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Supercalender Variables (I) The Effect of Supercalender Pressure on the Physical Characteristics of Paper

Kenneth L. Maves
Western Michigan University

SUPERCALENDER VARIABLES (I)
THE EFFECT OF SUPERCALENDER PRESSURE ON
THE PHYSICAL CHARACTERISTICS OF PAPER

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Kenneth L. Maves
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ABSTRACT

This work is concerned with the effect of supercalender pressures on the physical properties of paper.

The literature survey shows that very little work has been published concerning the effect of the variables of supercalendering on paper. In this investigation, a study is made of the effect of varied supercalendering pressures on 50 per cent rag ledger and coated folder paper. The experimental results show that definite trends were established on physical strength and optical properties when supercalender pressure was increased.

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INTRODUCTION

In the past fifteen years, more and more emphasis has been placed upon improving the surface qualities of paper by supercalendering. This has been brought about by the development of finer half-tones and improved techniques in the graphic arts industry which demand papers with high-quality surface characteristics. The tonnage of supercalendered paper has increased immensely and interest in the field has been broadened and intensified. In 1951, 1,400,000 tons of supercalendered paper was produced in the United States (1), based on the assumption that all the coated paper and one third of the fine paper and uncoated book paper was supercalendered. This shows a great demand for supercalendered paper by its chief consumer, the graphic arts industry.

Because of the increasing importance of supercalendering in the paper industry, a systematic investigation of its effect on the physical characteristics of paper is deemed necessary. This thesis is the first in a proposed series of studies into the effect of supercalender variables on paper by senior students in the Pulp and Paper Technology Curriculum. There are many variables affecting the supercalendering of paper, however Brecht (2) classifies them into two groups, namely,
those depending upon the quality and condition of the paper

before supercalendering and those depending upon the working conditions under which the supercalendering operation takes place. The variables included in the first group are: 1. the type of fibrous material in the paper, 2. the type of filler material present, 3. the degree of beating, 4. moisture content of the paper, 5. storage conditions before super-calendering, 6. hardness of the reels. The variables included in the second group are: 1. speed of operation of the super-calender, 2. working width of the sheet, 3. moisture content of the sheet in the supercalender, 4. temperature of the rolls, 5. pressure applied. Thomas (3) adds to this second group the variables, 6. diameter of the rolls, 7. type of filled rolls.

This investigation will be concerned with the study of the effect of pressure only on the physical properties of various types of commercially supercalendered paper. The other previously mentioned variables will be kept constant.

THEORY OF CALENDERING

Before continuing further, one must briefly go into the theory of calendering. E. E. Thomas (3) gives some fundamentals of calendering:

1. Calendering action is a combination of plastic flow, temperature and pressure.
2. There is a critical point in calendering beyond which any increase in calendering action upon the paper will result in a decrease in the standard of desirable qualities.
3. The attainment of desirable results depends upon the balance between responsiveness of the paper and amount of calendering action applied.
4. Calendering is a mechanical method by which paper with a given state of values is transformed into paper with a new state of values.

The only physical difference between a calender and a supercalender is the substitution of the chilled-iron rolls of calender with filled rolls of cotton or paper having elastic and resilient properties. Calenders are able to attain nip pressures of 2000 pounds per linear inch on machine coated papers whereas supercalenders can apply nip pressures up to 3500 pounds per linear inch on glassine papers (4). The chilled iron rolls of the calender do not polish the surface of the sheet to such a high degree as do the filled rolls of the supercalender. This polishing action is effected by "rolling friction" which is explained by Thomas (3) as follows: "With the application of load on the nips, the inert metal rolls cause a depression in the filled rolls at the point of contact and the material is pushed out on each side of the nip. If the rolls are rotated, the plastic material in the filled rolls will start to flow or creep because of the constant effort to return to a normal state. This 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 qualities." Wheeler (5) states that this polishing action of the supercalender is due to a variation in surface speed 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 giving it the desired gloss or finish.

LITERATURE SURVEY

In the past half century a great deal of material has been written about supercalendering, but most of it has dealt with the general aspects of the field. A great many assumptions have been made from practical supercalendering experience but literature regarding the specific effects of supercalendering on paper has been very scant. Of all the authors in the field, Brecht (2), and Mackin, Keller, and Baird (6) are the only ones coming to this author's attention, who have published their findings of investigations into the variables of calendering which are related to the scope of this thesis. Brecht and Mackin, Keller, and Baird carried out experimental work with laboratory apparatus, Brecht using a supercalender and Mackin, Keller, and Baird using a machine calender.

In the late 1930's Dr. Walter Brecht (2) and his associates studied the influences of supercalender variables on imitation art paper (90 per cent sulphite and 10 per cent straw) and ledger (100 per cent sulphite) with an eight-roll laboratory supercalender. He states that a change in pressure is accompanied by secondary effects, that of changing amount of friction between the rolls, and that of changing temperature. An increase in pressure increases the temperature, which in turn decreases the moisture content of the paper. The loss of moisture results in a decrease of the calendering effect. This calendering effect of pressure was measured in Brecht's investigation, in terms of Bekk smoothness, gloss (Pulfrick Photometer), opacity, and reflectance.

In 1940, G. E. Mackin, E. L. Keller, and P. K. Baird (6) conducted an investigation, similar to that of Brecht's with a machine calender rather than a supercalender. At the Forest Products Laboratory, they investigated the effect of calendering pressures on sheet properties using an 18-inch fourdrinier paper machine equipped with a calender stack having seven chilled-iron rolls. The types of paper used in this investigation were groundwood book, sulphite bond, sulphate bond and kraft wrapping and the range of calender pressures was from zero to 2,860 pounds per linear inch. The calendering effect of varying pressures was measured in terms of tearing, strength, bursting strength, caliper, size number, tensile strength, fold, porosity time, gloss, and solid fraction.

Casey (4) says that smoothness is produced mainly by pressure. Brecht (2) found that smoothness on the supercalender increased rapidly with increasing pressure up to a pressure of 900 pounds per linear inch and that any further increase in pressure brought about a gradual decrease in smoothness. The moisture content of the paper was found to decrease up to 25 per cent at this pressure by Brecht (2). The caliper is reduced up to 25 per cent at supercalender pressure of 1150 pounds per linear inch, according to Riley (7). Mackin, Keller and Baird (3) show that the caliper decreases uniformly with increasing calender pressure and developed an equation for the relationship as follows:

$$C = \frac{1}{\frac{1}{C_o} + mP^{0.5}}$$

where C = caliper, C_o = caliper at zero pressure, P = pressure, and m = a constant. They found that increased pressure decreases caliper from 20 to 30 per cent.

On increasing supercalender pressures, tensile strength, stretch, and folding endurance show a slight rise according to Brecht (2). Mackin, Keller, and Baird (6) indicate a decrease in folding endurance of up to 20 per cent in the case of bond papers and up to 40 per cent in the case of kraft wrapping. Since this test is very erratic, only trends in folding endurance with increasing pressure can be observed and no definite conclusions can be drawn.

An increase in tensile strength with increasing calender pressures up to a maximum, followed by a slight decrease in tensile strength is shown by Mackin, Keller, and Baird (6). They developed an equation expressing this relationship of tensile strength to calender pressure as follows:

$$S = S_o + mP^n$$

where S = tensile strength, S_o = tensile strength at zero pressure,

$P =$ calender pressure, m and $n =$ constants. The drop in tensile with increasing pressure is explained by the fact that the sheet does not have uniform formation according to these authors. "A formation that has high spots will receive a greater part of the pressure on these spots at high calender pressures. Upon testing (for tensile strength), those parts subjected to high pressures would break under less tensile strength than is representative of the entire sheet."

Brecht and Mackin, Keller, and Baird (2) (6) agree that increasing pressure decreases the tearing strength somewhat. Brecht says that this is due to the increased stiffness or "hardness" of the paper caused by compression of the fibers. In their investigation, Mackin, Keller, and Baird found that tearing strength decreased from 10 to 20 per cent and that it decreased at a uniform rate upon increasing pressure.

In the investigations of Mackin, Keller, and Baird (6), it was shown that bursting strength was only slightly affected by calendering and only at calender pressures above 2000 pounds per linear inch was the bursting strength decreased.

An equation showing the relationship of the solid fraction, a ratio of the density of the sheet after calendering to its density before calendering, to the pressure was evolved by them. This equation is as follows:

$$SF = SF_o + m_2P^n$$

where SF = solid fraction, SF_0 = solid fraction at zero pressure, P = pressure, m_2 and n = constants. This solid fraction increases up to 30 to 40 per cent upon increasing calender pressure.

Mackin, Keller, and Baird (6) and Brecht (2) all agree that gloss is greatly increased on increasing pressures but Casey (4) states that gloss is produced mainly by friction.

The amount of increase depends as much upon the type of paper being calendered or supercalendered as it does upon the pressure being applied. The percentage increase in gloss as shown by an unfilled sheet is much greater than that shown by a filled sheet. To illustrate this, Mackin, Keller, and Baird (6) compared the gloss of an unfilled sulfite bond paper with a filled groundwood book paper. At 2400 pounds per linear inch, the sulphite bond showed an increase in gloss of 95 per cent, whereas, the groundwood book paper showed an increase of 50 per cent. A decrease in the brightness and opacity of the sheet upon increased supercalender pressures was found in Brecht's (2) investigation.

Since this investigation will be carried out at those moisture conditions and elevated supercalender pressures where blackening may occur, a discussion of blackening is thereby suggested. Blackening is an optical effect due to the compression of spots in the sheet which produce variations in brightness, gloss, and opacity in certain areas of the sheet (8). The air-fiber interface is destroyed when the fibers are highly compressed which results in reduced brightness and opacity (4). According to Albert (9), papers of high moisture content tend to blacken more readily than those of low moisture content when calendered at excessive pressures. At high moisture content the fibers are more plastic than at low moisture content (4), rendering them more easily compressed.

SUMMARY OF LITERATURE SURVEY

According to what was found in the literature, increasing supercalender pressure has the following effect on the physical characteristics of paper:

1. smoothness is increased
2. gloss is increased
3. opacity is decreased
4. brightness is decreased
5. caliper is decreased
6. tensile strength is increased
7. tear is slightly decreased
8. bursting strength is slightly decreased
9. solid fraction increased

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EXPERIMENTAL OUTLINE

The experimental work for this thesis will be carried out at a constant temperature and constant relative humidity on a three-roll laboratory sheet calender. Supercalendering variables will be controlled and kept as constant as possible with the exception of the pressure variable.

In order to study the effects of varying pressures on the physical characteristics of the paper, pressures will be varied under controlled conditions. Grades of paper that are commercially supercalendered will be used and will be tested before and after supercalendering. These grades will be as follows: machine coated groundwood book, machine coated sulphite, off-the-machine-coated sulphite and tub-sized ledger with either a sulphite or rag content furnish. The grades of book paper will be of basis weight 60 pound 25 X 38-500 and the ledger will be 32 pound 17 X 22-500.

The tests that will be conducted on these sheets before and after supercalendering are as follows:

1. smoothness
2. opacity
3. brightness
4. gloss
5. basis weight
6. caliper
7. porosity
8. mullen

9. tear
10. tensile
11. oil absorbtion
12. wax pick

All surface quality tests will be run on both the wire and felt side of the sheet. Each test will be run at regular intervals across the width of the sheet in order to establish an average. Commercially supercalendered samples will also be tested and the results will be used as a basis of comparison to the laboratory supercalendered sheets.

In order to duplicate commercial supercalendering as closely as possible on a three-roll laboratory sheet supercalender, the paper will be put through the supercalender a number of times depending upon the number of nips desired. The number of nips to be used will depend upon the grade of paper being supercalendered and will follow commercial practice as closely as possible.

Each nip pressure will be varied, that is, upon increasing the number of nips there will be a corresponding increase in nip pressure due to the weight of the rolls. With the laboratory supercalender this increase in nip pressure due to weight will be accomplished by increasing the applied load upon each successive nip. The increment of applied load on each nip will be equal to the weight of the top roll. At each pressure gradient, a carbon paper impression will be taken to determine the area of surface contact between the fiber roll and the steel roll. This will be done by inserting a piece of carbon paper and tissue paper between the rolls and then applying the desired pressure. A carbon impression of the width of surface contact will be left on the tissue paper and from this the area of surface contact can be calculated. Each sheet to be supercalendered will be the full width of the nip. In this way, by knowing the applied pressure and the area of surface contact, the pressure on the sheet at each pressure gradient can be calculated in pounds per square inch.

The tentative experimental procedure will be as follows: The samples to be supercalendered will be conditioned at a constant temperature of 72° F and relative humidity of 50 per cent for at least 24 hours. After conditioning, those sheets that are of uniform formation and are free from defects will be selected for testing and subsequent supercalendering. After testing, the sheet will be fed through the supercalender at the desired nip pressure with the felt side up. Upon the second pass through the supercalender, the sheet will be turned over with the wire side up and the applied pressure will be increased. The pressure increment will be equal to the weight of the top roll. The sheet will again be turned over with the felt side up and passed through the supercalender with another increase in applied pressure equal to the weight of the top roll. This procedure will be repeated until the sheet has passed through the desired number of nips.

After passing through the last nip, the paper will again be tested and the results will be tabulated, designating the final nip pressure as the pressure at which the sheet was supercalendered. A new sample will then be supercalendered following the preceding procedure but at a higher final nip pressure. Final nip pressure increases will be determined by preliminary experimentation. Runs will be made at various pressure increments to find which ones show best the results of increasing pressure on the physical characteristics of the paper. Enough runs will be made at each final nip pressure until constant test results are obtained and can be duplicated at that pressure. Supercalendering and 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 which is installed in a room with a constant temperature of 72° Fahenheit and 50 per cent relative humidity. In this way the variables of supercalendering, with the exception of pressure, which was under study, were kept constant.

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 10½ 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° Fahrenheit 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.

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 2785 pounds per lineal inch at the nip between the top roll and the paper-filled roll. The weight of the top roll is neglected in this calculation.

EXPERIMENTAL PROCEDURE

The following commercial grades of paper were used:

1. Thirty-two pound 50% rag ledger furnished by Whiting Plover Paper Company, Stevens Point, Wisconsin
2. Seventy-three pound coated folder, furnished by Kalamazoo Paper Company, Kalamazoo, Michigan

Samples of commercially supercalendered paper in these grades were also obtained, to be used as a basis for comparing the results from laboratory supercalendering.

The paper was conditioned at 72° Fahrenheit and 50 per cent relative humidity for at least 24 hours. Five sheets of the uncalendered paper, which were free from visible surfaceand internal defects, were selected from the sample for testing and supercalendering at constant temperature and relative humidity conditions. Five sheets of the commercially supercalendered paper were also selected for testing. The

The following tests were run on each sheet:

1. Basis weight
2. Caliper
3. Tear
4. Mullen
5. Tensile
6. Smoothness
7. Gloss
8. Brightness
9. Opacity
10. Porosity
11. Wax pick
12. Oil absorption

Physical strength tests were carried out with instruments as suggested by T.A.P.P.I. standards, the Elmendorf tear tester, a motor-driver Mullen tester, and a motor-driven tensile tester. These tests were run so as to be representative of the whole sheet but not to destroy the sheet for subsequent supercalendering.

Smoothness was run on a Bekk smoothness tester and opacity on a Bausch and Lomb opacimeter according to standard methods. Brightness and gloss of the sheets were found on a Photovolt photoelectric reflection meter equipped with a search unit for brightness and one for 70° specular gloss. Enough optical tests were run to represent the test value of the entire sheet.

Smoothness and gloss were run on both felt and wire side of the sheet, whereas, brightness and opacity were run on only the felt side.

Wax pick was run with Dennison waxes. Oil absorption was found on a Vanceometer.after 20 seconds of oil absorption by reading the number of micro amperes of reflectance from an oil film cast on the sheet. Caliper and porosity were run in the standard manner.

After the five sheets were tested, they were supercalendered in the following manner: The sheets were trimmed so that they were $1\frac{1}{2}$ inches wider than the nip of the supercalender. Pressure was applied to the top roll of the supercalender and the sheet was passed through the nip with the felt side up. It was then turned over and passed through with the wire side up. This was repeated until the paper had been passed through seven nips. After supercalendering, the paper was again tested in the previously mentioned manner.

The prescribed method of testing and supercalendering was repeated at five nip pressure increments; 6,000 pounds, 12,000 pounds, 18,000 pounds, 24,000 pounds, and 30,000 pounds. These pressures represent the total number of pounds of applied pressure at the nip and correspond to 10, 20, 30, 40, and 50 pounds per square inch gage air pressure as applied to the cylinders of the supercalender.

In order to present a more accurate picture of nip pressure, the following method was employed to find nip pressures in pounds per square inch rather than in total pounds or pounds per lineal inch: A strip of tissue paper and one of carbon paper was placed across the entire width of the open nip. The desired pressure was applied to the top roll, and a carbon impression of the area of the nip was left on the tissue paper. The area of the impression was measured, and by knowing 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.

After supercalendering and testing was completed on both grades of paper the test results were averaged at each pressure increment.

DATA AND RESULTS

The test results from each grade, after supercalendering at increasing pressures, are shown in the following tables and graphs. The graphs were drawn from the tabulated data, plotting test values versus nip pressures in pounds per square inch. Along with the tabulated data are evaluations of the commercially calendered samples.

Tables 1 and 2 show the results of physical strength tests and basis weights of each grade at each nip pressure increment.

TABLE 1

73-pound Coated Folder

Nip press. #/sq. in.	Before supercalendering	3200	3900	4850	5840	7070	Commercial sample
Basis weight[1] (lbs)	70.9	70.9	75.4	74.1	73.9	74.7	73.6
Tear (g.) M.D.	49	52	45	42	42	38	42
C.D.	59	49	53	52	52	50	51
Mullen (p.s.i.)	18.1	19.3	20.0	19.4	20.2	21.3	19.7
Tensile[2] (lbs) M.D.	13.1	12.9	12.7	12.7	12.7	13.0	13.0
C.D.	5.5	5.6	5.8	5.7	6.0	5.7	6.0

TABLE 2

32-pound 50% Rag Ledger

Nip press. #/sq. in.	Before supercalendering	3024	4530	5280	5870	6330	Commercial sample
Basis weight[3] (lbs)	34	33.6	33.2	33.4	33.8	33.4	33.5
Tear (g.) M.D.	113	98	95	93	92	89	89
C.D.	125	105	100	99	99	95	108
Mullen (p.s.i.)	46	49	51	55	53	51	49
Tensile[2] (lbs) M.D.	24.8	25.1	23.9	24.6	25.3	25.3	24.3
C.D.	13.8	15.2	15.2	15.6	16.1	15.2	15.4

1. 25 x 38-500 basis

2. 15 mm. strip width, jaw distance-180 mm.

3. 17 x 22-500 basis

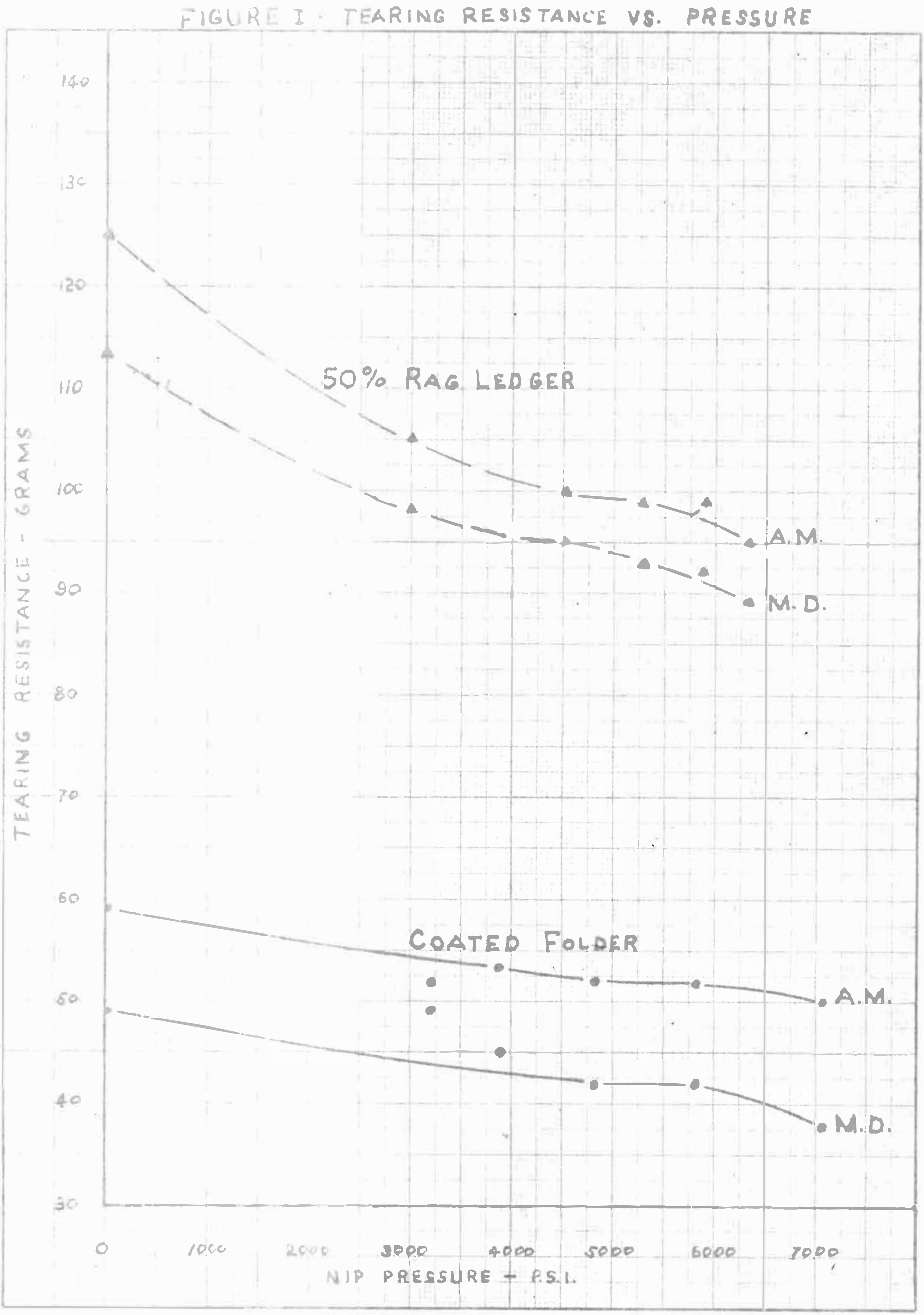


FIGURE I · TEARING RESISTANCE VS. PRESSURE
TEARING RESISTANCE - GRAMS
140
130
120
110
100
90
80
70
60
50
40
30
50% RAG LEDGER
A.M.
M.D.
COATED FOLDER
A.M.
M.D.
0
1000
2000
3000
4000
5000
6000
7000
NIP PRESSURE - P.S.I.

FIGURE I TENSILE STRENGTH VS. PRESSURE

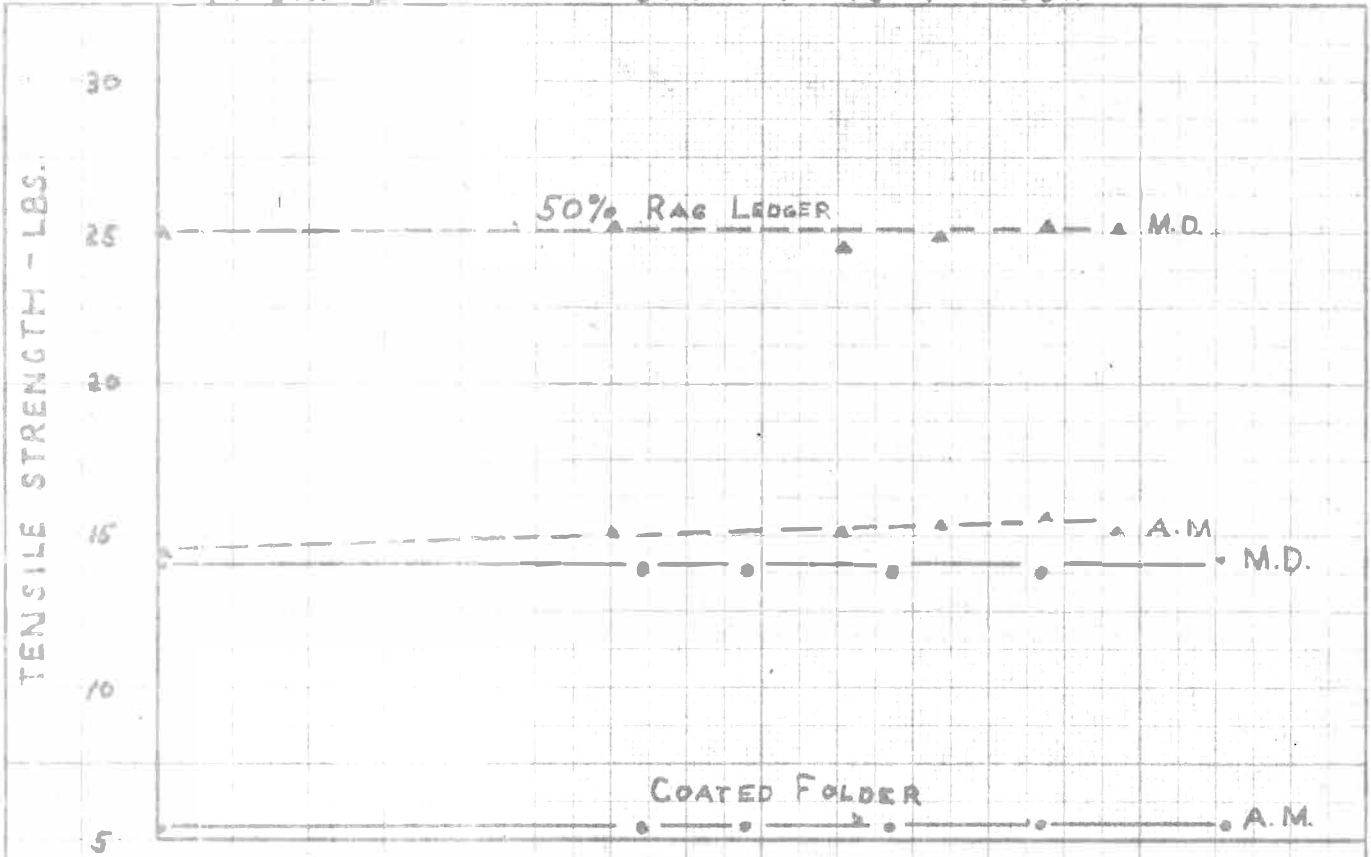
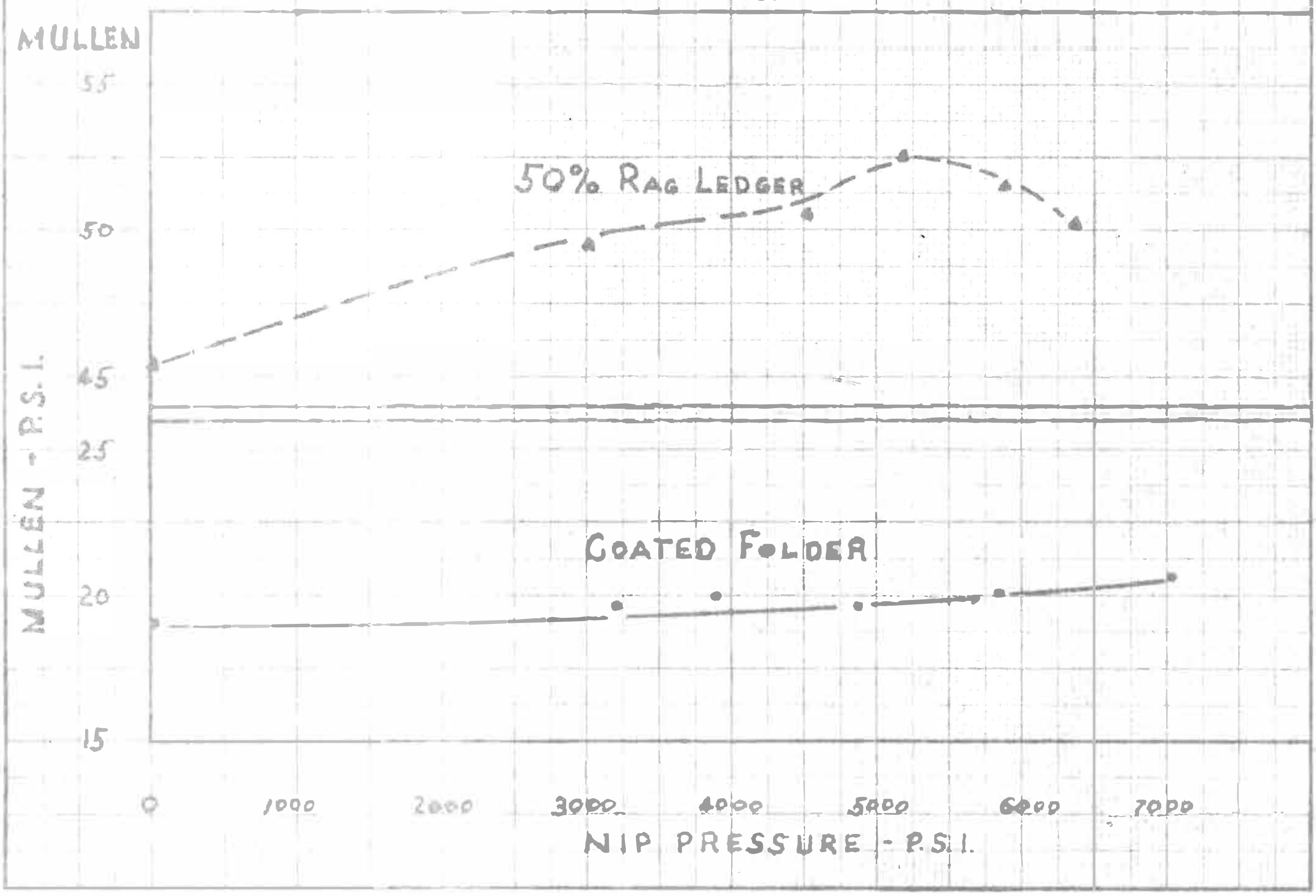


FIGURE III MULLEN VS. NIP PRESSURE



Graphical representation of tear is shown in Figure I, tensile in Figure II, and Mullen in Figure III, where test values are plotted against nip pressure.

Tearing strength decreased steadily in the case of both the coated folder and 50 per cent rag ledger, but tensile showed no appreciable change upon increasing the nip pressure. The coated folder showed a slight increase in Mullen, whereas, the rag ledger increased more sharply and then showed a decided drop after a nip pressure of 5,280 pounds per square inch was attained.

In Tables 3 and 4, the results of optical tests at various nip pressures are tabulated along with the results of evaluation of the commercially supercalendered sheets.

TABLE 3

73-pound Coated Folder

Nip press. #/sq. in.	Before Supercal-endering	3260	3900	4850	5840	7070	Commercial sample
Smoothness[4] (sec.) F.	54	340	530	502	553	393	409
W.	33	308	490	475	480	337	386
Gloss (P.V.)[5]	16.6						
F.		54.5	59.3	60.6	67.6	62.9	60.8
W.	16.2	53.1	55.8	60.0	65.2	64.1	60.1
Brightness[5] (P.V.)	74.5	74.5	75.2	74.9	73.5	72.8	75.1
Opacity[6]	97.5	96.8	96.9	96.3	95.6	95.1	97.0

4. Bekk smoothness

5. Photovolt photoelectric reflection meter

6. Bausch and Lomb opacimeter

TABLE 4

32-pound 50% Rag Ledger

Nip press. #/sq. in.	Before Supercal-endering	3024	4530	5280	5870	6330	Commercial sample
Smoothness[7] (sec.) F.	12	68	97	129	124	138	37
W.	13	79	108	104	128	128	52
Gloss[8] (R.V.) F.	9.5	19.3	22.3	24.6	27.4	28	16
W.	10.6	19.8	22.4	24.9	26.9	28	17
Brightness[8] (P.V.)	79.7	79.7	79.7	79.1	78.5	78.2	79.5
Opacity[9]	94.3	93.8	93.3	93.0	92.5	92.4	92.7

Gloss is shown graphically in Figure IV, smoothness in Figure V, opacity in Figure VI, and brightness in Figure VII, plotting test values versus nip pressure.

Figures IV and V show that the gloss and smoothness of the coated folder increase up to a nip pressure of 3900 pounds per square inch. Higher nip pressures do not increase the gloss very much, but after a pressure of 5,840 pounds per square inch has been reached, the smoothness decreases. The rag ledger merely showed a steady increase in both smoothness and gloss and no large initial rise. Opacity and brightness of both grades of paper, as illustrated in Figures VI and VII, show a decided decrease after a nip pressure of around 4,000 pounds per square inch was reached. The brightness of the coated paper increased slightly during the initial nip pressure increments.

7. Bekk Smoothness

8. Photovolt photoelectric reflection meter

9. Bausch and Lomb opacimeter

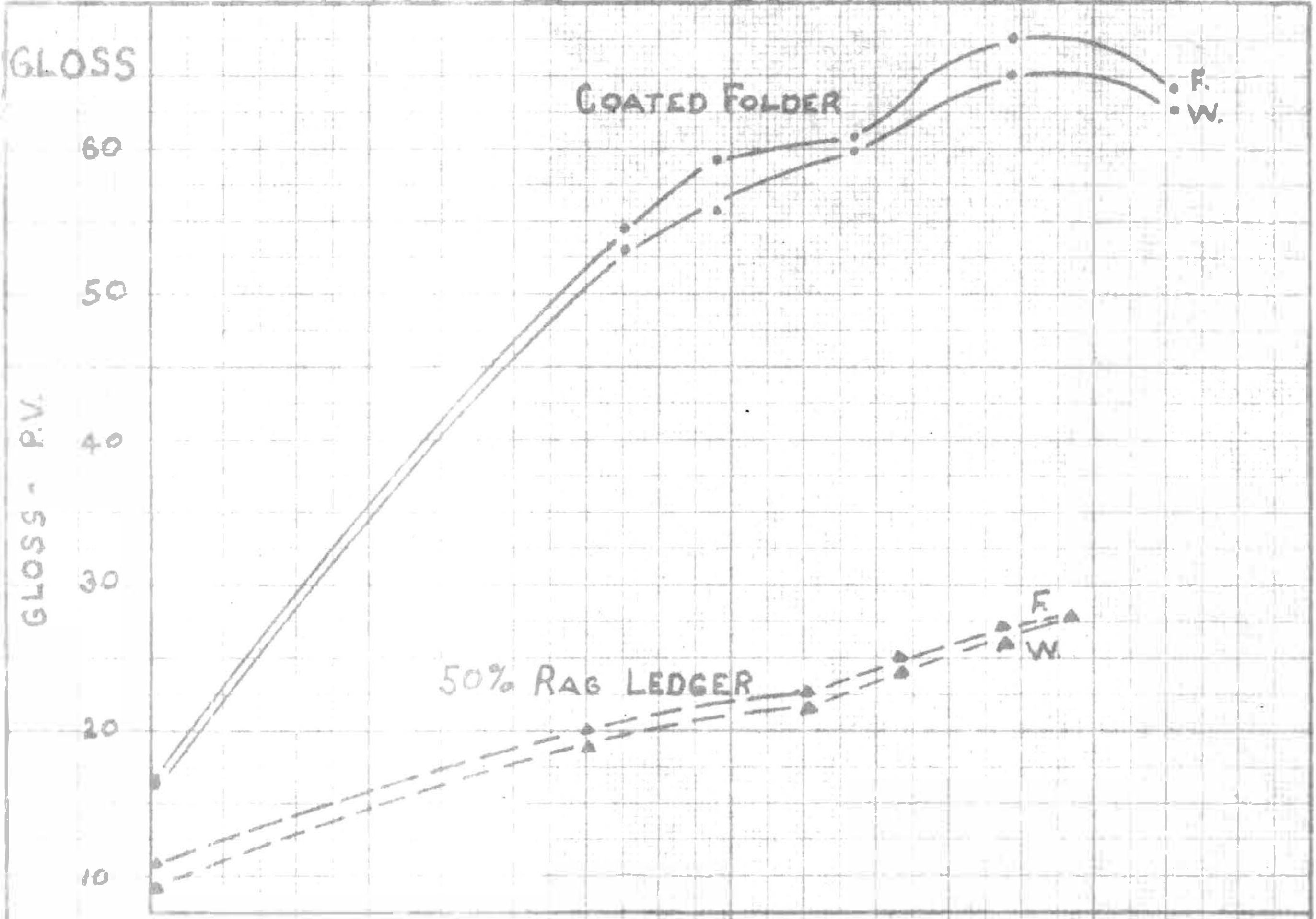


FIGURE IV GLOSS VS. PRESSURE

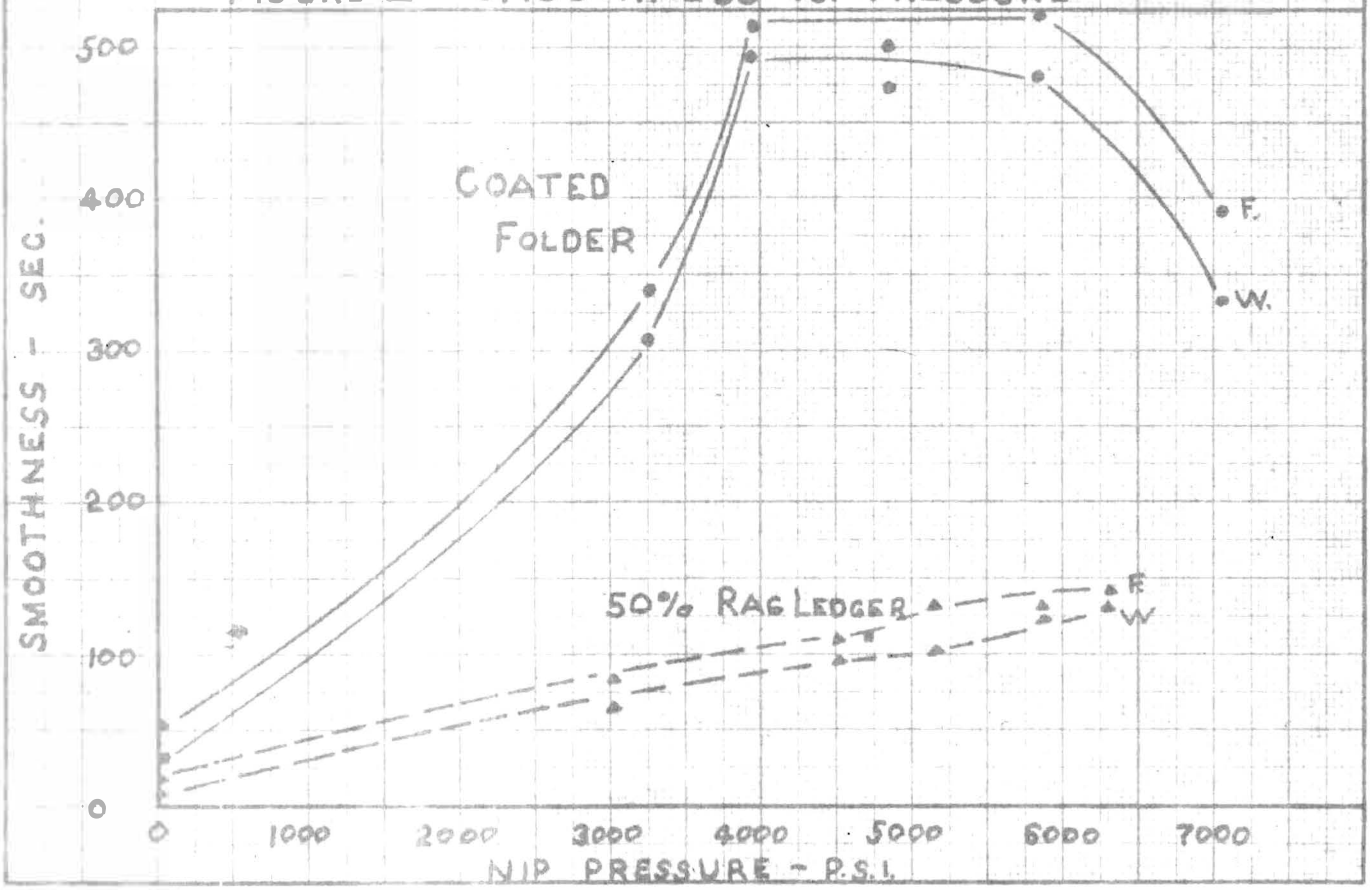


FIGURE V SMOOTHNESS VS. PRESSURE

FIGURE VI - OPACITY VS. PRESSURE

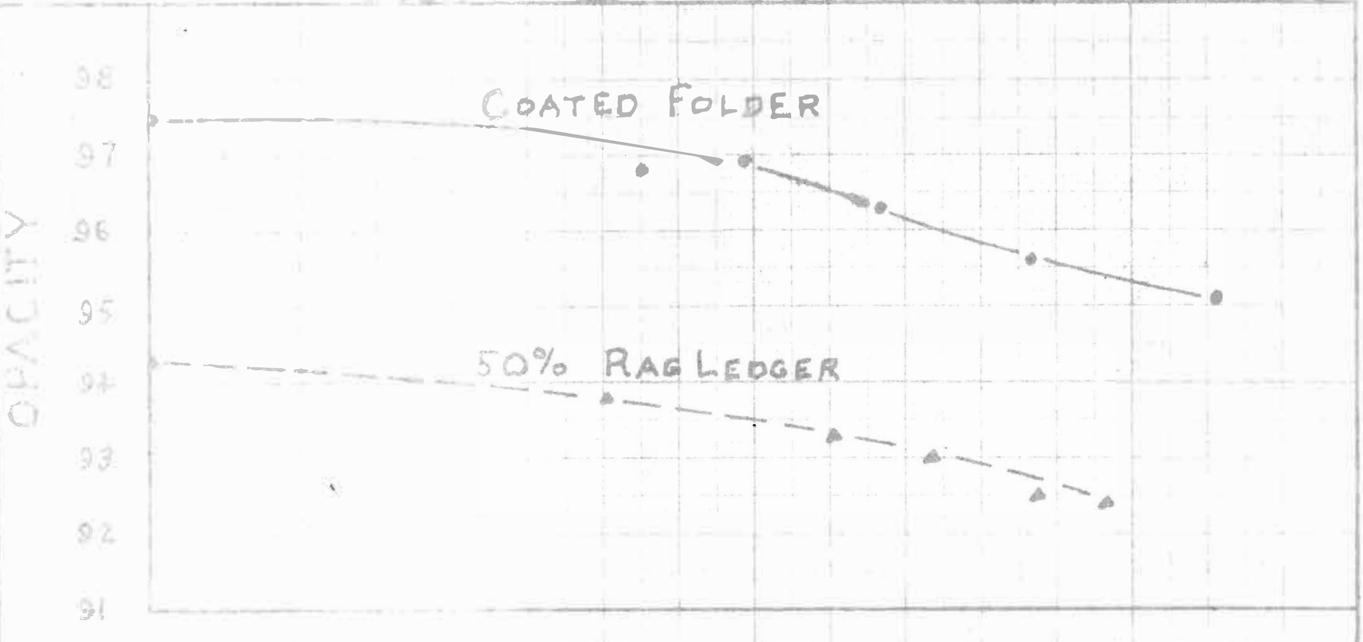
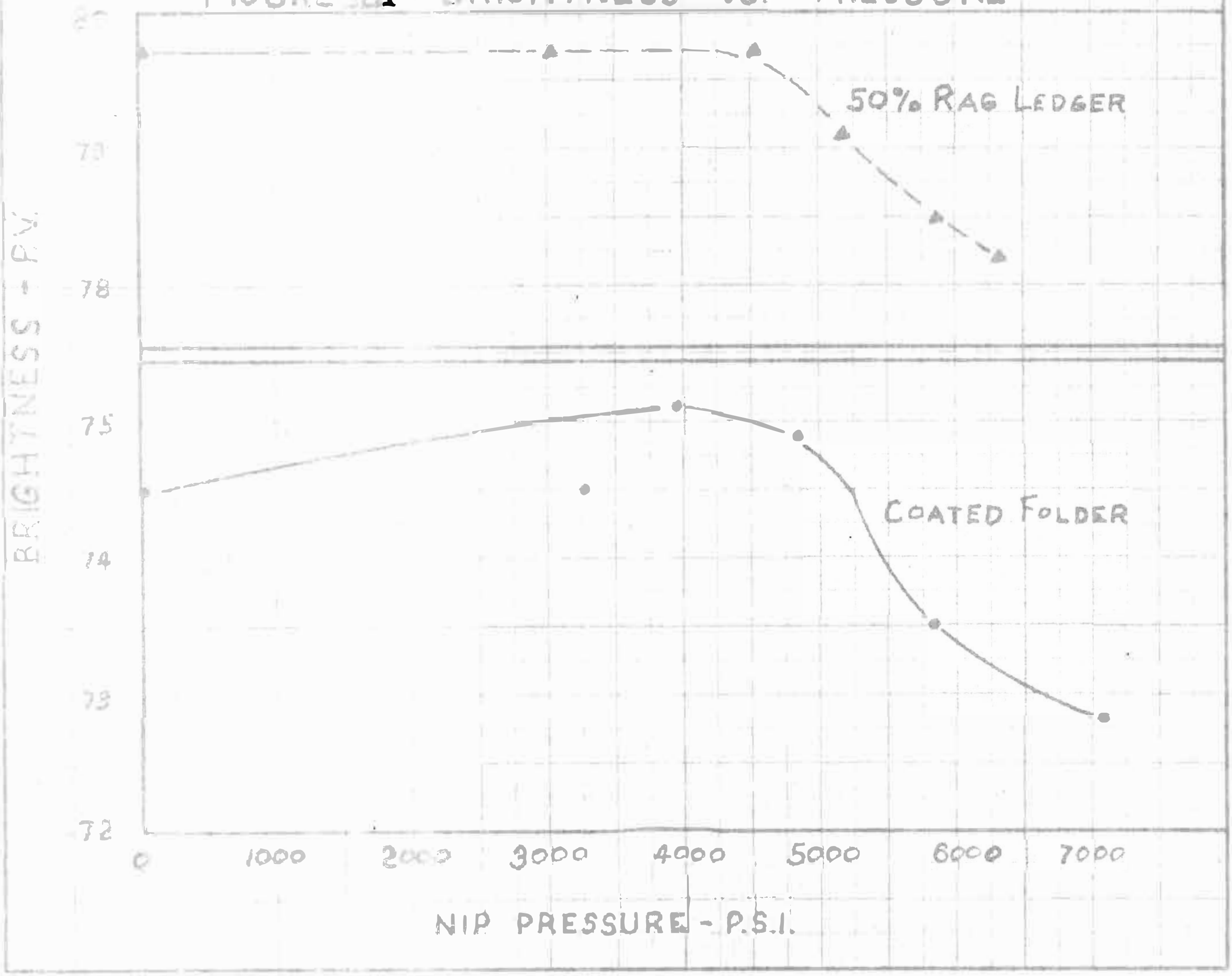


FIGURE VII - BRIGHTNESS VS. PRESSURE



In Tables 5 and 6, porosity, Vanceometer readings, and caliper are tabulated for each grade of paper supercalendered.

TABLE 5

73-pound Coated Folder

Nip press. #/sq. in.	Before Supercal-endering	3260	3900	4850	5840	7070	Commercial sample
Porosity[10] (sec.)	1120	2600	3510	3750	4300	5065	2855
Vanceometer[11] (microamps.)	65	87	90	93	100	100	78
Caliper (in.)	.00491	.00376	.00360	.00350	.00341	.00336	.00362

TABLE 6

32-pound 50% Rag Ledger

Nip press. #/sq. in.	Before Supercal-endering	3024	4530	5280	5870	6330	Commercial sample
Porosity[10] (sec.)	425	1250	1600	2270	2550	3140	845
Vanceometer[11] (microamps)	48	80	81	94	100	100	91
Caliper (in.)	.00659	.00508	.00492	.00484	.00477	.00470	.00543

These data are graphically represented in Figures VIII, IX and X.

Figure VIII shows a decidedly steady increase of porosity upon increasing pressures. Vanceometer readings, shown in

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10. Seconds per 100 ml. of air

11. Microamperes

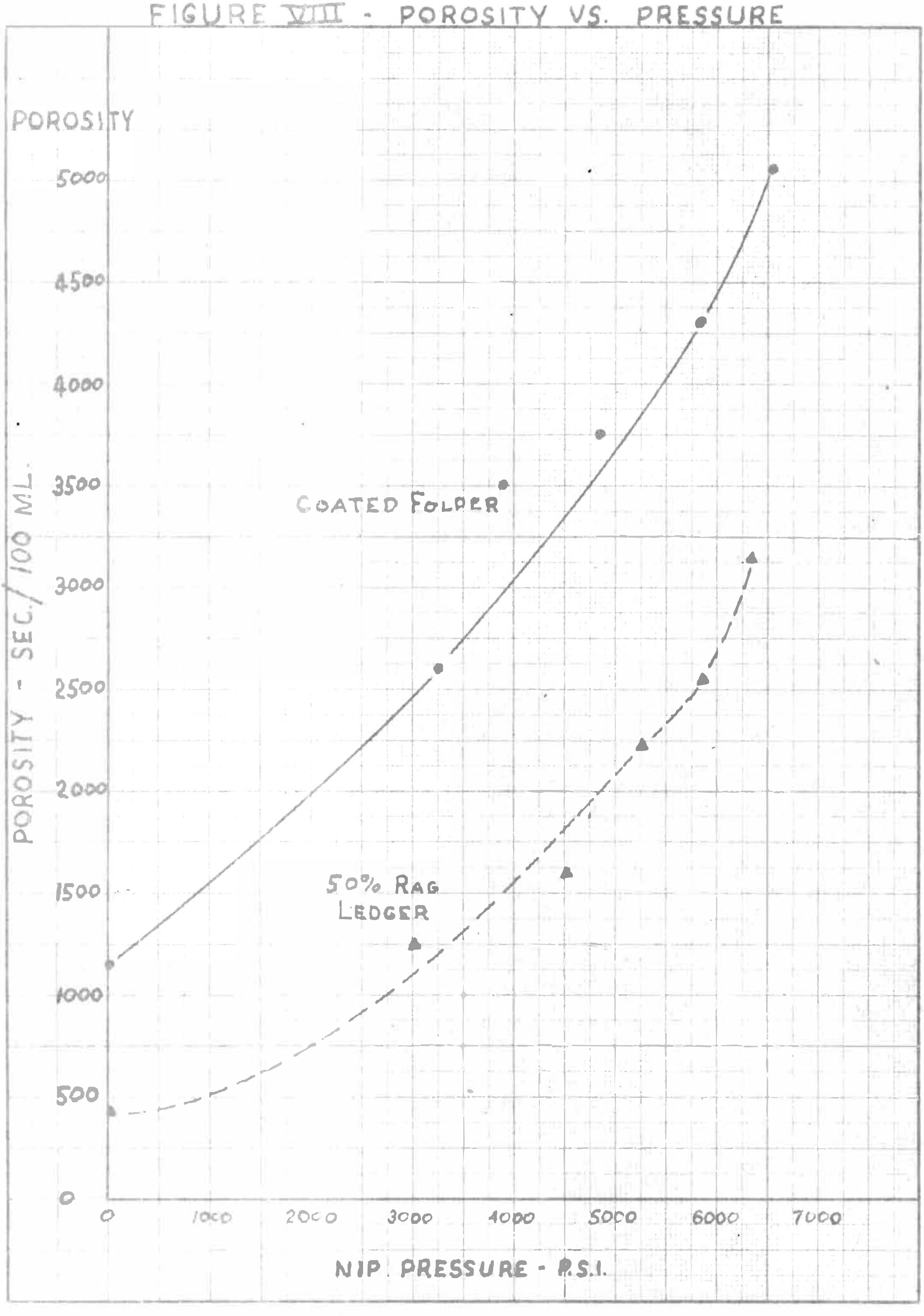
FIGURE VIII - POROSITY VS. PRESSURE
POROSITY
POROSITY - SEC./100 ML.
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
COATED FOLDER
50% RAG LEDGER
0
1000
2000
3000
4000
5000
6000
7000
NIP PRESSURE - P.S.I.

FIGURE IX - VANCEOMETER VS. PRESSURE

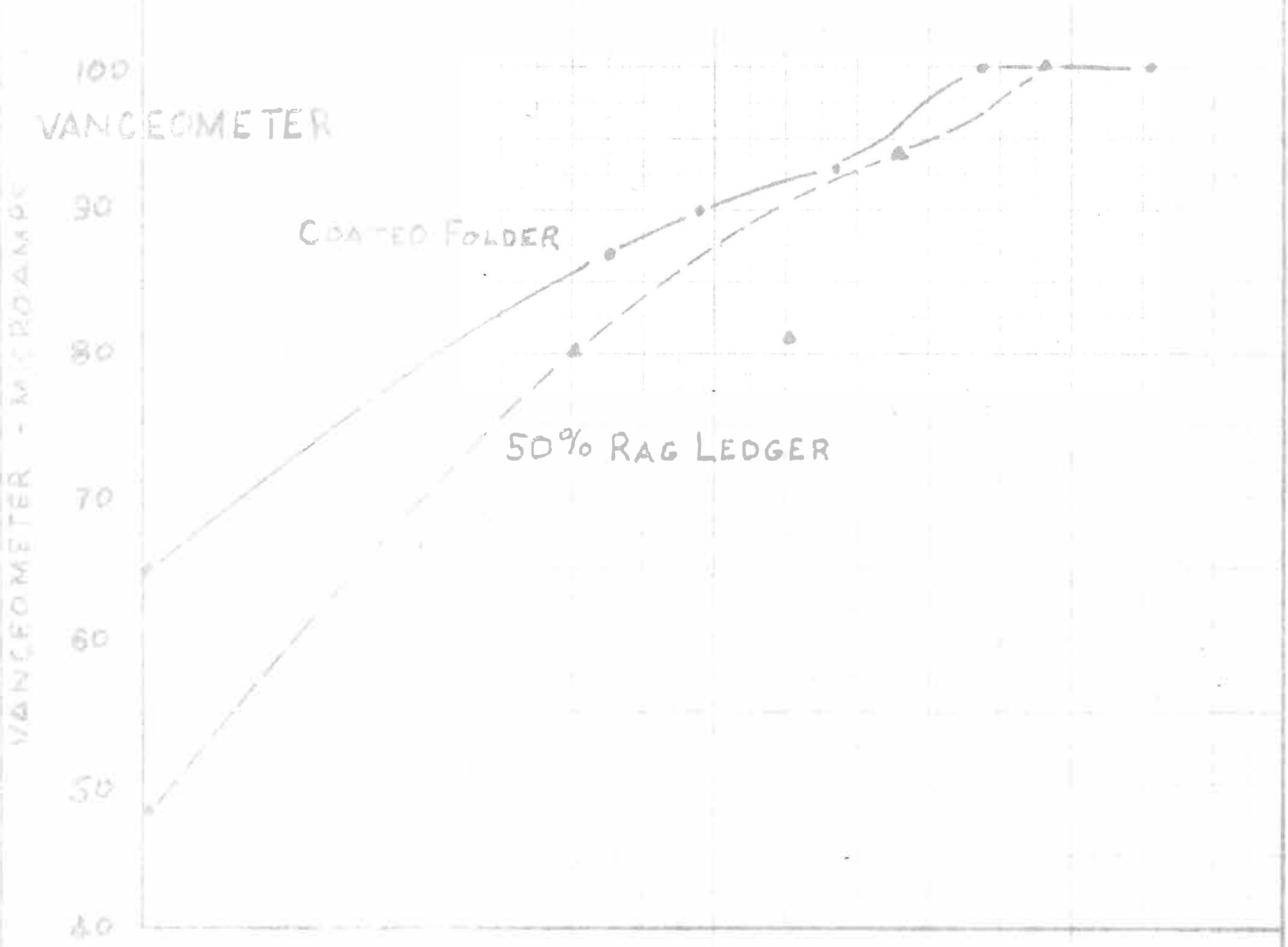

FIGURE X - CALIPER VS. PRESSURE

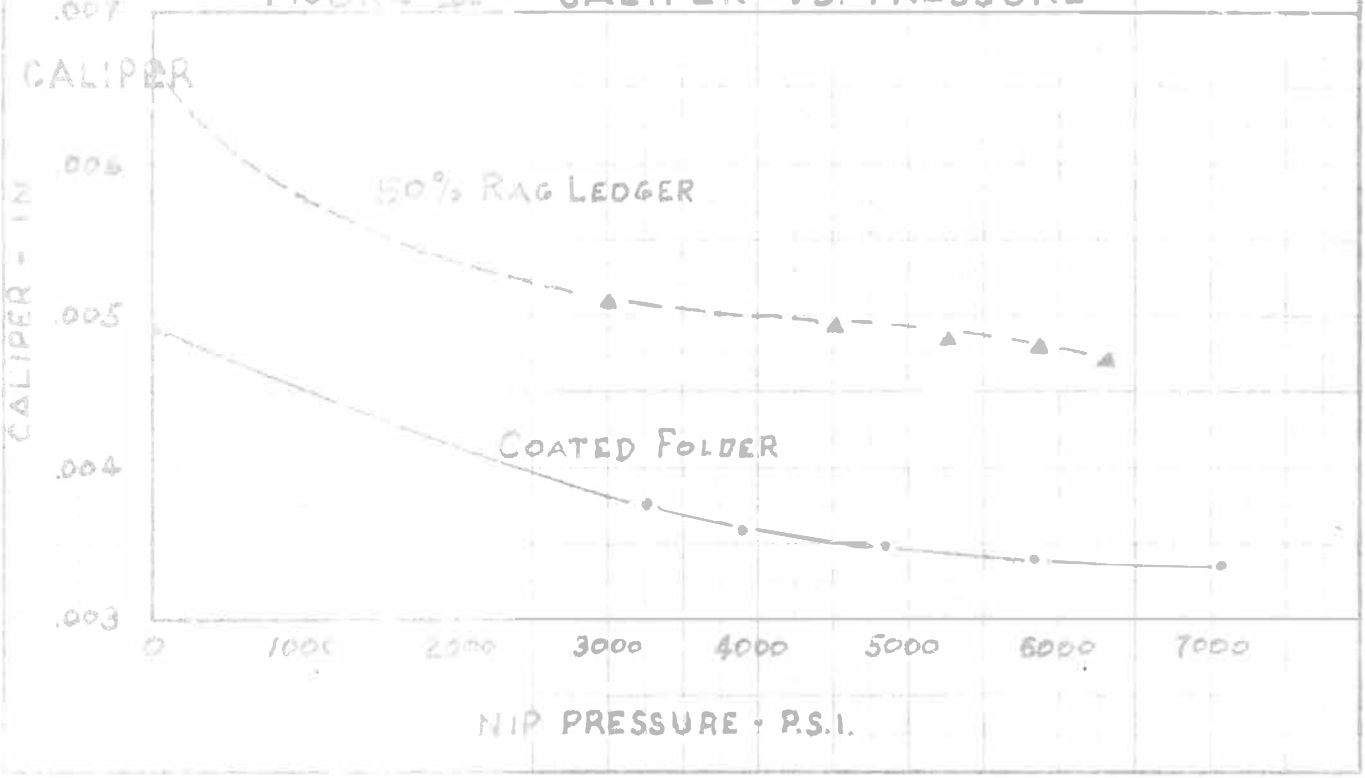

Figure IX increase sharply at initial pressures and reach 100 at 6,000 pounds per square inch. In Figure X, is shown a large initial decrease in caliper up to a nip pressure of around 3,000 pounds per square inch and then a slower decrease at higher pressures.

A Dennison wax pick test value of 3 for the coated folder and 19 for the 50 per cent rag ledger did not change upon increasing nip pressures.

SUMMARY AND CONCLUSIONS

From the data collected in experimental work with coated folder paper and 50 per cent rag ledger paper, it appears that the following changes take place in their physical properties upon increasing supercalendering nip pressures:

1. There is a loss in the tearing resistance of both grades by as much as 15 per cent of the original tear value.
2. Tensile strength shows no change in either case.
3. Increasing the pressure causes the Mullen of both grades to rise.
4. Both the gloss and smoothness of the two grades increase with increasing pressures, but the coated folder shows a greater increase in gloss and smoothness during initial pressure increments.
5. There is only a slight decrease in opacity and brightness.
6. Vanceometer readings show a definite increase, which indicates that oil absorption decreases when supercalender nip pressure is increased.

7. Caliper is decreased when nip pressure is increased.

The experimental data indicates that initial supercalender increases affect smoothness, gloss, oil absorption, and caliper to a greater extent than they do the other physical characteristics of the grades of paper which were studied.

The evaluations of the commercially supercalendered paper, when compared with the results obtained from laboratory supercalendering, show that at higher pressure increments, the experimental supercalendering had a greater effect on the physical characteristics of the sheet than did commercial supercalendering. However, these higher nip pressures were greater than those used in normal commercial operations, but the test results of the commercially supercalendered paper were comparable to the experimental results in the pressure ranges of normal commercial operations.

The experimental work of this study seems to show trends of the change in the physical characteristics of 50 per cent rag ledger and coated folder paper when supercalendering nip pressure is varied.

THE END

Kenneth Maves
June 8, 1953