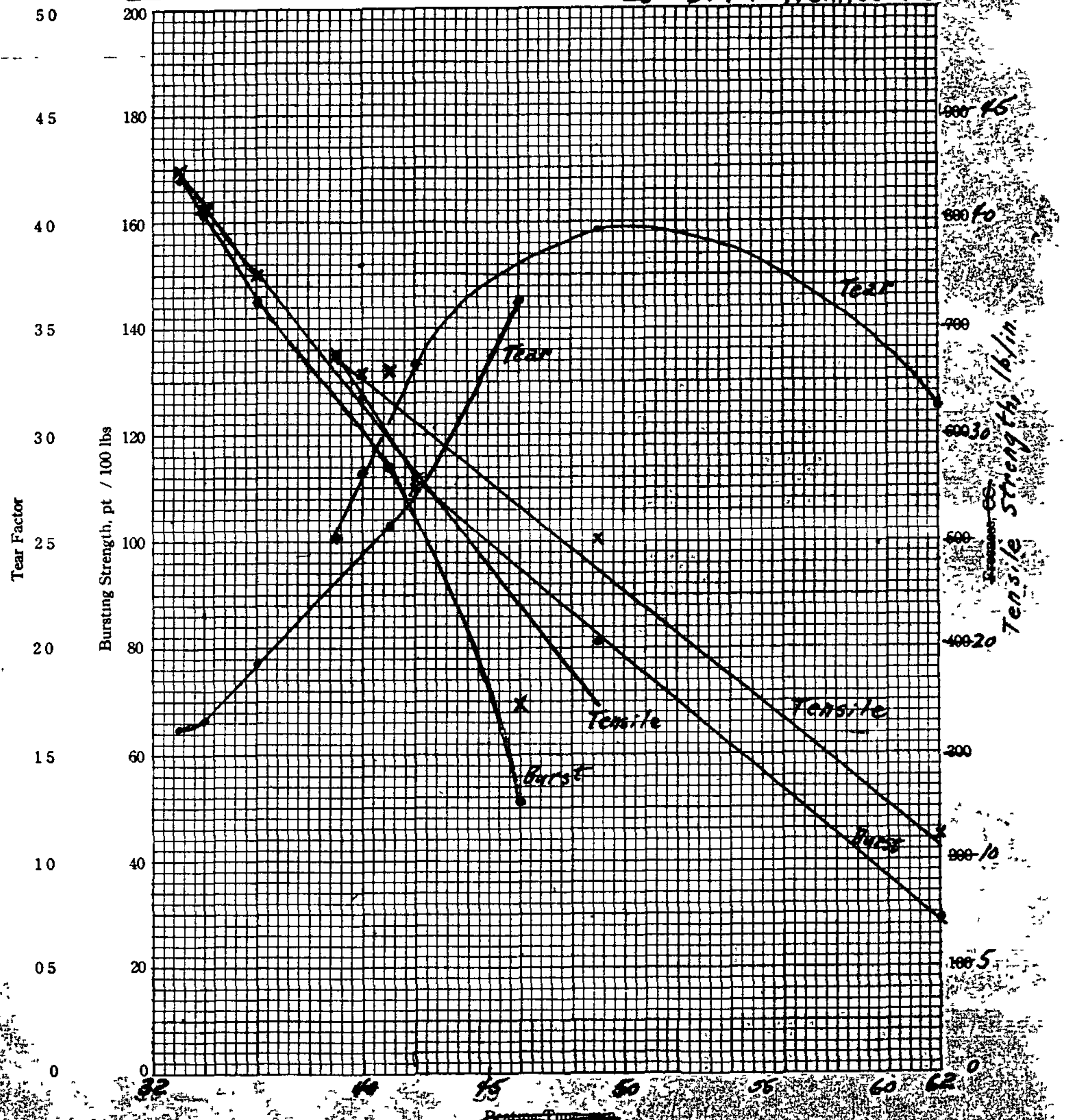
Project ______ Date ______

File No. ______ Type of Pulp ______

Cook ______

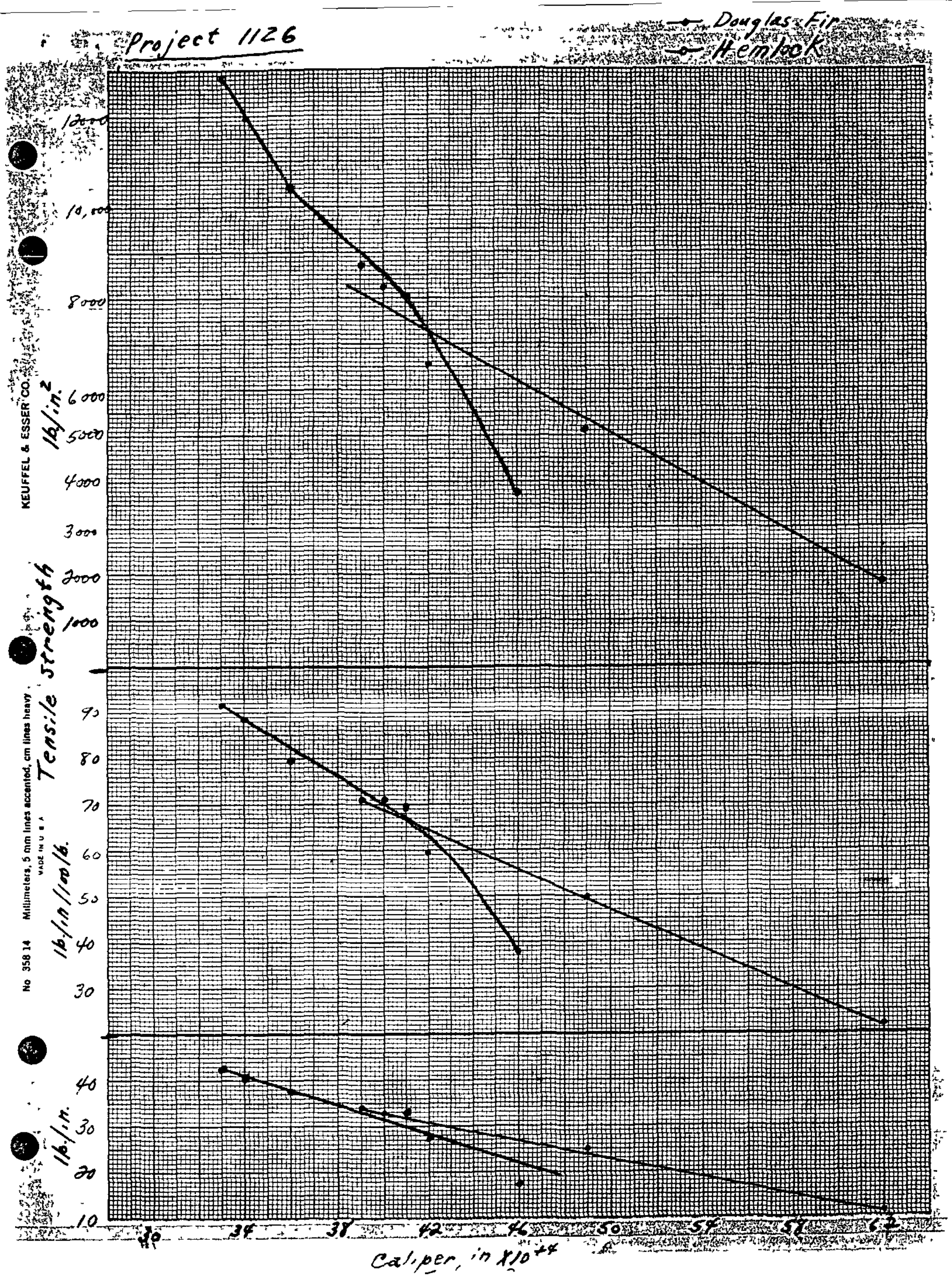
Project 1126

—•— ~~Hemlock~~ Douglas Fir
—•— ~~Douglas Fir~~ Hemlock

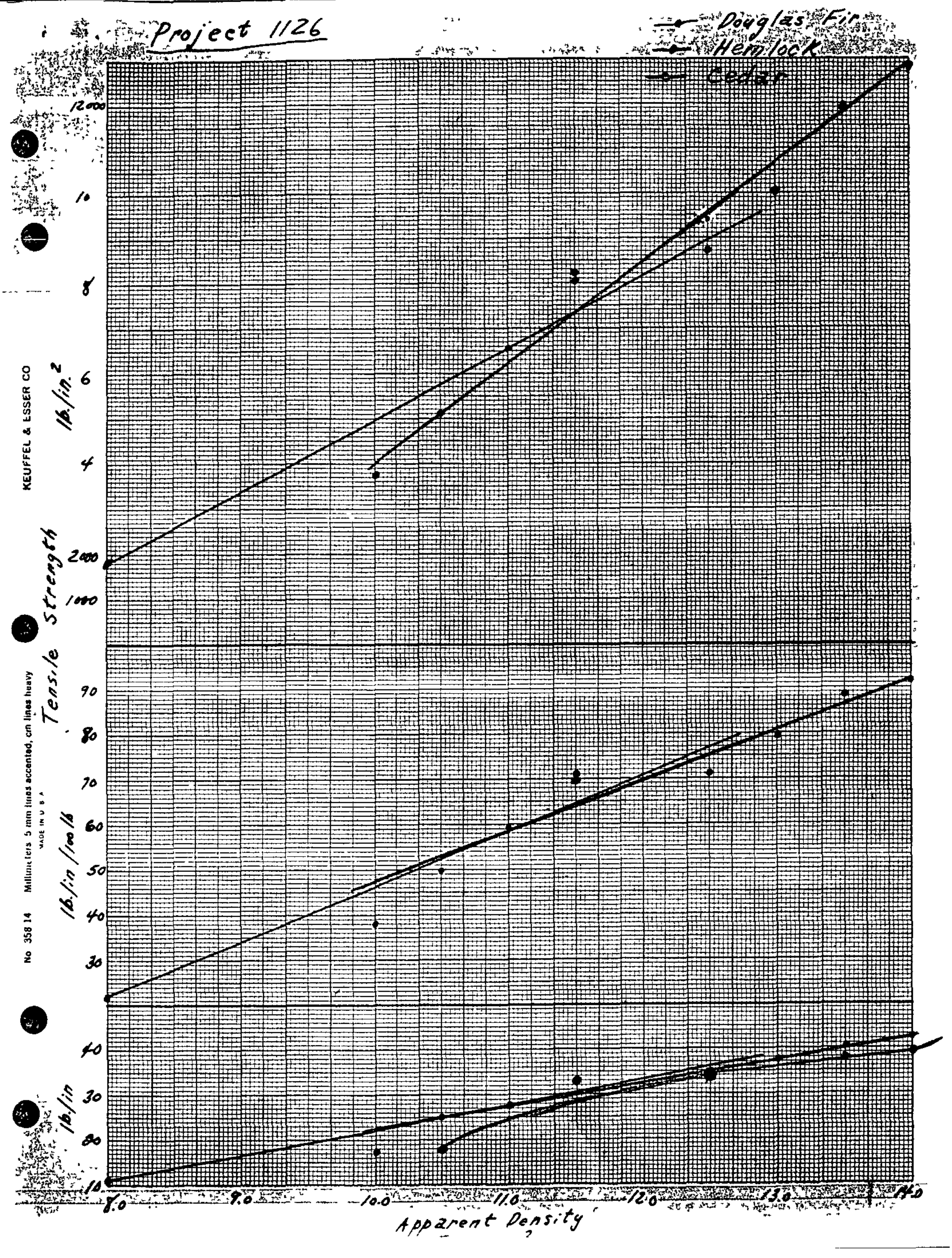


Caliper, in. X 10-4

Figure 2



Project 1126
Douglas Fir
Hemlock
12000
10,000
8000
6000
5000
4000
3000
2000
1000
lb./in.²
Tensile Strength
90
80
70
60
50
40
30
lb./in./100 lb.
40
30
20
10
lb./in.
30
34
38
42
46
50
54
58
62
Caliper, in X10⁺⁴
KEUFFEL & ESSER CO.
No 358 14 Millimeters, 5 mm lines accented, cm lines heavy.
MADE IN U.S.A.



Project 1126
Douglas Fir
Hemlock
Cedar
12000
10
8
6
4
2000
1000
lb./in.²
Tensile Strength
90
80
70
60
50
40
30
lb./in./100 lb.
40
30
20
10
lb./in
8.0
9.0
10.0
11.0
12.0
13.0
14.0
Apparent Density
KEUFFEL & ESSER CO
No 358 14 Millimeters 5 mm lines accented, cm lines heavy
MADE IN U S A

THE INSTITUTE OF PAPER CHEMISTRY

BEATING CURVES

Project ____ Date ____

File No. ____ Type of Pulp ____

Cook ____

Project 1126

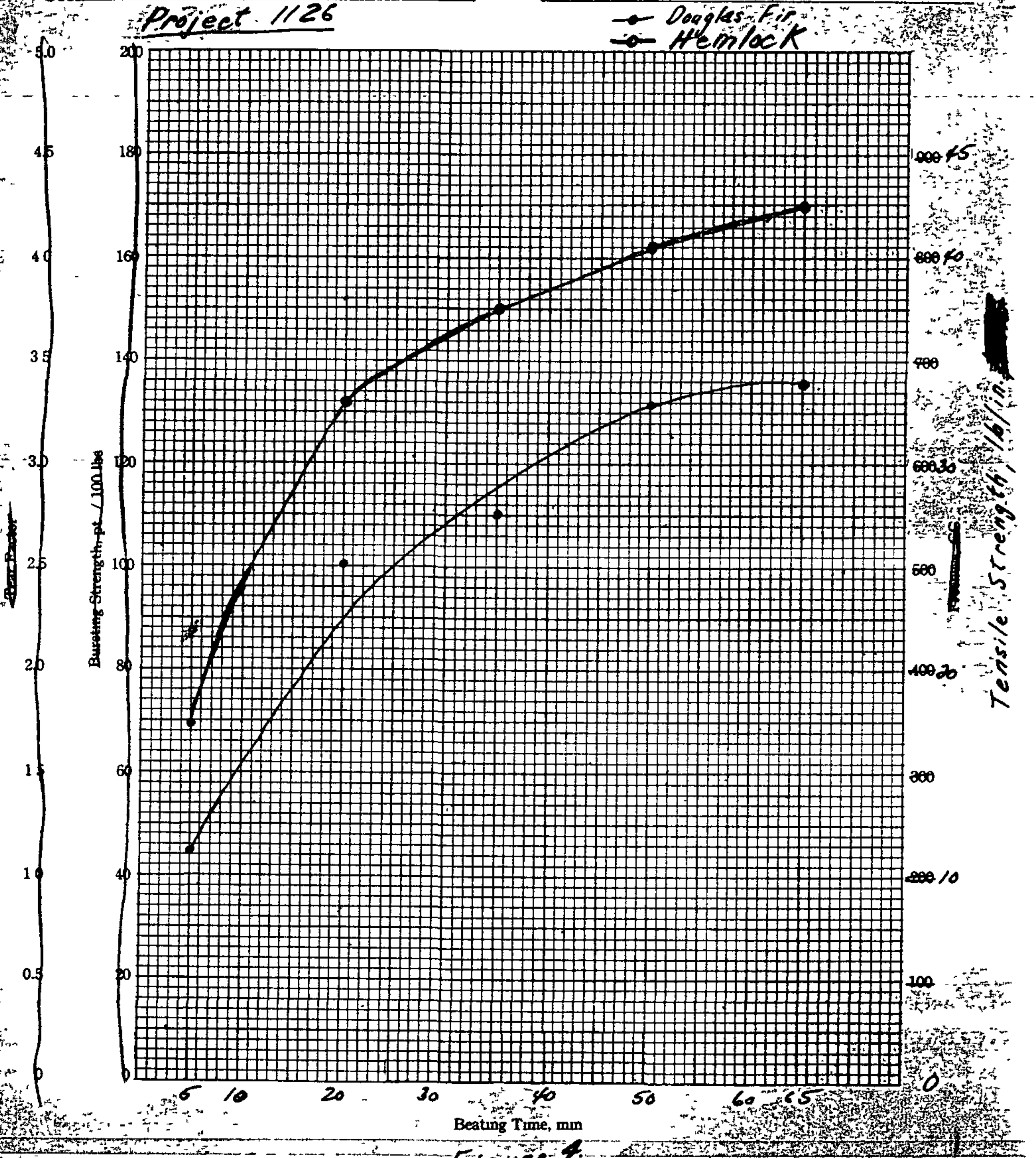


Figure 4.

THE INSTITUTE OF PAPER CHEMISTRY

BEATING CURVES

Project

File No.

Cook

Date

Type of Pulp

Project 1126

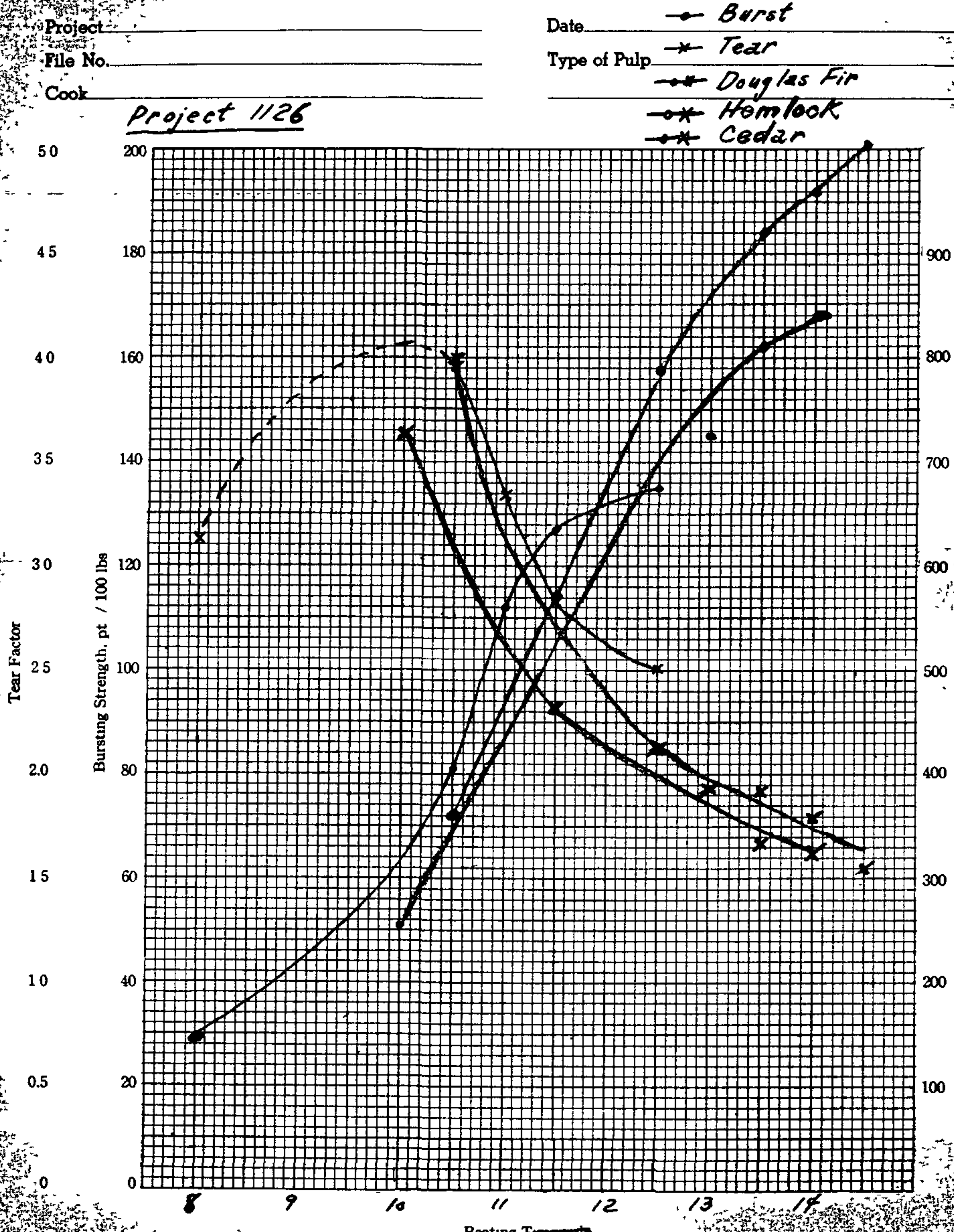


Figure 6.

THE INSTITUTE OF PAPER CHEMISTRY

BEATING CURVES

Project ______ Date ______

File No. ______ Type of Pulp ______

Cook ______

—•— Hemlock

—✱— Douglas Fir

Project 1274 C

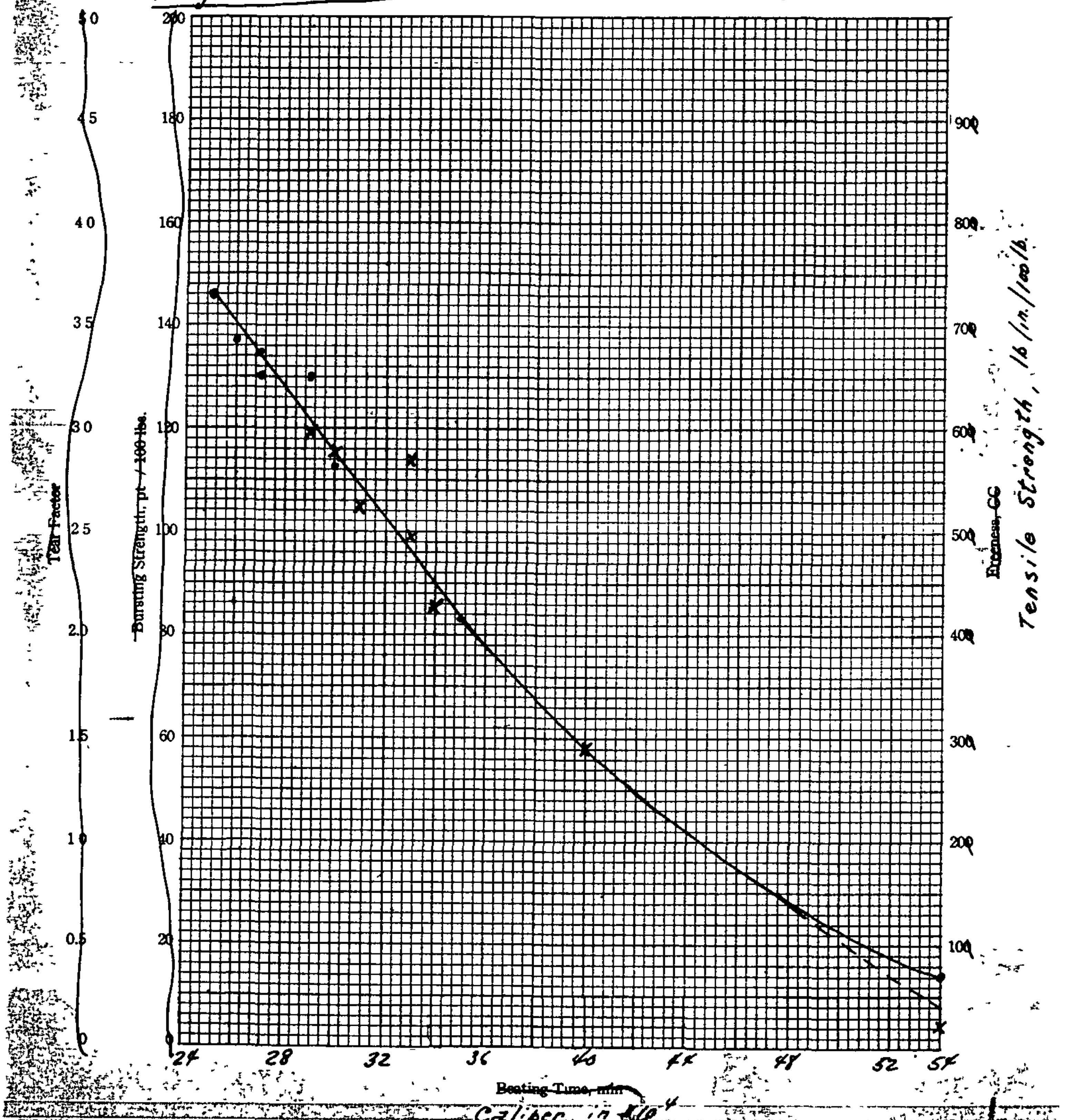


Figure 6.

THE INSTITUTE OF PAPER CHEMISTRY

BEATING CURVES

Project
File No.
Cook

Date
Type of Pulp

Project 1274C

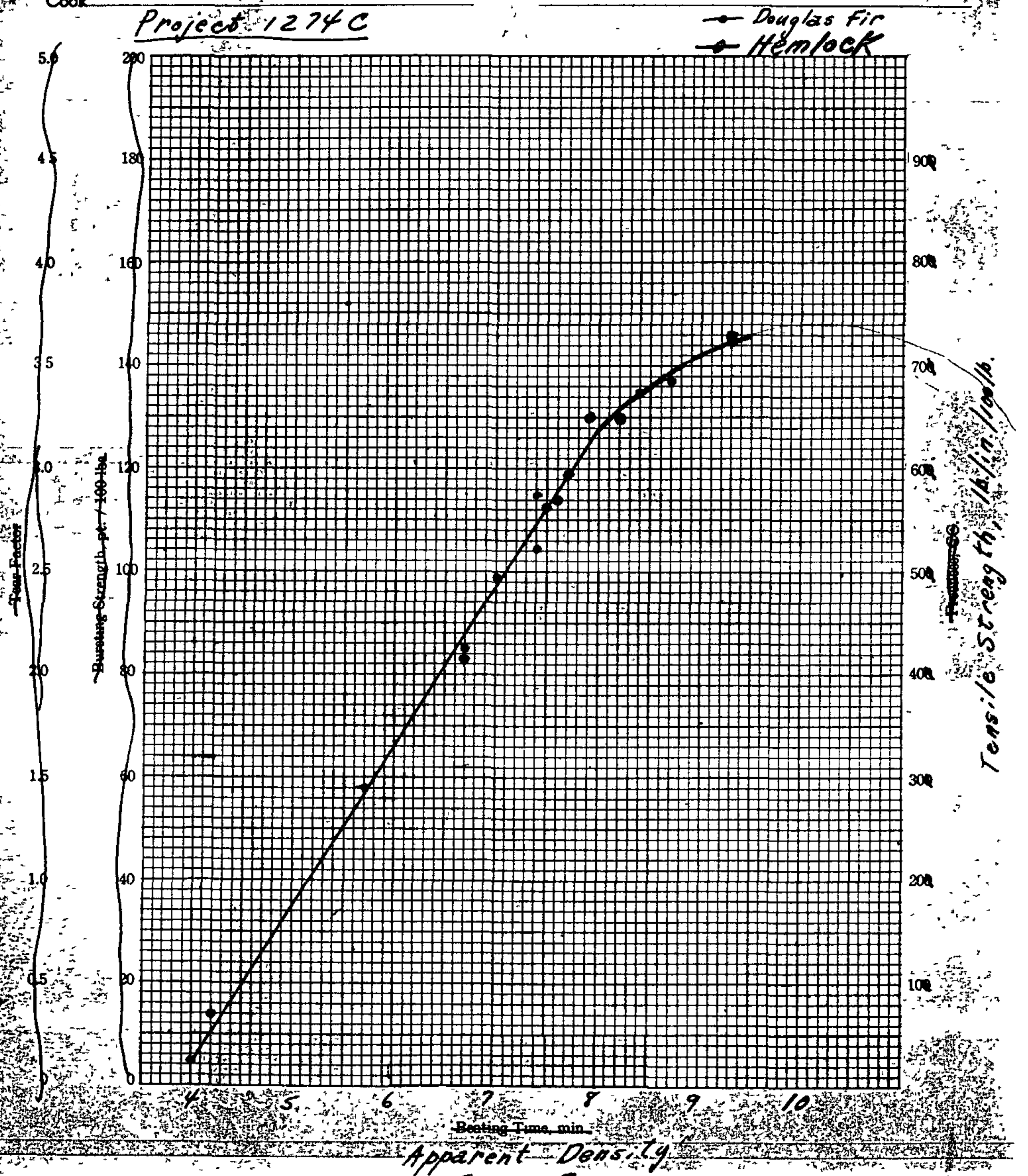


Figure 7

THE INSTITUTE OF PAPER CHEMISTRY

BEATING CURVES

Project ________ Date ________

File No. ________ Type of Pulp ________

Cook ________

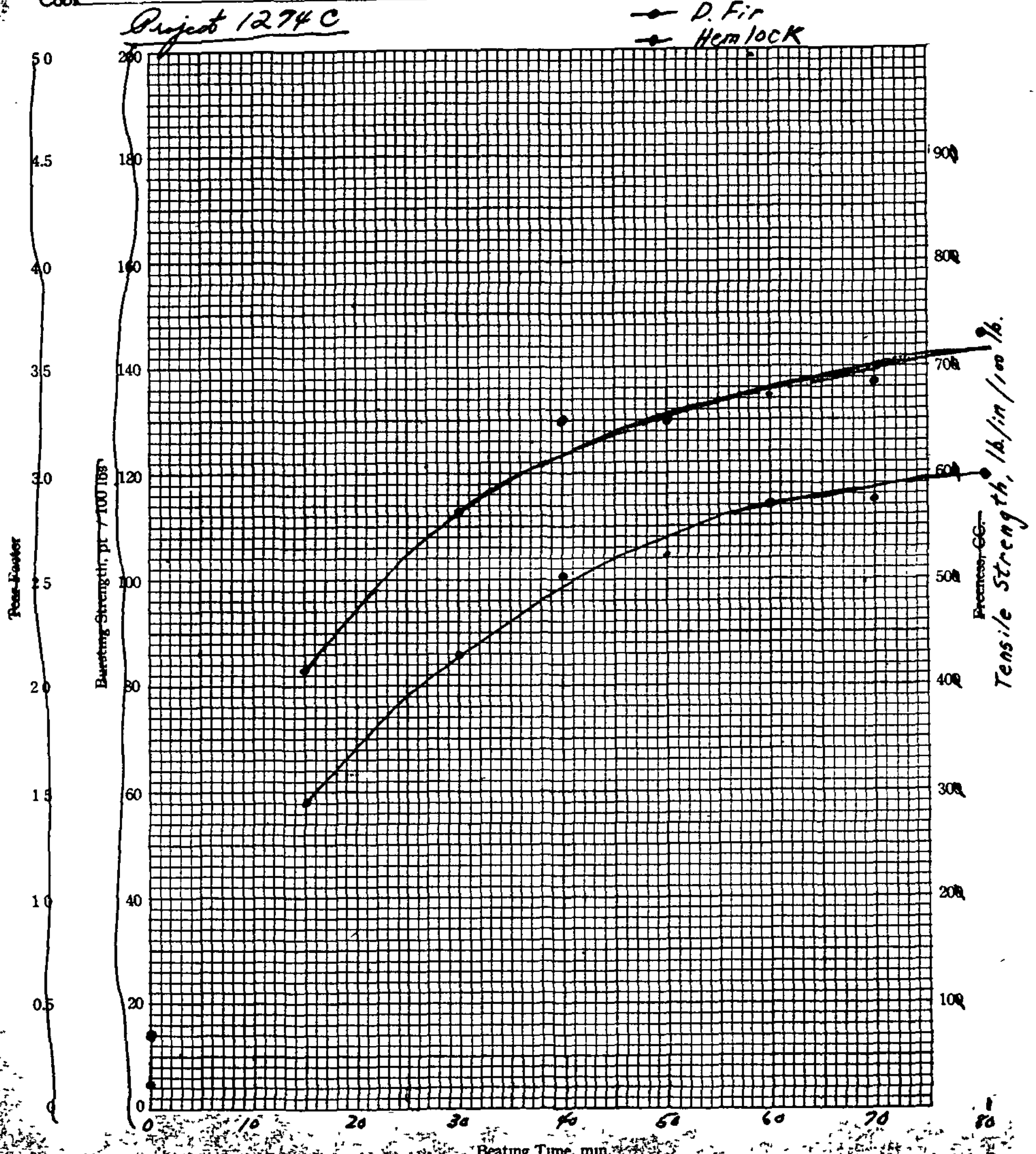


Figure 8.

THE INSTITUTE OF PAPER CHEMISTRY

BEATING CURVES

° Burst
X Tear

Project ____________________ Date ____________________

File No. ____________________ Type of Pulp —x Lampén Ball Mill

Cook ____________________ —x Pebble Mill

Proj 1348 —x Valley Beater

—x Morden

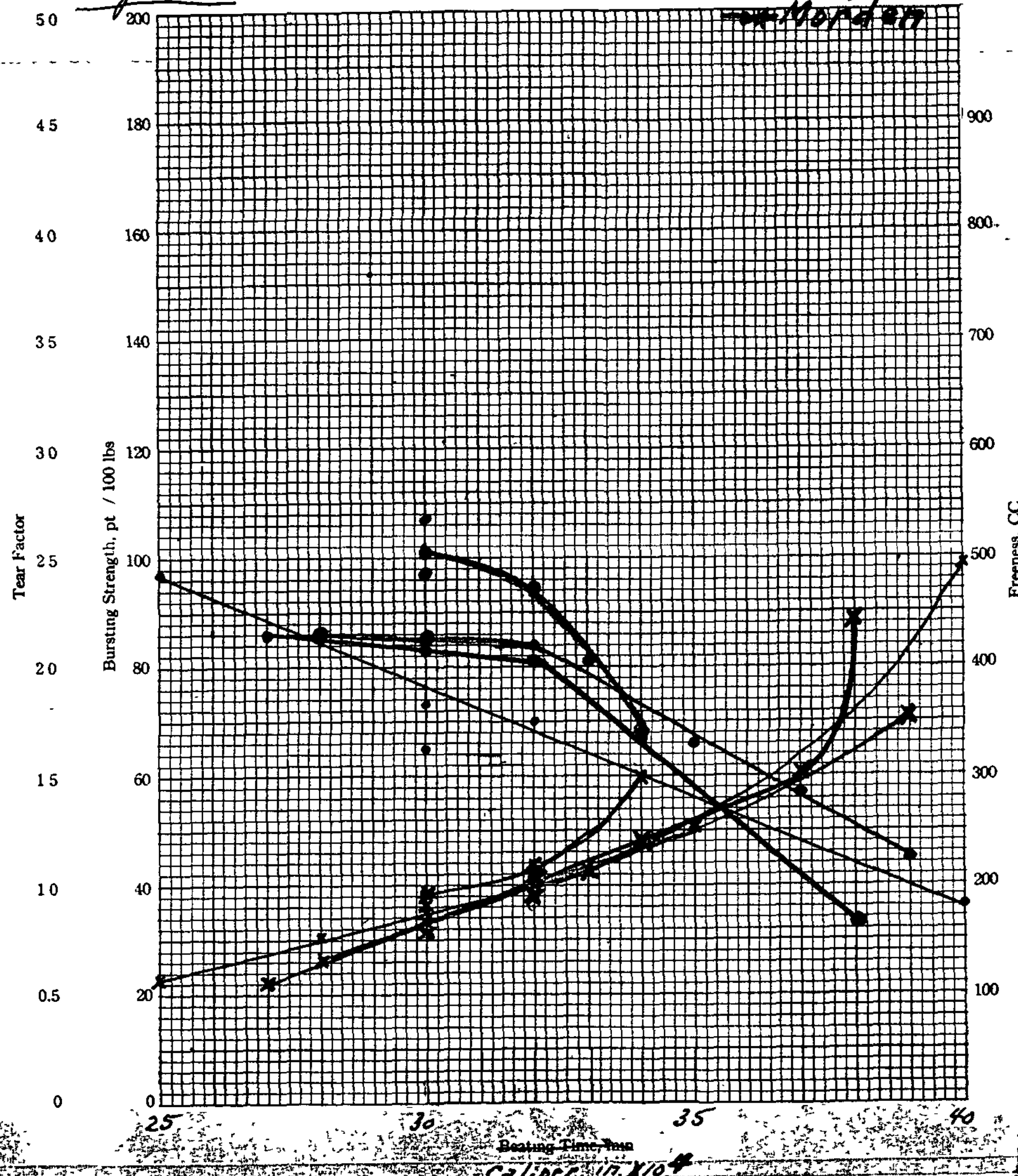


Figure 9

THE INSTITUTE OF PAPER CHEMISTRY

BEATING CURVES

• Burst
x Tear
—o✱ Lampén Ball Mill
—o✱ Pebble Mill
—o✱ Valley Beater
—o✱ Morden

Project ____________ Date ____________

File No. ____________ Type of Pulp ____________

Cook ____________

Proj. 1348 - Howard

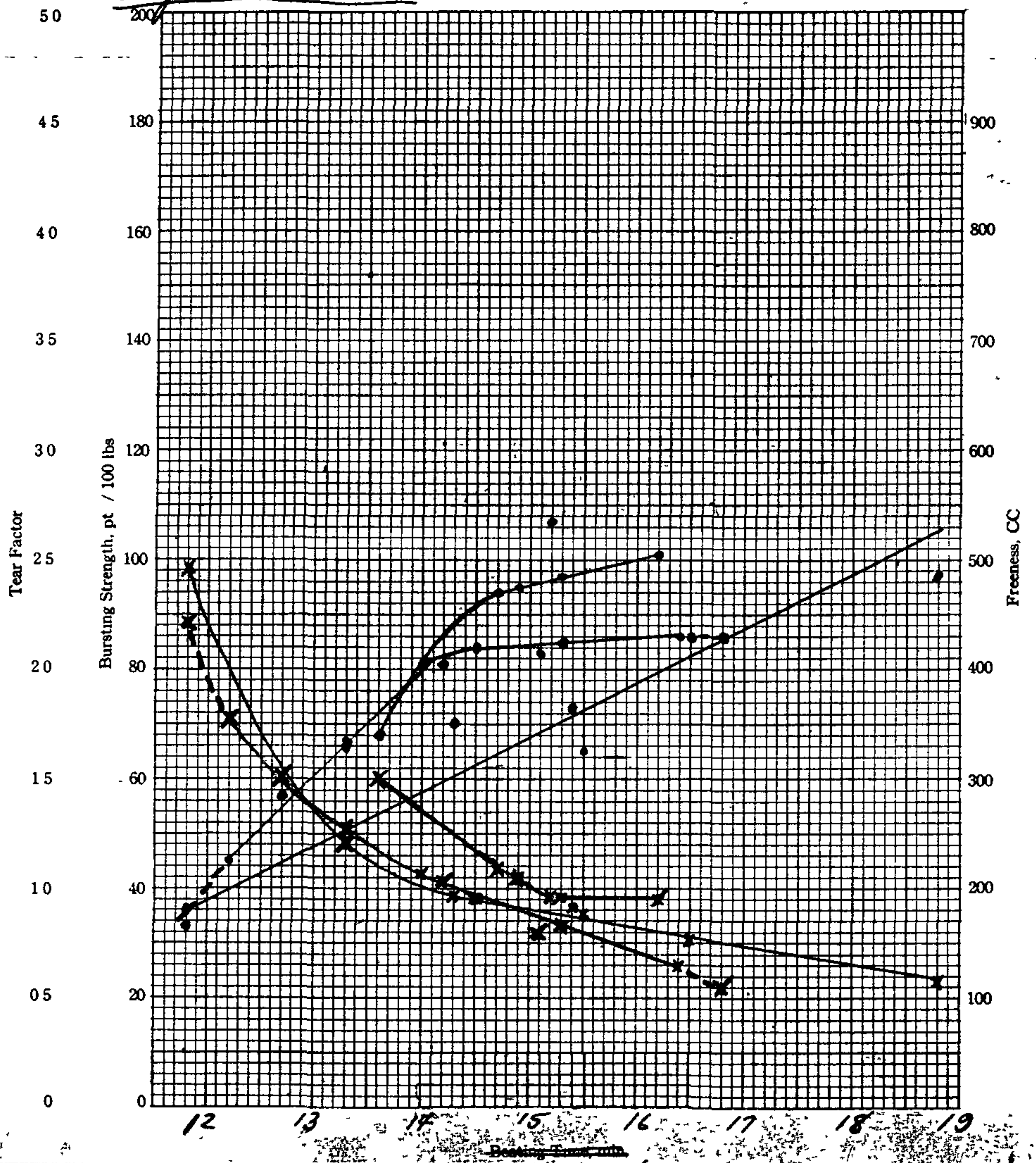


Figure 10

NO 358 11 10 × 10 to the half inch 5th lines accented
Engraving, 7 × 10 in
MADE IN U S A

KEUFFEL & ESSER CO

Project 1425

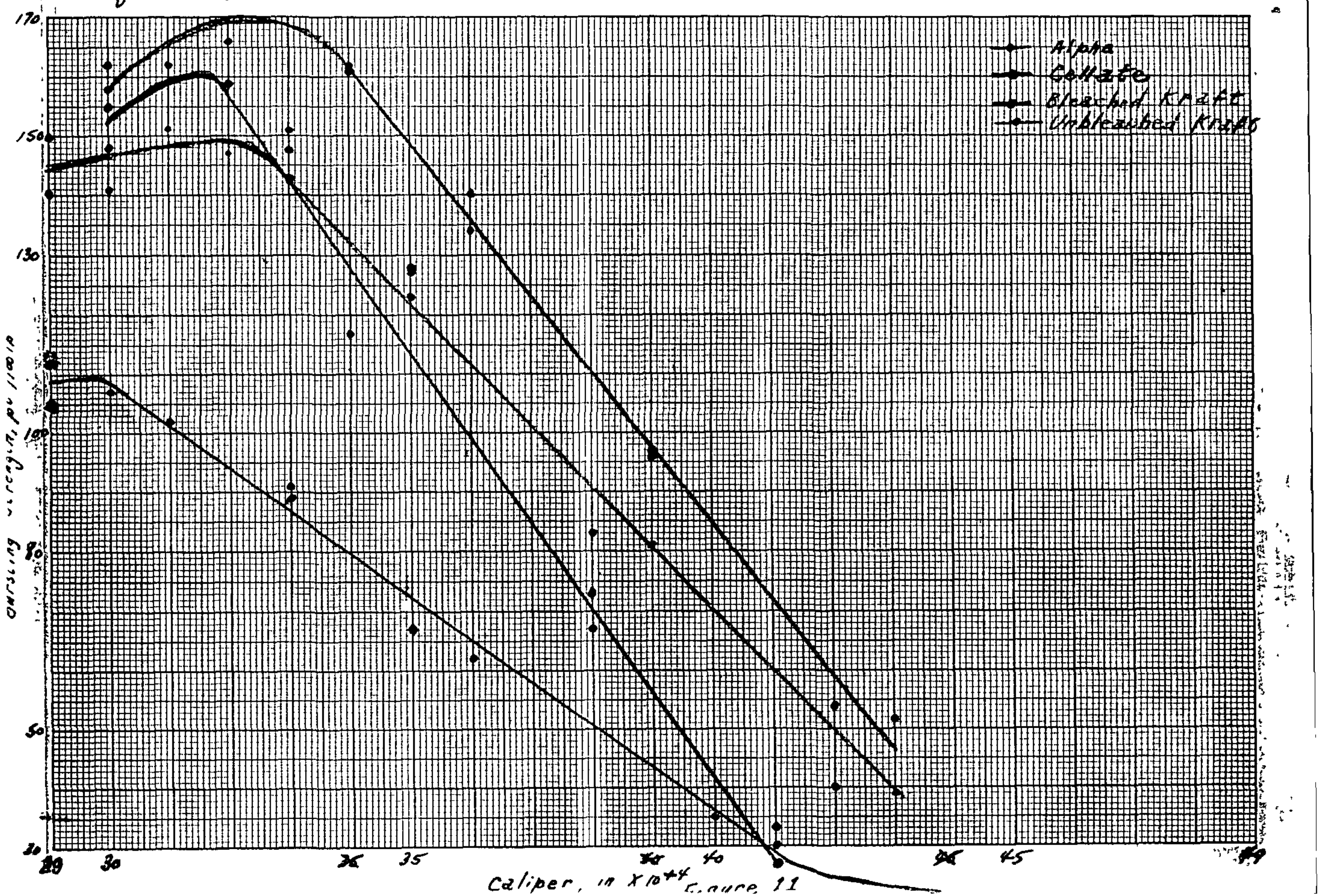
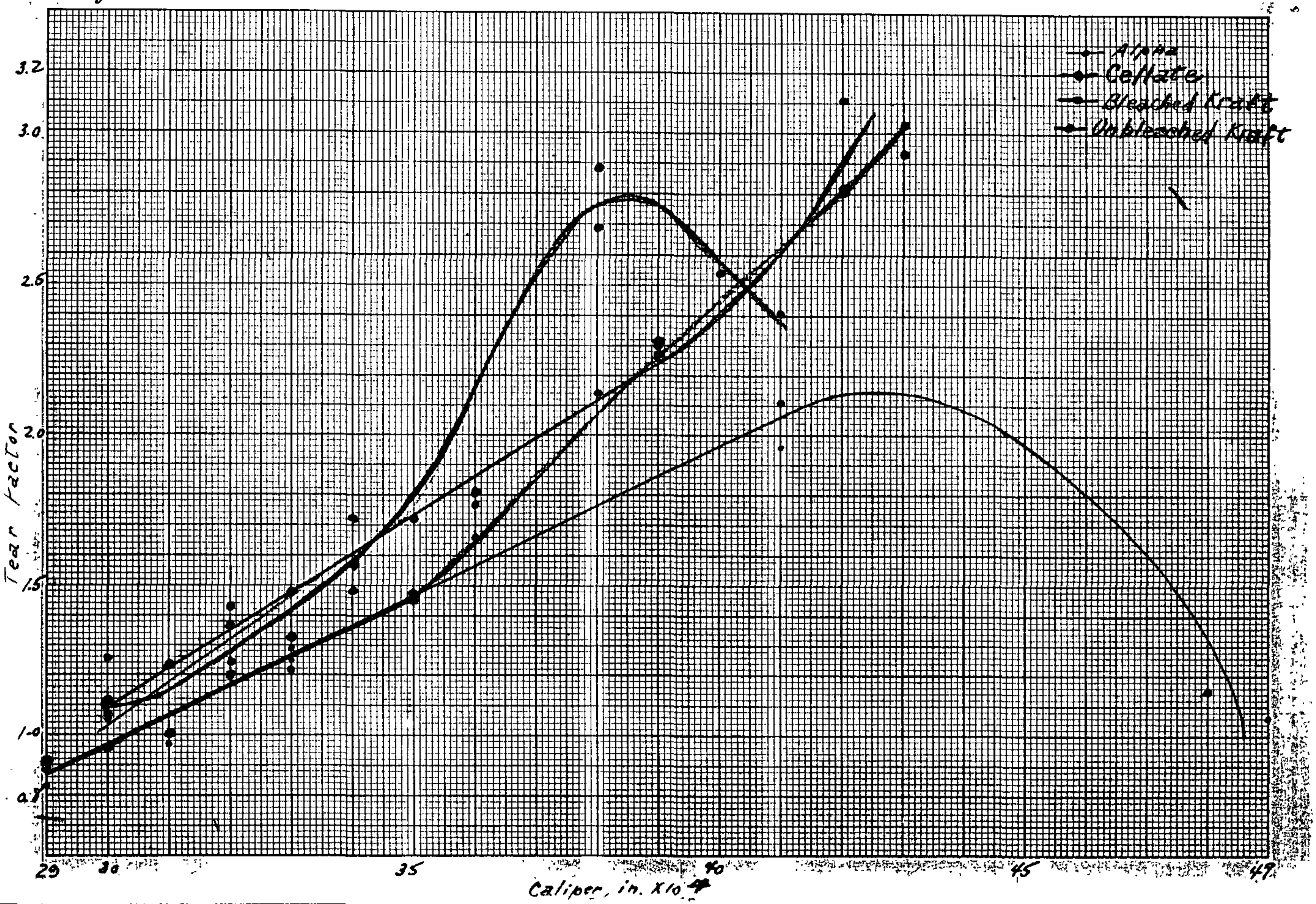


Figure 11

Project 1425



NO. 358-11. 10 × 10 to the half inch, 5th lines accented. Engraving, 7 × 10 in. MADE IN U.S.A. KEUFFEL & ESSER CO.

Project 1425

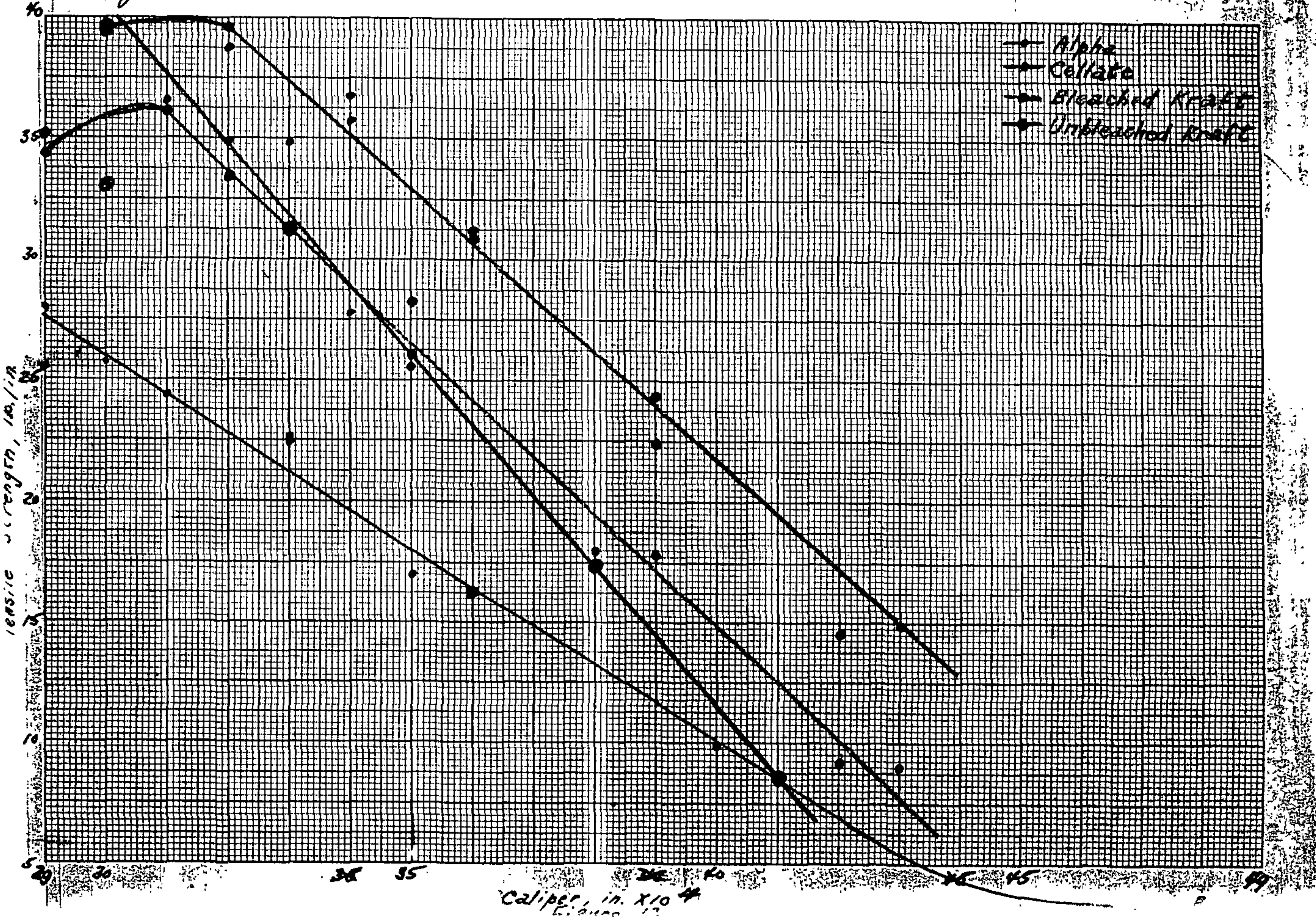
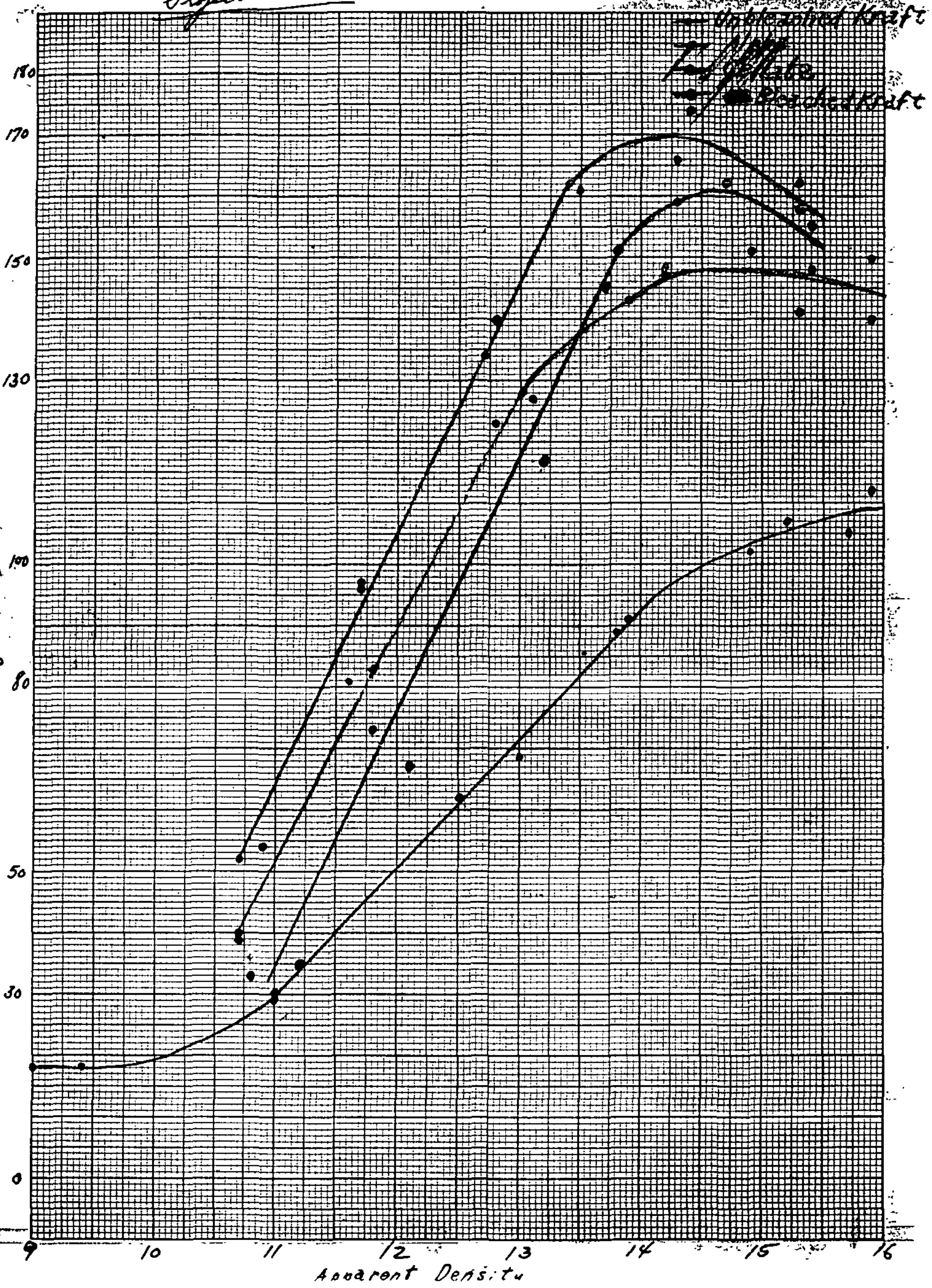


Figure 13

Project 1425



Project 1425

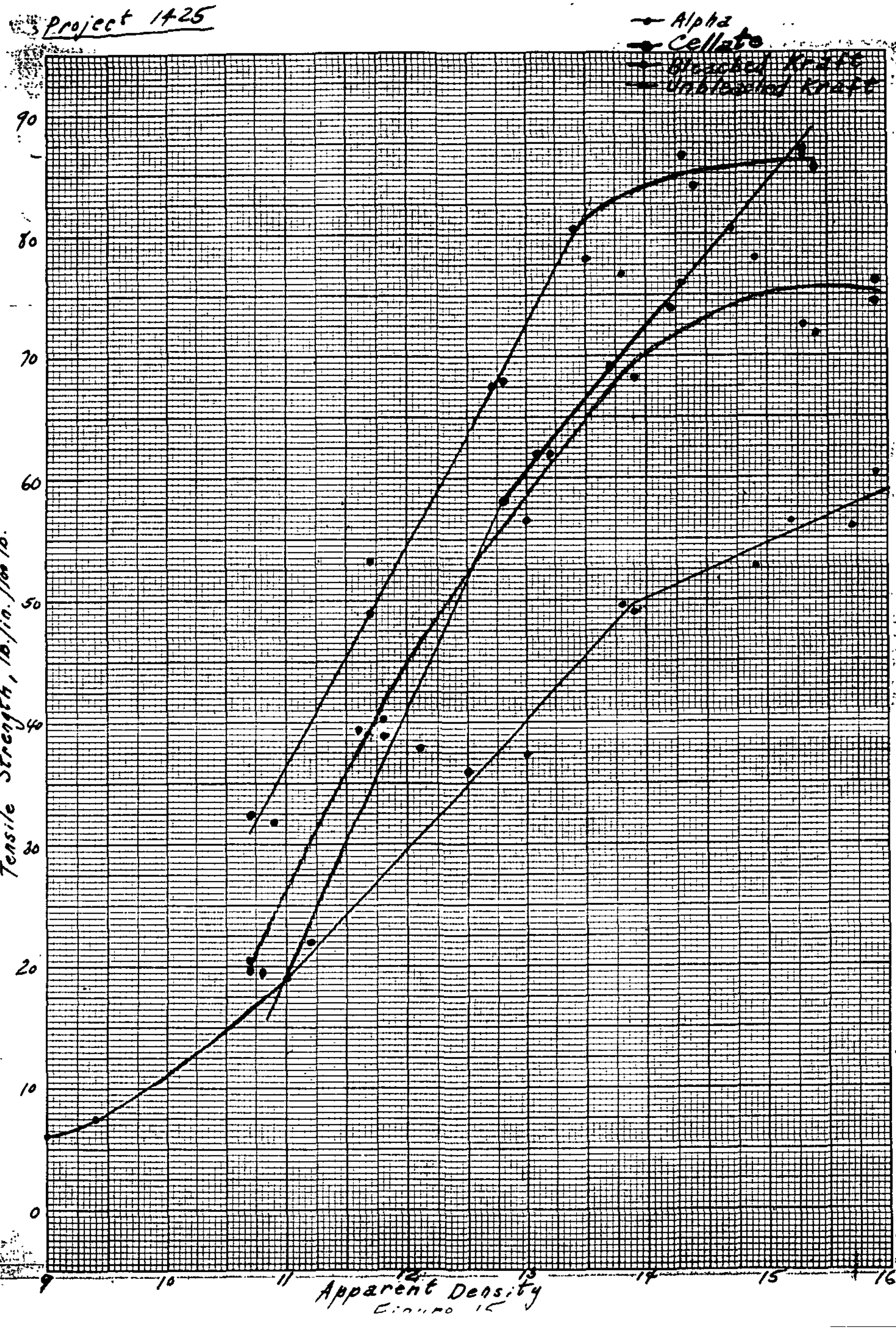


Figure 15

THE INSTITUTE OF PAPER CHEMISTRY

BEATING CURVES

Project ______________ Date ______________

File No. ______________ Type of Pulp ______________

Cook ______________

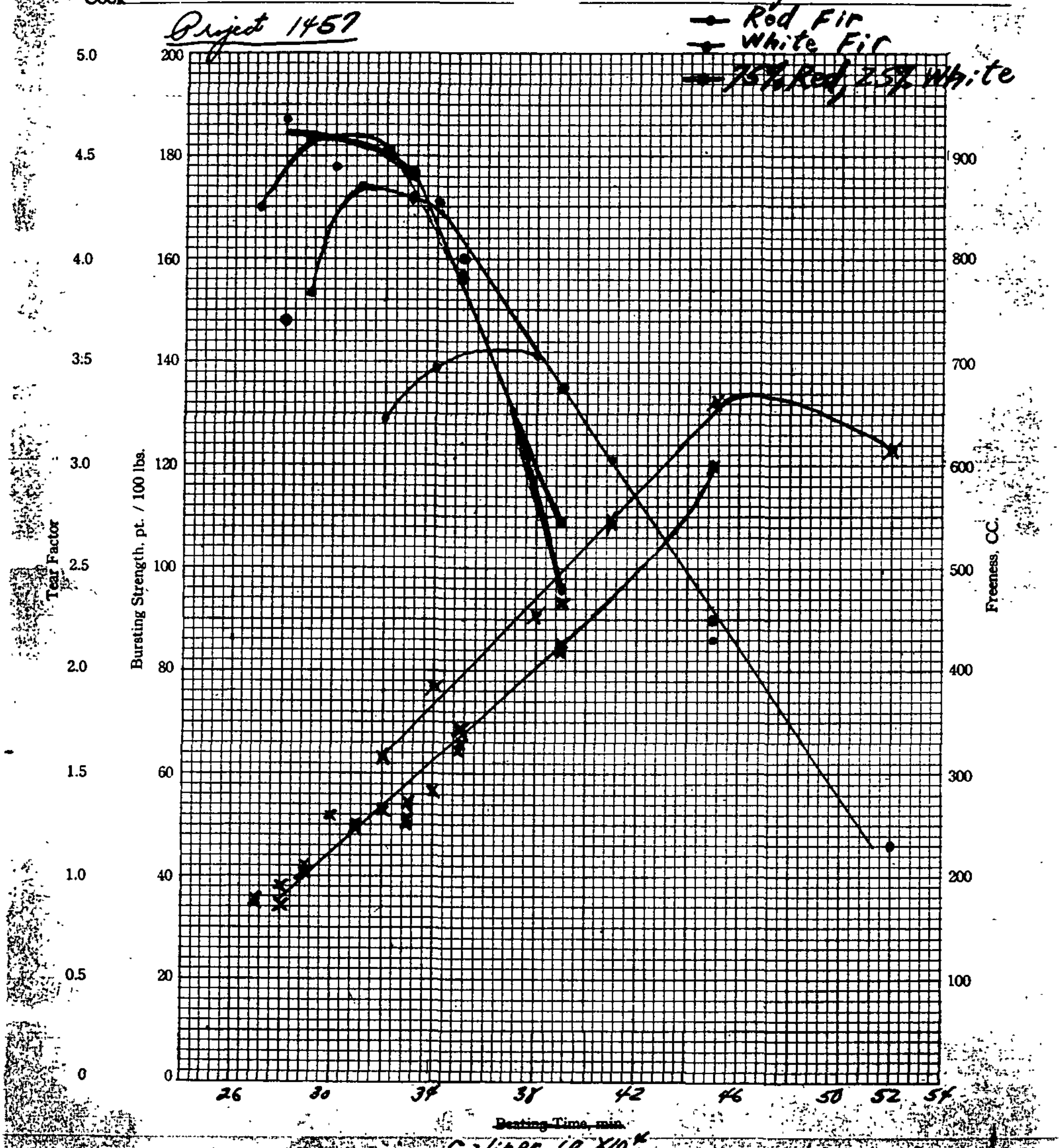


Figure 16.

THE INSTITUTE OF PAPER CHEMISTRY

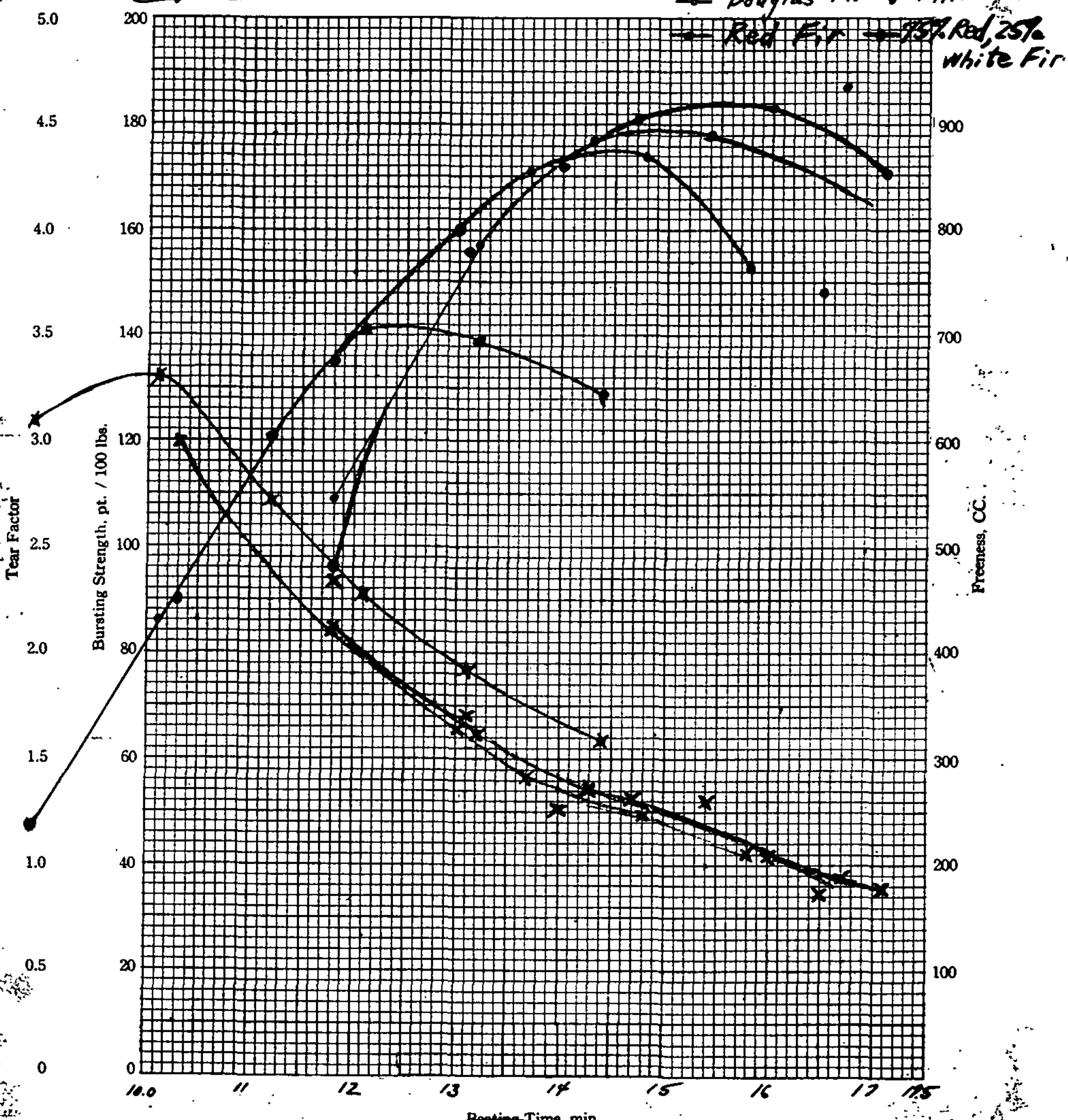
BEATING CURVES

Project ______ Date ______

File No. ______ Type of Pulp ______

Cook ______

Project 1457



Apparent Density

Figure 17.

THE INSTITUTE OF PAPER CHEMISTRY

BEATING CURVES

Project ______ Date ______

File No. ______ Type of Pulp ______

Cook ______

— Beater Run #1
—×— Beater Run #2
— Burst
— Tear
— Tensile
— Freeness

Project 1481

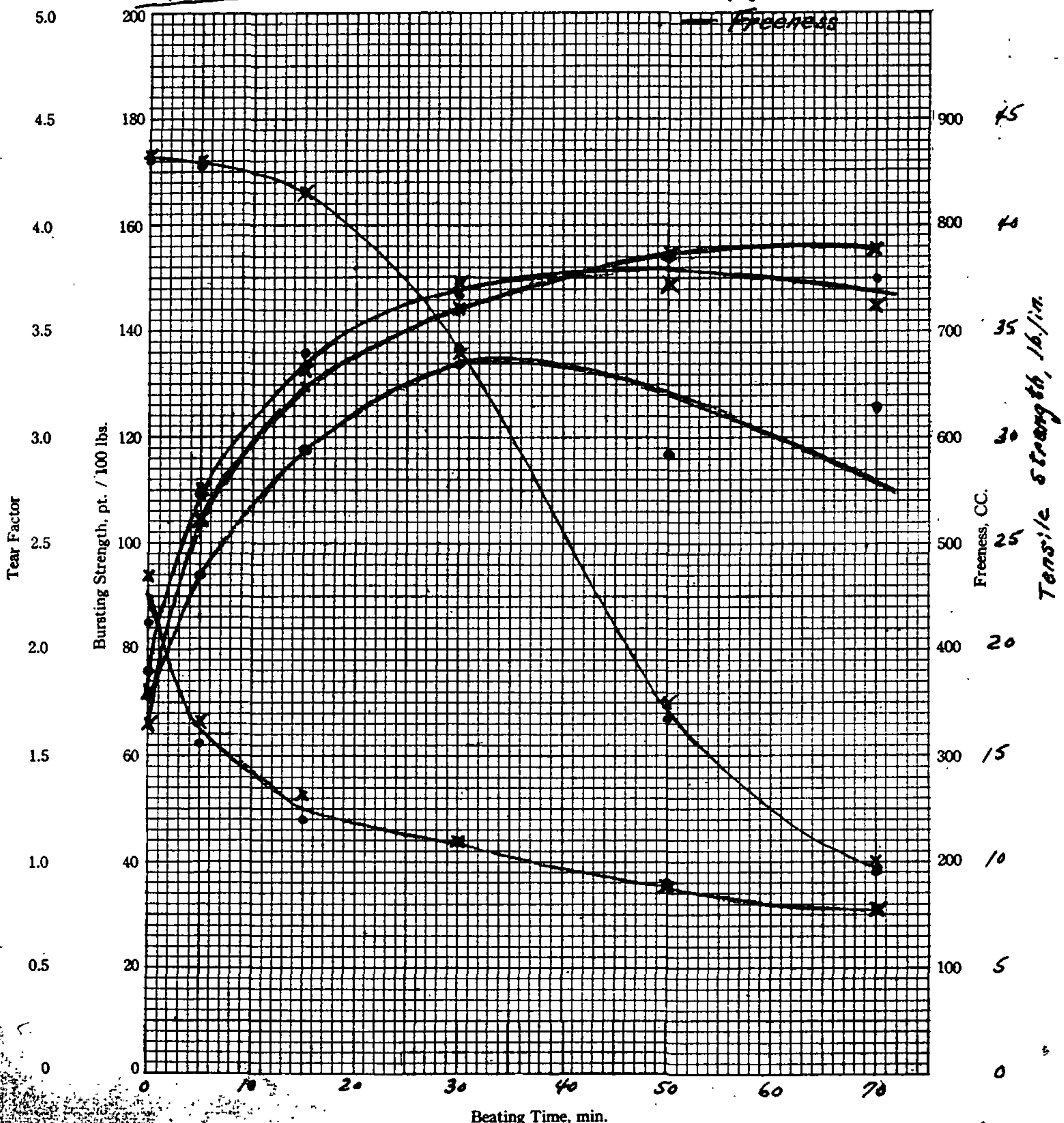


Figure 18

THE INSTITUTE OF PAPER CHEMISTRY

BEATING CURVES

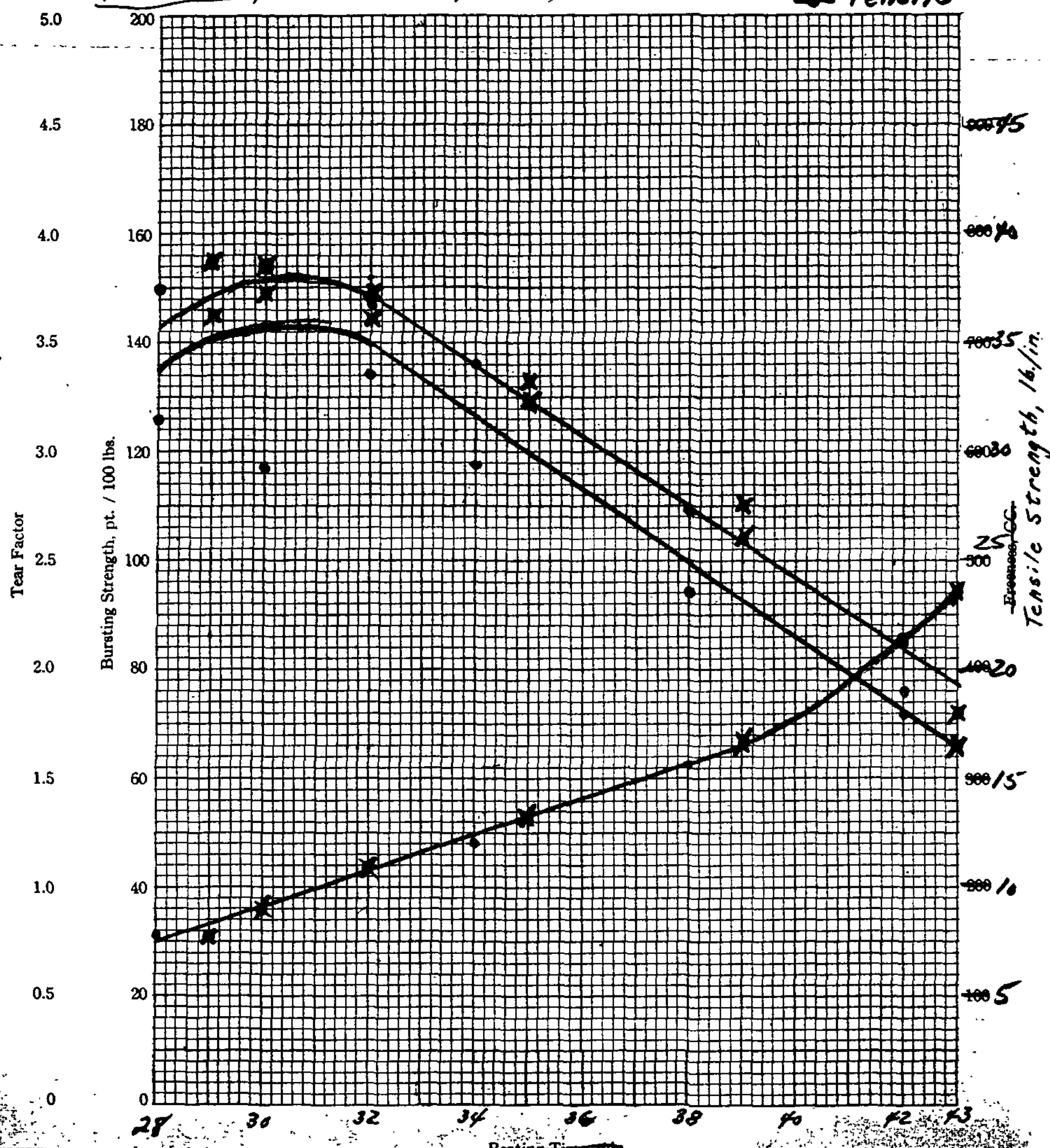
Project ____________________ Date ____________________

File No. ____________________ Type of Pulp ____________________

Cook ____________________

1481 – Cooperator's Pulp

—•— Beater Run #1
—✕— Beater Run #2
—•— Burst
—•— Tear
—•— Tensile



Caliper, in. X10+4

Figure 19.

THE INSTITUTE OF PAPER CHEMISTRY

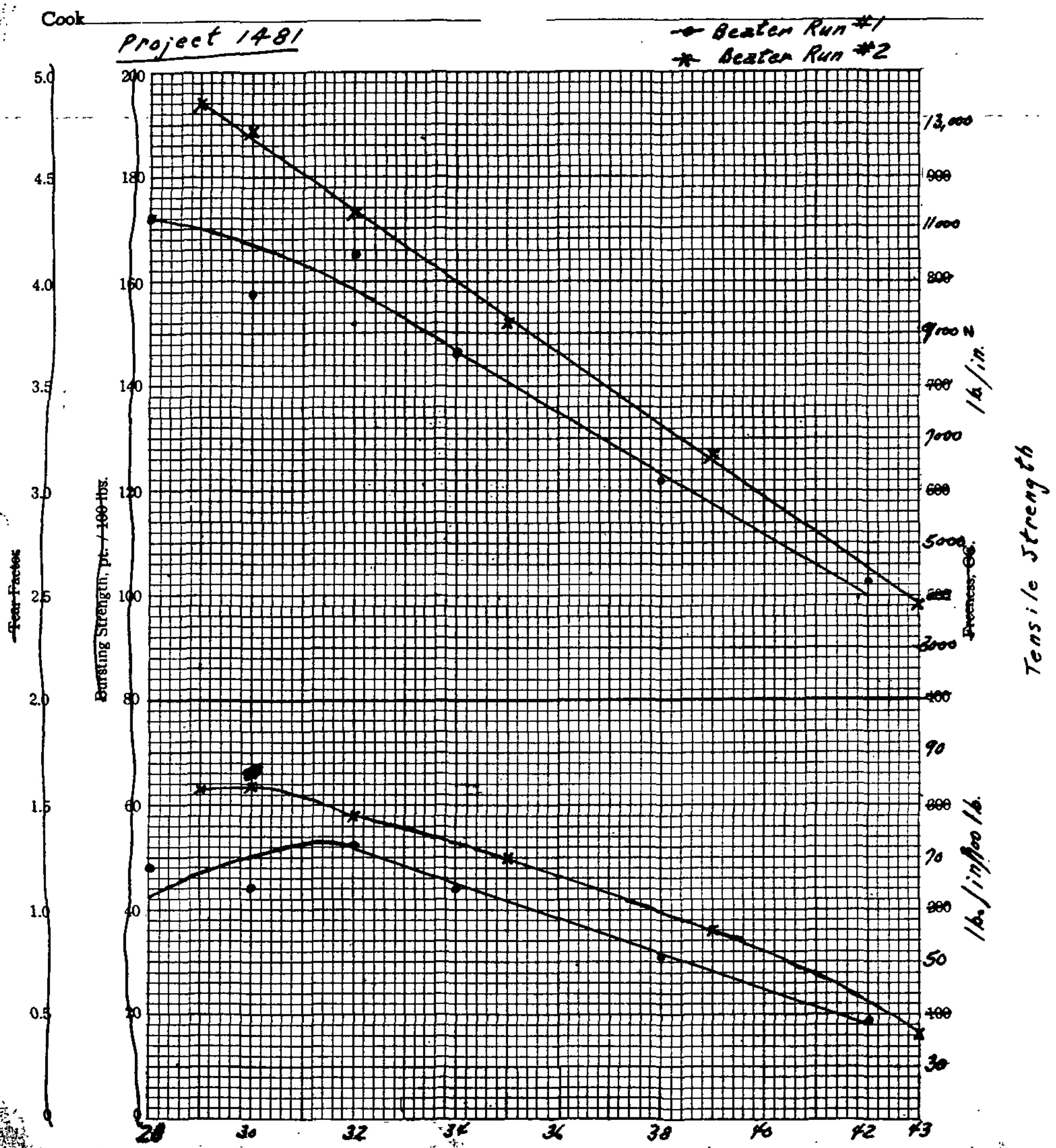
BEATING CURVES

Project ______ Date ______

File No. ______ Type of Pulp ______

Cook ______

Project 1481



Caliper, in. X10⁴

Figure 20

THE INSTITUTE OF PAPER CHEMISTRY

BEATING CURVES

Project ______ Date ______

File No. ______ Type of Pulp ______

Cook ______

Project 1481

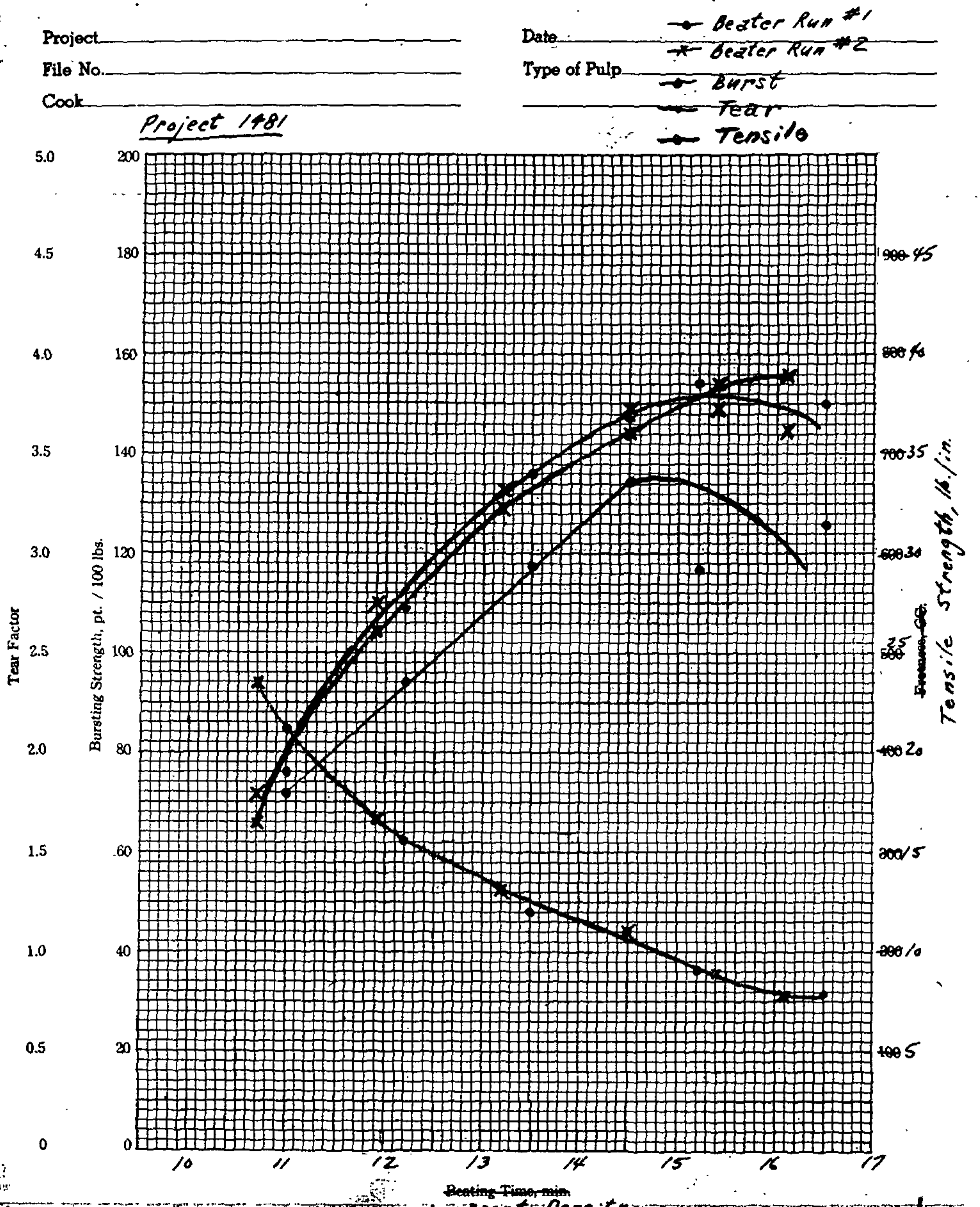


Figure 21

THE INSTITUTE OF PAPER CHEMISTRY

BEATING CURVES

Project ______ Date ______

File No. ______ Type of Pulp ______

Cook ______

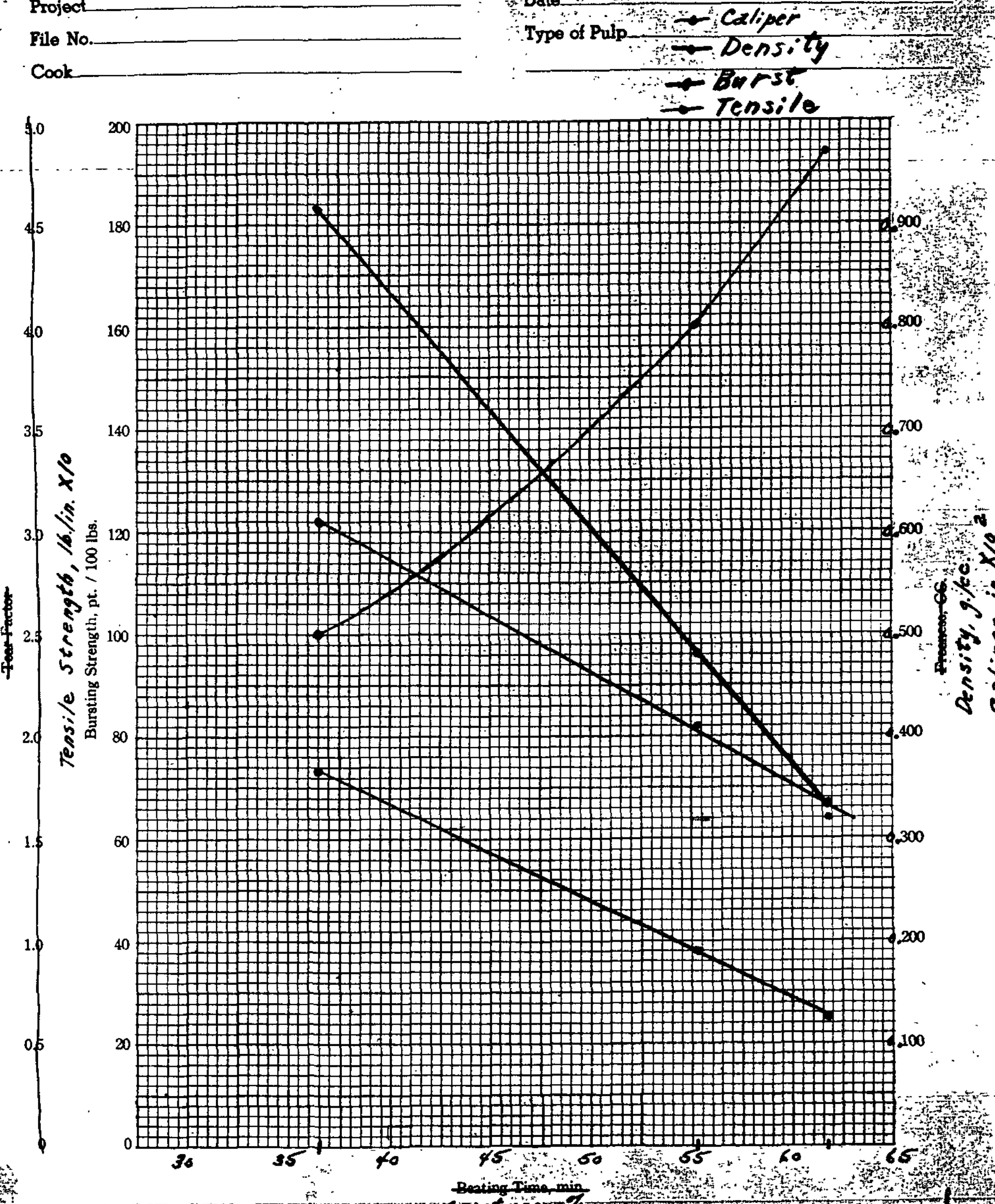


Figure 22

THE INSTITUTE OF PAPER CHEMISTRY

BEATING CURVES

Project
File No.
Cook

Date
Type of Pulp

- 65% Moisture
* 35% Moisture
- Caliper
- Density
- Burst
- Tensile

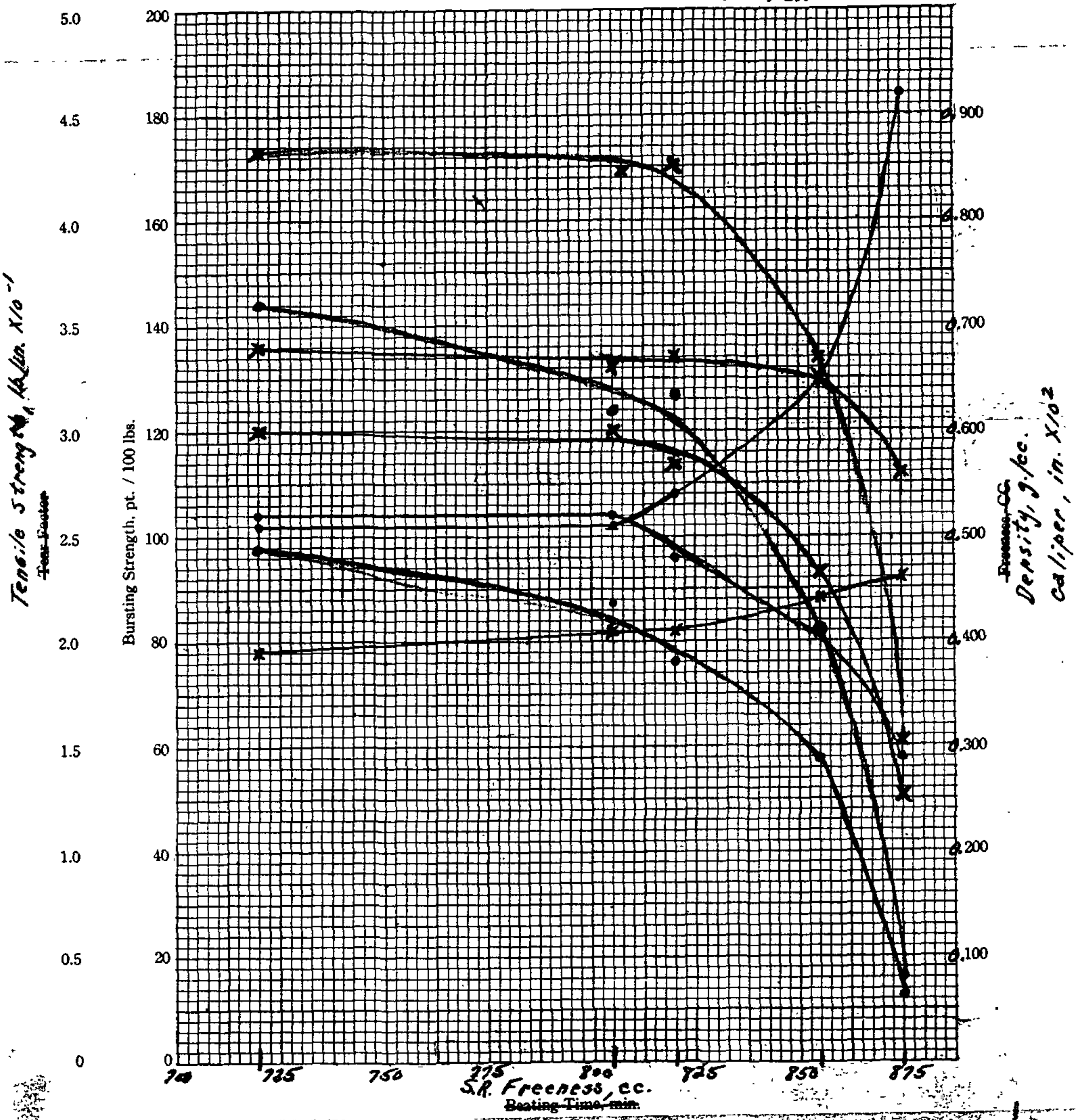


Figure 23

THE INSTITUTE OF PAPER CHEMISTRY

BEATING CURVES

Project

File No.

Cook

Date

Type of Pulp

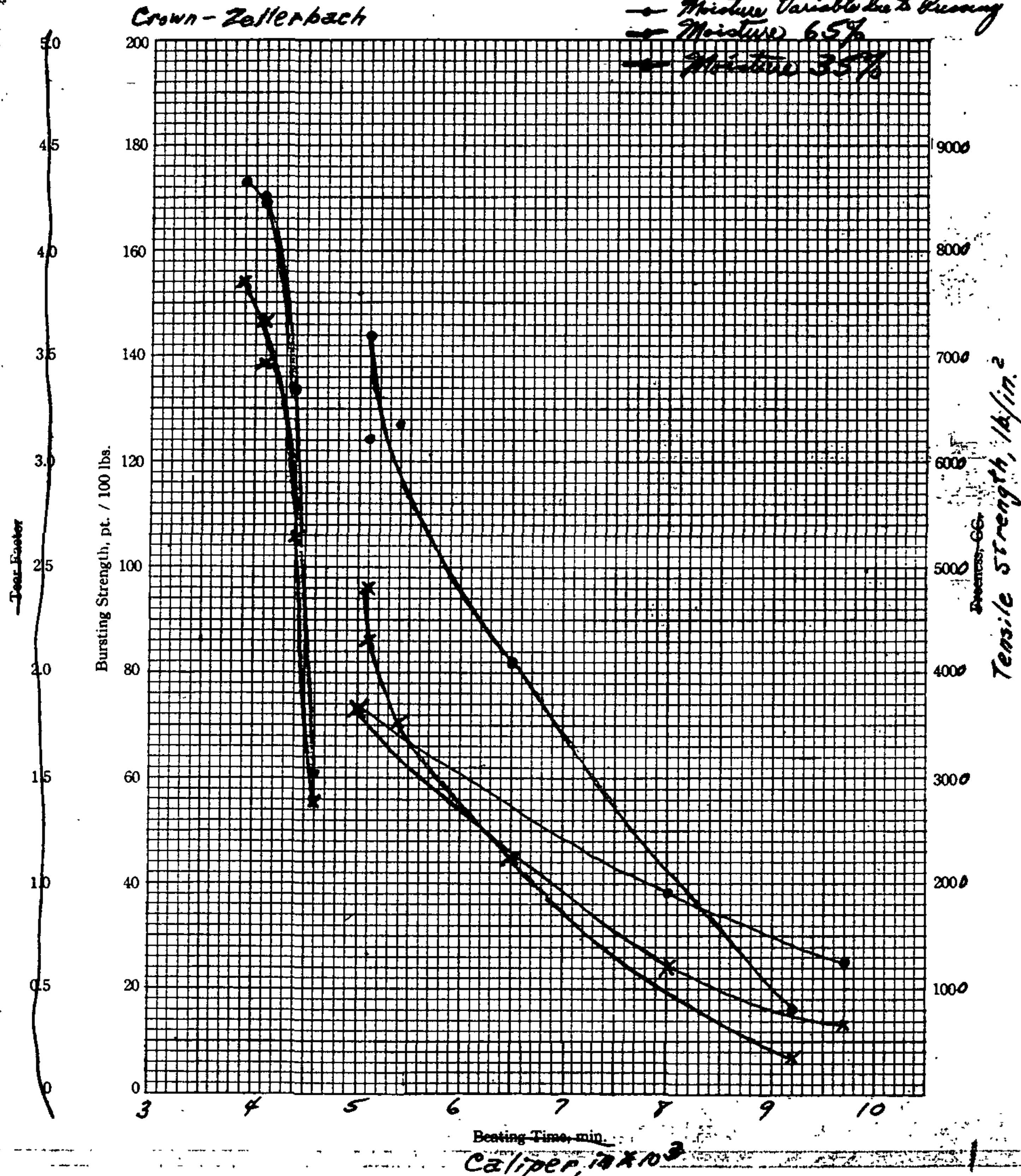


Figure 24

THE INSTITUTE OF PAPER CHEMISTRY

BEATING CURVES

Project ______________________ Date ______________________

File No. ______________________ Type of Pulp ______________________

Cook ______________________

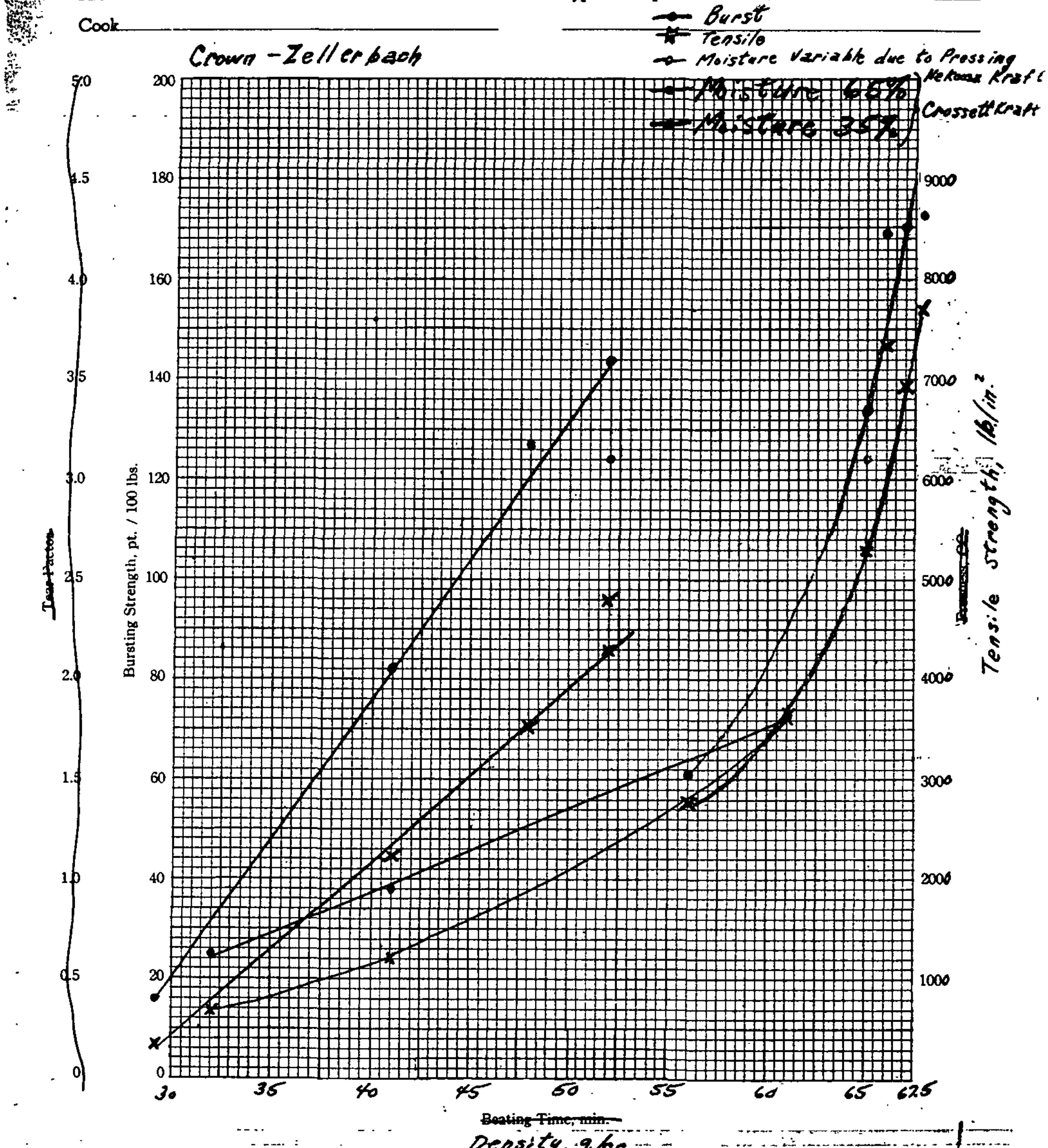


Figure 25

PROJECT REPORT FORM

Copies to: Files
Mr. Steele
Dr. Forman
Mr. Kottwitz

PROJECT NO. 1102-3
COOPERATOR Institute
REPORT NO. 4
DATE February 10, 1950
NOTE BOOK 898
PAGE 35 TO 38
SIGNED R. Elston
F. Kottwitz

THE EFFECT OF TEMPERATURE OF BEATING AND SHEET FORMATION ON STRENGTH CHARACTERISTICS OF BEATER EVALUATED PULP

INTRODUCTION

This work was initiated to determine what influence the extreme variations in water temperature offered by winter and summer might have on beater evaluations made in the laboratory. The temperature of beating and of sheet formation are often, for practical reasons, dependent upon water supply temperature.

This report summarizes the results of the evaluations made at 6° and at 27° C.

EXPERIMENTAL

Institute Method 403 was followed in making the beater evaluations using Weyerhaeuser bleached sulfite as a standard pulp. The low temperature beater runs were made at the prevailing temperature of tap water (6° C.) existing at the time of the runs. A temperature of 27° C. was selected as typical of mid-summer water temperatures. To maintain this temperature during beating, a series of strip heaters, controlled through a "Variac", were fastened to the outside wall of the beater. The temperature of sheet formation was controlled within 1° C. by addition of warm tap water to the sheet mold.

DISCUSSION OF RESULTS AND CONCLUSIONS

Complete evaluation data of the four beater runs are compiled in Table I.

In Table II are summarized the averages of data from the duplicate beater runs made at 6° and 27° C. Figures 1 and 2 are plots of the relationships of beating time to apparent density, burst and tear values. There appears to be no significant difference in the rate of beating at the two temperatures as determined by freeness. However, in the lower freeness range, bursting strength was 10 to 15% higher and tearing strength 40 to 50% higher for the pulps evaluated at the higher temperature. The apparent density of the sheets formed at 27° C. was somewhat lower than those formed at 6° C. Tensile strength seems to be unaffected by the temperature difference employed in this work.

TABLE I

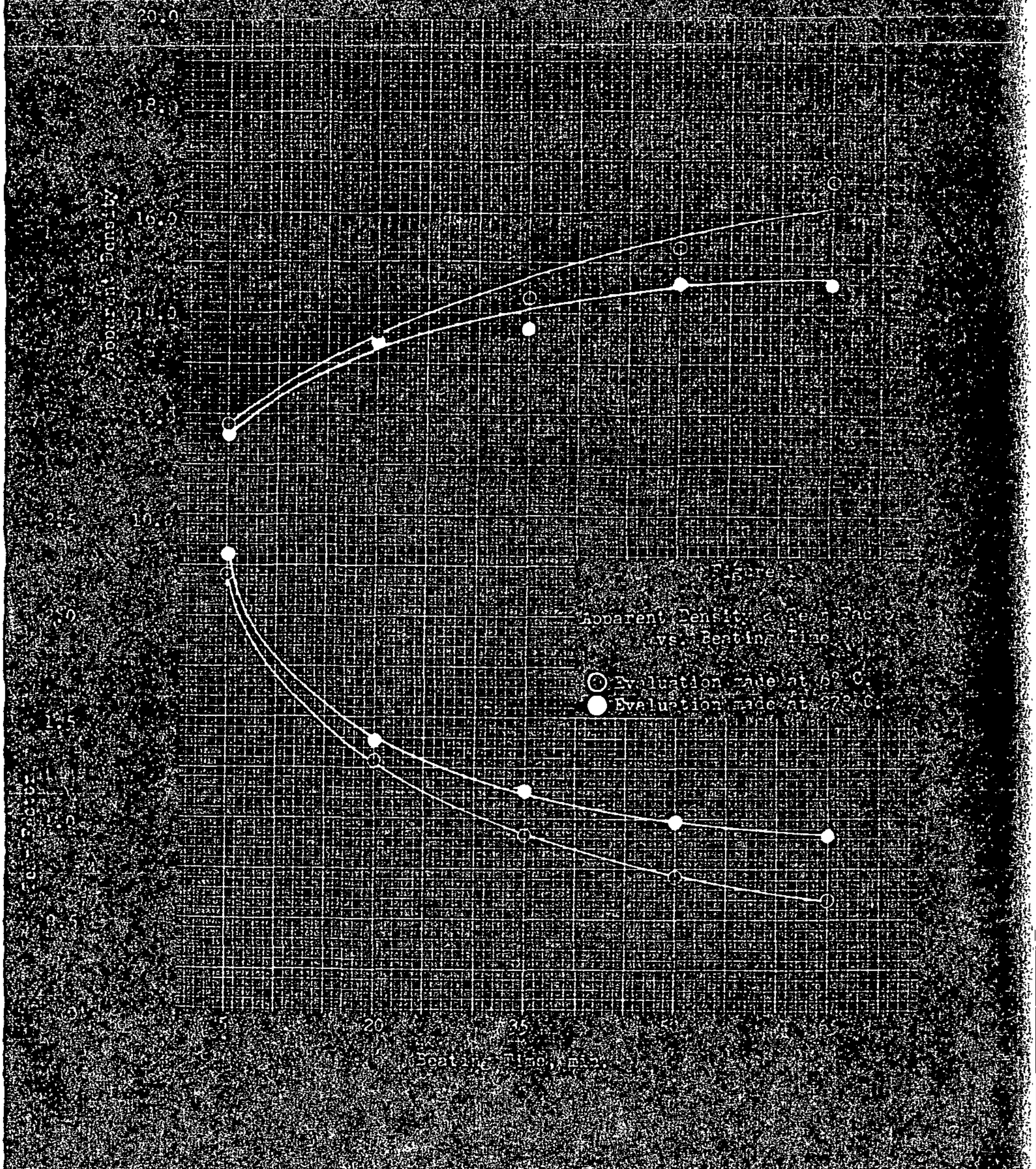
PHYSICAL PROPERTIES OF WEYERHAEUSER BLEACHED SULFITE PULP EVALUATED AT 6° C. AND AT 27° C.

Beating Time, min.	Schopper-Riegler Freeness, cc.		Basis Weight, 25x40--500, lb.		Caliper, in.		Apparent Density		Mullen Burst, pt./100 lb.		Tear Factor		Schopper Tensile, lb./in./100 lb.	
Temperature, 6° C.														
5	880	875	47.7	46.5	0.0041	0.0039	11.6	11.9	34	37	2.26	2.13	22.4	23.2
20	720	730	52.9	46.1	0.0039	0.0034	13.6	13.6	80	77	1.32	1.24	47.7	46.2
35	530	515	42.8	45.5	0.0030	0.0032	14.3	14.2	83	86	0.91	0.90	48.3	51.0
50	340	330	40.5	45.1	0.0027	0.0029	15.0	15.6	79	89	0.69	0.73	53.6	55.9
65	215	215	46.7	45.9	0.0028	0.0028	16.7	16.4	87	75	0.60	0.59	59.3	50.8
Temperature, 27° C.														
5	875	875	45.5	46.9	0.0040	0.0040	11.4	11.7	35	35	2.42	2.17	22.6	23.8
20	720	730	45.8	46.4	0.0034	0.0035	13.5	13.3	80	80	1.33	1.44	46.5	46.2
35	515	505	44.2	44.7	0.0033	0.0032	13.4	14.0	93	94	1.22	1.05	46.9	52.1
50	340	345	—	46.6	—	0.0032	—	14.6	—	94	—	0.99	—	55.3
65	220	225	—	46.8	—	0.0032	—	14.6	—	91	—	0.92	—	55.3

TABLE II

AVERAGE VALUES FROM DUPLICATE BEATER EVALUATIONS
AT 6° C. AND 27° C.

	Beating Time, min.	Temperature 6° C.	Temperature 27° C.
Schopper-Riegler Freeness, cc.	5	880	875
	20	725	725
	35	525	510
	50	335	345
	65	215	225
Apparent Density	5	11.8	11.6
	20	13.6	13.4
	35	14.3	13.7
	50	15.3	14.6
	65	16.6	14.6
Mullen Burst, pt./100 lb.	5	36	35
	20	79	80
	35	85	94
	50	84	94
	65	79	91
Tear Factor	5	2.20	2.30
	20	1.28	1.39
	35	0.91	1.14
	50	0.71	0.99
	65	0.60	0.92
Schopper Tensile, lb./in./100 lb.	5	22.8	23.2
	20	47.0	46.4
	35	49.6	49.5
	50	54.8	55.3
	65	55.1	55.3



Figure

Apparent Density & Tear Factor
vs. Beating Time

PROJECT REPORT FORM

cc: Files
Mr. MacLaurin
Dr. Forman
Mr. Kottwitz
Mr. Elston

PROJECT NO. 1102-3
COOPERATOR Institute
REPORT NO. 5
DATE July 10, 1950
NOTE BOOK 898
PAGE 39 TO 78
SIGNED R. Elston

F. Kottwitz

PRELIMINARY EXPERIMENTS WITH ION-EXCHANGE RESINS AS A POSSIBLE METHOD OF SULFITE WASTE LIQUOR UTILIZATION

INTRODUCTION

Scaling has long been recognized as the principal obstacle to successful evaporation of sulfite waste liquor. During the course of work on this subject, there has been developed in the laboratory a successful method of evaluating the scaling tendency of a liquor as well as accomplishing the primary objective, reduction of scaling by the use of ion-exchange.

EXPERIMENTAL EQUIPMENT

A. Laboratory Evaporator

The best possible test of scaling is to duplicate the conditions under which sulfite liquor would be evaporated on a commercial basis. To try to achieve this end, an evaporator was constructed of laboratory glassware. A stainless steel tube, (i.d. 0.308") serves as a heat exchanger. The tube is removable so that scale within can be photographed or dissolved for analysis. There are provisions for either the removal of condensate (concentration) or for returning it to the system (reflux). Evaporation is carried out under vacuum. The evaporator is normally operated with approximately 2,200 cc. of 45-50% O.D. solids liquor. It has heat exchange capacity to remove about 1,200 cc. of condensate per hour. (See Figures 1 and 2 for evaporator details).

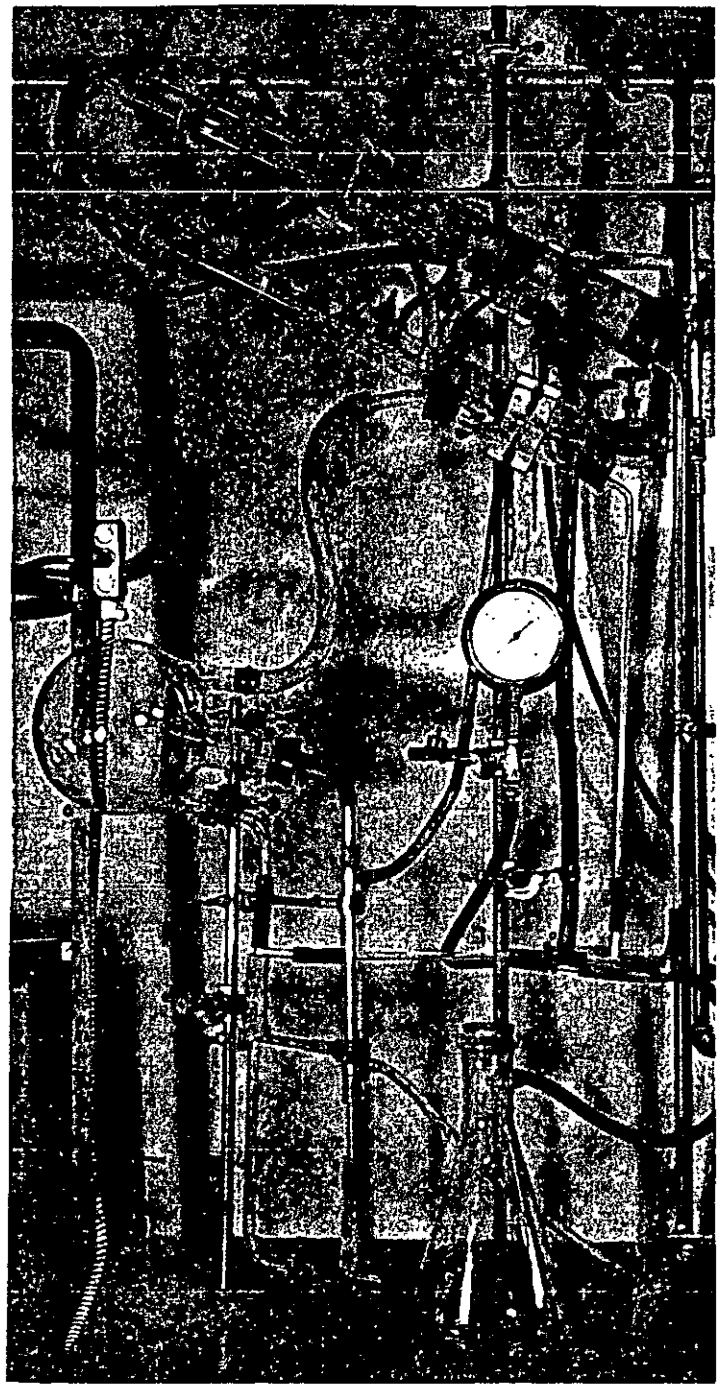


Figure 1

Laboratory Evaporator

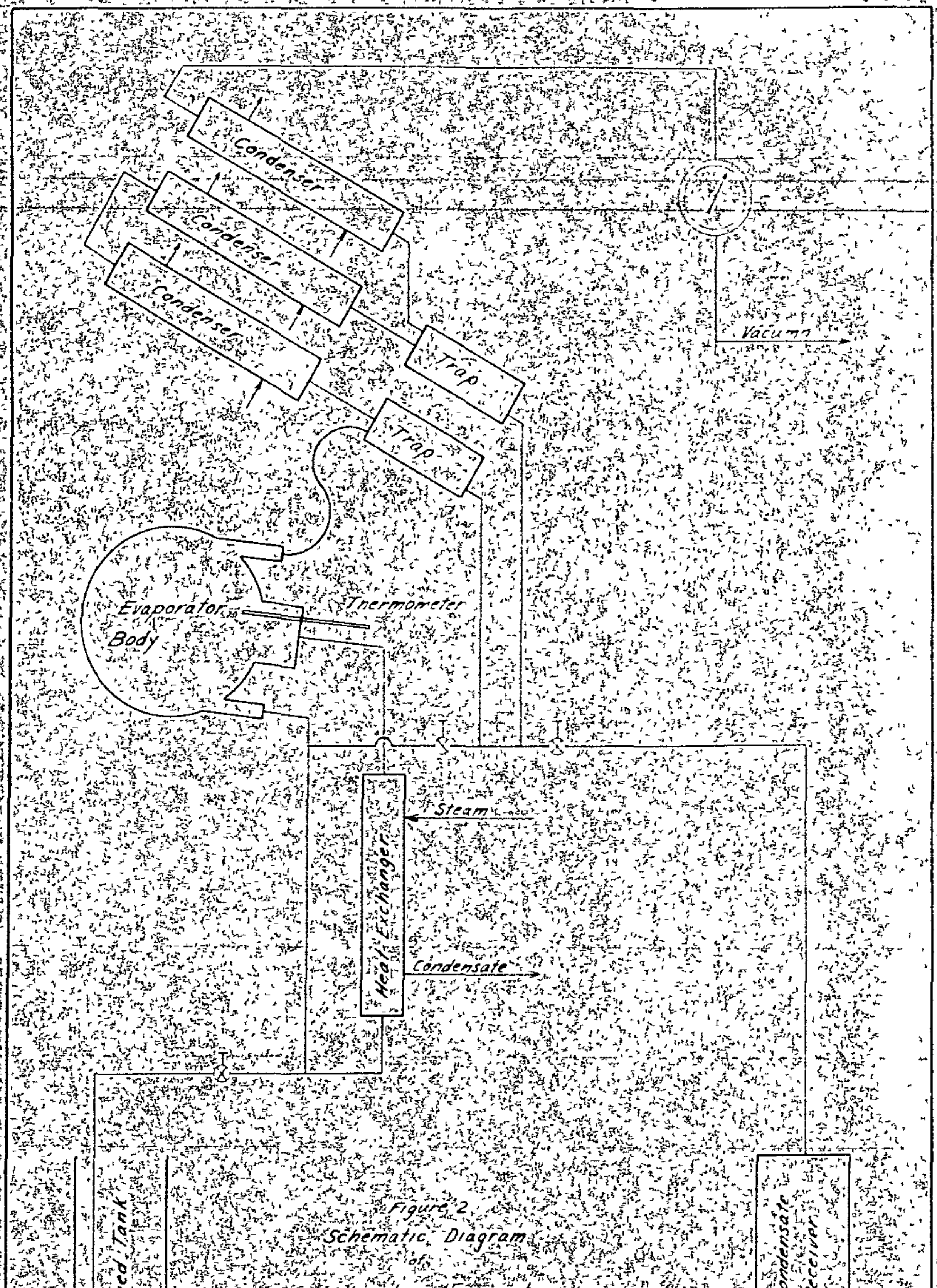


Figure 2
Schematic Diagram
of
Laboratory Evaporator

B. Ion-Exchange Equipment

Four ion-exchange resins were selected as being typical of the types commercially available. In Table I the resins are tabulated and the dimensions are given for the glass columns in which they are contained. Figure 3 is a photograph of the ion exchange equipment.

TABLE I

ION-EXCHANGE COLUMNS

Column No.	1	2	3	4
Ion Exchange Resin	Nacilite HCR	Amberlite IR-120	Permutit Deacidite	Amberlite IRA-400
Type	Cation –	Cation Strongly Acidic	Anion Weakly basic	Anion Strongly basic
Regenerant	HCl	NaCl	NaOH	NaCl
Exchange cycle	H^+	Na^+	OH^-	Cl^-
Column Diameter, in.	2.125	1.875	0.99	0.99
Bed depth, in.	29.5	29.5	24.0	24.0
Bed volume, cu. ft.	0.0614	0.0466	0.01037	0.01037

EXPERIMENTAL

Calcium sulfate is usually considered to be the compound chiefly responsible for evaporator scaling. It accounts for approximately 2.5% of the ovendry solids of a typical sulfite waste liquor. Four methods of calcium sulfate removal by ion exchange have been considered. By use of cation exchangers, calcium may be replaced by

Figure 3

Laboratory Ion Exchange Columns

either (1) the hydrogen ion, (2) some other cation, frequently sodium. The sulfate ion may be replaced through the use of anion exchangers by (1) the hydroxyl or (2) the chloride ion. In each of these instances sparingly soluble calcium sulfate is converted to a soluble compound. The complete operating cycle for the ion exchange columns in brief is:

(1) regeneration

(2) washing

(3) exhaustion with liquor

(4) displacement of the liquor with water

(5) backwashing to clean and reclassify the bed

A procedure has been standardized for making scaling test runs in the laboratory evaporator. A temperature of 62° C. and a vapor head pressure of 23" Hg. vacuum have been arbitrarily selected as operating conditions. Steam at 7 p.s.i. gauge is supplied to the heat exchanger. Four liters of liquor to be tested are fed continuously to the evaporator over a period of 2.5 hours. During this same period, 2.8 liters of evaporator condensate are collected in a receiver. When all of the liquor has been drawn into the system, collection of the condensate is stopped and refluxing is begun. The total time of the test has been arbitrarily established at 20 hours.

SUMMARY OF RESULTS

In this and in a previous bracket of experimental work the four afore-mentioned methods of scale reduction through ion exchange have been successfully carried out on a laboratory scale. Table II is a summary of data for the most pertinent experimental runs. The Appendix contains photographs showing scaling in the heat exchanger tube by untreated liquor. Photographs of the tube after successful application of ion exchange are also included.

Analysis of liquors passed through a Cation exchanger operating either an H+ or Na+ cycle shows a substantial decrease in calcium content. Subsequent evaporation of liquors passed through a Na+ regenerated cation bed, showed a complete reduction of scaling.

Analysis of liquors passed through anion beds have indicated a marked reduction in the sulfite content. Liquors prepared in this manner have shown a complete freedom from scaling by the evaporation test.

A series of repeated runs were made on each of two resins, the Amberlite IR-120 and Amberlite IRA-400 to determine if the liquor in any manner poisoned the resin beds. The tests showed that in 10 runs, there were no indications of decreased capacity or efficiency. Figures 4 and 5 are photographs of the heat exchanger tube after tests of liquors passed through the exchanger beds during the tenth cycle. The absence of scaling is evident.

A semi-quantitative analysis of resin capacity and regenerant requirements has been determined for two of the most promising cycles with sodium chloride regeneration, (Amberlite IR-120 and Amberlite IRA-410 resins).

When examining the data, consideration must be given to the fact that the calculations are based upon semi-quantitative data taken from purely arbitrary conditions which are not necessarily optimum.

The material outlined in this report is intended to be considered as a preliminary survey of the possibilities of ion-exchange as a method of waste liquor recovery. Although the results appear to be promising, a more thorough study is necessary in order to obtain the most efficient utilization of the processes. Therefore, as a guide for future investigation, several important problems are listed below:

1. The maximum permissable ion concentration below the scaling level
2. The intensity of scaling which may be tolerated
3. The optimum regenerant quantity and concentration, as it is affected by point 1.
4. The optimum flow rates in the exchange cycle
5. The optimum volume of wash water
6. Recycling of wash water for regeneration and/or optimum utilization
7. Analysis of liquors for possible use in chemical recovery processes and/or for heating value
8. Based upon the findings of the above items, make cost analyses of the more promising exchange processes. Consideration should be given to the value of chemical or heat recovery and/or the reuse of raw materials.

TABLE II

OPERATING CONDITIONS AND RESULTS OF THE PRINCIPLE EXPERIMENTAL RUNS

Resin	Nacilite HCR	Amberlite IR-120	Amberlite IR-120	Amberlite IR-120	Permutit Deacidite + Amberlite, IRA-400	Permutit Deacidite -	Amberlite IRA-400	Amberlite IRA-400
Resin Type	Cation	Cation	Cation	Cation	Anion	Anion	Anion	Anion
Regenerant	30% HCl	NaCl	NaCl	NaCl	NaOH	NaOH	NaCl	NaCl
Regenerant quantity	0.75 gal./ft.^{3}	14.0 lbs./ft.^{3}	14.0 lbs./ft.^{3}	14.0 lbs./ft.^{3}	13.5 lbs./ft.^{3}	10.5 lbs./ft.^{3}	29.8 lbs./ft.^{3}	29.8 lbs./ft.^{3}
Throughput volume, gals./ft.^{3}	33.0	23.8	51.0	75	40.7	39.0	114.5	229.0
Ion removal, % (1)	39.0	97.8	-	-	81.0	-	-	-
Scaling, weight (2) gms.	None	None	0.330	0.432	None	None	None	0.516

(1) Based upon actual analysis of the ion exchanged

(2) An average figure for the scale of an untreated liquor is 0.650 gms.

TABLE III

APPROXIMATE COST FOR PROCESSING THE WASTE LIQUOR FROM ONE TON OF SULFITE PULP[1]

Ion exchanger	Amberlite IR-120	Amberlite IRA-400
Type	Cation	Anion
Volume required, cu. ft.	36.3	16.2
Wash water requirement, gals.	800	648
Regenerant requirement (sodium chloride), lb.	254-508	241-482
Regenerant cost,[2]	\$2.25-4.50	\$2.12-4.23

[1] 1850 gallons of 13% O.D. liquor

[2] The cost of sodium chloride is \$.88/100 lbs.

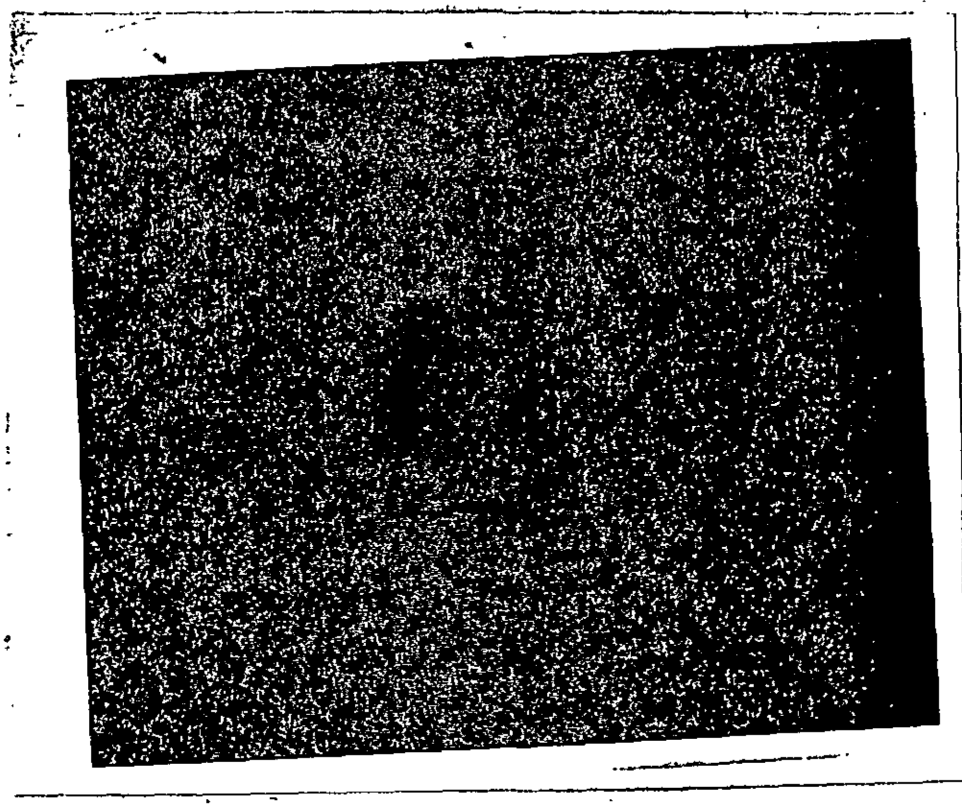


Figure 4

Heat Exchanger Tube After Evaporation of

Sulfite Liquor Treated by Amberlite IR-120.
(10th Cycle)

Throughput Volume 23.8 gal./ft.^{3}

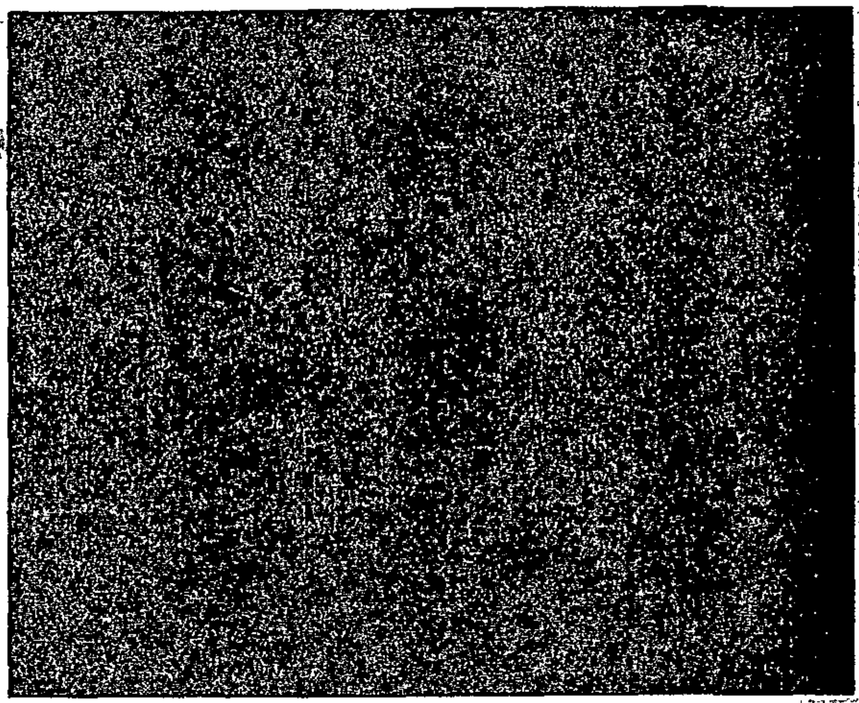


Figure 5

Heat Exchanger Tube After Evaporation of

Sulfite Waste Liquor Treated By Amberlite IRA-400
(10th Cycle)

Throughput Volume 114.5 gal./ft.^{3}

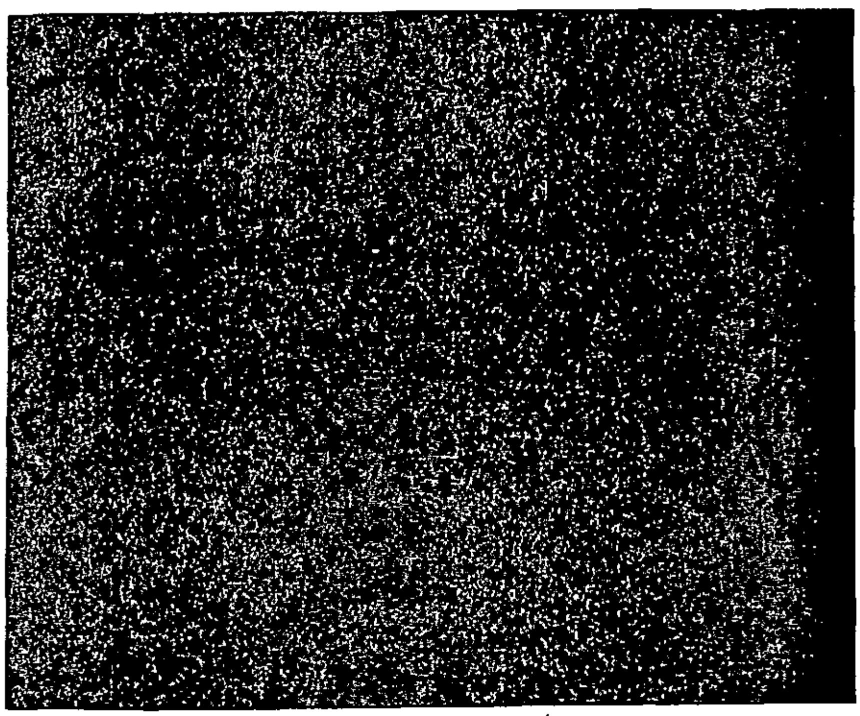


Figure 6

Heat Exchanger Tube after Evaporation of

"As Received" Sulfite Liquor