RP190

THE PREPARATION OF FIBER TEST SHEETS

By Merle B. Shaw, George W. Bicking, and Leo W. Snyder

ABSTRACT

The need in the paper-making research at the bureau for a laboratory test that is analogous to paper-mill processes has led to the construction of a suction sheet machine and the development of a method of preparing fiber sheets. The test procedure relates to the forming of the sheet on the mold and the subsequent operations of couching, pressing, and drying. A complete description of the equipment and technic employed is given.

Test data on the finished papers show that the fibers are uniformly distributed in sheets made by the method described, and that the different sheets of a series made from a given sample of stock are in close agreement, and can be duplicated as desired. The personal equation is reduced to a minimum and comparable results are obtained by different operators.

The size of the finished sheets is adequate to supply specimens for each kind of test ordinarily made to evaluate the quality of paper.

The results obtained warrant the view that the method is practical and is useful for mill control or paper-making research.

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I. INTRODUCTION

In investigating new materials for paper it is often desirable to study the behavior of the fibers under paper-manufacturing conditions without actually making paper-machine runs, which are costly and require considerable quantities of fibrous materials. Several laboratory methods for evaluating the quality of pulp for paper-making purposes have been proposed,[1] but none has as yet been adopted as a standard procedure. This paper describes the method which has been developed[2] in the paper laboratory of the Bureau of Standards and is used in the preparation of fiber test sheets.

The determination of the strength of fibers for paper making includes several different operations—sheet forming, pressing, drying, and testing—and all need to be standardized in order to obtain a method that is reliable as a whole. The pulp used in making fiber

[1] The Bibliography of Wood Pulp Strength Testing, W. F. Moore, Paper Trade J., **89**, No. 12, pp. 62-72, Sept. 19, 1929, gives very complete abstracts of many of the published articles on this work.

[2] Method of Making Uniform Fiber Sheets for Test Purposes, Merle B. Shaw and George W. Bicking, Paper Trade J., **79**, No. 21, pp. 51-53; Nov. 20, 1924. Also included in B. S. Tech. Paper No. 340, Caroá Fiber for Paper Making, pp. 326-332.

sheets at the bureau is in most cases taken from stock prepared in the semicommercial beaters of the mill equipment. The sheet-making method adopted and described relates to the forming, couching, pressing, and drying of the sheet.

II. DESCRIPTION OF APPARATUS

1. AGITATOR

An agitator is used to separate the clots of fibers without beating action and to mix the pulp and water preparatory to forming the sheet. The agitator (fig. 1) consists of a vertical shaft having a 2-blade propeller fitted in the lower end, and is driven by a ⅛-horsepower motor at a speed of 1,750 revolutions per minute. It is mounted on a board free to move up and down in vertical guides on either side.

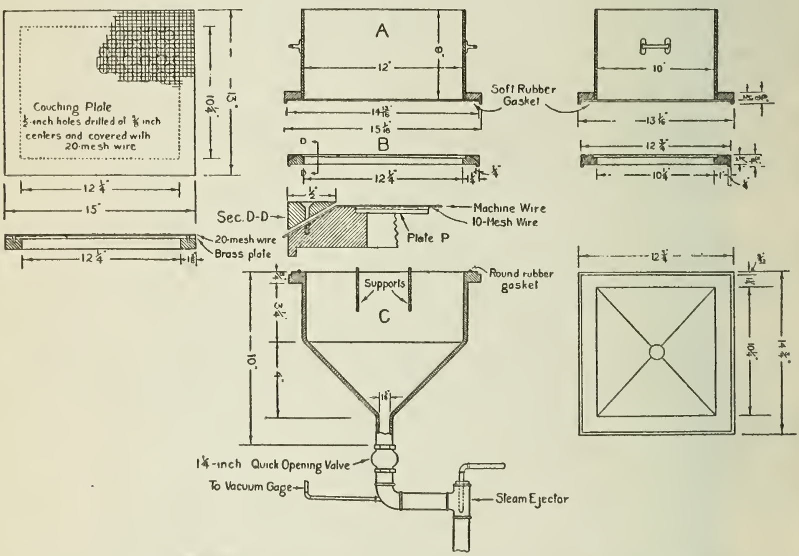

FIGURE 2.—*Working drawing of sheet machine and couching plate*

A counterweight facilitates the movement and keeps the apparatus in the position desired. A stop watch used to indicate the duration of the mixing is started and stopped simultaneously with the motor by means of a lever bar tripped by the motor switch. The watch can also be operated by hand.

The mixing vessel has a capacity of 1½ gallons. A baffle plate, *B*, 1 inch in width, extending from top to bottom and fastened to the side wall, breaks up the swirl of the liquid and produces the necessary turbulent motion.

2. SHEET MACHINE

The sheet machine is a suction mold. It consists of 3 sections, 2 brass and 1 aluminum (fig. 2, *A*, *B*, and *C*, respectively).

Fitted into the casting of the top section, *A*, is a 10 by 12 inch sheet brass box (18 gage brass), open at top and bottom and forming a

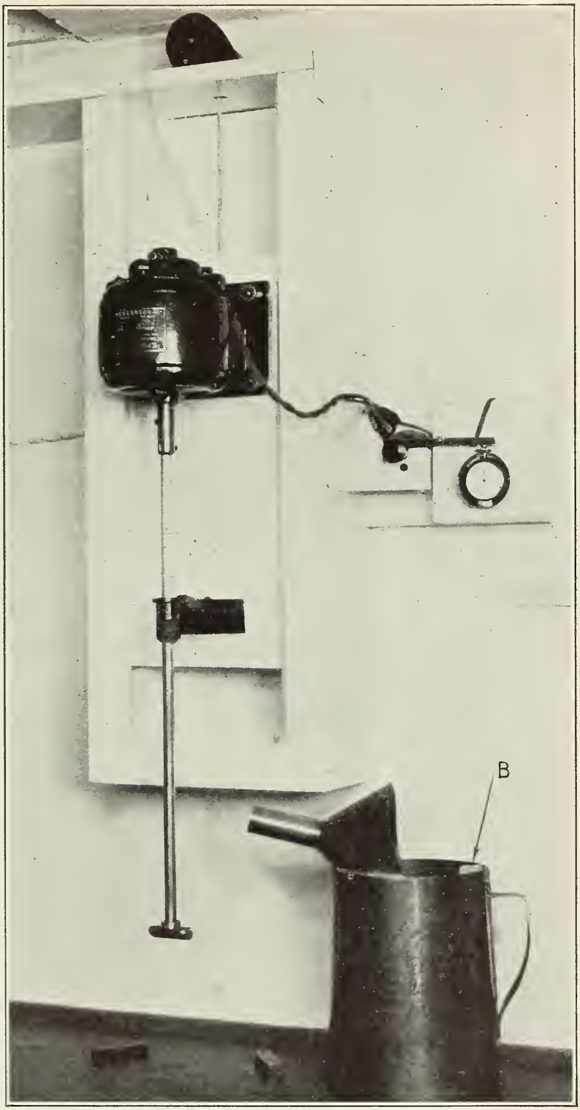

FIGURE 1.—*Agitator and mixing vessel*

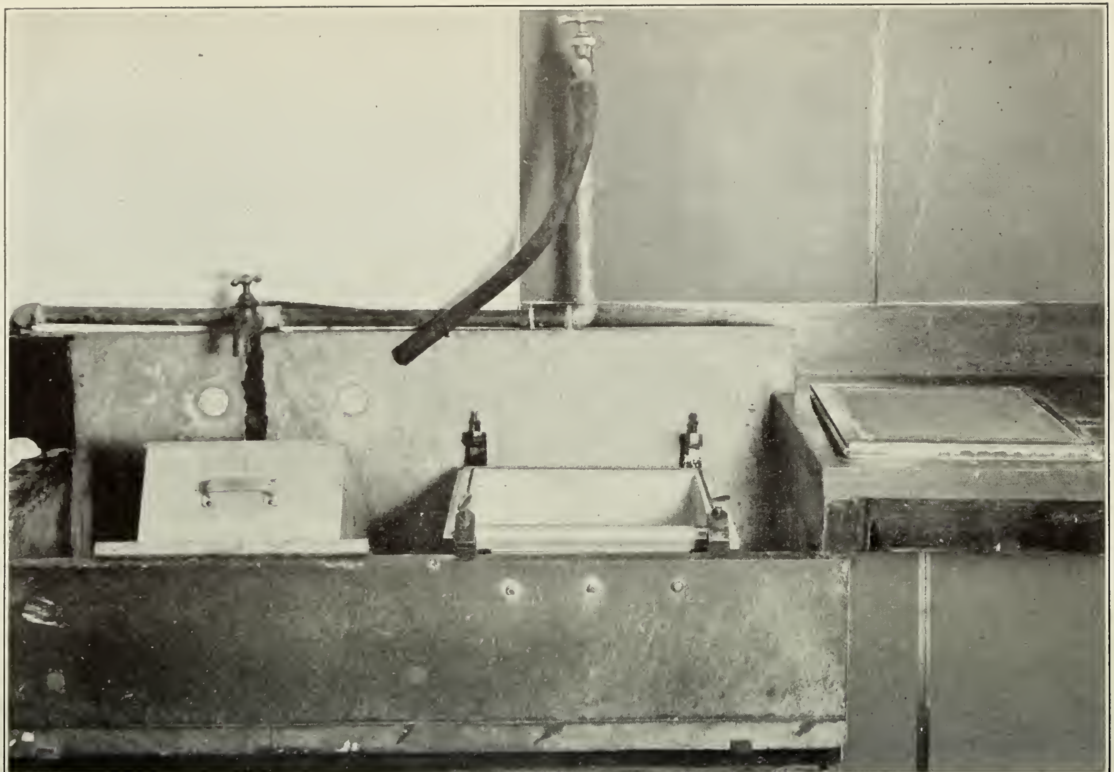

Figure 3.—*Sheet machine with parts separated*

deckle box.[3] On the under side of the casting a rubber gasket is cemented (with shellac) to effect a tight seal when the mold is assembled and the top is clamped down. With a 10 by 12 inch deckle area a trimmed sheet 8 by 10½ inches in size is obtained. From a sheet of this size test specimens may be cut for each kind of test ordinarily made to evaluate the quality of paper. Since no difficulty is encountered in making 10 by 12 inch sheets of uniform formation and weight, these dimensions are believed to be the most satisfactory and economical.

In the mold casting, *B*, is a perforated brass plate, *P*, drilled with ½-inch holes at ⅝-inch centers. The plate is covered first by No. 10 brass wire cloth, soldered to it at the edges, and then by No. 80, stretched taut over the mold and held securely by a frame screwed to the casting. A mixture of litharge and glycerine poured on the edges of the mold makes the joint tight and thus prevents leakage. The mold plate supporting the screens must be level if a uniform sheet is to be secured.

The lower casting, or mold support, *C*, has a water outlet fitted with a quick-opening gate valve. A steam ejector is placed in the discharge pipe below to accelerate the suction. Two vertical ⅛-inch aluminum plates across the casting prevent sagging of the mold plate. A rubber tube fitted in a groove in the top of the casting makes a tight seal with the mold when the machine is in operation.

In most of the sheet-making machines now in use the clearance between the wire on which the sheet is formed and the suction outlet is small. The rate of drainage for these machines is nearly always specified, and is nearly always very slow. If much suction is applied during the forming of the sheets the fibers are drawn to the area over the suction opening and the sheet formed is therefore of uneven thickness and weight. If a baffle plate is placed above the suction opening the fibers are then drawn to the edges of the sheet, causing, as before, resultant inequalities in the substance of the sheet. These conditions are prevented and uniform fiber distribution is obtained with the bureau's sheet machine by increasing the height of the mold plate above the outlet valve and changing the form of the base casting. The casting (fig. 2, *C*) consists of a rectangular box perpendicular to the mold plate, a truncated pyramid, and a cylindrical section for pipe connections, the heights of which are 4 inches, 4 inches, and 2 inches, respectively.

3. COUCHING PLATE AND FELT

A perforated brass plate (fig. 2) is used in transferring, or "couching," the sheet from the mold for the subsequent pressing and drying operations. The plate, which is ⅛-inch thick and drilled with ½-inch holes at ⅝-inch centers, is similar to the mold plate and is mounted in a frame of the same size as the mold casting. A No. 20 wire screen is stretched over the plate and soldered to it at the edges.

Hand sheets have generally been couched by placing an absorbent material, such as a blotter or felt, over the web of pulp, pressing it lightly against the molded sheet, and lifting it and the adhering sheet from the mold. This procedure requires extreme care in removing the sheet to prevent any undue stresses that might disturb the original

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[3] A deckle box is a frame laid upon a wire mold to confine the paper pulp to a definite area, thus limiting the size of the sheet.

position of the fibers, particularly in lightweight sheets, because of their tendency to tear and leave portions adhering to the screen. By use of the perforated plate the sheet with couching felt and plate superposed can be inverted, returned to the sheet machine, and transferred to the felt by suction. This modification simplifies the couching procedure considerably.

Blotters and felts are the couching materials generally used in removing hand sheets from the screen. Experimental data as to their comparative value were not available, however, and tests were therefore made to determine the number of times each could be used, ease with which they could be handled, and their comparative effect on the strength of the finished fiber sheets. The blotting paper used had the following properties.[4]

Weight:		
25 by 40 inches, 500 sheets	pounds	266.0
19 by 24 inches, 500 sheets	do	121.3
Thickness	inch	.028
Bursting strength	points	34.4
Fiber composition:		
Rag	per cent	50.0
Chemical wood	do	50.0
Absorption (1 cc distilled water)	seconds	41.0

The felt was similar in quality to paper-machine felts, smooth, napless, and of a weave that permitted ready passage of air through it when suction was applied. Other physical properties were:[5]

Weight per square yard	ounces	19.2
Thread count per inch, warp		70
Thread count per inch, filling		40
Thickness	inch	.040

In preparing the stock for the hand sheets the pulp was beaten only until it was free from clumps of fibers, no attempt being made to develop its maximum strength. The standard procedure, described hereinafter (III), was used in the sheet-making operations except in the couching with the blotters. Couching by suction was tried but the close texture of the blotting paper rendered it too impermeable to air and prevented effective action of the suction on the web of pulp. The couching plate could not be used therefore, and the sheets had to be removed by hand. The sheet on the mold was covered with a blotter and over it a 4½-inch brass pipe was rolled. The sheet and blotter were then lifted together from the plate, and laid sheet up on another blotter placed on a metal plate. Two more blotters and another metal plate were laid on the sheet and the unit was ready for pressing.

Pressures ranging from 30 to 240 lbs./in.^{2}, increasing by 30-pound steps, were employed. In each case two sets of five sheets each—one couched with blotters, the other with felts—were used, the pressure being applied for three minutes. Other sheets were weighed after being pressed and then dried to constant weight to determine the amount of moisture in the pressed sheets. The results are recorded graphically in Figure 4. It will be noted that less water was left in the sheets couched and pressed with blotters. In no case, however, was the amount present in excess of that in paper going to the dryers

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[4] The tests were made according to the official methods of the Technical Association of the Pulp & Paper Ind.

[5] Methods of measurements are described in U. S. Government Master Specification No. 345a, General Specification for Textile Materials (Methods of Physical and Chemical Tests).

(leaving the last press) of a commercial paper machine. The amount of moisture removed from the hand sheets will, of course, depend not only on the type of couching material used, but also on the number of thicknesses employed and the duration of the pressing.

Since the differences in the comparative moisture content of the sheets pressed with blotters and felts were as great as 10 per cent, it was thought that they might affect the strength of the finished papers. Tests made on the sheets indicate, however, that the final strength was not affected by the amount of moisture in the sheet when ready

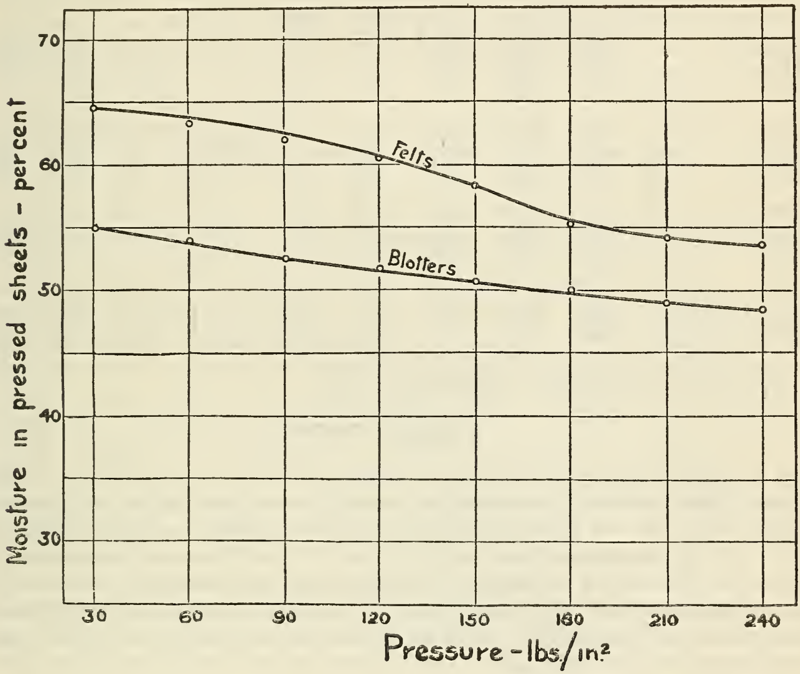

FIGURE 4.—*Comparative moisture content of sheets pressed with blotters and felts*

for drying. The measurements (Table 1) show very good agreement in the results obtained with the blotters and felts.

As to the relative serviceability of the two couching materials, however, felts were found to be preferable to blotters. Blotters become unsatisfactory after being used a few times in preparing hand sheets. Although subsequent drying and pressing smooths the surface and permits their being employed again, they are not as satisfactory as when new, and the number of times they can be used is limited. Felts, on the other hand, are easily kept in good condition, and when properly cared for their period of service has practically no determinate limitation.

TABLE 1.—*Comparative strength of hand sheets pressed with blotters and felts*

Material between which sheets were pressed	Pressure	Physical tests on finished hand sheets: Weight (25 by 40 inches, 500 sheets)	Bursting strength	Folding endurance: Long direction [1]	Folding endurance: Short direction [1]	Tensile strength (strip 15 by 100 mm): Long direction [1]	Tensile strength: Short direction [1]	Tearing strength: Long direction [1]	Tearing strength: Short direction [1]
	*Lbs./in.*²	*Pounds*	*Points*	*Double folds*	*Double folds*	*kg*	*kg*	*g*	*g*
Blotters	30	65.6	28.4	53	40	3.2	3.3	62.8	63.6
Felts	30	64.5	27.0	53	55	3.1	3.3	66.0	64.4
Blotters	60	64.4	31.3	85	76	3.4	3.3	65.6	63.6
Felts	60	63.2	31.0	67	70	3.4	3.4	65.2	66.8
Blotters	90	64.8	32.5	58	55	3.8	4.2	64.8	64.0
Felts	90	61.5	32.0	60	58	3.4	4.0	65.2	66.4
Blotters	120	67.4	33.1	142	92	4.2	4.2	62.0	66.0
Felts	120	66.2	33.5	75	87	4.2	4.1	67.2	65.2
Blotters	150	69.0	32.3	98	86	4.3	4.3	62.0	66.0
Felts	150	70.1	32.0	88	91	4.2	4.3	65.2	64.8
Blotters	180	70.1	32.8	88	75	4.5	4.6	70.4	74.0
Felts	180	69.3	34.0	89	93	4.2	4.1	64.8	67.2
Blotters	210	68.2	34.8	102	95	4.8	4.8	73.6	74.4
Felts	210	69.9	34.0	87	85	4.8	4.5	68.8	69.2
Blotters	240	70.8	35.3	163	132	5.1	4.9	78.0	77.6
Felts	240	65.1	35.0	128	135	4.6	4.5	69.2	70.0

[1] Test strip cut from the hand sheet in the direction indicated.

4. SHEET PRESS

A hydraulic press is used for pressing the fiber sheets before drying them. The press is operated by means of a hand pump. The two platen surfaces are 12 by 14 inches in size, and the vertical displacement of the lower surface is 8 inches. This distance gives ample space for pressing a number of hand sheets at one time. The ram has a sectional area of approximately 50 square inches, and sufficient force can be transmitted to it to maintain on the hand sheets any pressure up to 800 lbs./in.^{2}

5. SHEET DRYER

The dryer consists of a steam-heated cylinder and a carrying felt which covers most of the cylindrical surface. The diameter and the length of the cylinder are 12 and 14 inches, respectively. A thermometer placed between the carrying felt and the cylinder in preliminary experimental tests showed the temperature used to be approximately 90° C. A pressure gauge attached to the dryer is of value in preventing excessive temperature by showing when steam pressure develops within the cylinder.

III. OPERATION OF APPARATUS

Sheets are frequently made at the bureau in connection with the semicommercial work to note changes in the strength of the pulp during the progress of the beating operation. The tabular data given herein are on stock taken from the semicommercial beater.

A 2-quart dipper of stock is withdrawn from the beater as a sample, which is sufficient for several hand sheets, and to it 6 dippers of water are added. A measured volume of the diluted stock is made into a hand sheet, and from the weight of the dried sheet the volume of stock required for the desired test sheets is determined. The quantity of stock requisite for a test sheet of the specified weight is then taken and is diluted further to approximately 1 gallon in the 1½-gallon container used with the agitator. (Fig. 1.) The concentration of the final mixture is approximately 0.15 per cent.

The base, or mold support, of the sheet machine is filled with water, the mold and deckle box are set in place, and the assembled parts are clamped together. Water is run into the deckle box to a height of 4 inches, making about 2 gallons above the screen. The propeller shaft of the agitator is lowered into the container of diluted stock and operated for one-half minute. The stock is then immediately poured into the assembled sheet-making apparatus, the container being continuously moved back and forth, criss-crossing the mold, to insure uniform distribution. The dilution of the stock in the deckle box is about 0.05 per cent, which is ample for good felting of the fibers.

The steam-ejector valve and the quick-opening gate valve, respectively, are opened immediately after the transfer of the stock, to prevent settling of the fibers. The water and pulp are drawn down, and the sheet of fibers is formed on the wire. The length of time required for emptying the sheet machine depends on the rate at which water drains from the pulp—the "slowness" of the stock. When the machine contains only water the time is five seconds. Quick emptying is necessary to prevent unequal distribution of the fibers. It has been found desirable to continue the suction at least one minute after the water has been discharged from the base in order to facilitate the subsequent drying of the sheet.

After the sheet is formed the deckle box is removed, a felt is laid over the sheet, and the couching frame is placed on it. The couching frame, felt, sheet of pulp, and mold are then removed as a unit, inverted, and replaced on the mold base. Suction is again applied, and the fiber sheet is thus transferred to the felt.

The fiber sheet and the felt on which it rests are removed together from the mold and placed sheet up on a metal plate. Another felt and another plate are laid on the sheet of pulp. A number of sheets are prepared in this manner and stacked one above the other. The completed stack of fiber sheets, felts, and plates is placed in the hydraulic press and subjected to a pressure of 200 lbs./in.^{2} for three minutes.

The pressure applied for compacting the sheet has considerable influence on the ultimate strength of the paper. To obtain comparative data in testing the strength of pulp it is imperative that a standard pressure be used. Previous tests by other investigators [6] have shown that strength increases with increase in pressure, the rate of change being more rapid, however, at the lower pressures. Since 200 lbs./in.^{2} gives reliable results for all pulps and is the pressure recommended as

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[6] The Determination of the Effect of Pressure on the Strength of Test Sheets in the Strength Testing of Pulp, E. P. Cameron, Pulp & Paper Mag. of Canada, **21**, No. 5, pp. 127-135; Feb. 1, 1923. The Effect of Pressure on the Strength of Test Sheets in the Strength Testing of Pulp, E. P. Cameron and J. M. Payne, Pulp & Paper Mag. of Canada, **22**, No. 3, pp. 53-60; Jan. 17, 1924.

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a tentative standard by the Technical Association of the Pulp and Paper Industry it was the pressure adopted. The duration of the pressure has no appreciable effect on the strength of the sheet. Holding the load constant for three minutes gives very satisfactory results, and this period of time was adopted as standard.

The drying is accomplished by feeding the sheets between the cylinder and the carrying felt of the dryer and turning the cylinder slowly by hand. If the paper-making stock is "free" the sheet is removed after two revolutions of the cylinder, turned over, and replaced in the dryer, care being taken to avoid wrinkling the paper. If the stock is "slow," however, the sheet is not turned over, because of its tendency to cockle and wrinkle. In either case the cylinder is turned until the paper is apparently dry.

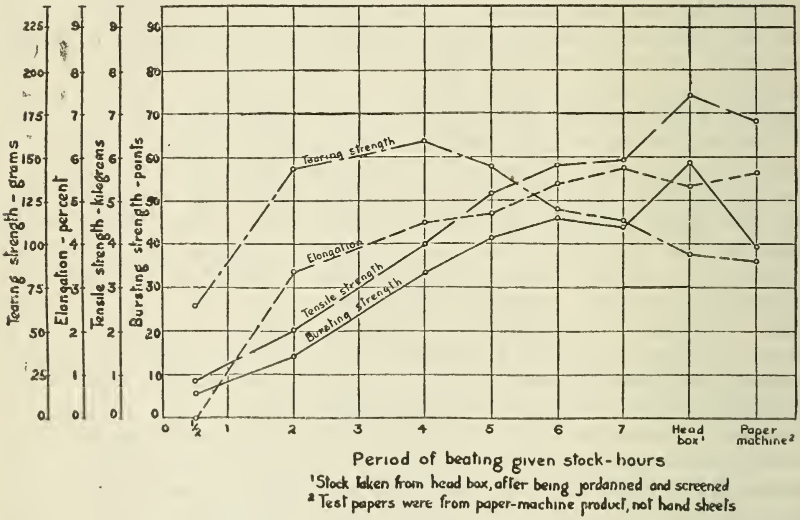

FIGURE 5.—*Comparison of strength properties of fiber sheets*

(Stock from beater run No. 1122)

The dried sheets are trimmed to 8 by 10½ inch size, and the various strength properties of the paper are determined. The measurements are made by the official methods of the Technical Association of the Pulp and Paper Industry,[7] under the standard atmospheric conditions for paper testing, 65 per cent relative humidity and 70° F. temperature.

IV. TEST DATA ON FINISHED HAND SHEETS

Measurements on hand sheets made by the method described are given in Tables 2 and 3. The stock for the sheets of Table 2 was taken at the recorded intervals of beating in connection with a research problem in which it was desired to know the change in strength as the beating progressed. Data on paper made on the semicommercial Fourdrinier paper machine from the same stock at the completion of

[7] Paper Testing Methods, published by the Technical Association of the Pulp & Paper Ind., 18 East Forty-first Street, New York, N. Y.

the beating are included for comparison. Two different beaters of stock, Nos. 1122 and 1123, were used and two different weights of hand sheets were made. As the measurements show, the fibers were uniformly distributed, and sheets of practically constant weight were produced regardless of the condition of the pulp being tested. The results of some of the tests on the lighter-weight papers are also shown graphically in Figure 5. The data for the heavier papers would give curves similar in slope but placed higher on the vertical scale.

TABLE 2.—*Measurements for sheets made from different samples of stock* [1]

Beater run No.	Beating interval [2]	Weight (25 by 40 inches, 500 sheets)	Bursting strength	Ratio of bursting strength to weight (25 by 40, 500 sheets)	Thickness	Folding endurance: Long direction [3]	Folding endurance: Short direction [3]	Tensile strength (strip 15 by 100 mm): Long direction	Tensile strength (strip 15 by 100 mm): Short direction	Elongation (strip 15 by 100 mm): Long direction	Elongation (strip 15 by 100 mm): Short direction	Tearing strength: Long direction	Tearing strength: Short direction
	Hours	*Lbs.*	*Points*	*Per cent*	*Inch*	*Double folds*	*Double folds*	*kg*	*kg*	*Per cent*	*Per cent*	*g*	*g*
1122	½	54. 8	5. 9	10. 8	0. 0069	0	0	0. 89	0. 84	0. 00	0. 00	65. 6	62. 4
1122	2	57. 4	14. 3	24. 9	. 0063	16	19	2. 01	2. 03	3. 30	3. 50	140. 0	142. 4
1122	4	56. 7	33. 6	59. 2	. 0056	623	518	4. 03	4. 08	4. 56	4. 50	154. 4	162. 4
1122	5	54. 3	41. 7	76. 9	. 0053	2, 207	1, 619	5. 15	5. 13	5. 00	4. 50	134. 4	162. 4
1122	6	55. 8	45. 9	82. 2	. 0051	3, 627	3, 728	5. 86	5. 79	5. 35	5. 45	115. 2	120. 8
1122	7	57. 3	44. 0	76. 9	. 0051	3, 359	3, 330	5. 72	6. 23	5. 55	5. 90	112. 8	112. 8
1122	(4)	56. 4	59. 0	104. 9	. 0048	-------	-------	7. 30	7. 57	5. 15	5. 55	93. 6	91. 2
1122	(5)	56. 5	39. 4	69. 7	. 0036	4, 418	5, 480	8. 24	5. 39	3. 05	8. 23	88. 0	90. 4
1122	½	105. 1	15. 8	15. 0	. 0125	7	7	2. 45	1. 88	3. 05	2. 85	213. 6	196. 0
1122	2	115. 7	41. 7	36. 1	. 0110	127	145	4. 64	4. 85	4. 30	4. 60	337. 6	344. 0
1122	4	113. 9	70. 2	61. 7	. 0095	8, 028	7, 888	8. 93	8. 87	5. 50	5. 90	362. 4	323. 2
1122	5	112. 4	83. 2	74. 0	. 0090	10, 098	10, 974	10. 20	10. 00	6. 20	6. 35	300. 0	297. 6
1122	6	113. 7	102. 5	90. 3	. 0089	15, 184	16, 113	12. 01	11. 89	7. 20	7. 00	278. 4	284. 8
1122	7	118. 0	100. 8	85. 5	. 0094	-------	-------	12. 70	12. 10	7. 35	7. 05	280. 0	309. 6
1123	½	57. 8	8. 0	13. 8	. 0074	0	0	. 94	1. 07	. 00	. 00	84. 8	88. 8
1123	2	57. 2	21. 1	36. 8	. 0060	50	33	2. 54	2. 24	3. 50	3. 60	164. 0	169. 6
1123	4	57. 2	40. 1	70. 2	. 0055	999	1, 246	3. 92	4. 33	5. 04	5. 02	164. 0	176. 8
1123	5	57. 1	44. 6	78. 0	. 0053	3, 075	3, 575	4. 65	5. 09	5. 36	6. 20	148. 0	143. 2
1123	6	56. 8	46. 7	82. 2	. 0053	3, 187	3, 380	5. 01	5. 21	5. 39	5. 92	133. 6	136. 0
1123	7	56. 7	53. 7	94. 6	. 0050	2, 488	2, 747	5. 50	5. 68	5. 93	5. 68	126. 6	108. 6
1123	(4)	59. 6	56. 0	94. 0	. 0049	-------	-------	7. 08	6. 77	5. 82	5. 56	98. 4	105. 6
1123	(5)	57. 5	37. 2	64. 6	. 0038	3, 080	2, 688	9. 20	4. 85	2. 48	7. 63	98. 4	108. 0

[1] Hand sheets were made by Martin J. O'Leary, assistant paper maker.
[2] Reckoned from beginning of furnishing. Time required for furnishing was 15 minutes.
[3] Samples were taken from the sheets in the direction indicated. The values in the long and short directions, which should be equal in the ideal case, are given separately merely to indicate the uniform formation of the sheets.
[4] Head box: Sample taken from head box, after being jordanned and screened, during paper-machine run.
[5] Test papers were from paper-machine product, not hand sheets.

As there is no definite relation between the data obtained on lightweight and heavyweight papers made from the same stock, it is necessary to standardize the weight of the test sheets when adopting a standard method. A number of investigators have recommended that hand sheets of relatively heavy weight be made for test purposes. Since the quality of the heavier sheets bears little relation to the strength values of the usual machine-made paper, it is desired in the work at the bureau that the weight of the hand sheets correspond to that of the paper-machine product, and, therefore, the lighter-weight sheets are regularly made.

Table 3 reports the values obtained on the individual sheets made from a given sample of stock and test samples taken from the machine product made from the same stock after being run through the Jordan. The measurements for the different hand sheets are in good agreement, the variations being hardly greater than the usual experimental errors of the measuring instruments, and no larger than for the different test samples of the machine-made paper. The results show that the method permits duplication of sheets as many times as desired.

TABLE 3.—*Measurements for different sheets made from one sample of stock*

Test paper	Bursting strength	Tensile strength (strip 15 by 100 mm)		Elongation (strip 15 by 100 mm)		Tearing strength (4 ply)	
		Long direction	Short direction	Long direction	Short direction	Long direction	Short direction
	Points	*kg*	*kg*	*mm*	*mm*	*g*	*g*
Hand sheet [1]	53	5.6	6.2	7.5	6.0	29	29
Do	49	5.2	6.0	6.5	6.0	32	27
Do	54	5.0	6.1	6.0	6.0	33	26
Do	56	5.8	5.5	5.4	4.5	32	29
Do	54	6.1	6.2	7.0	5.8	32	25
Do	56	5.0	5.9	4.3	6.0		
Do	57	5.7	4.9	5.3	4.8		
Do	55	5.5	5.5	6.0	5.9		
Do	51	5.6	5.3	5.8	6.0		
Do	52	5.5	5.2	5.5	5.8		
	53.7	5.50	5.68	5.93	5.68	31.6	27.2
Machine made [1]	37	10.0	4.7	2.5	7.2	24	28
Do	35	9.6	4.9	2.7	8.5	24	25
Do	43	8.8	5.3	2.5	8.5	24	25
Do	36	9.8	4.8	2.7	8.0	26	29
Do	41	9.1	4.7	2.2	7.5	29	26
Do	35	8.9	5.0	2.0	6.7	23	26
Do	35	9.7	5.0	2.5	8.0	23	30
Do	36	9.6	4.6	2.5	7.7	24	30
Do	33	9.4	4.4	2.5	5.7	26	26
Do	41	7.1	5.1	2.5	8.2	23	25
	37.2	9.20	4.85	2.46	7.60	24.6	27.0

[1] From stock of beater No. 1123; beating interval 7 hours. Stock for machine-made paper was jordanned and screened.

V. SUMMARY

A laboratory method for making small sheets of fibers in studying the paper-making quality of pulp has been developed, and a suction sheet machine has been designed. The method relates to the forming of the sheet of fibers on the screen and the subsequent operations of couching, pressing, and drying. The finished sheet is adequate to supply specimens for each kind of test ordinarily made to evaluate the quality of paper.

With the equipment and procedure described, sheets uniform in quality—formation, weight, etc.—can be made by an operator of average skill. Measurements of the physical properties show that the different sheets made from a given sample of stock are in good agreement and that the sheets can be duplicated as desired. The personal equation is reduced to a minimum, and truly comparable results can be obtained by different operators. The data warrant the view that the method is practical and is useful for pulp quality measurements.

WASHINGTON, March 3, 1930.