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CONTENTS OF VOLUME 19

Page

273. Performance Tests of a Liquid Laundry Soap Used With Textile Materials ..... *F. R. McGowan, F. W. Smither, and Charles W. Schoffstall* 1
274. Use of United States Government Specification Paints and Paint Materials ..... *P. H. Walker and E. F. Hickson* 27
275. Design of Specimens for Short-Time "Fatigue" Tests ..... *L. B. Tuckerman and C. S. Aitchison* 47
276. Compressive Strength of Sand-Lime Brick Walls ..... *H. L. Whittemore and A. H. Stang* 57
277. Comparative Wearing Qualities of Pima and Ordinary Cotton Used in Mail Bags ..... *F. R. McGowan, Charles W. Schoffstall, and A. A. Mercier* 73
278. Effect of Twist on the Physical Properties of a Number 7s Yarn ..... *F. R. McGowan, Charles W. Schoffstall, and A. A. Mercier* 85
279. Testing of Fire-Clay Brick with Special Reference to Their Use in Coal-Fired Boiler Settings ..... *R. F. Geller* 97
280. Reclamation of Gasoline Used in Dry Cleaning ..... *C. C. Hubbard* 141
281. Malleability and Metallography of Nickel ..... *P. D. Merica and R. G. Waltenberg* 155
282. Technology of Cotton Machinery. Part I.—Calculations on Pickers ..... *A. A. Mercier* 183
283. Effect of Tire Resistance on Fuel Consumption ..... *W. L. Holt and P. L. Wormeley* 213
284. A Study of the Seasonal Variation of Radio-Frequency Phase Difference of Laminated Phenolic Insulation Materials ..... *J. L. Preston and E. L. Hall* 225
285. Release of Internal Stress in Brass Tubing ..... *Robert J. Anderson and Everett G. Fahlman* 235
286. Comparative Durability of Chrome and Vegetable Tanned Sole Leathers ..... *R. C. Bowker and M. N. V. Geib* 267
287. A Hot-Wire Anemometer for Measuring Air Flow Through Engine Radiators ..... *Carl G. F. Zobel and L. B. Carroll* 287
288. Comparative Cold-Rolling Tests of Open-Hearth Steel Strip (Deep-Drawing Stock) and Electrolytic-Iron Strip ..... *John R. Freeman, jr., and R. D. France* 297
289. Comparative Slow Bend and Impact Notched Bar Tests on Some Metals ..... *S. N. Petrenko* 315
290. The Relation Between Heating Value of Gas and Its Usefulness to the Consumer. A Critical Review of the Published Data ..... *E. R. Weaver* 347
291. Tests of Hollow Tile and Concrete Slabs Reinforced in One Direction ..... *Douglas E. Parsons and Ambrose H. Stang* 465
292. Relative Merits of Cotton and Jute Cement Sacks ..... *Robert J. Morris* 515

Page

293. Condensation of Water from Engine Exhaust for Airship Ballasting ---------- *Robert F. Kohr* 537
294. Wearing Qualities of Tire Treads as Influenced by Reclaimed Rubber ---------- *W. L. Holt and P. L. Wormeley* 579
295. Initial Temperature and Mass Effects in Quenching ---------- *H. J. French and O. Z. Klopsch* 589
296. Flow in a Low-Carbon Steel at Various Temperatures ---------- *H. J. French and W. A. Tucker* 619
297. A Statistical Study of Conditions Affecting the Distance Range of Radio Telephone Broadcasting Stations ---------- *C. M. Jansky, jr.* 641
298. Radio-Frequency Resistance and Inductance of Coils Used in Broadcast Reception ---------- *August Hund and H. B. De Groot* 651
299. Dielectric Constant, Power Factor, and Resistivity of Rubber and Gutta-Percha ---------- *H. L. Curtis and A. T. McPherson* 669
300. Development of a Standard Bending Test for Rope Yarns ---------- *Charles W. Schoffstall and Robert C. Boyden* 723
301. A Comparative Study of Paper Fillers ---------- *Merle B. Shaw and George W. Bicking* 733

I. INTRODUCTION

The performance of a washing or scouring agent is of specific interest to both manufacturer and user of textile materials, for it directly affects the utility of the textile material to a large extent. While its cleansing property is a primary factor in the selection of a laundry soap, there are a number of other characteristics which are desirable. The laundry agent is most efficient when, with the greatest economy of materials and time, the fabric is restored to its original state without impairing its color, appearance, or feel.

The bureau realized that a complete research on laundry washing agents would be impracticable at this time. The tests herein reported were made primarily for the War Department, and the results would form a useful part of the data in the fuller investigation. Since three independent full scale practical tests under service conditions in Government laundries resulted in favorable reports, it is believed that the publication of this report of the bureau's tests would be of immediate service to laundry owners and housewives.

Some of these characteristics are more important than others, depending on the point of view. The housewife may be willing to neglect the time factor and to some extent the saving in laundry materials if by so doing the color of the garment is not changed or the garment does not shrink too much. The manufacturer may insist, along with a minimum of shrinkage, that the appearance and feel of the cloth be unchanged or improved, and that the economy of time and materials be a maximum.

The War Department requested this bureau to investigate the properties of a liquid laundry soap to determine its utility as a cleansing agent for their purposes. In order to do this it was necessary to plan a comprehensive program, which included tests on performance and economy both as a washing and a scouring agent in comparison with other laundry soaps and scouring agents.

II. PURPOSE

The purpose of this investigation was to compare the properties of a liquid laundry soap with other washing and scouring agents with respect to (*a*) shrinkage in dimensions, (*b*) shrinkage in weight, (*c*) effect on the fastness of dyes to washing, and (*d*) appearance and feel after scouring.

III. APPARATUS, MATERIALS, AND GENERAL CONSIDERATIONS OF THE STUDY

1. APPARATUS

The apparatus used were two wooden laundry machines, 24 inches wide by 24 inches diameter, with a capacity of 3 to 10 pounds per operation. The speed of the machine was 25 r. p. m.

2. MATERIALS WASHED OR SCOURED

The materials washed were cotton knit underwear, cotton knit tubing, lightweight wool fabrics, and wool (cotton warp) blankets. The materials scoured were mohair yarns, wool tops, and raw (Utah) wool.

3. WASHING AND SCOURING AGENTS

The cleansing agents used were as follows: For washing—liquid laundry soap, washing soap, washing soap and soda ash; for scouring—liquid laundry soap, washing soap, vegetable oil-soda soap, olive-oil soap, olive-oil soap and soda ash. In several cases the material was run with plain water, using no washing or scouring agent, so that the effect of the different temperatures and the pounding action of the wheel could be noted.

4. ANALYSIS OF SOAPS USED

Liquid laundry soap was made up of a solution of suitable oil-potash soap containing about 15 per cent of organic volatile solvent and about 25 per cent of an anhydrous soap. It contained no insoluble matter or free alkali, and only traces of carbonated alkali and chloride.

Granulated soap was a soap containing not less than 95 per cent of a soda-tallow soap, not more than 0.5 per cent of free alkali, nor more than 3 per cent of carbonated alkali or silicate plus chloride, and practically no insoluble matter.

Olive-oil soap, which is the trade name for Castile soap, was a soda soap made from olive-oil foots.

Vegetable oil-soda soap, as mentioned in this report, contained a little coconut oil.

Soda ash was the commercial 58 per cent soda ash.

Results of a bacteriological examination made by the Bureau of Chemistry, Department of Agriculture, show that the liquid laundry soap kills *B. typhosus* in 10 minutes in dilution 1 to 5 (R. W. method modified).

5. LAUNDRY PRACTICE

It will be noted in this report that no reference is made to a standard laundry practice. It is not believed that such a practice exists to-day because of the fact that different garments have their peculiarities which warrant changes either in temperature, time in solution, or type of washing, according to fiber composition, construction, color, or use. It is also true that in different parts of the country and for different hardnesses of water the amounts of cleansing compounds added vary considerably. The tests made for this report have been both mild and severe to include the majority of these different laundry practices which might be found throughout the country.

6. APPLICATION OF AGENTS TO WHEEL

In all instances in applying the agent to the wheel care was taken to place the soaps in solution in beakers before applying. This was found to be necessary even in the case of granulated soaps, which took from 15 to 30 minutes for complete disappearance of soap particles. It was thought that this was necessary, as direct application to the wheel would cause soap streaks. In applying the liquid laundry soap it was found that a very quick and uniform solution was formed. In all instances the wheels were turned over before loading to obtain uniform suds and thorough mixing.

7. EFFECT OF LONG TESTS USING SOAPS

Reference is made to the seven-hour test on wool cloth where it was desired to obtain information on the effect of repeated washing or long washing on the color of the material. Because of the excess amount of suds which formed in the wheel and flowed over when using washing soap, the water in the wheel was reduced to such an extent that additional water had to be added on three occasions. This is, perhaps, an instance where close observations should be kept on wheels using washing soap. It might be said that for continuous washings the levels of the water are decreased, which, in turn, changes the amount of pounding in the wheel, producing an uncontrollable variable in washing.

8. ALKALINITY

Because of the fact that excess amounts of alkali when applied to woolen fabrics have a weakening effect, it is usual in scouring and washing to have the washing bowl as free as possible from excess alkalinity, which warrants the use of neutral soap. Observations were made throughout these tests of the alkalinity of each washing. In all instances where olive-oil soap, washing soap, and combinations of washing soap and soda ash were used, alkalinity was noted, including rinses, which numbered as high as four in some cases. Observations made both on the bowl itself and in the rinse for liquid laundry soap showed a neutral solution. Tests for alkalinity of the Utah wool itself showed alkalinity on the tips of the fleece. When washed with liquid laundry soap the test for alkalinity of the solution was shown to be negative. However, it was not possible to obtain a neutral solution with the addition of a very small amount of soda ash. In using the ordinary scouring compounds and adding an amount of liquid laundry soap equal to the sample extracted, it was noted in the third and fourth rinses that it was not possible to eliminate the alkali. This is probably because of the great affinity of wool for alkali.

9. CONDITION OF WHEEL

Two separate wheels were used in making these laundry tests. One wheel was kept for washing with liquid laundry soap and another for other soaps. Observations after the wheels had been allowed to stand a period of two weeks showed a very clean wheel for liquid laundry soap, while the wheel used for the other soaps showed a precipitation or coating of a white substance, an accumulation of which is very objectionable in laundries and which is termed "fouling."

10. FILE OF REFERENCE SAMPLES

Complete reference specimens have been prepared and are on file in the textile section, Bureau of Standards, Washington, D. C. These may be consulted by anyone interested. This file consists of one booklet of 33 specimens of wool fabrics, one booklet of 4 specimens of cotton-wool blankets, one exhibit of 5 specimens of tops, one exhibit of 10 specimens of mohair yarns, and one exhibit of 9 specimens of Utah wools.

IV. TEST PROCEDURE AND RESULTS

1. SHRINKAGE IN DIMENSIONS OF COTTON KNIT UNDERWEAR

In this test two different weights were selected, an infant's 16-cut[1] garment and a boy's 10-cut union suit.

In this test 4½ inches of water of a 5-drop hardness[2] at 130° F. was used for a period of one-half hour. This was followed by two warm-water rinses of five minutes each and a cold rinse of five minutes. The soap treatments were as follows: (*a*) No cleansing agent, (*b*) 1 gill of liquid laundry soap, and (*c*) 1 ounce of washing soap (in solution) and one-third ounce of 58 per cent soda ash. In each case where an agent was added, the wheel was turned over several times to thoroughly mix the solution before loading.

After washing, the garments were squeezed by hand and dried in a rotary dryer for 15 minutes. The specimens were permitted to condition overnight before measurements were again taken.

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[1] Cut is the number of needles per inch on the machine.

[2] The hardness in water is caused by the presence of salts of calcium and magnesium. The water used in this test was such that five drops of neutral soap solution in alcohol mixed with 40 cm of the water when shaken produced suds.

The following table gives the dimensions before and after washing:

TABLE 1.—*Shrinkage in measurements of knit underwear*

Garment		Agents	Measurement		Dimensions		
No.	Weight				Before	After	Difference
					Inches	*Inches*	*Inches*
1	*Cut* 16	No agent	Width		11.7	11.7	0.0
			Total length	right	30.3	26.8	−3.5
				left	30.3	26.8	−3.5
			Trunk	right	22.9	20.8	−2.1
				left	23.0	20.9	−2.1
			Inseam	right	6.5	5.5	−1.0
				left	6.8	5.7	−1.1
			Armhole length	right	8.4	7.6	−.8
				left	8.5	7.7	−.8
2	16	Liquid laundry soap	Width		11.3	11.9	+.6
			Total length	right	29.9	26.5	−3.4
				left	30.2	27.0	−3.2
			Trunk	right	22.5	20.7	−1.8
				left	22.8	20.9	−1.9
			Inseam	right	7.7	5.7	−2.0
				left	7.4	5.5	−1.9
			Armhole length	right	8.5	7.3	−1.2
				left	8.6	7.7	−.9
3	16	Washing soap	Width		11.2	11.9	+.7
			Total length	right	30.1	26.3	−3.8
				left	30.0	26.2	−3.8
			Trunk	right	22.3	20.0	−2.3
				left	22.4	20.0	−2.4
			Inseam	right	7.6	5.3	−2.3
				left	7.6	5.3	−2.3
			Armhole length	right	8.5	7.5	−1.0
				left	8.4	7.4	−1.0
4	10	No agent	Width		13.0	13.3	+.3
			Total length	right	47.0	45.5	−1.5
				left	47.0	45.2	−1.8
			Trunk	right	24.3	26.0	+1.7
				left	24.5	26.0	+1.5
			Inseam	right	22.8	19.5	−3.3
				left	22.3	19.2	−3.1
			Armhole length	right	6.5	6.3	−.2
				left	6.5	6.3	−.2
5	10	Liquid laundry soap	Width		12.5	13.1	+.6
			Total length	right	47.1	44.3	−2.8
				left	47.2	44.5	−2.7
			Trunk	right	24.4	25.3	+.9
				left	24.6	25.4	+.8
			Inseam	right	22.8	18.5	−4.3
				left	22.5	18.4	−4.1
			Armhole length	right	6.6	6.2	−.4
				left	6.5	6.1	−.4
6	10	Washing soap	Width		12.4	13.0	+.6
			Total length	right	47.1	43.8	−3.3
				left	47.3	44.2	−3.1
			Trunk	right	24.4	25.4	+1.0
				left	24.7	25.6	+.9
			Inseam	right	22.6	18.6	−4.0
				left	23.2	18.8	−4.4
			Armhole length	right	6.5	6.1	−.4
				left	6.5	6.1	−.4

The difference of the effect of these treatments is shown in Table 2. There is included a ratio of the respective treatments obtained by dividing the lowest of the three into each of the other two.

TABLE 2.—*Summary of shrinkage in dimensions of cotton knit underwear with different washing treatments*

Type	Measurement	Shrinkage in dimensions			
		No agent	Liquid laundry soap	Washing soap	Time
		Inches	*Inches*	*Inches*	*Hours*
16-cut	Width	0.00	+0.60	+0.70	½
	Total length	−3.50	−3.30	−3.80	½
	Trunk	−2.10	−1.85	−2.35	½
10-cut	Width	+.30	+.60	+.60	½
	Total length	−1.65	−2.75	−3.20	½
	Trunk	+1.60	+.85	+.95	½
Net total of shrinkage results		5.35	5.85	7.10	----------
Ratio		1.00	1.11	1.33	----------

The results of these tests are graphically illustrated in Figure 1 where the results are plotted above and below the original length line. An average shrinkage as shown by the ratio and the graph indicates that liquid laundry soap is superior to washing soap.

Because of the fact that these tests were made on new garments, which generally show some change in dimensions, a further test was run to show the effect of further washing after this preliminary one-half hour washing. The garments from the first test were run for a period of seven hours. The other conditions of the run were the same as before. In drying, the garments were squeezed by hand, but were not subjected to the extractor or drying tumbler. They were permitted to hang on a line for several days, but care was taken that the arms and legs did not hang too long so that subsequent stretching would result.

The results of these continuous washings are given in Table 3 and graphically shown in Figure 2.

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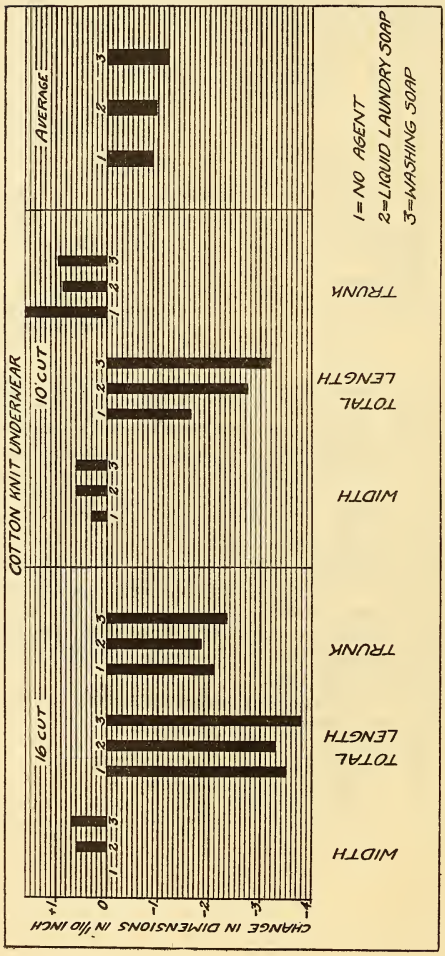

FIG. 1.—*Cotton knit union suits. Graphical representation of the shrinkage in inches of measurements of parts of underwear in using various washing treatments for one-half hour*

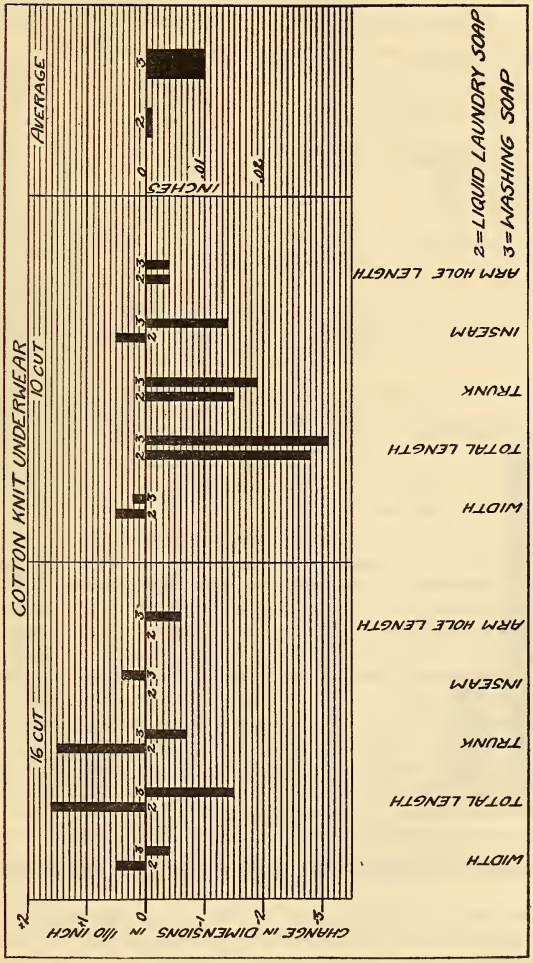

FIG. 2.—*Cotton knit union suits. Graphical representation of the shrinkage in inches of measurements of parts of underwear in using various washing treatments for seven hours*

TABLE 3.—*Effect of repeated washings on cotton knit underwear. Measurements taken after seven-hour run*

Type of garment	Treatment	Measurement	Dimensions		
			Before[1]	After	Difference
			Inches	*Inches*	*Inches*
16-cut	Liquid laundry soap	Width	11.9	12.4	+0.5
		Total length	26.8	28.4	+1.6
		Trunk	20.8	22.3	+1.5
		Inseam	5.6	5.6	.0
		Armhole length	7.5	7.5	.0
		Total			+3.6
Do	Washing soap	Width	11.9	11.5	−.4
		Total length	26.3	24.8	−1.5
		Trunk	21.0	20.3	−.7
		Inseam	5.3	5.7	+.4
		Armhole length	7.5	6.9	−.6
		Total			−2.8
10-cut	Liquid laundry soap	Width	13.1	13.6	+.5
		Total length	44.4	41.6	−2.8
		Trunk	25.3	23.8	−1.5
		Inseam	18.5	19.0	+.5
		Armhole length	6.2	5.8	−.4
		Total			−3.7
Do	Washing soap	Width	13.0	13.2	+.2
		Total length	44.0	40.9	−3.1
		Trunk	25.5	23.6	−1.9
		Inseam	18.7	17.3	−1.4
		Armhole length	6.1	5.7	−.4
		Total			−6.6

[1] Dimensions taken after previous one-half-hour test.

In totaling the differences found in Table 3 and summarizing the differences of the two treatments it is found that liquid laundry soap has a total difference of +3.6 and −3.7 inches, giving a sum of −0.1 inch as compared with washing soap with a total of −9.4 inches. It can also be noted from an examination of Figures 1 and 2 that the two types of garments shrank differently irrespective of the treatment, but in each case the shrinkage due to the liquid laundry soap treatment was materially less. In noting the results of test after this long continuous washing with the original figures of the garments prior to washing a further comparison can be made. The total differences for liquid laundry soap are −2.8 and −9.4 inches as compared with the differences for washing compound, −10.2 and −12.8 inches, the total difference being 12.2 inches against 22.9 inches, showing approximately 50 per cent less shrinkage from the use of liquid laundry soap.

2. SHRINKAGE IN DIMENSIONS OF COTTON KNIT UNDERWEAR TUBING

Various lengths of what is known as 8-cut cotton knit tubing were submitted to the wheel with 4½ inches of soft water at 130° F., using 1 gill of liquid laundry soap for the first treatment and 2 ounces of

soap and two-thirds ounce of soda ash for the second treatment. An average of three pieces was taken for each test. The following table shows results of measurements before and after washing:

TABLE 4.—*Shrinkage in dimensions of cotton knit underwear tubing*

Treatment	Specimen No.	Length of piece		
		Before	After	Difference
		Inches	*Inches*	*Inches*
Liquid laundry soap	1	26.4	23.2	3.2
	2	22.8	21.7	1.1
	3	22.1	20.2	1.9
Total		71.3	65.1	6.2
Washing soap and soda ash	4	23.5	18.8	4.7
	5	33.6	20.0	13.6
	6	21.6	18.4	3.2
Total		78.7	57.2	21.5

The total shrinkage in length of the tubing shown in Table 4 indicates that the specimens washed with washing soap and soda ash shrank three times as much as with liquid laundry soap. These results are illustrated in Figure 3.

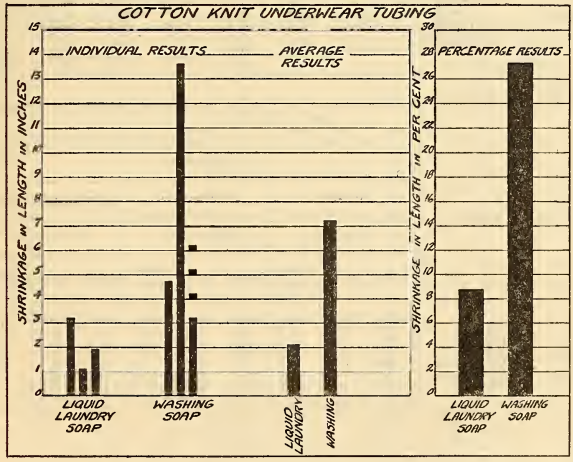

FIG. 3.—*Cotton knit tubing. Graphical representation of the shrinkage in length of pieces shown in inches and percentage in using washing soap and liquid laundry soap treatments*

3. SHRINKAGE IN DIMENSIONS OF LIGHTWEIGHT WOOL FABRICS

For these tests three lightweight wool flannels, light blue, pink, and white, were selected because of the nature of the dye, the fading of which was to be studied later. The lengths of time of washing were one-half hour and one hour, and the temperatures of the solution were 90 and 130° F., which covers the range of the more common laundry practices. The water was of a five-drop hardness maintained at 4½ inches height. The treatments are indicated in Tables 5 to 10, inclusive.

TABLE 5.—*Shrinkage in dimensions of lightweight wool fabrics washed for one hour at 90° F.*

Color	Measurement	Treatment					
		Washing soap and soda ash			Liquid laundry soap		
		Dimensions			Dimensions		
		Before	After	Difference	Before	After	Difference
		Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Pink	Length	21.3	16.3	−5.0	20.2	17.7	−2.5
	Width	27.3	23.2	−4.1	27.3	24.3	−3.0
White	Length	20.6	16.8	−3.8	19.5	17.1	−2.4
	Width	28.3	27.9	−.4	28.3	28.2	−.1
Blue	Length	20.1	16.5	−3.6	18.7	16.9	−1.8
	Width	27.3	23.5	−3.8	27.3	24.5	−2.8
Total		144.9	124.2	−20.7	141.3	128.7	−12.6

TABLE 6.—*Shrinkage in dimensions of lightweight wool fabrics washed for one-half hour at 130° F.*

Color	Measurement	Treatment								
		No agent			Washing soap			Liquid laundry soap		
		Dimensions			Dimensions			Dimensions		
		Before	After	Difference	Before	After	Difference	Before	After	Difference
		Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Pink	Length	25.6	23.3	−2.3	28.3	24.9	−3.4	26.1	23.5	−2.6
	Width	27.4	24.3	−3.1	27.5	24.7	−2.8	27.4	24.3	−3.1
White	Length	27.5	24.5	−3.0	18.4	16.3	−2.1	19.0	16.9	−2.1
	Width	27.8	28.0	+.2	27.9	27.7	−.2	27.8	28.0	+.2
Blue	Length	25.9	21.9	−4.0	25.5	22.7	−2.8	24.9	23.4	−1.5
	Width	27.4	24.2	−3.2	27.4	24.4	−3.0	27.3	24.9	−2.4
Total		161.6	146.2	−15.4	155.0	140.7	−14.3	152.5	141.0	−11.6

TABLE 7.—*Shrinkage in dimensions of lightweight wool fabrics washed for one hour at 130° F.*

Color	Measurement	Treatment											
		No agent			Washing soap and soda ash			Washing soap and sour			Liquid laundry soap		
		Dimensions			Dimensions			Dimensions			Dimensions		
		Before	After	Difference	Before	After	Difference	Before	After	Difference	Before	After	Difference
		Ins.	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*
Pink	Length	24.2	20.2	−4.0	21.0	14.3	−6.7	19.5	14.2	−5.3	23.1	18.0	−5.1
	Width	27.3	24.2	−3.1	27.3	23.0	−4.3	27.3	24.0	−3.3	27.3	24.1	−3.2
White	Length	18.1	15.6	−2.5	11.2	8.3	−2.9	------	------	------	20.4	18.2	−2.2
	Width	27.9	29.1	+1.2	28.8	28.9	+.1	------	------	------	28.3	28.8	+.5
Blue	Length	18.1	14.1	−4.0	23.3	16.1	−7.2	22.2	15.1	−7.1	22.5	18.5	−4.0
	Width	27.4	24.2	−3.2	27.3	23.1	−4.2	27.4	23.0	−4.4	27.3	24.0	−3.3
Total		143.0	127.4	−15.6	138.9	113.7	−25.2	96.4	76.3	−20.1	148.9	131.6	−17.3

In order to note the change in area the following tables were prepared. The area is expressed in square inches and the shrinkage in per cent loss in area.

TABLE 8.—*Change in area of lightweight wool fabrics washed for one hour at 90° F.*

Treatment	Measurement	Color			
		Pink	White	Blue	Total
Washing soap and soda ash	Before ... square inch	581	583	550	1,714
	After ... do	378	468	388	1,234
	Difference ... do	203	115	162	480
	Shrinkage ... per cent	35.0	19.7	29.4	28.0
Liquid laundry soap	Before ... square inch	550	552	510	1,612
	After ... do	430	482	415	1,327
	Difference ... do	120	70	95	285
	Shrinkage ... per cent	21.8	12.7	18.6	17.7

TABLE 9.—*Change in area of lightweight wool fabrics washed for one-half hour at 130° F.*

Treatment	Measurement	Color			
		Pink	White	Blue	Total
No agent	Before ... square inch	702	765	710	2,177
	After ... do	566	686	530	1,782
	Difference ... do	136	79	180	395
	Shrinkage ... per cent	19.4	10.3	25.4	18.2
Liquid laundry soap	Before ... square inch	715	529	680	1,924
	After ... do	572	474	583	1,629
	Difference ... do	143	55	97	295
	Shrinkage ... per cent	20.0	10.4	14.2	15.3
Washing soap	Before ... square inch	777	514	698	1,989
	After ... do	615	452	554	1,621
	Difference ... do	162	62	144	368
	Shrinkage ... per cent	20.9	12.1	20.6	18.5

TABLE 10.—*Change in area of lightweight wool fabrics washed for one hour at 130° F.*

Treatment	Measurement	Color			
		Pink	White	Blue	Total
No agent	Before ..... square inches	660	505	495	1,660
	After ..... do	489	453	342	1,284
	Difference ..... do	171	52	153	376
	Shrinkage ..... per cent	25.9	10.3	30.9	22.7
Washing soap and sour	Before ..... square inches	533	----------	609	1,142
	After ..... do	342	----------	348	690
	Difference ..... do	191	----------	261	452
	Shrinkage ..... per cent	35.9	----------	43.0	39.5
Washing soap and soda ash	Before ..... square inches	573	322	636	1,531
	After ..... do	330	240	372	942
	Difference ..... do	243	82	264	589
	Shrinkage ..... per cent	42.5	25.5	41.5	38.3
Liquid laundry soap	Before ..... square inches	630	577	615	1,822
	After ..... do	435	525	445	1,405
	Difference ..... do	195	52	170	417
	Shrinkage ..... per cent	31.0	8.7	27.6	22.9

These results are shown graphically in Figure 4.

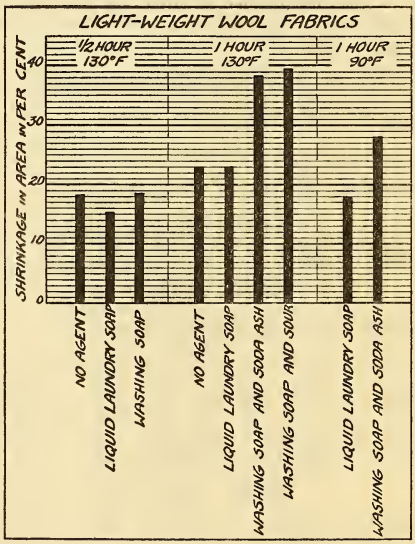

FIG. 4.—*Lightweight wool fabrics. Graphical representation of the per cent shrinkage in area of wool fabrics using various washing treatments for various lengths of run and various temperatures*

In Figure 5 is shown the per cent shrinkage in area plotted against the length of the run for washing treatments at 130° F. Tables 8, 9, and 10 and Figures 4 and 5 show the superiority of liquid laundry soap. The shrinkage in area, irrespective of treatment for each color, is shown in Figure 6 to compare the shrinkage properties of the different materials.

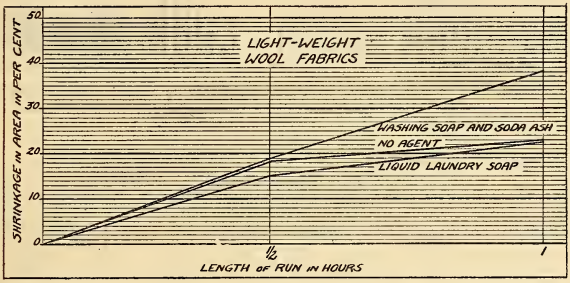

FIG. 5.—*Lightweight wool fabrics. Per cent shrinkage in area against length of run for washing treatments at 130° F.*

4. FASTNESS OF DYES TO WASHING OF LIGHTWEIGHT WOOL FABRICS

The specimens of lightweight wool fabrics run through the washing treatments just described were tested for purity of color, using the Pfund colorimeter. In the percentages given in Table 11, the lower the per cent the slighter the change in color from the original sample. These figures check to a comparative degree with visual observations.

TABLE 11.—*Results of tests for fading of lightweight wool fabrics*

Treatment		Change in purity of color		
		Color		
Time and temperature	Agent	Pink	White	Blue
		Per cent	*Per cent*	*Per cent*
Original samples		0	0	0
½ hour, 130° F	No agent	9.9	6.3	7.7
	Washing soap and soda ash	10.7	3.4	5.1
	Liquid laundry soap	3.0	2.0	3.1
1 hour, 130° F	No agent	17.0	4.1	8.4
	Washing soap and soda ash	19.8	5.7	19.0
	Washing soap and sour	13.2		6.6
	Liquid laundry soap	3.7	3.1	4.1
1 hour, 90° F	Washing soap and soda ash	8.5	3.6	7.2
	Liquid laundry soap	3.3	2.8	4.3
7 hours, 130° F	Washing soap and soda ash	38.5		27.0
	Liquid laundry soap	10.5		.5

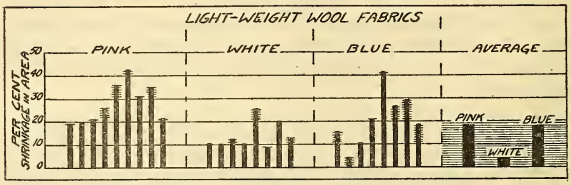

FIG. 6.—*Lightweight wool fabrics. Graphical representation of the per cent shrinkage in area for various colors irrespective of other variables of the washing treatment*

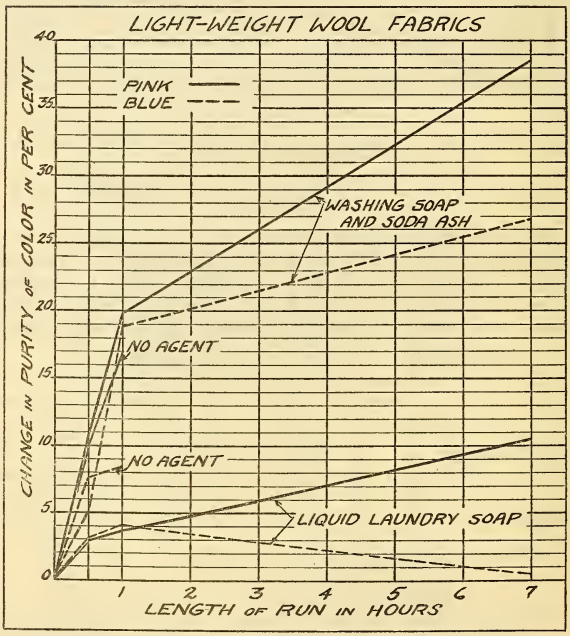

FIG. 7.—*Lightweight wool fabrics. Per cent loss or change of purity of color against the length of run in hours for various treatments at 130° F.*

The per cent loss or change of purity of color is plotted against the length of run for the washing treatments at 130° F. in Figure 7.

In Figure 8 is shown a graphical representation of the results of fading, using various washing treatments.

5. SHRINKAGE IN DIMENSIONS OF WOOL (COTTON WARP) BLANKETS

This test was run on wool (cotton warp) bed blankets to determine the extent of shrinkage and the fading of the pattern. The conditions of the test were temperature of the water, 97° F.; 4½ inches of five-drop hardness water; and length of run, one-half hour. The shrinkage in dimensions is given in Table 12.

TABLE 12.—*Shrinkage in dimensions of wool (cotton warp) blankets*

Type of blanket	Sample No.	Dimensions					
		Before		After		Difference	
		Width	Length	Width	Length	Width	Length
		Ft. in.	*Ft. in.*	*Ft. in.*	*Ft. In.*	*In.*	*Ft. in.*
Checked pattern	1	6 ¼	6 6⅞	6 1⅝	6 ¼	+1⅜	−6⅝
	2	6	6 8⅞	5 11¾	6 1⅝	−¼	−7¼
	3	5 11⅝	6 6⅞	6 1½	6 ¾	+1⅞	−6⅛
	4	5 11⅝	6 6⅞	5 11⅛	6 ½	−½	−6⅜
Plain	1	5 2¾	7 3½	5 3	6 6⅜	+¼	−9⅛
	2	5 3	7 4⅛	5 ⅝	6 3⅝	−2⅜	−1 ½
	3	5 2⅜	7 2¼	5 1	6 4	−1⅜	−9¾
	4	5 3	7 3½	5 1⅞	6 5¾	−1⅛	−9¾

In the above table, samples Nos. 1 and 3 for both checked pattern and plain blankets were washed with liquid laundry soap; samples Nos. 2 and 4 were washed with washing soap and soda ash.

In order to compare the shrinkage in terms of area, the following table is submitted:

TABLE 13.—*Shrinkage in area of blankets*

Type of blanket	Sample number	Area			Difference
		Before	After	Difference	
		Sq. in.	*Sq. in.*	*Sq. in.*	*Per cent*
Checked	1	5,702	5,170	522	9.1
	2	5,800	5,280	520	9.0
	3	5,650	5,350	300	5.3
	4	5,640	5,150	490	8.7
Plain	1	5,500	4,940	660	12.0
	2	5,550	4,580	970	17.5
	3	5,380	4,640	740	13.8
	4	5,510	4,810	700	13.7

In the above table samples Nos. 1 and 3 for both checked pattern and plain blankets were washed with liquid laundry soap; samples Nos. 2 and 4 were washed with washing soap and soda ash.

A graphical comparison of the different treatments as to their effect on shrinkage in area of blankets is shown in Figure 9.

A visual examination of the change in color was made, since a test on the pattern could not be made on the Pfund instrument. It was noted that the specimens treated with liquid laundry soap faded much less than the specimens treated with washing soap and soda ash.

6. SCOURING OF MOHAIR YARNS

This test on mohair yarns was made to compare different scouring soaps with respect to their per cent loss in eliminating the dirt and oil emulsions added to the material, also to note the felting appearance and the shrinking in yardage. The following table shows the results of tests on shrinkage in weight and yardage.

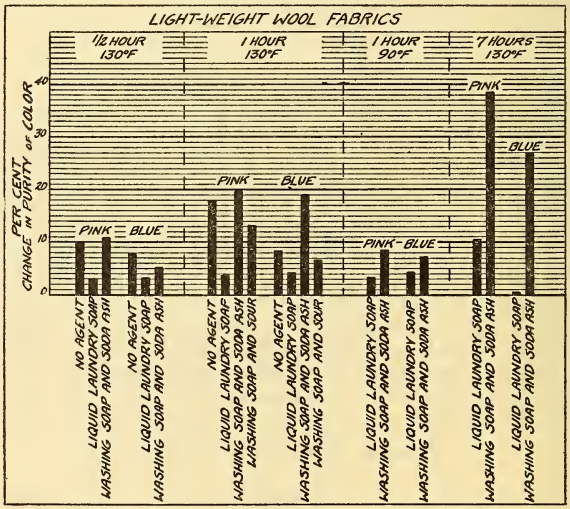

FIG. 8.—*Lightweight wool fabrics. Graphical representation of the per cent loss or change of purity of color resulting from various washing treatments for various lengths of run and temperatures*

TABLE 14.—*Shrinkage in weight and yardage of mohair yarns with various treatments*

Sample No.	Weight				Treatment	Yardage		
	Before	After	Difference	Loss		Before	Loss	Loss
	g	*g*	*g*	*Per cent*		*Yards*	*Yards*	*Per cent*
1	7.753	7.389	0.364	4.69	Washing soap	120	6½	5.41
2	7.805	7.535	.270	3.46	Vegetable oil-soda soap	120	3½	2.92
3	7.948	7.644	.304	3.83	Olive-oil soap	120	2¼	1.88
4	7.780	7.385	.395	5.08	Liquid laundry soap	120	1½	1.25
11	13.145	12.607	.538	4.10	Washing soap	120	5	4.17
12	13.225	12.675	.550	4.15	Vegetable oil-soda soap	120	3½	2.92
13	13.150	12.610	.540	4.10	Olive-oil soap	120	4½	3.75
14	13.220	12.630	.590	4.46	Liquid laundry soap	120	3	2.50

For visual comparison, these results were plotted graphically as shown in Figure 10.

These results show that liquid laundry soap was more effective in removing the dirt and oil emulsions than any of the other treatments. This was also noted in the appearance of the materials after the treatments.

7. SCOURING OF WOOL TOP

Lengths of 10 to 12 inches were cut from a wool top and each dipped and squeezed for three minutes in the bowl. This was re-

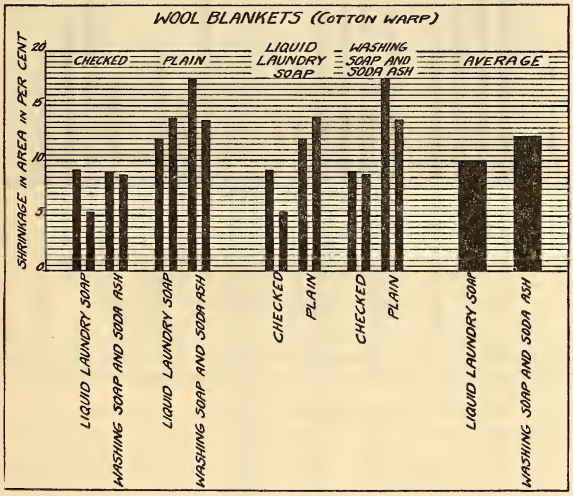

FIG. 9.—*Wool (cotton warp) blankets. Graphical representation of per cent shrinkage in area of checked and plain pattern blankets for various washing treatments at 97° F.*

peated several times for each specimen. The temperature of the bowl was 120° F. The object of this test was to simulate the back-washing operation on tops and to note the shrinkage in weight and change in whiteness and the felting properties of the fibers after the different treatments.

The results on shrinkage in weight are shown in Table 15, and the change in whiteness as obtained on the Pfund instrument is shown in Table 16.

Figures 11 and 12 have been plotted to show graphically these results. Liquid laundry soap was superior to the other treatments in

the cleansing operation, as is shown in these figures. A visual comparison checked with the results as given here for the specimens which were run through the liquid laundry soap treatment appeared more nearly white.

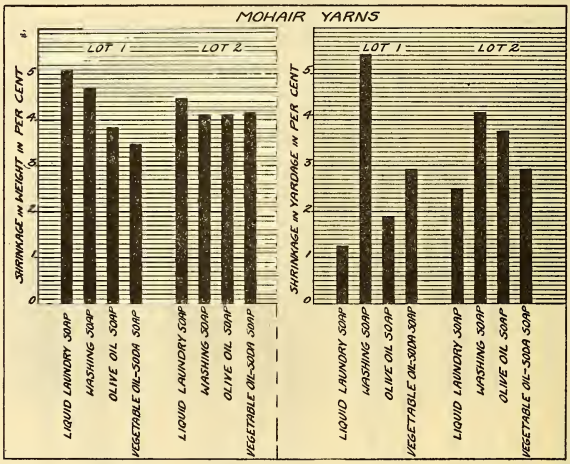

FIG. 10.—*Mohair yarns. Graphical representation of per cent shrinkage in weight and loss in yardage resulting from various scouring treatments at 110° F.*

TABLE 15.—*Shrinkage in weight of tops after various treatments*

Treatment	Weight			Difference
	Before	After	Difference	
	Pound	*Pound*	*Pound*	*Per cent*
Washing soap	0.069	0.065	0.004	5.8
Olive-oil soap	.071	.067	.004	5.6
Liquid laundry soap	.068	.063	.005	7.4

TABLE 16.—*Change to whiteness as shown by the Pfund instrument*

Reagents	Readings		
	First	Second	Average
Original top	0	0	0
Olive-oil soap	8.7	11.5	10.1
Washing soap	11.8	14.0	12.9
Liquid laundry soap	13.1	13.7	13.4

8. SCOURING OF UTAH WOOL FLEECE

A series of observations were made on a fine Utah wool to ascertain the loss in weight and whiteness after scouring resulting from different temperatures of the bowl, from different numbers of bowls,

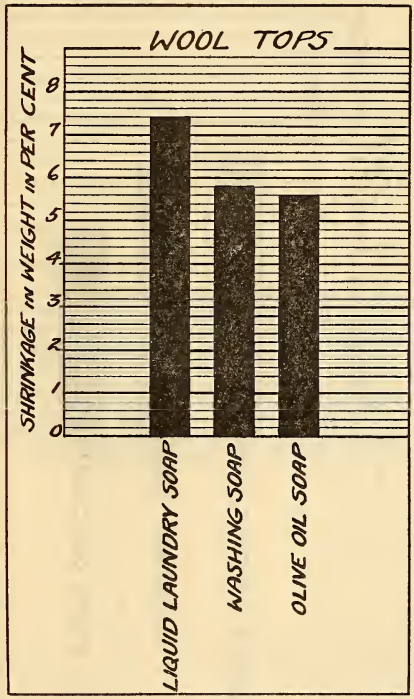

FIG. 11.—*Wool tops. Graphical representation of the per cent loss in weight in tops resulting from various backwashing treatments*

and from different soap treatments. The tests were carried out on a specimen weighing approximately two-tenths of a pound and placed in a treatment without a warm bowl first. The time for each test was 10 minutes in addition to three warm rinses of two minutes each. The specimens were squeezed by hand and allowed to condition to a constant weight before all weight determinations.

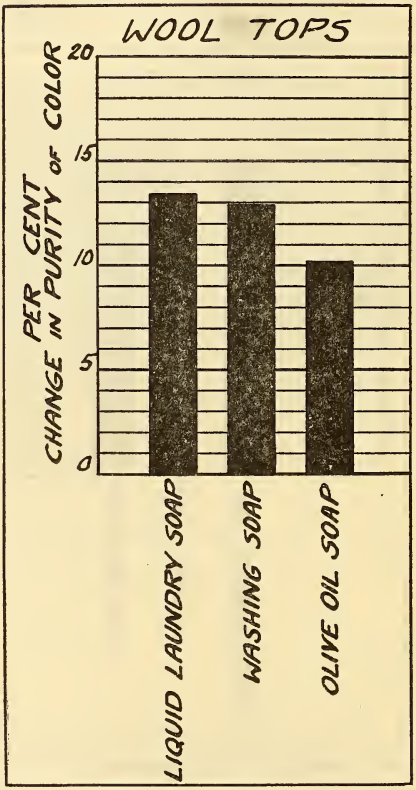

FIG. 12.—*Wool tops. Graphical representation of the per cent change in purity of color (a change from yellowish gray to white) resulting from scouring tops with various treatments*

The results of weight are as follows:

TABLE 17.—*The shrinkage of weight resulting from different temperatures of bowls, using liquid laundry soap*

Specimen No.	Temperature	Treatment	Weight			Loss	Yield
			Before	After	Difference		
	°F.		Pound	Pound	Pound	Per cent	Per cent
1	100	Liquid laundry soap	0.222	0.099	0.123	55.4	44.6
2	110	do	.196	.084	.112	57.2	42.8
3	130	do	.208	.088	.120	57.7	42.3

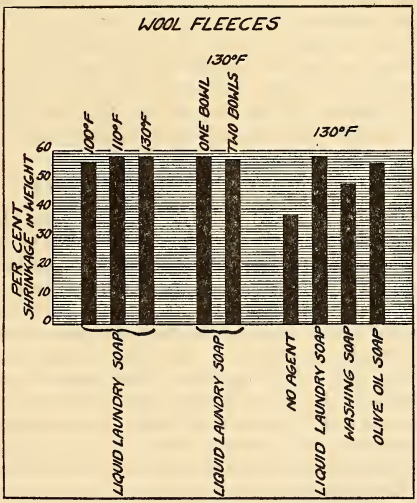

FIG. 13.—*Wool fleeces. Graphical representation of the per cent loss in weight in scouring raw wool for (a) the per cent loss for different temperatures, (b) the per cent loss of one and two bowls, and (c) the per cent loss using various scouring treatments*

Measurements of changes to whiteness could not be obtained because of the difficulty in preparing a smooth surface specimen, which is necessary for reading on the Pfund instrument.

TABLE 18.—*Effect of one and two bowls, using liquid laundry soap treatment*

Specimen No.	Temperature	Treatment	Number of bowls	Weight			Loss	Yield
				Before	After	Difference		
	°F.			Pound	Pound	Pound	Per cent	Per cent
3	130	Liquid laundry soap	1	0.208	0.088	0.120	57.7	42.3
8	130	do	2	.201	.087	.114	56.7	43.3

TABLE 19.—*Effect of different treatments*

Specimen No.	Temperature	Treatment	Weight			Loss	Yield
			Before	After	Difference		
	°F.		Pound	Pound	Pound	Per cent	Per cent
3	130	Liquid laundry soap	0.208	0.088	0.120	57.7	42.3
5	130	Olive-oil soap	.201	.090	.111	55.3	44.7
6	130	Washing soap	.220	.114	.106	48.2	51.8

A graphical comparison of these results is shown in Figure 13. Using liquid laundry soap, very little additional cleansing was obtained by increasing the temperature from 100 to 130° F., an increased loss in weight of 2.3 per cent resulting. The results obtained using one and two bowls were likewise very close, a difference of only 1 per cent, which may be within the experimental error. A comparison of the various scouring treatments showed that liquid laundry soap was superior to washing soap and olive-oil soap.

V. SUMMARY AND CONCLUSIONS

The results of the tests on underwear, where the shrinkage in dimensions is considered the most important factor in the washing of garments, showed that using this particular liquid laundry soap less change resulted. To ascertain the effect of repeated washings, after the preliminary washing of the new garments a 7-hour run was made. Liquid laundry soap showed decided superiority in this test. Further observation was made on the effect of washing underwear by noting the "feel" of the garment. The garments washed with washing soap and soda ash had a marked stiff and harsh feel. Liquid laundry soap showed no material difference in feel from the original unwashed material. It is believed that it is not possible to retain the original dimensions of knitted garments after washing, because of the fact that in finishing and boarding the garments are stretched to obtain the necessary finished appearance of salable garments.

The test on knit tubing, which shows how much the trunk measurement of underwear would shrink, showed the superiority of liquid laundry soap. The trunk measurement is considered very important, for the least possible amount of shrinkage is desirable so that the garment will be comfortable when worn.

In the test on lightweight wool flannels, the superiority of liquid laundry soap was shown, using different lengths of time of runs and different temperatures so that the range of laundry practice could be covered. Measurements of the shrinkage in dimensions and change in color showed the superiority of liquid laundry soap to a marked degree, especially in the seven-hour run for change in color. In this

latter case, with liquid laundry soap the color changed very slightly from the original while for washing soap and soda ash a very marked degree of fading was shown, also a change in color, for the blue changed to a greenish color and the pink to a brown.

In the tests on blankets for shrinkage in dimensions and change in color, the superiority of liquid laundry soap was shown by a fair margin. The limitations of the instrument for testing color did not permit actual readings to be obtained on change in color, but visual examination showed that the specimens resulting from the liquid laundry soap treatment changed but slightly, while the others were more marked.

The tests on scouring mohair yarns to eliminate the dirt and the emulsions, which are added prior to the spinning for the purpose of lubrication, showed that liquid laundry soap took out a larger percentage of this dirt, etc., than washing soap, olive-oil soap, or vegetable oil-soda soap. In noting the specimens after this backwashing process, the Pfund instrument showed the liquid laundry soap treated specimens to be more nearly white than the others. This was particularly noticeable in the finer of the two mohair yarns that were tested. Tests for shrinkage in length showed that specimens washed with liquid laundry soap shrank the least.

Tests on wool top which had been exposed for a period of time and had become slightly yellow showed that liquid laundry soap removed more of the dirt and emulsions than either soap with soda ash or olive-oil soap. Observations made on the loftiness of these specimens after washing showed that the most resilient of the specimens was that washed using liquid laundry soap. When pulling out 30 to 50 fibers between the thumb and forefinger, it was noted that the fiber came out straighter from those washed with liquid laundry soap, and with the least resistance. This test is very crude, but it indicates a desirable property in that the fiber will be less liable to breakage and that it is possible to spin finer yarns from the tops.

Liquid laundry soap again showed its superiority over the other agents in the scouring of a fine grade of Utah wool fleece. Temperatures of 100, 110, and 130° F. were used. A slight increase in the shrinkage in weight was noted with increases in temperature. It was further noted that there was a considerable gain in whiteness of the specimens as the temperature increased and that the best results were at 130° F. The scouring test, using an additional bowl, showed no further loss in weight, but did show an increase in whiteness. Comparison was then made of the loss in weight with other scouring agents. Liquid laundry soap showed to better advantage than the other scouring agents. A further test was run in which the specimen was washed first with olive-oil soap and after drying was washed again with liquid laundry soap. The specimen increased in whiteness.

In Table 20 there is given a summary of the results of this investigation in comparative form. To obtain these results, the lowest value has been arbitrarily assigned the base 100 and the ratios are obtained by dividing the results obtained by the lowest value.

This table shows rather conclusively the superiority of this particular liquid laundry soap over the various other treatments.

TABLE 20.—*Summary of the relation between results obtained by the liquid laundry soap treatment to the other treatments*

Material tested	Kind of test	Length of run	Temperature	Ratio, lowest value assigned the base 100						
				No agent	Liquid laundry soap	Washing soap	Washing soap and soda ash	Washing soap and sour	Olive-oil soap	Vegetable oil-soda soap
		Hours	°*F.*							
Cotton knit underwear 10 to 16 cut.	Shrinkage in dimensions.	½	130	100	111	133	------	------	------	------
		½+7	130	------	100	9,400	------	------	------	------
Cotton knit underwear tubing.	do	½	130	------	100	347	------	------	------	------
Lightweight wool fabrics (flannels) pink, blue, white.	Shrinkage in dimensions.	1	90	------	100	159	------	------	------	------
	Color fastness				100	------	186	------	------	------
	Shrinkage in dimensions.	½	130	119	100	121	------	------	------	------
	Color fastness			295	100	------	237	------	------	------
	Shrinkage in dimensions.	1	130	100	101	------	169	174	------	------
	Color fastness			271	100	------	409	182	------	------
	do	7	130	------	100	------	596	------	------	------
Wool (cotton warp) blankets.	Shrinkage in dimensions.	½	97	------	100	------	121	------	------	------
Mohair yarns	Shrinkage in weight	⅙	120	------	125	116	------	------	104	100
	Shrinkage in length				100	256	------	------	150	156
Wool top	Shrinkage in weight	------	120	------	132	104	------	------	100	------
	Whiteness				133	128	------	------	100	------
Utah wool fleece	Effect of temperature.	⅙	100	------	100	------	------	------	------	------
		⅙	110	------	103	------	------	------	------	------
		⅙	130	------	104	------	------	------	------	------
	Effect of increasing number of bowls.	⅙	(1)130	------	102	------	------	------	------	------
		⅙	(2)130	------	100	------	------	------	------	------
	Shrinkage in weight	⅙	130	------	120	100	------	------	115	------

WASHINGTON, August 15, 1924.