A Comparison of Five Methods of Drying Cotton Fabrics

By Dorothy Saville

Department of Home Economics Research

Bulletin B-510

October, 1958

Contents

ACKNOWLEDGEMENT

Appreciation is expressed to Mr. H. B. Dowell, Pres., Commander Mills, Sand Springs, Okla. for the fabrics.

A Comparison of Five Methods of Drying Cotton Fabrics

Dorothy Saville
Department of Home Economics Research

Introduction

The drying of fabrics as a part of the laundering process may affect both the appearance and the durability of the fabrics. That drying in an automatic dryer is the most convenient and may involve the least labor of any procedure is a recognized fact, but comparisons of the effects on fabrics of drying in automatic dryers and on outdoor lines should take into consideration differences in climatic conditions and differences in drying procedures.

To obtain information on the effects of several drying procedures in home laundering that might be used by homemakers in Oklahoma and regions with similar climatic conditions, muslin, bleached and unbleached, was washed and dried by five procedures: (1) automatic dryer, (2) indoor drying, (3) outdoor drying, 6 hours sun, (4) outdoor drying, 1½ hours sun, and (5) outdoor drying, 6 hours shade. Measurements were made to find the effects of the various methods of drying on fabric yellowing and bleaching as measured by reflectance, breaking strength, stiffness, weight, and number of yarns per inch. The laundering was done between June 8 and September 20, 1956.

Materials and Methods

FABRICS

Unbleached and white muslin sheeting (type 128) were used for the experiment. The fabrics were alike except for the finishing. The white muslin had been bleached with a hydrogen peroxide bleach and finished with about 5 percent sizing to which bluing had been added. The yardage of both fabrics was obtained in continuous length.

SAMPLES

Swatches were cut from the fabrics to provide suitable pieces of cloth for laundering and for the necessary fabric measurements. The swatches were cut 17 inches by 21 inches (warp direction) and hemmed to a size

16 inches by 20 inches. The sheetings were sufficiently wide (81 and 90 inches) to yield four swatches crosswise of the fabric.

A total of 384 swatches were used for the measurements. One hundred twenty swatches, 60 from each fabric, 12 for each drying procedure, were used for measurements of reflectance, weight and number of yarns per inch at each test period. (These 120 samples are identified in Table 2 as Set 1.) Two hundred sixty-four swatches were used for determinations of breaking strength and stiffness. Of the 264 swatches, 24 were used for measurements before laundering, thus leaving 240 swatches to be laundered. Of the 264 swatches used for measuring breaking strength and stiffness, each swatch provided seven samples for breaking strength, warp and filling, and three for stiffness, warp and filling.

Each of the 120 swatches provided one measurement of weight, five of number of yarns per inch, warp and filling, and five of reflectance. Measurements of yarns per inch and reflectance were made in the same position on the swatch at each test period.

Because removal of swatches for determination of breaking strength and stiffness at the test periods would reduce the wash load, the 240 swatches were divided into sets of 120 each. (These are designated as Sets 2 and 3 in Table 2.) The laundering was started with one set of swatches. As swatches were withdrawn, an equal number of swatches of the second set was added. Since swatches of the second set were not added to the wash load until after the first 10 launderings, an additional 10 launderings were needed to give these swatches the 40 launderings. This procedure kept the wash load uniform and, in the end, provided twice the amount of data on breaking strength and stiffness that would otherwise have been obtained.

MEASUREMENTS

All determinations of fabric properties were made before the fabrics were laundered and again after 10, 20, 30, and 40 launderings.

Yellowing and Bleaching

Yellowing of White Muslin.—Yellowing of the white muslin dried by the five different procedures was determined by reflectance. Reflectance was measured with a Gardner Automatic Multipurpose Reflectometer having tristimulus filters: green, blue and amber. To indicate the change in the white fabric, the reflectance data might be expressed in terms of whiteness or yellowness depending on the computation. In this investigation, numerical values were computed for yellowness.

Bleaching of Unbleached Muslin.—The change in unbleached muslin was measured in the same way as that in the white muslin and results expressed as yellowness. Since the change in unbleached muslin is so commonly described as bleaching, the term bleaching is used to denote loss of yellowness in the unbleached muslin.

Breaking Strength

Breaking strength was determined by the strip method. It is a measure of the weight in pounds required to rupture a strip of cloth 1 inch wide.

Stiffness

Stiffness was determined by projecting a strip of cloth 6 inches by 1 inch from a horizontal surface until the end touched an incline surface which was at a 41° angle to the horizontal surface. The greater stiffness in a fabric, the longer the overhang since a stiff fabric is more resistant to bending than a limp one. The length of the overhang was recorded. The bending length, which is one-half of the length of the overhang, is a measure of the bend of a fabric under its own weight.[1]

Weight

Each swatch was weighed at each test period on a Torsion balance having a capacity of 120 grams. Because swatches dried by the different procedures were not the same weight before laundering, loss in weight is reported in percent.

Yarns per Inch

The yarns were counted over a 1 inch width on each swatch at every test period.

WASHING AND DRYING SAMPLES

Washing Procedure

Two automatic agitator-type washers of the same brand and model were used for the washing. The swatches were divided so that the two machines would have equal loads and the same swatches would always be washed in the same machine. The washers were preheated, the fabrics added, and the washers filled with water 65° ± 1° C. A low sudsing, built synthetic detergent was used in the washing. The same quantity, by

[1] ASTM Committee D-13 ASTM Standards on Textile Materials. American Society for Testing Materials. Philadelphia 3, Pa. 1957. pp. 259-260.

weight, was used for each washing. The washing was done in water with hardness ranging from the upper limits of moderately hard to hard water.[2] A steam-heated tank provided ample hot water to fill and operate the two machines simultaneously. After the machines were filled, the synthetic detergent, previously dissolved in hot water, was added. The swatches were washed 6 minutes before the spinning and rinsing cycles began.

The samples were dampened and ironed on an automatic ironer only after washings before each test period. This was done to make fabrics smooth enough for testing.

Drying Procedures

Fabrics were dried on outdoor lines between 8:00 a.m. and 4:00 p.m. on days which were clear or predicted to be clear in the early morning.[3] If it became cloudy for more than 30 minutes or there was likelihood of a sudden shower, the swatches were taken off the line and rehung the next clear day to complete the period of exposure. Four times it was necessary to remove the swatches before they received 6 hours exposure (sunlight and shade).

All line dried swatches were pinned to the lines from one end so that the swatch hung in the lengthwise (warp) direction. The distance between lines was sufficient to prevent swatches from blowing against each other or any other surface. All outdoor lines were in an east-west direction, and those used for drying in sunlight were fully exposed to the sun throughout the day.

Automatic Dryer. The fabrics were dried in an electric automatic dryer at the medium temperature setting for a total of 37 minutes. In order to have a full load in the dryer, pieces of previously laundered white muslin were run through the last rinse cycle of the washer and added to the dryer.

Indoor Drying. The swatches hung on indoor lines were left to dry from four to six hours. There was some indirect light from windows on one side of the room, but venetian shades at the windows were kept completely closed.

---

[2] All About Home Laundering. Ruud Manufacturing Co. 1954. p. 20.

[3] Weather forecasts and data on solar radiation were obtained from the Department of Physics and Meteorology, Oklahoma State University, Stillwater, Okla.

Outdoor Drying, 6 Hours Sun. The swatches were hung on the line between 8:15 and 8:30 a.m. about three-fourths of the total days of drying. It was impossible to get the same exposure of fabrics at each interval of 10 launderings, but an attempt was made to balance the irradiation of the fabrics by sometimes changing the hour the fabrics were hung on the line. From Table 1 it may be seen that the total radiation of a six-hour period between 8 and 4 o'clock might be increased or decreased depending on the time of day of the exposure.

Outdoor Drying, 6 Hours Shade. The shaded lines were in an adwere usually on the line by about 8:30, the irradiation of fabrics dried the shorter period was less than it would have been had the fabrics been dried for 1½ hours during midday when solar radiation was higher.

Outdoor Drying, 6 Hours Shade. The shaded lines were in an adjacent location and spaced the same distance apart as the others, but they had a roof above them to provide complete shade for the fabrics between 8:00 a.m. and 4:00 p.m. during the period June through September.

Results

IRRADIATION OF FABRICS

The amount of solar radiation received by the fabrics in the outdoor drying is given in Table 2. The fact that the amount of radiation was so uniform for the laundry intervals was due in large part to the amount of solar radiation being much the same for the hours 8 to 4 through the months of June, July, August, and September, 1956. (See Table 1.) Such uniformity in radiation between the four months may not be expected each year.[4]

Table 1. Solar radiation for hours 8 to 4 for four summer months in 1956 when the cotton fabrics were dried on outdoor lines. Average per day in gm cal per sq cm.

	Av. Solar Radiation per Hour—gm cal per sq cm							
Month	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00
June	25.0	42.4	55.2	67.1	75.1	78 5	76.3	68.6
July	24.2	41.4	56.8	68.2	75.4	77.5	73.2	68.0
Aug.	22.9	40.8	56.0	68.7	74.4	78.2	74.2	67.2
Sept.	21.0	39.9	57.3	70.5	75.5	77.9	73.9	65.4

[4] Dorothy Saville, *Effects of Outdoor Drying on Cotton Fabrics with Special Reference to Solar Radiation.* Oklahoma Agricultural Experiment Station Bulletin No. B-508. August, 1958. pp. 8-9.

Table 2. The solar radiation to which fabrics were exposed in outdoor drying for different lengths of time and intervals of laundering.

	Total solar radiation for hours of drying — in gm cal per sq cm											
Set* of	Hours in sunlight 6 hrs.				Hours in sunlight 1½ hrs.				Hours in shade 6 hrs.			
Swatches	60	120	180	240	15	30	45	60	60	120	180	240
1 & 2	4095	8101	12192	16051	719	1466	2227	2821	____	____	____	____
3	4006	8097	11956	15978	747	1508	2102	2792	____	____	____	____

* Set 1 was used for measurements of reflectance, yarns per inch, and weight. Sets 2 and 3 were used for measuring breaking strength and stiffness.

During the four months in 1956 in which the fabrics were dried outdoors, the solar radiation was extremely low at every hour on only one day. The highest radiation from 8 a.m. to 4 p.m. was on June 1 when the radiation was 582 gm cal per sq cm. Slightly more than half of the days had a total radiation of over 500 gm cal per sq cm for the 8-hour period. Four days the total radiation was between 200 and 300 units, and on only one day did radiation drop below 100.

The deterioration of a cotton fabric is greater upon exposure to sunlight when there is moisture present or when the humidity is high. Rapid drying is also a particular advantage in outdoor drying when the solar radiation and the temperatures are high.

YELLOWING AND BLEACHING

Yellowing of White Muslin.—From Figure 1 it may be seen that white muslin dried by all five procedures was more yellowed than the unlaundered muslin. The most yellowing occurred in the white muslin dried in the dryer. The next most yellowed fabric was that dried in the sun 6 hours. The least yellowed muslin was that dried on indoor lines; however, the differences in white muslin dried on indoor lines, in the sun 1½ hours and in the shade 6 hours were not significant.

The laundered fabrics did not all appear to be alike (in color) after being dried by the five procedures. Regardless of the position of the white fabrics dried by the different procedures in relation to one another, the fabric dried in the sun 6 hours was easily picked out as appearing less like the others than they were like each other. It appeared visually to be less white. The reflectance measurements were for determination of increased yellowness of the laundered fabric compared with the unlaundered or new fabric. Presumably, the white muslin receiving the long sun drying became a more yellowed white and also another "color" of white.

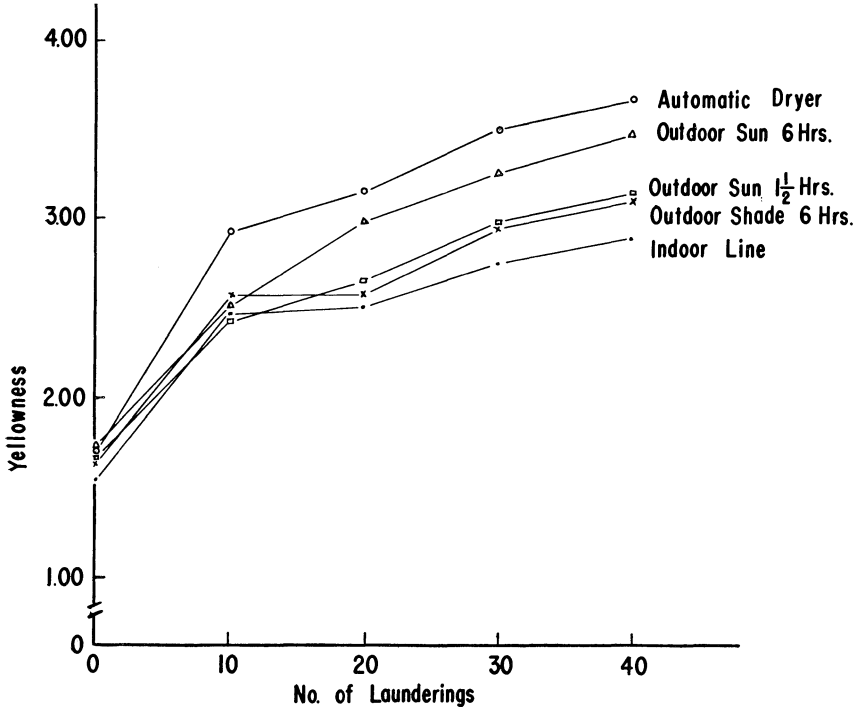

Figure 1.—Yellowness of white muslin (as measured by reflectance).

Bleaching of Unbleached Muslin.—The amount of bleaching of the unbleached muslin varied greatly among the five methods of drying. (See Figure 2.) In the order of increased bleaching, the methods of drying were: automatic dryer, indoor line, outdoor shade, sun 1½ hours, and sun 6 hours. The difference between drying in a dryer and on indoor lines was small. Outdoor drying produced much more bleaching. There was a marked difference in appearance of unbleached muslin dried by the first two methods and that dried outdoors.

The fabrics dried in the sun 1½ hours and in the sun 6 hours changed little between 30 and 40 launderings. Bleaching in the outdoor shade continued between 30 and 40 launderings, and at 40 launderings more nearly approached that of short sun drying than at any other laundry interval. It is evident from Figure 2 that long drying in outdoor

shade (indirect sunlight) was unsatisfactory for prevention of bleaching of the unbleached muslin.

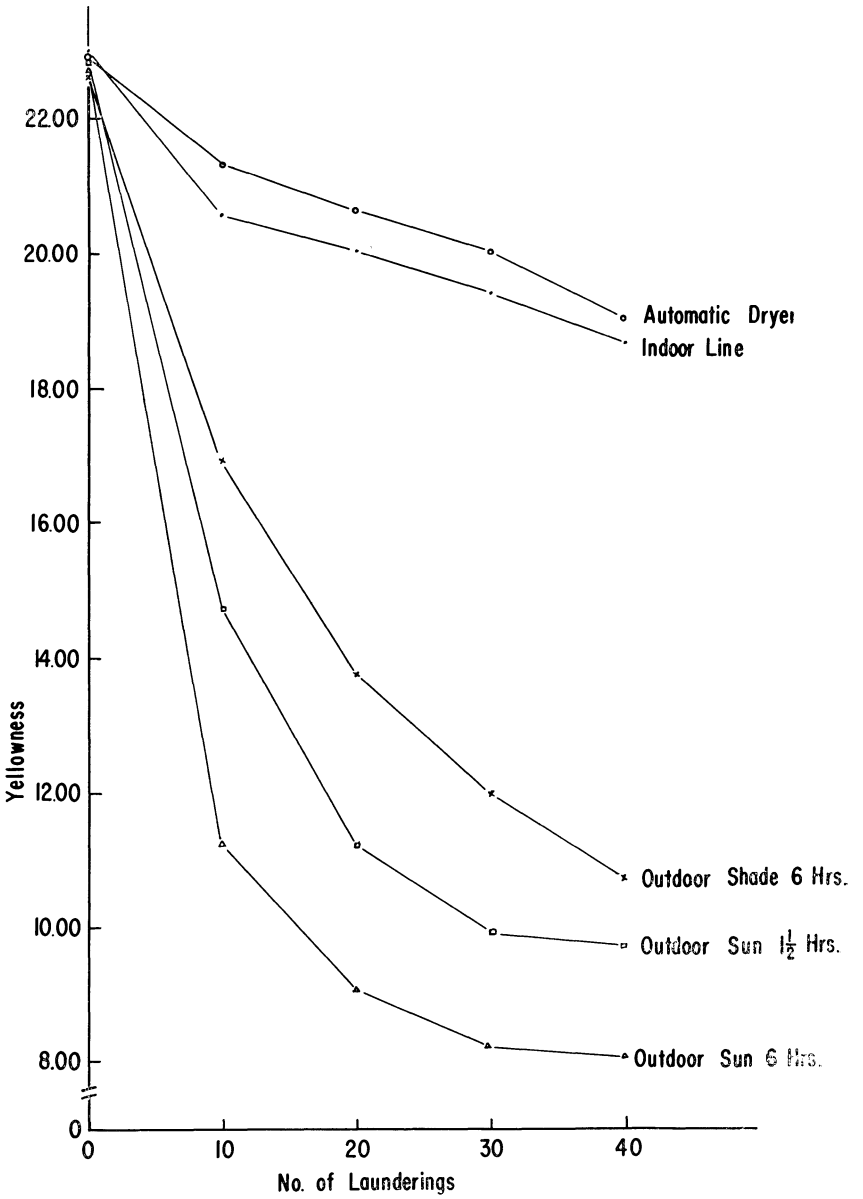

Figure 2.—Bleaching of unbleached muslin (as measured by reflectance).

BREAKING STRENGTH

Drying in the sun 6 hours was the poorest of the five methods of drying for retention of bleaking strength in both fabrics and in both the warp and filling directions. (See Figures 3, 4, 5, and 6.)

The breaking strength of the white muslin was the same for warp and filling in the unlaundered fabric. In the unbleached muslin the strength was about 7 pounds higher in the filling than in the warp direction. This would be expected since in finishing the fabric into white muslin the yarns per inch warpwise are increased and fillingwise they are decreased, yet according to specifications for sheeting, the minimum strength should be the same in the warp and in the filling.

The maximum loss of strength was in the filling direction of the white muslin for the 6-hour sun drying. This loss at 40 launderings was nearly 11 pounds or over one-fifth of the filling strength of the unlaundered fabric.

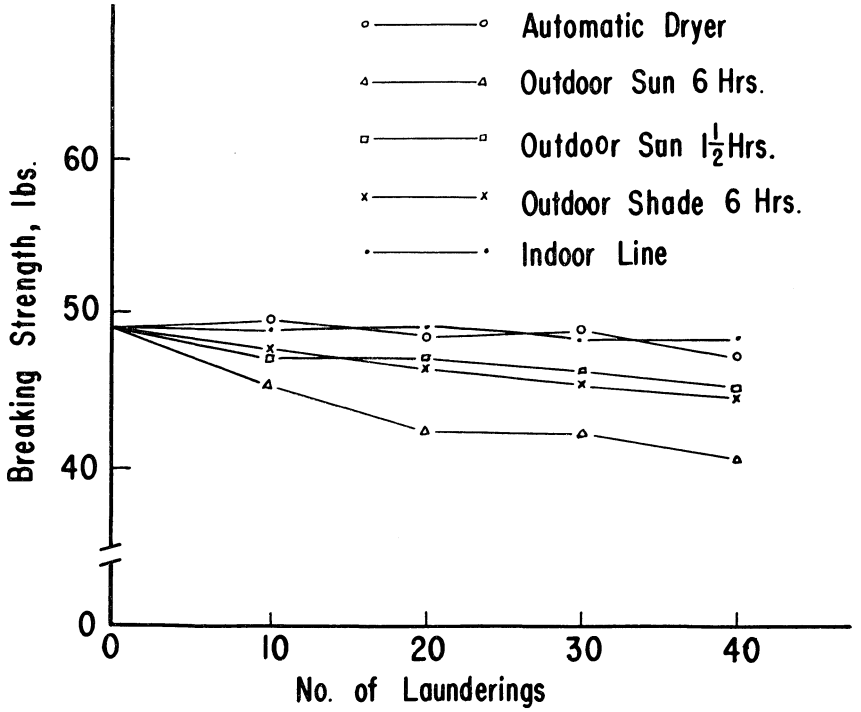

Figure 3.—Breaking strength, warpwise, white muslin.

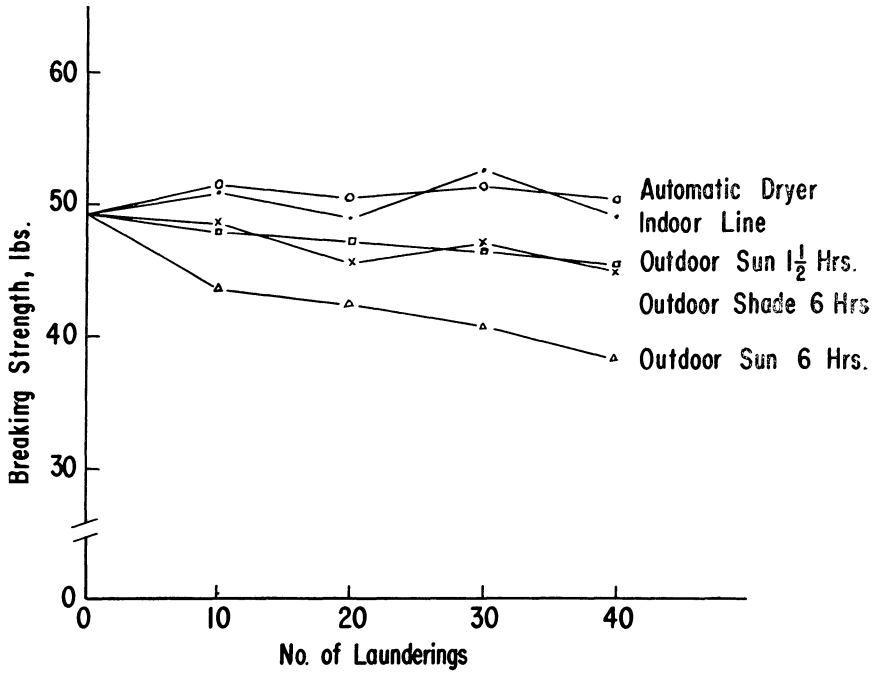

Figure 4.—Breaking strength, fillingwise, white muslin.

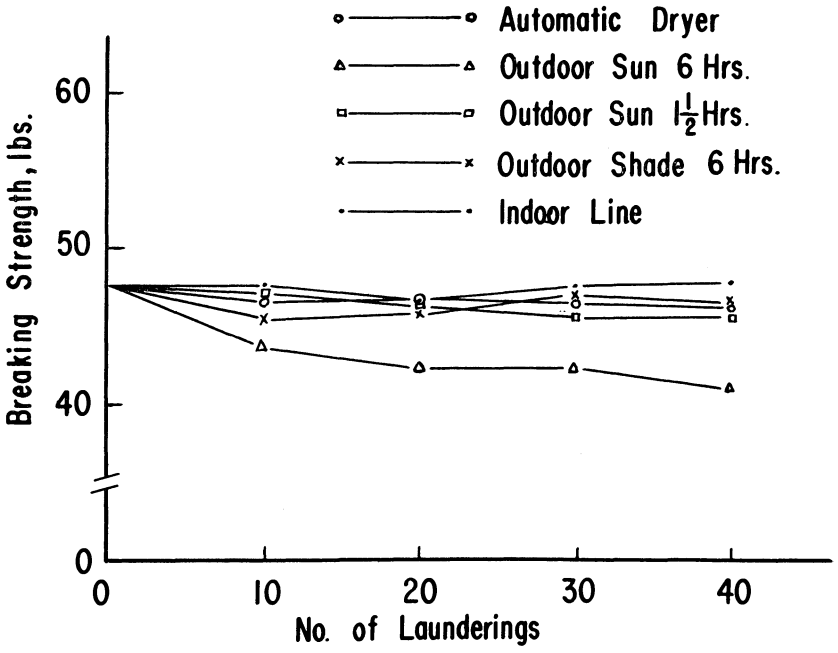

Figure 5.—Breaking strength, warpwise, unbleached muslin.

At 40 launderings the strength of the white muslin dried on indoor lines and in an automatic dryer was about the same as the strength of the new fabric. The white muslin dried in the shade 6 hours and in the sun 1½ hours had similar losses in strength of about 4 pounds, but this was much less than the loss in the 6-hour sun drying.

For unbleached muslin, the loss of strength of fabrics dried in the sun 6 hours was considerably greater than the loss in the other methods of drying. The differences in strength between the other four methods were small as compared with the difference between any one of them and long sun drying.

A breaking strength which was as high or higher at test intervals than that of the unlaundered fabrics was due to shrinkage in the fabrics. The difference in number of yarns per inch was insignificant in the warp direction of the laundered as compared with unlaundered white muslin; but the difference was sufficient to have had some effect on the breaking strength in the filling direction of the white muslin and in both directions in the unbleached muslin.

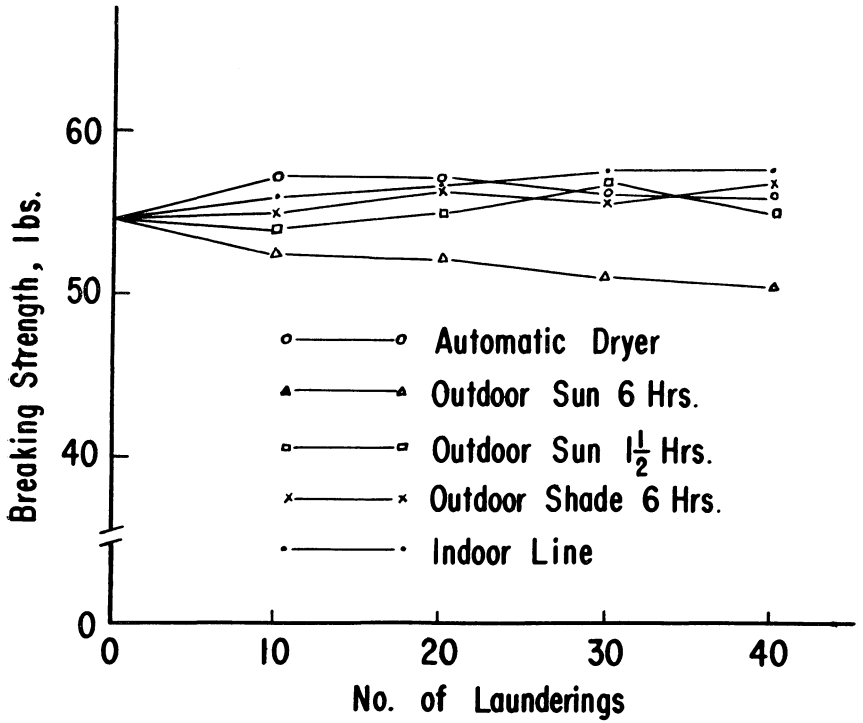

Figure 6.—Breaking strength, fillingwise, unbleached muslin.

Although the loss of breaking strength between 0 and 10 launderings was greater than between any other 10 launderings for both fabrics dried in the sun 6 hours, a continuous decrease in strength occurred throughout the 40 launderings.

STIFFNESS

Although stiffness is considered of most importance in connection with starches and other finishing agents used on fabrics, measurement of fabric stiffness in this investigation was for the purpose of finding whether the methods of drying produced differences in the laundered fabrics.

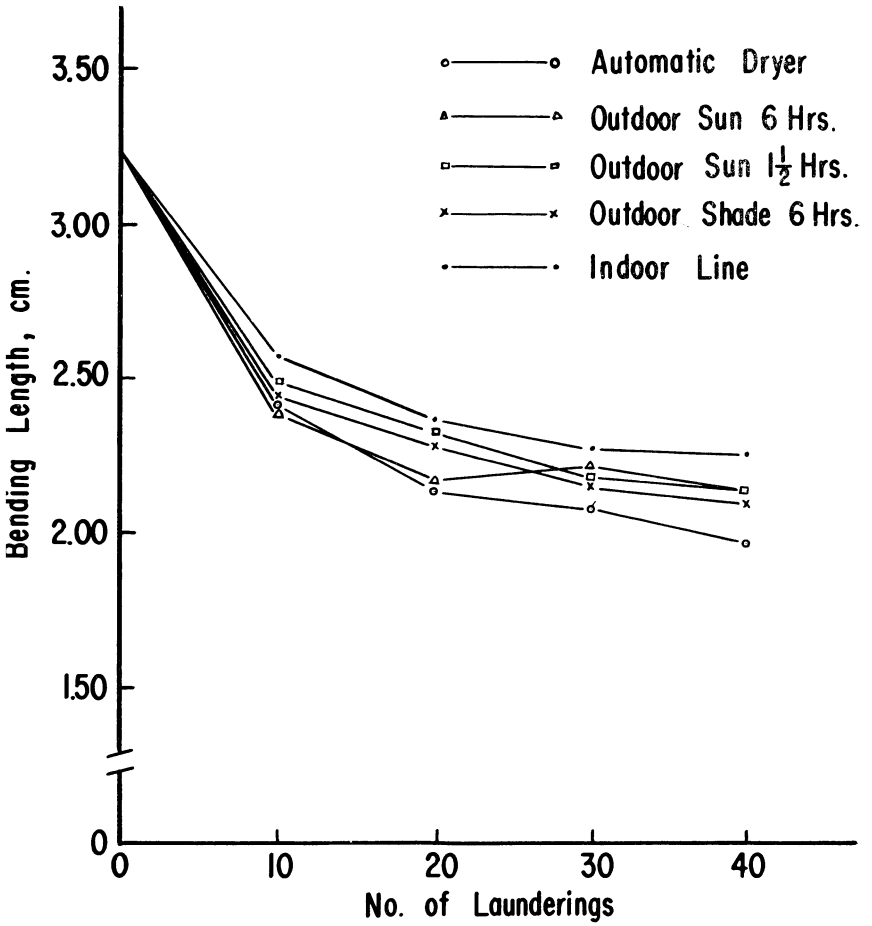

Figure 7.—Bending length, warpwise, white muslin.

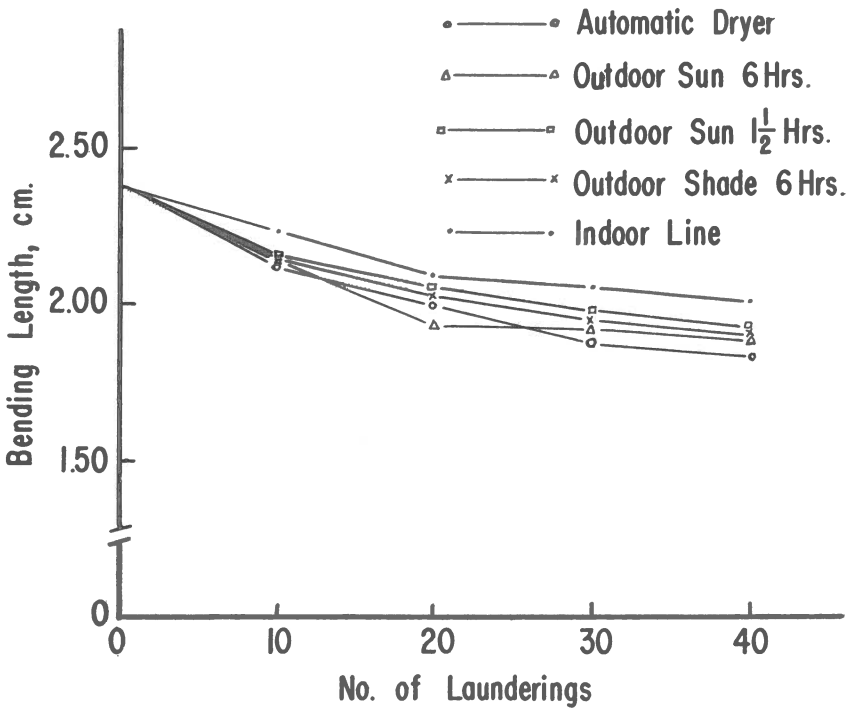

Figure 8.—Bending length, fillingwise, white muslin.

The results on stiffness of the muslins dried by the different methods are shown in Figures 7, 8, 9, and 10. The best stiffness in both fabrics and in warp and filling was retained in the indoor line drying and the poorest in the automatic dryer. However, differences in stiffness, particularly in the filling direction, were probably not large enough to have practical significance.

Since the greatest loss of weight due to removal of sizing and change in properties of the yarn and in number of yarns per inch due to shrinkage occurred within the first 10 launderings, it may be assumed that changes in stiffness at 20, 30, and 40 launderings were due largely to change in the fabric and not to effects of sizing or shrinkage.

A gradual decrease in stiffness except in the filling direction of the unbleached muslin occurred during the laundering of both fabrics.

At most of the test periods, little difference was found between the short and the long periods of outdoor drying. The whipping and blowing of the fabrics on the line had little effect on fabric stiffness.

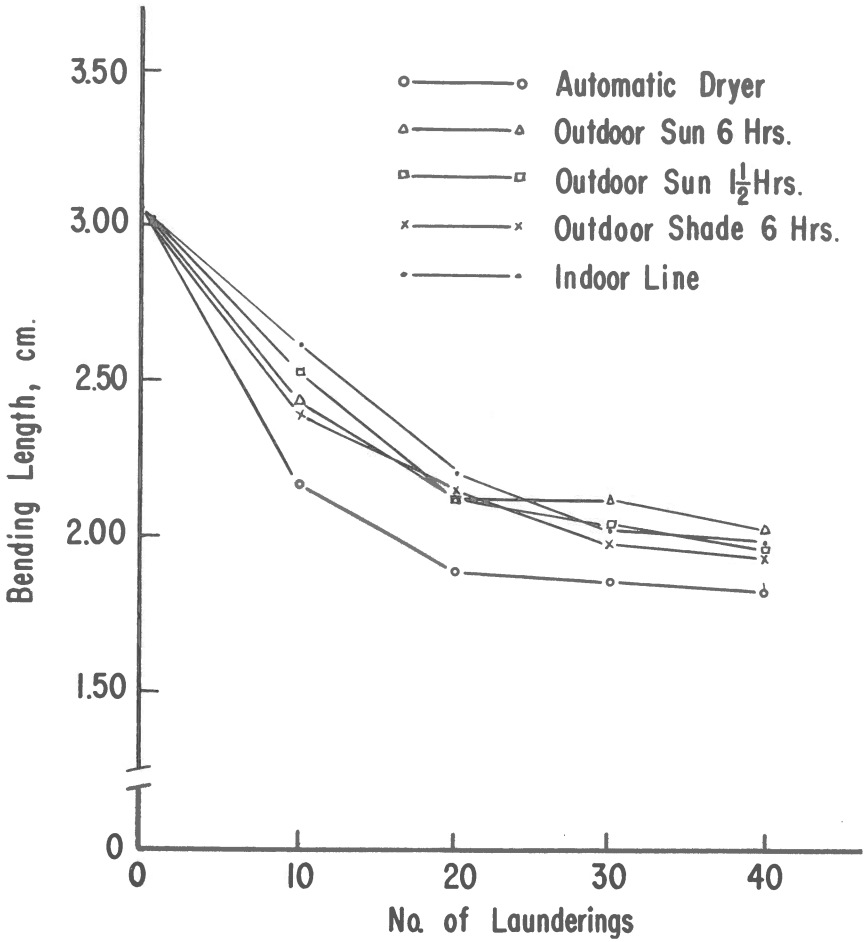

Figure 9.—Bending length, warpwise, of unbleached muslin.

WEIGHT

Removal of sizings and other finishing materials applied to cloth in finishing, and the loss of fiber are represented by loss of weight. The greatest loss of weight in both muslins occurred during the first 10 launderings in which sizing was removed. Of the two fabrics, the unbleached fabric lost more weight than the white muslin. Although the loss of weight tended to level off after 10 launderings, a decrease in weight continued throughout the 40 launderings. (See Figures 11 and 12.)

The maximum and minimum losses of weight of the white muslin at each test interval were not for the same methods of drying each time

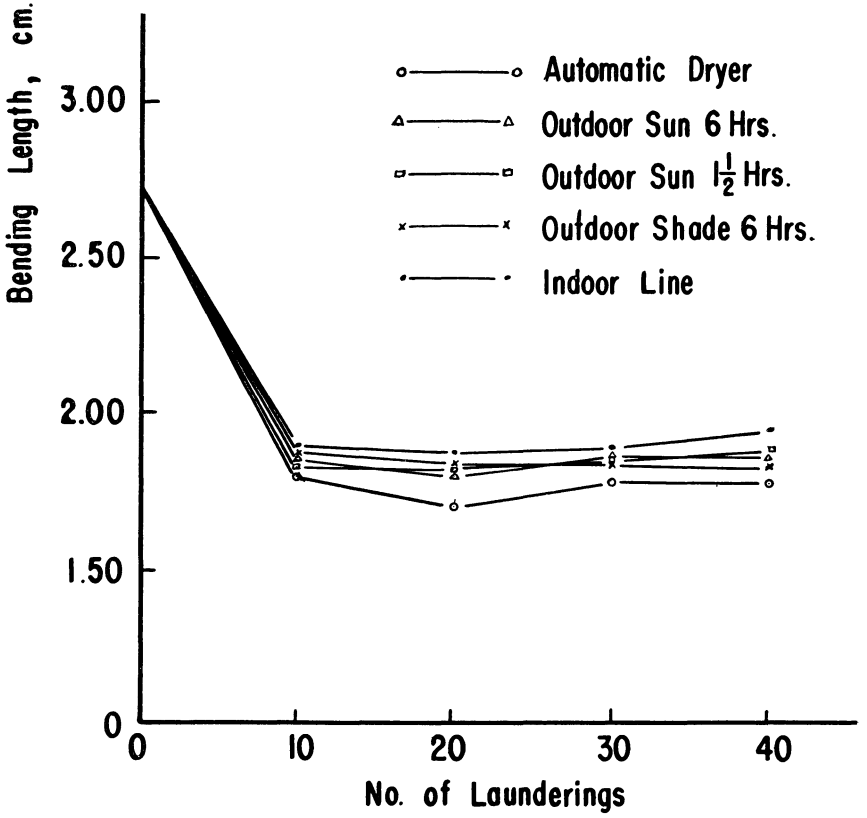

Figure 10.—Bending length, fillingwise, of unbleached muslin.

and in most instances the differences in loss of weight were greater between laundry intervals than between methods of drying. The differences in loss of weight of the white muslin dried by the five procedures were not significant. At 40 launderings, the fabric dried in the sun 6 hours showed a loss in weight which might become pronounced over more launderings.

The greater loss of weight of unbleached muslin dried in the sun 6 hours and the marked increase in this difference at 30 and 40 launderings showed the 6-hour sun drying to be different from the other methods. Over a relatively few launderings this difference in loss of weight might not be important, but over many launderings, it might be.

Similarity of results for sun drying 1½ hours and shade drying 6 hours do not indicate that the whipping or blowing of the fabrics on the line was a cause of excessive loss of fiber. Loss of weight of the fabrics receiving the long sun drying may be due to the effects of sunlight (radiation) on the cellulose and of subsequent washing on this chemically changed fiber.

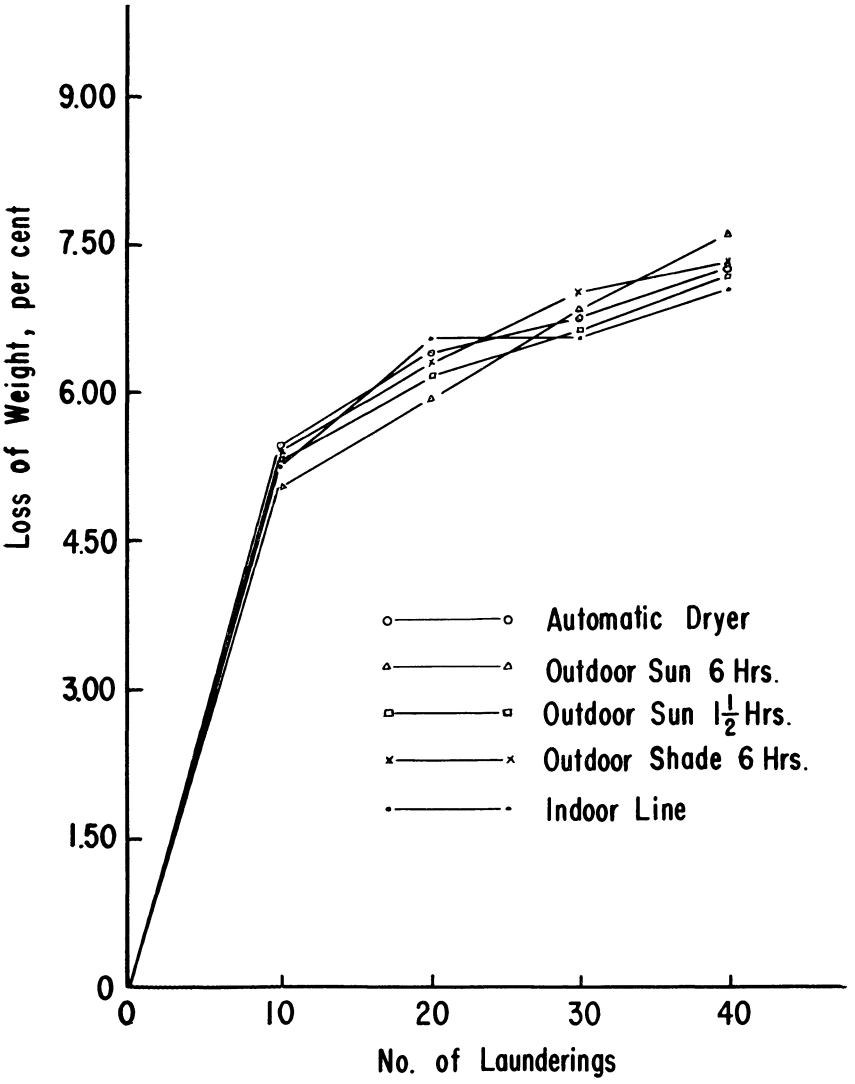

Figure 11.—Loss of weight in percent, white muslin.

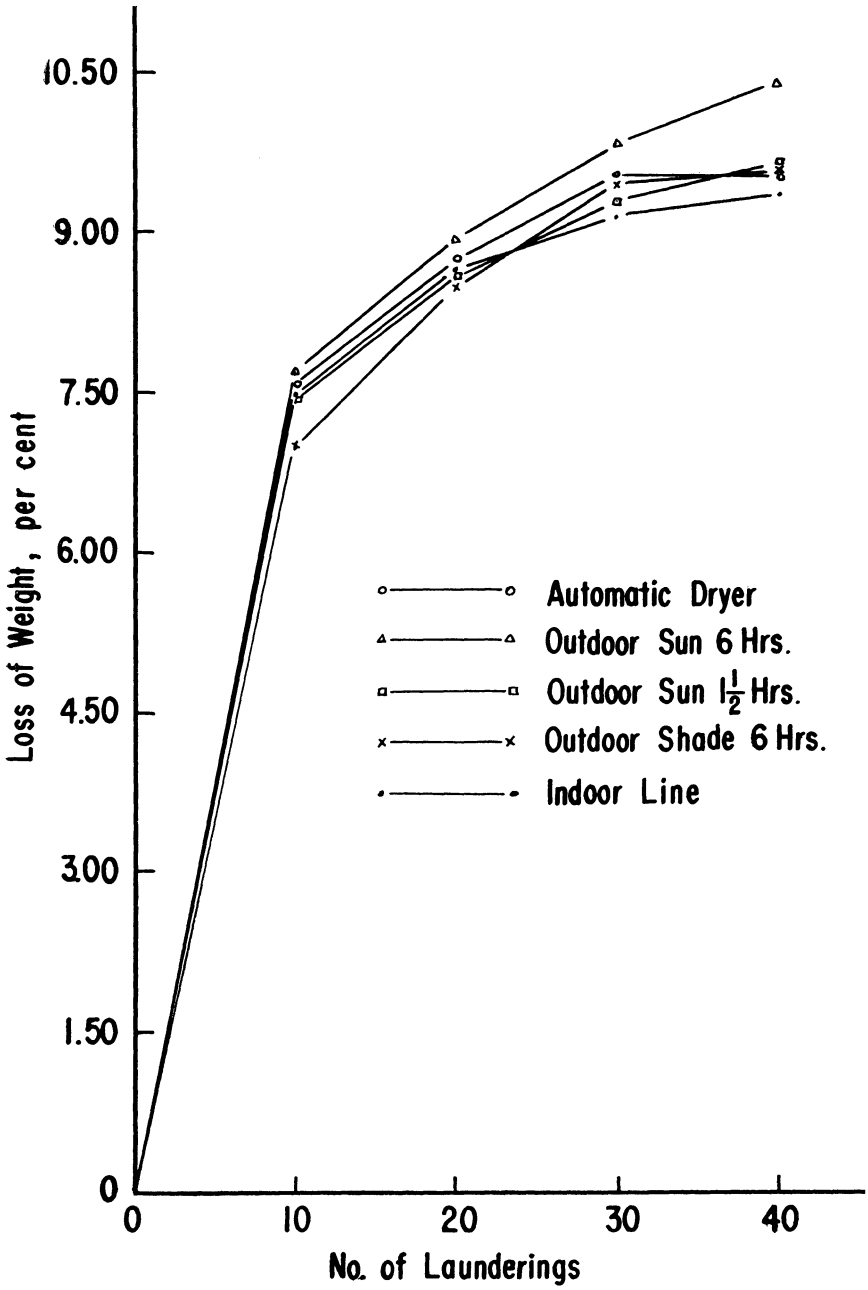

Figure 12.—Loss of weight in percent, unbleached muslin.

YARNS PER INCH

The increase in number of yarns per inch due to shrinkage in laundering was negligible in the warp direction of the white muslin but amounted to as much as four yarns per inch in the filling direction. The increase in total number of yarns per square inch was greater in the unbleached than in the white muslin. After 40 launderings, the count in the unbleached muslin had increased about six yarns per inch warpwise and four to five fillingwise. (See Figures 13, 14, 15, and 16.) The difference in yarns per inch warpwise as a result of method of drying was negligible. In the filling or crosswise direction of both muslin, the increase in yarns per inch due to method of drying was greatest in fabrics dried in the automatic dryer. However, the difference between this method and other methods of drying was an unimportant one in fabrics with as high count of yarns as the muslins had. Probably the difference in yarns per inch was due to the ironing. Since the swatches were ironed only after the last launderings before fabric measurements were made, wrinkles or creases were more difficult to remove than if the fabrics had been ironed after each washing.

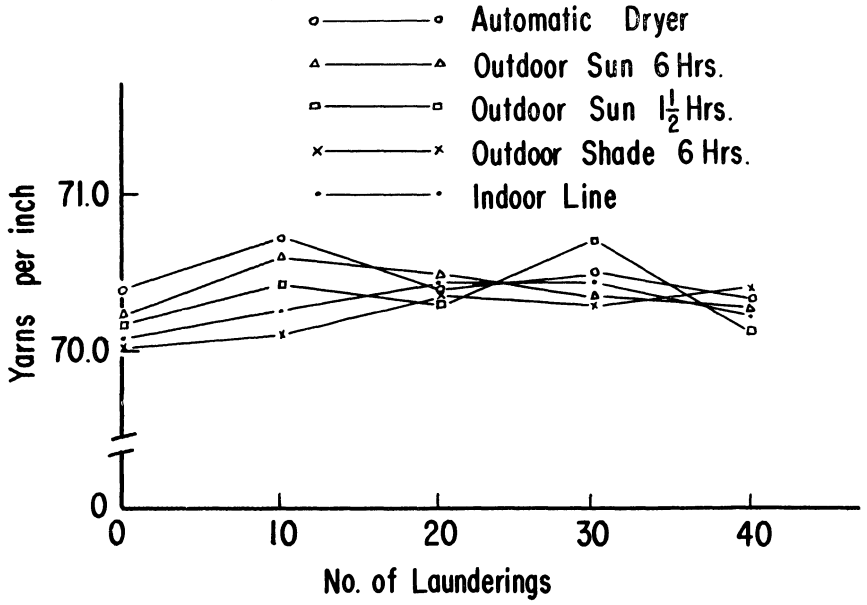

Figure 13.—Yarns per inch, warpwise, in white muslin.

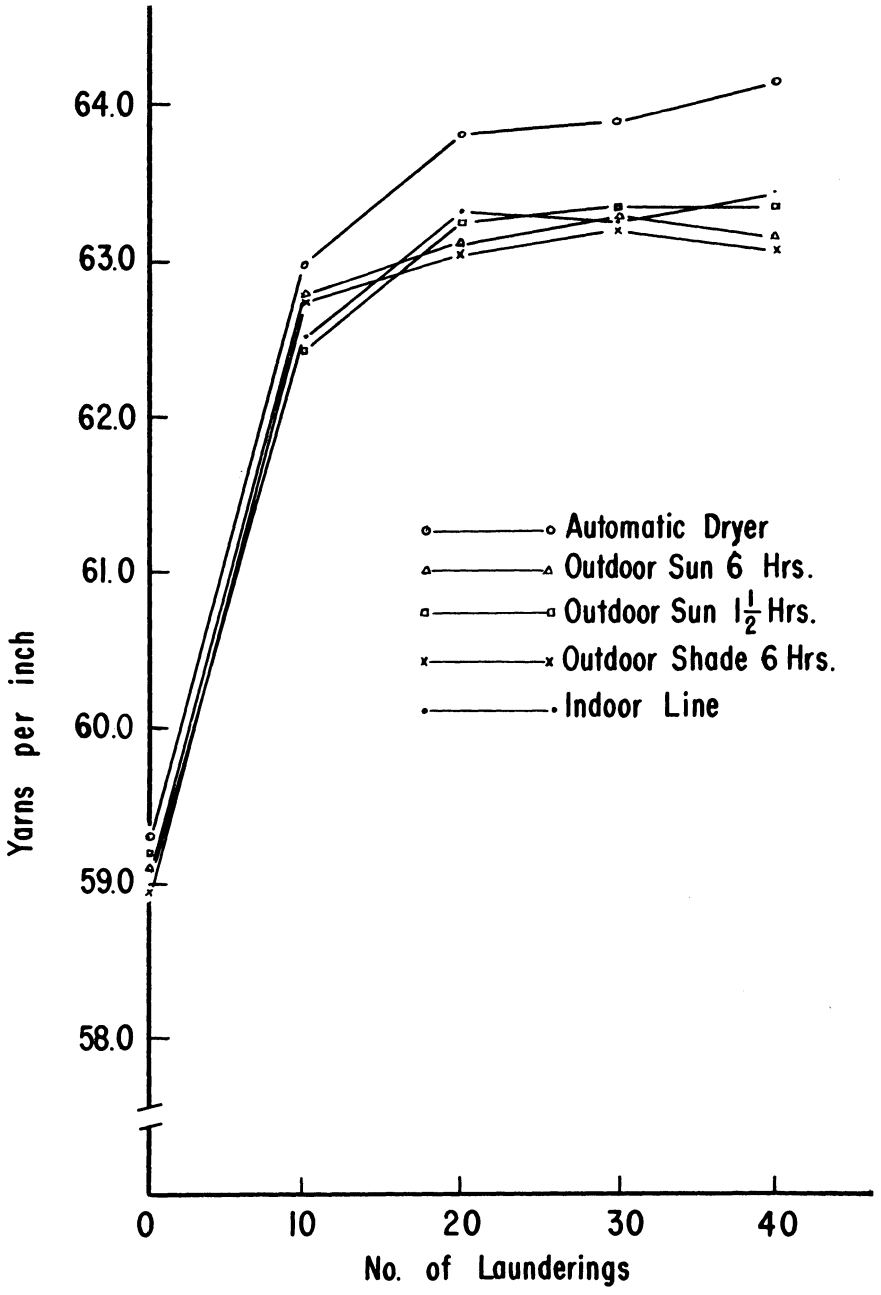

Figure 14.—Yarns per inch, fillingwise, in white muslin.

The increase in yarns per inch which occurred fillingwise in the white muslin and in both directions in the unbleached muslin may have affected some other properties of the laundered fabrics. However, since

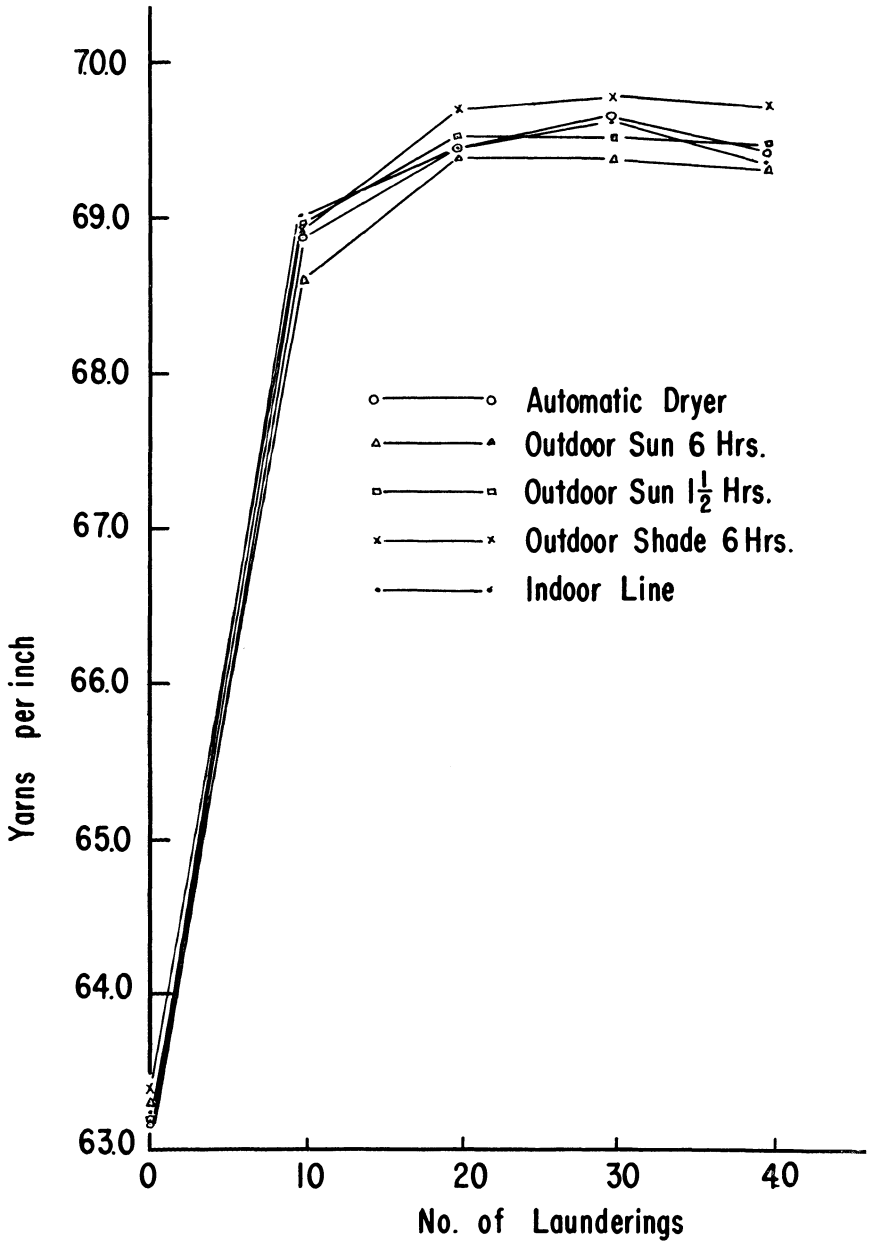

Figure 15.—Yarns per inch, warpwise, unbleached muslin.

most of the increase took place within the first 10 launderings, it is likely that measurements made at subsequent test periods were unaffected by change in number of yarns per inch.

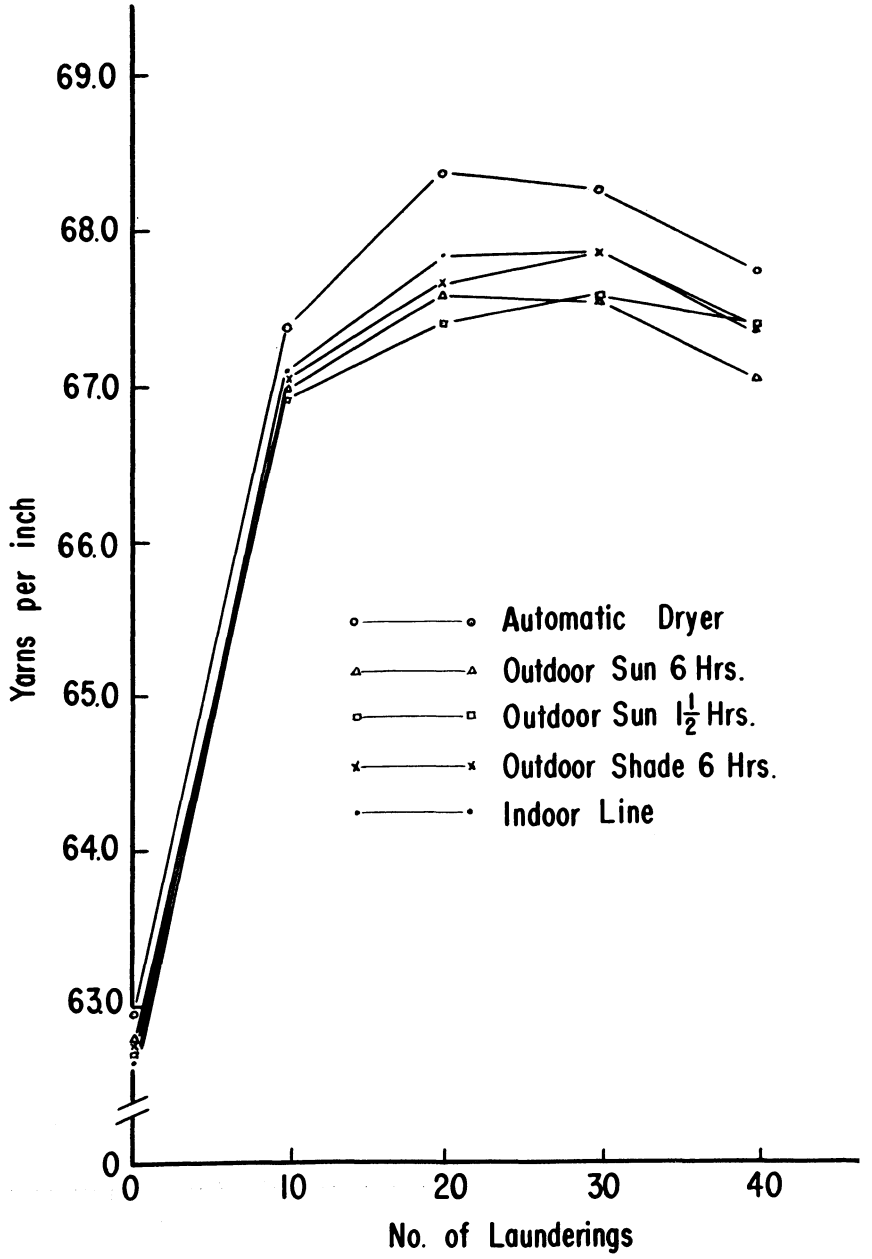

Figure 16.—Yarns per inch, fillingwise, unbleached muslin.

Summary

Two sheetings, white and unbleached muslin, were used to determine the effects of five methods of drying on: yellowing and bleaching, breaking strength, stiffness, weight, and number of yarns per inch of the fabrics. Swatches of the fabrics were cut and hemmed to a 16 inch by 20 inch size and laundered a total of 40 times. They were washed by a home laundry procedure and dried by: (1) indoor line, (2) automatic dryer, (3) outdoor sun, 6 hours (between the hours of 8 a.m. and 4 p.m.) (4) outdoor sun, 1½ hours, and (5) outdoor shade, 6 hours.

Most yellowing of the white muslin was produced by drying in an automatic dryer and in the sun 6 hours. The white muslin did not become whiter with increased irradiation. No important difference was found in the amount of yellowing produced in the white muslin by drying on indoor lines, in the sun 1½ hours, and in the shade.

By far the least bleaching of unbleached muslin occurred in the automatic dryer and indoor line drying. Most bleaching occurred in 6 hours sun drying; next was 1½ hours sun and then 6 hours shade drying.

Loss of strength was greatest in both fabrics dried in the sun 6 hours. For the white muslin, results were similar for indoor line and automatic dryer, and for sun 1½ hours and shade 6 hours. For the unbleached muslin, only the 6-hour sun drying differed materially from the other four methods of drying.

Stiffness was reduced most in the automatic dryer and least in the indoor line drying, but the differences between methods of drying may not have been sufficient to affect serviceability of the fabrics.

Due to removal of sizing in the first launderings, the loss of weight was greater after 10 launderings than between 10 and 40 launderings. There was no important difference in loss of weight of white muslin dried by the five methods. Loss of weight was greatest in unbleached muslin dried in the sun 6 hours.

The number of yarns per inch increased by several yarns in the filling direction of the white muslin and in both warp and filling in the unbleached muslin. The method of drying had little effect on number of yarns per inch warpwise. Although the number of yarns per inch was higher fillingwise for fabrics dried in the dryer, the difference may be considered unimportant.

Results from this investigation showed only disadvantages from long sun drying or continued irradiation of the cotton fabrics.

10/58—2½M