THE ABSORBENCY OF THREE TYPES OF DISH TOWELING AS DETERMINED BY RATE AND IMMERSION TESTS

By

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I. INTRODUCTION

The utility of fabrics for dish towels partially depends on their ability to absorb water, yet no one method for measuring this important property has yet been generally accepted. In attempting to measure the water absorption of towels one is looking for an indication of the value of the fabric as a drying agent.

The ideal method for testing absorbency is to duplicate the actual conditions of use. However, this would be difficult, if not impossible, to do, but it is desirable to imitate service conditions as nearly as possible.

In measuring the water absorption by towels there are three factors, partially dependent upon one another, which should be considered. First, the surface tension effect on which depends the ease with which the material is wetted; second, the capillary action which depends to some extent on surface tension but which is also affected by the size of the fiber, type of yarn, construction of the fabric, etc.; and third, the amount of water absorbed.[1] It is with this third factor that this study is primarily concerned.

The objectives of this investigation were to determine:

1. The rate at which the selected toweling fabrics absorbed moisture.
2. How much moisture the toweling fabrics absorbed.
3. How absorbency changed as the toweling fabrics were subjected to laundering.

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[1] P. Larose, "The Water Absorption by Towels," <u>American Dyestuff Reporter</u>, XXXI (March, 1942), 105.

II. REVIEW OF LITERATURE

Most of the methods proposed for measuring the water absorption by towels do not give the most important information; the amount of water that can be absorbed by the towel and the ease or rapidity with which that water is absorbed.

Several methods have been proposed for determining the total amount of absorption. The saturated atmosphere, wet brick, and immersion tests are most frequently used. It is necessary to have conditions that can be carefully and easily controlled. The immersion test method proposed by the American Association of Textile Chemists and Colorists[1] was selected for determining total absorption.

Under normal conditions, however, a portion of the towel is not used until it becomes saturated but until it contains less than 100 per cent by weight of water. This makes the initial rate of wetting an important factor in towel evaluation. The drop-square method, as used by many mills, is suitable for comparative quick testing at the mill, but is not suitable for a standard procedure.[2]

The capillary rise or wick-up method can be used to obtain a plot of capillary rise versus time. It is simple to perform and fast due to little manipulation.[3] In use, however, towels are generally applied against the

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[1] Technical Manual and Year Book of the American Association of Textile Chemists and Colorists, XXVI (1950), 132.

[2] V. B. Holland, "A Comparison of Methods for the Determination of Water Absorbency by Terry Towels," Textile Recorder, LXI (October, 1943), 38, 40, 42.

[3] Ibid., p. 38, 40, 42.

object to be dried with certain pressure. The wet object is covered with a rather thin film of water. Therefore, a method in which the toweling is brought in contact with a wetted surface is thought to be desirable.

Larose[4] described a method for measuring drying capacity in which pieces of toweling were weighed before and after contacting a damp porous plate for varying lengths of time. This method is time consuming due to the necessity of weighing many samples and involves the use of a large number of samples to obtain a plot showing different time intervals.

Kettering[5] proposed a modification intended for evaluating print cloths which used a capillary tube connected to the water source under a porous plate. The necessity for weighing was thus eliminated. Jackson and Roper[6] modified Kettering's original idea to make it more flexible and capable of being used to evaluate a wider range of fabrics of different absorptive powers. This test method was selected for determining rate of absorption.

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[4] Larose, op. cit., XXXI, 105-106.

[5] James H. Kettering, "Determination of the Rate of Water Absorption of Light-Weight Cotton Fabrics," American Dyestuff Reporter, XXXVII (February, 1948), 73-74.

[6] E. C. Jackson and E. R. Roper, "A Water Absorbency Apparatus," American Dyestuff Reporter, XXXVIII (May, 1949), 397-401.

III. THE EXPERIMENT

A. Introduction

Two methods for testing absorption of moisture by the toweling fabrics were selected, one to measure rate of absorption, the second to measure total amount of absorption. The towelings used in the experiment were subjected to a series of launderings, absorption being tested at specific intervals. It was considered desirable to find how absorbency changed as the fabrics were laundered.

In addition to the absorption tests, which comprise the main part of this investigation, several supplementary tests were performed, including thickness, yarn number and twist, weight of test specimens and weight in ounces per square yard, breaking strength, and yarns per inch. These tests were undertaken to obtain further information about the selected fabrics.

B. Description of Equipment

A modification of the method of Jackson and Roper[1] was used to determine the rate of absorption of the towel specimens. The apparatus (see Fig. 1) was composed of a Water Reservoir (R), connected by a rubber tubing to one outlet of a Two Way Stopcock (A) at the base of a Burette (U). The other outlet of Stopcock (A) was connected by a rubber tube to a T-shaped glass tubing having a Stopcock (C) in the vertical portion of the T-shaped glass tubing, leading to a Drain (D). The other end of the horizontal portion of the T-shaped glass tubing was connected by a rubber tubing to one end of the horizontal portion of a second T-shaped glass

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[1] *Ibid.*, p. 397-398.

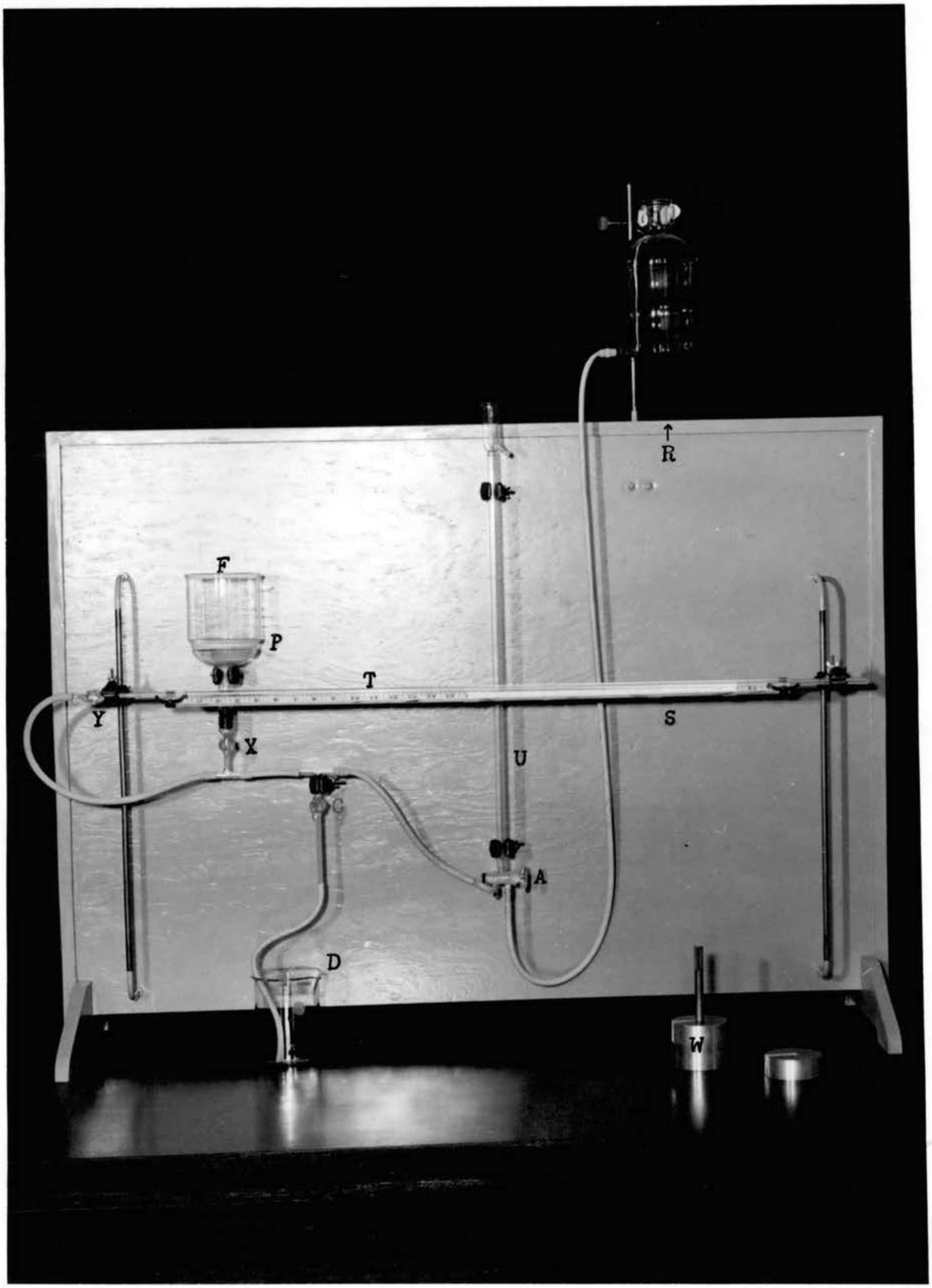

Fig. 1. Apparatus for Rate of Absorption Test

tubing. The other end of the horizontal portion of this second T-shaped glass tubing was connected to an open end horizontal Capillary Measuring Tube (T) of 3 mm. bore, 40 inches long. The vertical portion of the T-shaped glass tubing extended upward through a rubber stopper into the base of a 90 mm. Buchner Fritted Funnel (F) furnished with a Porous Plate (P) of fine porosity. The capillary measuring tube was installed and held horizontal and level below the level of the Porous Plate (P). A Movable Scale (S) calibrated in grams of water per unit length was attached to the Horizontal Capillary Measuring Tube (T) in such a manner that the 0 end of the scale could be placed on the meniscus near the open end of the measuring tube when the machine was in equilibrium. Stopcocks (X) at the base of the funnel and (Y) at the end of the capillary measuring tube were used to control passage of water from the measuring tube into the funnel. Modifications included the use of a 90 mm. ($3\frac{1}{2}$ inch) Buchner funnel rather than a 3 inch funnel, and Weights (W) 3 inches in diameter which rested on the sample when it was placed against the porous plate. An 800 gram weight was used for the three fabrics tested.

The tentative test method of the American Association of Textile Chemists and Colorists[2] was used to determine the total absorption of water by the towel specimens. The apparatus consisted of a motor driven wringer, sinkers, tray, blotters, and 3000 ml. beakers in which to immerse the samples using the same water level as specified for the immersion tank.

C. Selection and Preparation of Test Specimens

Three toweling fabrics were selected for testing, all of which had cotton as a common fiber. Fabric A, sold under the trade name "Carosel"

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[2] Technical Manual and Year Book of the American Association of Textile Chemists and Colorists, XXVI (1950), 132.

by the U. S. Rubber Company, was of 80% cotton and 20% asbestos. The tiny bundles of asbestos fibers in the cloth are thought to blot up the water and produce a more absorbent fabric than cotton alone.[3]

Fabric B, a "Startex Printoweling," was a 65% cotton and 35% linen fabric. Fabric C, 100% cotton sacking, was selected since it is inexpensive and used widely.

Each toweling was divided into six specimens 20 inches in length and 16 to 18 inches in width depending upon the width of the cloth. The specimens were selected at random and labeled to indicate the number of times each would be laundered. All were carefully hemmed to prevent raveling.

D. Laundry Procedure

A total load of approximately three pounds was laundered each time. As towel specimens were removed from the laundry routine for testing, their weight was replaced by hemmed lengths of muslin.

Using water at 60° C. (140° F.) and sufficient detergent to produce a good suds, the specimens were washed for ten minutes. The fabrics were then removed from the water and centrifuged for one-half minute, followed by a one minute rinse in water at the same temperature as that used previously. After centrifuging for a second one-half minute following the rinse, the towel specimens were hung indoors to dry. When completely dry they were ironed with a mangle using the same setting for heat and speed each time they were ironed.

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[3] "Dishtowels from Asbestos," Science News Letter, LIV (September 25, 1948), 204.

E. Test Procedure

To determine the rate of absorption of water at each test interval by the selected toweling fabrics, ten 3 inch by 3 inch samples were cut from each of the three fabrics by means of a template and razor blade. The ten samples were then conditioned at a standard atmosphere of 65 ± 2% relative humidity and 70 ± 2° F. for at least four hours before testing. The samples were then weighed together and 1/10 of the total weight taken as the average weight of a sample.

The apparatus was put in equilibrium, and one of the test samples which had been prepared and weighed as described in the preceding paragraph was placed on the porous plate with the aid of a small forceps, care being taken to center the sample on the porous plate. The weight was placed on the sample immediately. The fabric sample began to absorb water almost as soon as it was placed on the plate and the meniscus in the measuring tube began to move. Since the measuring tube was calibrated for grams of water per unit length at the time the apparatus was assembled, the weight of water absorbed could be calculated from the distance the meniscus moved in the measuring tube. With the aid of a stopwatch, readings were taken at thirteen specified time intervals, beginning at ten seconds and continuing a total of four minutes. After making necessary observations on one sample, it was removed from the plate and discarded. The apparatus was again set in equilibrium and another sample tested.

To calculate total absorption by immersion, three 3 inch by 3 inch samples were prepared, conditioned, and weighed following the same procedure as that for the rate of absorption test. A sinker was fastened to the center of the test sample, which was then dropped into a beaker containing water at room temperature. The test sample was allowed to remain immersed for 20 minutes, after which it was taken from the water and the sinker removed. It was then quickly placed between two 7 inch by 8 inch pieces of the dry blotting paper to form a sandwich and passed once through the wringer. The test sample was then reweighed to the nearest 5 milligrams immediately after squeezing.

Procedures of the American Society for Testing Materials were followed in making tests for weight in ounces per square yard, thickness, breaking strength, and number of yarns per inch.[4] Weight in ounces per square yard was calculated on the basis of the weight of the ten samples prepared at each laundry interval for the rate of absorption test. Total weight of the test specimens was determined by weighing each specimen at standard conditions before laundering and after the specified number of launderings, the difference between the two weights being the loss in weight. Thickness was taken on the test specimens before laundering and at each laundry interval, while breaking strength (raveled-strip method) and number of yarns per inch were determined previous to laundering and after twenty launderings.

Yarn number (Grex System) and yarn twist[5] were determined for warp and filling yarns in the unlaundered fabrics.

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[4] American Society for Testing Materials, Committee D-13, A. S. T. M. Standards on Textile Materials, Philadelphia: (October, 1950), 113-115.

[5] Ibid., p. 279-281.

IV. DISCUSSION OF RESULTS

Rate of absorption test

Results of the test for rate of absorption are shown in Figs. 2 to 8 as the per cent of water absorbed by the three towelings at thirteen specified time intervals. Previous to laundering, and after one laundering, Fabric A absorbed a greater per cent of water than did Fabrics B and C. However, after the specimens had been laundered three times, Fabric C absorbed the largest per cent of water, and continued to be the most absorbent fabric in subsequent tests for rate of absorption.

Since all the samples were not equal in weight, a better indication of how much water was absorbed at any specific time in the rate of absorption test might be gained by reporting directly in milliliters (grams) the water absorbed by the toweling samples. Figs. 9 to 11 illustrate the amount of water absorbed by each fabric after one, two and four minute exposures to the porous plate at each laundry interval. Fabric A at one, two and four minute intervals absorbed approximately twice as much water after one laundering as it did when new, but remained relatively constant in absorption after the first laundering. Fabric B at the one, two and four minute intervals showed a sharp increase in absorption after being laundered once, followed by a decline after three launderings. After the third laundry interval, its absorption resumed an upward curve. It is probable that had the experiment been carried beyond twenty launderings, Fabric B would have continued to increase in absorbency before reaching its maximum. Readings for Fabric C at one and two minute exposures showed an upward trend from the new fabric until the tenth laundering, after which the

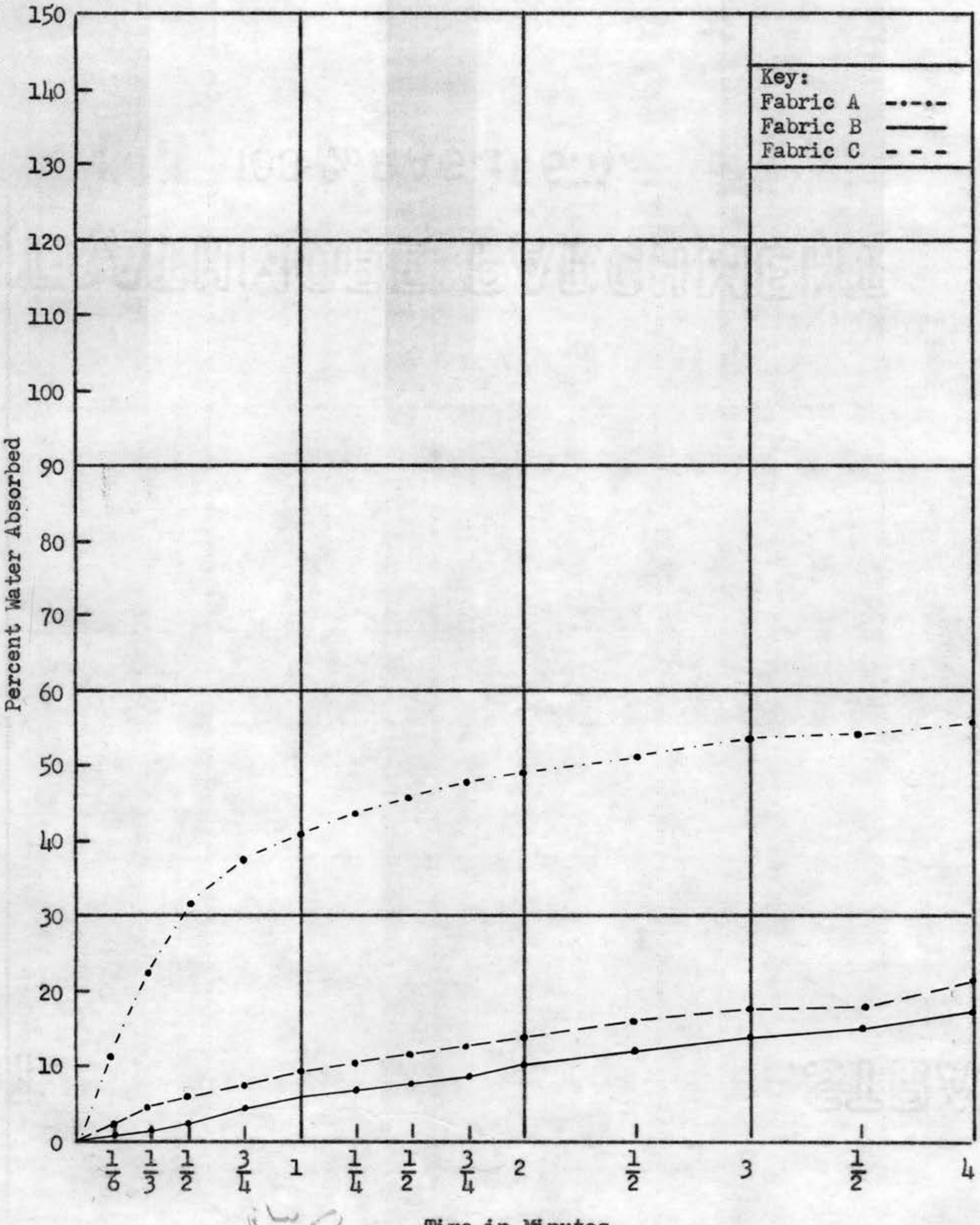

Fig. 2. Rate of Absorption Before Laundering

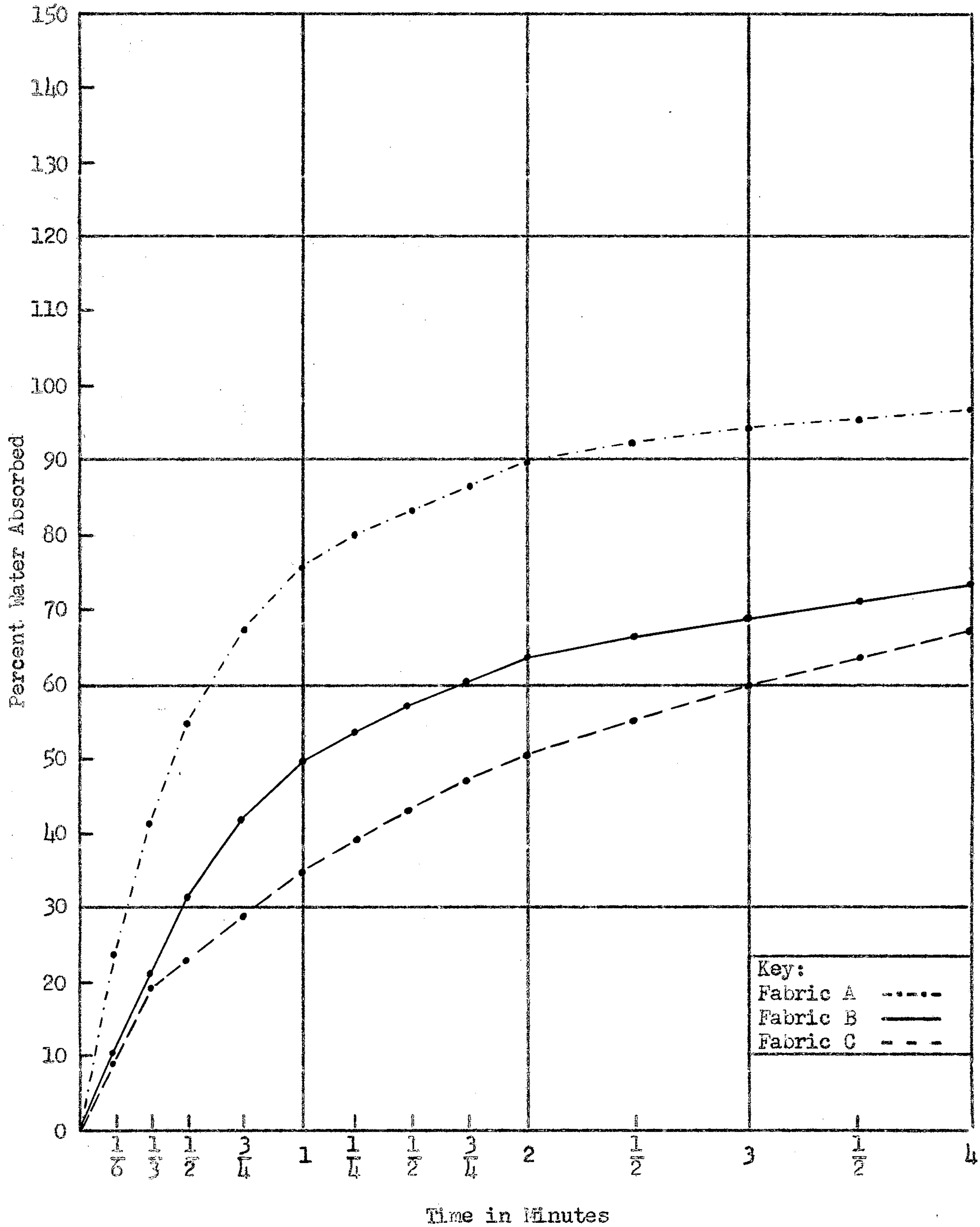

Fig. 3. Rate of Absorption After One Laundering

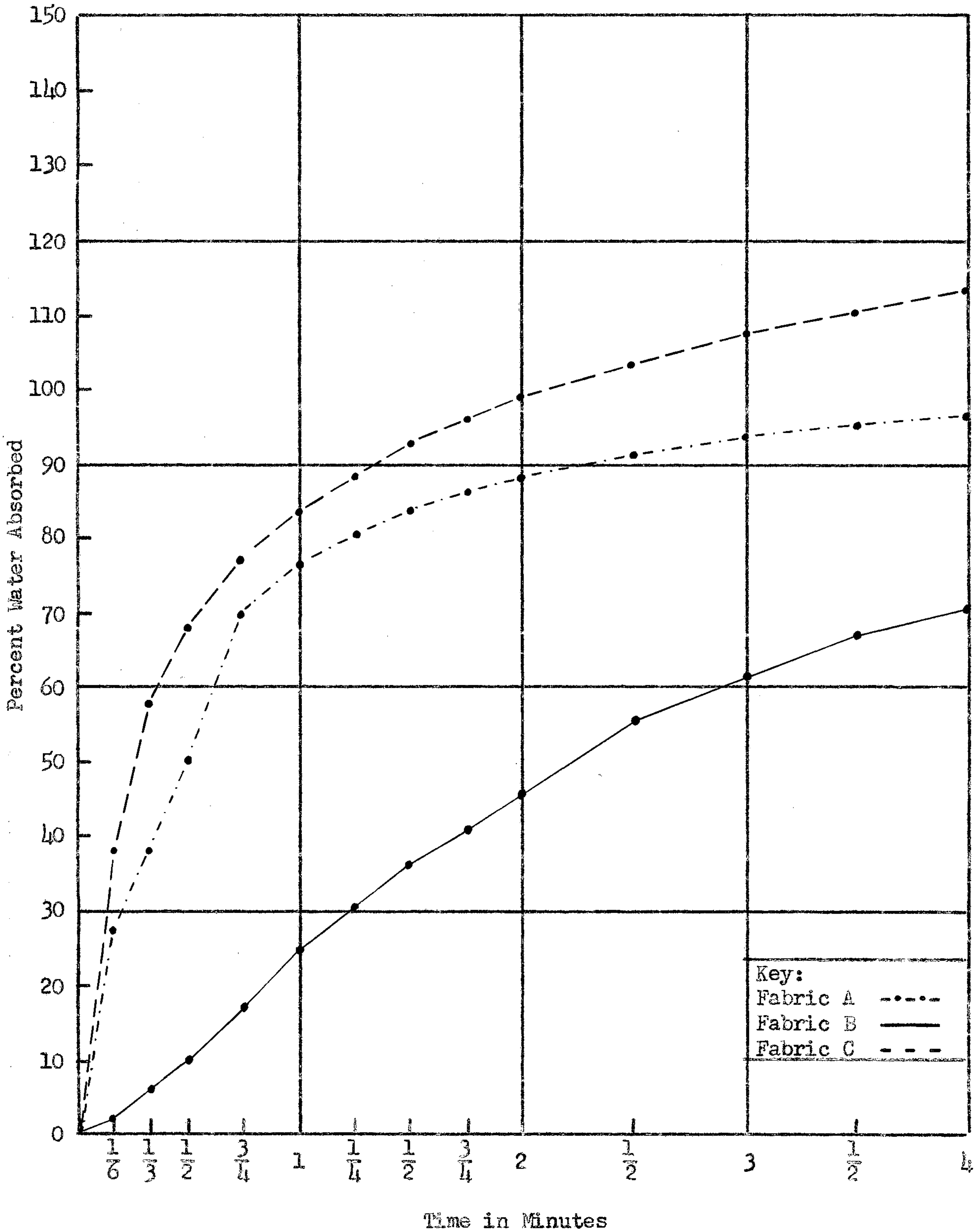

Fig. 4. Rate of Absorption After Three Launderings

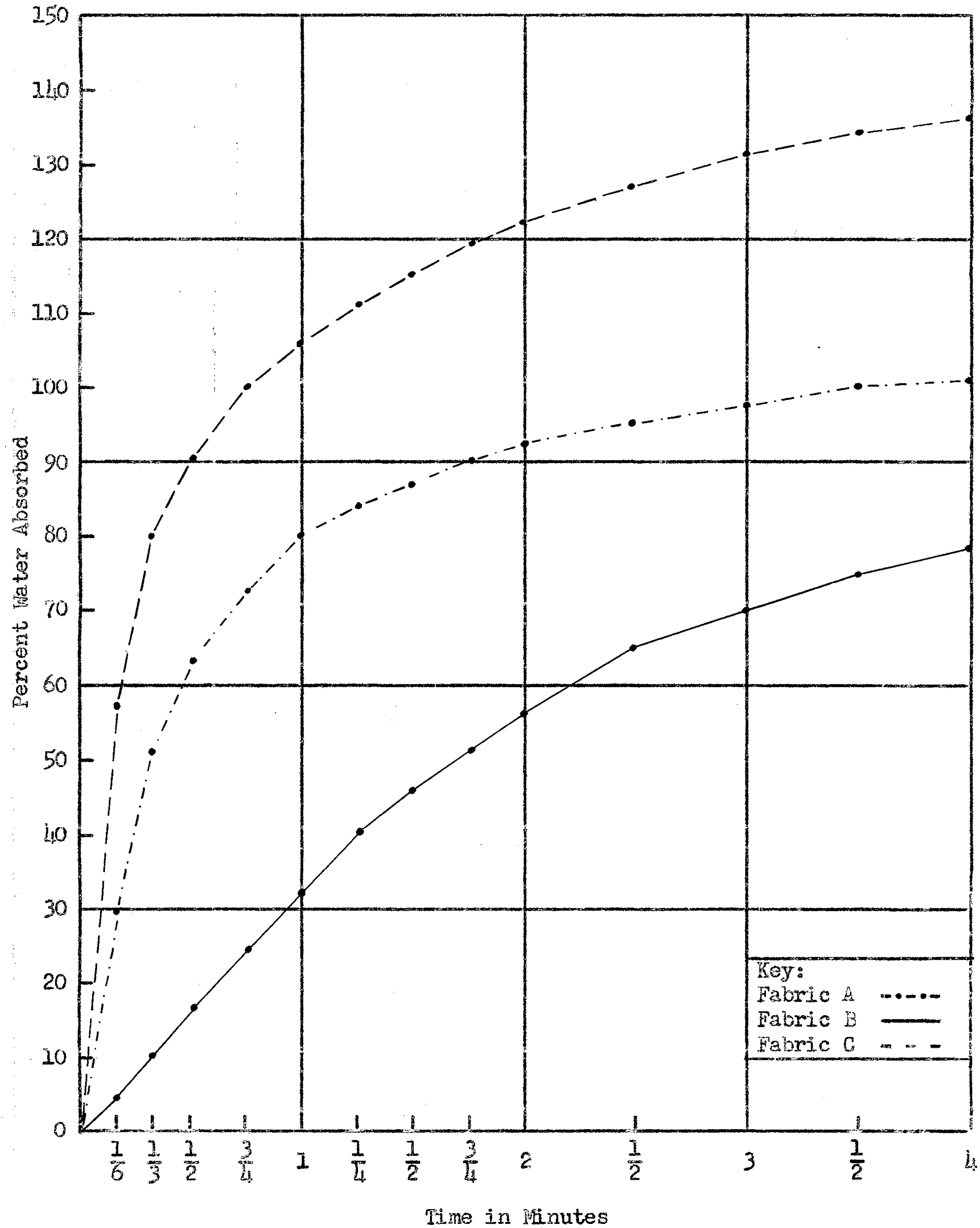

Fig. 5. Rate of Absorption After Five Launderings

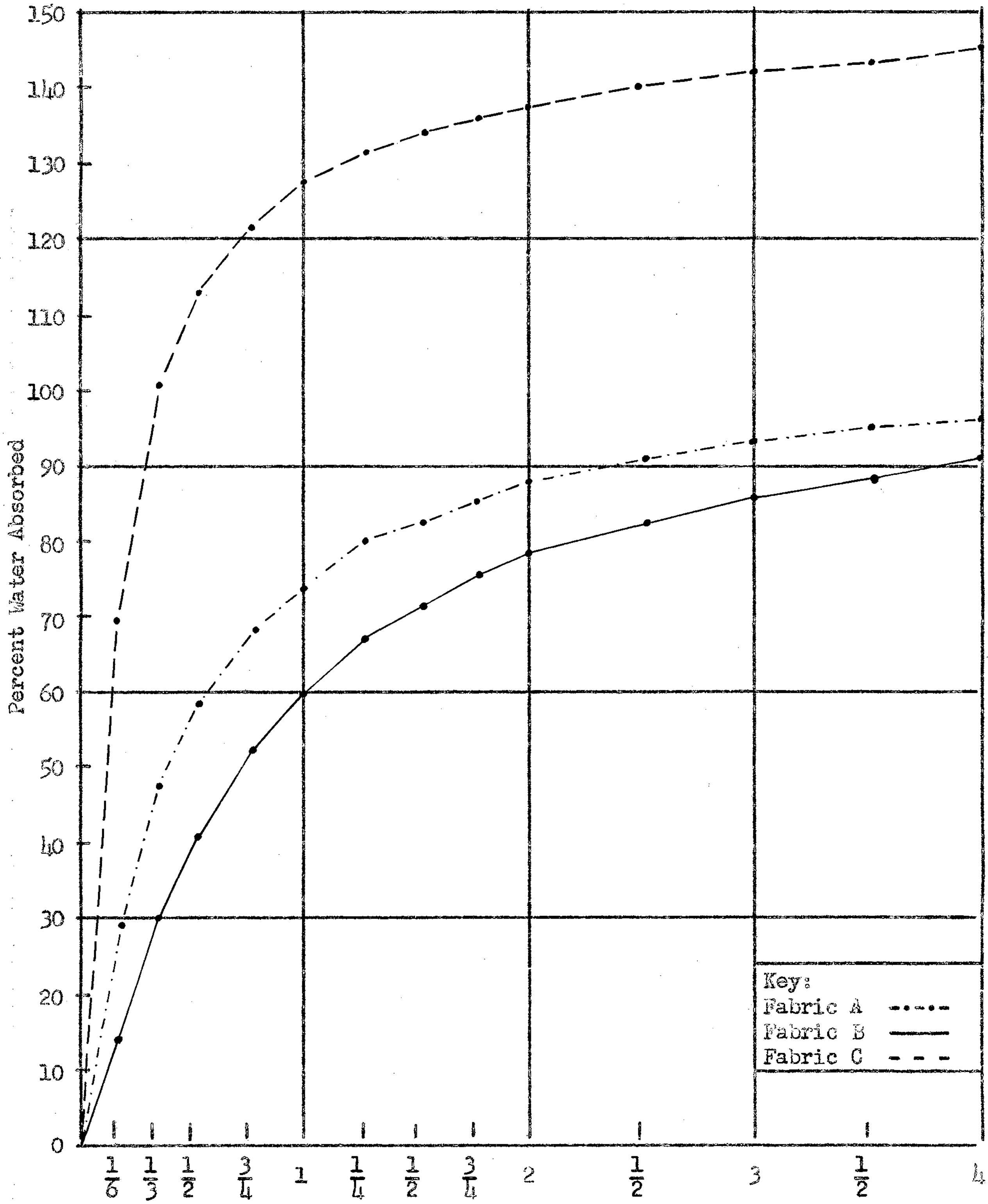

Fig. 6. Rate of Absorption After Ten Launderings

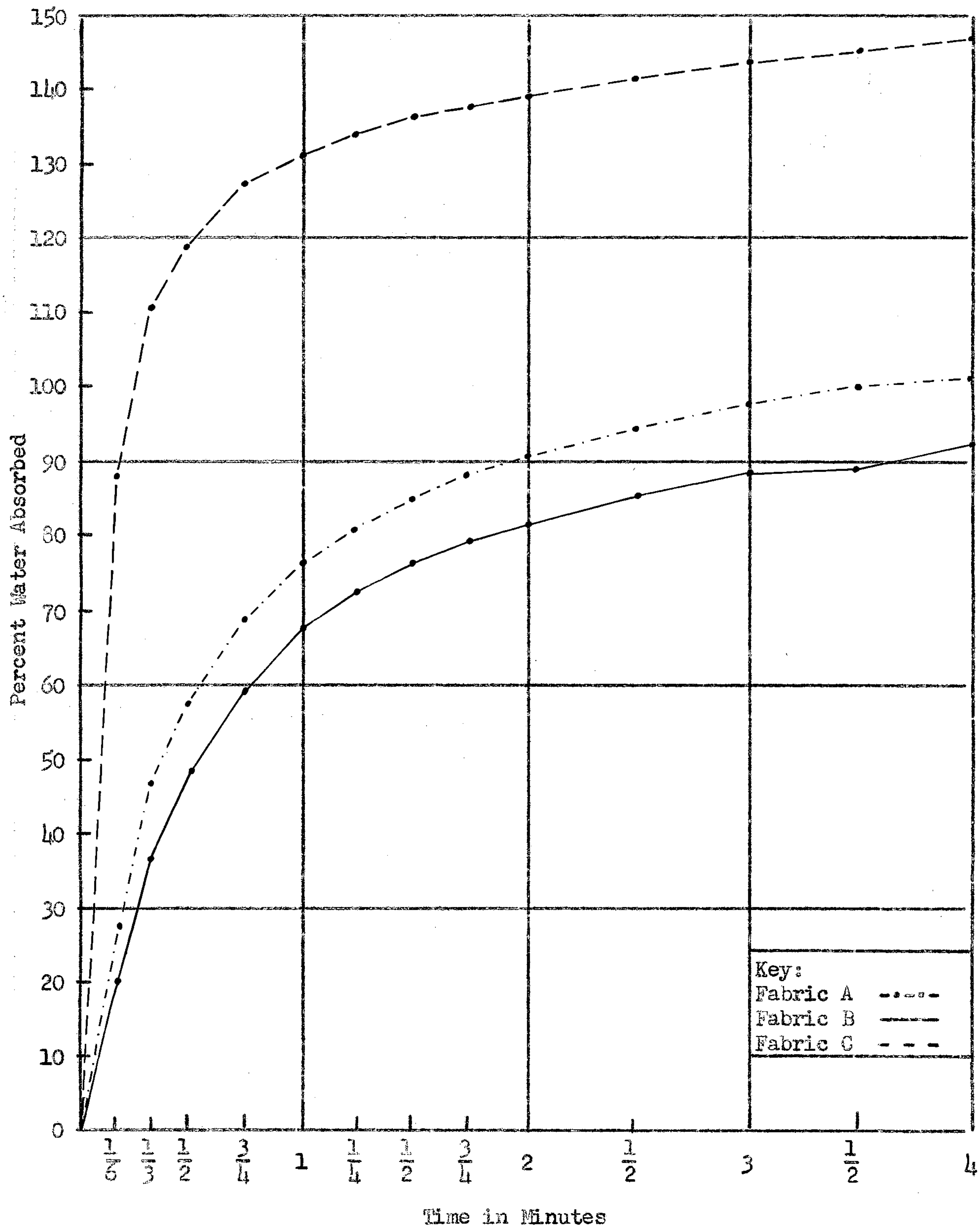

Fig. 7. Rate of Absorption After Fifteen Launderings

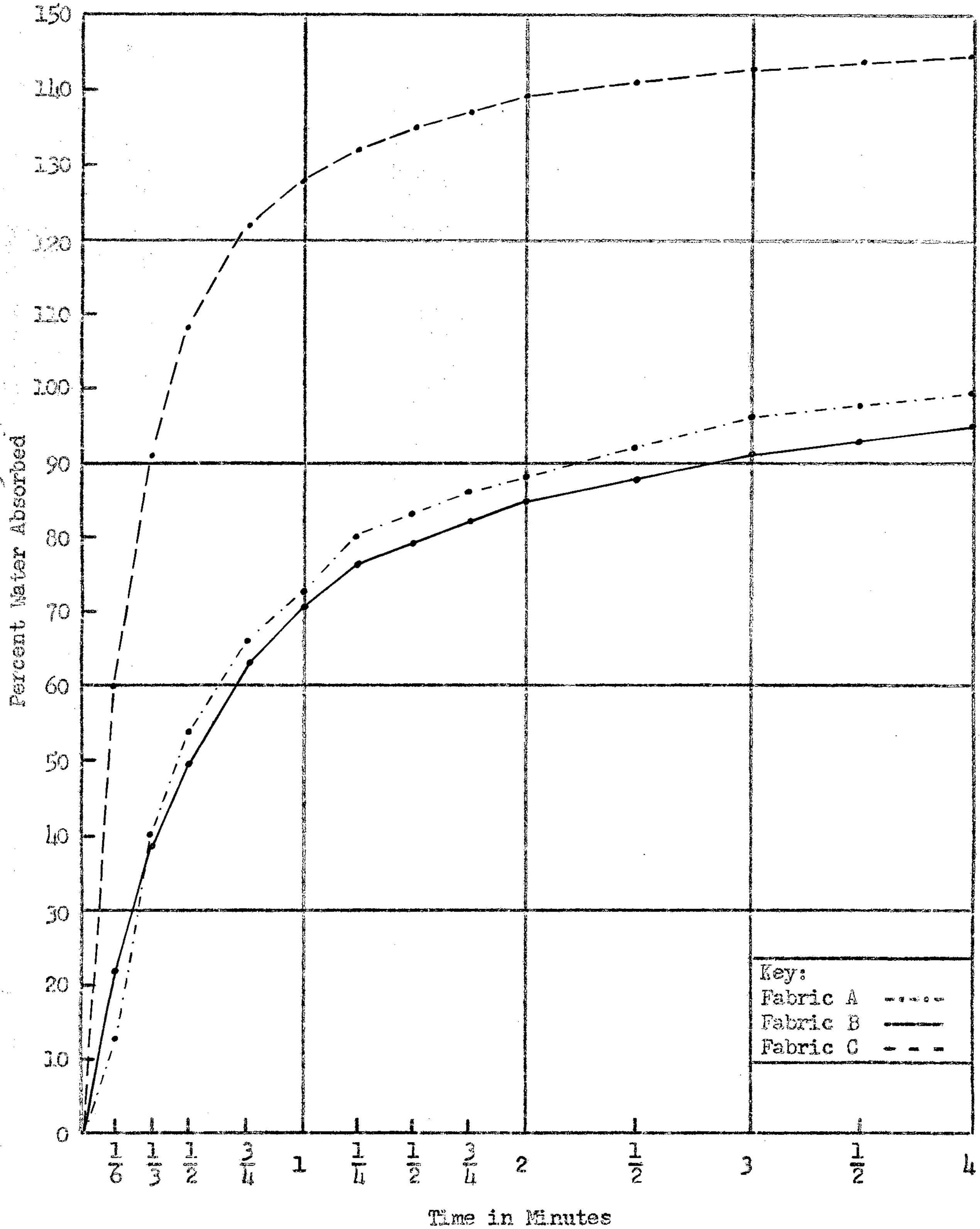

Fig. 8. Rate of Absorption After Twenty Launderings

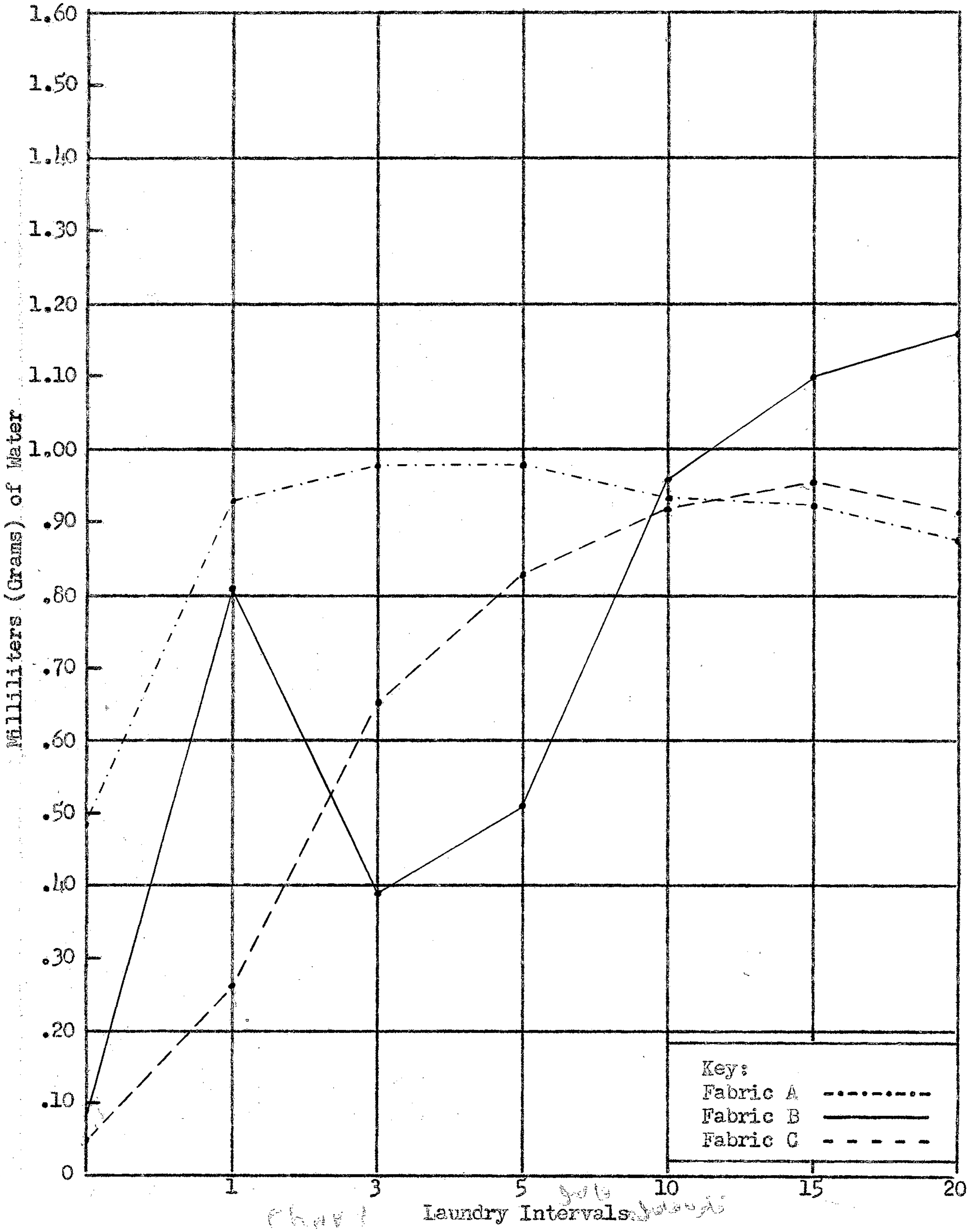

Fig. 9. Rate of Absorption at One Minute Expressed in Milliliters (Grams) of Water Absorbed

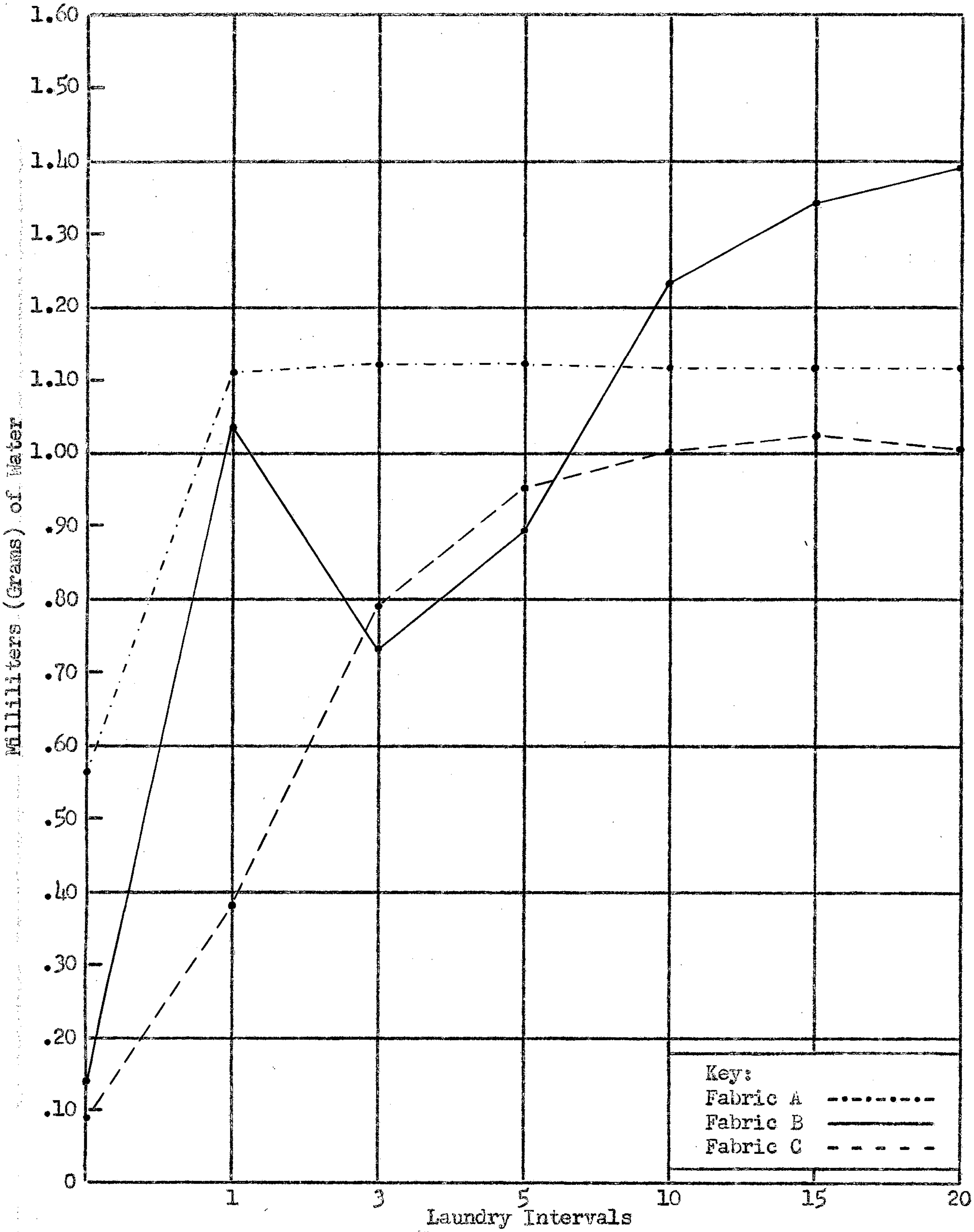

Fig. 10. Rate of Absorption at Two Minutes Expressed in Milliliters (Grams) of Water Absorbed

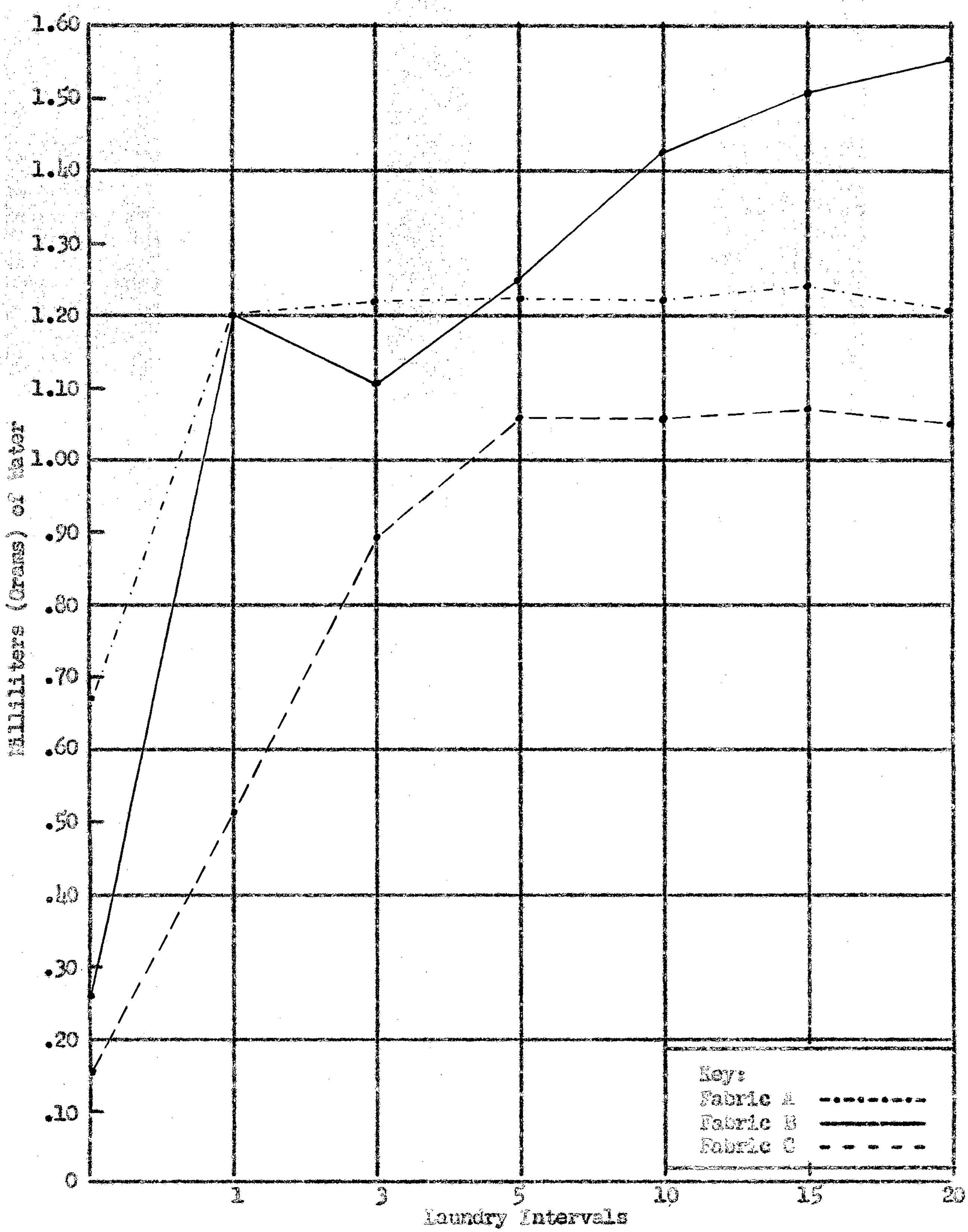

Fig. 11. Rate of Absorption at Four Minutes Expressed in Milliliters (Grams) of Water Absorbed

absorbency leveled off. When recorded at four minutes exposure to the porous plate, Fabric C indicated a leveling off of absorption following the fifth laundering.

It is pertinent to note in Figs. 2 to 11 that a large part of the water absorbed by all the toweling samples was taken up within the first minute of exposure to the porous plate. Variables which affect results of the rate of absorption test are atmospheric humidity, pressure on the towel sample, sample size in relation to plate size, water temperature, and plate porosity. In any series of tests, it is desirable to keep all of these factors constant. Some irregularities in the data of this experiment may be due to variations in atmospheric humidity and water temperature.

Comparing the curves representing the per cent of water absorbed (Figs. 2 to 8) with those representing the grams of water absorbed (Figs. 9 to 11), it is obvious that the curves for Fabrics A, B, and C are not in the same relationship. Due to differences such as weight, thickness, fiber content, etc., a fabric high in per cent of water absorbed would not necessarily absorb the greatest amount of water. Fabric A when new and after one laundering absorbed the greatest per cent of water (Figs. 2 and 3) and also the greatest amount of water (Fig. 11). For the remainder of the tests, Fabric C absorbed the largest per cent of water (Figs. 4 to 8) but absorbed the least amount of water (Fig. 11). Since this fabric was lighter in weight and thinner than Fabrics A and B, it was possible for this situation to exist. Fabric B, with the exception of one interval (Fig. 3) was low among the three fabrics in per cent of water absorbed (Figs. 2, 4 to 8) although after ten launderings it varied little from Fabric A. By the fifth laundering and thereafter, Fabric B was first in amount of water absorbed (Fig. 11).

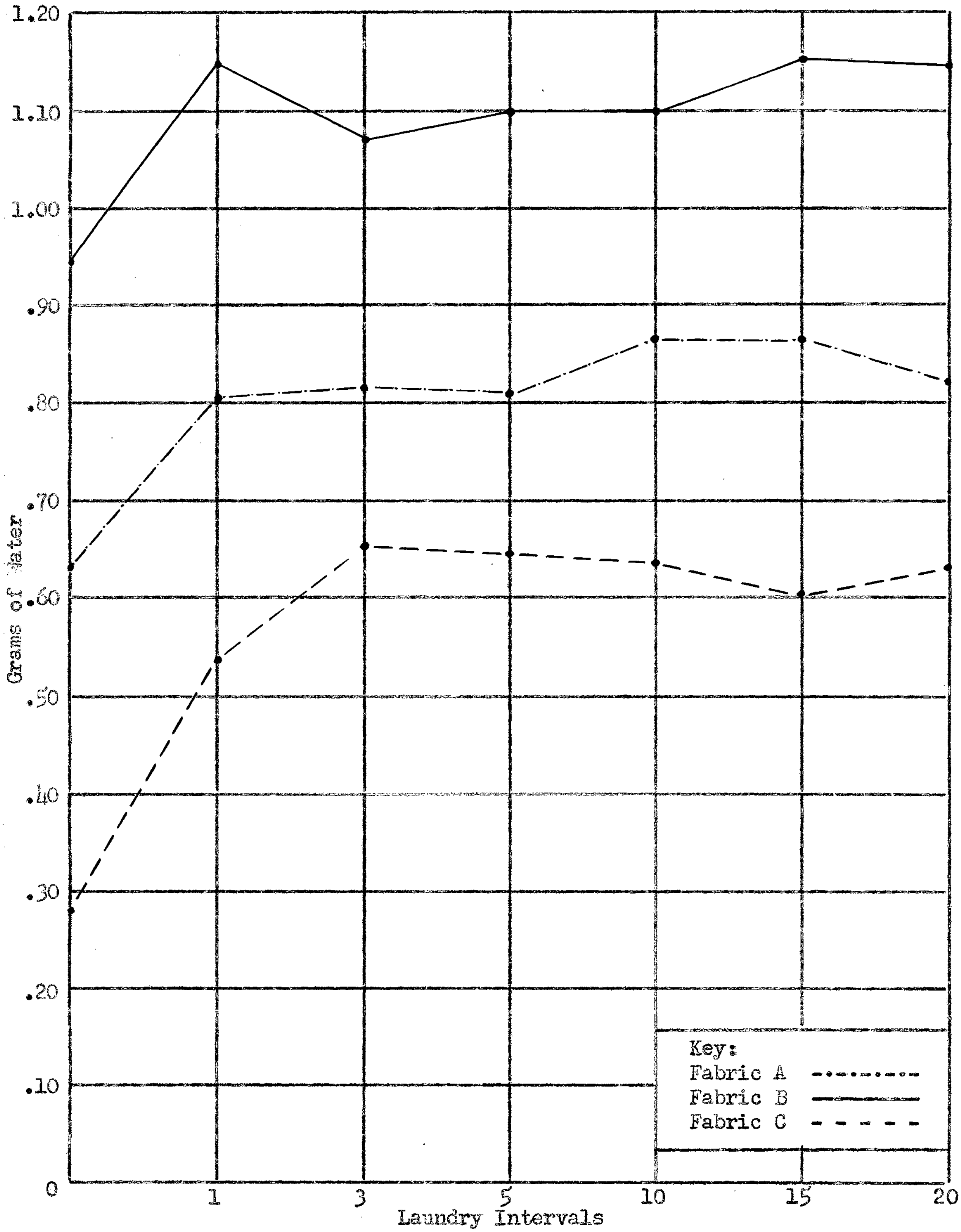

Fig. 12. Absorption by Toweling Before Laundering and at Six Laundry Intervals as Determined by Immersion

Rate of drying of the toweling was not considered in this experiment although it would be a point to be considered in dish toweling.

Immersion test

Curves produced when plotting the grams of water absorbed (Fig. 12) by the fabrics as determined by immersion, show Fabric B was first in amount of water absorbed, Fabric A second, and Fabric C third. This relationship varies from that produced by reporting absorption by immersed samples in per cent of water absorbed, because the three towelings were not equal in weight. Results given in Table 1 indicate that Fabric B absorbed the largest per cent of water, Fabric C the least, and Fabric A an intermediate quantity only for the new fabric. After the first laundering, and for succeeding launderings, Fabric C was first in per cent of water absorbed, Fabric B second, and Fabric A third.

Table 1

Per Cent of Water Absorbed by Immersed Samples
Before Laundering and at Six Laundry Intervals

	Laundry Intervals						
Fabric	0	1	3	5	10	15	20
A	56.1	63.0	63.9	66.3	66.1	71.0	67.6
B	61.3	72.2	68.8	69.2	71.1	72.0	70.2
C	38.0	72.2	83.4	82.4	87.1	83.4	88.2

Comparison of results of the absorption tests

Fabric A apparently reached its maximum absorption in the rate test following the first laundering (Fig. 11) since its absorbency changed little with subsequent washings. Absorption by Fabric A as determined by immersion (Fig. 12) remained constant from the first to the fifth laundering, increased slightly for the tenth and fifteenth launderings, and returned to the previous level following twenty launderings.

Fabric B indicated an upward trend in absorbency in the rate test (Fig. 11) with the exception of the unaccountable high rate at one laundering followed by a decline to the third laundering. Beginning with the fifth laundry interval the fabric resumed an upward trend in absorbency which continued for the duration of the experiment. Results of the immersion test indicated a similar trend for Fabric B (Fig. 12), but with a less regular increase of absorption between the laundry intervals.

Fabric C appeared to reach its maximum of absorption in the rate test at the fifth laundering (Fig. 11) while results of the immersion test indicated a maximum absorbency for Fabric C after three launderings (Fig. 12).

The total grams of water absorbed by the three fabrics at any laundry interval differed for the two tests (Figs. 9 to 12) due to the fact that the immersion samples were squeezed to remove excess moisture. The rate of absorption samples were actually wetter when they were removed from the porous plate than were the immersed samples at the time they were weighed.

<u>Other factors affecting absorbency</u>

An upward rise followed by a leveling off of the absorption curves as the fabrics were subjected to laundering was probably due to several factors. Repeated washings are generally considered to make cotton and linen fabrics more absorbent due to the removal of the naturally occuring waxes of the fiber which hinder absorption. Although Fabric C had been washed before its purchase, it may be noted in Figs. 11 and 12 that its absorption changed nearly as much as did that of Fabrics B and A from the original fabric to the first laundering. The removal of finishing materials such as sizing would probably be effected in the first laundering.

Another factor causing such leveling off of absorption might be the loss of fiber resulting in loss of weight and therefore less absorption of water when reported in grams, but not affecting per cent of water absorbed. This would explain the leveling off of the curves representing grams of water absorbed by the toweling (Figs. 11 to 12) in contrast to a continued upward trend of the curves representing per cent of water absorbed (Figs. 2 to 8).

Weight was recorded for each 20 inch by 18 inch towel specimen when it was new, and after it had been laundered a specified number of times. It was found that specimens of all three towelings lost weight after each laundering. Fabric A after twenty launderings had lost 5.71% of its weight, twice as much as Fabric B with a 2.8% loss and Fabric C with a 2.31% loss (Table 2).

Table 2

Loss of Weight Due to Laundering

Laundry Interval	Fabric A				Fabric B				Fabric C			
	Wt. in Grams		Loss		Wt. in Grams		Loss		Wt. in Grams		Loss	
	Before	After	Gms.	%	Before	After	Gms.	%	Before	After	Gms.	%
1	41.1	40.7	0.4	1.0	56.1	55.6	0.5	0.9	34.9	34.6	0.3	0.9
3	41.6	40.6	1.0	2.4	55.1	54.3	0.8	1.5	34.5	34.2	0.3	0.9
5	40.9	39.6	1.3	3.2	55.0	54.0	1.0	1.8	37.4	36.9	0.5	1.3
10	42.4	40.6	1.8	4.3	54.7	53.4	1.3	2.4	36.3	35.7	0.6	1.6
15	40.4	38.4	2.0	4.9	56.1	54.7	1.4	2.5	34.4	33.8	0.6	1.7
20	40.3	38.0	2.3	5.7	56.0	54.4	1.6	2.9	34.5	33.7	0.8	2.3

When weight was recorded for the towelings in ounces per square yard, it was found that there was an increase in weight in nearly all of the towel samples (Table 3). This increase in weight was due to shrinkage, causing any 3 inch by 3 inch sample to contain more yarns per inch (Table 4) than it had in the original fabric.

Table 3

Weight of Toweling in Ounces per Square Yard
Before Laundering and at Six Laundry Intervals

Laundry Intervals	A Ounces	A % Gain	B Ounces	B % Gain	C Ounces	C % Gain
0	5.93	---	7.52	---	3.75	---
1	6.33	6.3	8.25	8.0	3.77	0.5
3	6.44	7.9	8.01	6.1	3.99	6.0
5	6.21	4.5	8.08	6.9	3.95	5.1
10	6.43	7.8	8.02	6.2	3.70	-1.9
15	6.22	4.7	8.40	10.5	3.72	-0.8
20	6.16	3.7	8.34	9.0	3.66	-2.4

It was found that Fabrics A and C had lost considerable strength by the duration of the experiment (Table 4). It was assumed that the cloth had been weakened due to laundering, accompanied by a possible loss of

Table 4

Breaking Strength and Yarns per Inch of Toweling
Before Laundering and After Twenty Launderings

	Breaking Strength in Pounds (Strip Method)						Number of Yarns Per Inch			
	Before Laundering		Laundered		Per Cent Loss		Before Laundering		Laundered	
Fabric	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling
A	61.3	50.6	52.1	42.5	15.1	16.1	39.6	25.4	40.4	28.6
B	67.2	62.0	62.4	60.2	7.2	2.9	40.0	29.6	41.2	34.0
C	32.9	32.1	29.3	27.1	11.0	15.6	45.6	47.0	47.6	47.0

fiber. Fabric A lost 15.1% of its strength in the warp direction and 16.1% in the filling direction, while Fabric C which was much lower in strength than Fabrics A and B lost 11.0% of its strength warpwise and 15.6% fillingwise. Fabric B was strongest when new and lost less strength, 7.2% in the warp direction and 2.9% in the filling direction.

Thickness of the towelings which were laundered twenty times was greater than that of the unlaundered fabrics (Table 5). Since there was a

Table 5

Thickness of Toweling in Inches at Two Pounds Pressure Before Laundering and at Six Laundry Intervals

	Laundry Intervals						
Fabric	0	1	3	5	10	15	20
A	.0185	.0241	.0251	.0249	.0263	.0264	.0266
B	.0151	.0248	.0257	.0262	.0264	.0280	.0280
C	.0176	.0189	.0202	.0199	.0189	.0192	.0194

decided loss in weight and a decrease in strength, thickness as determined by the procedure used in this experiment was not a good measure of degradation of the toweling. Fabrics A and B changed more in thickness than did Fabric C due to larger and less tightly twisted yarns which tended to expand with repeated washing. These two fabrics likewise gained more in yarns per inch (Table 4), due to shrinkage, than did Fabric C, another reason for their greater change in thickness.

Yarn number and yarn twist for Fabrics A and B were similar, indicating that from the standpoint of yarn construction, the respective yarns might hold comparable amounts of water. Since toweling B was better in both rate of absorption and amount of absorption than A, characteristics of the fabrics other than yarn twist and size such as fiber content contributed to better absorption. Fabric C, however, had a much smaller yarn with higher twist, limiting the amount of water which could be suspended within the yarn structure (Table 6).

Table 6

Yarn Number and Yarn Twist* of Toweling

	Yarn Number (Grex System)		Twists Per Inch	
Fabric	Warp	Filling	Warp	Filling
A	716.6	762.7	14.1	14.8
B	734.1	919.7	12.1	12.2
C	298.1	298.2	21.8	20.7

* all yarns were z twist

V. SUMMARY AND CONCLUSIONS

Three towelings which differed in fiber content and were considered representative of several types of dish toweling were selected for testing. Absorption of water by these fabrics was determined by employing two different test procedures; a rate of absorption test, and an immersion test. The three fabrics were tested for absorbency before laundering, and after one, three, five, ten, fifteen, and twenty launderings. Results of these tests were reported in two ways: the per cent of water absorbed, and the amount (grams) of water absorbed. Absorbency ratings for the three fabrics in per cent of water absorbed were different from absorbency ratings for amount of water absorbed.

1. Results of the rate test indicated that a large part of the water absorbed by the three towelings was taken up within the first minute of exposure to the porous plate.
2. The three towelings did not reach their maximum absorbency (amount of water absorbed) at the same time; Fabric A reached its maximum after the first laundering, Fabric B was still increasing in absorbency when the experiment was terminated following twenty launderings, and Fabric C reached its maximum absorbency after five launderings.
3. Of the three towelings tested, Fabric B was best in amount of water absorbed in both rate and immersion tests. It had good retention of weight, being almost as good as Fabric C and better than Fabric A. It had higher strength than Fabric A and much higher than Fabric C, retaining its original strength through

twenty launderings better than Fabrics A or C.

4. Fabric A was intermediate in amount of water absorbed in rate and immersion tests. It lost more weight than Fabrics B and C, probably due to a loss of the asbestos fiber from the yarn. Fabric A also lost a higher per cent of strength than did the other fabrics although it had a much higher strength than Fabric C.

5. Fabric C was the least absorbent fabric as determined by the rate and immersion tests in terms of amount of water absorbed, but it was best in per cent of water absorbed. It lost less weight than the other two fabrics, was much lower in original strength, and lost considerable strength as a result of laundering.

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TYPIST PAGE

THESIS TITLE: THE ABSORBENCY OF THREE TYPES OF DISH TOWELING AS DETERMINED BY RATE AND IMMERSION TESTS

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