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Supercalender Variables (III) The Effects of Static Pressure and Rolling Pressure on Paper

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SUPERCALENDER VARIABLES (III)
THE EFFECTS OF STATIC PRESSURE AND ROLLING PRESSURE ON PAPER

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ABSTRACT

This thesis is the third in a series of fundamental investigations of the variables of supercalendering. The variables studied in this thesis are the internal effects derived from rolling pressure and of static pressure on paper. These variables were investigated by testing four grades of paper after being subjected to supercalendering and comparing them with similar grades pressed by a hydraulic press. The experimental results show that a definite comparative trend in the internal effects of paper were established between the rolling pressure caused by supercalendering and static pressure given by a hydraulic press. The physical properties tested were Mullen, Opacity and Caliper. The only exception to the comparative trend established were the results obtained from the tests of a ground wood sheet.

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INTRODUCTION

While the process of calendering paper is probably as old as the art of paper making itself, within the past decade, interest in this phase has been broadened and intensified with the advent of on-the-machine coating of paper, and it is now an established practice to calender this grade of paper at speeds and pressures much higher than those formerly used. The need for supercalendering was brought about by a demand of the graphic arts industry for a type of paper which would meet standards of high-quality surface characteristics. The development within this industry of finer half-tones, improved printing speeds and techniques, has increased immensely the need for large tonnages of supercalendered paper. Thus, the interest in this field has been broadened and greatly intensified during the last eighteen years. This is shown by the figures released for 1953,[1] that 4,051,000 tons of paper were supercalendered for use by the graphic arts industry in the United States, based on the calculation that all of the coated and one-third of the uncoated and fine paper was supercalendered. It is of interest to note that only approximately one-fourth of this amount of supercalendered paper was produced here in

the United States in 1951.

Because of the increasing importance of supercalendering in the paper industry, it was deemed necessary to continue the systematic investigation of its effects on paper started by the senior students in the Pulp and Paper Technology Curriculum. This is the third thesis in this series of studies. The object of this investigation will be the study of the effects of static and rolling pressures to see if they can or cannot be related. If this is possible, an attempt will be made to predict from a small-scale static test in the laboratory, the internal effects which would result from supercalendering.

FUNDAMENTAL EFFECTS

Supercalendering is done to improve the surface quality of paper more than can be accomplished by the action of the chilled-iron rolls in the calender stacks at the dry end of the paper machine. The fundamentals[2] involved in the process of supercalendering or ironing paper which must be recognized are as follows:

1. The process of supercalendering paper is a mechanical method by which the surface properties are improved. Supercalendering, therefore, mainly reflects in the end results, the standard of qualities incorporated by the paper making and coating processes.

2. Supercalendering action comprises three elements - pressure applied, plastic flow available in both paper and filled

rolls, and temperature.

3. The efficiency of conversion by calendering is a matter of balance between the responsiveness of the coated paper and the amount of the calendering action provided. The responsiveness of the coated paper, in turn, is predetermined by the quality of paper and its coating.

4. There exists a definite limit in the amount of calendering action that the paper and/or coating properties can withstand. Beyond this limit, calendering action causes a decrease rather than an increase in the standard of quality in end results.

5. Coated paper properties are the sum of the internal properties of the paper itself, plus the external properties of the coating.

6. Of the number of variables encountered in the production of a suitable calendered paper, only one variable may be manipulated in calendering action. This results from the conditions under which the supercalendering operation takes place or is brought on by the action of the supercalendering machine itself. This variable in turn, is broken down into - pressure, speed, temperature and rolls.

7. The second variable is that which depends upon the quality and condition of the paper itself, or namely, the physical properties of the paper.

8. Finally, in recognition of item 4, it will be conceded

that too much machine calendering of the web robs the supercalendering in its efforts to attain desired results, and subsequently may affect printing press operation.

THEORY OF CALENDERING

The only physical difference, according to V.F. Walters,[3] between calenders and supercalenders is the substitution of the alternate, intermediate inert metal rolls with filled rolls of material possessing resilient or elastic properties.

The behavior of filled rolls under operating conditions is a manifestation of the law governing the behavior of plastic bodies, known as the "law of rolling friction," which is explained by E.E. Thomas[4] as follows: "With the application of load on the nips, the inert metal rolls cause a depression in the plastic rolls at the point of contact and the plastic is pushed out on each side of the nip. If now the rolls are rotated, the plastic material will start to flow or creep, because of the constant effort to return to normal state. Thus plastic flow causes a relative motion of the filled roll surface on the metal roll surface, thus producing the polishing or friction action so essential to obtaining high finish or smoothing effect. The intensity of this action is governed by the amount of plastic flow furnished by filled rolls and paper passing through the nip contact pressure." It was further stated by Wheeler[5] that this polishing action of the supercalender

is due to a variation in surface speeds while going through the nip. At the entrance to the nip, the speed of the filled fiber roll and the chilled-iron roll are the same. Following into the nip, the fiber roll distorts, reducing its diameter thereby slowing its surface speed. When leaving the nip, the fiber roll re-expands to its original diameter and resumes its original speed. This action serves to polish the sheet and gives it the desired gloss or finish.

INTERPRETATION OF LITERATURE SURVEY

Some of the properties which usually change as a result of the supercalendering effort include:

1. Smoothness
2. Gloss
3. Opacity
4. Tensil strength
5. Thickness (caliper)
6. Brightness
7. Porosity
8. Stretch
9. Density
10. Oil absorption
11. Tear
12. Bursting strength

The many variables already mentioned seeming to cause the difference between supercalendered and unsupercalendered paper have been divided into two groups by Brecht.[6]

The first of the two groups contain those variables depending upon the quality and condition of the paper before supercalendering. The second group is comprised of those variables dependent upon the working conditions of the supercalendering machine. The standard in attainment results from calendering is a matter of balance between the responsiveness of the paper and coating to the amount of calendering action provided as stated by Thomas,[4] leads to a closer inspection of the variable in the two groups.

Group I Variables (Those related to paper)

1. Fiber characteristics

(a) Individual fiber strength.

Total utilization of individual fiber strength ordinarily amounts to less than 10 and 15 per cent of the theoretical strength which could be obtained if fibers were held together by forces equal to intrafiber bonds according to F.T. Carson.[7] It is his theory that lack of strength in paper should be attributed to a lack of fiber bonding and not to a deficiency in actual fiber strength.

(b) Fiber shape (round or flat).

In the case of flat fibers, the pressure per unit area from a force would obviously be less than in the case of round fibers under an equal force. For this reason, it seems reasonable to assume that the rag fibers, known to be flat ribbon like fibers, will resist a much higher pres-

sure without breaking down in fiber to fiber contact than would round fibers, their intrafiber strength being equal.

(c) Degree of beating.

Beating is a definite function of fiber bonding. Brown[8], using the Kozeny equation[9], found that the beaten fibers could be bonded together under less pressure than was required for an unbeaten sulphite pulp. He noted that the area involved in interfiber bonding was not noticeable in handsheets made from the unbeaten pulp. However, when this same pulp was beaten to a Schopper-Riegler freeness of 610 ml. an interfiber bonding of 25 to 30 per cent was found on the surface of the pulp. Too long a beating time caused the direct opposite effect to occur in fiber bonding. It was F.T. Ratliff[10], using unbleached kraft who found that the slope of the bonded area-strength curve fell off in the final stages of beating. He concluded that this strength failure was due to the breaking down of intrafiber bonds.

Thomas[4] found that there is a critical point in calendering action after which the desirous qualities of the paper decreased rather than increased. A possible similiarity can be drawn between the two types of fiber bonding.

Average beating time
or
higher pressure on
calender nips → Increased fiber to fiber contact area → Increased bonding

Very long beating time
or
very high pressure on
calender nips → Desirous qualities decreased

Beating fibers is, therefore, a definite function of fiber bonding which should not be neglected when strength of paper is being studied or investigated.

2. Degree of fiber bonding.

Theories and hypothesis have been proposed in an attempt to explaine fiber bonding, but none have been substantially proven. A widely used theory is the partial solubility theory. An early hypothesis by Urquhart,[11] and a later theory by Campbell and Pidgeon,[12] proposed that cellulose is water-soluable in certain stages. In this state the fibers are literally cemented together during the drying stages by crystallizing of the cellulose as the water is evaporated.

In 1943, a theory was proposed by Clark that the sur face of well-beaten fibers make up a two dimensional colloidal system. The fibrillae on the surface have two dimensions in the colloidal range, but are held to the fiber in the third. To prove his theory, he demonstrated with two sheets of water saturated cellophane. When the two sheets were pressed together and dried, there resulted the formation of a strong bond between the two sheets.

J. P. Casey[14] has recently brought forth the theory that the predominating force in interfiber bonding is one of secondary valence or molecular cohesion between hydroxyl groups of adjacent fibrillae.

Relating these theories to supercalendering, it seems that the moisture content of the paper when pressure is applied would definitely influence the fiber bonding in the paper being supercalendered if these theories are assumed factual.

3. Moisture content in the paper.

The cellulose fibers in paper become stronger and more plastic as the moisture content increases. There is, however, a critical point of approximately four per cent whereafter a blackening of the paper occures.[15] However, at a controlled higher per cent moisture, the same finish may be obtained using low pressures as was obtained with lesser moisture contents and at higher pressures.

According to Jayne, Tongren and Jackson,[16] their findings showed that the acting surface tension of the water in paper is so important in relationship to fiber bonding that the presence of even small amounts of reagents which reduce surface tension will lower the compacting force and result in a sheet of low density and low strength properties.

4. Type of filler.

J. Strachan[17] found that crystallinity of fillers like talc and clay, and adjuvants like starch and aluminum

stearate used in the furnish help to produce a high finish. They were found to be even more effective when applied to the paper during drying and before calendering.

5. Paper condition after treatment by machine calendering.

Work by Thomas[4] shows that excessive work done on the paper by the machine calender will restrict the desirable qualities obtainable from the paper after final supercalendering.

6. Hardness of the reels of paper .

Group II Variables (Those related to the supercalendering)

1. Pressure.

The working pressure is directly proportional to the force on the calender rolls, and inversely proportional to the nip area contact (nip width x working width) of the paper with the supercalender.[18]

2. Width of the paper used.

The working width of the paper determines the pressure, expressed in pounds per linear inch, that is exerted on the paper.[19]

3. Speed of the machine operation.

4. Hardness of the filled rolls.

The hardness of the roll is the determining factor on how much roll surface will come in contact with paper during the supercalendering action. The amount of resiliency or "give" which the filled roll exhibits when in contact with the paper determines to some degree the amount of surface finish and internal physical change occuring in the paper by supercalendering.

5. Supercalender roll diameter.

Briefkosten[20] states that a possible reason for the varying sheet caliper across the paper is that the diameter of the roll is too small in comparison to the pressure applied.

Sumary of Literature Survey .

According to the Survey of the Literature and the findings of Maves[18] and Walker,[19] the effects from supercalendering paper are due to the function of two groups of variables, the variables which are related to paper and those which are related to the supercalender.

A comparison of the Literature Survey and the experimental results obtained at Western Michigan College shows that pressure exhibits the following effects on the physical characteristics of paper.

		Literature Survey	Experimental (18)	Experimental (19)
1.	Smoothness	increased	increased	increased
2.	Gloss	increased	increased	not run
3.	Opacity	decreased	decreased	decreased
4.	Brightness	decreased	decreased	decreased
5.	Caliper	decreased	decreased	decreased
6.	Tensil strength	increased	no change	increased
7.	Tear	decreased	decreased	decreased
8.	Bursting strength	decreased	increased	increased

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EXPERIMENTAL OUTLINE

The experimental work for this thesis will be carried out as near as possible to a constant temperature and constant relative humidity on a three-roll wheeler laboratory sheet supercalender, and a Carver Hydraulic Press. Supercalendering variables and the static pressure from the hydraulic press will be controlled and kept as constant as possible with the exception of the pressure variables.

The effects of calendering are thought to be divisible into two kinds: (1) the surface effects and (2) the internal effects. Surface effects are no doubt in large part frictional effects. But, the internal effects, beyond the reach of friction, are thought to be due intirely to rolling pressure.

Static pressure is known to have certain effects upon paper; most obviously it effects thickness. In this work, the effects of static and rolling pressure will be studied to determine if they can or can not be related. One conceivable consequence of this work may be that one might be able to predict from a small-scale static test the internal effects which would result from calendering. Such a small preliminary test might be used to predict the right pressure, or the right degree of calendering needed to obtain a specified caliper. It might also be used to predict strength of the calendered paper and it might give advance indication of calender "blackening".

PROCEEDURE:

The experimental proceedure will be as follows: 40 pound 100% ground wood, 70 pound coated raw stock, 60 pound tub-sized sulphite bond and 60 pound 75% rag bond grades will be used in this experiment. The samples to be tested will be conditioned at a constant temperature of 72 degree F and relative humidity of 50 percent for at least 24 hours. After conditioning, those sheets that are of uniform formation and are free from defects will be selected for supercalendering and static pressing. The sheets will be run eight nips through the supercalender and held at one minute intervuls in the Carver Press. Subsequent tests will then be run on the samples.

For rolling pressure variations, paper will be calendered in a laboratory supercalender. Gauge pressures ranging from 10 pounds to 50 pounds arbitrarily selected will be used. To determine the nip pressure at each pressure gradient, an impression will be taken to determine the area of surface in contact between the fiber roll and the steel roll. This will be done by inserting a wrinkled aluminum foil between the rolls and then applying the desired pressure. A smoothed out impression of the surface contact will be left and from this the nip area will be calculated. As a matter of fact, pressure in the nip is obviously not equal throughout the contact area. It varies from zero at the edge of the pressure area up to some maximum along the center line

parallel to the roll axis. We will attempt to determine the peak load pressure at each gauge pressure.

This same grade of paper will then be studied for effects derived from static pressure. For this determination a Carver Hydraulic Press will be used. The paper will be subjected to the identical pounds per-square inch pressure on this machine as was obtained from the supercalender.

Because the static test gives only internal effects, only Mullen, opacity and caliper will be tested for and compared. After many series of comparision tests are run and averaged, these averages will be graphed to show the comparative results. Testing will be completed on one grade of paper before continuing to the next grade.

EXPERIMENTAL WORK

The experimental work for this investigation was carried out on a three-roll laboratory sheet supercalender and a hand operated hydraulic press. The supercalender is installed in a room kept at a constant temperature of 72 degrees F and 50 percent relative humidity. In this way the variables of supercalendering, with the exception of pressure, which was under study, were kept constant. The Carver Press is located in the pulp laboratory. The paper was kept in the humidity room at all times with the exception being only when subjected to pressure by the Carver Press. All comparative tests were run in the humidity room after proper conditioning.

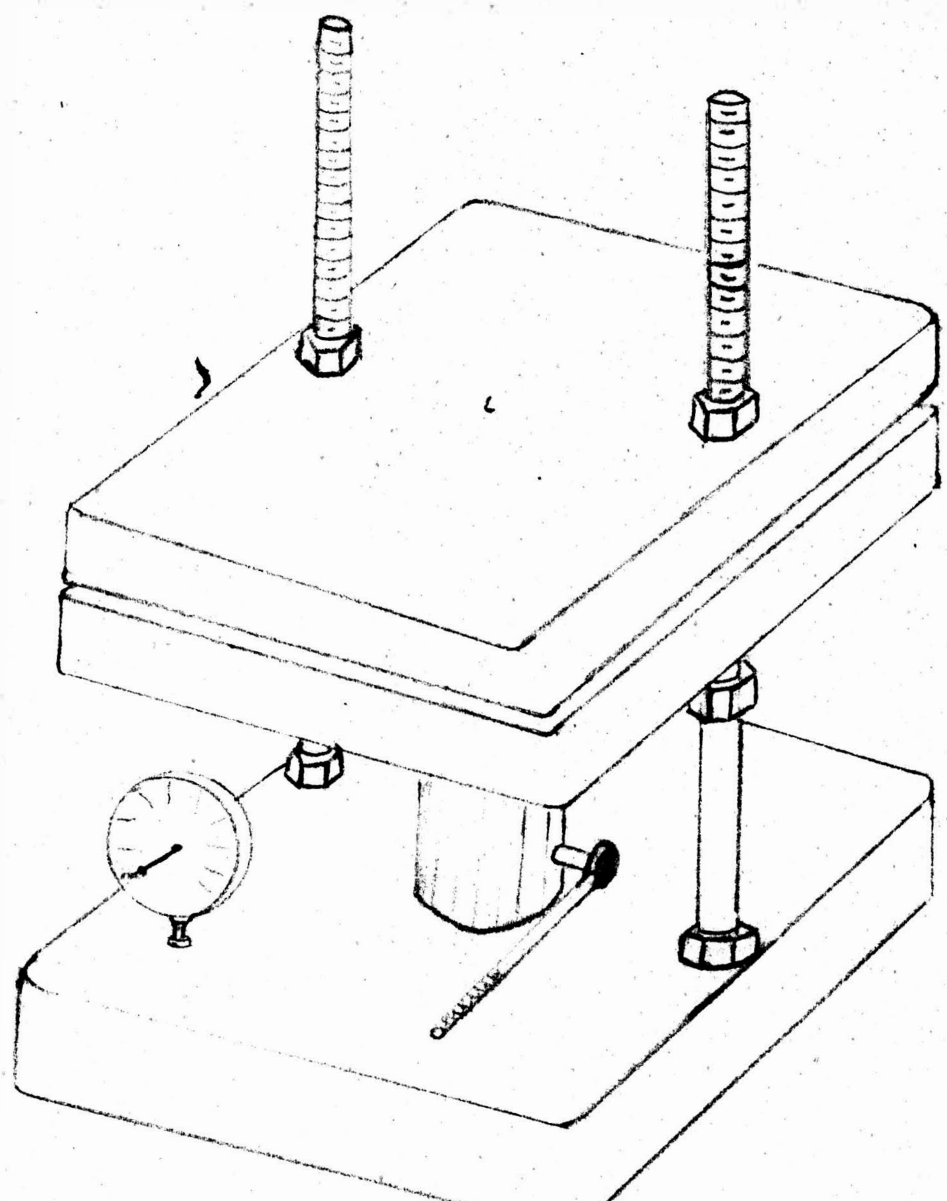
CARVER HYDRAULIC PRESS

The hydraulic press is a mechanical, hand operated machine, very similar to a automobile jack. It is powered by oil which gives mechanical leverage up to a maximum of 25,000 pounds per square inch. Oil pumped through a reducing valve raises the bottom platform against the upper platform and pressure is indicated in pounds per square inch by an oil gauge placed in the oil lines after the valve.

The top and bottom platforms may be raised or lowered to accomodate variability of the thickness to be pressed. The gauge has two scales which indicate pressures in pounds per square inch or pound per square one and one quarter inch. A detailed drawing of this instrument is shown in Fig. 1. This machine is located in the pulp laboratory.

CARVER HYDRAULIC PRESS FIG. I

This hydraulic press is located in the pulp laboratory at Western Michigan College. Oil pressure applied to the lower bed creates pressures equivalent to 20,000 pounds per square inch.



LABORATORY SUPERCALENDER

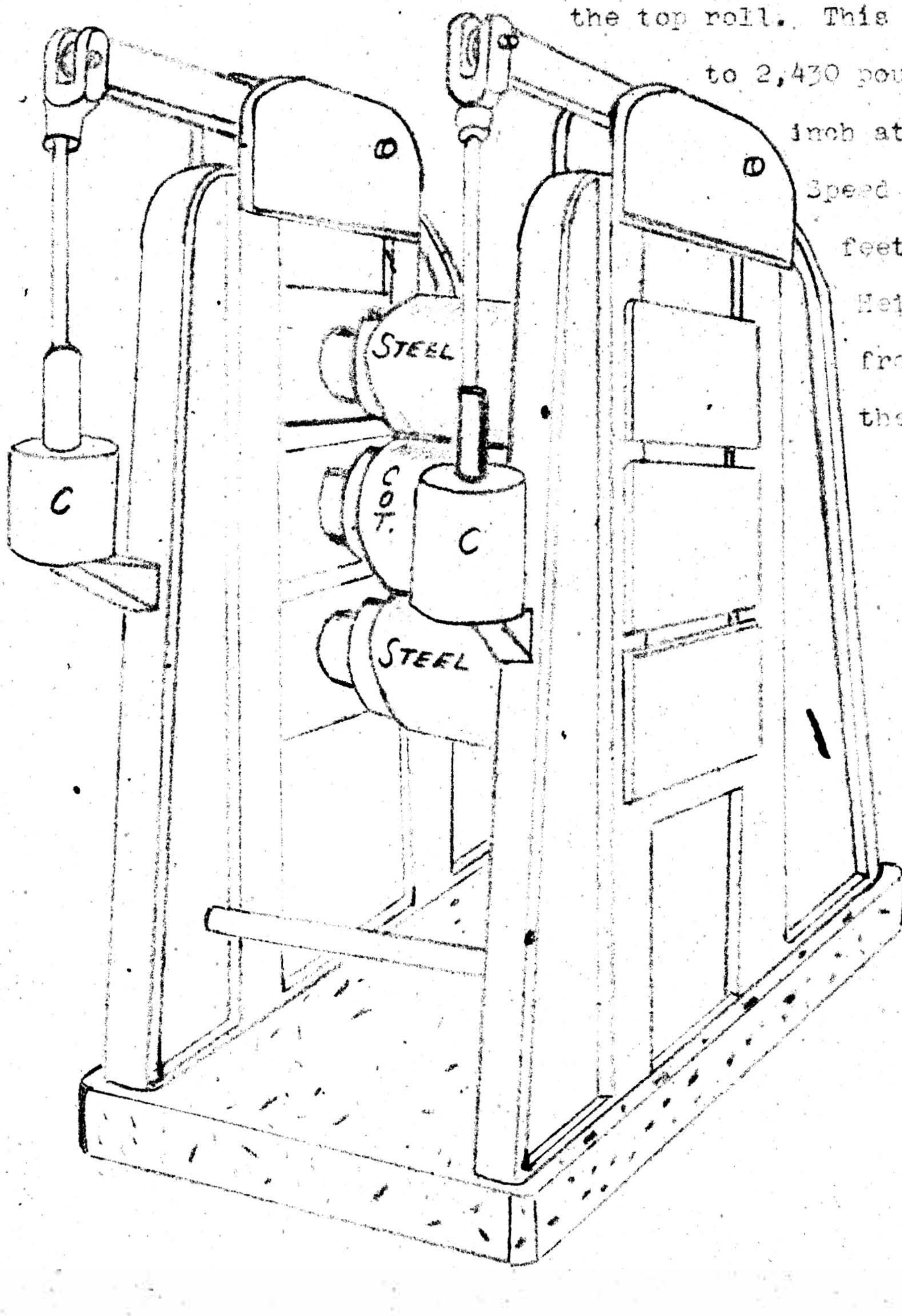
The laboratory supercalender, with which experimental work was done, was designed and built by the Wheeler Roll Company of Kalamazoo. It is a three-roll sheet supercalender with a paper-filled middle roll and two polished, steel rolls. The rolls are $10\frac{1}{2}$ inches in diameter with 14-inch faces and are mounted on antifriction bearings. The supercalender is driven by a two horsepower electric motor at a constant speed of 34.4 feet per minute. Because of the low speed, high temperatures are not accomplished as in the case of high speed commercial supercalenders, which attain temperatures up to 180 degrees F through the friction of the rolls.

Pressure is applied to the top steel roll pneumatically through two Hannefin-Foxboro air cylinders whose pistons have a surface area of 30 square inches. The pistons are connected to lever arms, one on each side of the top roll, with a lever ratio of ten to one. Compressed air can be admitted to either the top or the bottom of the cylinders. Consequently, pressure can be applied to the top roll of the supercalender by applying air to the top of the cylinders, or the roll can be raised free of the paper-filled roll by applying air to the bottom of the cylinders. Air to each cylinder is controlled by a separate reducing valve, and pressures are indicated in pounds per square inch gage by two air gages which are placed in the air lines after the valves.

LABORATORY SUPERCALENDER FIG. 2

This three roll laboratory supercalender is located at Western Michigan College in the constant temperature-humidity room of the Pulp and Paper Department.

The two steel rolls are 10.5 inches in diameter, and the middle cotton filled roll is 12.0 inches in diameter. The nip between the cotton and steel rolls is 13.6 inches long. Air pressure applied to the two cylenders, C, cause forces up to 33,000 pounds on the top roll. This is equivalent to 2,430 pounds per lineal inch at the nip. Speed equals about 36 feet per minute. Height is 69 inches from the floor to the top.



Available air pressures up to a maximum of 55 pounds per square inch, can be applied to the cylinders. After the line pressure has been multiplied by the cylinder areas and lever-arm ratios, a calculated maximum of 33,000 pounds can be applied to the top roll, or 5800 pounds per square inch at the nip between the top roll and the paper-filled roll. A detailed drawing of this instrument is shown in Fig. 2.

EXPERIMENTAL PROCEEDURE

The following grades of paper were used:

1. Sixty pound tub sized sulphite bond, furnished by Michigan Paper Company, Plainwell, Michigan.
2. Seventy pound coated raw stock, furnished by Kalamazoo Paper Company, Kalamazoo, Michigan.
3. Sixty pound 75% rag bond, furnished by Whiting Plover Paper Company, Stevens Point, Wisconsin.
4. Fourty pound 100% ground wood sheet, supplier unknown.

The paper was conditioned at 72 degrees F and 50 percent relative humidity for at least 24 hours. Thirty sheets of the uncalendered paper, which were free from visible surface and internal defects, were selected from each grade for super-calendering and pressing at constant temperature and relative humidity conditions.

The following physical test were run after the calendering and pressing:

1. Mullen Test

on the aluminum foil. This area of impression was measured, and by using the total number of pounds applied to the nip and the number of square inches of nip area, the pressure at the nip was calculated in pounds per square inch.

The tables below indicate how this nip area was found:

GUAGE PRESSURE		NIP AREA	(Found by foil measurements)
10 pounds	equals	2.06	Square inches
20 "	"	3.21	" "
30 "	"	3.92	" "
40 "	"	4.62	" "
50 "	"	5.18	" "

Formula for finding average nip area pressure:

$$\frac{\text{Guage pressure x 30 sq. in. piston surface x 2 each x 10:1 leverage ratio}}{\text{Nip area at guage pressure}}$$

The above formula is equal to average nip area pressure.

Nip area pressure at various gauge pressures:

GUAGE PRESSURE				NIP AREA PRESSURE
10 pounds	equals	$\frac{10\#x30x2x10}{2.06 \text{ sq. in}}$	equals	2905 #/sq. in.
20 "	"	$\frac{20\#x30x2x10}{3.21 \text{ sq. in.}}$	"	3750 " " " "
30 "	"	$\frac{30\#x30x2x10}{3.92 \text{ sq. in.}}$	"	4600 " " " "
40 "	"	$\frac{40\#x30x2x10}{4.62 \text{ Sq. In.}}$	"	5225 " " " "
50 "	"	$\frac{50\#x30x2x10}{5.18 \text{ sq. in.}}$	"	5800 " " " "

2. Caliper

3. Opacity

Physical tests were carried out with instruments as suggested by T.A.P.P.I. standards. A electric motor-driven Mullen Tester was used for the Mullen Test. Opacity was run on a Bausch and Lomb Opacimeter and Caliper was run in a standard manner.

The sheets were trimmed so that they were the exact width of the nip length. Pressure was applied to the top roll of the supercalender and the sheet was passed through the nip with the wire side up. It was then turned over and passed through with the felt side up. This was repeated until the paper was passed through eight nips. The supercalendering was continued at five pressure incruments; 2905, 3750, 4600, 5225, and 5800 pounds per square inch. These pressures represent the total number of pounds per square inch of applied pressure at the nip and correspond to 10, 20, 30, 40, 50 pounds per square inch guage pressure as applied to the cylinders of the supercalender.

To find the accurate picture of the nip pressure, the following method was employed to find the nip pressure in pounds per square inch rather than in total pounds or pounds per lineal inch: A wrinkled aluminum foil was placed across the entire length of the open nip. The desired pressure was applied to the top roll. Upon release of the pressure on the top roll, a smoothed out impression was left

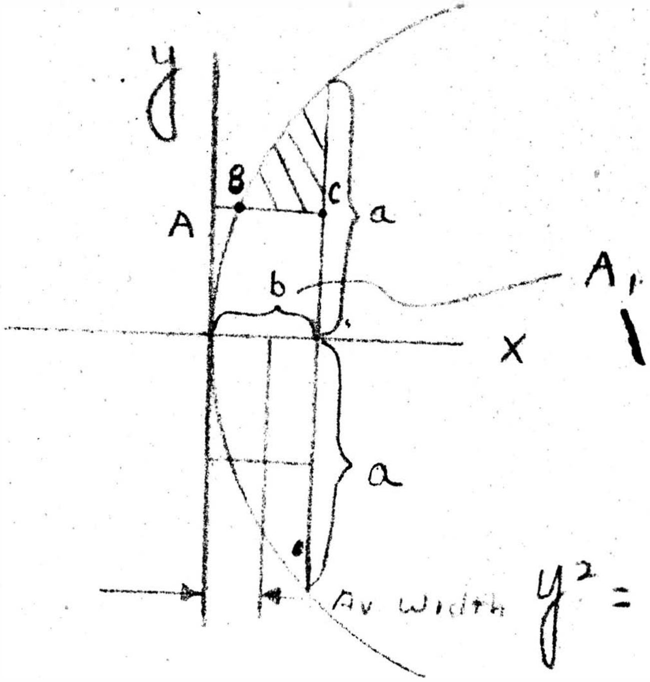
For determing and comparing the rolling pressure given by the supercalendering action on paper with static pressure effects; a Carver Hydraulic Press was used. The selected grades of paper were cut into two inch squares. These squares were conditioned to standard temperature and humidity and only a few squares at a time were taken out of the humidity room for pressing in the static press. After pressing for one minute at the desired pressure, the squares of samples were returned to the humidity room and reconditioned before physical testing.

To correlate the pressures obtained by the supercalender with that applied to the squares by the Carver Press; it was necessary to postulate the assumption of the parabla. (See fig. 3) From this assumption it was found that the peak load pressure applied at the supercalender was one and one half times that of the average nip area pressure.

It was also necessary to have a good smooth finish with which to press the paper against in the Carver Press. It was further necessary to have the unit small enough to obtain proper pressure on the squares, and large enough to accomodate the physical testing to which the paper was to be later subjected.

A circular metal disc, machined and polished to 1.625 inches by .25 inches thick, was selected to be used for this purpose. These measurements gave a area to the

FORMULA USED TO FIGURE MAXIMUM PRESSURE IN NIP FIG. 3



$$y^2 = Kx$$

$$a^2 = Kb$$

$$K = a^2/b$$

$$y^2 = \frac{a^2}{b}x, \quad \frac{by^2}{a^2} = x$$

$$A_1 = \int_0^a \int_A^C dx\,dy = \int_0^a \int_{\frac{by^2}{a^2}}^{b} dx\,dy$$

$$= \int_0^a \left[b - \frac{by^2}{a^2} \right] dy$$

$$= \left[by - \frac{by^3}{3a^2} \right]_0^a$$

$$= ba - \frac{ba^3}{3a^2} = \frac{2ba}{3}$$

$$\text{Av. Width} = \frac{2}{3}\,ba/a = \frac{2}{3}\,b$$

disc of 1.95 square inches.

Pressures used on the Carver Press were determined as follows:

Supercalender Gauge Pressure		Average Nip Area Pressure			Peak Load Pressure #/sq. in.
10 pounds	equal to	2905 #/sq. in.	x1.5	equals	4360 #/sq. in.
20 "	" "	3750 " " "	" "	"	5625 " " "
30 "	" "	4600 " " "	" "	"	6900 " " "
40 "	" "	5225 " " "	" "	"	7850 " " "
50 "	" "	5800 " " "	" "	"	8700 " " "

Gauge Pressure		Peak Load Pressure		Area of Disc.		Carver Press Pressure
10 pounds	equal to	4360	x	1.95	equal	8,500 #/sq in
20 "	" "	5625	x	1.95	"	11,000 " " "
30 "	" "	6900	x	1.95	"	13,500 " " "
40 "	" "	7850	x	1.95	"	15,300 " " "
50 "	" "	8700	x	1.95	"	17,000 " " "

After the testing of the supercalendered and Carver pressed paper was completed on the four grades of samples, the test results were averaged and compared by grades at each pressure increment.

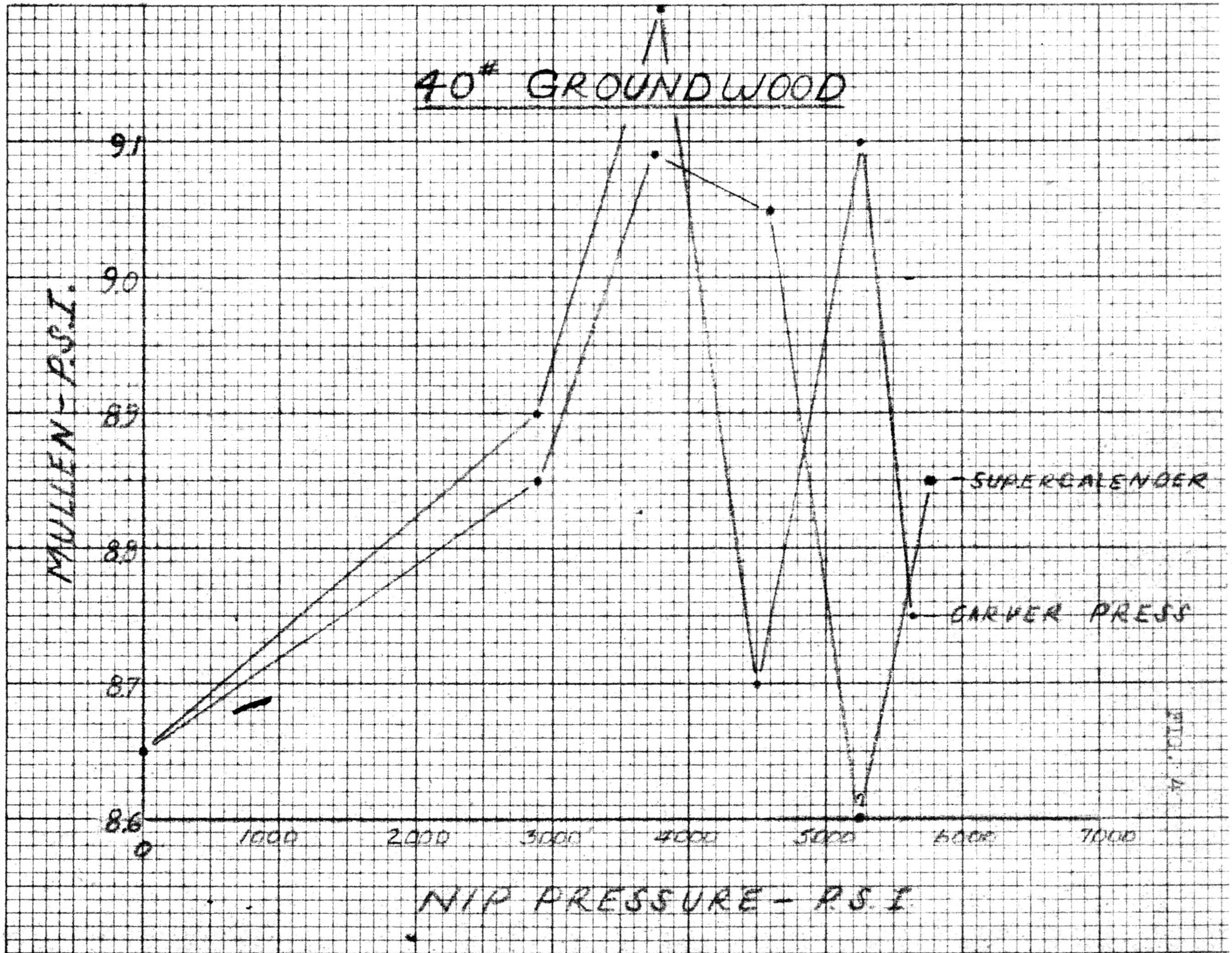
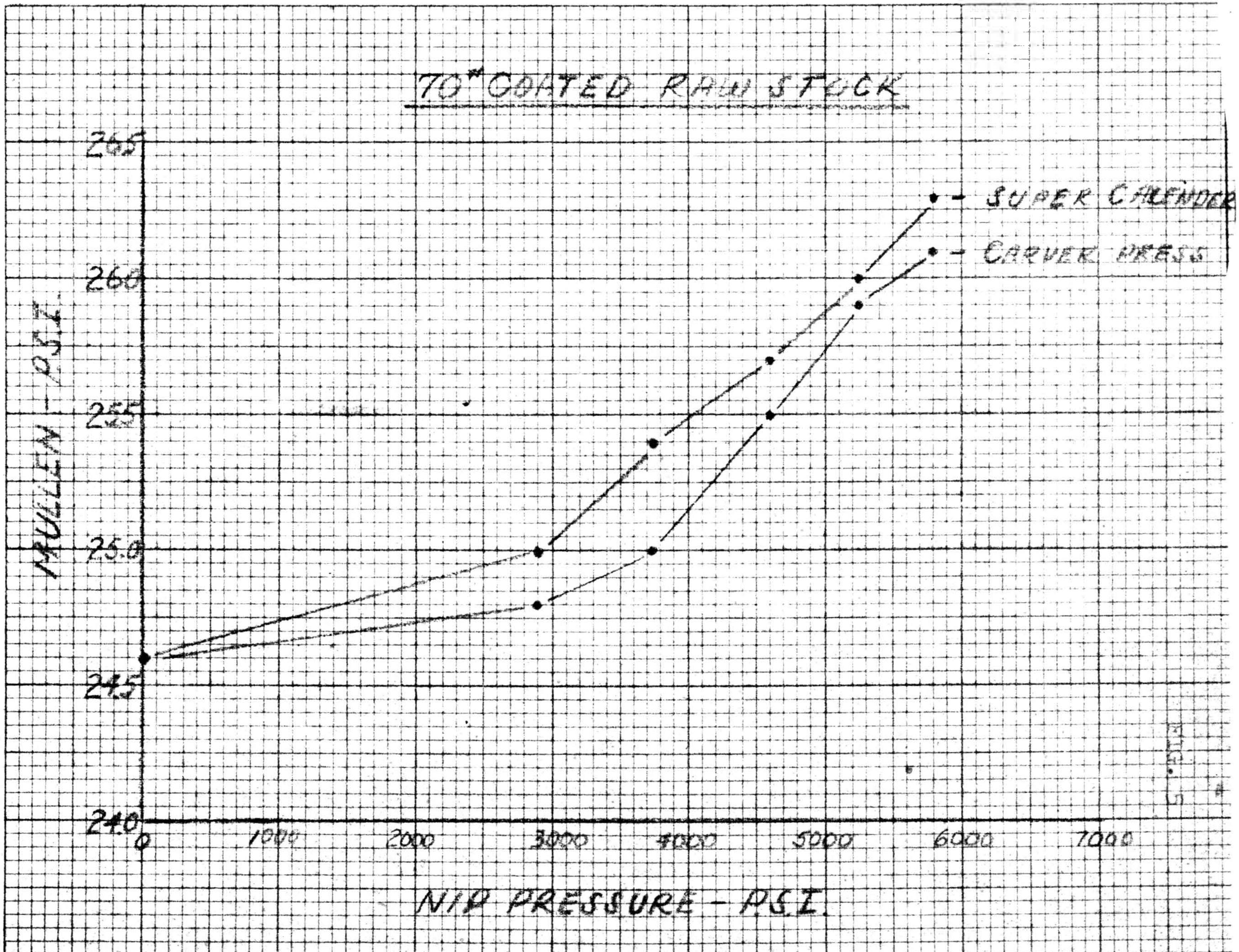
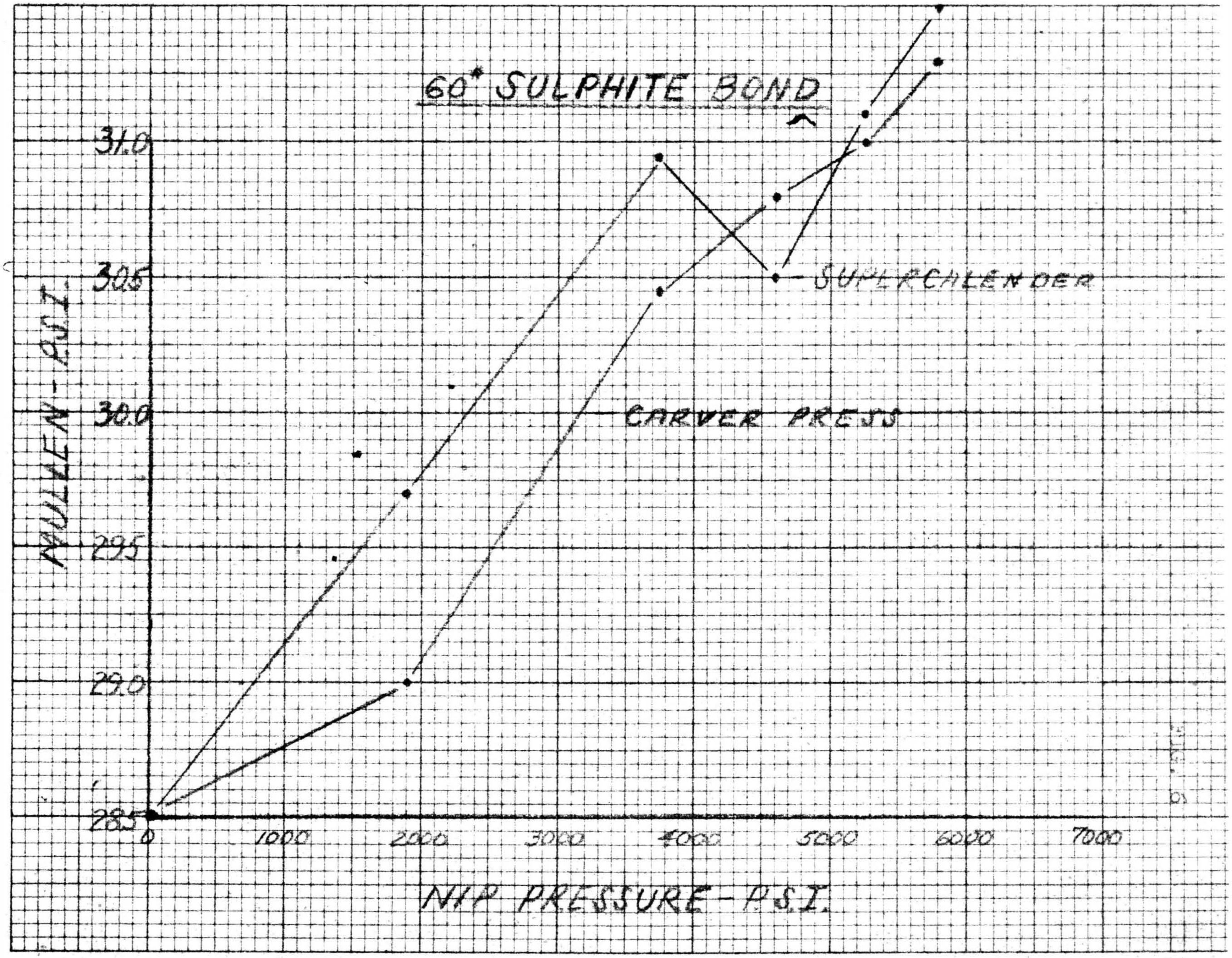
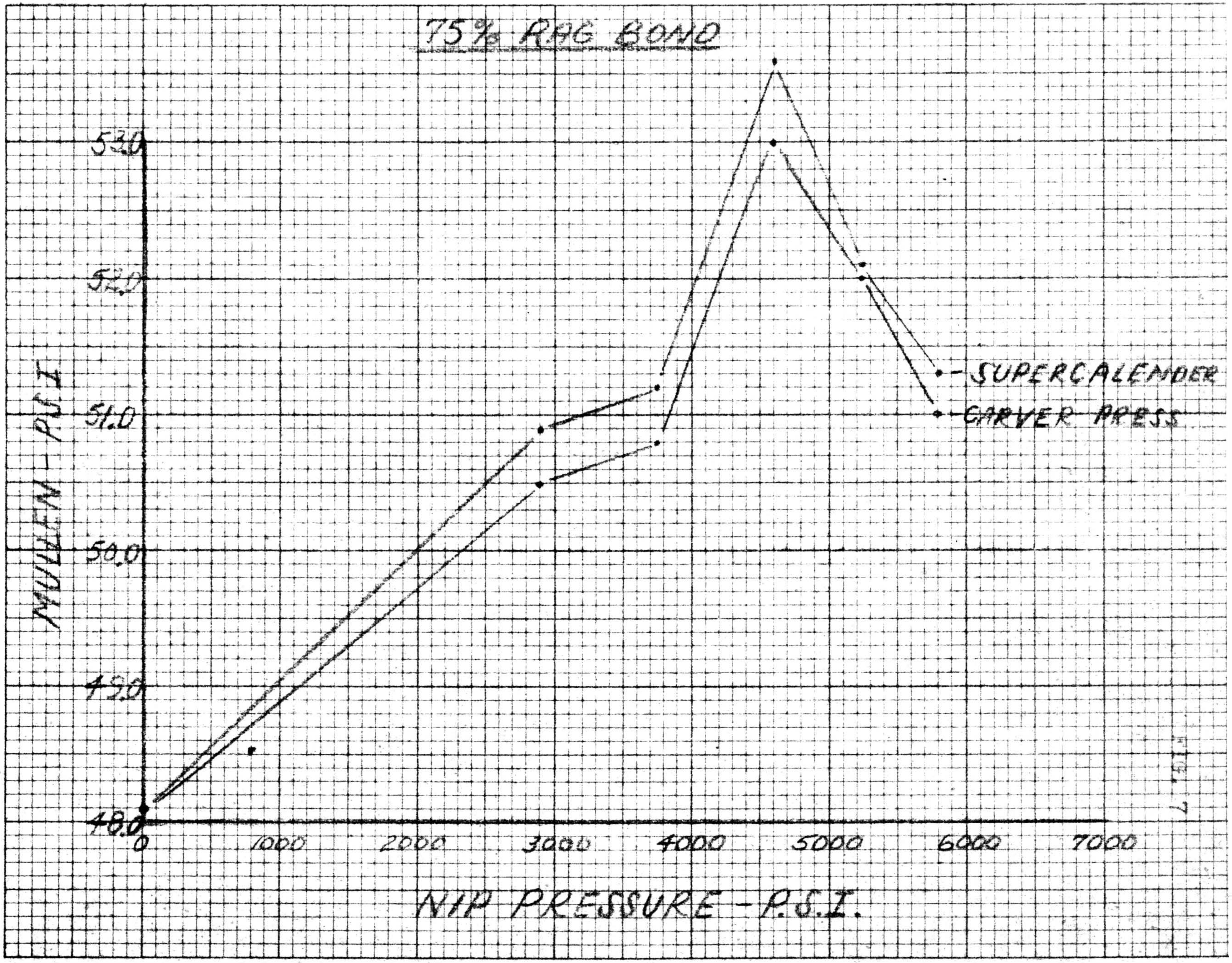

40# GROUNDWOOD
MULLEN - P.S.I.
91
90
89
88
87
86
0
1000
2000
3000
4000
5000
6000
7000
NIP PRESSURE - P.S.I.
SUPERCALENDER
CARVER PRESS

FIG. 4



70# COATED RAW STOCK
MULLEN - PSI
265
260
255
250
245
240
0
1000
2000
3000
4000
5000
6000
7000
NIP PRESSURE - PSI
SUPER CALENDER
CARVER PRESS


60# SULPHITE BOND
MULLEN - P.S.I.
31.0
30.5
30.0
29.5
29.0
28.5
0
1000
2000
3000
4000
5000
6000
7000
NIP PRESSURE - P.S.I.
SUPERCALENDER
CARVER PRESS


75% RAG BOND
MULLEN - PSI
53.0
52.0
51.0
50.0
49.0
48.0
0
1000
2000
3000
4000
5000
6000
7000
NIP PRESSURE - P.S.I.
SUPERCALENDER
CARVER PRESS
FIG 7

DATA AND RESULTS

The test results from each grade, after calendering and hydraulic pressing, are shown in the following tables and graphs. The graphs drawn from tabulated data, test values ploted versing nip pressures in pounds per square inch.

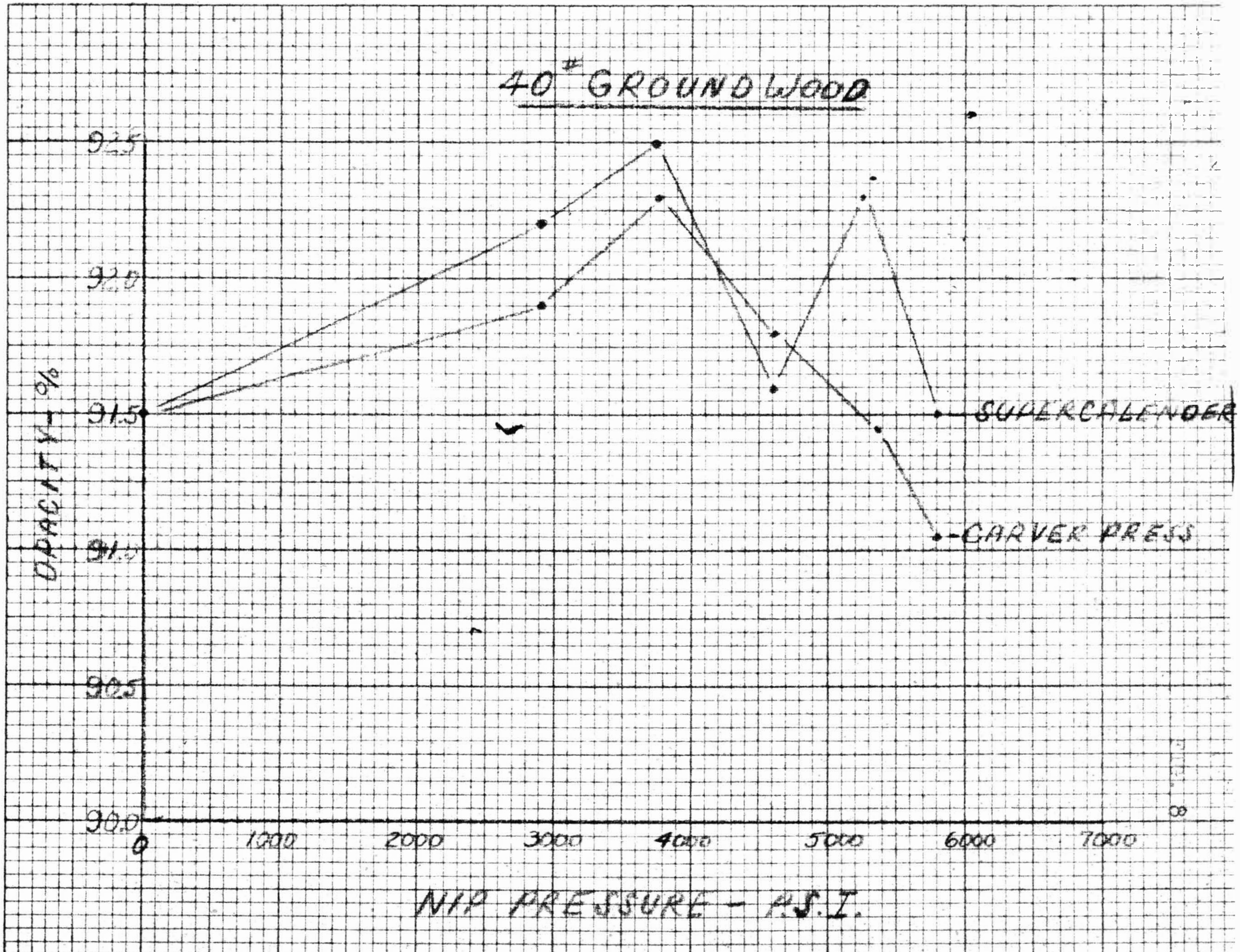
Table A and Figures 4; 5;6;and 7, show the mullen test results, which were obtained from the four grades of paper by the action of supercalendering and hydraulic pressing on these papers. It is noted that little correlation in the groundwood sheet results, was found.

TABLE A

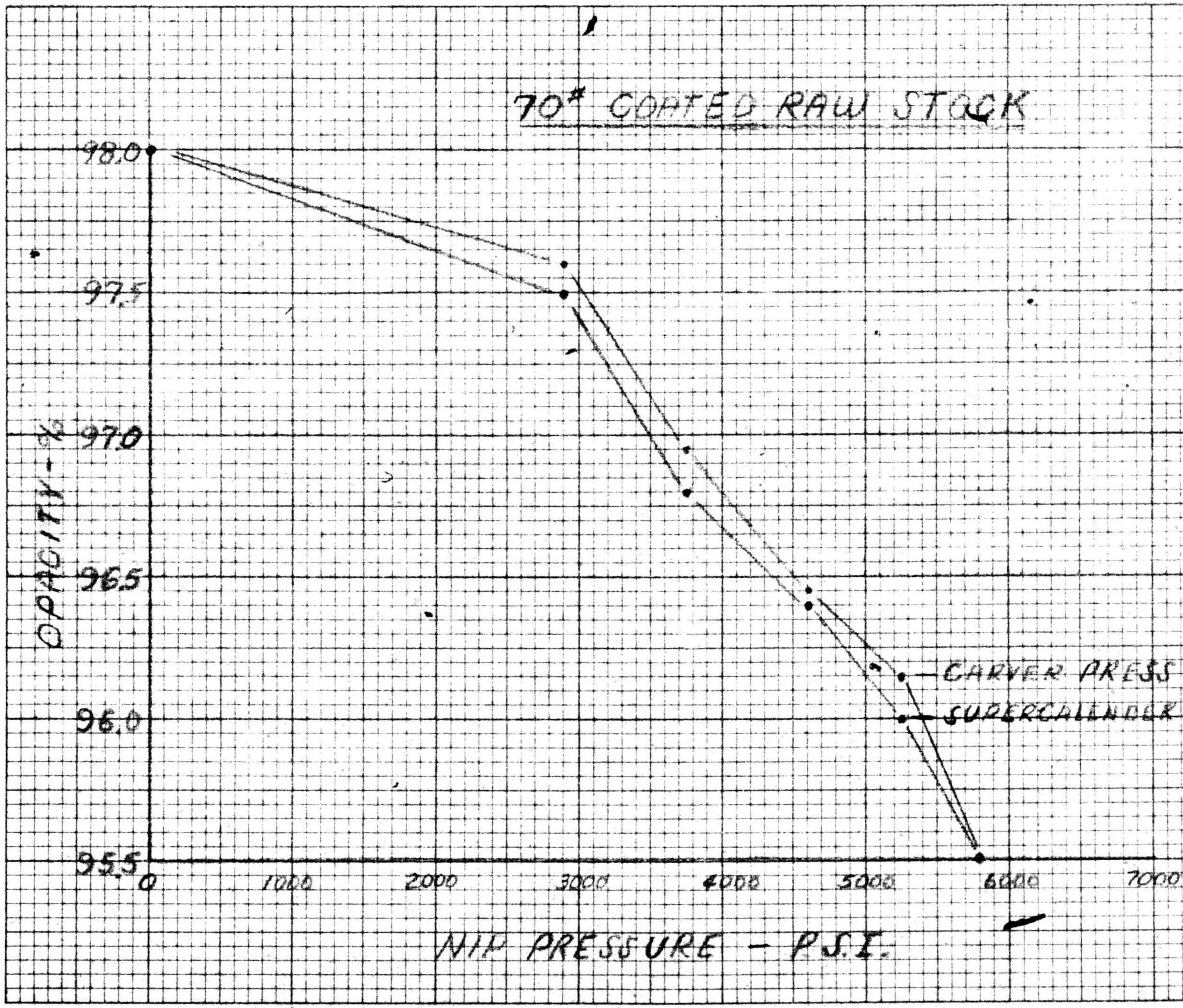
MULLEN TEST RESULTS

GRADES		NIP PRESSURES - POUNDS PER SQUARE INCH					
		0	2900	3750	4600	5225	5800
Groundwood	Carver Press	8.65	8.9	9.2	8.7	9.1	8.75
	Supercalender	8.65	8.85	9.09	9.05	8.6	8.85
Coated	Carver Press	24.6	24.8	25.0	25.5	25.9	26.1
	Supercalender	24.5	25.0	25.4	25.7	26.0	26.3
Sulphite	Carver Press	28.5	29.0	30.5	30.8	31.0	31.3
	Supercalender	28.5	29.7	30.95	30.5	31.1	31.5
Rag	Carver Press	48.1	50.5	50.8	53.0	52.0	51.0
	Supercalender	48.1	50.0	51.2	54.6	52.1	51.3

Table B and Figures 8; 9; 10; 11; show the results of the tests after using a Bausch and Lomb opacimeter on the paper. In this test, the groundwood sheet gave better correlation than those obtained from the mullen test. The three other grades again gave very good correlation.

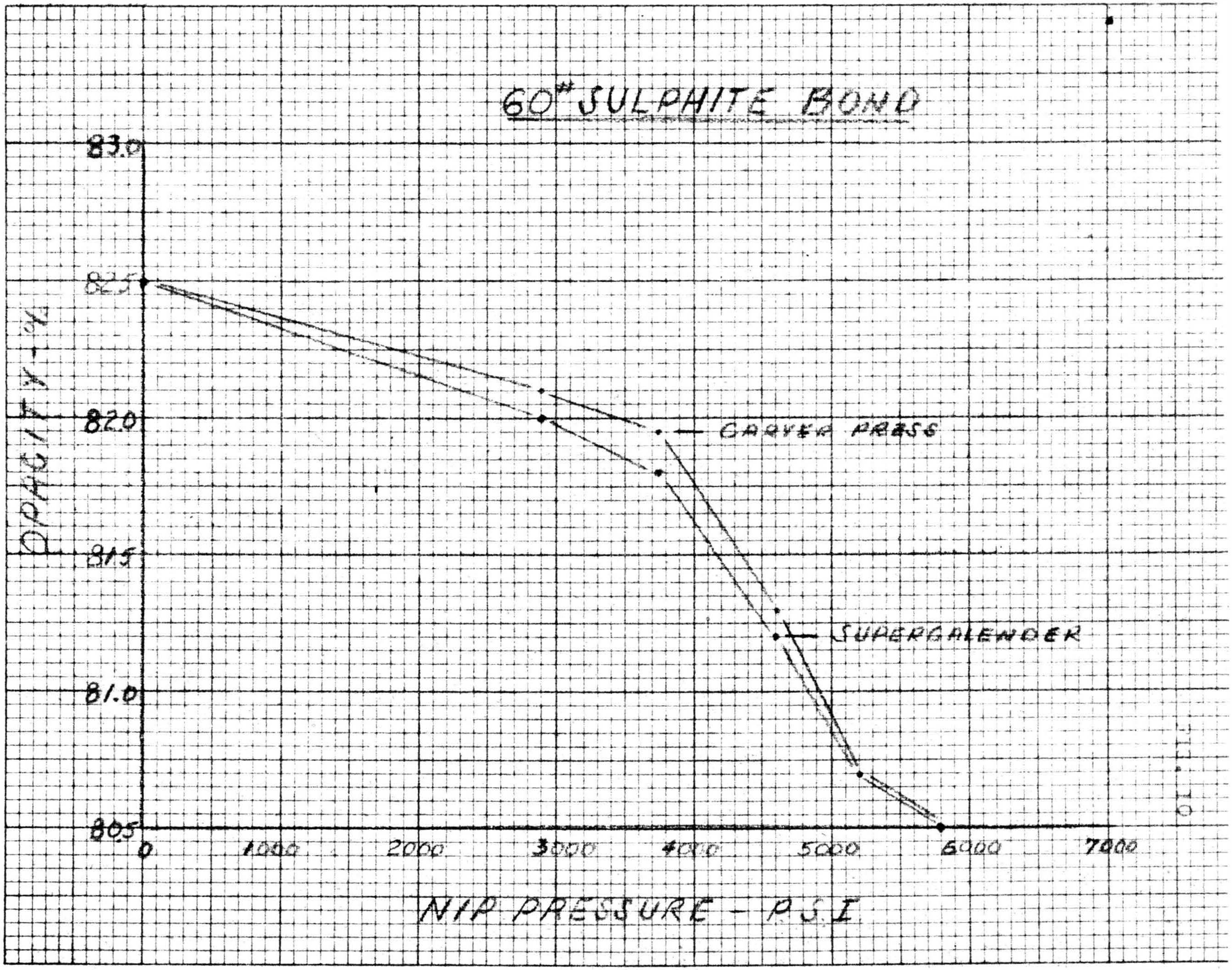


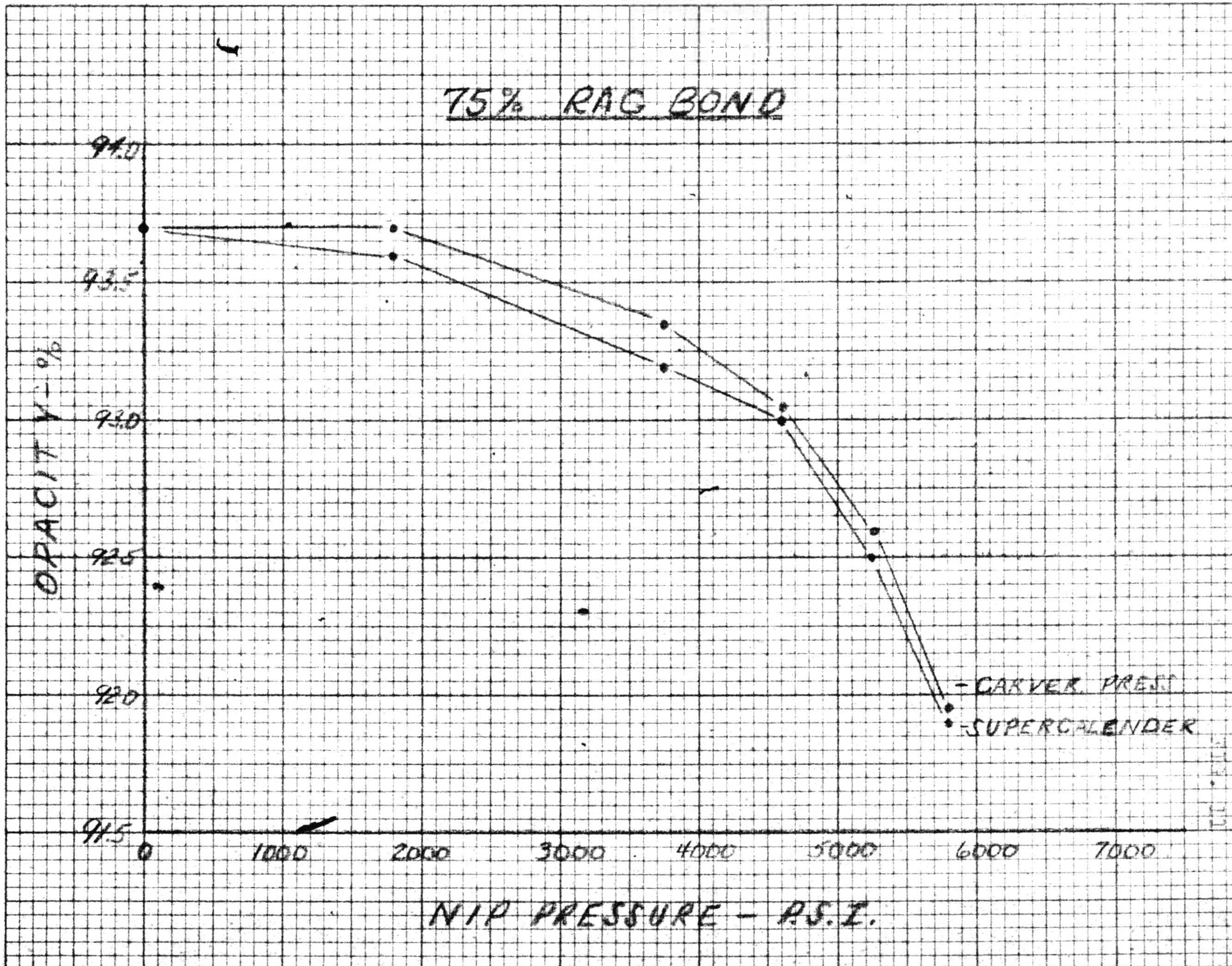
40# GROUNDWOOD
OPACITY - %
92.5
92.0
91.5
91.0
90.5
90.0
0
1000
2000
3000
4000
5000
6000
7000
NIP PRESSURE - P.S.I.
SUPERCALENDER
CARVER PRESS



70# COATED RAW STOCK
OPACITY - %
98.0
97.5
97.0
96.5
96.0
95.5
0
1000
2000
3000
4000
5000
6000
7000
NIP PRESSURE - P.S.I.
CARVER PRESS
SUPERCALENDER

FIG. 9


60# SULPHITE BOND
83.0
82.5
82.0
81.5
81.0
80.5
OPACITY - %
CARVER PRESS
SUPERCALENDER
0
1000
2000
3000
4000
5000
6000
7000
NIP PRESSURE - P.S.I.



75% RAG BOND
94.0
93.5
93.0
92.5
92.0
91.5
OPACITY - %
0
1000
2000
3000
4000
5000
6000
7000
NIP PRESSURE - P.S.I.
- CARVER PRESS
- SUPERCALENDER

TABLE B

OPACITY TEST RESULTS

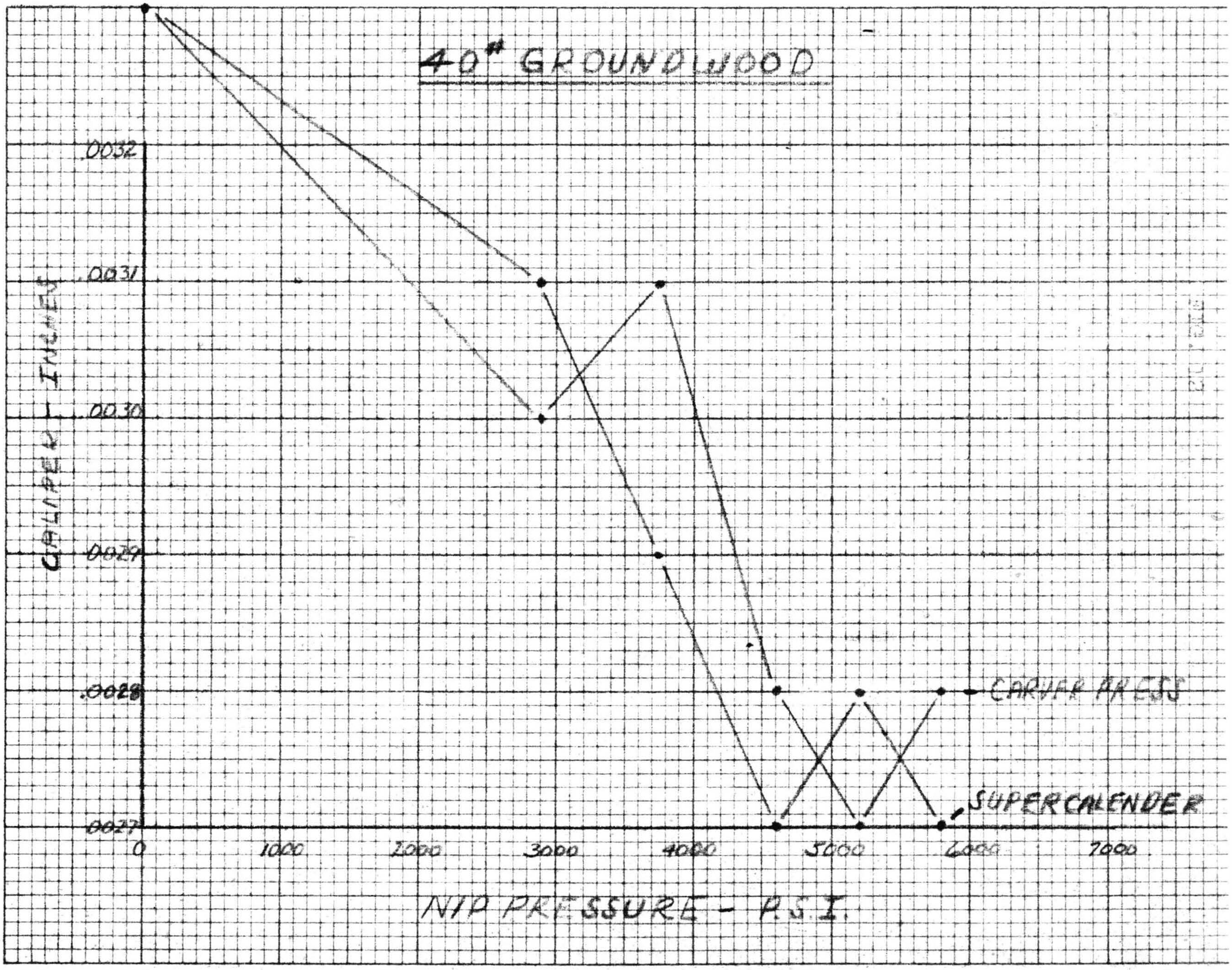
GRADES		NIP PRESSURES - POUNDS PER SQUARE INCH					
		0	2900	3750	4600	5225	5800
Groundwood	Car. Press	91.5	91.9	92.3	91.8	91.45	91.05
	SuperCal.	91.5	92.2	92.5	91.6	92.3	91.5
Coated	Car. Press	98.0	97.6	96.95	96.45	96.15	95.5
	SuperCal.	98.0	97.5	96.8	96.4	96.0	95.5
Sulphite	Car. Press	82.5	82.1	81.95	81.3	80.7	80.5
	SuperCal.	82.5	82.0	81.6	81.2	80.7	80.5
Rag	Car. Press	93.7	93.7	93.35	93.05	92.6	91.95
	SuperCal.	93.7	93.6	93.2	93.0	92.5	91.8

In Table C and Figures 12; 13; 14; 15; the results of caliper are tabulated for each grade of paper used. Again, the groundwood sheets did not follow the trend established by the other three grades.

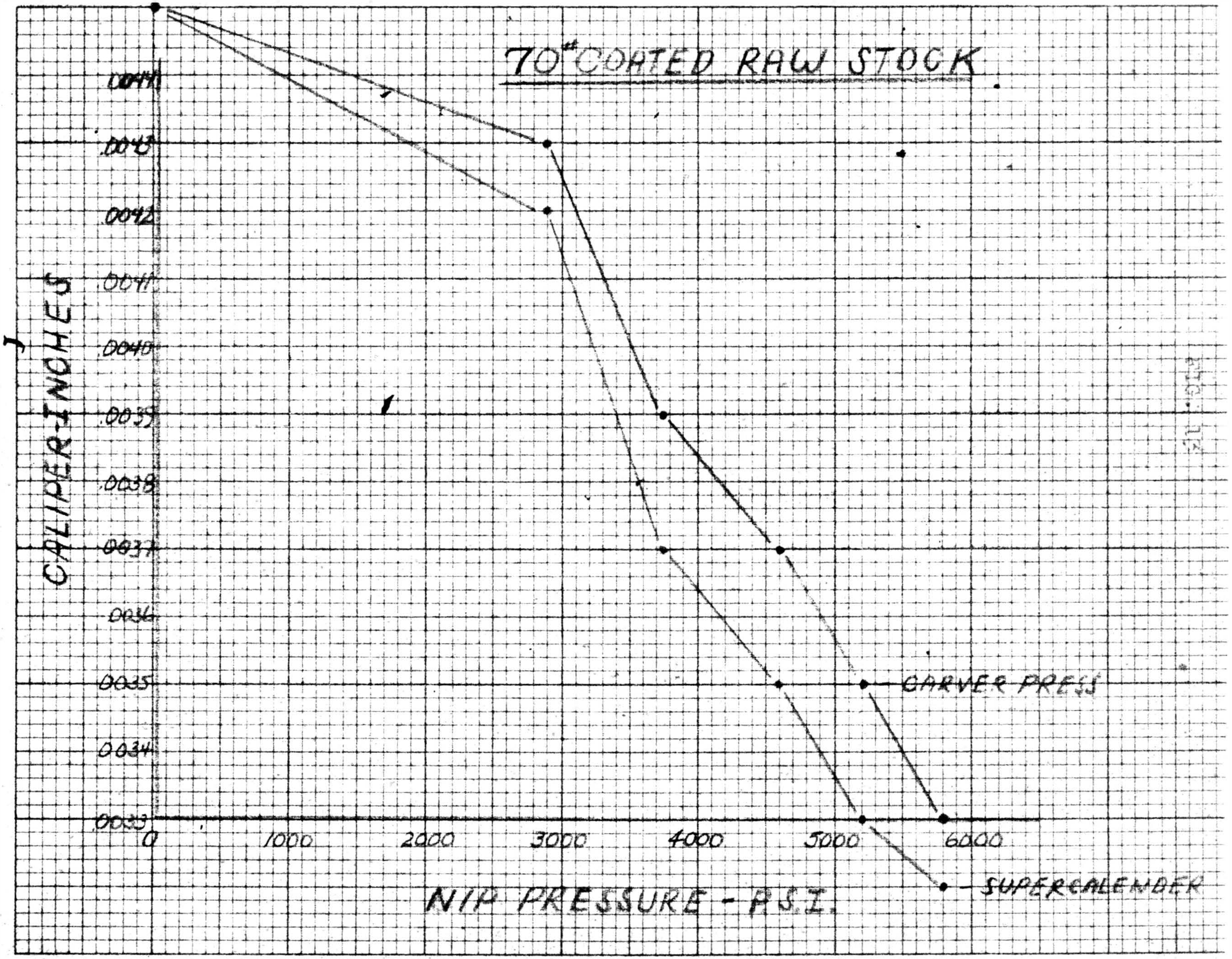
TABLE C

CALIPER TEST RESULTS

GRADES		NIP PRESSURES - POUNDS PER SQUARE INCH					
		0	2900	3750	4600	5225	5800
Groundwood	Car. Press	.0033	.0030	.0031	.0028	.0027	.0028
	SuperCal.	.0033	.0031	.0029	.0027	.0028	.0027
Coated	Car. Press	.0045	.0043	.0039	.0037	.0035	.0033
	SuperCal.	.0045	.0042	.0037	.0035	.0033	.0032
Sulphite	Car. Press	.0044	.0040	.0038	.0036	.0035	.0034
	SuperCal.	.0044	.0038	.0036	.0035	.0034	.0033
Rag	Car. Press	.0047	.0039	.0039	.0038	.0036	.0035
	SuperCal.	.0047	.0039	.0038	.0037	.0036	.0034



40# GROUNDWOOD
CALIPER - INCHES
.0032
.0031
.0030
.0029
.0028
.0027
0
1000
2000
3000
4000
5000
6000
7000
NIP PRESSURE - P.S.I.
CARVER PRESS
SUPERCALENDER


70# COATED RAW STOCK
CALIPER-INCHES
.0044
.0043
.0042
.0041
.0040
.0039
.0038
.0037
.0036
.0035
.0034
.0033
0
1000
2000
3000
4000
5000
6000
NIP PRESSURE - P.S.I.
CARVER PRESS
SUPERCALENDER

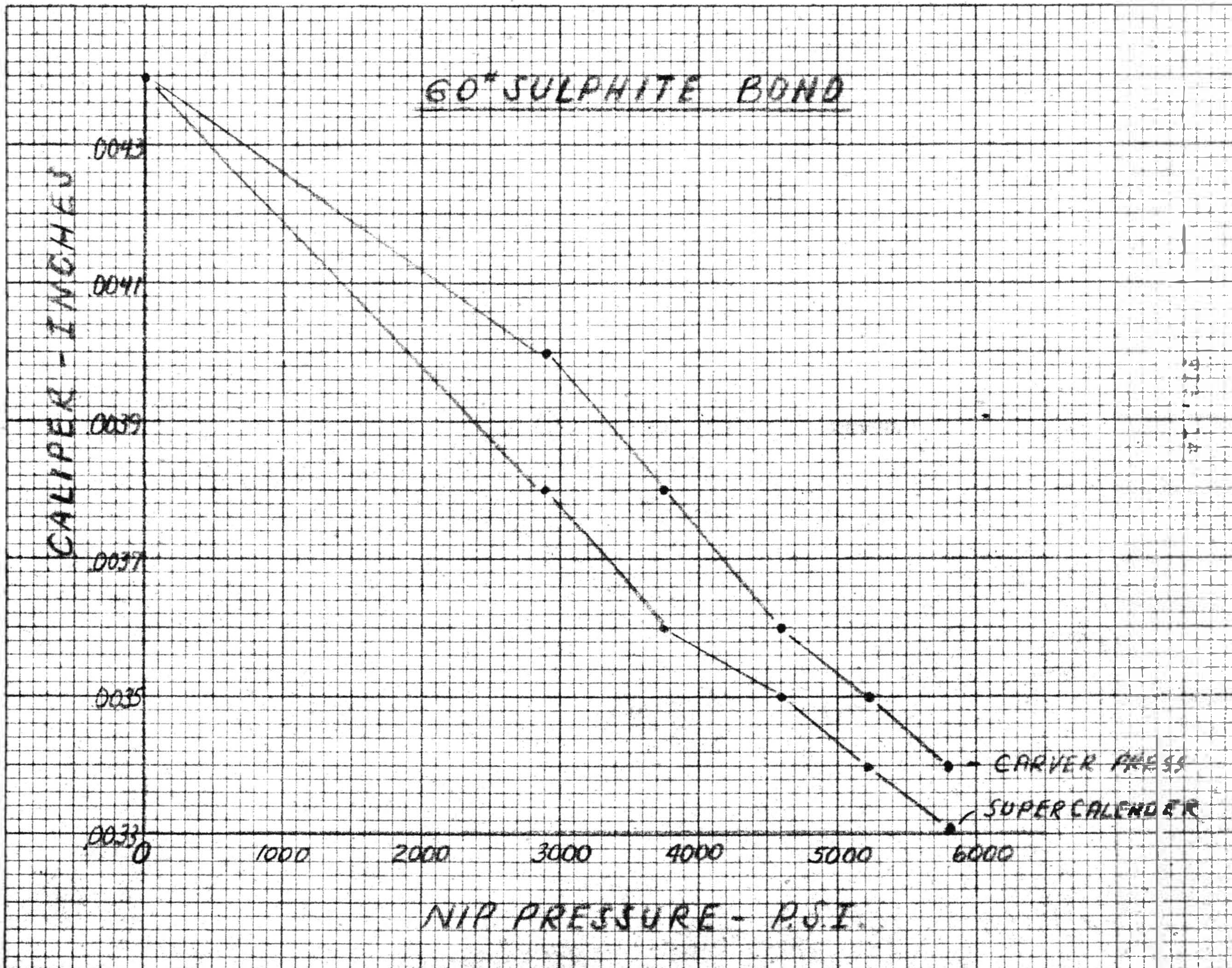
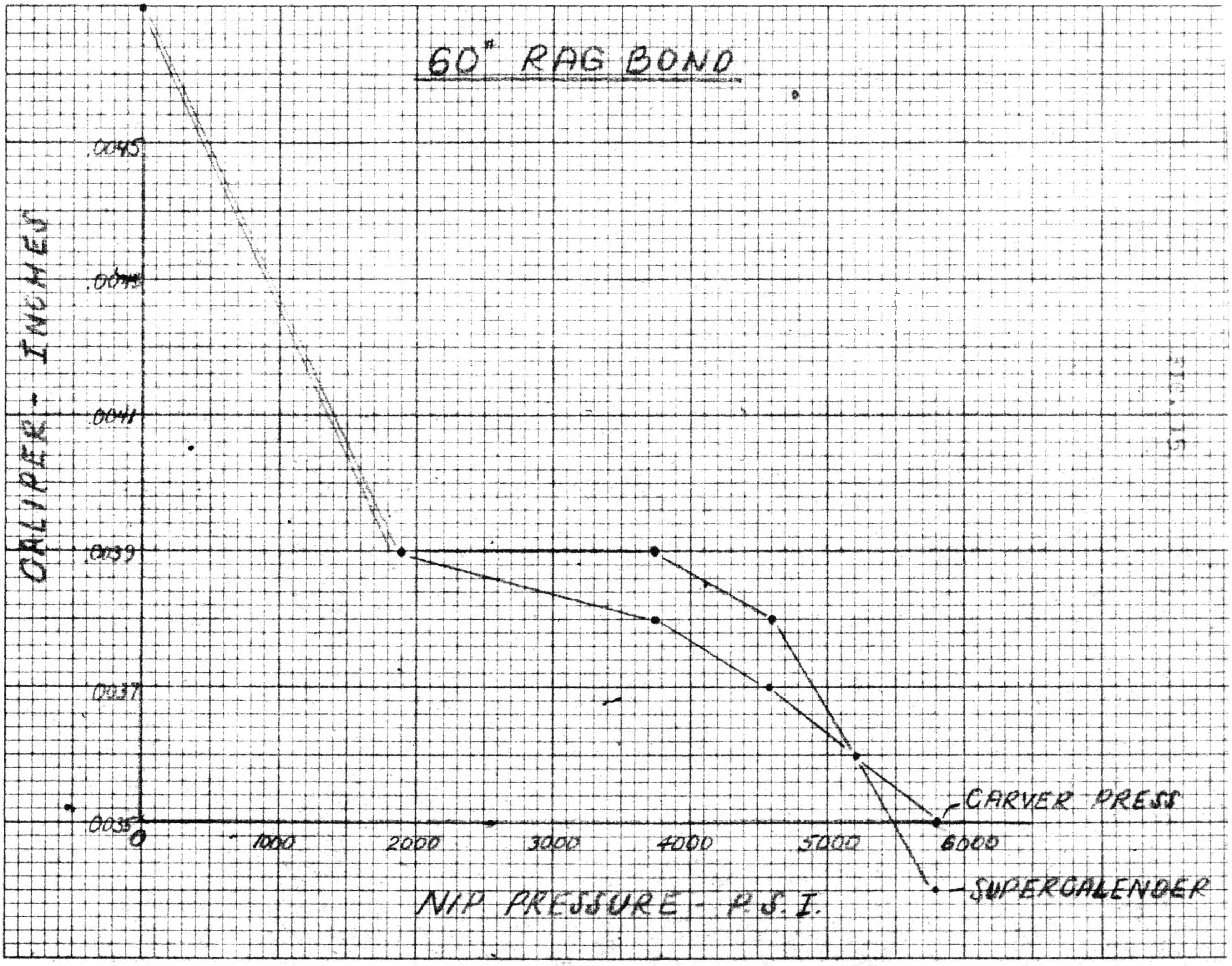

60# SULPHITE BOND
CALIPER - INCHES
.0043
.0041
.0039
.0037
.0035
.0033
0
1000
2000
3000
4000
5000
6000
NIP PRESSURE - P.S.I.
CARVER PRESS
SUPERCALENDER

FIG. 14



60" RAG BOND
CALIPER - INCHES
.0045
.0041
.0039
.0037
.0035
0
1000
2000
3000
4000
5000
6000
NIP PRESSURE - P.S.I.
CARVER PRESS
SUPERCALENDER

SUMMARY AND CONCLUSIONS

From the data collected in the experimental work with ground wood, coated, sulphite bond and 75% rag bond; it appears that the following comparative trends were established by the use of the laboratory supercalender and the Carver Hydraulic Press in their internal physical properties:

1. In the Mullen tests, the sulphite, rag and coated sheets showed that a definite correlative trend was established. The ground wood however followed a similar pattern only to the 20 pound gauge pressure. After this point, the author could locate no common points for comparision.
2. In the Opacity tests, the sulphite, rag and coated sheets gave a good indication of definite trend in these grades. The groundwood followed a similar trend during the first three pressure increments. No definite pattern can be found after this point.
3. In the caliper tests, all four grades of the paper showed a definite camparative decrease made by the two types of pressure given the paper. The groundwood sheets also gave a reasonable correlation in this test.

The experimental data indicates that it is possible to predict from a small scale static test some of the internal effects one would encounter after supercalendering similar-type papers. These results are: Mullen test, opacity and caliper. It is possible that other physical tests may also correlate.

The experimental work also shows that the hypothesis using the parabla assumption to determine the peak load pressure is correct. This thesis proved that the peak load pressure at the area of contact,between the steel roll and the cotton-filled roll, is a three-halves ratio of the average nip area pressure at that contact point.

The End

Donald V. Martin

June 6, 1955