ABSORPTIVITY OF CERTAIN TEXTILE FABRICS

by

FERN MARIE OLINE

A. B., Sterling College, 1926

A THESIS

submitted in partial fulfillment of the

requirements for the degree of

MASTER OF SCIENCE

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1937

TABLE OF CONTENTS

INTRODUCTION

Terry toweling fabrics must be durable and absorbent to be most useful to the consumer. Certain standards have been set up for durability in these fabrics but little is known concerning their ability to absorb moisture. Knowledge of the amount and rate of absorption is important in the wise purchase of such fabrics.

The purpose of this study is to compare certain towels representative of terry fabrics of double-loop and single-loop construction as to (1) ability to absorb moisture in terms of rate of absorption, (2) ability to absorb moisture in terms of amount of absorption, (3) durability in terms of breaking strength.

PRESENT STATUS OF KNOWLEDGE

It is thought that the ability of a fabric to absorb moisture is largely dependent upon the amount of surface exposed and the twist and ply of the yarns used in its construction. The pile loops increase the surface area of a terry fabric and largely determine how much moisture it can absorb and how quickly. Producers agree that to be most effective the loops must be soft, reasonably close together, and sufficiently long. There should be little twist in the yarns and the foundation fabric should be loosely woven.

Terry Fabric Construction

Johnson (1927) describes clearly the process of weaving terry fabrics. Such fabrics form a branch of the pile industry and require special mechanism for their production. Turkish towels come under the classification of fabrics of terry weave. This weave is obtained by using two different warps in the loom, one called the ground warp, the other the pile warp, which are wound on different beams. The ground warp is held as tense as the strength of the material will permit, and when interlaced with the filling, the groundwork of the fabric is formed. The pile warp is not held as tightly as the ground warp so that it may form the necessary loops during weaving. Since the pile yarns are used only in making the loops, it is evident they do not contribute materially to the strength of the fabric. Both ground and pile threads are interlaced with the weft threads. Generally the ground and pile warps are used in equal proportions, arranged alternately in the loom or in alternate pairs.

According to Fox (1922), from one to six picks are inserted to each transverse line of loops and are beaten back in groups rather than separately. Between the last pick of the first group and the first of the second one, a gap is left whose width is varied to suit the length of pile to be manufactured. In beating back a group of three picks this gap must be closed by making the weft slide along the tense ground warp, and so draw the pile warp forward with the weft, thus forming loops upon the upper and lower surface. By using a suitable shedding harness each thread may be looped above or below at pleasure, but all must loop either in one direction or the other. Hence, a Turkish toweling fabric differs from true terry, because in the latter the same number of loops need not be formed in every line.

In some of the cheapest towels, according to Johnson (1927), the producer employs what is known as a one-pick weave, that is, a weave in which only one filling thread interlaces with the warp for every horizontal row of loops. Viemont, Hays, and O'Brien (1936) in their study of towels found that most of the terry towels on the market today have three filling yarns to every horizontal row of loops. This makes what is called a three-pick terry. Occasionally four or five rows of filling are inserted for each row of loops resulting in a four or five-pick terry weave, but these higher picks are found chiefly in upholstery fabrics, rarely in towels.

They found also that in some towels one pile yarn was used for each ground warp, in other words, the ground and pile yarns alternated. This gave the same number in each set of yarns to the inch. In other towels there were two pile yarns to each ground warp. This arrangement resulted in twice as many pile as ground yarns to the inch. Such towels are sometimes called double thread towels. Most important among these types of terry fabrics are those of three-pick construction some having single, others double loops.

According to Consumer Research (1936) most Turkish towels may be classified into four types of construction as follows:

Type 1. Single-ply ground with half as many ground as pile yarns; single-ply filling.

Type II. Single-ply ground warp with an equal number of ground and pile yarns; single-ply filling.

Type III. Two-ply ground warp with an equal number of ground and pile yarns; single-ply filling.

Type IV. Two-ply ground warp with half as many ground as pile yarns; single-ply filling.

Viemont, Hays, and O'Brien (1936) give the same classification as a result of their investigation. Both seem to agree that type four is less common and not particularly to be desired.

Durability of Turkish Towels

As a result of some studies of terry fabrics certain standards have been set up by which the wearing qualities may be judged. Cook (1931) states that the strength and durability of a towel depend largely on the construction of the background. In warp direction, according to Consumer Research (1936) the fabric strength depends upon the strength of the threads and the number per inch which forms the groundwork, i.e., the part of the warp not involved in forming the pile loops. In the most common weaves a strong durable towel has the ground warp yarns equal in number to the pile yarns, whereas a weak towel has only one-half as many ground as pile yarns. When the number of ground yarns equals the number of pile yarns the ground yarns may commonly be either single-ply or two-ply, and when the ground yarns equal one-half the number of pile yarns, the ground yarns usually, but not universally, are single-ply.

According to Consumer Research (1936), it is comparatively easy to determine by inspection whether the construction of a towel is such that the number of ends or threads of the ground is equal to one-half the number of ends or threads out of which the pile or raised part of the towel is formed, because it appears to be universally the practice in the double-loop towels to weave two pile threads as one so that all loops occur in pairs, that is as double loops. In weaving other towels, pile threads are woven singly so that all loops occur one by one. By simple inspection at the store the housewife can, with the present weaving practice, reject towels having the commonest type of undesirable construction, namely, those having twice as many pile as ground yarns.

Cook (1931) states that pile loops may be long or short according to the quality and design of the towel. The entire purpose of the pile is to increase the surface area in order to aid in the amount and rapidity of absorption. Long loops therefore increase both these factors but a proper balance must be maintained between the weight of the pile and the strength of the background to secure maximum service.

This author states that the pile loops are separated by the filling threads. In the poorest towels one thread is used between rows of pile with the quality of the towel increasing with each added filling thread between pile rows until six, the highest number, has been reached. Since the filling yarns hold the pile in place it is easy to see that there must be a relation between the weight of the pile and the number of the filling between each set of pile loops. A towel having too few filling yarns makes a weak structure so that the loops are easily pulled out. A towel constructed with a heavy pile and a weak background will pull apart.

Viemont, Hays, and O'Brien (1936) state that the warpwise breaking strength of the fabric is perhaps the best indicator of durability in bath towels. Breaks generally appear first in this direction because the ground warp yarns get the strain of weaving and much of the strain of wear as well. The strength of the ground warp yarns is influenced by the length and the amount of fiber used as well as by the amount of twist put into the yarn. In general, twisting increases the strength of the yarns and helps to hold the short fibers in place. To some extent the number of yarns to the inch also influences the breaking strength of the cloth.

They also state that the filling has little strain on it, and requires less twist than does the ground warp. Since the chief function of the filling is to hold the pile yarns in place and to help form the foundation material, it need not be so strong as the warp. However, they found that in half the towels studied, the cloth was as strong or stronger, fillingwise as warpwise. In many cases the greater strength was due to fewer ground warp than filling yarns to the inch. This explains why the ground warp often breaks first. In towels where the strength of the ground warp is as much as the filling, uniform wear may be expected.

Johnson (1927) says that in many cases the failure of a Turkish towel to withstand the strain of usage and washing is due to the weakness of the ground warp. This warp alone is held taut in the loom, a procedure that causes any strain encountered lengthwise to be borne entirely by the ground warp, since the pile warp is too loose to take up much of it. And yet in the case of many Turkish towels, the filling is sometimes over twice as strong as the warp. When producing better grade towels, the manufacturer realizes this weakness and uses ply yarns in the ground warp in order to give the fabric as much strength as possible.

Cook (1931) says that quality and strength of yarn are affected by the amount of fiber or coarseness of the yarn and the amount of twist put in by spinning. Regardless of the size of the yarn, increasing the number of turns or twists increases the strength, but at the same time decreases the rate and amount of absorption.

This author states that absorption can be measured in terms of the speed at which water is drawn along the fibers, and the amount of water which the material can hold. The speed or rate depends upon the amount of surface in contact with moisture and the amount of twist in the yarn. The amount of water absorbed depends upon the size of the towel, the area of pile surface, the twist of the yarn, and in some degree the kind of background.

Absorption of Turkish Toweling

Some studies have been made on methods of measuring the amount and rate of absorption. Stevenson and Lindsay (1926) tested methods for measuring absorption. They recommended the wet-bulb thermometer, and eosin dye methods for measuring the rate of absorption in fabrics, and the saturated atmosphere, immersion and wet brick methods for measuring the amount of absorption. They say concerning the wet-brick method that "it most nearly approaches the actual conditions under which towels are used, because the fabric is in contact with a wet surface".

They found that by immersing a light-colored, hard, porous brick in water for various periods of time and then weighing it, that in one and one-half hours it had absorbed all the water possible. Draining for one and one-half hours in a pan a little larger than the brick did away with excessive moisture on the surface of the brick.

Samples of dry fabrics were placed on the surface of the wet brick. Evaporation was prevented and samples held firmly against the brick by glass covers. Eosin dye was sprinkled over the surface of the materials in preliminary tests to see when all the samples had become moist. In ten minutes all had become moist enough to dissolve the dye.

Haven (1932) says: "Towels depend for their excellence upon a high rate of moisture absorption. This may be considered from the standpoint of total absorption, namely the capacity to hold large amounts of water, or again from the standpoint of rapidity of absorption. Some fabrics are slow to absorb water, but ultimately will retain large amounts. Other types, especially certain forms of light toweling, are swift to absorb water but have a very limited total capacity. Total capacity of fabrics is easily measured by immersion of a definite sized sample for a given period of time in distilled water."

In measuring the rapidity of absorption, Haven used a table with a ground glass top illuminated from beneath. At one end a shelf was so arranged that a tray containing water could be tilted at an angle of approximately 45 degrees and so placed that the surface of the water was on a level with the top of the table. Distilled water at room temperature was used. Strips of material were immersed in this water and the absorption traveled along the strips at a moderate

rate which could be seen clearly above the illuminated glass. Since even tension of the strips was important, loops were made in one end of the strips and small steel weights were slipped into these; the other end was clamped to the table top. The distance from the water to the far end of the table was carefully measured before water was put into the pan. Two or more strips of material were laid on the table with strips of graph paper between them. The strips were placed in water at the same time and the absorption line recorded on graph paper at periods of thirty seconds.

Hess and Reidheimer (1934) made a comparison of accuracy and suitability of the eosin dye, the wet surface, and Haven's method for measuring absorption. They found that with slight changes of technique Haven's method is comparatively accurate and rapid for testing the rate of absorption of water by fabrics such as Turkish toweling, providing the work is done under controlled conditions of relative humidity and temperature.

These authors suggested the use of glass rods on the table top to keep the strips of toweling from touching the top of the table when they became saturated. Since this did not seem entirely effective, the clamps were removed and weights were used at both ends of the strip. Tests were made with the table top in a vertical position but water rose only about three inches and so slowly that it was hard to measure. With the table top in a horizontal position the water traveled about ten inches and much more rapidly.

Hess and Reidheimer's comment concerning the wet surface method described by Stevenson and Lindsay is that variations in structure and the fact that first samples would absorb moisture so that there is less present for following specimens, makes possible inaccuracy.

These investigators substituted a ten-inch unglazed porcelain disk. The disk became saturated in a few minutes and an even surface moisture was maintained by keeping it in a shallow tray of water during the test. Specimens of Turkish toweling two inches square and weighing about one gram were dried in a conditioning oven and cooled in a desiccator. The specimen was placed on the disk, covered with a square of glass and allowed to remain for periods of thirty seconds. At the end of the first period the specimen was placed in a tared weighing bottle and weighed on a chainomatic balance. It was then replaced on the disk, covered with the glass and left thirty seconds longer. This was repeated until saturated, and the weight became constant.

METHOD OF PROCEDURE

Before selecting towels for testing, a preliminary study was made to find the type of Turkish towels available on the market in Manhattan, Kansas. An inspection of the merchandise sold in the various stores was made, and one towel of each type was analyzed without in any way destroying the fabric. This analysis consisted of the determination of size and weight of towel, number of threads per inch, relative length of loops, number of pile warp used to make the loop, number of filling to each row of loops, weave of background, ply of yarns, type of selvage, and type of border. The equipment used was a trip scales, tape measure, hand lens, and a pick. All towels were found to be of three pick construction.

Because towels only of this construction were obtainable locally, it was thought that it would be of interest to study their performance, comparing double-loop with single-loop fabrics.

Selection of Fabrics

Towels representative of double-loop and single-loop three-pick terry construction, recognized by sales persons as "best sellers", were selected from those on the market. Four fabrics of each class were studied, a sufficient number of towels of each kind having been purchased to furnish the yardage required for the tests. It was assumed that towels of similar design, size, and price, available at the time of purchase were of identical construction. An analysis of the fabric does not bear out this assumption, although such variations as were found might have occurred within the fabric itself. Samples of the eight fabrics are shown in Figure 1. Each of the fabrics studied was designated by numbers I to VIII, and the two towels of each kind designated by the letters T and L.

Analysis of Fabric

The towels were laundered three times at a commercial laundry. The water for washing was softened with a zeolite softener. A flake soap, neutral in reaction, was used as the detergent. The towels were put through three suds, the first cold, the second warm, the temperature being increased to 180 degrees for the last. Then they were rinsed four times and dried in a tumbler without ironing. After being returned by the laundry each towel was rinsed by squeezing and moving it about for 3 minutes in 3 liters of distilled water maintained at 30 degrees centi-

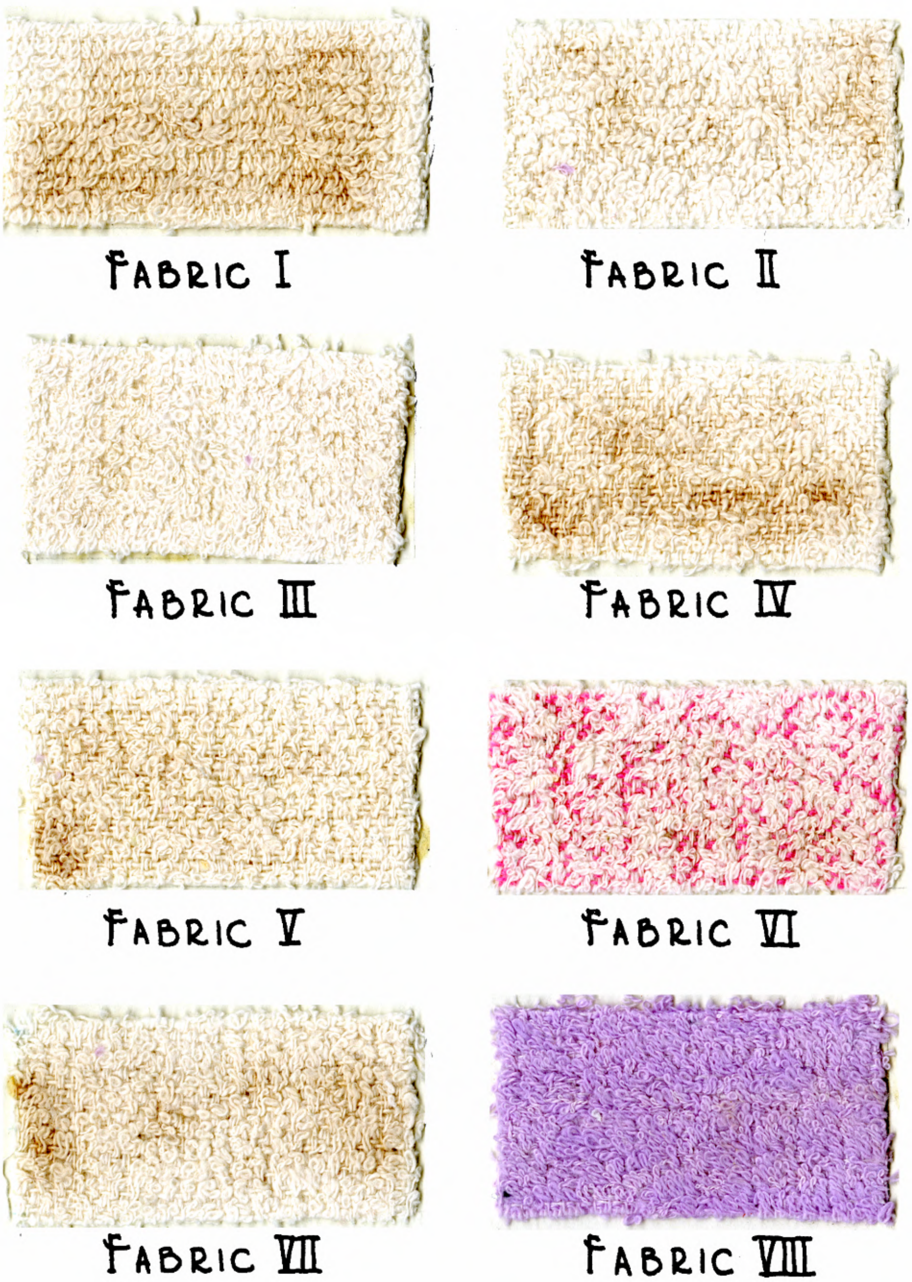


Fig. 1. Terry Fabrics Used in This Study

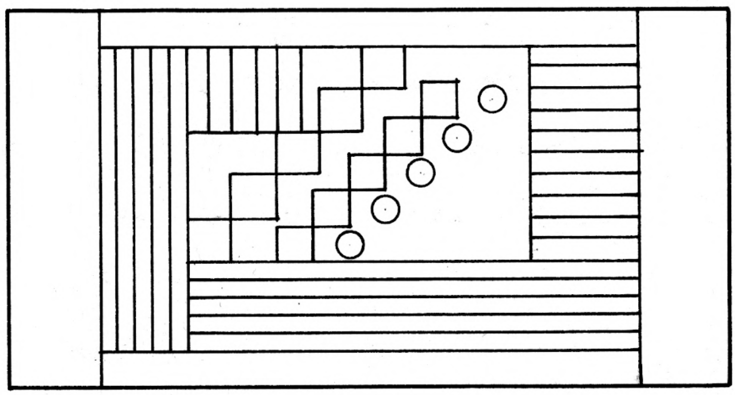
grade. This was done to remove traces of such substances as are soluble in distilled water. After having the water squeezed out of them, the towels were shaken out slightly and hung on the line with four pins across one end, and dried without ironing.

All samples for testing were cut from one towel of each kind except in the cases of numbers 4 and 6. These were so small that to provide the required area the second towel was necessary. The diagram for cutting specimens is shown in Figure 2.

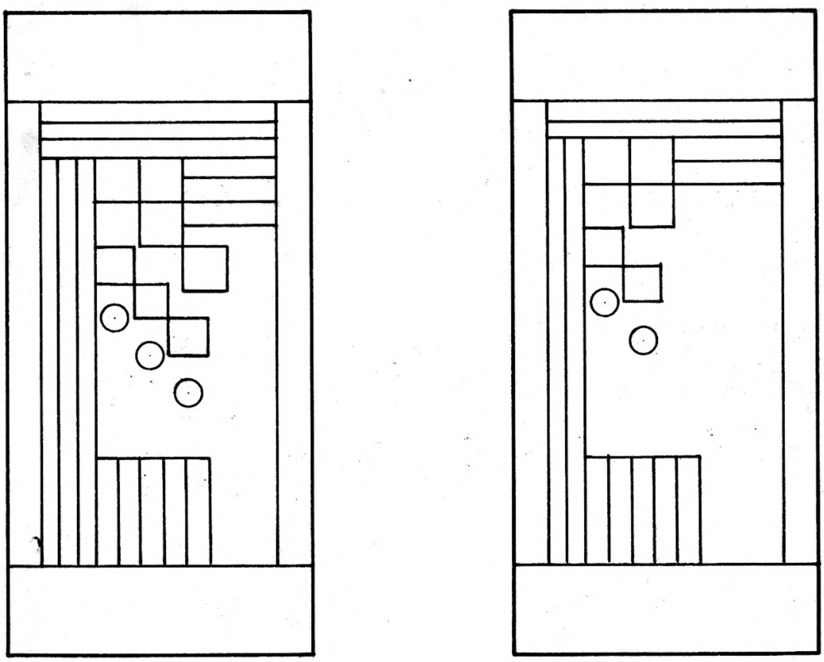
The samples were conditioned at least four hours before testing and all tests were made in a room maintained at standard conditions.

Analyses of the towels were made to determine size and weight before and after laundering, type of selvage, weight per square inch of fabric, weave including shot of filling, number of pile warp used to make the loop, length of loop in pile, number of loops per square inch, picks and ends of ground, ends in pile, breaking strength of fabric and of pile yarns, and the ply and twist of the yarns.

Standard tests prepared by Committee D-13 on Textile Materials of the American Society for Testing Materials (1936) were used for determining size, weight, thread count, and breaking strength of the fabric. The latter was deter-



A



B

FIG. 2. DIAGRAM SHOWING THE PORTIONS OF TOWEL FROM WHICH SPECIMENS WERE SECURED.
A. ALL SPECIMENS CUT FROM ONE TOWEL.
B. SPECIMENS CUT FROM 2 TOWELS.

mined by the strip method.

The length of loop was determined as follows: The number of loops made by one yarn across a two inch strip was counted, and the pile yarn raveled out and measured. Two inches were subtracted from the length of the yarn and the remainder divided by the number of loops. An average of the result obtained from five yarns was used to determine the length of the loops.

For testing the breaking strength of the pile, strips similar to those used for testing the breaking strength of the fabric were cut. Serigraphs were prepared by raveling ground warp and filling from these strips until three inches of the pile warp was exposed as suggested by Hess (1932). These serigraphs were broken in the Scott tester.

Twist of the yarns was determined by means of a twist counter. The number of twists per inch was calculated for each of the three sets of yarns by averaging the results obtained on five yarns of each.

Tests for Absorption

Rate of absorption was tested by Haven's method as modified by Hess and Reidheimer (1934). In this method two strips of material, with a strip of graph paper between, were placed on a table with a ground glass top which was illuminated from beneath. The ends of the fabric strips were placed in a pan of water at a level with the table top, and the rate at which water traveled could be clearly seen and marked on the graph paper. The distance traveled during 30 second intervals was marked, a stop watch being used to time the test. Fine copper wires were stretched across the top of the box and fastened by small nails which held the wires about an inch above the surface of the glass. This made less contact with the fabric than the glass rods used by Hess, and yet kept the strips from sagging as they became heavy with water. The rate was determined both warpwise and fillingwise, and was expressed in term of the number of inches that moisture traveled along the one-inch strip in five minutes.

Amount of absorption was measured by two methods. One method was reported by Stevenson and Lindsay (1926), and later modified by Hess and Reidheimer (1934), but in this case was used to determine rate of absorption. A technique similar to the modification was used to determine the amount of absorption in this study. A porous porcelain disk was placed in a shallow tray of water. It became saturated in a few minutes and two-and-one-half-inch squares of the material, which had been weighed previously, were placed upon the disk. At the end of two hours the samples were placed in tared weighing bottles and weighed on a chainomatic balance. Then they were replaced on the disk, and weighed approximately every two hours until the weight became constant. All weighings and measurements were made under standard conditions of temperature and humidity. The weight of the water absorbed, multiplied by its specific gravity, was divided by the weight of the dry sample in grams. The result may be considered a factor indicating the amount of absorption of that fabric. Such a factor gives a basis for comparison of amount of absorption by various towels.

A drip method developed by Fletcher (1937) was also used in measuring the amount of absorption. Water was allowed to drip slowly from a graduated burette upon a sample of material clamped between two 3-inch aluminum rings until the material became saturated and a drop came through. These rings were about a quarter of an inch thick and had a hole in the center an inch and a half in diameter. A diagram of the apparatus used is shown in Figure 3. A factor indicating the amount of absorption of the fabric was determined by multiplying the number of cc. of water that the material held by the specific gravity of water, and dividing by the weight of the sample in grams.

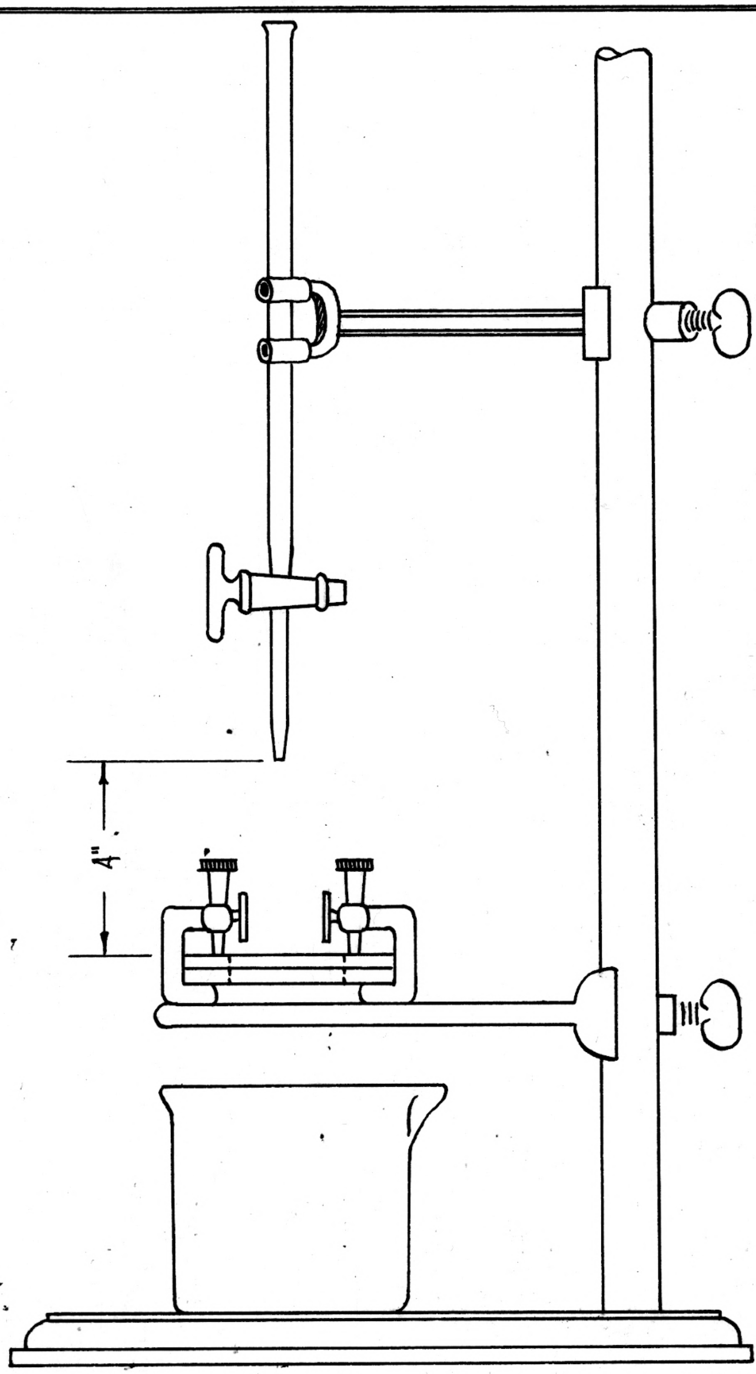


FIG. 3. DIAGRAM OF APPARATUS USED TO DETERMINE AMOUNT OF ABSORPTION.

FINDINGS AND DISCUSSION

A marked similarity in fabric construction was evident in the towels studied, although there was a wide range in price and marked differences in appearance and texture. The variation in length of pile, the means of introducing it into the fabric, and the looseness or firmness with which the fabric was woven account for differences in appearance. Diagrams of the two characteristic constructions appear in Figure 4. The construction of fabrics I, IV and VII are like A. Fabric VII has double loop pile. Since double pile warp yarns are introduced into the fabric as single yarns, the construction pattern is similar to that used for single loops. Fabrics II, III, V, VI and VIII are constructed like B.

The results of fabric analysis are summarized in Table 1. Analyses were made of the laundered fabric.

Fabric Analysis

The towels analyzed ranged in price from \$0.15 to \$0.59, there being two of the higher price, two of the lower, and four \$0.25 towels. One of the \$0.15 towels was of single-loop and the other of double-loop construction,

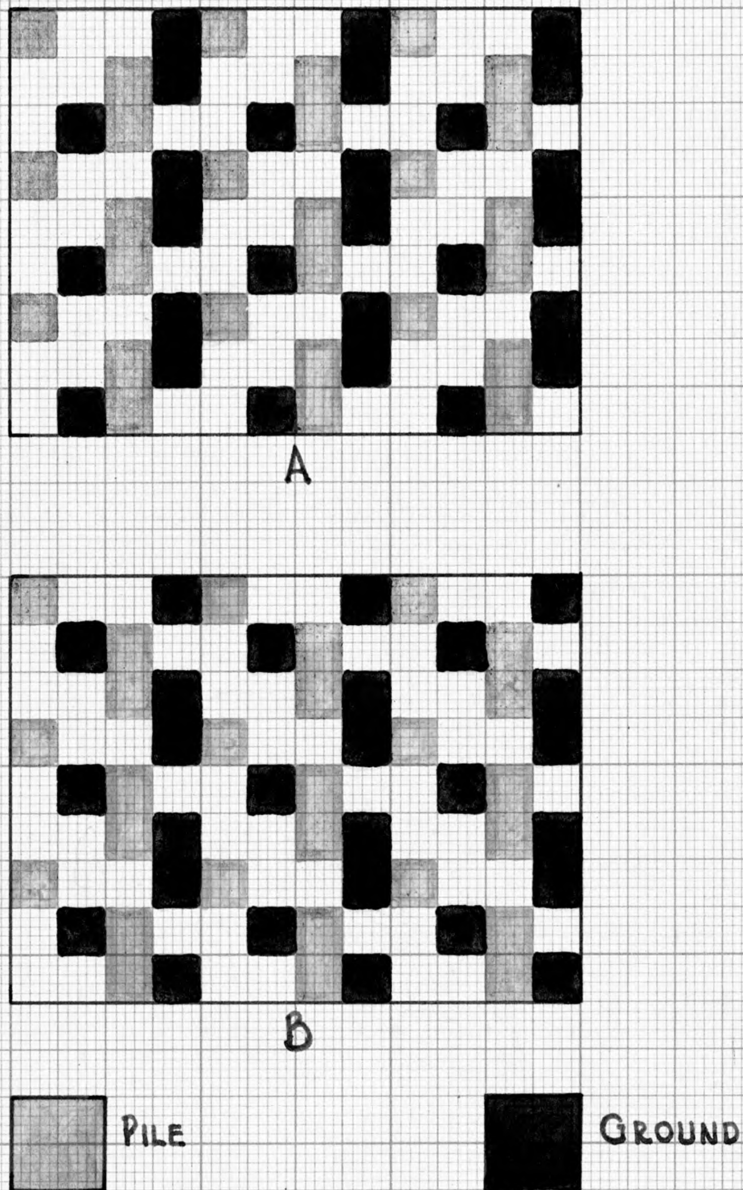


Fig. 4. Diagrams of the two characteristic construction patterns found in the eight terry fabrics. A represents fabrics I, IV, and VII; B, fabrics II, III, V, VI, and VIII.

Table 1. Fabric Analysis of the Eight Terry Fabrics Used in Tests of Absorption.

Towel	Yarn in loop	Price	Selvage	Size in Inches: As purchased	Size in Inches: Laundered	Weight in Grams: As purchased	Weight in Grams: Laundered	Weight in Grams: Per sq. in.	Thread per Inch: Warp	Thread per Inch: Filling	Thread per Inch: Pile
I	single	$0.25	woven	22.25 x 41.00	22.25 x 39.25	190.2	190.1	0.21	36	33	36
II	single	0.25	woven	21.75 x 43.00	21.25 x 40.25	193.2	195.3	0.24	30	29	30
III	single	0.59	woven	22.25 x 42.25	21.12 x 40.50	229.1	232.3	0.27	41	49	41
IV	single	0.15	woven	19.50 x 39.00	19.25 x 39.25	123.8	124.5	0.17	25	29	25
V	double	0.25	woven	21.50 x 43.25	21.75 x 41.12	152.4	151.7	0.18	21	26	42
VI	double	0.15	cut	19.50 x 40.75	17.50 x 36.12	125.4	125.9	0.19	26	30	51
VII	double	0.25	woven	22.00 x 43.50	22.00 x 41.25	178.3	179.5	0.19	20	27	40
VIII	double	0.59	woven	21.50 x 43.00	21.50 x 41.50	241.9	243.6	0.27	28	39	56

Towel	Ply of Yarns: Warp	Ply of Yarns: Filling	Ply of Yarns: Pile	Twist per Inch: Warp	Twist per Inch: Filling	Twist per Inch: Pile	Loops: No. per sq. in. on both surfaces	Loops: Length in in.	Tensile strength lbs.: Warp	Tensile strength lbs.: Filling	Tensile strength lbs.: Pile	Stretch in inches: Warp	Stretch in inches: Filling	Stretch in inches: Pile
I	single	single	single	17	16	11	376	0.23	39.8	33.6	16.4	.52	.53	.99
II	single	single	single	15	11	18	294	0.28	27.0	45.4	17.9	.29	.55	1.08
III	double	single	single	15	13	18	626	0.21	48.2	52.0	15.5	.55	.40	.68
IV	single	single	single	14	11	13	241	0.27	21.8	43.3	11.2	.31	.52	.59
V	single	single	single	15	13	20	380	0.23	17.5	36.7	14.8	.27	.53	.78
VI	single	single	single	17	16	17	504	0.23	19.7	28.8	17.6	.28	.37	.74
VII	single	single	single	15	12	17	374	0.24	18.3	40.2	19.7	.28	.50	.96
VIII	single	single	single	15	14	22	812	0.27	35.2	45.2	19.5	.32	.45	.93

as was also the case with the \$0.59 towels. Among the \$0.25 towels, two groups were of single loop and two of double loop construction.

The range in size was from 19 x 40 inches to 22.0 x 43.5 inches; in weight, from 122.7 grams to 241.9 grams. The weight increased with the price of the towel, both \$0.15 towels weighing below 130 grams and both \$0.59 towels over 200 grams. The size of the towel did not increase directly with the price although the smallest towel sold for the lowest price.

The towels shrank little in width due to laundering. This varied from 0.12 to 0.50 inch, with the exception of one which shrank 2 inches. In length, the shrinkage varied from 1.50 to 4.63 inches, with an average shrinkage of 2.95 inches. Both \$0.15 towels shrank more than the others but the double-loop towel showed the greatest shrinkage in both length and width.

All but two of the towels were heavier after laundering, the increased weight varying from 0.4 to 3.2 grams. The loss of weight in the towels was probably due to sizing material which washed out. The increased weight in the others was probably due to soap curd taken up by the fabric.

All yarns used in the towels were single-ply with the exception of one, a \$0.59 towel, which had a double-ply ground warp. This fact agrees with the statement of Viemont, Hays, and O'Brien (1936) that two-ply yarns are usually found in the higher priced towels.

As a rule the warp and pile yarns were more highly twisted than the filling yarns, the average for the warp being 15, for the pile 16, and for the filling 13 per inch. The pile and filling of the double-loop towels were more highly twisted than in single-loop construction, but there was not much difference in the amount of twist in the warp.

The towels showed a wide variation in the number of threads to the inch in all three sets of yarns. In those tested, the ground warp ranged from 20 to 41 per inch, the pile, from 24 to 56, and the filling, from 26 to 49 per inch. The number of threads per inch tends to increase with the price of the towel.

Statements are made to the effect that low priced towels often have a cut selvage which has been hemmed or machine-stitched over the edge. In the towels used in this study only one of the $0.15 towels had a cut selvage.

The breaking strength of the warp and filling strips was higher in the single-loop towels. The warpwise breaking strength ranged from 21.8 to 48.2 pounds for an inch strip, the filling from 33.6 to 52.0 pounds. In the double-loop towels, the warpwise breaking strength ranged from

17.5 to 35.2 pounds for an inch strip, and the filling, from 28.8 to 45.2 pounds. An average of warp and filling for each type showed the single-loop construction to be about 30 per cent stronger than the double-loop. With one exception, the breaking strength of the filling was stronger than that of the warp. Johnson (1927) and Viemont, Hays, and O'Brien (1936) likewise reported from their studies that the filling was usually stronger than the warp. The greater strength of the filling may have been due to the fact that there were more filling than ground warp yarns to the inch as was true for all but two of the towels. The breaking strength of the fabric increased with the price of the towel.

The breaking strength of the pile was higher in the double-loop than in the single-loop towels, that for single-loop ranging from 11.2 to 17.9 pounds per inch while the double-loop ranged from 14.8 to 19.7 pounds per inch.

Tests for Absorption

As Cook (1931) has stated, the amount of water absorbed depends upon the size of the towel, the area of pile surface, the twist of the yarn, and in some degree, the construction of background. The findings of this study seem to point to the greater importance of the amount of pile.

Tables 2 and 3 show the results of the two tests for amount of absorption. Both methods show a higher average for double-loop towels than single-loop in the total amount of water absorbed. Results of both methods for determining amounts of absorption show that a $0.15 double-loop towel had the highest absorptivity. However, when ounces per towel were calculated, this towel ranked lowest because it was smaller than any other towel. It was approximately the same size as the others before laundering but due to its loose construction it shrank more than the others. Tests for tensile strength on this towel show that it would stand little strain fillingwise.

The average absorption of moisture in ounces per square yard ranged from 46.4 to 63.7. The average was slightly higher for double-loop than for single-loop towels. Among the single-loop towels studied, the amount of absorption was 96 per cent that of the double loop.

For each towel, the factor indicating the amount of water absorbed was a little higher by the drip method than by the porous brick method. In the latter, these factors ranged from 5.1 to 6.0, while by the drip method they ranged from 5.3 to 7.0. Absorption as measured by the drip method was uniformily greater than by the porous brick method, on the average 12 per cent more moisture being taken up by the

Table 2. Amount of Absorption of the Eight Terry Fabrics Determined by the Porous Brick Method.

Towel	Weight of dry fabric in grams	Weight of water absorbed x specific gravity	Absorption factor	Ounces water absorbed per sq. yd.	Ounces water absorbed per towel
I	1.30	6.73	5.1	47.9	32.2
II	1.54	7.89	5.1	55.5	36.6
III	1.73	7.79	4.5	55.8	36.8
IV	1.09	6.37	5.8	46.4	25.6
V	1.10	6.42	5.8	47.5	32.9
VI	1.19	7.25	6.0	51.6	25.1
VII	1.26	7.26	5.7	50.7	35.4
VIII	1.71	8.89	5.2	63.7	43.3

Table 3. Amount of Absorption of the Eight Terry Fabrics Determined by the Drip Method.

Towel	Cc. water held by 2 sq. in. of	Weight of dry fabric in grams	Cc. water x specific gravity	Absorption factor	Ounces water absorbed per sq. yd.	Ounces water absorbed per towel
I	2.37	.43	2.36	5.5	51.7	34.8
II	2.79	.49	2.78	5.6	61.0	40.2
III	3.03	.56	3.02	5.3	65.7	43.3
IV	2.37	.36	2.36	6.5	52.0	28.7
V	2.41	.37	2.40	6.4	52.4	36.1
VI	2.75	.39	2.74	7.0	60.2	29.3
VII	2.68	.40	2.67	6.6	58.7	41.0
VIII	3.25	.57	3.24	5.7	72.2	49.0

fabrics. It would seem that because of the speed with which amount of absorption may be measured by the drip test, this method might well be adopted for laboratory procedure. The results seem to be as reliable as those obtained by the other method. The methods do not measure the amount of absorption under identical conditions. Using the porous brick method a long period of time is allowed for equilibrium to be established between the moist brick and the fabric, a certain amount of evaporation taking place throughout the test. Using the drip method it is evident that a thin film of water may be held between the yarns of the fabric which may be greater in amount than that held when the fabric is in contact with a moist surface. In neither method are conditions of absorption like those set up when a dry towel is used to take up moisture from the skin.

The rate of absorption was also a little higher for double-loop towels when that for warp and filling was averaged. This average was expressed in inches that the moisture traveled in 5 minutes, and ranged from 4.87 to 5.69 for single-loop towels, and from 4.80 to 6.12 for double-loop. Based upon this average the rate for single-loop towels is 92 per cent that for double-loop. Table 4 shows the rate of absorption for the eight fabrics. The rate for warp was higher than for filling in all towels except two, one of

Table 4. Rate of Absorption Expressed in Inches That Moisture Travels in 5 Minutes as Determined For One Inch Strips of Warp and Filling For the Eight Terry Fabrics.

Towel	Inches moisture traveled in 5 minutes		
	Warp	Filling	Average of warp and filling
I	5.70	4.95	5.32
II	5.38	4.40	4.87
III	5.45	4.42	4.93
IV	5.64	5.75	5.69
V	6.16	5.77	5.96
VI	6.65	5.66	6.12
VII	6.05	6.09	6.07
VIII	4.85	4.75	4.80

these being of single and the other of double-loop construction. This is what might be expected since the loops help in carrying the moisture along the warp. When averaged, the rate for the filling was 93 per cent that for the warp. Figures 5 and 6 compare the rate of absorption of strips cut warpwise and fillingwise for the eight fabrics.

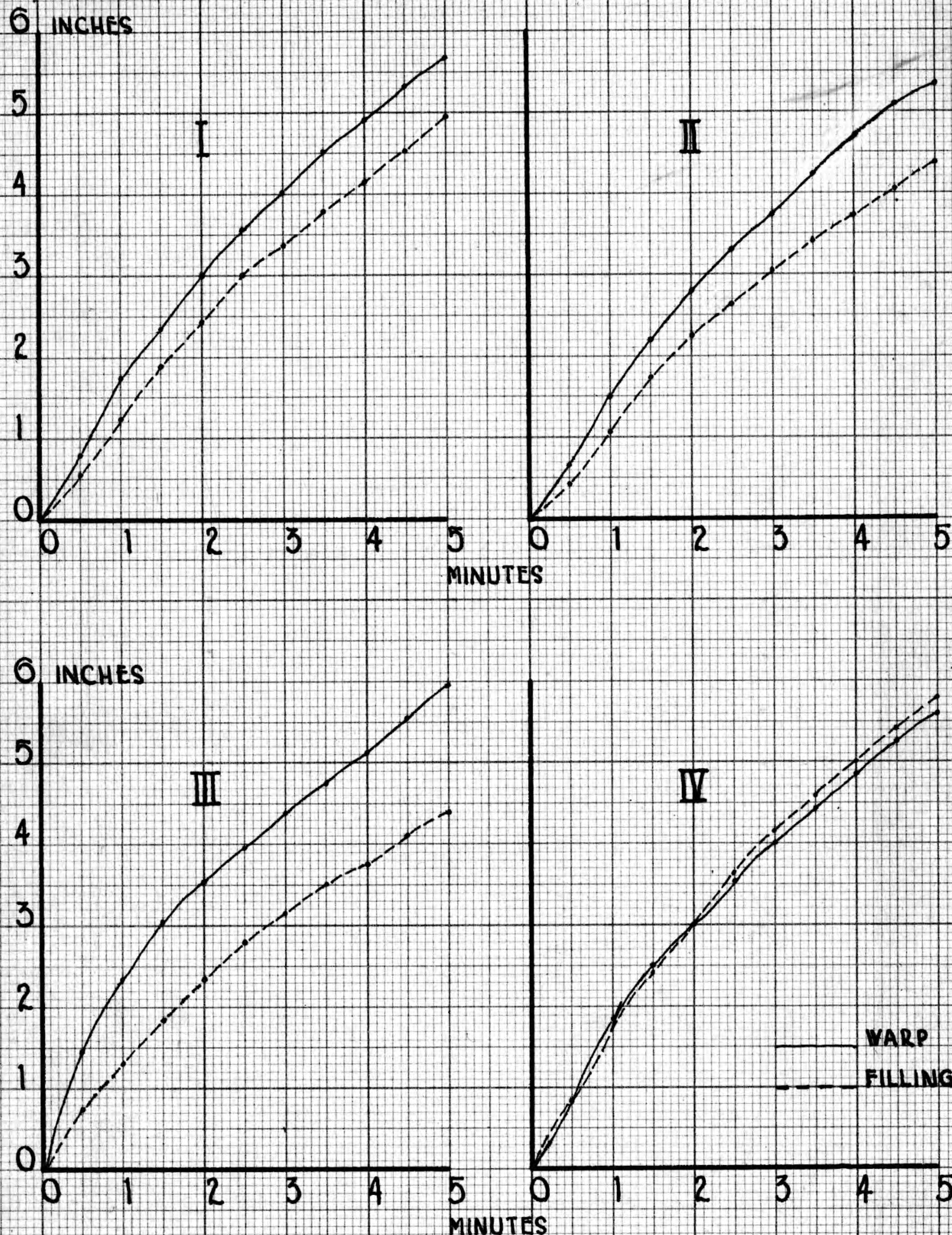


FIG. 5. COMPARISON OF THE ABSORPTION RATE OF STRIPS CUT WITH THE WARP AND THE FILLING OF THE FOUR FABRICS OF SINGLE LOOP CONSTRUCTION.

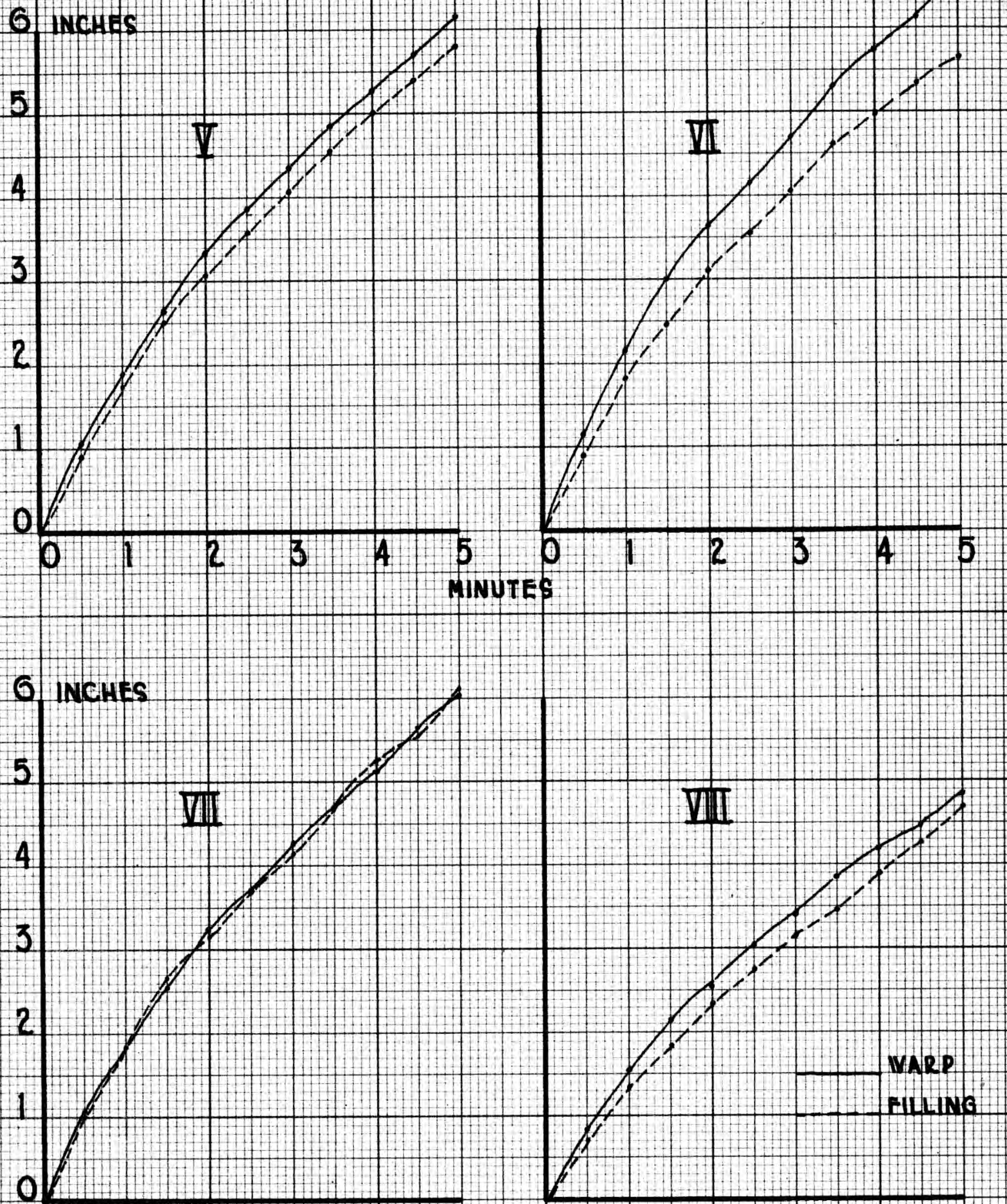


FIG. 6. COMPARISON OF THE ABSORPTION RATE OF STRIPS CUT WITH THE WARP AND THE FILLING OF THE FOUR FABRICS OF DOUBLE LOOP CONSTRUCTION.

The rate of absorption for both warp and filling was higher in double-loop than in single-loop towels with one exception which was lower than any single-loop towel. This towel also ranked lowest among double-loop towels in both tests measuring the amount of absorption as indicated by the factor. However, it was highest in the number of ounces absorbed per square yard.

CONCLUSION

From the limited number of cases studied it would seem that the increased absorptivity of double-loop towels does not compensate their lack of durability as expressed in terms of breaking strength.

ACKNOWLEDGMENT

The writer wishes to express her appreciation to Professor Alpha Latzke who directed this study, to Professor Katharine Hess who gave valuable suggestions, and to Dr. Hazel Fletcher who assisted in working out methods for testing absorption.

LITERATURE CITED

Cook, Rosamond C., Kelley, Nina, Yeatman, Retta, and Clark, Julia.
Win, don't lose in buying. Ohio Home Econ. Assoc., 13 p. 1931.

Committee D-13 On Textile Materials.
American society for testing materials standards on textile materials. Philadelphia. American Society for Testing Materials. 295 p. Oct. 1936.

Fletcher, Hazel.
Methods for measuring amount of absorption in fabrics. Unpublished report, Kans. State College of Agr. and Appl. Sci., 5 p. 1937.

Fox, Thomas W.
The mechanism of weaving. 5th ed. Chicago. Macmillan, 603 p. 1922.

Haven, George B.
Mechanical fabrics. New York. Wiley and Sons, 905 p. 1932.

Hess, Katharine.
Modified serigraph method. Textile World, 81:25. Jan. 1932.

Hess, Katharine, and Reidheimer, Dorothy.
The determination of the absorption of water by fabrics. Am. Dyestuff Reporter. 23:715-716. Dec. 1934.

Johnson, George H.
Textile fabrics. New York. Harpers. 385 p. 1927.

Stevenson, Lillian, and Lindsay, Margaret.
Methods of testing the absorption of water by cotton toweling. Jour. Home Econ. 18:193-198. April, 1926.

Turkish bath towels. Consumers' Research Bul. 2 (7): 3-4. April, 1936.

Viemont, Bess M., Hays, Margaret B., and O'Brien, Ruth.
Guides for buying sheets, blankets and bath towels. U.S. Dept. Agr. Farmers' Bul. 1765, 27 p. 1936.