A STUDY OF THE EFFECT OF THREE "NON-RINSING"
COMPOUNDS ON THE TENSILE STRENGTH
OF COTTON PERCALE

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THESIS

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INTRODUCTION

Interest in the new detergents and the new non-rinsing procedure led to an interest in developing a problem around it in order to know what to teach homemaking students and homemakers concerning it. Synthetic washing compounds have become increasingly popular with house wives for laundering. Several of these compounds have been advertised by their producers the past two years as a "no-rinse" type of detergent. These producers claim that the "no-rinse" detergents will save time, work, and water and give "amazing whiter brighter washes." Since more and more of these compounds are advertised and are being sold with a "no rinsing needed" statement on the container, a need was felt to determine whether or not the non-rinsing procedure affected the tensile strength of cotton fabrics under home laundering conditions.

To date, very little work has been done to determine the effect of non-rinsing on cotton fabrics. In February of 1951 Consumers Union[1] reported limited tests with several of the detergents advertised as "no-rinse". White pillow cases were washed with the regular washes of clothes using one of two detergents advertised as "no-rinse". Some of the pillow cases were rinsed and others were dried and ironed without

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[1] "Synthetic Detergents," Consumer Reports, February 1951, p. 53.

rinsing. After five washings all pillow cases were given whiteness determinations made with a reflectometer. The unrinsed pillow cases were definitely not as white as those which had been rinsed. Rinsing occasionally did not bring the unrinsed pillow cases back to the whiteness of those which had been rinsed each time they were washed. Other results of the effect of non-rinsing were not reported in this article.

A study on the effect of home laundering methods on the durability of fiber mixtures in toweling was made by Wallace[2], in 1948. Ninety towels composed of all cotton, all linen, and mixtures of cotton, linen, and rayon were used. Each towel was used in the foods laboratory one class period and then washed and rinsed in an automatic home washer. One hundred grams of a synthetic detergent were used for each nine pounds of dry towels. Samples of the towels were tested after each five washings for tensile strength and other characteristics. Greatest increase in tensile strength was exhibited after the fifth washing for the warp and after the tenth washing for the filling in the all cotton and all linen towels because of continued shrinkage.

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[2]Lois Vick Wallace, "The Effect of Home Laundering Methods on the Durability of Fiber Mixtures in Toweling," Unpublished Master's thesis, The University of Tennessee, Knoxville, June 1948.

The same year a study was made by Sowell[3] on the serviceability of kitchen towels subjected to normal home laundering with slightly different techniques. In this study ninety-eight kitchen towels were tested for tensile strength and wear received from home laundering without being subjected to household use. Each towel was given fifteen home launderings with samples tested after each five launderings. A soapless detergent was used and all the towels were rinsed. The average filling strength was greater than the corresponding warp tensile strength. The greatest increase in tensile strength appeared after the fifth laundering.

Another study was reported by Pearson.[4] This was a study of the effect of soaps and detergents on standard consumer fabrics undertaken to determine, in general, what effect soap and detergents have on cotton and rayon materials. Tests on tensile strength, thread count and other characteristics were also determined. Three soaps and three soapless detergents were used. A chambray, a cotton suiting, a spun rayon, and a filament rayon were the fabrics analyzed. The samples, without being sub-

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[3]Mary Frances Sowell, "The Serviceability of Kitchen Towels Subjected to Normal Home Laundering," Unpublished Master's thesis, Dept. of Home Economics, University of Tennessee, Knoxville, August 1948.

[4]Hope Pearson, "A Study of Soaps and Detergents--Their Effect on Standard Consumer Fabrics," Unpublished Master's thesis, Dept. of Home Economics, University of Tennessee, Knoxville, August 1948.

jected to soil or use, were washed with each soap and detergent in an automatic home washing machine, rinsed, and ironed twenty times with a standard iron. While most of the cotton samples showed an increase in tensile strength, those washed in the soapless detergents showed the greatest gain. Most of the samples gained in thread count after the laundering period. Soaps had the least effect on the color change. The conclusion was reached that soaps and detergents do have some effect on the serviceability of cottons and rayons, but the samples should be subjected to many more laundering tests. Both showed a gain in tensile strength for cottons and a loss in tensile strength for rayons with the soapless detergents showing the greatest gain.

In a study evaluating different types of detergents used in home laundries Watts[5] reported the effect on physical properties of a selected fabric as measured by bursting strength and abrasion. Samples from a percale sheet were agitated for two minutes in an oscillator type washing machine. Those to be soiled were put into the soil made from vacuum cleaner dust and distilled water and the machine run for two minutes. Samples marked seven day soil were stored for seven days before washing. Samples

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[5]Frances Myra Watts, "The Evaluation of Different Types of Detergents used in Home Laundries. II. Effect on Physical Properties of a Selected Fabric as Measured by Bursting Strength and Abrasion," Unpublished Master's thesis, Dept. of Home Economics, State College of Washington, Pullman, Washington, 1948.

with one day soil were left twenty-four hours and then washed. The launder-ometer was used to wash the samples, then they were rinsed twice in distilled water and ironed in an electric ironer at a temperature of 350° F. Samples were conditioned for four hours in a room 70° F. and sixty-five per cent humidity before the tests were made. When alkyl sulfate detergent was used the unsoiled sample showed the greatest strength. Ten minutes of washing resulted in a stronger percale than either the two or the seven minute washes. Washes were controlled to three temperatures, 80°, 120°, and 180° F. The best temperature at which to launder percale was found to be 120° F.

The above studies show the effects of using soapless detergents on fabrics when they have been rinsed. One exception was that reported by Consumers Union;[6] the pillow cases were dried and ironed without rinsing. Whiteness determinations were made, but the effect of non-rinsing on thread count and tensile strength was not reported.

The purpose of the present study is to determine the effect of three "non-rinse" washing compounds upon the tensile strength of cotton percale, in order to have some basis for recommendation as to use when teaching laundering to homemaking students and homemakers. Cotton percale was washed under home laundering methods using a gyratator type electric washing machine, a water temperature of 120° F, and a standard rotary home ironer.

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[6] "Synthetic Detergents," Consumer Reports, February 1951, p. 53.

PROCEDURE

Source of Materials

White cotton percale priced at forty-nine cents a yard was purchased from a retail store in Denton, Texas. The label on the percale stated that it "is wash fast under government tests and must also pass standard tests for resistance to sunlight and crocking. It is woven 39 or more inches wide and shrunk in finishing to a 35 or 36 inch width." Thread count of the original material as purchased, was 87 x 72.

Three synthetic detergents which advocated the non-rinsing washing process were available in the local stores at the time this study was begun. The price of each detergent purchased from the local retail stores was thirty-one cents for a one pound-three ounce box. One of each was purchased and used for this study.

Sampling Procedure

Eight yards of percale was purchased. Seven three-fourths yard pieces and four one-half yard pieces were cut from the original fabric by pulling a thread and cutting along this line. These pieces of fabric were marked according to the treatment which they were to receive, Table 1. Strips (six inches by one and one-half inches) were cut from each piece after every fifth laundering for the tensile strength tests.

TABLE 1

PLAN FOR SAMPLING AND TREATMENT OF PERCALE

Total Yards	Samples 6" x 1½" Strips			Detergent(6)	Treatment	Total Washings(7)
	Warp	Filling	Code			
	No.	No.				
3/4	30	30	r(1)	I	Rinsed	30
3/4	30	30	u(2)	I	Unrinsed	30
1/2	5	5	u'(3)	I	Unrinsed	5
3/4	30	30	r	II	Rinsed	30
3/4	30	30	u	II	Unrinsed	30
1/2	5	5	u'	II	Unrinsed	5
3/4	30	30	r	III	Rinsed	30
3/4	30	30	u	III	Unrinsed	30
1/2	5	5	u'	III	Unrinsed	5
3/4	30	30	C(4)	...	.....	30
1/2	5	5	O(5)	...	None	..

(1) Samples marked "r" were washed thirty times and rinsed twice after each washing.

(2) Samples marked "u" were washed thirty times and not rinsed.

(3) Samples marked "u'" were washed once each week and not rinsed.

(4) Samples marked "C" were washed thirty times in clear water to be used as a control.

(5) Sample marked "O" was the original as purchased from the store.

(6) Five tablespoons of detergent was used for each ten gallons of water.

(7) All samples were washed thirty times with the exception of those marked "O" and"u'". The temperature of the water was 120° F. (48.8° C.). The machine was run three minutes with detergent only, then the samples were added and the machine run for ten minutes.

Classification of Detergents

The detergents will hereafter be designated as detergent I, detergent II, and detergent III. A chemical analysis of these detergents is given in the appendix.[7]

Detergent I contains twenty per cent sodium salt of sulfated alcohols.[8] The label on the container states that it is a "miracle suds that science made for everything you wash. It is different; it is patented. Use no water softener or soap with it. A dazzling clean wash with or without rinsing."

Detergent II contains thirty-four per cent keryl benzene sodium sulfonate.[8] The label on the container states that it has a "super-wetting action. Use alone- don't add soap or water softener. Save half your work- no rinsing needed."

Detergent III contains thirty-eight per cent nonylnaphthalene sodium sulfonate.[8] The label on the container states that it has a "miracle ingredient that floats dirt away. Cuts washday time in half! No rinsing needed."

Laundry Procedure

All but "0" samples (Table 1), without being subjected to any type of use were washed in a gyratator type electric home washer and ironed with a standard electric rotary ironer.

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[7] See Table 3 in appendix.

[8] "Synthetic Detergents for Home Laundering," Consumer's Research Bulletin, August 1950, p. 20.

The samples received a total number of thirty washings in soft[9] water of approximately the same temperature (120° F.) wash. A temperature of 120° F. was chosen because Watts[10] found that a stronger percale resulted when this temperature was used. Five tablespoons of detergent was used to each ten gallons of water because it was found by previous testing of different amounts of detergent that this amount would maintain a good suds throughout the washing time. The same treatment was given to each sample; the machine was run for three minutes after the detergent was added, then the samples were put in and washed for ten minutes. With the exception of samples marked "r" none were rinsed after washing. The samples were run through a wringer and hung on a cord line inside a room to dry. The control sample was washed in clear water for ten minutes on the same day the other samples were washed. After each washing and before they were completely dry all samples were ironed with a standard rotary ironer with the dial control set on "cotton". After each fifth washing strips were cut as shown in Fig. 1.

Tensile Strength

Tensile strength tests were made on all samples continuously the same day for both the warp and filling yarns after each fifth washing. Tensile strength tests were made

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[9]Chemical analysis of the water is given in Table 4 in the appendix.

[10]Watts, op. cit., p. 48.

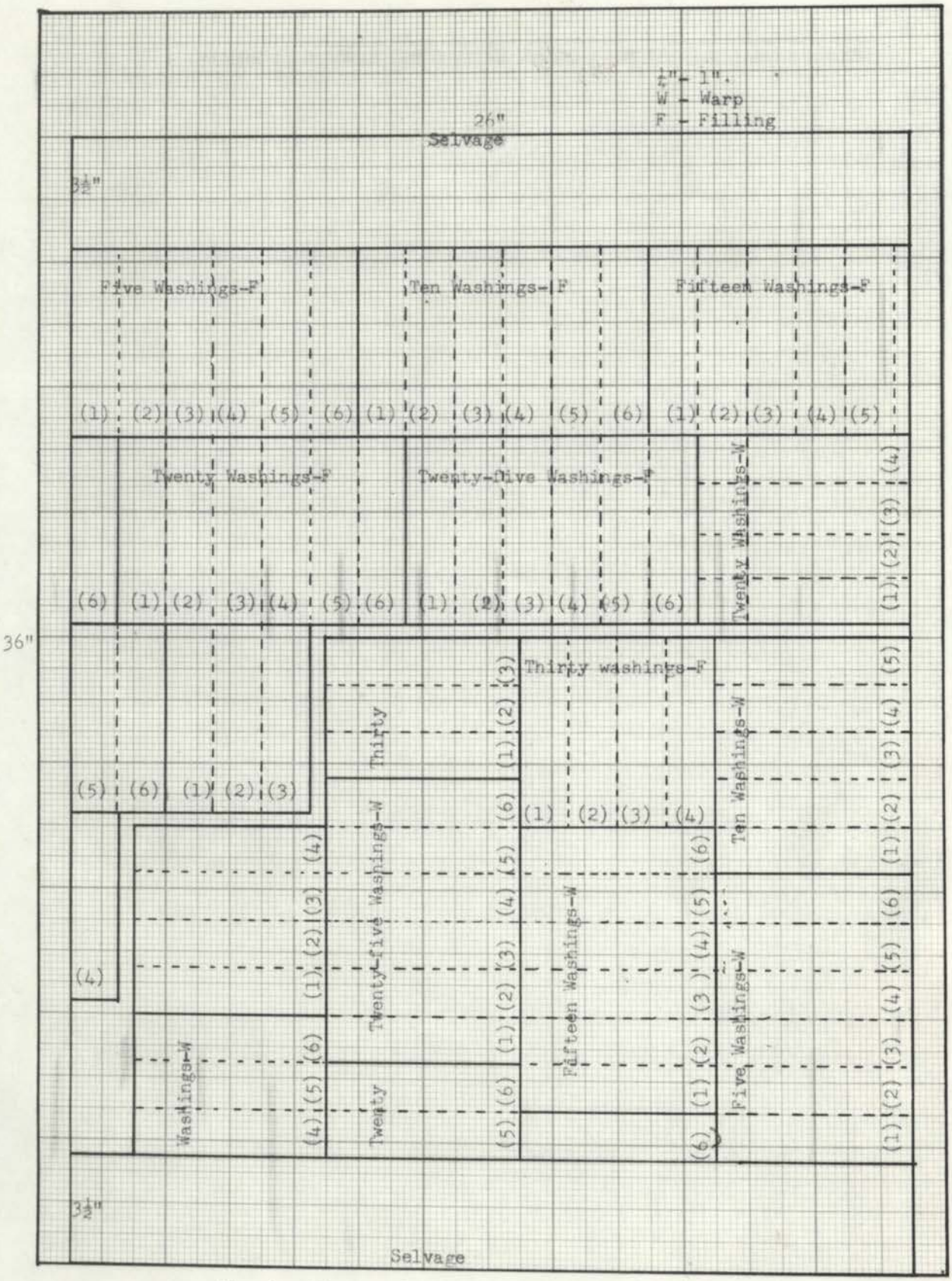

Fig. 1.--Diagram for cutting strips from the 3/4 yard samples.

using the raveled strip method.[11] A tensile testing machine conforming to the requirements of the Standard Specifications for Textile Testing machines (A.S.T.M. Designation: D 76) of the American Society for Testing Materials was used.[12] One sample of the original fabric was also tested for tensile strength of both the warp and filling yarns.

Since relative humidity and temperature of the room could not be controlled, the laboratory tests were made under ordinary room conditions at the same time of day on a sunny, dry afternoon. Samples from each washing process were tested continuously on the same day. Humidity records were obtained from the government records taken in Denton, Texas on each day the tensile strength tests were made. They appear in Table 7 in the appendix.

Thread Count

The Alfred Suter Thread Counter was used in making the thread count. The actual number of warp and filling yarns in one inch were counted in five or more places in the samples and the average number of yarns per inch calculated. No two spaces counted included the same yarns. The directions given for thread count in the A.S.T.M. Standards on Textile Materials were followed.[13] Thread counts were made on each fifth washing and on the original sample.

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[11] A.S.T.M. Standards on Textile Materials. A.S.T.M. Committee D-13. Philadelphia, Pennsylvania: American Society for Testing Materials, October 1946, p. 87.

[12] Ibid., p. 86.

[13] Ibid., p. 85.

RESULTS

Detergent I

Rinsed-Warp sample.--From Fig. 2 it is evident that the warp strength of the rinsed sample showed a gradual increase in tensile strength from 42.4 to 44.0 pounds, followed by a sudden drop to 40.0 pounds at the 30th washing. The rinsed sample followed the same pattern as the control (washed in clear water); that is, it showed increase or decrease in strength for the same tests, although it remained greater than the control until after the 30th washing when it was 1.2 pounds less.[14] Furthermore, both the rinsed and the control samples had less strength than the original (no water or detergent treatment) after the 30th washing, namely 2.4 and 1.2 pounds.

As seen in Fig. 3 the thread count of the warp thread in this sample increased after five washings above both the original and the control values, but after thirty washings it was equal to the control but less than the original.[15] This seemed to indicate that the changes in thread count have some relationship to the changes in tensile strength in that the strength decreased as the thread count lowered.

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[14]Data used in Fig. 2 are given in detail in Table 5 in the appendix.

[15]Data used in Fig. 3 are given in detail in Table 6 in the appendix.

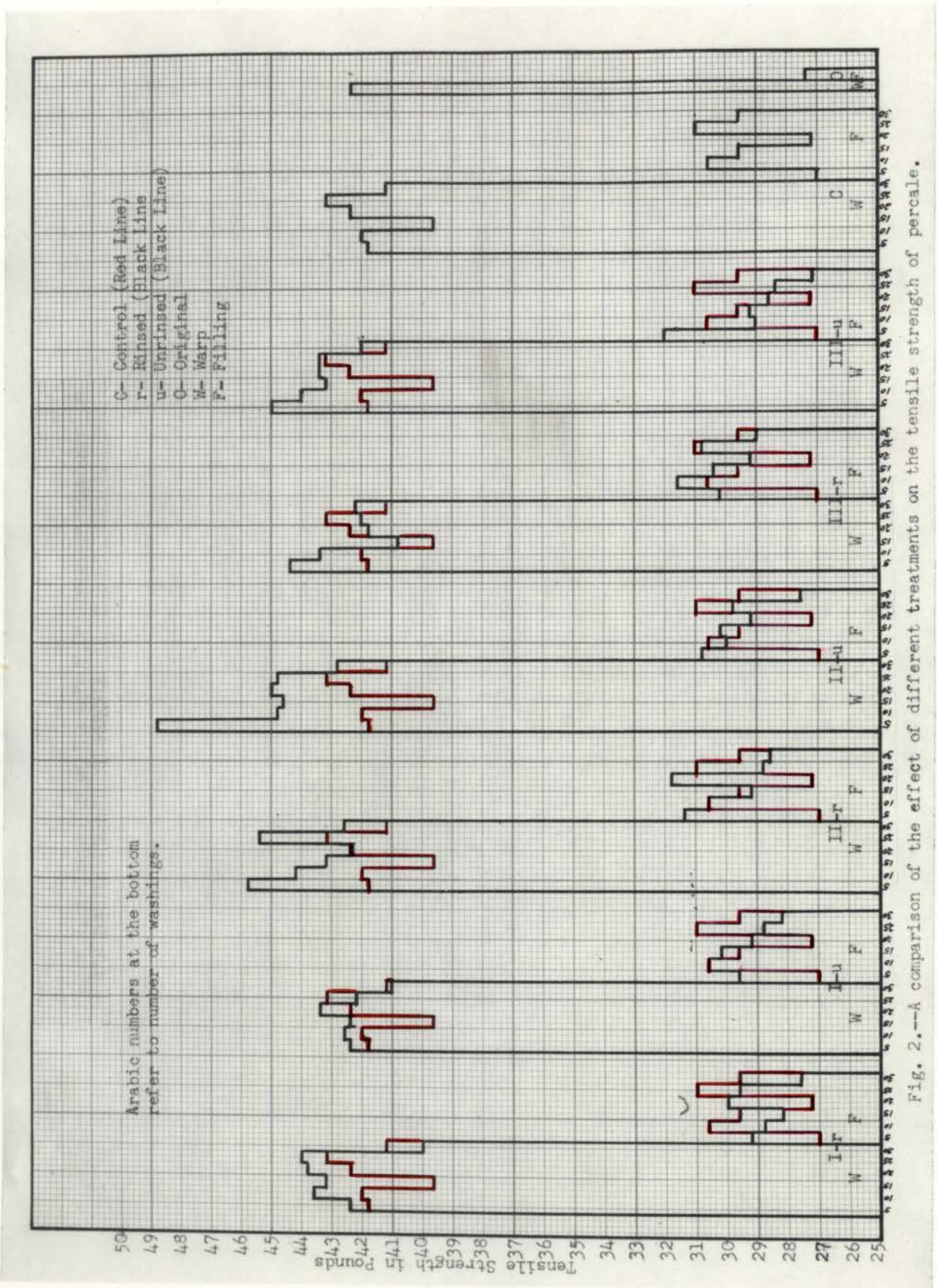

Fig. 2.--A comparison of the effect of different treatments on the tensile strength of percale.

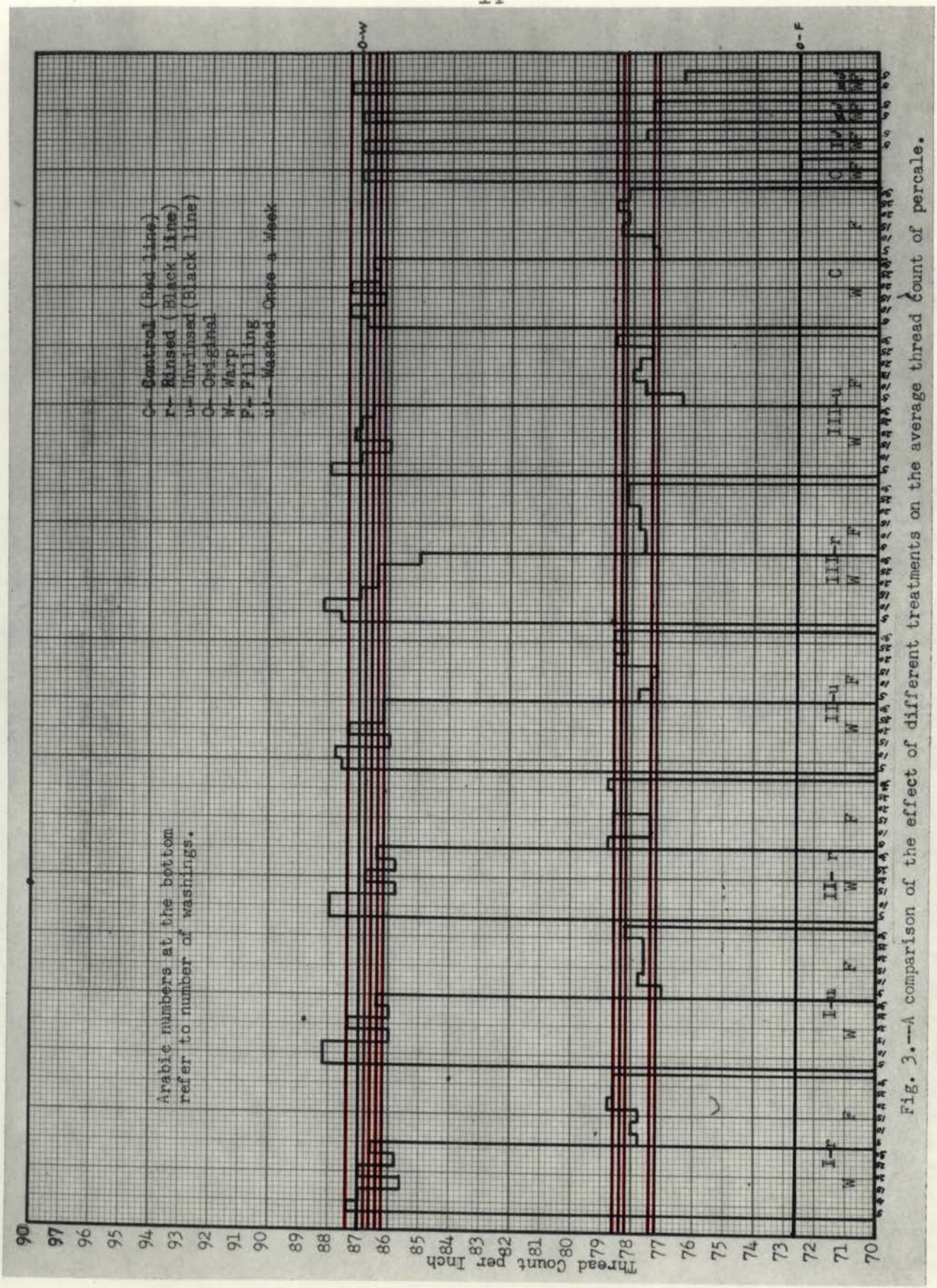

Fig. 3.--A comparison of the effect of different treatments on the average thread count of percale.

Unrinsed-Warp sample.--The warp strength of the unrinsed sample showed a gradual increase in tensile strength from 42.4 to 43.4 pounds followed by a sudden drop to 41.0 pounds after the 30th washing. The strength of this sample was greater than the control until the 25th and 30th washings when it dropped below the control 1.0 and 0.2 pounds, respectively. Furthermore, both the unrinsed and control samples had less strength than the original after the 30th washing, namely 1.4 and 1.2 pounds.

After the 20th washing thread count increased in all samples causing an increase in strength at the same time. Thread count was highest after the 5th and 10th washings, thereafter it showed a decrease. After the 30th washing the thread count was lower than either the original or the control.

As shown in Table 2 the unrinsed sample which was washed once each week for five weeks gained 0.6 pounds more strength than the unrinsed sample after five washings. This may be due to the fact that there was more time for fiber change between washings.

The sample washed in this detergent once a week for five weeks had the same count as the original, a higher count than the control, and a lower count than the corresponding unrinsed sample after five washings.

Rinsed-Filling sample.--The filling strength of the rinsed sample showed a continuous drop in tensile strength

from 29.2 to 28.2 pounds followed by an increase to 30.0 pounds after which it dropped to 27.6 pounds following the 30th washing. The strength of this sample was greater than the control at the 20th washing, then after the 25th and 30th washings it had less strength 1.2 and 2.0 pounds, respectively. Both the rinsed and control samples had greater strength than the original after thirty washings, namely 0.2 and 2.2 pounds.

The high strength recorded for this sample after the 20th washing could be due to the high thread count which also occurred at this same time. The thread count in the filling direction showed an enormous increase after the 5th washing because of shrinkage, 5.2 threads per inch. It then showed a gradual increase after succeeding washings.

Unrinsed-Filling sample.--As seen in Fig. 2 the filling strength of the unrinsed sample increased in tensile strength from 29.6 to 30.6 pounds followed by a continuous decrease to 28.2 pounds in the 30th washing. This sample showed greater strength than the control until after the 25th and 30th washings where it was 2.2 and 1.2 pounds less, respectively. Furthermore, both the unrinsed and control samples had greater strength than the original after thirty washings, namely 0.8 and 2.2 pounds.

The thread count seemed to be in direct contrast to tensile strength. Highest thread count was recorded after the 30th washing and the lowest strength was recorded at this

same time. Thread count of this sample was greater than the original and equal to the control after thirty washings.

According to Table 2 the unrinsed sample washed once each week for five weeks had 0.6 pounds less strength than the unrinsed sample after five washings.

The sample washed only once a week in this detergent had a higher count than the original, the control, or the corresponding unrinsed sample after five washings.

TABLE 2

THE AVERAGE TENSILE STRENGTH OF THE UNRINSED SAMPLES FROM EACH DETERGENT AS COMPARED WITH THOSE WASHED ONLY ONCE EACH WEEK

Detergent	Tensile Strength of Warp			Tensile Strength of Filling		
	u[a] Pounds	u'[b] Pounds	Difference in Pounds	u Pounds	u' Pounds	Difference in Pounds
I	42.4	43.0	+0.6	29.6	29.0	-0.6
II	48.4	45.6	-2.8	30.8	30.2	-0.6
III	45.0	45.2	+0.2	32.0	29.0	-3.0

[a]Unrinsed.

[b]Unrinsed, but washed only once each week.

Detergent II

Rinsed-Warp sample.--As shown in Fig. 2 the tensile strength of the rinsed sample decreased from 45.8 to 42.4 pounds, followed by a sudden increase to 45.4 pounds then a

decrease to 42.6 pounds after the 30th washing. After all washings this sample had greater strength than the control showing 1.4 pounds more strength after the 30th washing. The original sample had 0.2 pounds less than the rinsed and 1.2 pounds more strength than the control.

The thread count had no direct relation to tensile strength for this sample. The high tensile strength recorded after the 25th washing is in direct contrast to the low thread count. After thirty washings the count was lower than both the control and the original samples.

Unrinsed-Warp sample.--The tensile strength of the unrinsed sample gradually decreased in strength from 48.8 to 42.8 pounds after the 30th washing. It remained stronger than the control after all washings showing 1.6 pounds more strength after the 30th washing. The original sample had 0.4 pounds less than the unrinsed and 1.2 pounds more than the control.

The thread count showed no direct relation to the tensile strength of this sample. The thread count decreased from a point well above both the control and original samples after five washings to a point below both after thirty washings.

The unrinsed sample was 2.8 pounds stronger after five washings than that which had been washed only once each week for five weeks as seen in Table 2.

The thread count in the sample washed only once a week was equal to the original and lower than the corresponding

unrinsed sample after five washings.

Rinsed-Filling sample.--According to Fig. 2 the rinsed sample decreased in tensile strength from 31.4 to 29.2 pounds followed by a sudden increase to 31.8 pounds then dropping to 28.6 pounds after the 30th washing. The strength of this sample was greater than the control at the 20th washing after which it dropped 2.2 and 1.0 pounds below the control after the 25th and 30th washings, respectively. After the 30th washing both the rinsed and the control samples had greater strength than the original, namely 1.2 and 2.2 pounds.

The thread count and the tensile strength reached high points after the 20th washing, otherwise they were in direct contrast. Recorded thread count was the same after thirty washings as after five washings, although both were well above the control and the original samples.

Unrinsed-Filling sample.--The filling strength of the unrinsed sample showed a gradual decrease in tensile strength from 30.8 to 27.6 pounds after the 30th washing. This sample showed greater strength than the control after the 20th washing but decreased to 1.2 and 2.0 pounds less than the control after the 25th and 30th washings, respectively. Furthermore, both the unrinsed and the control samples had greater strength than the original after thirty washings, namely 0.2 and 2.2 pounds.

Figures 2 and 3 indicate that no direct relationship

existed between thread count and tensile strength. The thread count was higher than both the original and the control after thirty washings in contrast with the decrease in strength of the samples.

After five washings the unrinsed sample was 0.6 pounds stronger than the unrinsed which had been washed once each week.

The sample washed only once each week had a higher thread count than the original, but a lower count than both the control and the corresponding unrinsed samples after the same number of washings.

Detergent III

Rinsed-Warp sample.--The tensile strength of the rinsed sample decreased from 44.4 to 40.8 pounds followed by a gradual increase to 42.2 pounds after the 30th washing. This sample had less strength than the control after the 20th and 25th washings, when it showed an increase of 1.0 pounds over the control. Both the rinsed and control samples had less strength than the original, namely 0.2 and 1.2 pounds.

No direct relationship is shown in Figures 2 and 3 between thread count and tensile strength. The thread count was higher after five and ten washings; then gradually decreased until it was lower than that of the original, the control, and all the other samples tested after thirty washings.

Unrinsed-Warp sample.--According to the evidence in Fig. 2 the tensile strength of the unrinsed sample gradually decreased from 45.0 to 42.0 pounds after the 30th washing. It had greater strength than the control after each washing, showing an 0.8 pound greater strength after the 30th washing. Furthermore, both the unrinsed and control samples had less strength than the original, namely 0.4 and 1.2 pounds.

The thread count followed almost the same pattern as the tensile strength; that is, it showed increase or decrease after the same washings. After five washings the count decreased from a point well above both the control and original samples to a point equal to the control, but below the original.

As seen in Table 2 the unrinsed sample had 0.2 pounds less strength after five washings than that which was washed only once each week.

The sample washed once each week in this detergent had a higher thread count than the control and original, but a lower count than the corresponding unrinsed sample after five washings.

Rinsed-Filling sample.--The filling strength of the rinsed sample showed an increase from 30.2 to 31.6 pounds followed by a decrease to 29.2 pounds, then an increase to 30.8 in the 25th washing, and a decrease to 29.0 pounds after the 30th washing. This sample followed the same pattern as the control, although it had greater strength

until the 25th and 30th washings where it showed a less strength of 0.2 and 0.6 pounds, respectively. Both the rinsed and the control samples had more strength than the original after the 30th washing, namely 1.6 and 2.2 pounds.

No direct relationship was apparent between thread count and tensile strength. After thirty washings thread count was higher than the original and equal to the control.

Unrinsed-Filling sample.--The unrinsed sample showed a gradual decline in tensile strength from 32.0 to 27.2 pounds after the 30th washing. This was 2.6 and 2.4 pounds less in strength than the control in the 25th and 30th washings, respectively. The unrinsed sample had 0.2 pounds less, and the control had 2.2 pounds more strength than the original.

There was a direct relationship between thread count and tensile strength. After thirty washings the thread count was higher and the tensile strength was lower than both the original and the control samples.

According to Table 2 the unrinsed sample had 3.0 pounds more strength after five washings than that which was washed only once each week.

The sample washed once each week for five weeks in this detergent had a lower thread count than the control, but a higher count than both the original and the corresponding unrinsed sample after five washings.

Humidity

When tensile strength figures are given it is assumed that determinations were made in standard conditions of 65 per cent relative humidity at 70° F.[16] According to Hartsuch[17] the moisture in the atmosphere where the test is made influences the strength of textile fibers; and cotton is the only fiber that gains strength when it is wet. Fabrics do change their moisture content as the atmosphere changes. They absorb or give off moisture as the humidity rises or falls.[18]

Since this study could not be made under standard conditions of humidity and temperature a discussion of the relationship of humidity to tensile strength is included here.

The humidity was high (75 per cent) when samples from the 5th washing were tested. Since the recorded warp tensile strength (See Fig. 2) was extremely high for both the rinsed and unrinsed samples for detergents II and III, this was probably not due to humidity, because samples from detergent I and the control, tested at the same time, showed no unusual strength. After the 25th washing unusual strength was shown for the rinsed sample of detergent II and for the control.

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[16] A.S.T.M., op. cit., p. 84.

[17] Bruce M. Hartsuch, Introduction to Textile Chemistry, p. 109.

[18] A. S. T. M., A Primer of Textile Testing and Standards for Textile Testing, p. 19.

Humidity was also higher that day as seen in Table 7 in the appendix.

Both rinsed and unrinsed samples from detergents II and III which were tested after the 5th washing when the humidity was high showed high strength, which may be due to humidity. The unusual strength shown in the rinsed samples of detergents I and II after the 20th washing was not due to humidity because it was low (27 per cent) that day.

The difference in the results of the 15th and 20th washings for both warp and filling strengths was not due to humidity because the humidity recorded was the same for both of these test days. The sudden drop in both the warp and filling strengths for the majority of the samples from the 25th to the 30th washings was not due to the humidity because tensile strength tests were made for both washings continuously on the same day and the humidity was 56 per cent, which was high.

DISCUSSION

In order to know what to recommend or use in teaching laundering, samples from cotton percale were washed in three "no-rinse" detergents thirty times. Half of the samples were rinsed after each washing; the others were left unrinsed. The control was washed in clear water thirty times, while the original sample remained untreated. Tensile strength tests and thread counts were made after each five washings.

After thirty washings with detergents II and III the warp yarns of both the rinsed and unrinsed samples had greater tensile strength than the control, but lower tensile strength than the warp yarns washed in detergent I. The use of these detergents, whether rinsed or unrinsed, increased the tensile strength of warp yarns in the percale above the increase caused by water alone. The non-rinsing process resulted in greater warp strength in the percale washed in detergents I and II, while the warp yarns in the rinsed sample had more strength with detergent III. Since both detergent II and III were sodium sulfonates and detergent I was a sulfated alcohol, the difference in the results would not be due to their contents. Thread count of the warp in the rinsed sample for detergent I was equal to the control, but the count was lower for detergents II and III,

indicating that this was not responsible for the low strength of the warp yarns in samples washed in detergent I. The unrinsed sample had a lower thread count in the warp when washed in detergents I and II, but a higher count after washing in detergent III, indicating that the strength of those washed in detergent II was not due to a higher thread count, but the strength of those washed in detergent III might be attributed to the higher thread count. In general, the thread count of the warp yarns gradually decreased as the tensile strength decreased.

After thirty washings both the rinsed and unrinsed filling yarns of samples washed in each detergent showed less tensile strength and a higher thread count than the control. In general, the result of the use of the synthetic detergents, whether rinsed or unrinsed, decreased the filling strength of all the samples below that caused by water alone. The tensile strength of the filling yarns was greater for those samples washed in detergents II and III and rinsed, but lower for those washed in detergent I. The effect of the detergents on the tensile strength of the filling yarns in all samples, rinsed or unrinsed, was greater than on the tensile strength of the warp yarns. Thread count taken in the filling direction showed greatest increase up to five washings gradually gaining until the highest count for all samples was reached after the 20th to 30th washings. In these results, thread count did not seem to have much relationship to the tensile strength.

Percale washed in detergent II, whether rinsed or unrinsed, had a greater warp strength as compared with the original than that washed in detergents I and III, but the percale washed in detergent III had a greater filling strength as compared with the original and those washed thirty times in detergents I and II.

The results indicate that humidity may have had some effect on the tensile strength, although, the differences in the results of tests for the 15th and 20th washings could not be attributed to humidity because it was the same for both of those days. Furthermore, the differences in the strength of the 25th and 30th washings could not be due to humidity because tensile tests for both were made on all samples for all detergents continuously at the same time of the same day.

After thirty washings with detergents I and II the results of the non-rinsing process showed an increased tensile strength in the warp yarns, but a decrease in the filling yarns. Whereas, the results of the non-rinsing process showed a decrease in the warp yarns, but an increase in the filling yarns of the samples washed in detergent III. This study showed that the process of rinsing or non-rinsing did not seem to make much difference in the tensile strength of the whole sample, but many more tests would need to be made before any valid conclusions might be drawn.

In general, the greatest loss of tensile strength for both warp and filling occurred after the 25th and 30th

washings, thereby confirming Pearson's[19] conclusion that fabrics should be subjected to many more than twenty washings before valid conclusions could be drawn.

The greatest increase in tensile strength in warp yarns was exhibited after the 5th washing for the warp samples in detergents II and III and for the filling after the 5th and 10th washings in all detergents. This is comparable to the results obtained with soapless detergents by Wallace[20] for cotton and linen towels, and by Sowell[21] for cotton towels even though humidity was controlled for these and the humidity in this study was not controlled.

In this study the white percale, washed thirty times in each of the detergents, rinsed or unrinsed, showed no appreciable color change which could be detected with the eye. These results were different from those reported by Consumers Union[22] which stated that the unrinsed pillow cases were not as white as those which had been rinsed. Since the reflectometer was used by Consumers Union and no such tests were made for color change in this study no valid conclusions may be drawn here.

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[19]Pearson, op. cit., p. 30.

[20]Wallace, op. cit.

[21]Sowell, op. cit.

[22]"Synthetic Detergents," Consumer Reports, February 1951, p. 53.

SUMMARY

Interest in the new detergents and the new non-rinsing procedure led to the development of this problem, in order to know what to teach high school homemaking students regarding it. The results of this study show that there is a tendency for the tensile strength to increase up to five or ten washings and then to decrease, but even after thirty washings it showed greater strength than the control which was washed in water alone.

There would be an advantage in using the non-rinsing procedure in home laundering in that it would save time, work, and water.

From the housewife's standpoint there was no appreciable difference in color in the white percale used and there was no yellowing of the unrinsed samples, except in the case of the control which was washed thirty times in clear water. This yellowing was due, possibly, to the minerals in the water.[23] As far as tensile strength and thread count is concerned the non-rinsing procedure may be safely recommended to homemaking students and homemakers, but there may be other effects of non-rinsing which are not covered in this study.

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[23]Chemical analysis of water is given in the appendix.

The samples which were washed at weekly intervals for five times more nearly simulated home washing conditions, but were not washed enough times to draw any valid conclusions. The holding-over period of one week may make a difference, thus, more work needs to be done on this phase of the non-rinsing procedure before any further recommendations can be made to the housewife.

APPENDIX

TABLE 3

CHEMICAL ANALYSES OF SYNTHETIC DETERGENTS TESTED*

Detergent	Identification of Detergent		Sodium Sulfate	Sodium Carbonate	Sodium Chloride	Sodium Phosphates		Sodium Silicates	CMC	PH	Flourescent Dye
		%	%	%	%	%		%	%		
I	(1)	20	17	0.8	0.7	Di Tripoly Pyro	10.9 23.7 15.8	3.6	0.3	9.7	Present
II	(2)	34	28	2.8	0.4	Tri	12.8	8.4	0.3	10.1	Present
III	(3)	38	0.6	...	2.9	Di Tripoly Pyro	2.2 2.6 33.7	...	0.2	8.6	Present

Detergent III contained 10.3% magnesium sulfate ∕0.3% matter insoluble in water(filler).

(1). Sodium salt of sulfated alcohols.
(2). Keryl benzene sodium sulfonate.
(3). Nonylnaphthalene sodium sulfonate.

*"Synthetic Detergents for Home Laundering," Consumers' Research Bulletin, August 1950, p. 20.

TABLE 4

AVERAGE CHEMICAL ANALYSIS OF DENTON WATER*

Element	P.P.M.
pH	8.85
Silica residue	18.70
Total hardness	12.00
Calcium	2.72
Sodium (calc.)	163.00
Potassium	1.80
Carbonate	50.50
Sulphate	98.00
Phosphate	.21
Total solids	588.00
Total alkalinity	348.00
Carbonate hardness	4.10
Magnesium	5.70
Sodium (detr.)	188.00
Fe and Al	15.60
Bicarbonate	301.00
Chloride	27.70

*Courtesy of Dr. J.K.G. Silvey, Professor of Biology and Chairman of the Division of Science, North Texas State College, Denton, Texas.

TABLE 5

AVERAGE TENSILE STRENGTH OF PERCALE BEFORE AND AFTER WASHING

Washing Number	I-r		I-u		II-r		II-u		III-r	
	W	F	W	F	W	F	W	F	W	F
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
5	42.4	29.2	42.4	29.6	45.4	31.4	48.4	30.8	44.4	30.2
10	43.6	28.8	42.6	30.6	44.2	30.6	44.8	30.0	43.4	31.6
15	43.2	28.2	42.4	30.2	43.2	29.2	44.6	30.2	40.8	30.4
20	43.8	30.0	43.4	29.2	42.4	31.8	45.0	29.2	41.8	29.2
25	44.0	29.6	42.2	28.8	45.4	28.8	44.8	29.8	42.0	30.8
30	40.6	27.6	41.0	28.2	42.6	28.6	42.8	27.6	42.2	29.0

TABLE 6

AVERAGE NUMBER OF THREADS PER INCH BEFORE AND AFTER WASHING

Washing Number	I-r		I-u		II-r		II-u		III-r	
	W	F	W	F	W	F	W	F	W	F
5	87.4	77.8	88.2	77.0	88.0	78.8	87.6	77.8	87.6	77.6
10	87.0	78.0	88.2	77.8	88.0	77.4	87.8	77.4	88.2	77.6
15	85.6	77.8	86.0	77.6	85.8	77.4	86.0	77.2	87.0	77.8
20	87.0	78.8	87.4	77.6	86.8	78.6	87.4	78.6	86.4	77.8
25	85.8	78.6	86.0	77.6	85.8	78.6	86.2	78.2	86.4	78.2
30	86.6	78.6	86.4	78.2	86.4	78.8	86.2	78.6	85.0	78.2

I- detergent number.
r- rinsed sample.
u- unrinsed sample.
W- warp sample.
F- filling sample.

TABLE 5--Continued

III-u		C		I-u'		II-u'		III-u'		O	
W	F	W	F	W	F	W	F	W	F	W	F
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
45.0	32.0	41.8	27.0	43.0	29.0	45.6	30.2	45.2	29.0	42.4	27.4
44.0	29.0	42.0	30.6	....	....	....	....	....	....	....	....
43.2	29.2	39.6	29.6	....	....	....	....	....	....	....	....
43.4	28.6	42.4	27.2	....	....	....	....	....	....	....	....
43.4	28.4	43.2	31.0	....	....	....	....	....	....	....	....
42.0	27.2	41.2	29.6	....	....	....	....	....	....	....	....

TABLE 6--Continued

III-u		C		I-u'		II-u'		III-u'		O	
W	F	W	F	W	F	W	F	W	F	W	F
88.0	76.4	86.8	77.2	87.0	77.6	87.0	77.4	87.4	76.4	87.0	72.6
87.0	77.6	87.4	77.4	....	....	....	....	....	....	....	....
86.0	78.0	86.2	78.4	....	....	....	....	....	....	....	....
87.2	77.8	87.4	78.2	....	....	....	....	....	....	....	....
87.0	77.4	86.4	78.6	....	....	....	....	....	....	....	....
86.6	78.6	86.6	78.2	....	....	....	....	....	....	....	....

I- detergent number.
u- unrinsed sample.
W- warp sample.
F- filling sample.
u'- unrinsed sample washed once each week.
C- control.
O- original sample without treatment.

TABLE 7

TEMPERATURE AND RELATIVE HUMIDITY DATA*

Washing	Date	Temperature	Relative Humidity
		F.	%
5	April 6	77°	75
10	April 9	75°	31
15	April 13	72°	27
20	April 17	76°	27
25	April 22	74°	56
30	April 22	74°	56
5(u')	May 3	90°	21

*Courtesy of Official U.S. Weather Observer, Texas Agricultural Experiment Station, Substation No. 6, Denton, Texas.

PLATE 1

AFTER FIVE WASHINGS

Detergent I

Rinsed

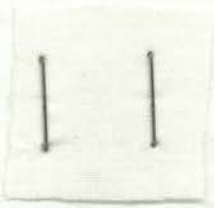
Unrinsed

Unrinsed (washed once a week)

Detergent II

Rinsed

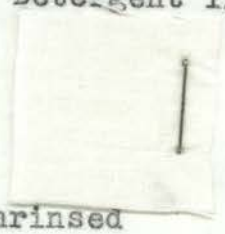
Unrinsed



Unrinsed (washed once a week)

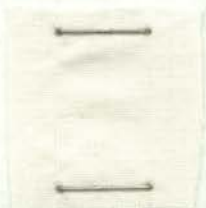
Detergent III

Rinsed



Unrinsed

Unrinsed (washed once a week)



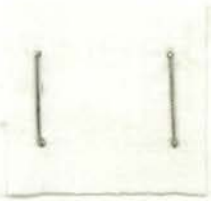
Control (washed in water only)

Original

PLATE 2

AFTER TEN WASHINGS

Detergent I



Rinsed

Unrinsed

Detergent II

Rinsed

Unrinsed

Detergent III

Rinsed

Unrinsed

Control

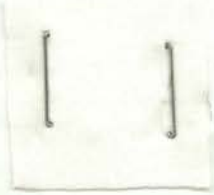
Original

PLATE 3

AFTER FIFTEEN WASHINGS

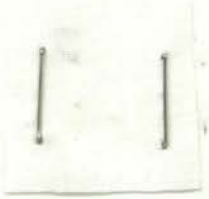
Detergent I

Rinsed

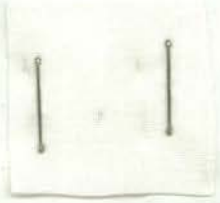


Unrinsed

Detergent II



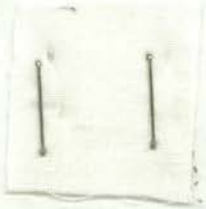
Rinsed



Unrinsed

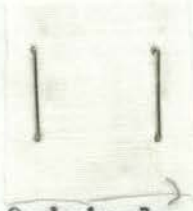
Detergent III

Rinsed



Unrinsed

Control



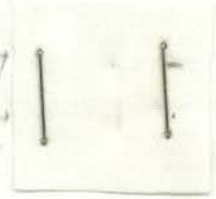
Original

PLATE 4

AFTER TWENTY WASHINGS

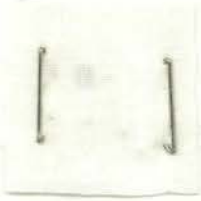
Detergent I

Rinsed



Unrinsed

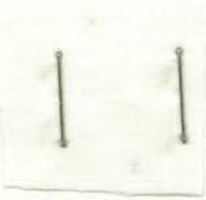
Detergent II



Rinsed

Unrinsed

Detergent III



Rinsed

Unrinsed

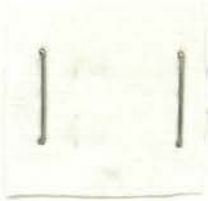
Control

Original

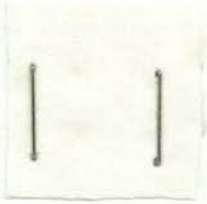
PLATE 5

AFTER TWENTY-FIVE WASHINGS

Detergent I

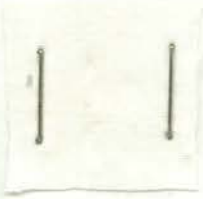


Rinsed



Unrinsed

Detergent II



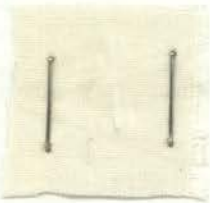
Rinsed

Unrinsed

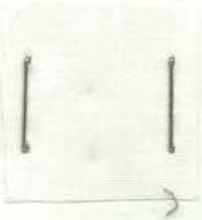
Detergent III

Rinsed

Unrinsed



Control



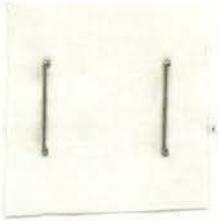
Original

PLATE 6

AFTER THIRTY WASHINGS

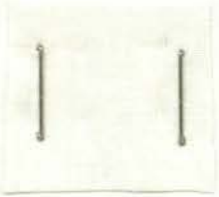
Detergent I

Rinsed

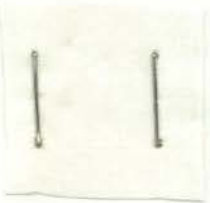


Unrinsed

Detergent II



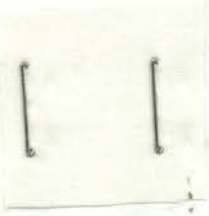
Rinsed



Unrinsed

Detergent III

Rinsed



Unrinsed

Control

Original

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