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THERMAL PROPERTIES OF MOIST FABRICS

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ABSTRACT

The "chilling effect", or "clamminess", that moist fabrics produce when in contact with the body was evaluated by subjective tests, by measurement of the drop in temperature that ensued when the moist fabrics were placed on an artificial "skin" surface, and by tests with a moisture-sensitive paper designed to measure the extent of contact which the fabrics made with a surface. Using fabrics of various fiber compositions and constructions, a good qualitative relation was found in these tests. Fabrics which produced considerable chilling in subjective tests were found to make good contact and to cause a substantial drop in skin temperature. Conversely, fabrics which caused little or no clamminess made poor contact and the accompanying drop in temperature was relatively small. The results of these experiments show clearly the progressive improvement of the fabrics with respect to chilling, as their wool content is increased, and also the superiority of certain types of construction that minimize the extent of contact of the fabrics with the skin.

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I. INTRODUCTION

Practical experience has demonstrated that moist fabrics in contact with the body produce an unpleasant sensation, commonly referred to as a "chilling effect" or a "clammy feel." The intensity of the sensation varies with different fibers and fabrics; thus, on the basis of general experience, the merits of wool fabrics over similar cotton fabrics have long been recognized. This is one of the reasons, for example, for the preference usually given to woolen underwear and other garments for use in cold climates under conditions where physical labor causes considerable perspiration. It also accounts for the preference commonly expressed for woolen bathing suits.

In selecting fabrics for warmth, the thermal resistance is a factor of primary importance, and this property has been measured by

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many investigators [1, 2, 3, 4, 5, 6].[2] In general, the results indicate that for comparable thicknesses and densities there are no outstanding differences between different fabrics. The chilling effect noted above, however, has suggested that marked differences may be obtained as the amount of moisture contained in a fabric is increased, and accordingly an investigation was undertaken to evaluate this and other factors contributing to the phenomenon of chilliness, or clamminess, in wet fabrics.

II. MATERIALS

Thirty-six samples of knit underwear fabric, prepared especially for experimental purposes, were used throughout the investigation. The fabrics consisted of plain and special knits of various weights and thicknesses and of different fiber compositions, as described in tables 1 and 2. Both unlaundered and twice-laundered samples were examined.

TABLE 1.—*Description of fabrics*

Sample	Type of spinning	Type of knitting	Fiber content of yarn	Nominal weight of undershirts (1 dozen, size 40) unlaundered
				lb
A	Cotton	Rib	100% cotton	10½
B	do	do	75% cotton, 25% wool	10½
C	French	do	50% cotton, 50% wool	10½
D	do	do	do	10½
E	do	do	25% cotton, 75% wool	10½
F	do	do	100% wool	10½
G	Cotton	do	100% cotton	8 to 8¼
H	do	do	75% cotton, 25% wool	8 to 8¼
I	French	do	50% cotton, 50% wool	8 to 8¼
K	do	do	25% cotton, 75% wool	8 to 8¼
L	do	do	100% wool	8 to 8¼
M	Cotton	do	100% cotton	5½ to 6
N	do	do	75% cotton, 25% wool	5½ to 6
O	French	do	50% cotton, 50% wool	5½ to 6
Q	do	do	25% cotton, 75% wool	5½ to 6
R	do	do	100% wool	5½ to 6
CA	do	Mesh stitch	50% cotton, 50% wool	8 to 8¼
CB	do	do	do	5½ to 6
CC	do	Waffle stitch	do	10½
CD	Filament	Rib	100% acetate filament	Light [a]
CE	do	do	100% viscose-rayon filament	Do.
CF	do	do	100% nylon filament	Do.
FC	French	Flat	50% cotton, 50% wool	10½
FI	do	do	do	8 to 8¼
FM	Cotton	do	100% cotton	5½ to 6
FO	French	do	50% cotton, 50% wool	5½ to 6
XA	do	Shaker stitch	do	10½
XB	Cotton and French	Duofold type	100% cotton in, 100% wool out	10½
XC	do	do	100% cotton out, 100% wool in	10½
XD	French	Interlock	50% cotton, 50% wool	8 to 8¼
XE	do	Terry stitch	do	10½
XF	Cotton	Alternate rib feed	75% cotton, 25% wool	10½
XG	do	Rib	50% cotton, 50% wool	8 to 8¼
XH	do	Flat fleece lined	100% cotton	10½
XI	Woolen	Rib	100% wool	10½
XJ	Cotton	Raschel	100% cotton	10½

[a] The nominal weights of these fabrics in pounds per dozen undershirts of size 40 was not given. Their actual weights in ounces per square yard are as follows: *CD*, 3.4; *CE*, 4.2; *CF*, 5.4

[2] Figures in brackets indicate the literature references at the end of the paper.

TABLE 2.—*Properties of twice-laundered fabrics*

Sample	Weight of fabrics	Thickness of fabrics at pressure of 0.1 lb/in.²	Air permeability [a] at pressure drop of 0.5 in. H_2O	Thermal [b] transmission
	oz/yd²	*in.*	*ft³/(min×ft²)*	*Btu/(°F×hr×ft²)*
A	11.4	0.063	86	1.24
B	12.3	.073	82	1.24
C	12.0	.078	85	1.20
D	10.8	.066	126	1.25
E	11.7	.070	137	1.24
F	9.8	.076	197	1.18
G	9.8	.061	101	1.30
H	9.7	.072	109	1.20
I	10.9	.077	94	1.20
K	9.5	.073	195	1.26
L	9.9	.067	215	1.20
M	6.0	.048	180	1.33
N	6.3	.055	193	1.26
O	6.2	.054	239	1.25
Q	6.4	.057	268	1.24
R	7.0	.080	310	1.15
CA	8.3	.068	238	1.32
CB	4.9	.055	390	1.32
CC	13.0	.108	144	1.23
CD	3.6	.023	[c] 249	1.48
CE	4.2	.028	[c] 242	1.48
CF	5.5	.032	[c] 106	1.42
FC	9.1	.060	102	1.26
FI	6.9	.044	195	1.33
FM	5.7	.045	189	1.34
FO	5.4	.040	256	1.33
XA	9.9	.070	164	1.22
XB	10.7	.095	178	1.16
XC	10.9	.091	162	[d] 1.07
XD	10.4	.072	99	1.24
XE	10.4	.097	116	1.12
XF	10.7	.077	106	1.24
XG	9.8	.074	121	1.29
XH	8.9	.115	81	1.04
XI	9.0	.089	204	1.18
XJ	8.2	.075	504	1.31

[a] Measured with the instrument described by Schiefer and Boyland [7].
[b] Measured with the instrument described by Cleveland [8].
[c] The values for the air permeability of samples *CD*, *CE*, and *CF* are for a pressure difference across the fabric of 0.05 inch of water, not 0.5 inch as used for all other samples. The air permeability of these samples was too high to measure at 0.5-inch pressure difference.
[d] With sample *XC*, a duofold fabric, the test was first carried out with the wool layer inside (i. e., against the heating plate of the apparatus) and then with the cotton layer inside. The results were 1.07 and 1.14, respectively.

III. EXPERIMENTAL PROCEDURE

1. SUBJECTIVE TESTS

These tests were carried out in a room conditioned at 21.1° C and 65-percent relative humidity. Samples of the fabrics, 3½ inches square, were soaked in water at the temperature of the conditioning room, and then dried in a towel until they contained the desired amount of water. The fabrics were tested when containing 100, 150, and 200 percent of moisture, based on their conditioned weights. All the fabrics were used in subjective tests, although each fabric was not tested with every other fabric because of the large number of tests that would be required. They were tested two at a time, on five male subjects, by simultaneously placing one fabric on the right and the other on the left arm (radial ulnar region of the forearm). The subject was than asked whether he detected a difference in chilling effect between the two arms, and if so, which fabric gave the greater sensation of chilling. Each fabric was left on the arm for 15 seconds, and then removed, because it was found that the subject's immediate reaction appeared to be most reliable. Although some persons were able to perceive slight differences better than others, the subjective reactions of various individuals were in very good agreement.

2. MEASUREMENT OF DROP IN SURFACE TEMPERATURE

The apparatus used to determine the drop in surface temperature was essentially a constant-temperature oil bath (fig. 1). In order to provide conditions under which a substantial drop in "skin" temperature could be measured, the heated surface was covered with several layers of asbestos sheeting and a layer of waterproof rubberized cloth, the total thickness of this cover being approximately 3/16 inch. The skin temperature was measured by four copper-constantan thermocouples, symmetrically placed on the outerside of the rubberized cloth, and held in position by a thin layer of cellulose nitrate cement. The thermocouples were connected in series, and the ice point (0° C) was

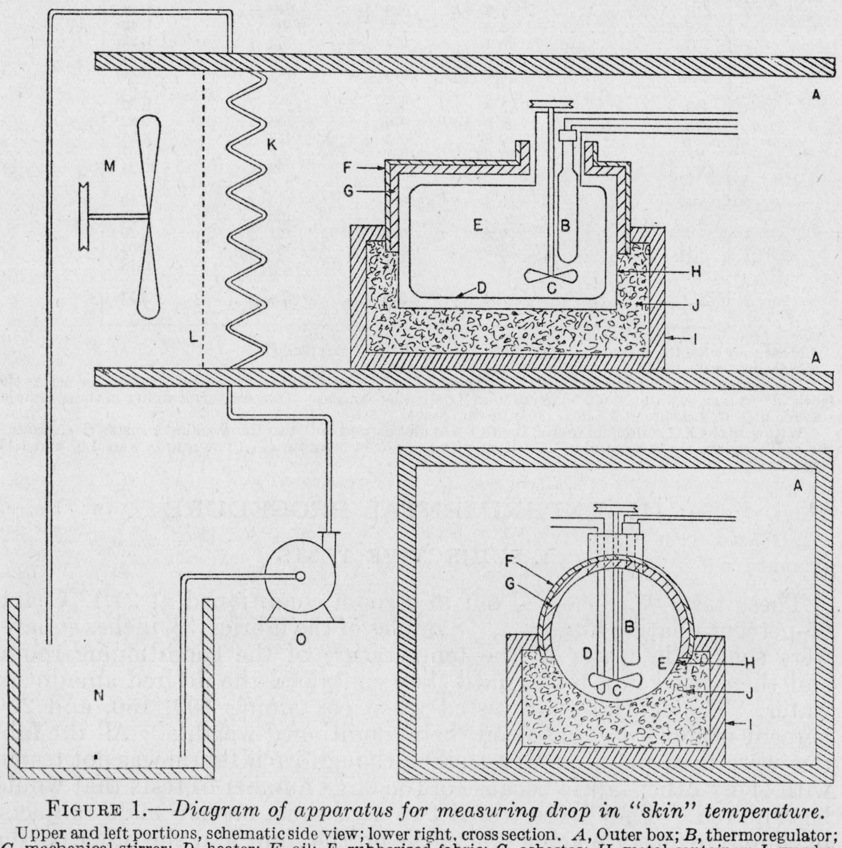

FIGURE 1.—*Diagram of apparatus for measuring drop in "skin" temperature.*

Upper and left portions, schematic side view; lower right, cross section. *A*, Outer box; *B*, thermoregulator; *C*, mechanical stirrer; *D*, heater; *E*, oil; *F*, rubberized fabric; *G*, asbestos; *H*, metal container; *I*, wooden box; *J*, insulation; *K*, radiator; *L*, cheesecloth; *M*, fan; *N*, water tank; and *O*, pump.

used as the reference temperature. A switch arrangement made it possible to measure with a potentiometer each individual electromotive force, as well as the sum of the four individual values. The average skin temperature was calculated from one-fourth of the value of the potential difference of the four units in series. To insure a highly constant skin temperature, the heating apparatus was placed in a small conditioning cabinet, which in turn was placed in a room maintained at 21.1° C and 65-percent relative humidity. Water at room temperature is circulated through the radiator, *K*; the fan, *M*, blows air at room temperature first over the radiator and then over the heating apparatus. Since the water in the radiator does not respond to the relatively short-period temperature fluctuations of the air in the room, the temperature within the cabinet is considerably more constant than that in the room. Using this device, the average temperature of the "skin" surface was constant to ±0.1° C. The internal temperature of the bath was held at 50.0°±0.05° C, and the average corresponding skin temperature was 37.5° C.[3]

The experimental procedure consisted in first measuring the skin temperature when the apparatus, without a test fabric on it, was in equilibrium with its surroundings. Subsequently, a moist fabric was placed on the apparatus. The moist fabrics were prepared by soaking approximately 3.5- by 6-inch samples in distilled water, the temperature of which was the same as that of the conditioning room, and then pressing the samples gently between towels until they contained 150 percent of moisture, based on the weight of the conditioned cloth. The moist fabric was placed on the apparatus so as to cover the thermocouples, and was covered immediately with a cheesecloth belt (approximately 4 in. wide) weighted at both ends (0.3 lb per end) in order to hold the sample in close contact with the heated surface. The change in surface temperature was followed as a function of time, the first reading being made 30 seconds after the initial contact of the moist fabric with the heated surface. Observations were made for 10 minutes and then discontinued, because it was found that further changes in temperature occurred only very slowly.

3. "CONTACT" TESTS

Since it is reasonable to expect that the chilling effect of wet fabrics may be related to the extent of contact which they make with the skin, a method was devised to check this hypothesis. A moisture-sensitive paper was prepared by impregnating a soft paper[4] with a water-soluble dye of high tinctorial power,[5] according to the following procedure. A mixture consisting of 5 g of dye, 30 g of crude milled rubber, and 1 liter of Stoddard's solvent was prepared by first dissolving the rubber in the solvent, and then grinding together the dye and rubber solution in a mortar. To insure uniformity of distribution, the mixture was subsequently placed on a mechanical shaker for half an hour. The dye is insoluble in the organic solvent and does not appear red under these conditions; the rubber aids in dis-

[3] Since a setup that would discriminate between fabrics with fairly similar thermal properties was required, the drop in skin temperature was accentuated by using a relatively hot skin (37.5° C) and a thick layer of insulation. The good correlation of these measurements with subjective tests demonstrates the validity of this procedure for the purpose of evaluating the fabrics.

[4] The paper was a soft sheet made from wood pulp (No. 1 alpha), containing a small amount of rosin size (sizing value by the dry indicator method: 28 sec), basis weight 23 to 24 lb, 17 by 22 in.—500 sheets.

[5] The dye was basic fuchsine (du Pont fuchsine concentrated powder, L7596).

persing the dye and imparts to the finished paper certain desirable properties. Strips of the paper were dipped in the impregnating mixture and hung up to dry at room temperature. The last traces of solvent were removed from the papers by placing them in a vacuum oven at 65° C for 15 to 20 minutes. After trimming the papers to the desired size, they were ready for use.

The test for contact was carried out by placing pieces of the wet fabrics, 3½ inches square, on the papers for 10 minutes, under a pressure of 0.5 lb per square inch. A piece of the sensitized paper was first laid on a dry glass surface. The wet fabric was then placed on top of the paper, and covered with a glass square of similar size, and weights to bring the pressure to the stated amount. After 10 minutes the fabrics and weights were removed. The papers, which were practically colorless originally, became red where the moist fabrics touched them, thereby indicating the extent of contact of the fabrics.[6] Photometric measurements of the reflectance of the papers were subsequently made, thus making it possible to assign to each fabric a numerical value indicative of its contact at any given moisture content. The measurements were made by means of a Martens photometer with a filter to isolate the 560-millimicron line.

IV. RESULTS AND DISCUSSION

1. QUALITATIVE RELATION BETWEEN SUBJECTIVE AND OBJECTIVE TESTS

This investigation was undertaken not to develop a standard technique for evaluating the chilling properties of fabrics, but rather to develop a method for studying a phenomenon which has been observed empirically for a long time. Owing to the many complex factors which contribute to this phenomenon, an attempt will not be made to present the data on a quantitative basis. It is recognized, furthermore, that only one aspect of the larger problem of the thermal properties of fabrics has been studied. Nevertheless, several significant relationships were noted, and these will be discussed in more or less general terms, making no effort to account for small differences between the many and diverse fabrics included in the investigation.

The results of the subjective tests were in very good agreement with the direct measurements of drop in temperature and degree of contact. The results of a typical set of subjective experiments are given in table 3, and may be compared with the corresponding objective measurements of figures 2 to 21. When, as, for example, with sample *A*, the subject experienced pronounced chilling, a substantial drop in temperature was measured, and the fabric was found to make good contact with the skin. On the other hand, a smaller drop in temperature was measured, and poor contact was observed in fabrics such as sample *F*, which did not produce a sensation of chilling to the subject. This correlation between subjective reaction and contact was especially interesting when the fabrics were placed on the moisture-sensitive papers immediately after their removal from the arm. Invariably, when the subjects experienced pronounced differences in comfort, similar outstanding differences in contact were observed. Likewise,

[6] This test does not actually measure the contact which the fabrics make with the human skin, but for the purposes of the present investigation, the test is believed to be an adequate indirect measure of this property.

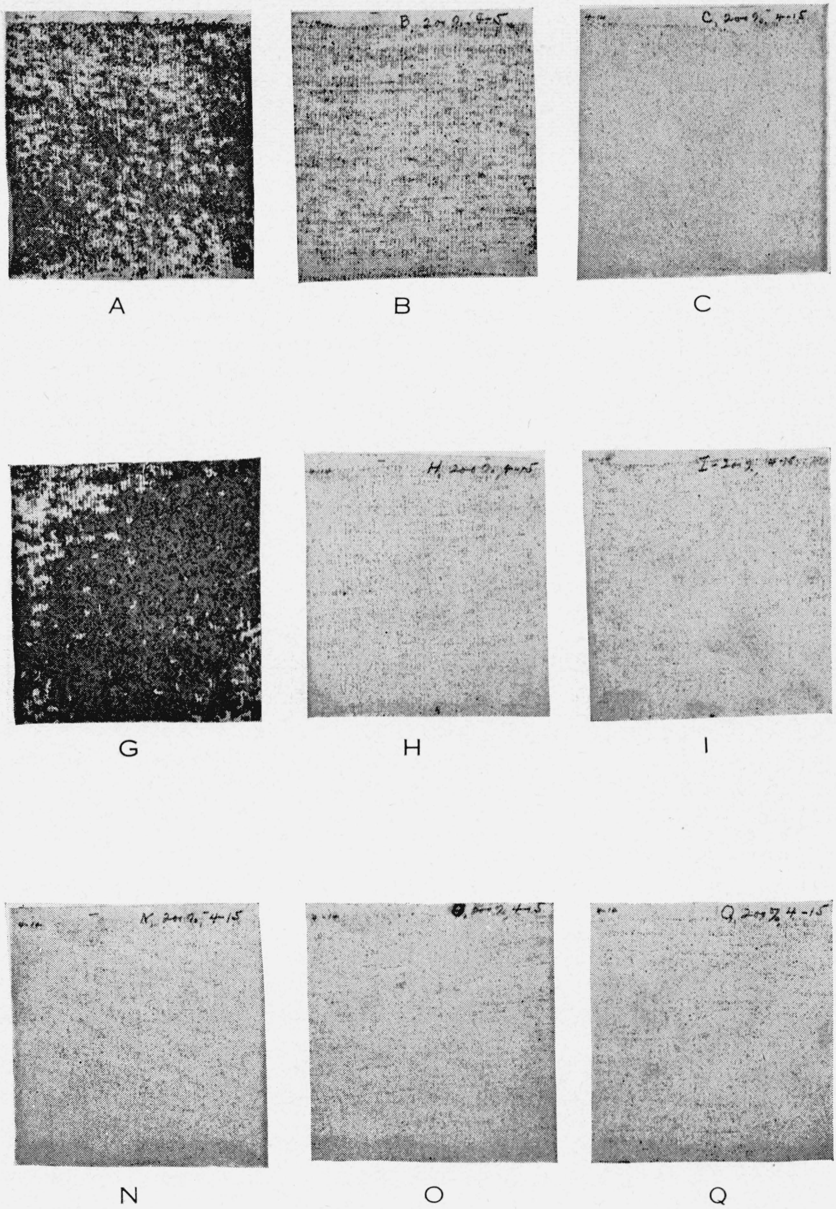

FIGURE 2.—*"Contact" impressions obtained with fabrics containing 200 percent of moisture.*

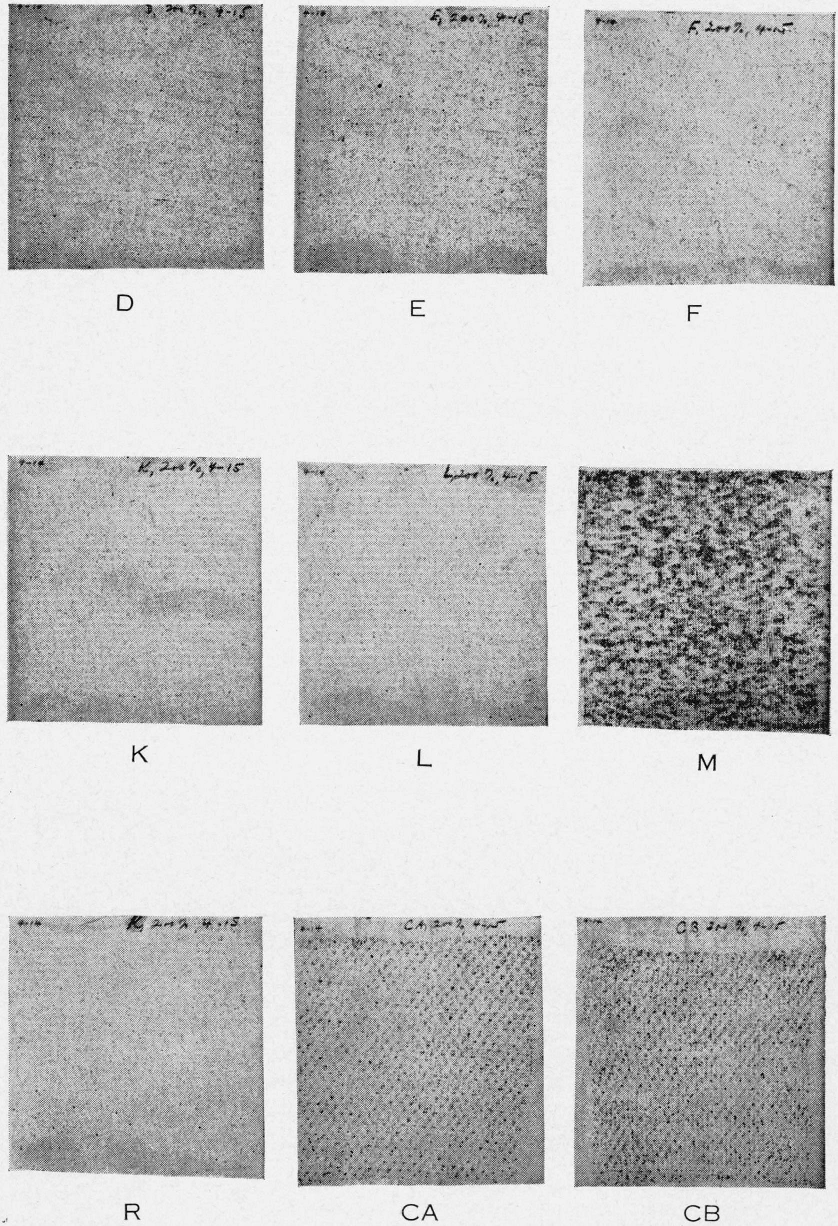

FIGURE 3.—"*Contact*" *impressions obtained with fabrics containing 200 percent of moisture.*

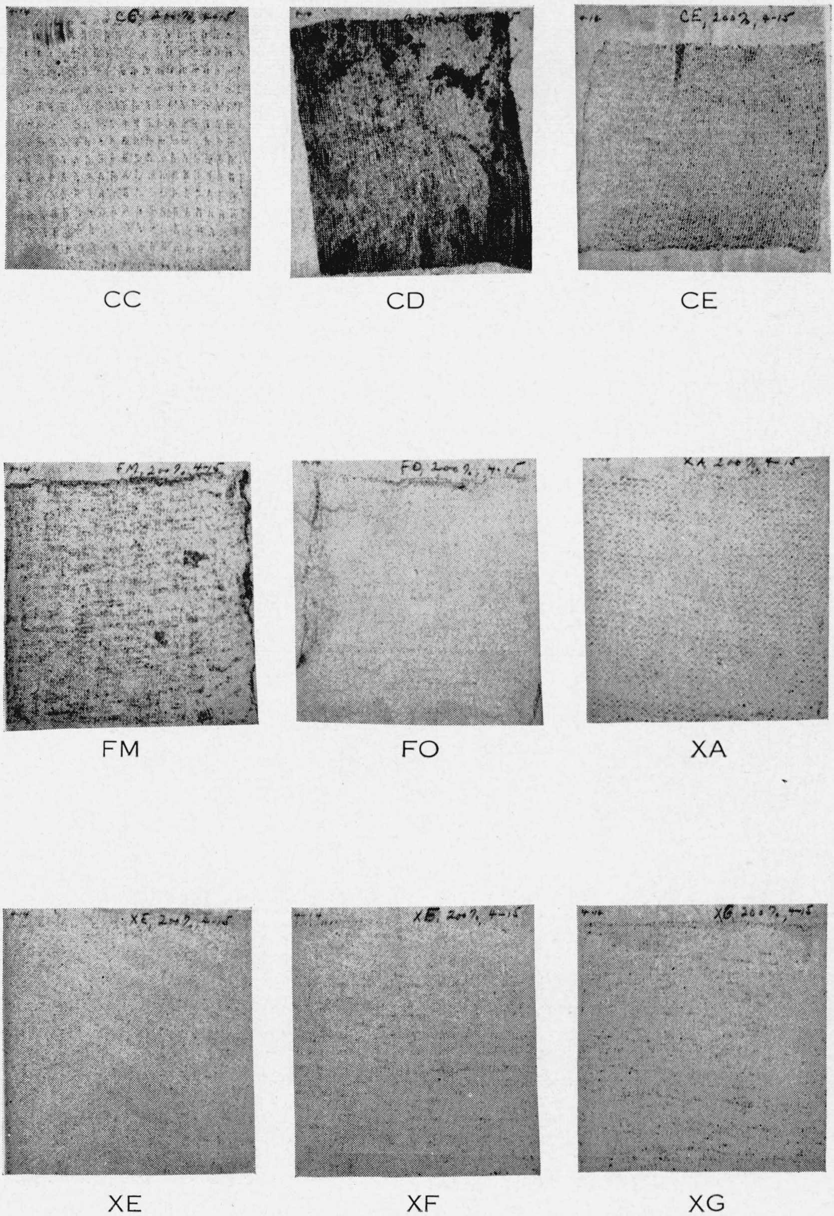

FIGURE 4.—*"Contact" impressions obtained with fabrics containing 200 percent of moisture.*

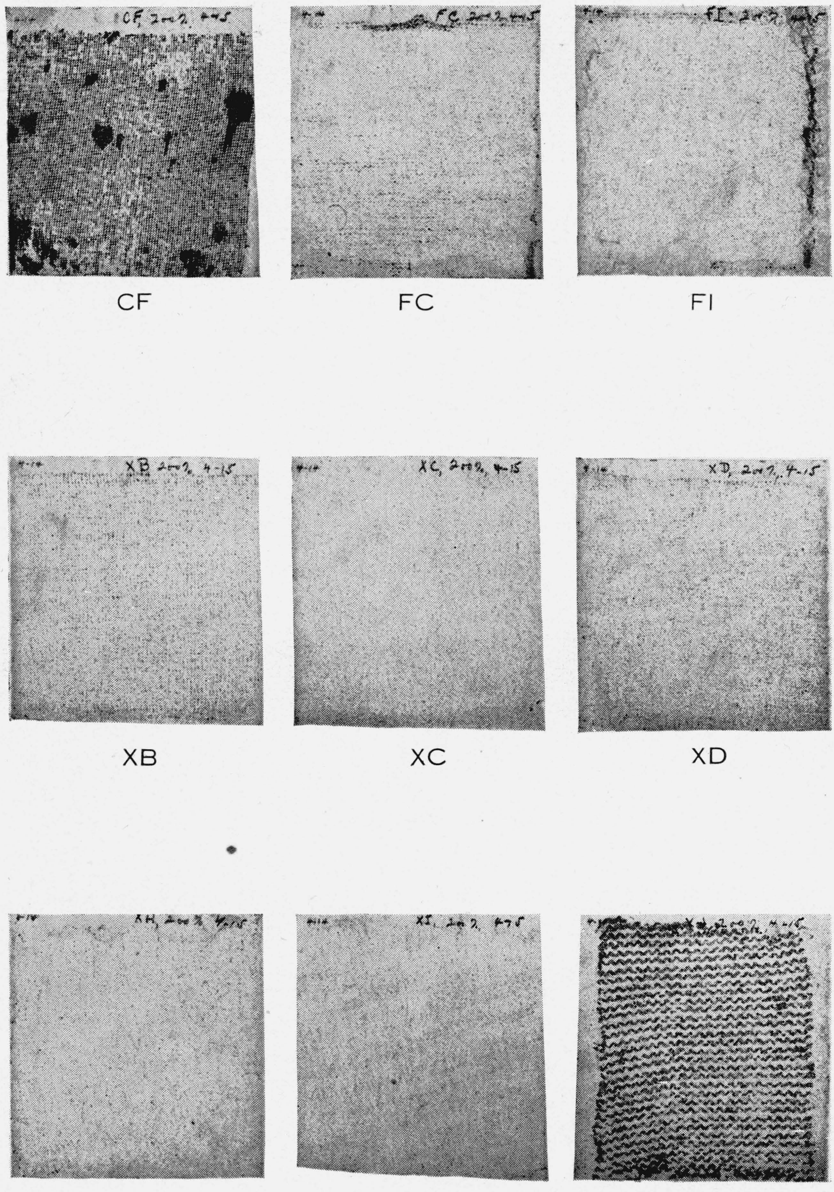

FIGURE 5.—*"Contact" impressions obtained with fabrics containing 200 percent of moisture.*

when the individuals perceived little or no difference in chilling effect, the sensitized papers showed that the two fabrics made similar contact. A typical series of contact papers, obtained when the fabrics contained 200 percent of moisture, is shown in figures 2 to 5. It is clear that, although all the fabrics contained equal percentages of water, some made better contact with the papers than others. Thus, for example, samples *A, G, M, FM,* amd *XJ* made very good contact, whereas others, such as *F, L, R, XC,* and *XI,* made poor contact. By increasing and decreasing the amounts of water in the fabrics their "tolerance" to moisture was estimated. It was found that even at 450 percent of moisture some of the fabrics (*L, CB, XE,* and *XH*) still did not completely color the papers. On the other hand, at 50 percent of moisture only fabrics *A, B, G, M, CF, FM,* and *XJ* colored the papers at all, and then only lightly. This variation in contact is shown graphically in figures 6 to 13, where the reflectance of the papers as measured photometrically is plotted against percentage of moisture in the fabrics.

To facilitate a more detailed discussion, the fabrics may be grouped according to weight, construction, and fiber composition.

TABLE 3.—*Subjective results obtained with fabrics containing 200 percent of moisture on the basis of their conditioned weights*

Samples compared	Subjective reaction	Samples compared	Subjective reaction
A and *F*	*A* much colder.	*F* and *XI*	*F* somewhat colder.
M and *O*	*M* much colder.	*CE* and *CF*	*CF* slightly colder.
N and *R*	Neither produces much chill, but *N* slightly colder.	*CE* and *CD*	Both cold, *CD* colder.
		XB and *XC*	*XB* cold, *XC* warm feel.
Q and *FO*	Neither causes much chilling, but *FO* slightly colder.	*FO* and *FI*	No difference.
G and *L*	*G* much colder.	*FM* and *FC*	*FM* colder.
		XJ and *XA*	Both cold, but *XJ* colder.
H and *K*	Both rather cool, *H* slightly cooler than *K*.	*CB* and *CA*	Very little difference, but *CA* may be slightly colder.
I and *FI*	*FI* slightly colder.	*CC* and *CD*	*CD* much colder.
A and *E*	*A* much colder.	*XE* and *XH*	Both comfortable, but *XE* very slightly colder.
B and *D*	*B* colder.		
C and *XD*	No difference noted.		
XF and *XG*	Both produce some chilling, but *XF* slightly colder.		

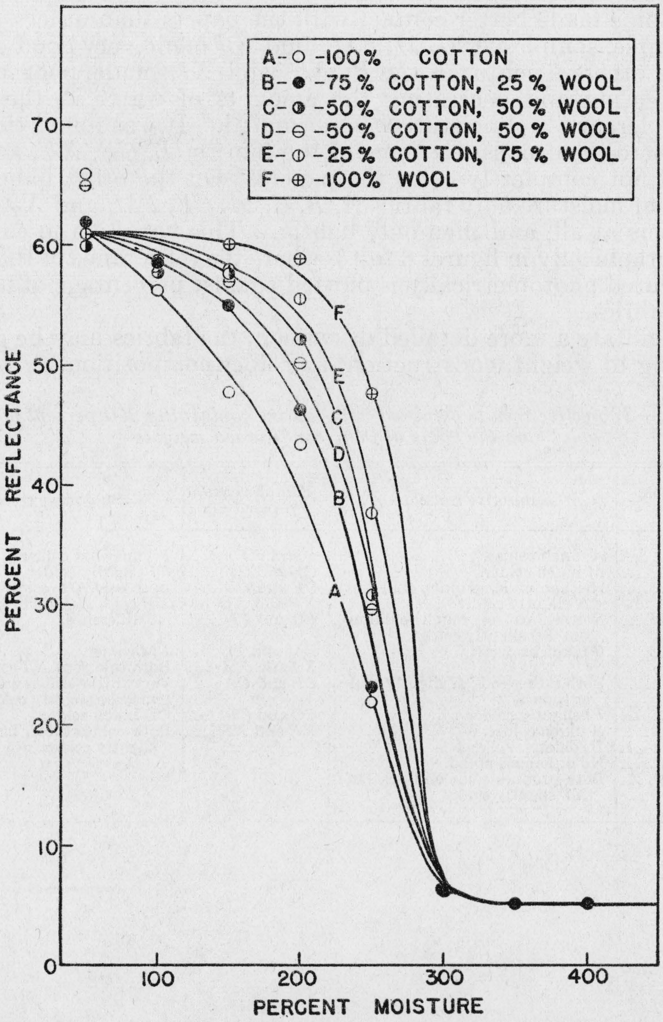

FIGURE 6.—*Reflectance of "contact" impressions obtained with fabrics containing various percentages of moisture.*

10½-lb fabrics composed of various percentages of cotton and wool.

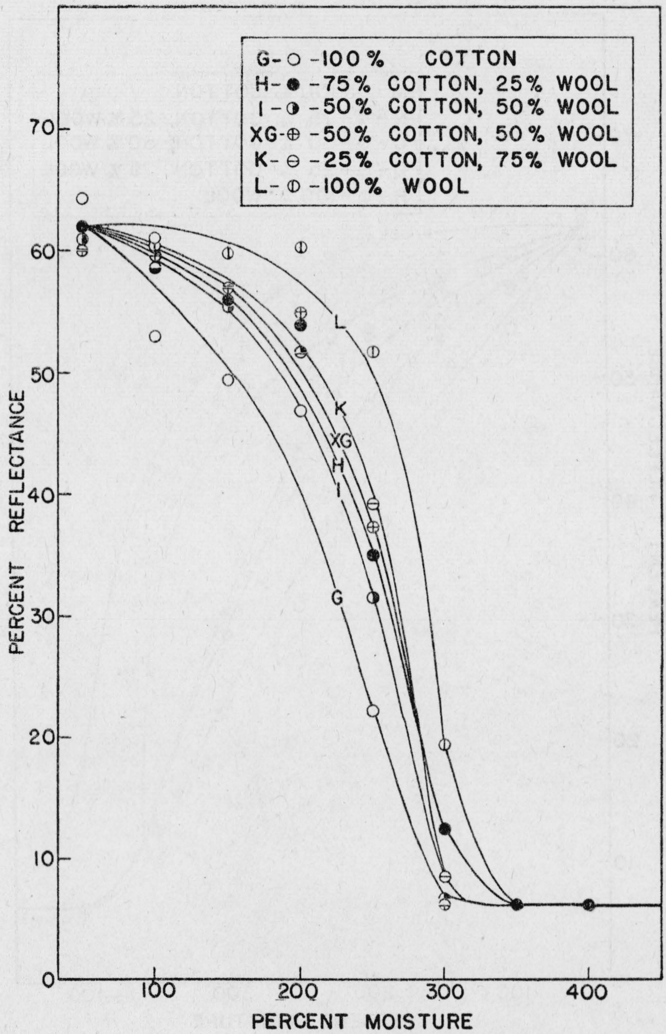

FIGURE 7.—*Reflectance of "contact" impressions obtained with fabrics containing various percentages of moisture.*

8- to 8¼-lb fabrics composed of various percentages of cotton and wool.

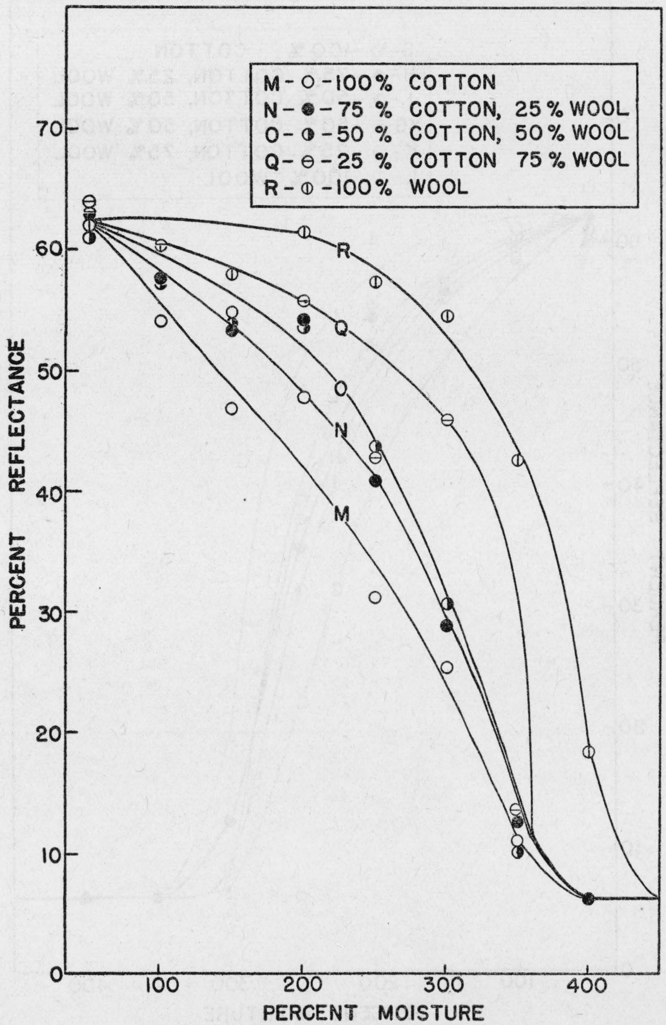

FIGURE 8.—*Reflectance of "contact" impressions obtained with fabrics containing various percentages of moisture.*

5½- to 6-lb fabrics composed of various percentages of cotton and wool.

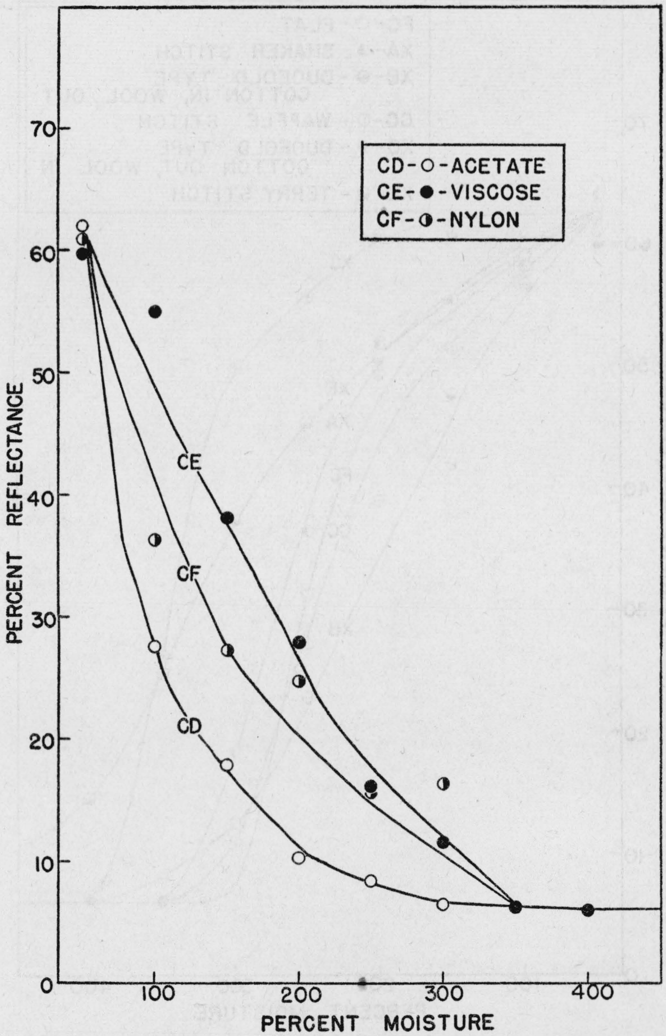

FIGURE 9.—*Reflectance of "contact" impressions obtained with fabrics containing various percentages of moisture.*

Lightweight fabrics made of continuous filament acetate, viscose, and nylon.

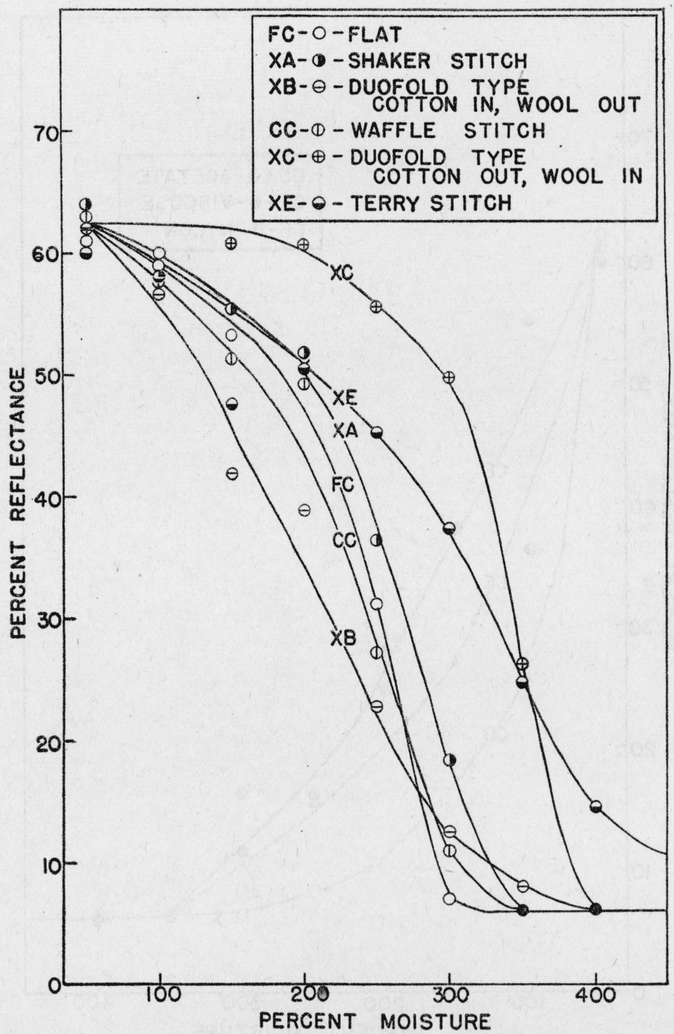

FIGURE 10.—*Reflectance of "contact" impressions obtained with fabrics containing various percentages of moisture.*

10½-lb fabrics of different constructions, composed of 50 percent of cotton and 50 percent of wool.

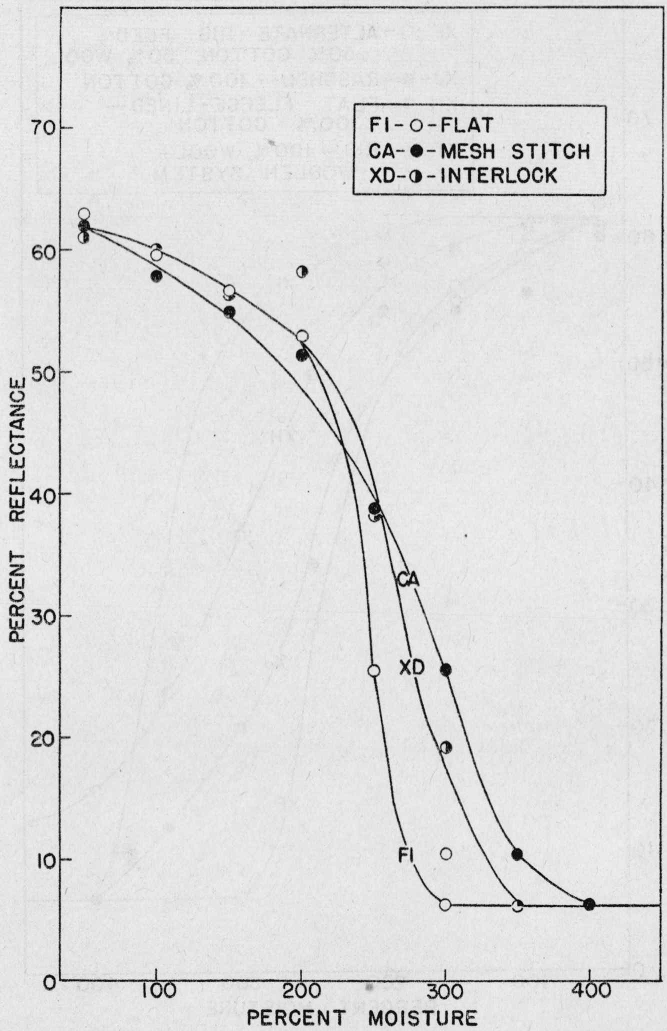

FIGURE 11.—*Reflectance of "contact" impressions obtained with fabrics containing various percentages of moisture.*

8- to 8¼-lb fabrics of different constructions, composed of 50 percent of cotton and 50 percent of wool.

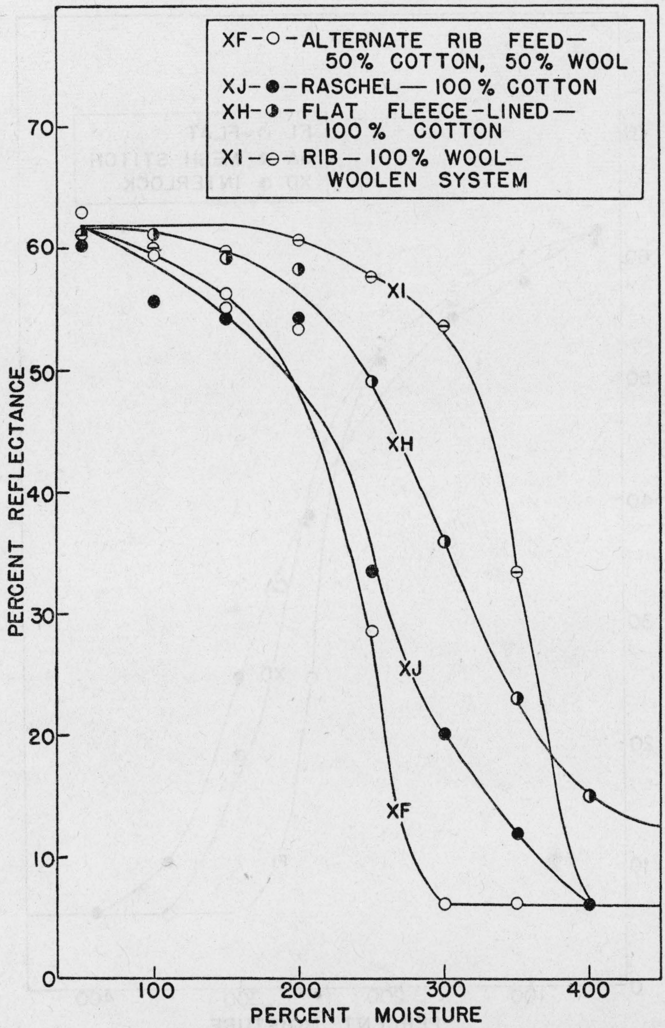

FIGURE 12.—*Reflectance of "contact" impressions obtained with fabrics containing various percentages of moisture.*

10½-lb fabrics of different constructions and various fiber compositions.

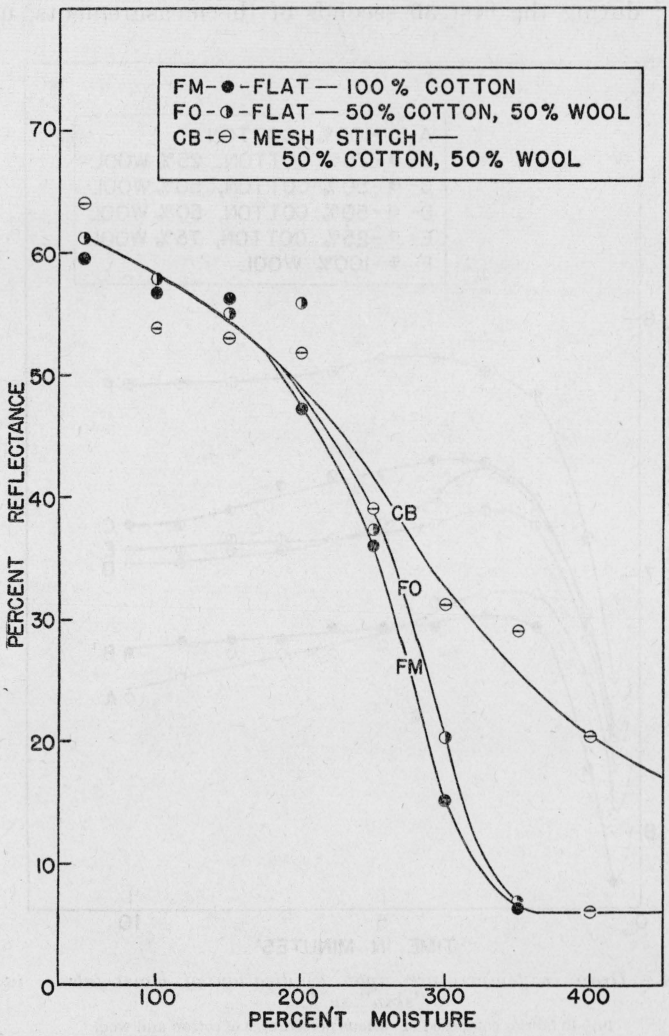

FIGURE 13.—*Reflectance of "contact" impressions obtained with fabrics containing various percentages of moisture.*

5½- to 6-lb fabrics of different constructions and various fiber compositions.

2. INFLUENCE OF FIBER CONTENT ON CHILLING EFFECT

Figures 14 to 17 show the drop in temperature caused by laundered fabrics of comparable weight and construction but of different fiber compositions. The curves show a rapid initial drop in surface temperature [7] during the first 30 seconds of the measurements, usually

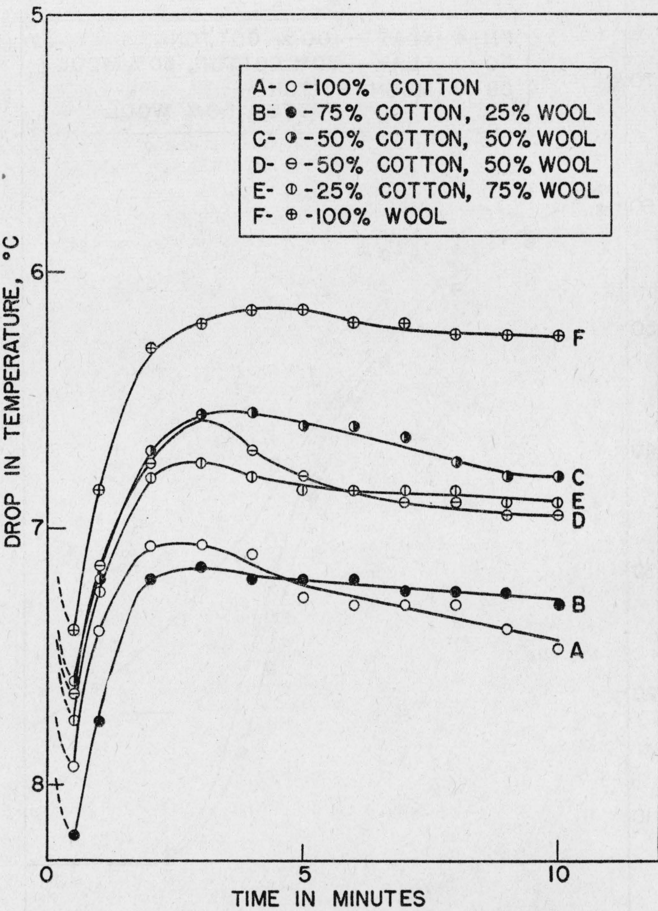

FIGURE 14.—*Drop in temperature upon application of moist fabrics to heated "skin" surface.*

10½-lb fabrics composed of various percentages of cotton and wool.

followed by a slight increase in temperature, after which an approximately steady state is reached.

Since the thermocouple readings are influenced by the underside of the moist fabric as well as by the skin, the readings do not correspond precisely to the skin temperatures. This fact probably accounts in large measure for the unusual shape of the curves in the early portion

[7] In the course of measurements on the transmission of heat through textile fabrics, Rees [5] observed a very small drop in temperature when fabrics conditioned at 25° C and 65-percent relative humidity were brought in contact with a hot plate. The magnitude of the drop was greater for cotton than for woolen fabrics.

of the measurements. Thus, the rapid initial drop in temperature caused by the contact of the moist sample is followed by a rise in temperature, corresponding to an interval in which the heat supplied exceeds the heat lost by evaporation. When the loss of heat by evaporation becomes sufficiently great, a decrease in the thermocouple temperature again ensues. The heavier fabrics, because of their

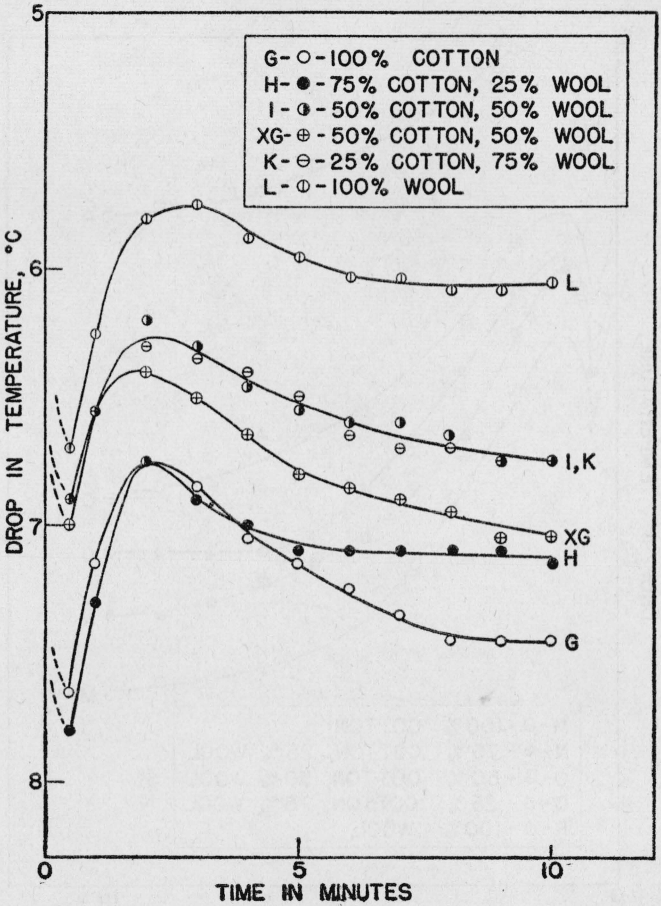

FIGURE 15.—*Drop in temperature upon application of moist fabrics to heated "skin" surface.*

8 to 8¼-lb fabrics composed of various percentages of cotton and wool.

higher heat capacity and greater (absolute) content of water, cause a larger initial drop in skin temperature (compare figs. 14 to 17). On the other hand, a longer time is required for the evaporative losses to exceed the heat supplied in the case of the heavier samples.

In general, the results given in figure 14 show a regular, progressive decrease in the chilling effect of the 10½-lb [8] fabrics with increase in their wool content. Similar results for samples of nominal weights of 8 to 8¼ lb and 5½ to 6 lb are shown in figures 15 and 16, respectively. Sample *R* (fig. 16), which showed the smallest decrease in temperature

[8] The nominal weight of these fabrics is 10½ lb per dozen suits of size 40. For brevity, they will henceforth be designated "10½-lb fabrics," and a similar designation will be used for fabrics of other nominal weights. Although nominally the same, the fabrics differ appreciably in actual weight, as shown in table 1.

of all the rib-knit samples, was characterized by a very fuzzy surface after laundering and was considerably thicker than the other fabrics of comparable weight. Comparison of the curves showing a drop in surface temperature (figs. 14, 15, and 16) with those showing the reflectance [9] of the contact papers (figs. 6, 7, and 8) reveals a good qualitative relation between these two sets of measurements.

Figures 9 and 17 show the reflectance of the contact papers and the

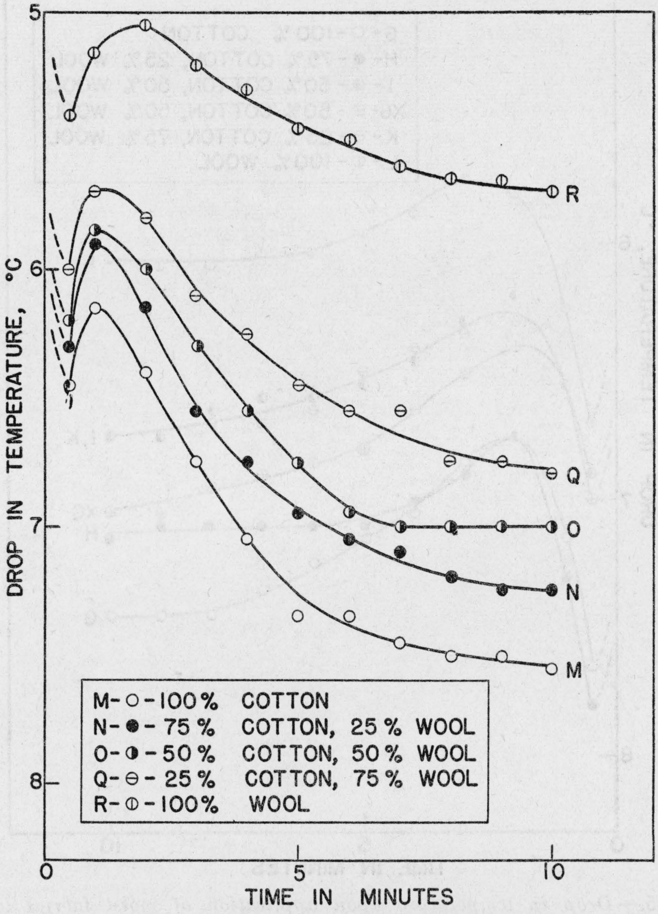

FIGURE 16.—*Drop in temperature upon application of moist fabrics to heated "skin" surface.*

5½- to 6-lb fabrics composed of various percentages of cotton and wool.

drop in temperature, respectively, of the lightweight, continuous-filament underwear samples. These fabrics cause a big drop in temperature, but the differences between the acetate, viscose, and nylon fabrics are not large, and are of questionable significance. The diffi-

[9] The more color produced on the papers as a result of contact with the wet fabrics, the lower is their reflectance.

culty in manipulating these very thin fabrics in the various tests may account in part for the low correlation of the contact and temperature measurements.

3. INFLUENCE OF CONSTRUCTION ON CHILLING EFFECT

Figures 18 and 19 show curves of the drop in temperature obtained with fabrics of varied knit but of the same fiber content (50% cotton,

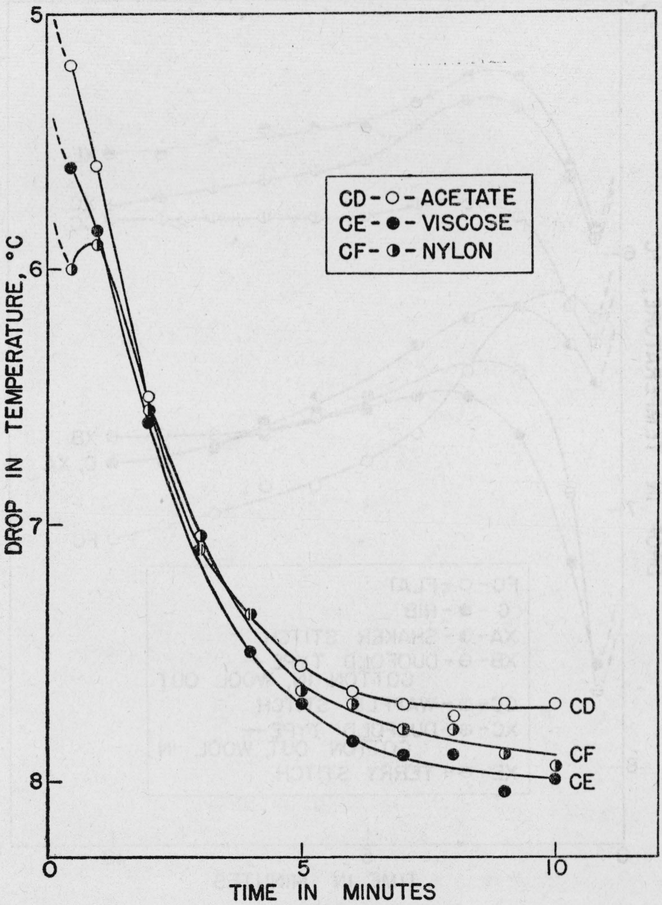

FIGURE 17.—*Drop in temperature upon application of moist fabrics to heated "skin" surface.*

Lightweight fabrics made of continuous filament acetate, viscose, and nylon.

50% wool). The curves of rib-knit fabrics (samples *C* and *I*) are included for comparison. Because of the complexity introduced by fabrics of different constructions, the apparent relation between drop in temperature (figs. 18 and 19) and extent of contact (figs. 10 and 11) is not so close as with fabrics of simple rib knit. However, fabrics *XE* and *XC* (terry stitch and duofold[10] with wool inside, respectively)

[10] The duofold fabrics consist of two layers, one all cotton and the other all wool.

appear to be superior to the conventional rib knit. Since the duofold fabrics are identical, except that one has cotton and the other wool on the inside, a comparison of the results for these two samples clearly shows the advantage of having wool next to the skin rather than cotton. Although fabrics which are superior at one moisture percentage are usually superior at another also, this is not always the case, as is shown by crossing of the reflectance curves.

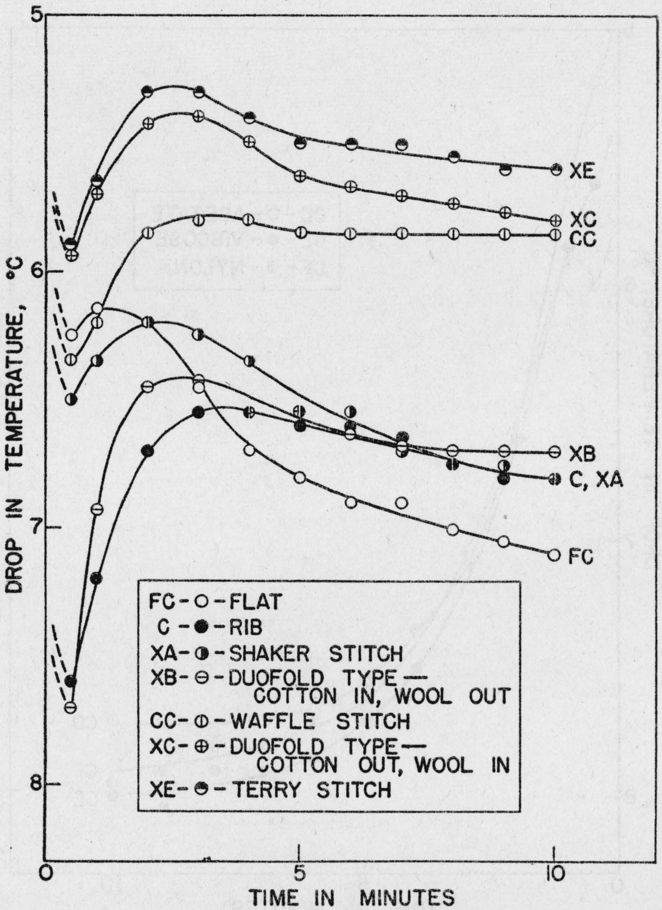

FIGURE 18.—*Drop in temperature upon application of moist fabrics to heated "skin" surface.*

10½-lb fabrics of different constructions, composed of 50 percent of cotton and 50 percent of wool.

Figures 20 and 21 show the drop in temperature for two groups of fabrics of various constructions and fiber compositions. Figures 12 and 13 indicate the contact made by the same fabrics. The results of the two sets of measurements show a good qualitative relation, the fabrics causing the least drop in temperature being the ones which make the poorest contact. Sample *XI*, which is an all-wool fabric spun on the woolen system, is among the best of all the fabrics tested.

The marked improvement that a fleece lining makes in an all-cotton fabric is illustrated by the curve for *XH*.

Throughout the investigation the moisture content of the samples was calculated on a percentage basis. If the fabrics had been tested with a given moisture content per unit area, the relative merits of the

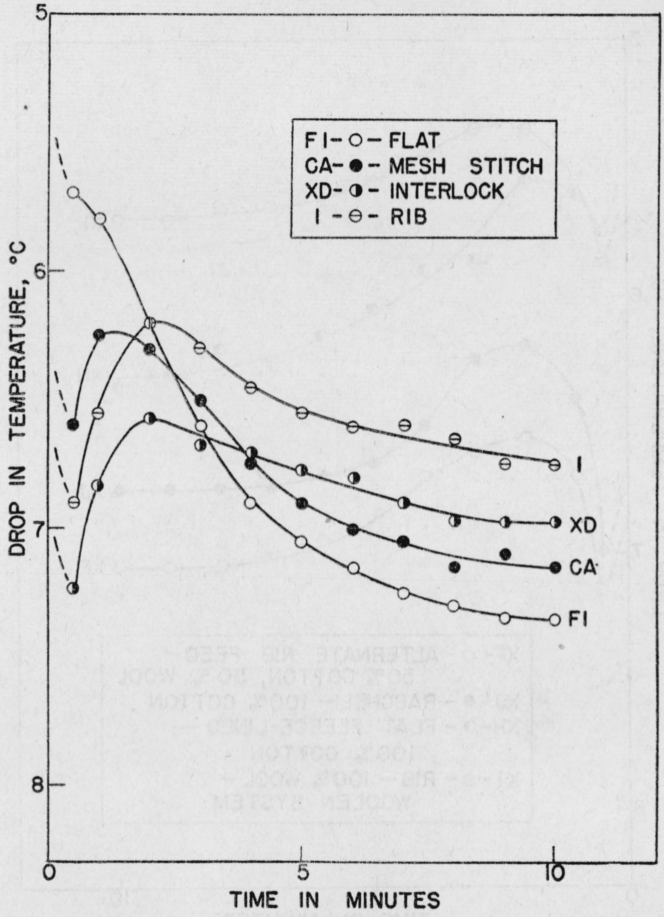

FIGURE 19.—*Drop in temperature upon application of moist fabrics to heated "skin' surface*

8- to 8¼-lb fabrics of different constructions, composed of 50 percent of cotton and 50 percent of wool.

various fabrics may have been somewhat changed. It is believed, however, that a similar basic relation between subjective tests, direct measurements of drop in temperature, and extent of contact, would still have been found.

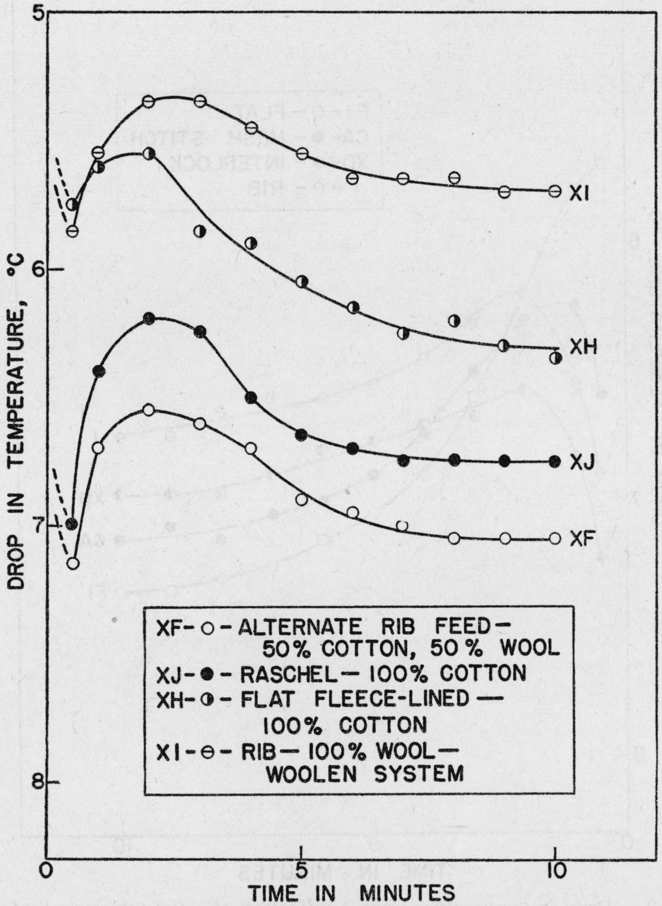

FIGURE 20.—*Drop in temperature upon application of moist fabrics to heated "skin" surface.*

10½-lb fabrics of different constructions and various fiber compositions.

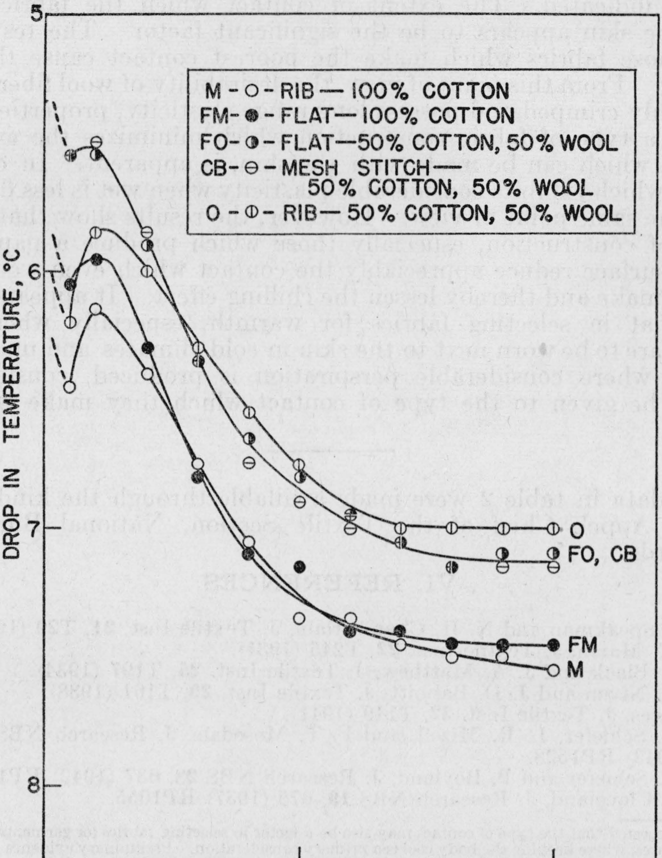

FIGURE 21.—*Drop in temperature upon application of moist fabrics to heated "skin" surface.*

5½- to 6-lb fabrics of different constructions and various fiber compositions.

V. CONCLUSION

Although it is difficult to rate on an absolute basis the "chilling effect" produced by the diverse fabrics which were included in these tests, several important conclusions can nevertheless be drawn—thus, a progressive improvement of the fabrics as their wool content is increased and the superiority of certain types of construction are clearly indicated. The extent of contact which the fabrics make with the skin appears to be the significant factor. The tests show that those fabrics which make the poorest contact cause the least chilling. From this point of view, the desirability of wool fibers which are highly crimped and possess long range elasticity, properties which permit a type of fabric construction which minimizes the extent of contact which can be made with the skin, is apparent. In contrast cotton which exhibits considerable plasticity when wet is less desirable from the same point of view. However, the results show that special types of construction, especially those which produce a napped, or fuzzy, surface reduce appreciably the contact which even wet cotton fabrics make and thereby lessen the chilling effect. It appears, therefore, that in selecting fabrics for warmth, especially when these fabrics are to be worn next to the skin in cold climates and under conditions where considerable perspiration is produced, consideration should be given to the type of contact which they make with the body.[11]

The data in table 2 were made available through the kindness of W. D. Appel, Chief of the Textile Section, National Bureau of Standards.

VI. REFERENCES

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[11] It is suggested that the type of contact may also be a factor in selecting fabrics for garments to be worn in hot climates, where keeping the body cool is a primary consideration. Preliminary evidence is available which indicates that for hot, humid regions, thin, flat fabrics are highly desirable.

WASHINGTON, January 4, 1944.

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[Continued on p. 4 of cover]

[Continued from p. 3 of cover]

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$$x=[0(.001)7(.01)50(.1)300(1)2{,}000(10)10{,}000;12D]$$

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