THE SERVICE QUALITIES OF CERTAIN SPUN RAYON FABRICS OF WOOL-LIKE TEXTURE

by

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INTRODUCTION

Positive progress in the development of spun rayon fabrics can be attributed to the interesting and desirable effects obtainable through the use of rayon staple. In the past eight years domestic consumption of this textile commodity has increased from 8 million pounds to 100 million pounds a year in 1939 (11). Its present importance in nationalistic countries and its rapid growth in the United States indicate the value of rayon staple to both the consumer and industry. In 1938 three totalitarian states which lacked foreign exchange and certain natural fibers manufactured 90 percent of the world's rayon staple. This same year the American cotton industry consumed 90 per cent of the rayon staple produced (12). The adaptability of this textile commodity to the cotton spinning system has made possible the utilization of idle machinery and has given new impetus to the cotton industry.

The manufacture of rayon staple is basically similar to that of filament rayon. Spun as filament yarn, the fiber is cut in lengths while wet. This method permits the filaments to contract and wrinkle, increases the ease of spinning and thus imparts a crimp essential for resiliency. Teca, acetate rayon staple, possesses a permanent crimp after the fibers have been impregnated with resins and sent over fluted rollers. Spun rayon yarns can be made with such varying degrees of luster, filament size, and staple length that these diversified characteristics extend the possibilities of creating fabrics having a wide range of textures and uses. Textural interest is definitely a contributing factor in consumer choice of fabrics.

Staple fiber makes possible the production of fabrics simulating wool. These new types of fabrics give the wearer the advantage of lighter weight garments, attractiveness in design and lower priced apparel. An added value is the inherent whiteness of rayon staple as compared with the whiteness of wool, which usually yellows with age and cleaning. The definite trend toward blends of spun viscose and acetate rayon yarns producing wool-like textured fabrics indicates wide consumer recognition of spun rayons.

The purpose of this study was to compare by means of breaking strength, shrinkage, crease resistance, and abrasion tests, the serviceability of representative spun rayon fabrics of wool-like texture and to determine, insofar as possible by laboratory tests, the spun rayon fabrics most satisfactory for women's dresses.

REVIEW OF LITERATURE

Little information was found that dealt with the service qualities of spun rayon fabrics of wool-like texture.

Schwarz (10) reported the physical properties of staple rayon as particularly suited to the fine fabrics field; though the poor wet strength of staple rayon goods eliminates it from the group of washable fabrics. Acetate rayon staple has a relatively high wet strength, as well as wool-like kinky qualities. Smith (14) reported that rayon staple when dry is not as strong as dry silk or cotton but when wet is stronger than wet wool. Wet acetate staple decreases less in breaking strength than wet viscose staple; however, each type recovers full strength when dried. Kohns (7) found that textile fabrics made from wool, as well as those made from mixed fibers, must be treated carefully in the wet condition in order to insure protection against excessive strain. The wet strengths of various spun rayon fabrics are not inferior to that of pure wool in the wet state.

The method developed by Von Kohorn (15) of imparting crimp by the use of fluted rollers and rapid drying, produces a permanent crimp in the fibers. Fabrics made from these fibers have a wool-like texture. Urea-formaldehyde is used extensively to give a wool-like finish, and LeBrun (8) reported the best results are obtained through its use. For a uniform degree of wool-like handle resulting from complete impregnation of the urea-formaldehyde resin, the cloth is cured for a 15-minute period at 200° F. This curing makes the resin insoluble in water and dry cleaning solvents. Tension during drying must be kept at a minimum. Jupholme (6) found this type of resin finish not only produced excellent crease resistant properties but also improved rayon's breaking strength at least 60 percent. It also lessened shrinkage and stretch and increased the wet breaking strength.

PROCEDURE

Three-yard lengths of seven pieces of spun rayon fabrics with wool-like textures were purchased. Four pieces were obtained from rayon converters in New York City and three from retail stores in Philadelphia, Pennsylvania, and Wichita, Kansas. The fabrics were moderately priced and varied from $0.60 to $0.85 a yard. The variation in width was from 38¾ inches to 40 inches. An effort was made to use materials of similar construction and weight. Six fabrics were of a plain weave and the seventh a twill weave. Samples of the fabrics used are found on Plates I and II.

The identification of fibers was made microscopically and chemically. Cellulose acetate rayon was identified by dissolving it in acetone. From longitudinal mounts and cross sections of the fibers which were prepared on the Schwarz fiber microtome, identification of fibers was made. All the fabrics were mixtures of acetate and viscose spun rayon except two, which were 100 percent acetate spun rayon.

The method used for determining the identification of sizing and finishing was the one approved by the American Association of Textile Chemists and Colorists (1). Finishes were extracted by two methods. Two samples of each fabric, of approximately five grams, were desized with carbon tetrachloride and Takalab, a starch and protein solubilizing enzyme, according to the method of Committee D-13 (3). Since a resin finish can be removed only by the acid treatment, the following method by Howlett and Urquehart (5) was also used to determine the amount of sizing. Two samples of each fabric of approximately five grams were boiled for 10 minutes in .1N nitric acid and rinsed four times in distilled water. The rinsed specimens were dried to constant weight and the amount of finish calculated.

Quantitative determinations of fiber content were made chemically by dissolving the cellulose acetate rayon in

EXPLANATION OF PLATE I

Samples of Fabrics Used

Fig. 1. A. viscose and acetate spun rayon

Fig. 2. B. Teca hopsacking

Fig. 3. C. acetate delphaille

PLATE I

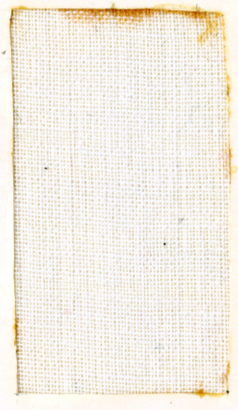

Fig. 1

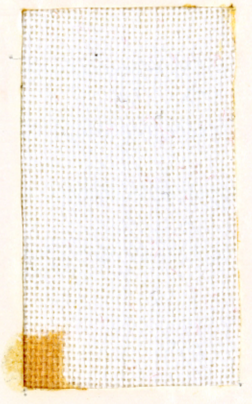

Fig. 2

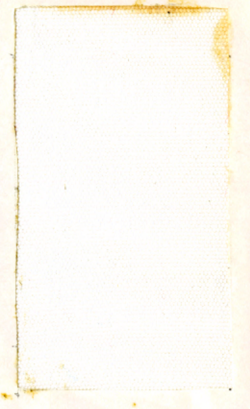

Fig. 3

EXPLANATION OF PLATE II

Samples of Fabrics Used

Fig. 4. D. viscose and acetate "Ru-Joan"

Fig. 5. E. viscose and acetate challis

Fig. 6. F. viscose and acetate spun rayon

Fig. 7. G. viscose and acetate challis

PLATE II

Fig. 4

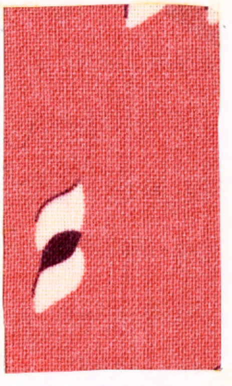

Fig. 5

Fig. 6

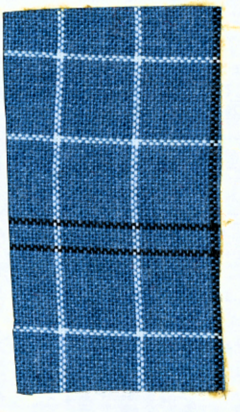

Fig. 7

acetone after the finishing materials were removed according to the method of Committee D-13 (3).

No test specimens were taken nearer the selvage than one-tenth the width of the fabric. To insure a representative sampling, no two specimens containing the same set of yarns were used. All twist, breaking strength, crease resistance, and abrasion tests were made under standard conditions for testing materials, namely, a relative humidity of 65 percent at 70° F. A tolerance of plus or minus 2 percent was permitted in relative humidity and plus or minus 3° F. in temperature.

The following physical characteristics of the fabrics were determined: weave, thickness, weight per square yard, thread count, twist, crimp, and yarn counts. Thickness, weight per square yard and thread count were determined according to the method of Committee D-13 (3). The Suter twist tester was used to determine the number of turns per inch in the yarn.

Crimp was determined by the Schwarz micro method (12) from camera lucida drawings of cross sections of the fabric. To ascertain the yarn counts of each fabric a sample was cut eight inches square. After being weighed, the warp and filling yarns were raveled and counted. The combined weights of the warp and filling raveled threads were compared with the weight of the original eight inch square. The small discrepancy, which was in favor of the piece of fabric, was divided between the warp and filling. From the dry weight, the length, and the crimp, the yarn counts were calculated according to the cotton system of yarn numbers.

The tests for serviceability of the fabrics were shrinkage, breaking strength, abrasion, and crease resistance before and after 5 and 10 dry cleanings. For these tests two pieces of sufficient yardage of each fabric were dry cleaned 5 and 10 times, respectively, by the Manhattan Cleaners and Dyers. The solvent used was a form of Stoddard's solvent containing one percent Sanitone. These fabrics were agitated with soiled garments for 10 minutes in the cleaning vats containing the solvent. The fabrics were rinsed and dried in a humidifier. A steam press was used to remove the wrinkles and care was taken not to stretch the fabrics.

For shrinkage determinations specimens used were 12 inches by 12 inches, according to Commercial Standards CS59-39(2). A 10-inch square whose sides were placed parallel with the warp and filling threads was outlined with white sewing cotton on the fabric prior to its being sent to the commercial dry cleaning establishment. The percentage shrinkage of each fabric, warpwise and fillingwise, was recorded after 1, 5, and 10 dry cleanings.

For the abrasion tests, each specimen 24 inches by six inches was abraded with crocus cloth for 500 strokes on the abrasion machine designed by the Massachusetts Institute of Technology (4). The 1-inch roller was used for flexing, and the six weights supplying the tension totalled three pounds. The effect of abrasion on the warp and filling yarns, before and after dry cleaning, was determined by comparing the breaking strength before abrasion with the breaking strength after abrasion.

The wet and dry breaking strengths of the fabrics were tested warpwise and fillingwise, by the raveled strip method designated by Committee D-13 (3). Ten warp and 10 filling samples were immersed in tap water at room temperature for two hours. They were removed from the water one at a time and broken immediately. The averages of the warp and filling breaking strengths, both wet and dry, were recorded. The elongation was determined from the autographic charts of breaking strength, and the percentage of elongation was calculated.

To measure the crease resistance of each fabric the creasing angle method developed by Schiefer (9) was followed. The specimens were two inches long and one-half inch wide with the long dimension in the warp or filling for tests in these respective directions. These were tested after they had been conditioned for at least four hours. Each specimen was suspended freely at the middle over a horizontal wire of approximately one mm. diameter. Angle 1, formed by bringing the two ends into coincidence and thereby forming a loop, was measured. The ends were held together with a pair of tweezers and placed under a load of one pound for a three-minute period. Then each specimen was suspended freely at the middle over the horizontal wire. At the end of the three-minute suspension period, angle 2, at the vertex where the specimen was folded, was noted. The resiliency ratio in percentage was calculated by dividing the angle after creasing with the angle before creasing and multiplying by 100.

FINDINGS AND DISCUSSION

A summary of the physical characteristics of the seven fabrics analyzed appears in Table 1. The thickness of the fabrics varied from .014 to .022 inches. Fabrics B, F, and G showed a balanced thread count. There was a wide range in the number of threads per inch in warp and filling of fabric C, the warp having 100.1 threads and the filling 48.0 threads per inch. There was a slight increase in

Table 1. Source, price, and physical characteristics of the spun rayon fabrics analyzed.

Fabric	Source	Price per Yard	Width in Inches	Percent of Fiber Content: Viscose	Percent of Fiber Content: Acetate	Percentage of Finish Removed by: Carbon Tetrachloride and Enzyme	Percentage of Finish Removed by: .1 N Nitric Acid	Weave	Kind of Yarn: Warp	Kind of Yarn: Filling	Thickness per 1/1000 Inch	Twist Per Inch: Warp	Twist Per Inch: Filling	Twist: Direction	Percent Crimp: Warp	Percent Crimp: Filling	Yarn Counts: Warp	Yarn Counts: Filling
A	A. M. Tenney and Company, New York City, N. Y.	$0.60	40	74.9	25.1	1.85	2.33	plain	singles	singles	.015	31.3 $\pm$ 2.3	34.8 $\pm$ 2.1	S	7.9	14.2	18.8	21.3
B	A. M. Tenney and Company, New York City, N. Y.	$0.75	40	---	100.0	0.59	0.70	plain	2 ply	2 ply	.020	10.7 $\pm$ 3.9	11.7 $\pm$ 1.2	Z	8.9	8.6	10.4	10.2
C	Hess-Goldsmith Company, New York City, N. Y.	$0.85	40	---	100.0	0.20	0.44	plain	singles	2 ply	.017	2.7 $\pm$ 0.7	83.8 $\pm$ 4.2	Z	8.4	17.8	23.9	13.4
D	Shetland Textiles Company, New York City, N. Y.	$0.75	$38\frac{3}{4}$	51.8	48.2	1.60	0.69	twill	singles	singles	.018	17.9 $\pm$ 3.3	13.6 $\pm$ 2.7	S	4.3	8.2	21.9	17.9
E	Rorabaugh Buck, Wichita, Kans.	$0.69	39	67.0	33.0	2.20	1.50	plain	singles	singles	.014	18.7 $\pm$ 3.0	20.0 $\pm$ 2.2	S	9.1	12.6	23.5	21.8
F	George Innes, Wichita, Kans.	$0.60	$38\frac{3}{4}$	80.6	19.4	1.73	1.20	plain	singles	singles	.022	12.9 $\pm$ 3.0	9.2 $\pm$ 2.8	S	12.8	12.9	10.8	10.6
G	Lit Brothers, Philadelphia, Pa.	$0.69	39	61.4	38.6	1.95	1.50	plain	singles	singles	.014	18.8 $\pm$ 2.1	26.0 $\pm$ 3.4	S	10.8	14.2	22.2	20.0

thread count after five dry cleanings of all the fabrics. On Fig. 8 are indicated the thread count, thickness, and weight per square yard in ounces for each fabric control. Thus, the control of fabric C weighed 5.91 ounces and fabric E weighed 3.83 ounces per square yard. Fabric F had the greatest thickness .022 of an inch, and fabric B possessed a thickness of .020 of an inch. The warp thread count for fabric F was 35.3 threads per inch and for fabric B, 35.8 threads per inch. The filling thread count for fabric E was 51.9 threads per inch and for fabric G 53.6 threads per inch.

The surface appearance, handle, and color of the seven fabrics were not affected by repeated dry cleanings. There was no apparent fading of the colored materials, and fabrics A, B, and C retained their original whiteness.

The amount of sizing and finishing materials present varied from 2.2 percent to 0.2 percent when the carbon tetrachloride and enzyme was used to remove the finishing materials. Fabrics B, C, and D contained gum, glue, and gelatine. Cane sugar was present in fabrics B, D, and G, and dextrin was found in fabrics C and E. Glycerine was present in fabrics E and F and calcium, barium, and magnesium were contained in fabrics G, A, B, and D. Qualitative tests for resins were not made, and it is not known what

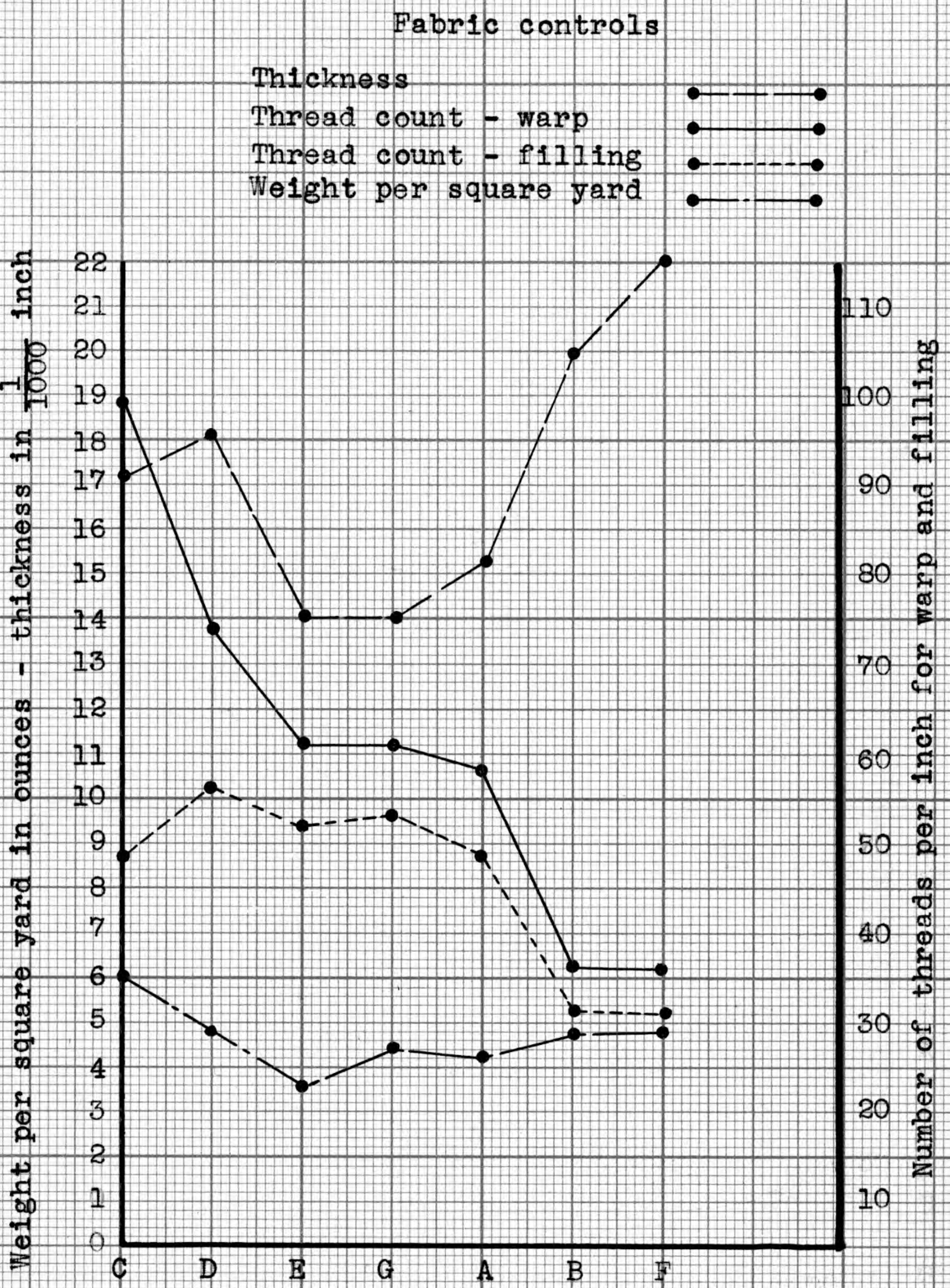

Fig. 8. Weight per square yard, thickness, and warp and filling thread count of the fabric controls.

resins were present. The acid treatment is the only known method of removing resins from textile fabrics. The sizing and finishing materials present after this acid treatment varied from 2.33 to 0.44 percent in fabrics A, B, and C. The remaining fabrics were somewhat lower in percentage of finishing materials present, and no definite conclusion was made concerning the percentage of resin content. The amounts of sizing and finishing materials present, determined by both methods, were comparable.

The crimp varied from 4.3 percent for fabric D to 12.8 percent for fabric F. The filling crimp ranged from 8.2 percent for fabric D to 17.8 percent for fabric C. In fabric F, with 12.8 percent in the warp and 12.9 percent in the filling, the amount of crimp was similar. The yarn counts in the warp were higher than in the filling in each instance, with the exception of fabric A which had a lower yarn count, percentage of crimp, in the warp. The yarn counts of the warp and filling of fabric B exhibited great similarity, as did the yarn counts of fabrics E, F, and G.

The amount of twist in the yarns of fabrics E and G was comparable, while fabric B had a similar twist of 10.7 and 11.7 turns per inch in warp and filling, respectively. The warp of fabric C had 2.7 turns per inch while the filling had 83.7 turns per inch. The high twist in the warp and filling yarns of fabric A did not increase its breaking strength, either dry, wet or after abrasion. The degree of twist for the seven fabrics had no relation to the percentage of shrinkage or resiliency ratio.

The effect of the number of dry cleanings upon the weight per square yard, shrinkage, and resilience is recorded in Table 2. The weight per square yard increased with each dry cleaning in every instance as a result of shrinkage. The greatest variation in percentage of shrinkage occurred in fabric C, whose warp shrank five percent after one dry cleaning, seven percent after five dry cleanings, and eight percent after 10 dry cleanings. The filling did not shrink, which fact was due probably to the thickness of the cloth and the tightly twisted yarns. The percentage of shrinkage for the remaining six fabrics was comparable in both warp and filling. Each fabric showed a rise in percentage shrinkage after five dry cleanings; though this was not the case after 10 dry cleanings.

The range of resiliency ratio was rather constant in six of the seven fabrics. There was a tendency for the number of dry cleanings to increase slightly, the resiliency ratio of both the warp and filling, with the exception of fabrics F and G which showed a small decrease after repeated dry cleanings. The filling of fabric B possessed

Table 2. Weight per square yard in ounces, resilience, and percentage shrinkage of warp and filling of spun rayon fabrics on the controls and after five and ten dry cleanings.

Fabric	Number of Dry Cleanings	Weight per Square Yard in Ounces	Resilience: Warp: Angle 1	Resilience: Warp: Angle 2	Resilience: Warp: Percent	Resilience: Filling: Angle 1	Resilience: Filling: Angle 2	Resilience: Filling: Percent	Percent Shrinkage: Number of Dry Cleanings	Percent Shrinkage: Warp	Percent Shrinkage: Filling
A	0	4.05	141.0	91.0	64.0	143.0	94.0	65.5	1	2.0	2.0
	5	4.46	127.8	88.0	69.0	124.0	81.5	65.5	5	5.0	3.0
	10	4.69	143.0	103.5	72.3	115.5	79.0	68.5	10	5.0	5.0
B	0	4.64	146.0	118.0	80.9	143.0	127.5	89.0	1	1.0	1.0
	5	5.03	127.0	103.0	81.0	114.0	95.5	84.0	5	4.0	3.0
	10	5.47	127.0	105.0	82.5	110.5	97.5	88.5	10	4.0	3.0
C	0	5.91	132.0	92.0	69.5	122.0	91.0	74.6	1	5.0	0.0
	5	6.40	129.0	91.0	70.5	115.0	85.0	74.0	5	7.0	0.0
	10	6.66	124.5	87.5	70.2	116.0	86.0	75.5	10	8.0	0.0
D	0	4.78	142.0	98.5	69.0	109.0	82.0	75.5	1	1.0	0.0
	5	4.85	122.0	85.0	69.5	108.0	81.0	75.5	5	3.0	1.0
	10	4.85	115.0	84.0	73.0	95.0	75.0	79.0	10	4.0	1.0
E	0	3.83	143.0	89.5	62.5	118.0	80.0	67.0	1	1.0	1.0
	5	3.86	142.0	93.0	64.0	117.0	81.0	68.0	5	3.0	5.0
	10	3.89	134.0	89.0	66.5	116.0	73.0	62.0	10	2.0	4.0
F	0	4.73	148.5	114.5	77.5	134.0	104.0	78.0	1	1.0	0.0
	5	4.85	140.0	105.0	75.0	140.5	110.5	78.5	5	3.0	2.0
	10	4.99	142.0	106.0	74.5	123.5	99.5	77.0	10	4.0	2.0
G	0	4.19	139.0	100.0	72.0	126.5	94.5	74.5	1	2.0	2.0
	5	4.51	128.0	96.3	70.2	123.0	92.0	74.5	5	4.0	4.0
	10	4.79	130.0	93.0	71.5	113.0	85.5	75.5	10	3.0	3.0

the highest resiliency with 89.0 percent for the control and 88.5 percent after 10 dry cleanings. The warp resiliency for this fabric was likewise high with 80.9 percent for the control and 82.5 percent after 10 dry cleanings. It is interesting to note that the fiber content of fabric B was Teca the 100 percent acetate rayon staple possessing a permanent crimp.

The breaking strengths of the dry cleaned fabrics were corrected because of the shrinkage and the resulting high thread count per inch. The breaking strength in pounds was multiplied by the thread count of the control and divided by the thread count of the sample to obtain the corrected breaking strength. The breaking strength in percentage was obtained by dividing the corrected breaking strength by the breaking strength of the control and multiplying by 100.

The breaking strength, either dry, wet, or after abrasion, had no relation to thread count and thickness of the fabrics tested. In the warp and filling of the seven fabrics there was a tendency for the dry breaking strength to rise after five dry cleanings. The dry breaking strength appeared to remain constant or decrease slightly after 10 dry cleanings, but the study was too limited to determine accurately the effect of repeated dry cleaning. In Tables 3 and 4 is recorded the warp and filling breaking strength,

Table 3. Thread count and breaking strength of dry, wet and abraded warp samples of spun rayon fabrics, of controls, and after five and ten dry cleanings.

Fabric	Number of Dry Clean-ings	Thread Count (per Inch) Warp		Warp - Breaking Strength								
				Pounds			Pounds Corrected*			Percent of Control**		
		Before Abrasion	After Abrasion	Dry	Wet	After Abrasion	Dry	Wet	After Abrasion	Dry	Wet	After Abrasion
A	0	57.8	56.2	27.5 ± 0.3	12.6 ± 0.4	9.8 ± 0.5	27.5	12.6	9.8	100.0	45.8	35.6
	5	58.2	57.0	26.6 ± 0.3	14.0 ± 0.4	7.2 ± 0.4	26.4	13.9	7.0	96.0	50.6	25.4
	10	61.2	57.2	26.7 ± 0.6	14.3 ± 0.2	8.2 ± 0.6	25.1	13.5	8.0	91.2	49.2	29.1
B	0	35.8	35.1	25.6 ± 0.5	19.3 ± 0.3	12.8 ± 0.5	25.6	19.3	12.8	100.0	75.3	50.0
	5	36.1	36.0	30.0 ± 0.5	19.0 ± 0.2	14.2 ± 0.3	29.8	18.8	13.8	116.4	73.4	46.4
	10	36.1	35.9	28.0 ± 0.7	19.0 ± 0.3	14.9 ± 0.4	27.7	18.8	14.5	108.2	73.4	56.7
C	0	100.1	100.3	32.9 ± 0.4	22.4 ± 0.3	12.8 ± 0.8	32.9	22.4	12.8	100.0	68.0	39.2
	5	101.5	100.1	35.8 ± 0.7	19.5 ± 0.5	10.6 ± 0.3	35.3	19.3	10.6	107.3	58.6	32.3
	10	101.5	100.9	35.5 ± 0.7	18.8 ± 0.5	12.0 ± 0.5	35.0	18.6	12.0	106.5	56.5	36.5
D	0	73.0	73.0	24.3 ± 0.4	13.1 ± 0.3	13.3 ± 0.3	24.3	13.1	13.3	100.0	53.0	54.7
	5	74.8	72.5	28.8 ± 0.5	16.0 ± 0.3	16.4 ± 0.3	28.1	15.6	16.5	115.5	64.2	68.0
	10	73.0	73.1	32.0 ± 0.3	12.8 ± 0.2	16.0 ± 0.1	32.0	12.8	16.0	131.5	63.7	66.0
E	0	60.8	60.0	29.2 ± 0.3	13.6 ± 0.3	2.0 ± 0.3	29.2	13.6	2.0	100.0	46.5	6.8
	5	63.4	61.5	30.5 ± 0.4	17.4 ± 0.4	3.4 ± 0.5	28.8	16.7	3.3	100.1	57.2	11.3
	10	63.2	59.6	31.4 ± 0.5	16.7 ± 0.3	4.0 ± 0.5	30.2	16.0	4.0	103.4	54.8	13.7
F	0	35.3	34.2	32.6 ± 1.0	14.9 ± 0.3	0.5 ± 0.0	32.6	14.9	0.5	100.0	45.7	1.5
	5	35.4	34.7	30.8 ± 0.3	11.0 ± 0.7	0.4 ± 0.0	30.7	10.9	0.4	94.0	33.4	1.2
	10	36.3	35.1	32.8 ± 0.3	12.4 ± 0.5	0.5 ± 0.0	31.8	12.0	0.5	97.4	36.8	1.5
G	0	60.2	59.2	37.3 ± 0.3	21.4 ± 0.0	5.1 ± 0.8	37.3	21.4	5.1	100.0	57.4	13.6
	5	62.1	60.4	35.4 ± 0.5	20.5 ± 0.4	8.9 ± 0.4	34.3	19.8	8.7	92.0	53.0	23.3
	10	62.5	59.3	41.2 ± 0.5	20.2 ± 0.4	10.0 ± 0.3	39.5	19.4	10.0	106.5	52.0	26.8

*Breaking strength of control x $\frac{\text{thread count of control}}{\text{thread count of sample}}$

**$\frac{\text{Breaking strength of sample}}{\text{Breaking strength of control}}$ x 100.

Table 4. Thread count and breaking strength of dry, wet and abraded filling samples of spun rayon fabrics, of controls, and after five and ten dry cleanings.

Fabric	Number of Dry Cleanings	Thread Count (per Inch) Filling		Filling - Breaking Strength								
				Pounds			Pounds Corrected*			Percent of Control**		
		Before Abrasion	After Abrasion	Dry	Wet	After Abrasion	Dry	Wet	After Abrasion	Dry	Wet	After Abrasion
A	0	48.1	47.8	19.9 ± 0.3	10.7 ± 0.3	10.5 ± 0.1	19.9	10.7	10.6	100.0	53.9	53.3
	5	50.5	50.7	22.4 ± 0.3	12.2 ± 0.6	11.4 ± 0.3	21.4	11.6	10.8	107.4	58.2	53.4
	10	51.4	50.0	20.0 ± 0.2	12.2 ± 0.3	11.0 ± 0.6	18.7	11.7	10.6	94.0	58.6	53.3
B	0	31.3	31.7	23.3 ± 0.6	20.5 ± 0.3	13.2 ± 0.3	23.3	20.5	13.1	100.0	88.2	56.3
	5	32.3	32.3	27.5 ± 0.5	18.1 ± 0.4	11.6 ± 0.4	26.7	17.5	11.2	114.5	75.4	48.3
	10	33.2	32.2	26.2 ± 0.4	16.6 ± 0.3	14.0 ± 0.6	24.8	15.7	13.6	106.2	67.4	58.3
C	0	48.0	48.7	36.1 ± 0.3	28.5 ± 0.2	36.5 ± 0.5	36.1	28.5	35.0	100.0	79.0	97.0
	5	51.1	50.9	37.4 ± 0.6	28.9 ± 0.4	37.3 ± 0.8	35.2	27.1	35.2	97.6	75.0	97.5
	10	52.8	51.4	39.8 ± 0.2	28.6 ± 0.3	37.4 ± 0.7	36.2	26.1	35.0	100.0	69.5	97.0
D	0	56.2	55.4	21.8 ± 0.5	12.0 ± 0.4	12.0 ± 0.5	21.8	12.0	12.3	100.0	55.0	56.4
	5	57.7	57.2	24.5 ± 0.6	11.2 ± 0.2	12.3 ± 0.5	23.8	10.9	12.1	109.1	49.8	55.5
	10	56.4	54.7	23.4 ± 0.5	10.7 ± 0.2	12.4 ± 0.7	23.3	10.7	12.5	106.5	49.1	57.3
E	0	51.9	51.8	16.0 ± 0.4	6.5 ± 0.3	0.5 ± 0.2	16.0	6.5	0.5	100.0	40.6	3.1
	5	53.4	52.8	18.0 ± 0.4	7.0 ± 0.3	0.6 ± 0.3	17.5	6.8	0.6	109.1	42.5	3.7
	10	53.9	53.0	16.6 ± 0.6	5.7 ± 0.2	0.7 ± 0.2	15.9	5.5	0.7	99.5	34.3	4.4
F	0	30.1	29.4	24.5 ± 0.5	11.4 ± 0.2	0.6 ± 0.0	24.5	11.4	0.6	100.0	46.6	2.5
	5	30.6	29.8	23.7 ± 0.5	7.7 ± 0.2	0.2 ± 0.0	23.3	7.6	0.2	95.2	31.0	0.8
	10	30.4	29.4	24.3 ± 0.3	9.2 ± 0.3	0.3 ± 0.0	24.1	9.1	0.3	98.5	37.1	1.2
G	0	53.6	53.3	32.9 ± 0.8	20.2 ± 0.4	6.0 ± 0.2	32.9	20.2	6.0	100.0	61.5	18.2
	5	55.8	55.0	36.4 ± 0.3	20.4 ± 0.5	8.2 ± 0.8	35.0	19.7	8.0	106.5	59.9	24.3
	10	55.3	55.0	35.4 ± 0.5	17.8 ± 0.3	7.1 ± 0.6	34.3	17.3	6.9	104.2	52.6	20.9

* Breaking strength of control x $\frac{\text{thread count of control}}{\text{thread count of sample}}$

** $\frac{\text{Breaking strength of sample}}{\text{Breaking strength of control}}$ x 100.

dry, wet and after abrasion and Figs. 9 to 15 show the effect of the number of dry cleanings on the dry, wet and after abrasion breaking strength in percentages of the controls.

The dry breaking strength of the warp varied from 24.3 pounds for the controls of fabric D to 37.3 pounds for fabric G. The greatest variation in the warp controls was found in the breaking strength after abrasion. The warp of fabric F broke at 0.5 pounds, while fabric D broke at 13.3 pounds.

There was a lower range in the dry breaking strength of the filling than in the warp. Fabric E broke at 16.0 pounds and fabric C at 36.1 pounds in the filling controls. The lowest wet strength of the filling was found in fabric E at 6.5 pounds. In contrast, fabric C broke at 28.5 pounds, the highest for the wet controls of the filling. As in the warp, the widest range in breaking strength of the filling controls occurred after abrasion. Fabrics E and F broke at 0.5 and 0.6 pounds respectively, and fabric C broke at 36.5 pounds, the highest for the abraded filling.

Fabrics B and C which were 100 percent acetate had higher wet breaking strength than the fabrics of viscose and acetate mixtures, which showed approximately 50 percent loss in wet breaking strength. The lowest wet breaking

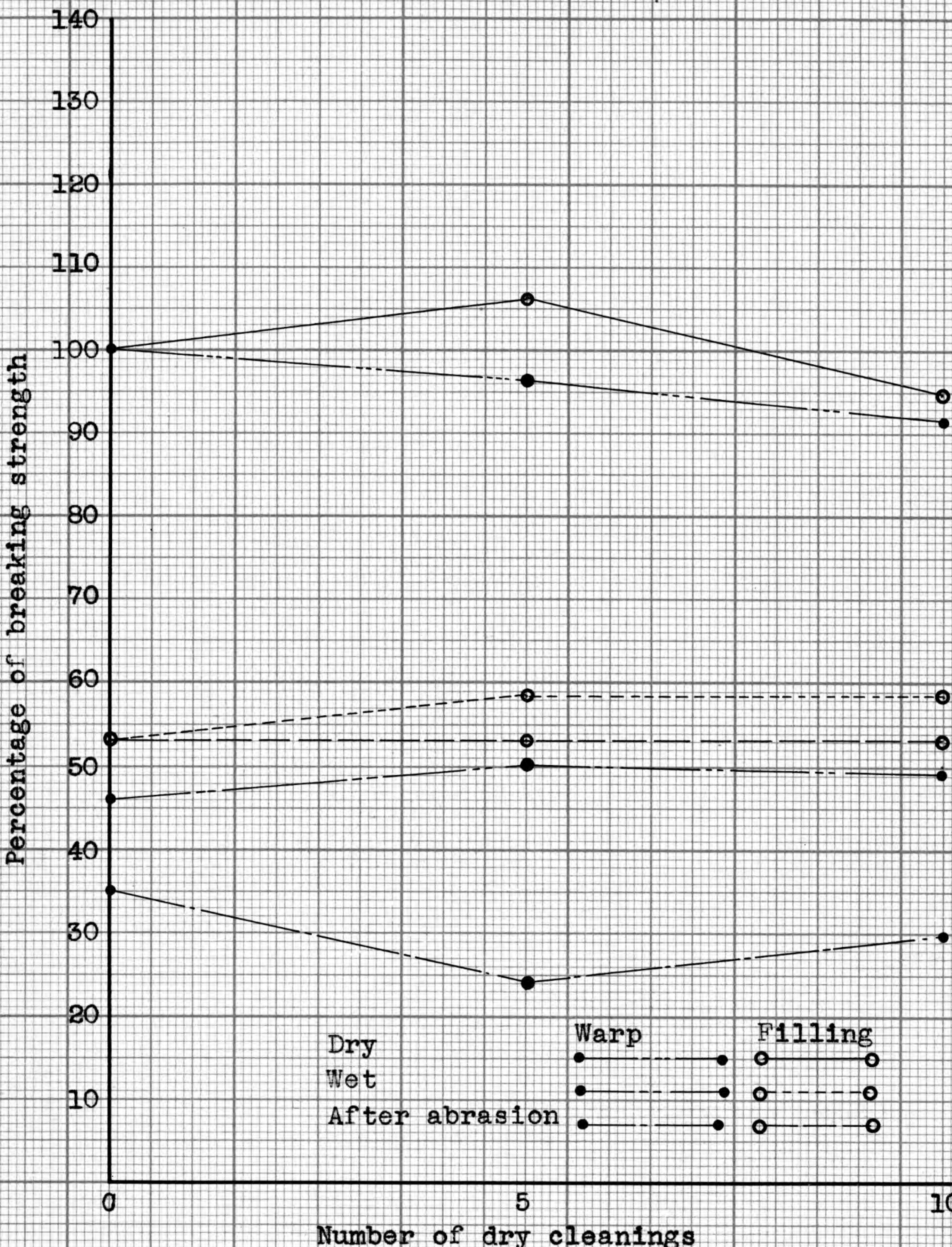

Fig. 9. Breaking strength, dry, wet, and after abrasion in percentage of the controls and after five and ten dry cleanings of fabric A.

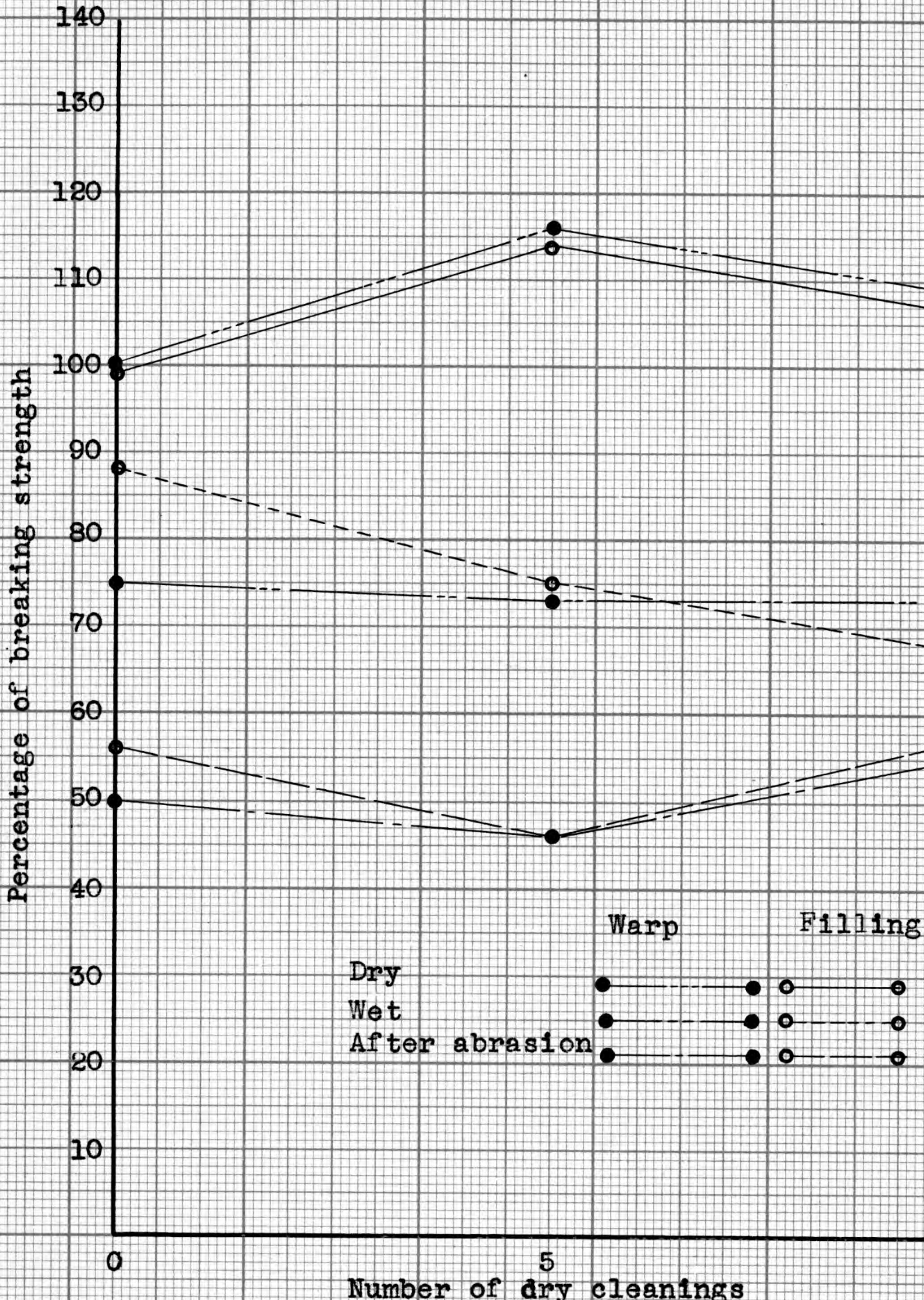

Fig. 10. Breaking strength, dry, wet, and after abrasion in percentage of the controls and after five and ten dry cleanings of fabric B.

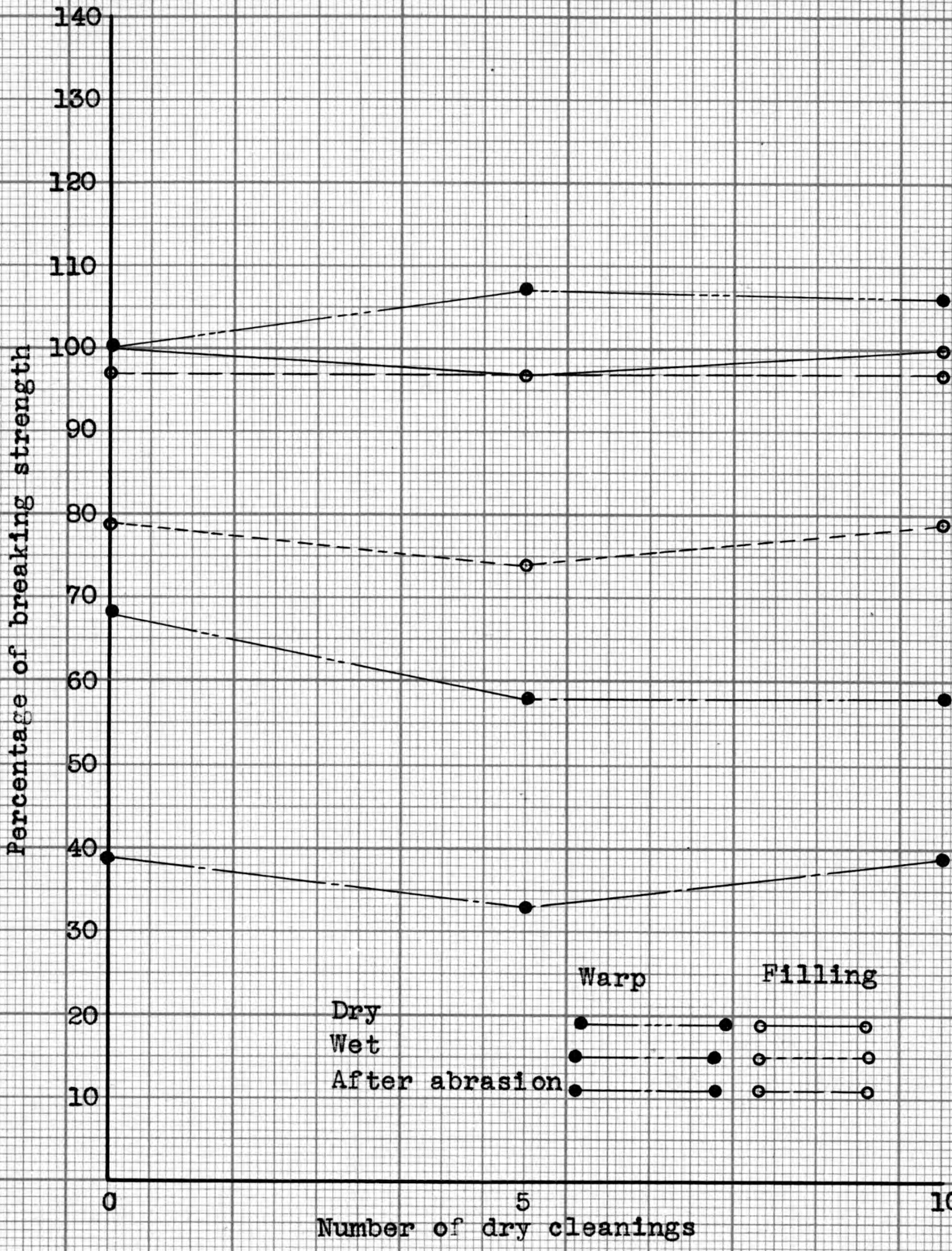

Fig. 11. Breaking strength, dry, wet, and after abrasion in percentage of the controls and after five and ten dry cleanings of fabric C.

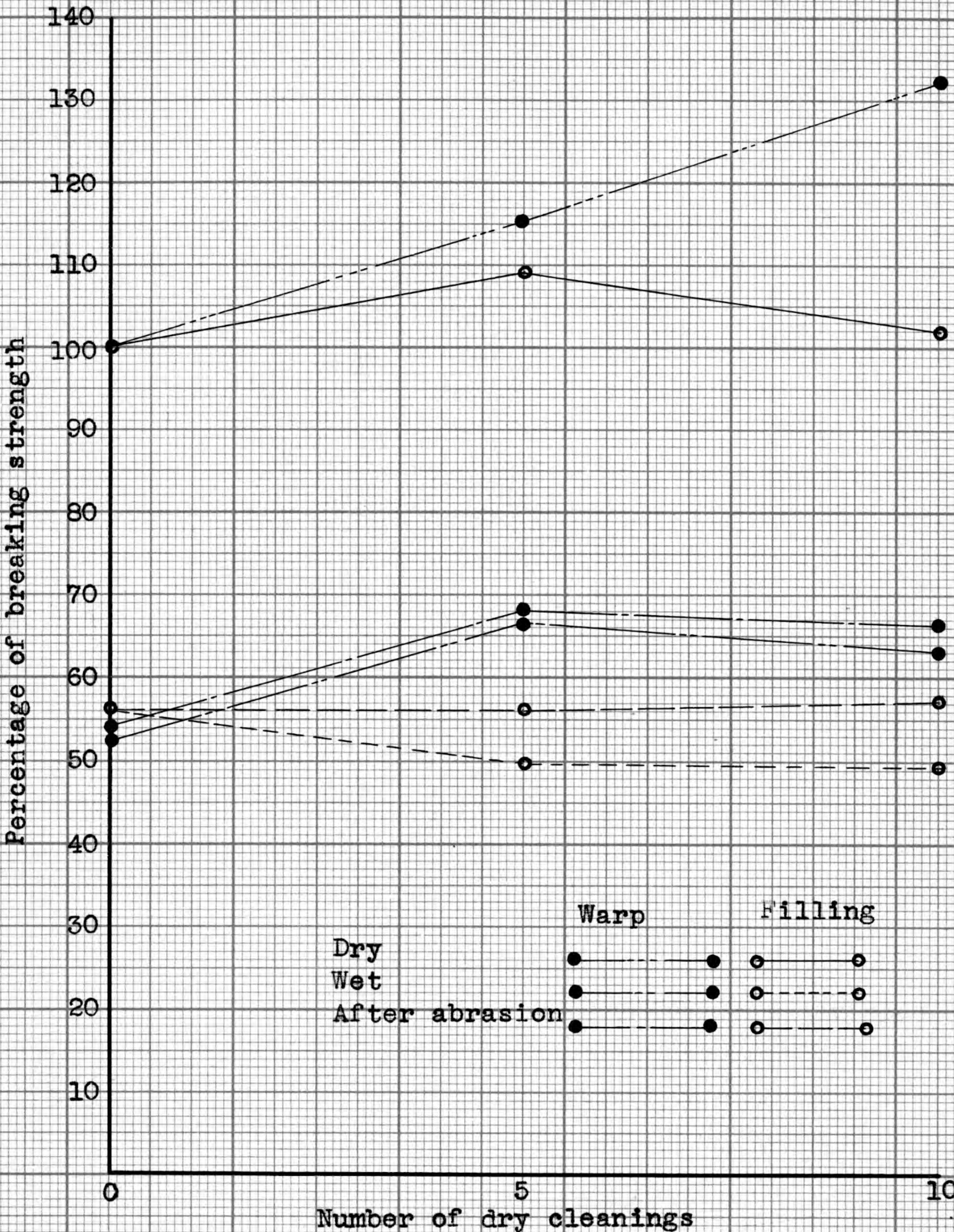

Fig. 12. Breaking strength, dry, wet, and after abrasion in percentage of the controls and after five and ten dry cleanings of fabric D.

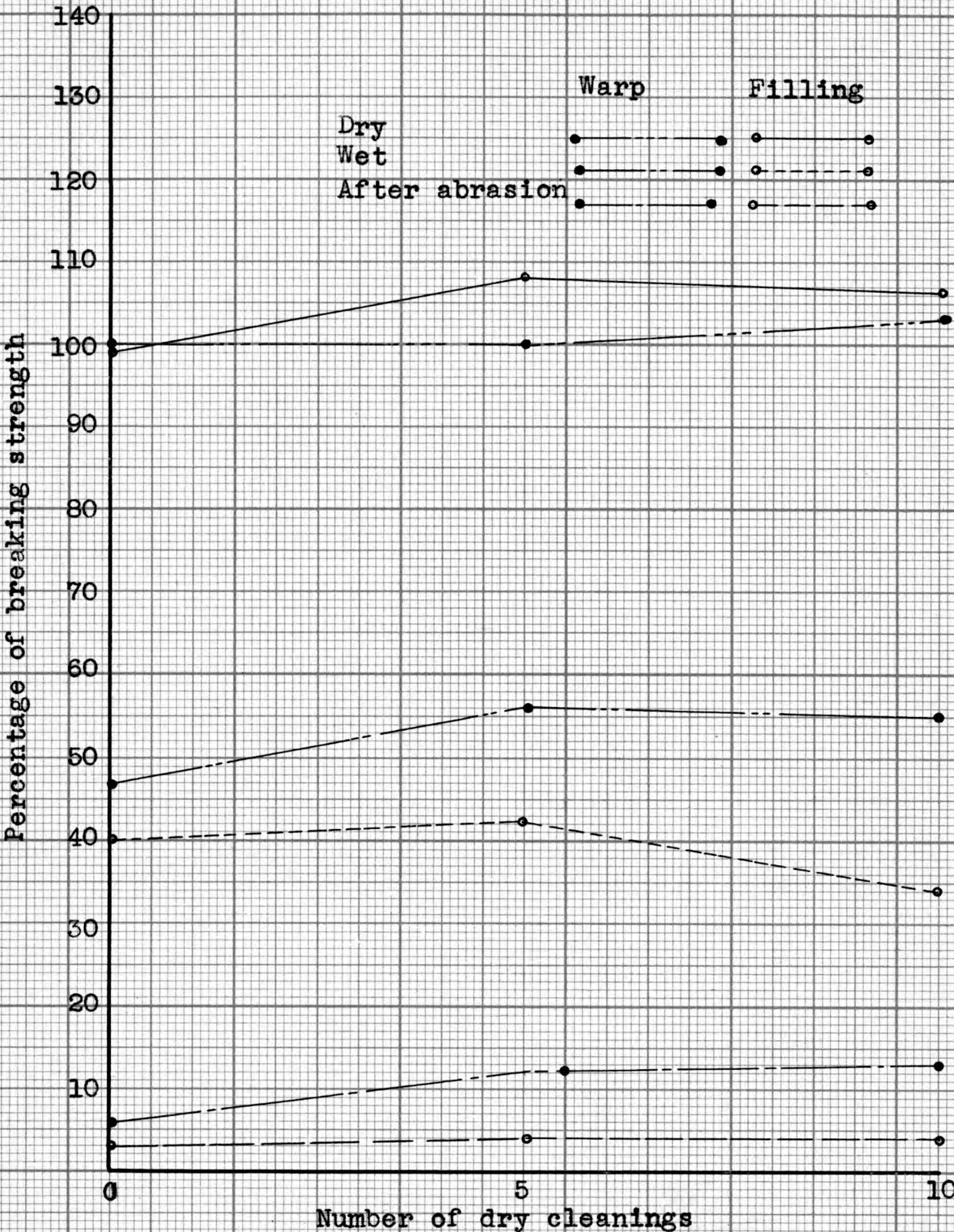

Fig. 13. Breaking strength, dry, wet, and after abrasion in percentage of the controls and after five and ten dry cleanings of fabric E.

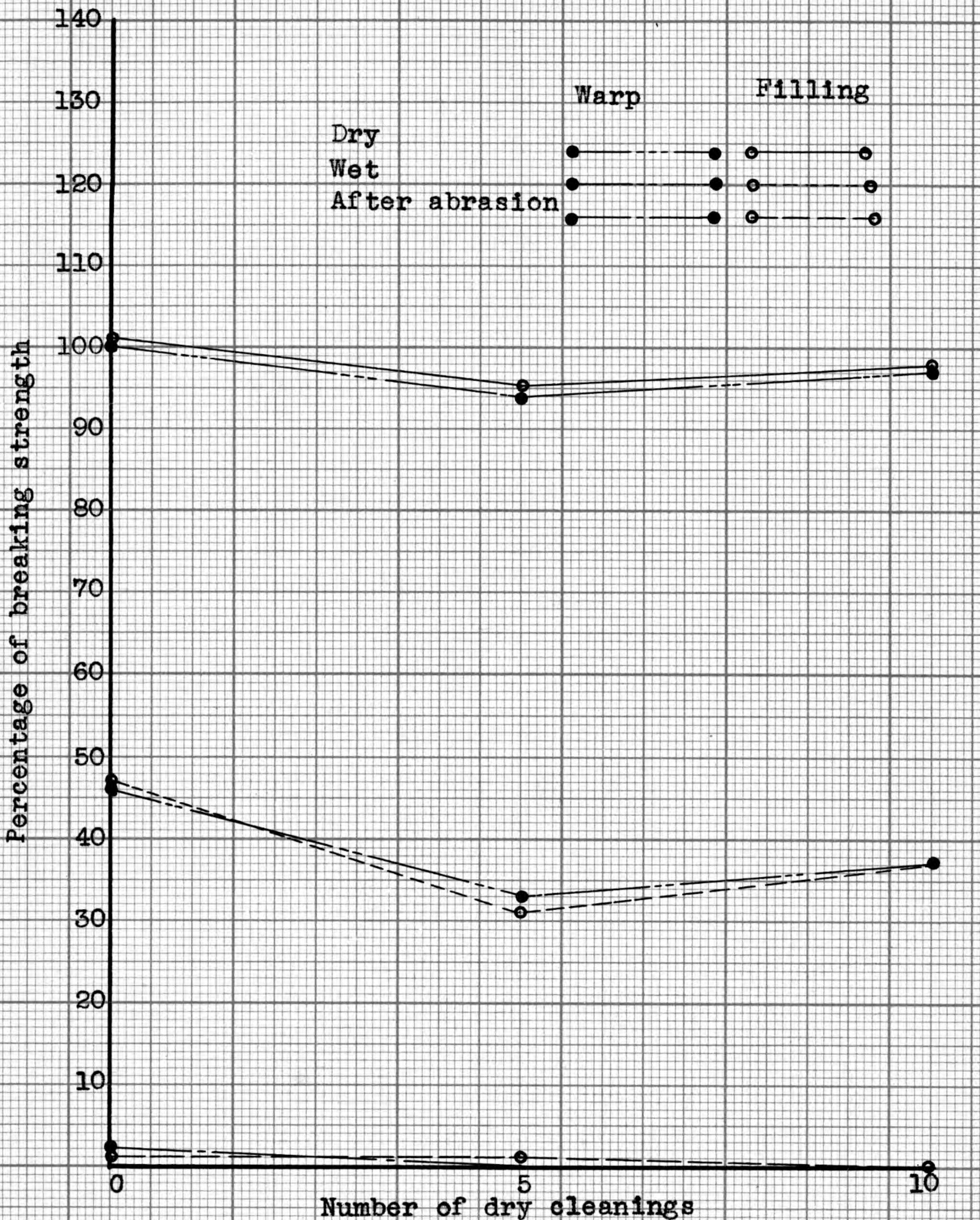

Fig. 14. Breaking strength, dry, wet, and after abrasion in percentage of the controls and after five and ten dry cleanings of fabric F.

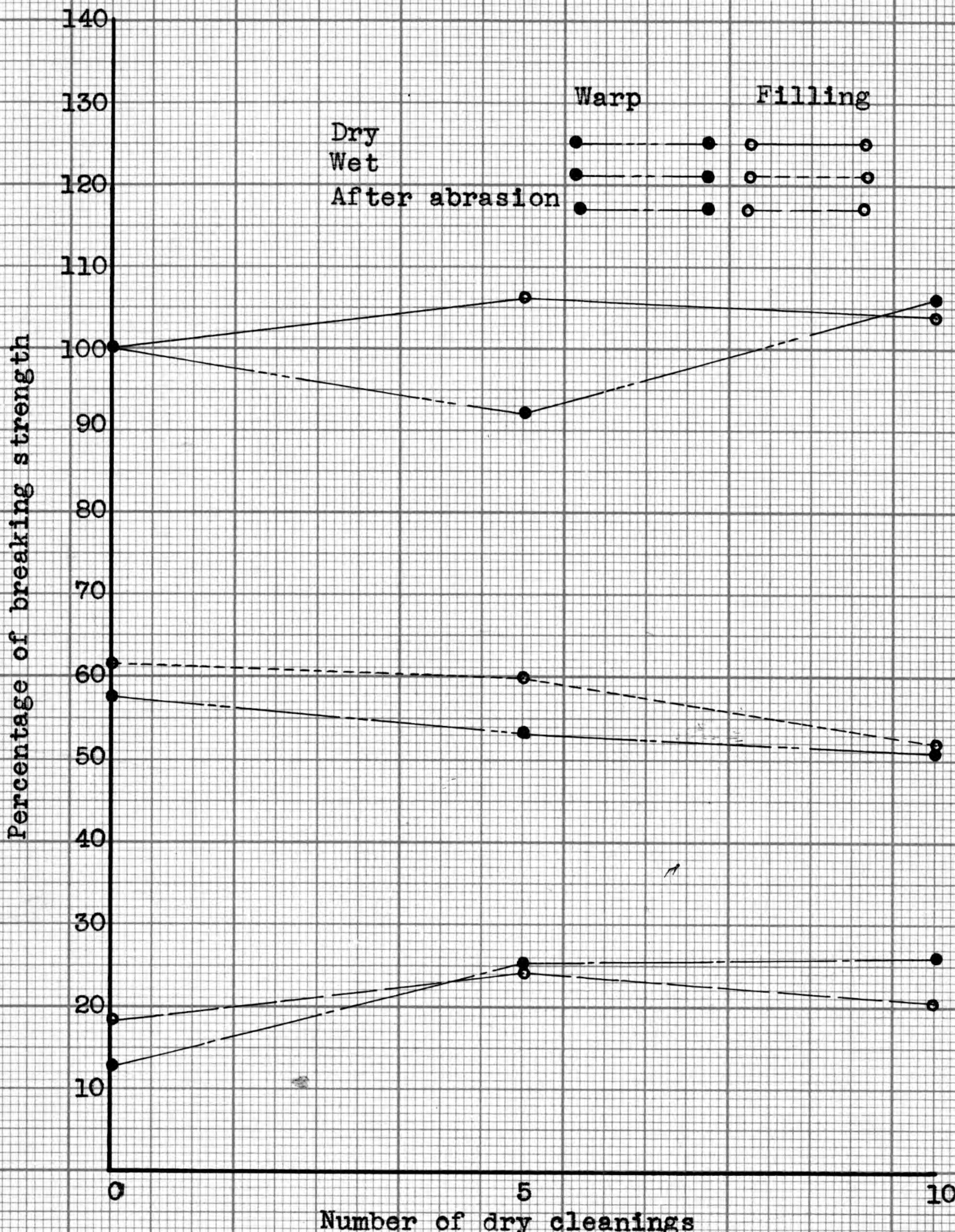

Fig. 15. Breaking strength, dry, wet, and after abrasion in percentage of the controls and after five and ten dry cleanings of fabric G.

strength of the warp of 33.4 percent was recorded in the warp of fabric F after five dry cleanings. Fabrics A, E, and F, containing 67.0 to 80.6 percent viscose, possessed comparable wet breaking strength. In the warp controls, fabrics D and G, containing 51.8 and 61.4 percent viscose, respectively, showed great similarity in their wet breaking strength.

Low resistance to abrasion was shown in the warp and filling of fabrics E and F, which contained 67.0 and 80.6 percent viscose respectively. The abraded warp of fabric F had the low breaking strength of 1.5 percent, while the abraded filling broke at 2.5 percent of the controls. In the warp, fabric D exhibited the greatest resistance to abrasion, breaking at 54.7 percent of the controls. The filling of fabric C, 100 percent acetate, showed only a slight decrease in strength after abrasion, which fact probably was due to the thickness and weight of the fabric and the high twist of the yarns. In fabric B, the abraded warp and filling breaking strength was comparable. Fabrics E, F, and G, which contained 60 percent or more viscose, showed a greater loss in breaking strength after abrasion in both warp and filling control and after 5 and 10 dry cleanings than those fabrics of 100 percent acetate.

The number of dry cleanings had little effect on the elongation of the fabrics when tested, either dry, wet, or after abrasion. In Tables 5 and 6 are presented the warp and filling elongations in inches and percentages. In Figs. 16 to 22 are recorded the effect of the number of dry cleanings on the percent of elongation, dry, wet, and after abrasion. The 100 percent acetate fabrics possessed the greatest wet elongation, varying from 30 to 40 percent in the warp and filling. The lowest wet elongation of the warp yarns in the control was found in fabric F, with 11.3 percent, and fabric E had the lowest wet elongation of the filling of 9.3 percent. For the abraded warp controls of the fabrics the percentage of elongation varied from 3.6 to 10.0 percent. In all cases the elongation after abrasion was lower than the dry or wet elongation. In the viscose and acetate mixtures, the dry, wet, and after abrasion elongations tended to be comparable. Of these mixtures, fabric A, with a content of 74.9 percent viscose, had the highest percentage of elongation for the dry, wet, and abraded specimens in both the warp and filling which fact probably was due to the high twist of the yarn.

Table 5. Dry, wet and abraded elongations, in inches and percentages, of the warp samples of spun rayon fabrics, on the controls, and after five and ten dry cleanings.

Fabric	Number of Dry Clean-ings	Warp Elongation					
		Inches			Percent*		
		Dry	Wet	After Abrasion	Dry	Wet	After Abrasion
A	0	0.63 ± 0.01	0.55 ± 0.03	0.31 ± 0.01	21.0	18.3	10.3
	5	0.61 ± 0.00	0.61 ± 0.03	0.30 ± 0.02	20.3	20.3	10.0
	10	0.61 ± 0.01	0.72 ± 0.02	0.26 ± 0.01	20.3	24.0	8.6
B	0	0.56 ± 0.01	0.91 ± 0.02	0.17 ± 0.00	18.6	30.3	5.6
	5	0.60 ± 0.00	0.94 ± 0.03	0.28 ± 0.02	20.0	31.3	9.3
	10	0.62 ± 0.02	0.93 ± 0.01	0.31 ± 0.01	20.6	31.0	10.3
C	0	0.80 ± 0.02	1.25 ± 0.03	0.47 ± 0.02	26.6	41.6	15.6
	5	0.87 ± 0.02	1.25 ± 0.05	0.26 ± 0.01	29.0	41.6	8.6
	10	0.93 ± 0.02	1.19 ± 0.02	0.30 ± 0.02	31.0	39.6	10.0
D	0	0.34 ± 0.02	0.36 ± 0.04	0.18 ± 0.00	11.3	12.0	6.0
	5	0.31 ± 0.01	0.31 ± 0.01	0.27 ± 0.02	10.3	10.3	9.0
	10	0.27 ± 0.01	0.33 ± 0.05	0.22 ± 0.00	9.0	11.0	7.3
E	0	0.43 ± 0.00	0.37 ± 0.03	0.16 ± 0.02	14.3	12.3	5.3
	5	0.39 ± 0.01	0.40 ± 0.01	0.18 ± 0.03	13.0	13.3	6.0
	10	0.43 ± 0.01	0.39 ± 0.01	0.17 ± 0.02	14.3	13.0	5.6
F	0	0.45 ± 0.03	0.34 ± 0.02	0.09 ± 0.03	15.0	11.3	3.0
	5	0.41 ± 0.00	0.31 ± 0.01	0.17 ± 0.00	13.6	10.3	5.6
	10	0.39 ± 0.01	0.34 ± 0.05	0.11 ± 0.02	13.0	11.3	3.6
G	0	0.43 ± 0.03	0.55 ± 0.03	0.24 ± 0.01	14.3	18.3	8.0
	5	0.50 ± 0.01	0.47 ± 0.02	0.26 ± 0.02	16.6	15.6	8.6
	10	0.56 ± 0.03	0.53 ± 0.01	0.27 ± 0.01	18.6	17.6	9.0

*$\frac{\text{Elongation in inches}}{3} \times 100$.

Table 6. Dry, wet and abraded elongations, in inches and percentages, of the filling samples of spun rayon fabrics, on the controls, and after five and ten dry cleanings.

Fabric	Number of Dry Cleanings	Filling Elongation					
		Inches			Percent*		
		Dry	Wet	After Abrasion	Dry	Wet	After Abrasion
A	0	0.66 ± 0.01	0.50 ± 0.01	0.30 ± 0.02	22.0	16.6	10.0
	5	0.67 ± 0.01	0.69 ± 0.04	0.30 ± 0.02	22.3	23.3	10.0
	10	0.63 ± 0.02	0.62 ± 0.01	0.40 ± 0.04	21.0	20.6	10.3
B	0	0.59 ± 0.00	0.92 ± 0.03	0.21 ± 0.01	19.6	30.6	7.0
	5	0.65 ± 0.01	0.93 ± 0.02	0.22 ± 0.02	21.6	31.0	7.3
	10	0.57 ± 0.02	1.00 ± 0.02	0.25 ± 0.03	19.0	33.3	8.3
C	0	0.64 ± 0.01	0.97 ± 0.05	0.61 ± 0.01	21.3	32.3	20.3
	5	0.59 ± 0.02	0.86 ± 0.01	0.63 ± 0.01	19.6	28.6	21.0
	10	0.64 ± 0.01	0.90 ± 0.01	0.39 ± 0.01	21.3	30.0	13.0
D	0	0.36 ± 0.01	0.46 ± 0.01	0.31 ± 0.01	12.0	15.3	10.3
	5	0.36 ± 0.00	0.48 ± 0.01	0.22 ± 0.01	12.0	16.0	7.3
	10	0.37 ± 0.00	0.36 ± 0.01	0.35 ± 0.02	12.3	12.0	11.6
E	0	0.34 ± 0.01	0.28 ± 0.02	0.11 ± 0.03	11.3	9.3	3.6
	5	0.35 ± 0.00	0.30 ± 0.01	0.15 ± 0.01	11.6	10.0	5.0
	10	0.34 ± 0.00	0.26 ± 0.01	0.12 ± 0.01	11.3	8.6	4.0
F	0	0.41 ± 0.01	0.45 ± 0.01	0.10 ± 0.01	13.6	15.0	3.3
	5	0.40 ± 0.01	0.36 ± 0.02	0.25 ± 0.01	13.3	12.0	8.3
	10	0.40 ± 0.01	0.33 ± 0.00	0.33 ± 0.02	13.3	11.0	11.0
G	0	0.62 ± 0.01	0.65 ± 0.02	0.16 ± 0.01	20.6	21.6	5.3
	5	0.64 ± 0.01	0.61 ± 0.00	0.34 ± 0.02	21.3	20.3	11.3
	10	0.58 ± 0.02	0.57 ± 0.01	0.22 ± 0.02	19.3	19.0	7.3

$^{*}\dfrac{\text{Elongation in inches}}{3} \times 100.$

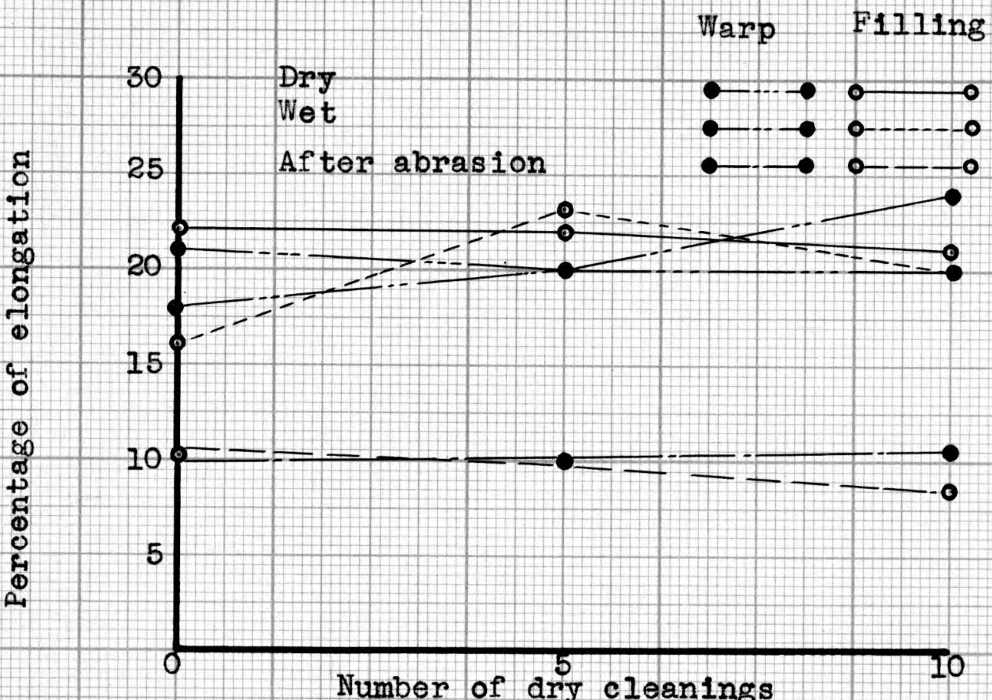

Fig. 16. Percent elongation, dry, wet, and after abrasion of warp and filling on control and after five and ten dry cleanings for fabric A.

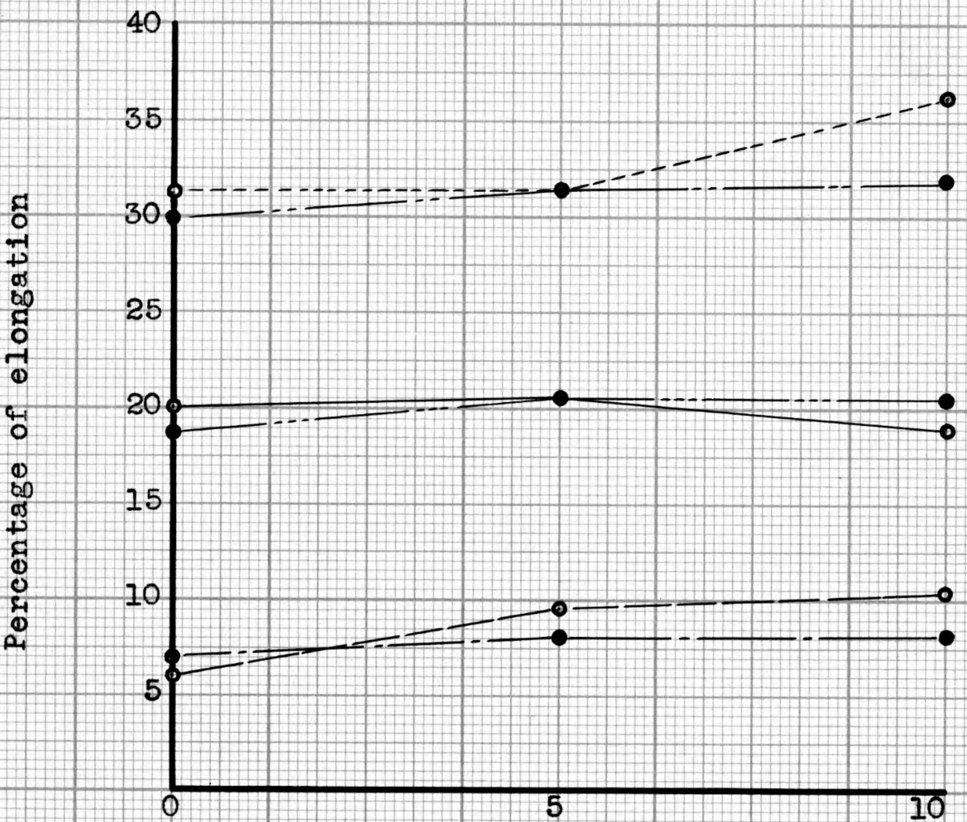

Fig. 17. Percent elongation, dry, wet, and after abrasion of warp and filling on control and after five and ten dry cleanings for fabric B.

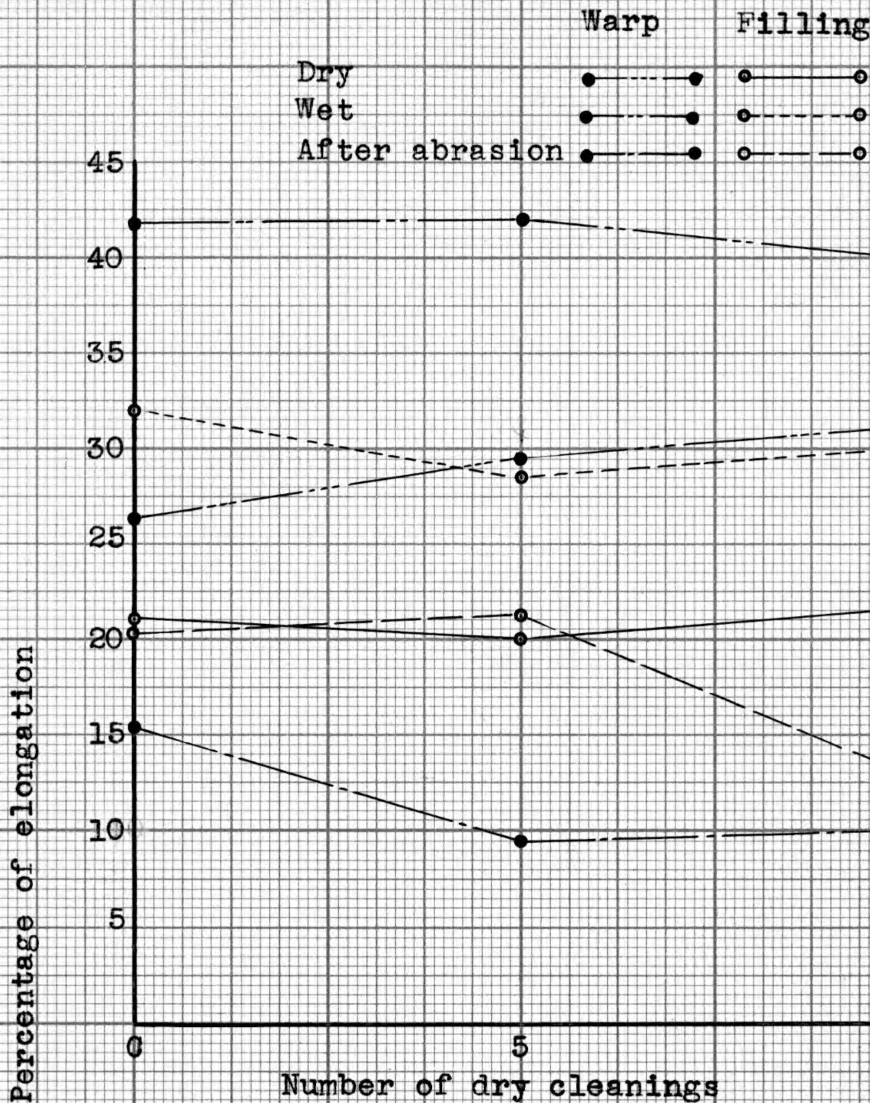

Fig. 18. Percent elongation, dry, wet, and after abrasion of warp and filling on control and after five and ten dry cleanings for fabric C.

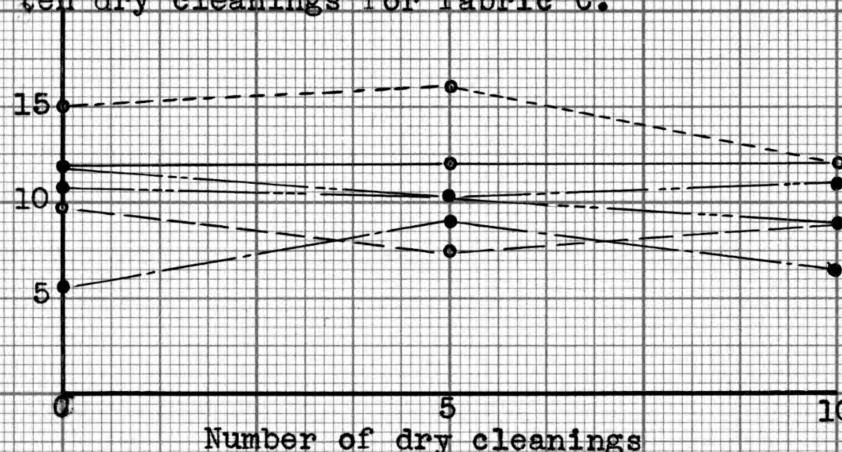

Fig. 19. Percent elongation, dry, wet, and after abrasion of warp and filling on control and after five and ten dry cleanings for fabric D.

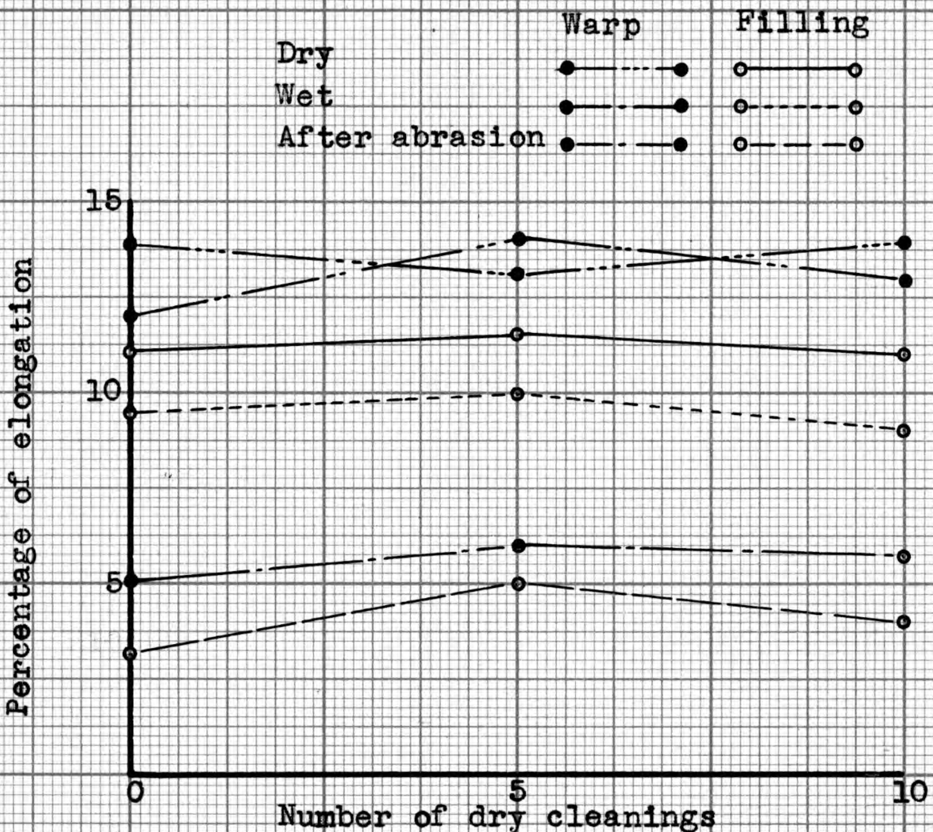

Fig. 20. Percent elongation, dry, wet, and after abrasion of warp and filling on control and after five and ten dry cleanings for fabric E.

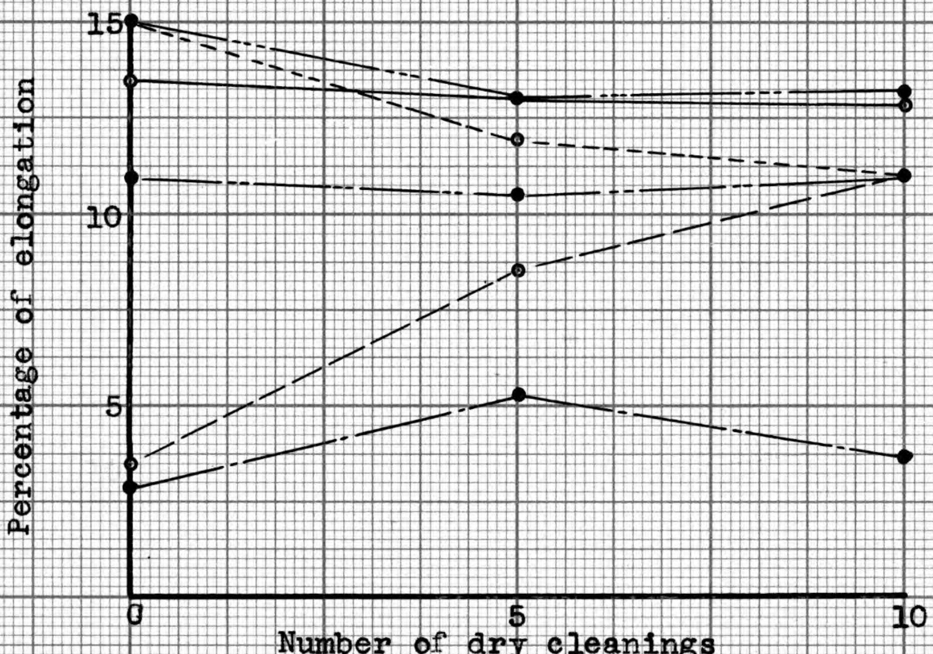

Fig. 21. Percent elongation, dry, wet, and after abrasion of warp and filling on control and after five and ten dry cleanings for fabric F.

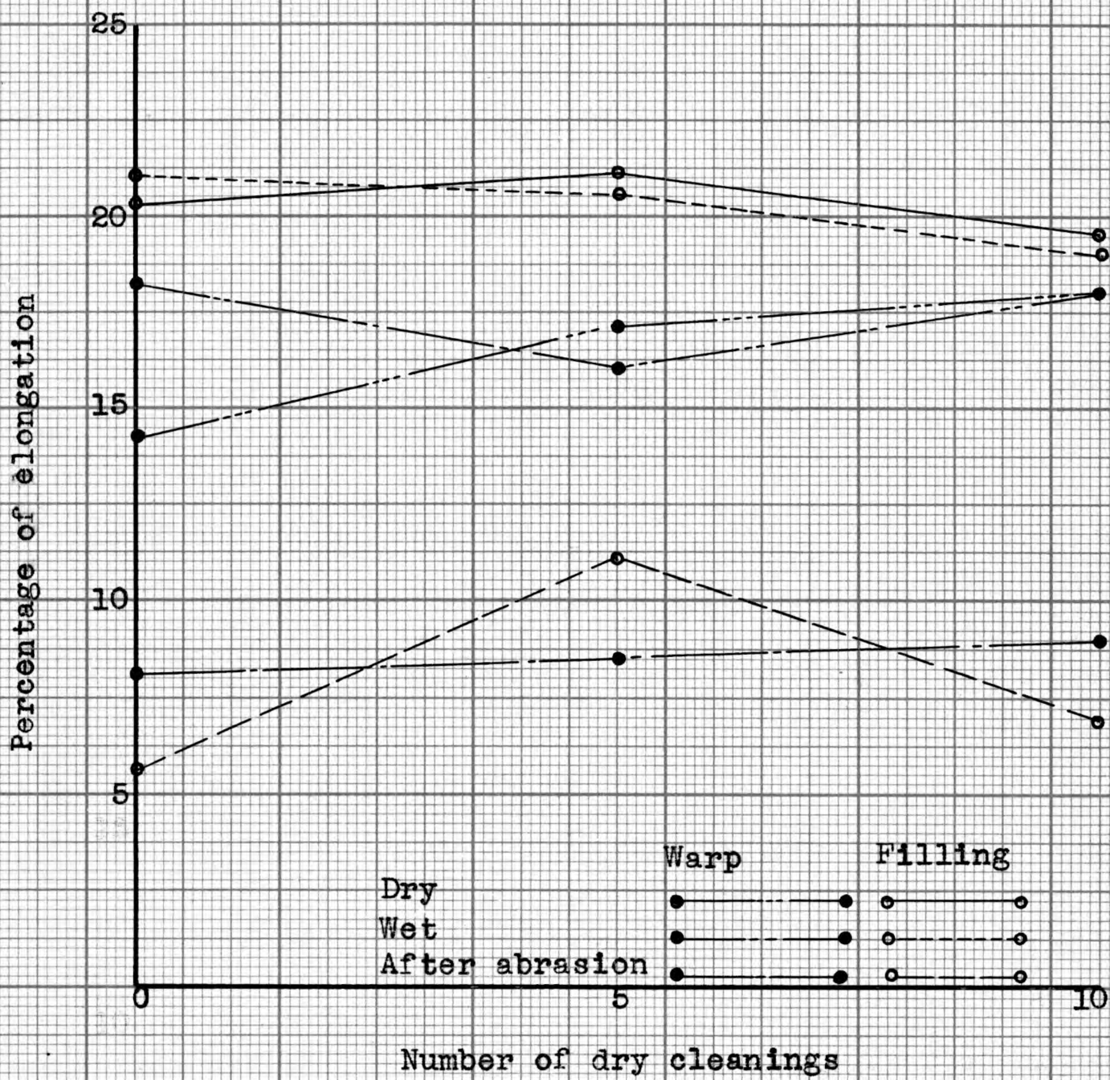

Fig. 22. Percent elongation, dry, wet, and after abrasion of warp and filling on control and after five and ten dry cleanings for fabric G.

SUMMARY

1. The surface appearance, handle, and color of the seven fabrics were not affected by repeated dry cleanings. There was no apparent fading of the colored materials, and fabrics A, B, and C retained their original whiteness.

2. The 5 and 10 dry cleanings had little effect on the breaking strength of the dry, wet and abraded fabrics.

3. There was a tendency for the breaking strength to increase after 5 dry cleanings and after 10 dry cleanings the breaking strength tended to remain fairly constant or even decrease slightly. The study was too limited to determine definitely the effect of repeated dry cleanings.

4. In these fabrics, there was no relation of thread count, thickness, and weight per square yard to breaking strength.

5. Fabrics of 100 percent acetate possessed a higher wet breaking strength than did the fabrics of viscose and acetate mixtures.

6. The fabrics which were 100 percent acetate exhibited the greatest wet elongation.

7. The abraded elongations for all fabrics were lower than either the dry or wet elongations.

8. There was a higher percentage shrinkage after five dry cleanings than after one dry cleaning in every fabric in both warp and filling.

9. The highest percentage of shrinkage occurred in the warp of fabric C, which had the lowest twist and the highest thread count.

10. The 5 and 10 dry cleanings had little effect on the degree of crease resistance of the seven fabrics.

11. The degree of crease resistance was greatest in fabric B, the Teca fabric which is an acetate rayon staple with a permanent crimp. All mixtures possessed a similar degree of crease resistance.

ACKNOWLEDGMENT

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