DEPARTMENT OF COMMERCE

TECHNOLOGIC PAPERS

OF THE

BUREAU OF STANDARDS

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No. 187

A STUDY OF TEST METHODS FOR THE PURPOSE OF DEVELOPING STANDARD SPECIFICATIONS FOR PAPER BAGS FOR CEMENT AND LIME

BY

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Bureau of Standards

MARCH 21, 1921

PRICE, 5 CENTS

Sold only by the Superintendent of Documents, Government Printing Office
Washington, D. C.

WASHINGTON
GOVERNMENT PRINTING OFFICE
1921

A STUDY OF TEST METHODS FOR THE PURPOSE OF DEVELOPING STANDARD SPECIFICATIONS FOR PAPER BAGS FOR CEMENT AND LIME

By Paul L. Houston

ABSTRACT

This technologic paper contains information relating to the methods of testing and the apparatus employed in determining the quality of paper bags for lime and cement. A brief description is given of the ordinary tests performed on paper, such as weight in pounds of the standard size ream 25×40—500, bursting strength in points, tensile strength in kilograms, stretch in centimeters, folding endurance in number of double folds, percentage of fiber composition, percentage of ash, and percentage of rosin sizing. A special test is developed for giving numerically the stresses and strains that the paper of these bags undergo in service. This test is called a resiliency or endurance test. A service test is also given to determine the breaking strength of the paper when the bags are filled and dropped. A comparison is made of the results of this test with the results of the above resiliency test. Another service test is developed for determinining the strength of the adhesives used in these bags. The results of all these tests are tabulated, and from these data the very best quality bags are chosen. In the conclusions, special consideration is given this choice of best bags in determining the characteristics of a good quality bag, and specifications are drawn up accordingly.

CONTENTS

I. INTRODUCTION

1. PURPOSE OF TESTS

The purpose of these tests is to aid the paper-bag manufacturers to meet the requirements of the lime and cement manufacturers in obtaining a suitable paper bag in which to ship their product. For a number of years the paper-bag manufacturers have attempted to manufacture such an article to substitute for the cotton bag

that had hitherto been used with great expense to the lime and cement industries because of the high price of cotton. The success of the paper-bag industry in this undertaking has been varied. A few of the consumers have given favorable reports on the use of their product, while others have claimed the bags fail in service. A number of consumers claim the glue gives way easily if the bags are held in storage any length of time. Since the bag manufacturers have been unable to derive any decided benefit from the above reports of the consumers, the present study was undertaken in order to develop specifications for these paper bags.

2. DISCUSSION OF MATERIALS AND APPARATUS USED

The materials used for this study were representative samples of paper bags obtained from a number of the leading bag manufacturers. The bags were given the following identification numbers: 14373, 14374, 14375, 14376, 14377, 14378, 14379, 14380, and 14381. The apparatus used was the Mullen paper tester, the paper scales, the 200 kg tensile-strength instrument, the 50 kg tensile-strength instrument, the folding endurance machine, microscope, glass slides, test tubes, extraction flasks, siphon cups, evaporating dishes and crucibles, all of which are used for ordinary physical and chemical tests. Descriptions and photographs of these instruments and apparatus may be obtained from circular of the Bureau of Standards No. 107, with the exception of the large 200 kg tensile-strength machine. The description and photograph of the tensile-strength apparatus in the above circular apply to the small 50 kg instrument. However, the 200 kg and the 50 kg instruments are practically identical in construction, the 200 kg machine being used for any material breaking at or under a load of 200 kg, the 50 kg machine for material breaking at or under a 50 kg load. In addition to the above paper-testing instruments a wooden platform with trapdoor and an ordinary foundry jolter were used for service tests. The wooden platform was built 3 feet high and allowed a bag filled with sand to be dropped through its trapdoor onto a solid wooden stand. The jolter consisted of a solid iron plate 3 inches thick which could be raised and lowered in rapid succession by means of air pressure. This machine, of course, was constructed with the necessary intake and outlet valves, air chamber, and piston to allow for the continuous jolting movement of the plate. For the purpose of developing a laboratory test that would give numerically the resiliency of bag

paper or the stress and strain that the paper of a bag undergoes in service and by which the results of the above service tests could be checked, the large 200 kg tensile-strength machine was adopted with the following additional attachments: A brass cylinder was constructed and fastened to the upright standard in such a way that it would revolve. The revolution of this cylinder was controlled by a small wire over a pulley from the weighted pendulum so that, as the pendulum moved from its vertical position due to the increasing loads, the cylinder revolved accordingly. This cylinder held a paper chart, and a glass recording pen was used to record both load and stretch. The pen was controlled by a small wire extending from the lower-jawed arm over a pulley in such a way that, as the lower jaw descended and the paper stretched under the load, the pen ascended and described a curve which registered stretch. It can thus be seen that the revolution of the cylinder caused the registering of load on the chart, while the ascension of the pen caused the registering of stretch. The result was a curve on the chart giving both the increasing load and increasing stretch until the paper broke. In order to read this curve it was necessary to draw up the chart so that load and stretch could be read at a glance. The method used was as follows: An ordinary blank piece of writing paper was used for this purpose and placed in position on the cylinder. A point on the paper was chosen as the zero point for load and stretch. Then the zero line for stretch was found by using a piece of steel between the jaws and by applying the various loads. Steel was used for this purpose because the chart was to be drawn up for a 70 kg load as a maximum, and steel would not stretch at this load. By this method the zero line for stretch was drawn with the recording pen from the zero point, and each kilogram load as indicated by the scale was pointed off as the load increased. At each kilogram point a line was drawn parallel to the base or zero line for load. This base line was found by operating the machine with nothing between the jaws and was drawn with the recording pen from the zero point. Each centimeter that the lower jaw descended from its starting position or zero point represented stretch and was pointed off accordingly. At the different centimeter points lines were drawn parallel to the zero line for stretch. In this way the chart was plotted to give accurately the stretch at different loads for any paper breaking under a 70 kg load.

3. SCOPE OF THE TESTS AND METHODS EMPLOYED

The object of these tests was, first, to discover all the physical and chemical properties of the paper of the bags; second, to check these results with the results of service tests on the bags themselves; third, to choose by the process of elimination the best bags of the series; and fourth, to develop specifications from this choice of best bags. For the ordinary physical and chemical tests the methods employed have been fully described in Circular of the Bureau of Standards No. 107, with the exception of the tensile strength and stretch tests. For these tests, the 200 kg instrument was used, and test samples were cut 2½ cm wide and long enough to allow 20 cm between jaws. In addition to the above tests a wet tensile test was conducted in the same manner as the dry tensile test described in the above Circular, with the following exceptions: The weight was removed from the pendulum of the 50 kg tensile-strength instrument, the machine was calibrated to find the corrections for the scale readings, and the paper was immersed for 10 minutes in water before testing. In both service tests bags were filled with 94 pounds of sand and then dropped or jolted until they broke open. In the jolter test the bags were jolted 1 inch high and 170 times per minute. An average of five tests was taken in each of these service tests to determine the strength of the bag. The method used for obtaining the resiliency of paper on the tensile-strength machine with its recording device was the following: In order to obtain curves or loops (as they should be called in this case) to show this resiliency or the endurance of paper under the repeated application of load, a load was taken in each case 10 per cent below the breaking point. This, of course, necessitated finding the tensile strength or breaking point for each grade of bag paper in both machine and cross direction. In order to do this an average of 10 tensile-strength tests was obtained. After obtaining in each case the desired load of 10 per cent below breaking point, each test sample was given this load, and then the load was released and the operation repeated until the test sample broke. All test samples for this work were cut 2½ cm wide and long enough to allow 20 cm of paper between jaws. Three test samples from each grade of paper, cut in both machine and cross direction, were used in order to obtain an average, and data were collected accordingly.

II. EXPERIMENTAL WORK

1. PHYSICAL AND CHEMICAL TESTS

Each sample of bag paper was given the ordinary physical and chemical tests, such as weight in pounds of the standard size ream 25×40—500, bursting strength in points, tensile strength in kilograms, stretch in centimeters, folding endurance in number of double folds, fiber composition in per cent, per cent of ash, and per cent of rosin sizing. From these tests the ratio in per cent of bursting strength to weight in pounds of the standard size ream, 25×40—500, and the breaking length in yards were obtained as the best means for comparing papers of the same grade. An explanation and description of this ratio and breaking length may be procured from Circular of the Bureau of Standards No. 107. The results of these tests are compiled in Tables 1, 2, and 4. In addition to the above tests the paper and bags were given the following special physical tests: The paper was tested for tensile strength in grams when it was wet, and was tested also for resiliency or endurance. The numerical results are shown in Tables 2, 3, and 4 and are presented graphically in Figs. 1 to 54. The bags were tested for breaking strength by determining the number of times each bag could be dropped before failure, as shown in Table 5, and for strength of adhesive by determining the length of time each bag could be jolted before failure, as shown in Table 6. The purposes of these special tests were the following: The wet tensile-strength test was made in order to indicate what the strength of the paper of the bags would be when they became wet in shipment. The stress-strain or resiliency test was made in order to obtain a series of loops for each test sample, giving first the stretch at applied load, second the stretch when load was released, third the increase in stretch for every time load was applied over the previous time, and fourth the number of times the paper could stand the strain of this load before it broke. The purpose of the drop test was to reproduce service conditions, because a bag is often dropped while being handled. On the other hand, the jolter test not only tested the strength of the adhesive used in the bags but also somewhat duplicated the treatment that a bag undergoes while being jolted and jarred in shipment from manufacturer to consumer. The following data were collected accordingly from all the above tests, and from these data it was not hard, by process of elimination, to choose the five bag papers which showed the best bursting strength, tensile strength, stretch,

folding endurance and resiliency, and which as bags showed the best breaking strength and possessed the strongest adhesive. At a glance, bag papers numbered 14373, 14374, 14378, 14379, and 14381 seem to be the strongest. In comparing the following results of the resiliency test with those results of the drop test, it will be noted that the above papers proved strongest in both cases. This proves that the resiliency test is a very good test for showing what the paper of a bag will do in actual service, and since it is strictly a laboratory test, it is highly to be recommended.

2. TABLES OF RESULTS

TABLE 1.—Results of Ordinary Physical and Chemical Tests on Cement and Lime Bag Paper

Bag-paper identification numbers	Weight of the standard size ream 25×40–500	Bursting strength in points	Ratio of bursting strength to weight of the standard size ream 25×40–500	Percentage fiber composition	Ash	Rosin sizing
	Pounds		Per cent		Per cent	Per cent
14373	150	134.0	89.3	100 jute and manila	4.10	3.40
14374	119	100.0	84.0	do	3.60	3.80
14375	143	108.0	75.6	95 jute and manila, 5 chemical wood	4.70	4.90
14376	127	96.0	75.6	100 chemical wood	3.30	3.30
14377	115	78.0	67.8	100 jute and manila	4.60	4.10
14378	176	132.0	75.0	50 jute and manila, 50 chemical wood	2.30	4.40
14379	142	143.0	107.0	75 jute and manila, 25 chemical wood	2.00	3.90
14380	172	159.0	92.4	100 chemical wood	1.27	.97
14381	181	155.0	85.7	do	.97	1.35

TABLE 2.—Results of Tensile-Strength Tests and Stress-Strain or Resiliency Tests on Cement and Lime Bag Paper

Bag-paper identification numbers	Weight of the standard size ream 25×40—500	Load at breaking point		Stretch at breaking point		Breaking length		Load 10 per cent below breaking point		Number of times load is applied	
		Machine direction	Cross direction	Machine direction	Cross direction	Machine direction	Cross direction	Machine direction	Cross direction	Machine direction	Cross direction
	Pounds	kg	kg	cm	cm	Yards	Yards	kg	kg		
14373	150	35.0	17.5	0.57	1.57	7130	3565	31.50	15.75	5.66	8.66
14374	119	28.0	16.5	.64	1.60	7160	4240	25.20	14.85	21.66	12.33
14375	143	27.0	11.0	.49	1.25	5770	2350	24.30	9.90	30.30	19.33
14376	127	26.5	13.0	.60	1.43	6380	3140	23.85	11.70	26.00	8.66
14377	115	21.5	8.8	.30	.70	5710	2340	19.35	7.92	11.00	11.66
14378	176	46.5	18.0	.54	1.34	5100	3120	41.85	16.20	49.66	4.66
14379	142	37.5	17.5	.64	1.06	8060	3770	33.75	15.75	12.00	9.66
14380	172	43.4	16.4	.45	1.12	7730	2910	39.06	14.76	1.00	2.00
14381	181	42.3	18.4	.50	1.14	7160	3110	38.07	16.56	59.00	9.66

TABLE 3.—Results of Stress-Strain or Resiliency Tests on Cement and Lime Bag Paper, Showing Different Stretches

	Loop 1	Loop 3	Loop 5	Loop 10	Loop 20	Loop 30	Loop 40	Loop 60
Bag identification No. 14373:								
Stretch at applied load—								
Machine direction.....per cent..	1.68	2.01	2.30	.....	.....	.....	.....	.....
Cross direction.....do....	5.66	5.77	.....	6.10	.....	.....	.....	.....
Stretch when load is released—								
Machine direction.....centimeters..	.25	.36	.40	.....	.....	.....	.....	.....
Cross direction.....do....	.90	.91	1.03	1.05	.....	.....	.....	.....
Bag identification No. 14374:								
Stretch at applied load—								
Machine direction.....per cent..	2.60	.....	.....	2.65	2.75	.....	2.95	3.15
Cross direction.....do....	6.28	6.96	7.56	7.80	.....	.....	.....	.....
Stretch when load is released—								
Machine direction.....centimeters..	.30	.....	.42	.47	.51	.....	.54	.56
Cross direction.....do....	.94	1.27	1.34	1.44	.....	.....	.....	.....
Bag identification No. 14375:								
Stretch at applied load—								
Machine direction.....per cent..	1.18	.....	1.56	1.90	2.22	2.60	.....	.....
Cross direction.....do....	3.85	5.13	.....	.....	5.40	.....	5.60	.....
Stretch when load is released—								
Machine direction.....centimeters..	.27	.....	.36	.44	.50	.....	.....	.....
Cross direction.....do....	.53	.86	.....	.....	.92	.....	1.00	.....
Bag identification No. 14376:								
Stretch at applied load—								
Machine direction.....per cent..	1.75	.....	2.16	2.51	2.75	.....	.....	.....
Cross direction.....do....	5.23	5.90	6.50	.....	6.60	.....	.....	.....
Stretch when load is released—								
Machine direction.....centimeters..	.31	.38	.44	.51	.60	.....	.....	.....
Cross direction.....do....	.80	.99	.....	1.02	.....	.....	.....	.....
Bag identification No. 14377:								
Stretch at applied load—								
Machine direction.....per cent..	1.16	.....	1.65	2.00	.....	.....	.....	.....
Cross direction.....do....	2.90	3.75	.....	4.05	4.30	.....	.....	.....
Stretch when load is released—								
Machine direction.....centimeters..	.23	.....	.36	.43	.....	.....	.....	.....
Cross direction.....do....	.40	.67	.....	.70	.75	.....	.....	.....
Bag identification No. 14378:								
Stretch at applied load—								
Machine direction.....per cent..	1.68	.....	.....	1.90	.....	.....	.....	.....
Cross direction.....do....	5.46	6.38	7.12	.....	.....	.....	.....	.....
Stretch when load is released—								
Machine direction.....centimeters..	.26	.....	.32	.40	.....	.....	.....	.....
Cross direction.....do....	.82	1.06	1.20	.....	.....	.....	.....	.....
Bag identification No. 14379:								
Stretch at applied load—								
Machine direction.....per cent..	2.31	.....	2.55	2.85	3.10	.....	.....	.....
Cross direction.....do....	4.93	5.28	5.45	5.60	6.00	.....	.....	.....
Stretch when load is released—								
Machine direction.....centimeters..	.38	.50	.58	.64	.70	.....	.....	.....
Cross direction.....do....	.80	.95	1.00	1.05	.....	.....	.....	.....
Bag identification No. 14380:								
Stretch at applied load—								
Machine direction.....per cent..	2.10	.....	.....	.....	.....	.....	.....	.....
Cross direction.....do....	3.13	3.60	.....	.....	.....	.....	.....	.....
Stretch when load is released—								
Machine direction.....centimeters..	.....	.....	.....	.....	.....	.....	.....	.....
Cross direction.....do....	.50	.78	.....	.....	.....	.....	.....	.....
Bag identification No. 14381:								
Stretch at applied load—								
Machine direction.....per cent..	1.53	.....	1.83	2.10	2.33	.....	.....	.....
Cross direction.....do....	3.13	3.90	4.50	4.95	.....	.....	.....	.....
Stretch when load is released—								
Machine direction.....centimeters..	.32	.....	.42	.49	.54	.....	.....	.....
Cross direction.....do....	.44	.56	.66	.72	.....	.....	.....	.....

TABLE 4.—Results of Wet Tensile Tests and Folding Endurance Tests on Cement and Lime Bag Paper

Bag-paper identification numbers	Wet tensile strength		Breaking length		Folding endurance in number of double folds	
	Machine direction	Cross direction	Machine direction	Cross direction	Machine direction	Cross direction
	kg	kg	Yards	Yards		
14373	1.38	1.40	476	482	10 000+	10 000+
14374	2.36	1.71	1026	746	10 000+	10 000+
14375	1.43	1.29	519	468	10 000+	1 998
14376	2.05	1.68	836	685	6 220	4 260
14377	1.17	.92	525	418	10 000+	5 011
14378	3.15	1.35	926	396	10 000+	10 000+
14379	1.31	.71	349	262	10 000+	10 000+
14380	.80	.30	243	90	7 244	10 000+
14381	1.26	.69	362	199	10 000+	10 000+

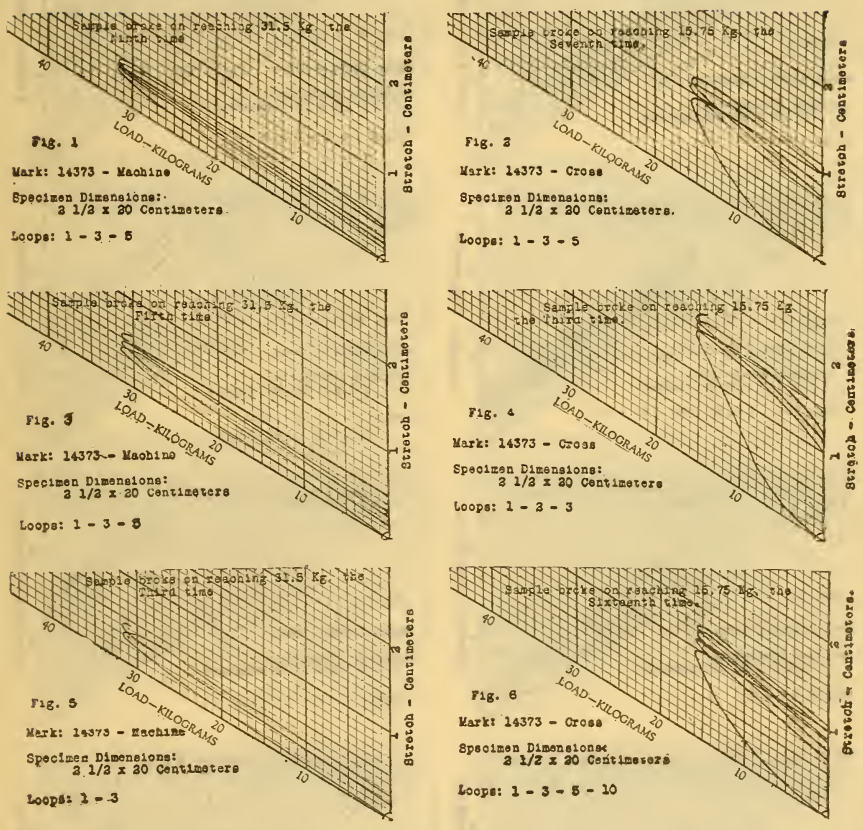
TABLE 5.—Results of Drop Service Tests on Cement and Lime Bag Paper

Bag-paper identification numbers	Position of bag when dropped	Number of drops before failure	Extent of failure
14373	On side and seam up	2	Paper failed at seam.
14374	do	3	Do.
14375	do	1	Paper and glue failed at seam.
14376	do	1	Paper failed across edge, and glue failed at end.
14377	do	1	Paper and glue failed at seam, and paper failed across bottom side.
14378	do	4	Paper failed at seam.
14379	do	4	Do.
14380	do	1	Paper failed across end, from side to side, and glue failed at end.
14381	do	3	Glue failed at seam and end.

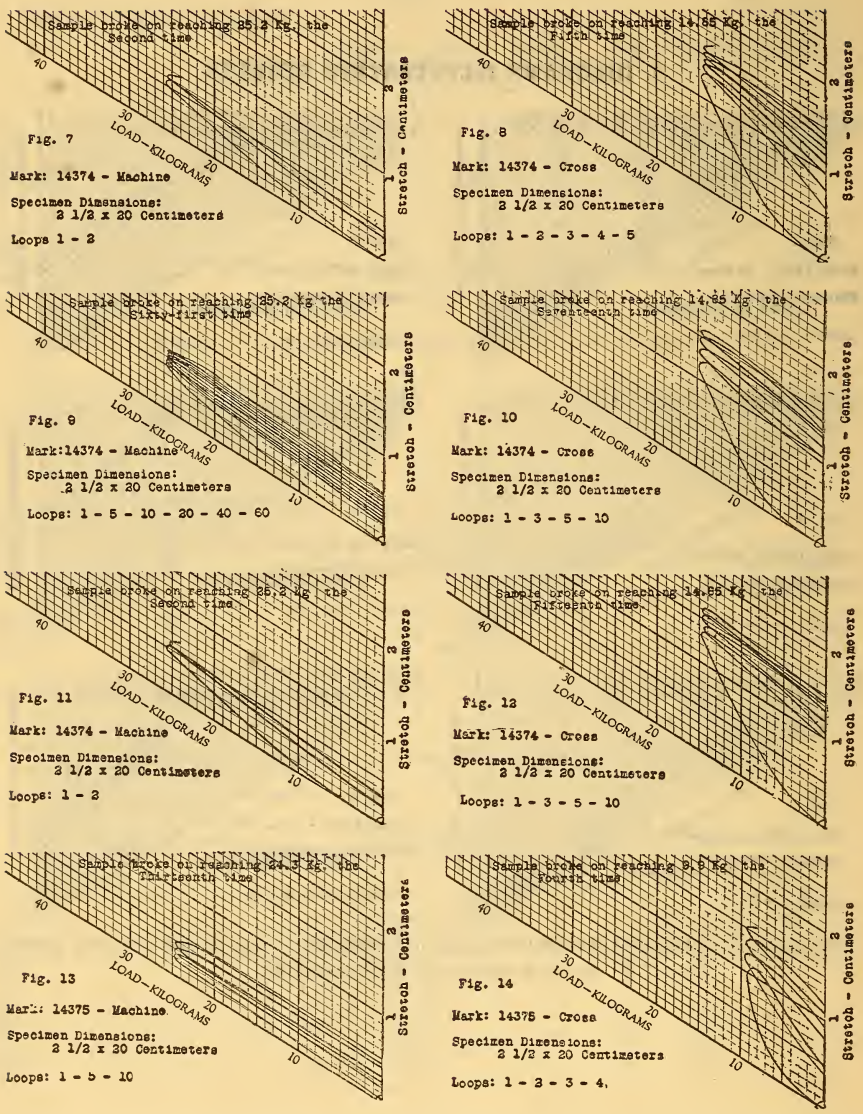
TABLE 6.—Results of Jolter Service Tests on Cement and Lime Bag Paper

Bag-paper identification numbers	Position of bag when jolted	Minutes jolted before failure	Extent of failure
14373	On side and seam up	24	Glue failed at end.
14374	do	60	No failure.
14375	do	1	Glue failed at end.
14376	do	18	Do.
14377	do	6	Do.
14378	do	40	Do.
14379	do	30	Do.
14380	do	2	Do.
14381	do	3	Do.

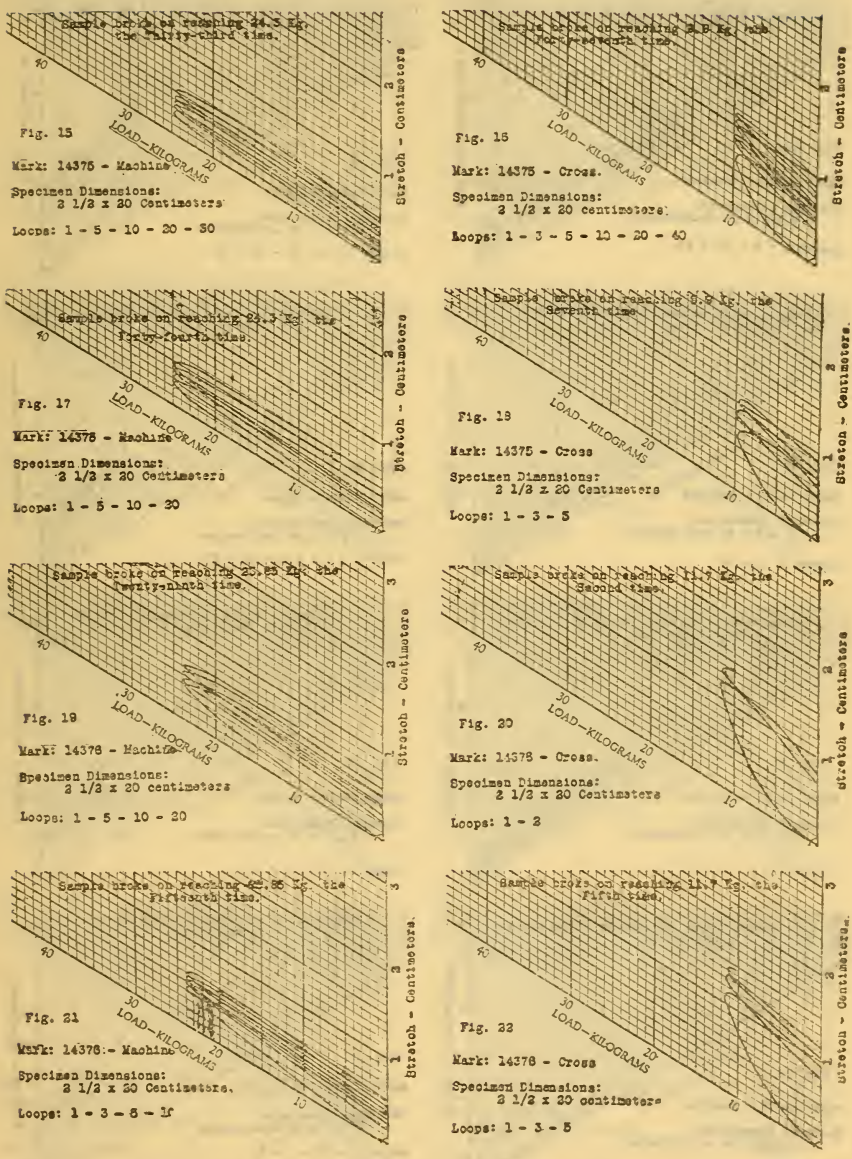
3. DIAGRAMS ILLUSTRATING RESULTS



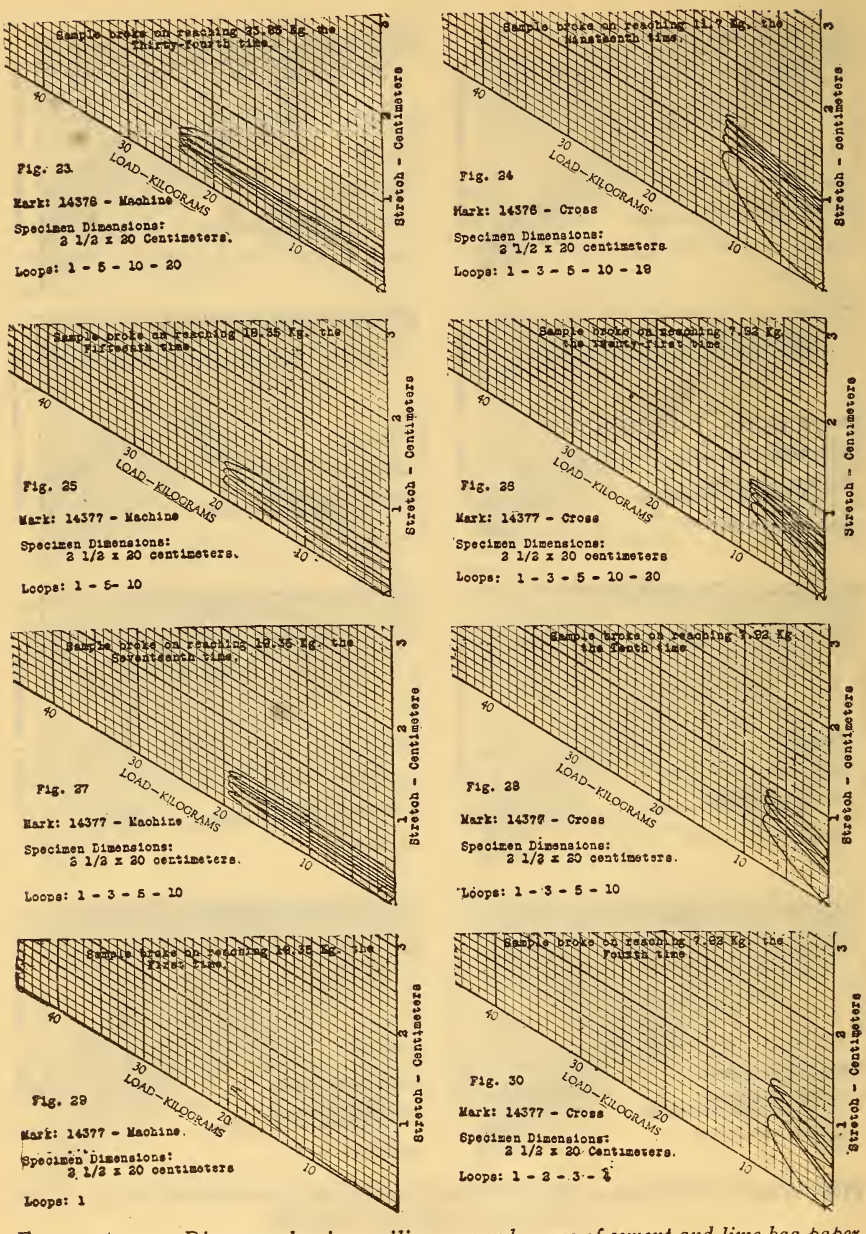
FIGS. 1 to 6.—*Diagrams showing resiliency or endurance of cement and lime bag paper in the machine and cross directions*



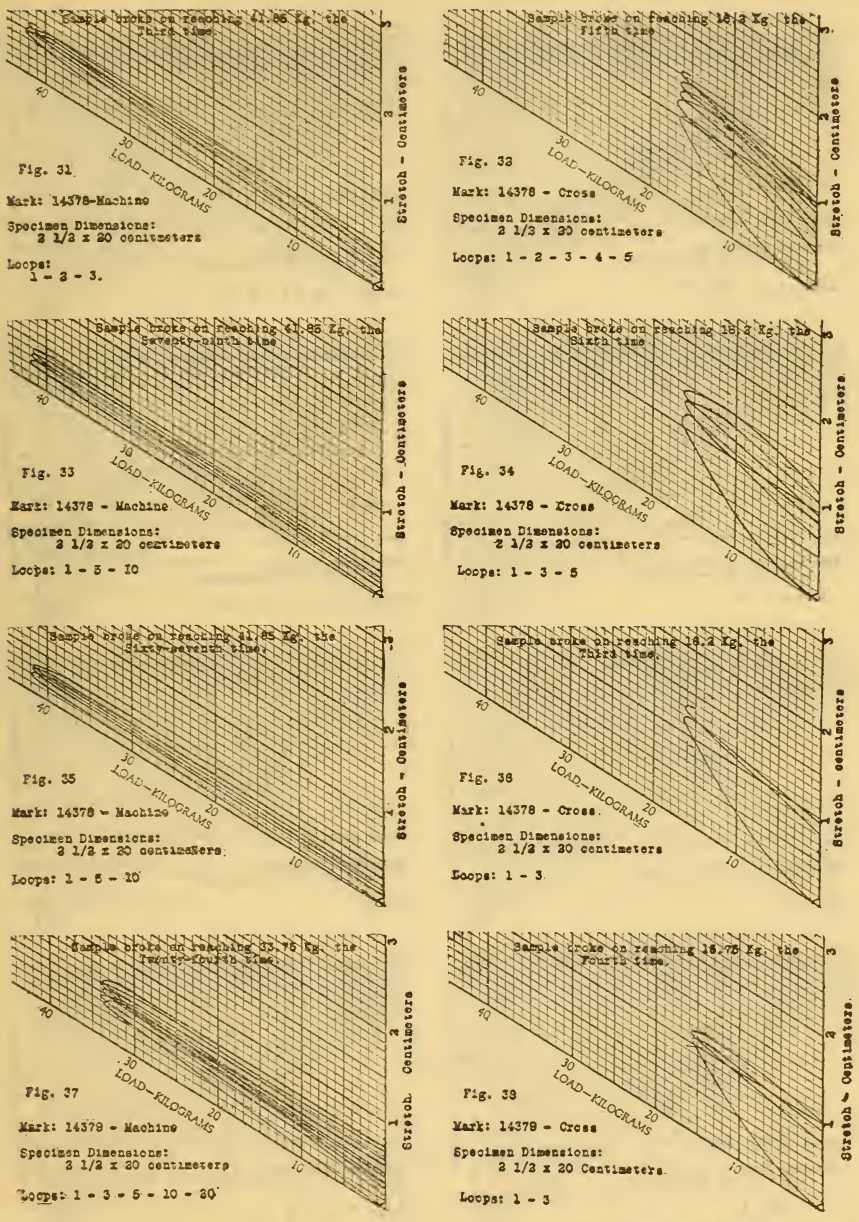
FIGS. 7 to 14.—*Diagrams showing resiliency or endurance of cement and lime bag paper in the machine and cross directions*



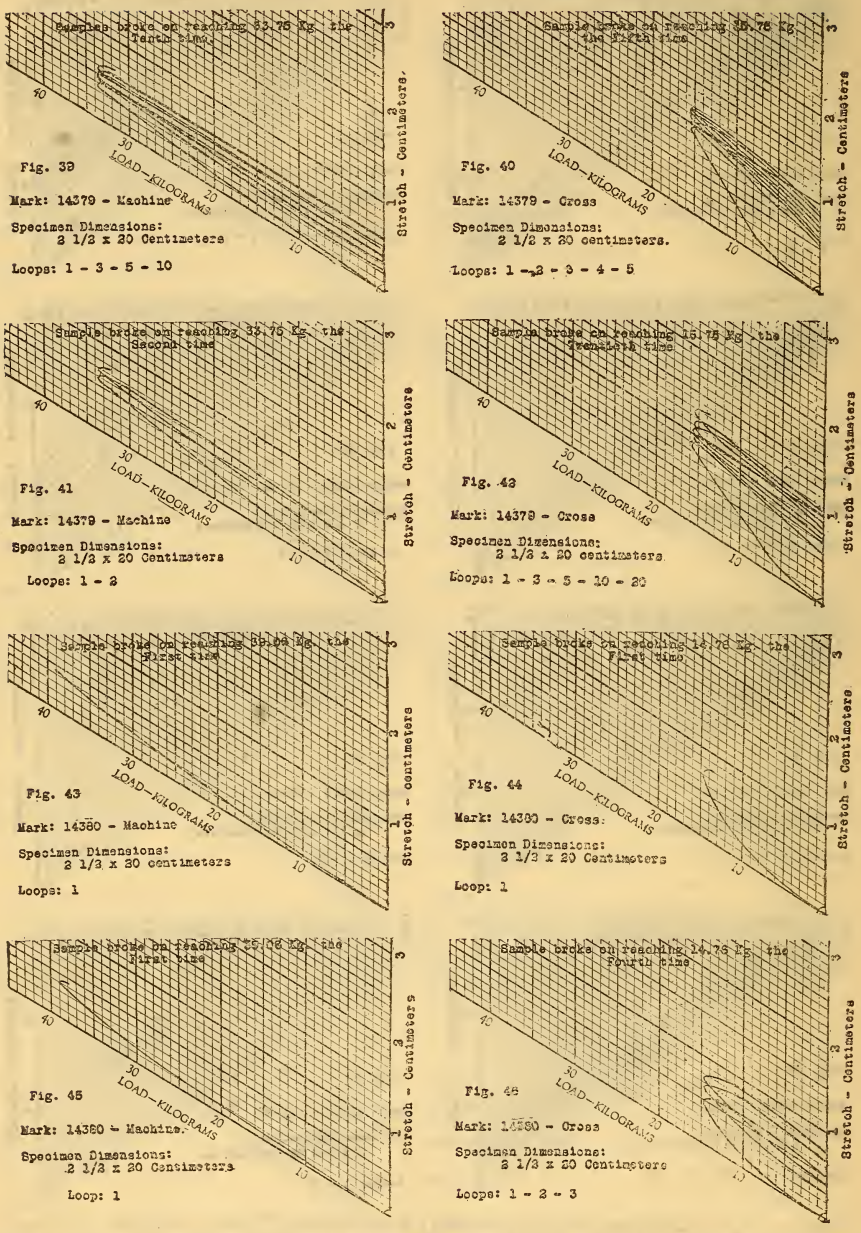
FIGS. 15 to 22.—*Diagrams showing resiliency or endurance of cement and lime bag paper in the machine and cross directions*



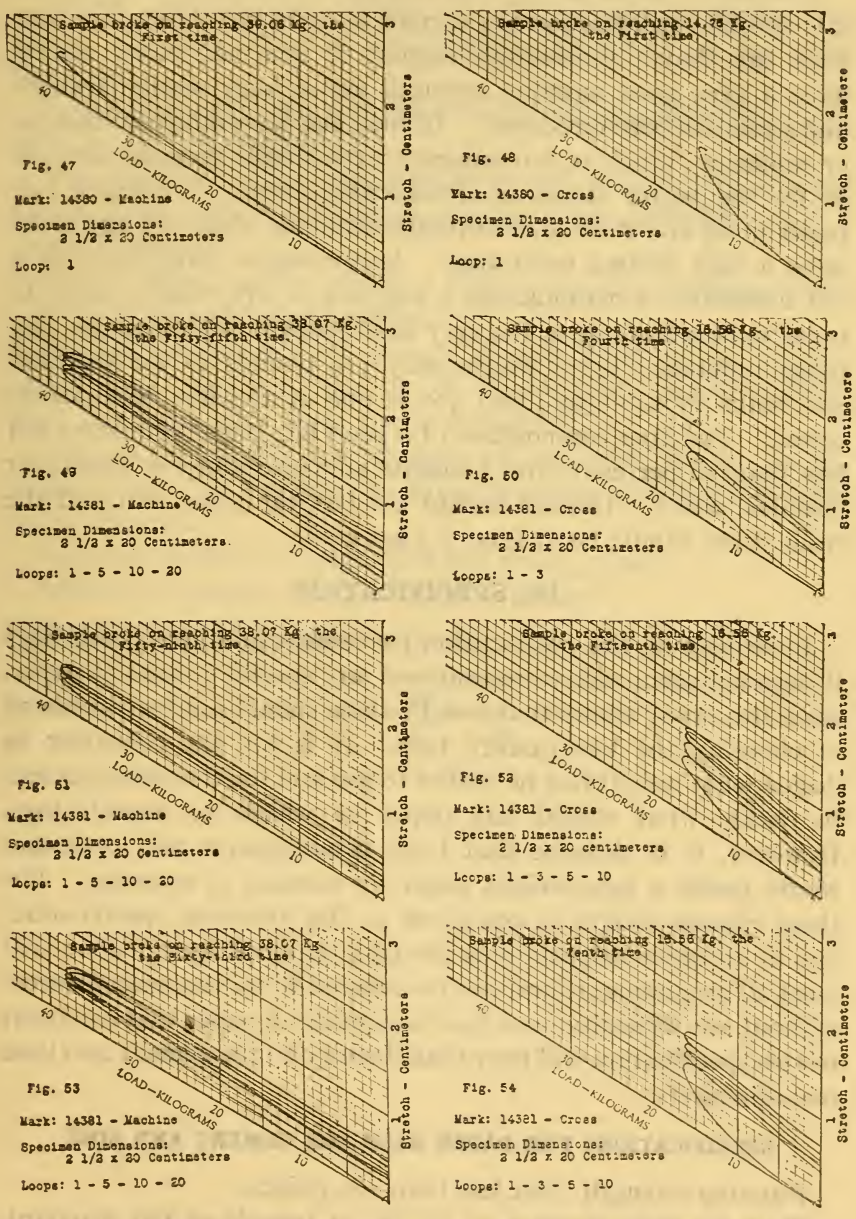
FIGS. 23 to 30.—*Diagrams showing resiliency or endurance of cement and lime bag paper in the machine and cross directions*



FIGS. 31 to 38.—*Diagrams showing resiliency or endurance of cement and lime bag paper in the machine and cross directions*



FIGS. 39 to 46.—*Diagrams showing resiliency or endurance of cement and lime bag paper in the machine and cross directions*



FIGS. 47 to 54.—*Diagrams showing resiliency or endurance of cement and lime bag paper in the machine and cross directions*

III. CONCLUSIONS

Conclusions to be drawn from the above results of tests, taking into special consideration the various tests on the chosen five best bags, are that a satisfactory cement or lime bag paper should have a very good bursting strength and a high tensile strength and stretch in both directions. It must also have a high endurance or resiliency, which is determined by the simple drop service test or by the better stress-strain laboratory test. A suitable bag paper must also show a good tensile strength when wet and must have a high folding endurance. As the above data show, it is not necessary to manufacture a bag out of very heavy paper in order to obtain a bag of the very best quality. For instance, bag paper numbered 14374 weighs only 119 pounds to the standard size ream 25×40—500, and yet is one of the five best papers tested. The fiber composition of a good bag paper should be not less than 50 per cent strong manila and jute and the remainder chemical wood. The ash should not be over 3 per cent and the rosin sizing should be at least 3.5 per cent.

IV. SPECIFICATION

In writing up the specification for cement and lime paper bags it does not seem wise to recommend any specific weight of paper, since this study shows that weight alone should not be considered in choosing the best-quality bags. It is for the consumer to decide what weight bag he wishes to use and for the manufacturer to decide what weight bag paper he wishes to manufacture. However, it is thought that both manufacturer and consumer would prefer a light-weight paper for reasons of economy. For these reasons weight is not given in the following specification, but in all other respects it is thought that this specification will meet all requirements and can be adhered to by the manufacurers without any difficulty, and that bags made of paper that conforms to this specification will prove satisfactory to the cement and lime manufacturers.

SPECIFICATIONS FOR PAPER BAGS FOR CEMENT AND LIME

Bursting strength: Not less than 100 points.

Ratio bursting strength to weight in pounds of the standard-size ream, 25×40—500: Not less than 75 per cent.

Fiber composition: Not less than 50 per cent manila and jute; the remainder as chemical wood.

Ash: Not over 3 per cent.

Rosin: Not less than 3.5 per cent.

Tensile strength (test sample 2½ cm wide and 20 cm between jaws): Not less than 28 kg (machine direction), 16 kg (cross direction).

Breaking length: Not less than 7000 yards (machine direction), 3500 yards (cross direction).

Wet tensile strength (test sample 15 mm wide and 90 mm between jaws): Not less than 2000 g (machine direction), 1300 g (cross direction).

Wet breaking length: Not less than 800 yards (machine direction), 400 yards (cross direction).

Folding endurance (test sample 15 mm wide and 90 mm between jaws): Not less than 10 000 double folds (machine direction), 10 000 double folds (cross direction).

Resiliency strength (test sample 2½ cm wide and 20 cm between jaws): Not less than 20 times (machine direction), 9 times (cross direction).

Breaking strength of bags: Not less than 3 times.

Adhesive strength: Not less than 30 minutes.

WASHINGTON, September 20, 1920.