Evaluating Starches For Textile Purposes

(*Reprint from Analytical Edition, Industrial and Engineering Chemistry, Vol. 14, Page 227, March 15, 1942.*)

By

W. T. SCHREIBER*

Chemist, Bureau of Agricultural Chemistry and Engineering

U. S. Department of Agriculture

and

WILLIAM L. STAFFORD

Chemical Engineer

Engineering Experiment Station

Alabama Polytechnic Institute

Engineering Bulletin No. 13

*Stationed at and cooperating with the Engineering Experiment Station of the Alabama Polytechnic Institute in its laboratories at Auburn, Ala.

ENGINEERING EXPERIMENT STATION
ALABAMA POLYTECHNIC INSTITUTE
AUBURN, ALA.

Contents

Evaluating Starches For Textile Purposes

ALTHOUGH the starching of textile fabrics has long been a major operation in the textile and laundry industries, it is still a moot question as to how the efficiency of this process may be judged. Uniform methods for evaluating starched fabrics and starch mixtures have not been generally adopted. This has undoubtedly contributed to the tendency of the processors, when buying starching materials, to stress price considerations rather than quality of product. The result seems to be that the manufacturer of a new kind of starch finds himself in an unfavorable trade position. The way has not been cleared for him to prove with any degree of certainty and dispatch the superiority of his product over another for any particular use. Without doubt, the initial step to overcome this handicap would be to make available technical test methods by which it will be possible to measure certain of the desirable properties imparted to fabrics by the starching operation, and to measure certain properties of starch mixtures which affect the starching operation.

It is the purpose of this paper to describe test methods for appraising the properties of starched fabrics and starch mixtures, and to give data obtained by application of these methods.

STICKINESS OF STARCHED FABRICS DURING DRYING

During either the ironing or drying over "dry cans" of starched fabrics, it is essential that these fabrics do not stick excessvely to the heating surfaces. If sticking occurs, there is a tendency for the quality and the uniformity of the fabric to suffer—i. e., the number of surface imperfections may be increased and the fabric construction distorted. Then, too, the wear life of the fabric may be adversely affected by the pulling action required to remove the fabric from the heated surface. Lastly excessive sticking may make it necessaryto clean the drying surfaces so frequently that both the plant operating efficiency and capacity will be reduced.

To determine the relative stickiness which may be expected from a starch mixture, the apparatus developed in this laboratory and described in this paper is suggested. The method, in brief, consists in pressing a heated metallic surface against a starched sample prepared for ironing and subsequently determining the pull necessary to free the sample from that surface.

METHOD FOR MEASURING STICKINESS

The apparatus used consisted of a rotary electric ironer and a Jolly balance with a pulley setup so arranged that a horizontally exerted pull may be measured (Figure 1).

Fabric samples 20 x 7.5 cm. (8 by 3 inches) were starched according to a definite procedure. It may be preferable in some instances to simulate the particular practice of a given plant. In the work of this laboratory, a starch mixture was cooked with live steam, at a fixed steam valve setting for exactly 30 minutes. The mixture was made up to volume with boiling water and thoroughly mixed.

The fabric samples were first immersed in water (50° C.) for five minutes, passed through a wringer having a given pressure setting, and then immersed for three minutes in the cooked starch mixture (90° C.). Each sample was separately "whizzed" in a small basket centrifuge for a given length of time—e. g., 10 seconds for samples which had been treated with thin-boiling starches and 30 seconds for those starched with thick-boiling starches. After centrifuging, the samples were placed in a small stoppered bottle to keep the moisture content fixed; they were then ready to be tested for stickiness.

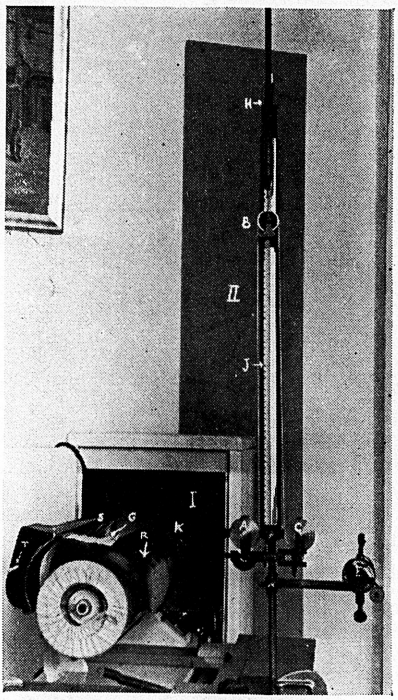

Figure 1.—Rotary Electric Ironer (I) and Jolly Balance Setup (II).

A, C—Fixed-position low-friction pulleys; B—Movable pulley; E—Reel; H—Spring; J—Jolly balance scale; K—Cord; R—Ironing roll; S—Heating shoe; T—Thermometer.

It is suggested that the samples be starched and tested in sets of 10 and that after each set has been tested, but not until then, the heated shoe surface be thoroughly cleaned.

The sample to be tested was placed in a fixed position on or over the roll of the ironer, so that when the shoe was lowered it covered the center portion of the sample, leaving uncovered equal lengths on both sides of the shoe surface. When the shoe had been heated

so that the thermometer, T (Figure 1), registered 150° C., the shoe was automatically lowered and allowed to rest under its own weight on the sample for 10 seconds, when the shoe carrying the sample with it was raised from the roll. During the drying interval a hook was attached to the free end of the sample nearest to the balance; the hook in turn was attached to a cord, K, which had been brought under pulley A over movable pulley B under pulley C and fastened to reel E.

As soon as the shoe was raised, the reel was slowly turned, thus winding or shortening the length of the cord and, hence, exerting a horizontal pull on the sample. This pull was simultaneously transmitted to the Jolly balance and could be accurately determined from the extension of the balance spring. The reel was turned until the fabric sample had been pulled free from the shoe. At the moment of separation the elongation of the spring was read and considered as the final reading. The difference between the zero reading of the spring and the final reading, after conversion into grams' pull from the calibration curve of the spring was considered to be stickiness factor for the starch mixture used or the force required to release the sample.

Table 1 gives data on stickiness.

Stormer Viscosity Method (used by the Laurel starch plant). Three grams of starch (dry basis) were wetted with 10 ml. of water in a 200-ml. Erlenmeyer flask, 100 ml. of boiling water were added with mixing, and the flask was fitted to an air condenser and immersed in a boiling water bath for 1 hour. Measurement was made at 90° C. in a Stormer viscometer. Values were expressed as the number of 1/5 seconds required for spindle to make 100 revolutions when actuated by a 70-gram weight.

TABLE 1.—Stickiness Data.

Starch*	Stormer Viscosity	C. P. R. No.	Force Required to Release Sample** (Grams)	Moisture Analysis*** (per cent)	Starched Fabrics Starch**** (per cent)
A	75	2	598	205	8.4
B	170	1	940	231	8.7
C	38	45	231	156	5.2

*Starch concentration, 40 grams per liter of water.
**Mean deviation 10 sets of 10 determinations, 29 grams.
***Dried at 105° C. to constant weight.
****Desized with desizing agent, heated with water under reflux 1 hour, washed with hot water, and dried at 105° C.

Corn Products Refining Company Fluidity Determination.—Starch (4.5 grams dry weight) was wetted with 10 ml. of water

(23.89° C., 75° F.), stirred for three minutes after the addition of 90 ml. of 1 per cent sodium hydroxide (75° F.), allowed to stand 27 minutes (75° F.), and transferred to a funnel having a standardized orifice, and the milliliters which passed through the orifice in 70 seconds were determined. This volume was considered to be the C. P. R. number. The orifice opening had been made so that 100 ml. water passed through the opening in 70 seconds.

PENETRATION OF STARCH MIXTURES

The speed with which a starch mixture will penetrate a fabric is of considerable importance to the starching operator.

Analysis of cloth used in all subsequent tests (desized with desizing agent)

Warp, 62 ends per inch; count, 20.4

Filling, 48 pick per inch; count, 19

Selvage, 80 ends

Ends in body, 4530

Body of cloth reeded, 2 per cent

No. of ends per beam, 2305

Width of each beam 36.75 inches

Total possible number of ends, 4646

Width of reed 73.25 inches (30 dents per inch)

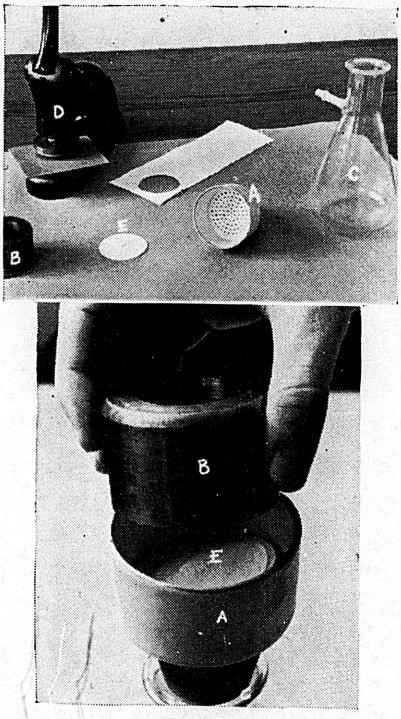

Figure 2.—Apparatus for Disk Penetration Method.

A—Buchner funnel; B—Weight; C—Flask; D—Die to cut samples; E—Sample.

Plant production capacity is more or less dependent upon how quickly a starch mixture will be taken up by and pass through a fabric. As an aid in evaluating this factor the two methods described below are suggested. The first or disk method is a modification of the procedure described by the Laundry Owners' National Association (2).

Disk Method (for measuring penetration through interstices of fabric and by capillary flow). This method consists in determining under fixed conditions the number of wet fabric disks through

which a given volume of starch will penetrate in a specified time (Table II).

Apparatus (Figure 2). A, Buchner funnel, 66 mm. in outside diameter, 56 mm. in inside diameter. B, weight, 510 grams. Outside diameter 56 mm., diameter of center opening 38 mm.

Procedure. Twelve desized fabric disks, E, 5 cm. (two inches) in diameter, were placed in funnel A, and weight B placed over the disks. Fifty milliliters of boiling water were poured through the opening in the weight onto the disks. After three minutes were allowed for the water to drain, 10 drops of the starch mixture (82.22° C., 180° F.) were added through the opening. At the end of another three minutes, the weight was removed, the disks were separated, and each was tested for starch with an iodine solution. The number of disks which gave a test for starch was considered to be the penetration number for that particular starch.

Method for Determining Penetration of Starch Mixtures Caused by Capillary Pull. — Apparatus (Figure 3).

A, rack to hold sample, B, measuring scale, and D, adjustable platform.

Procedure.—A strip of fabric 2.5 x 11.25 cm. (1 by 4.5 inches) which had been previously desized and then humidified at 65 per cent relative humidity and 21.1° C. (70° F.), was used as the test sample. Two small paper clamps were fastened to the strip, one at each end, and the sample was hung vertically from rack A parallel to ruler B.

A breaker containing a hot starch mixture (88.22° C., 180° F.) was raised under the free-hanging strip until the starch mixture reached a definite level—i. e., until the lower end of the strip had become immersed to about 1.25 cm. (0.5 inch) above the lower clamp. The platform, D, on which the beaker rested was made fast in

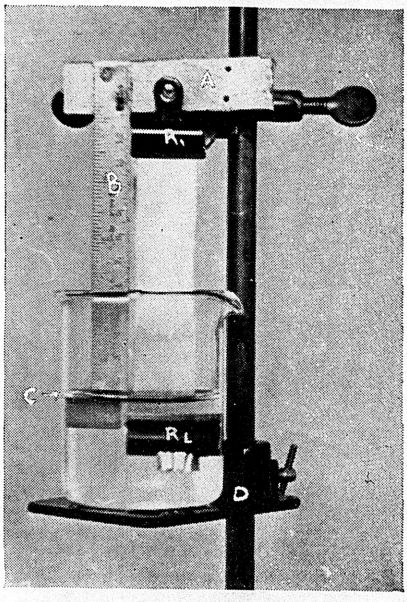

Figure 3.—Capillary Penetration Apparatus.

A—Rack to hold sample and ruler; B—Measuring ruler; C—Starch mixture level; D—Adjustable platform; S—Fabric Sample; R_1R_2—Clamps.

this position and an initial reading of the liquid level on the fabric was taken immediately. At the end of three minutes the platform was lowered and several drops of an iodine solution were applied to the test sample. The iodine solution made possible an accurate reading of the vertical creep or rise of the starch mixture during a three minute period. The difference between the initial and the final reading was considered to be a measure of the penetration.

TRANSPARENCY OF STARCH FILMS

A more or less continuous starch film is acquired on the surface of a fabric during the starching or finishing operation. In some types of fabrics it is almost imperative that this film be clear and transparent. A nontransparent film covering on a dyed fabric may change the tone of a previously matched shade, may detract from the brightness of a shade, or may partially hide the color of a delicate shade.

Method for Determining Transparency of Starch Films. The method suggested for measuring this property is based on a determination of the loss in light intensity caused by placing a starch film between a light of constant and known intensity, and a light

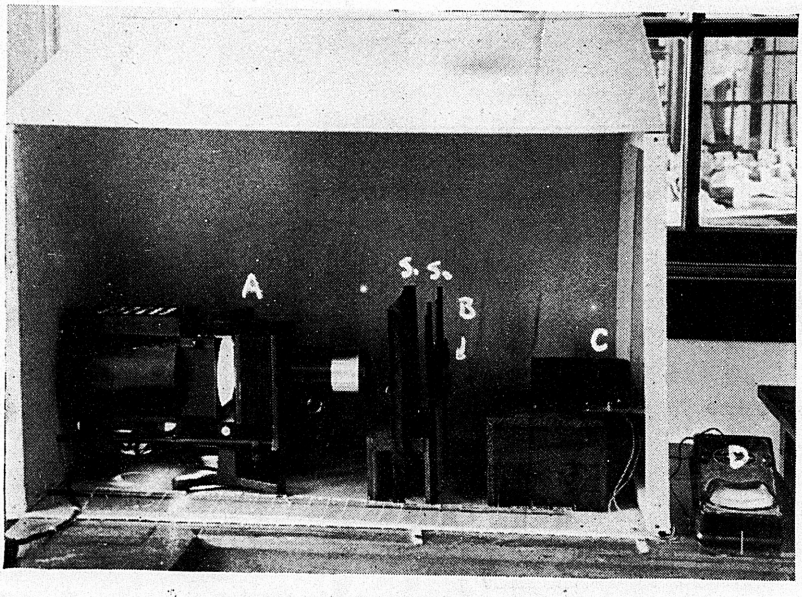

Figure 4.—Transparency Device.

A—Projector; B—Rack for holding sample slide; C—Photoelectric Cell; D—Galvanometer; S_1S_2—Cardboard shelf with slide.

intensity-measuring device. For convenience the starch film may be mounted on a microscope slide glass. The method makes use of a photoelectric cell, a galvanometer, and a 40-watt light bulb enclosed in a projector (Figure 4).

The entire setup, with the exception of the galvanometer, is enclosed in a light-tight box. A thickness gauge, calibrated in units of 0.0001 inch, is used to measure the thickness of the starch film.

Procedure. The thickness of a blank slide glass, as its center was measured.

A galvanometer reading was taken when the blank slide had been placed in the rack between the light source and the photoelectric cell and considered to be the initial reading. [All but a

TABLE 2.—Penetration of Starch Mixtures Through Fabric Interstices and by Capillary Flow.

Starch*	Stormer Viscosity	C. P. R. No.	No. of Disks**
A	75	2	5
B	170	1	4
C	38	45	8

*40 grams of starch per liter of water.
**Mean deviation was less than 0.3 disk.

TABLE 3.—Penetration Caused by Capillary Pull.

Starch*	Stormer Viscosity	C. P. R. No.	Capillary Rise in 3 Minutes Mm.	Mean Deviation Mm.
A	75	2	16.3	1.3
B	178	1	14.0	1.3
C	38	45	22.5	1.8

*40 grams of starch per liter of water.

TABLE 4.—Transparency of Starch Films.

Starch	Stormer Viscosity	C. P. R. No.	Light Intensity Less (per cent)	Film Thickness (Inch)
A	75	2	10.4	0.0040
B	170	1	26.3	0.0040
C	38	45	11.0	0.0040

1.25-cm. (0.5 inch) square portion at the center of the slide was screened from the light by the rack.]

The slide glass was coated by dipping in a hot starch mixture and the films on the slide were dried overnight at 65 per cent relative humidity and 21.1° C. (70° F.). (It may be advantageous to use a drying temperature corresponding to that used in the particular plant in which one may be interested.)

The coated slide was returned to the rack between the light and the cell and a final galvanometer reading was taken. [It is sug-

gested that all determinations be made at fixed conditions of humidity and temperature, preferably at 65 per cent relative humidity and 21.1° C. (70° F.)]

The combined thickness of the two starch films at the center of the slide was determined by measuring total thickness and subtracting that of the glass.

EFFECT OF CRUSHING STARCHED FABRICS

Of several fabrics, the one which is affected least by a given crushing or crumpling action will probably remain "fresh" for the longest time when worn in the form of a garment. In short, the method suggested consists in crushing a folded sample and then measuring the effect of that crushing action by determining the increase in the angle of bend from the normal caused thereby.

Experimental Method for Measuring Effect of Crushing. The Apparatus was made up of a crushing device and a means for measuring the angle with the horizontal made by a freely hanging portion of a sample. More specifically, the former consisted of a modified dissecting microscope chassis, having as a fixed stage a piece of pressed board and as the adjustable stage a metal plate. A mirror graduated in millimeter squares was mounted directly in

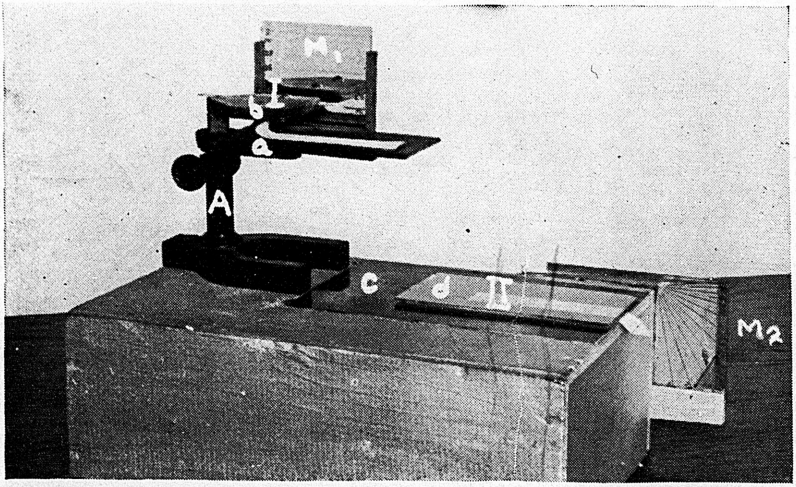

Figure 5.—Crushing Device (I) and Angle-Measuring Device (II).

A—Modified dissecting microscope; a—Fixed stage; b—Adjustable stage; c—Metal plate under sample; d—Glass plate, partially covers sample; M_1—Mirror; M_2—Mirror calibrated in degrees; S—Sample.

back of the device. By the use of this mirror it was possible accurately to adjust the height of the movable stage. The means for measuring the angle consisted of a smooth metal plate under the sample, a glass plate partially to cover the sample, and a mirror mounted vertically which was calibrated in degrees from 0° to 90°.

The test sample consisted of a regular piece of cloth cut 2.5 x 15 cm. (1 by 6 inches), one end of which had been trimmed to a point by cutting back from the center of the end to points 2.5 cm. (1 inch) along the sides of the strip. It was placed flat on the stage (a, Figure 5) with the marked side up and the pointed end towards A.

The movable plate, b, was brought down to a position 1 mm. distant from a. The sample was allowed to remain in this position for one minute, after which the plate was lifted. The sample strip was moved to the metal plate, c, with the marked side down and the pointed end toward the end of the box having the extended mirror. The edge of the square glass plate d, was placed along the 2.5-cm. (1-inch) line on the sample and thus all but the 2.5 cm. (1-inch) length including the pointed end was covered.

The sample and the glass plate were slid along the metal plate until the edge of the glass and, hence, the 2.5-cm. (1-inch) line coincided with the edge of the metal plate. In this position 2.5 cm. (1-inch) of the sample extended freely beyond the end of the box. After 10 seconds the angle of bend which the extending fabric made with horizontal was read directly from the mirror, M_2, mounted in back of the box. This angle was considered to be the zero or normal reading of the strip.

Again the sample was placed on stage a. The pointed end was lightly folded up and over, forming a U-shaped bend along the line 2.5 cm. (1 inch) from the tip. Plate b was then lowered to a position 1 mm. from a, creasing the sample along the 2.5 cm. (1-inch) line, and held in this position for one minute. The sample was then laid flat and pressed by lowering b to within 1 mm. of a and holding it there for one minute. Again the angle of the bend made by the sample with the horizontal was determined as described above. The difference between the two readings, before and after the sample had been exposed to the crushing action, was considered to be the angle of bend caused by that action.

The angle of bend given represents the angle of deformation from the normal caused by a given crushing action on the fabric—i. e., when the adjustable stage was lowered to point 1 mm. from

the fixed stage. It follows that the smaller this angle the less it has been affected by this action.

STIFFNESS OF FABRICS

One of the factors which, to a large extent, determines the so-called "body" and "handle" of a fabric is stiffness. This property may be judged by the results obtained by the use of the method of Peterson and Dantzig (1,4).

Experimental Method for Measuring Stiffness.—This method (4) depends upon the deformation of a supported strip bent under its own weight. The apparatus consisted of a set of rubber-covered rolls through which samples passed in a horizontal plane and a shelf fastened at a 45-degree angle with the vertical at the zero reading of the scale (Figure 6).

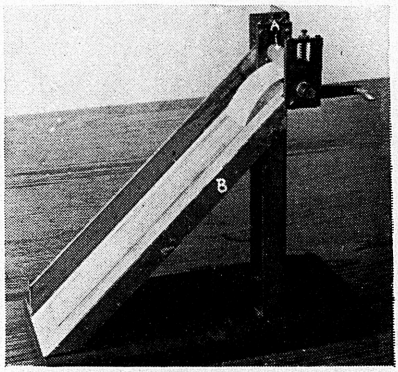

Figure 6.—Stiffness Tester.

A—Set of rubber rolls; B—Shelf, set at 45° angle with vertical.

A fabric sample 5 x 10 cm. (2 by 4 inches) was inserted lengthwise between the rollers and slowly fed through those rollers in the direction of the scale until the end of the sample barely touched the metal shelf. The distance in millimeters from the nip of the rolls to the point on the shelf where the strip made contact multiplied by 0.43 was considered to be the stiffness of the fabric tested. It follows that the larger the reading the greater will be the stiffness.

SMOOTHNESS OF FABRICS

The surface characteristics of a fabric are undoubtedly made up of a number of contributing properties, which in turn, have a bearing upon the "feel", appearance, and, in some instances, the utility of the fabric. One of these properties is smoothness. The method of Mercier (3) for measuring the coefficient of friction of a fabric may be used to evaluate the smoothness of a fabric.

Method for Measuring Smoothness of Starched Fabrics (3).—

Two boards, each 55 cm. (22 inches) long and 15 cm. (6 inches) wide, are hinged together at one end. One of the boards rests on three small supports which can be adjusted to bring the board to a horizontal position. The angle between the boards can be changed by a screw arrangement, and this angle or its tangent read on a scale on the upper surface of the horizontal board. The block of wood 20 cm. (8 inches) long and 15 cm. (6 inches) wide weighs about 560 grams (1.25 pounds). This block of wood and the inclined plane are covered with the fabric to be tested. Clamps for holding the fabric on the block and on the inclined plane are shown in Figure 7.

A spring keeps the fabric under tension on the block and a small weight clamped to the lower end of the fabric keeps the fabric taut on the inclined plane during the test.

The wooden block, covered with sample of fabric to be tested, was placed on the inclined plane which had also been covered with another piece of the same fabric. The angle between the inclined plane and the horizontal was then increased until, with the assistance of light tapping on the inclined board, the block began to slide. A reading of the tangent of the angle thus made by the inclined plane was considered to be the smoothness factor of the fabric tested. The smaller the angle, and, hence, the smaller the tangent, the greater will be the smoothness.

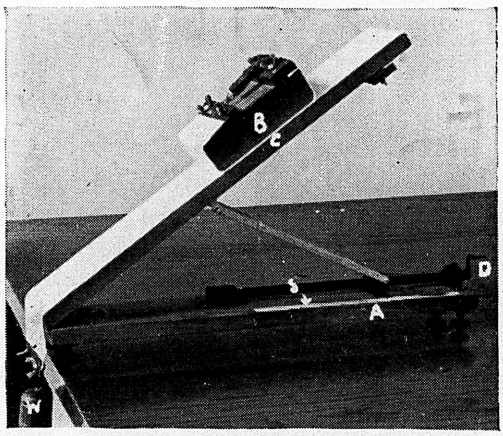

Figure 7.—Smoothness Tester.

A—Base board; B—Sliding block, covered with sample; C—Adjustable board, covered with sample; D—Crank to adjust angle between A and C; S—Scale measuring between A and C; W—Weight to hold sample under tension.

TABLE 5.—Effect of Crushing Starched Fabrics.

Starch*	Stormer Viscosity	C. P. R. No.	Angle of Bend	Mean Deviation
A	75	2	29.1	1.3
B	170	1	29.4	1.3
C	38	45	24.7	2.0

*40 grams of starch per liter of water.

TABLE 6.—Stiffness of Starched Fabrics.

Starch*	Stormer Viscosity	C. P. R. No.	Stiffness Factor	Mean Deviation
A	75	2	33.11	2.4
B	170	1	31.39	1.7
C	38	45	30.10	1.3

Fabrics were conditioned and tested at 65 per cent relative humidity and 70° C.

*40 grams of starch per liter of water.

TABLE 7.—Smoothness of Starched Fabrics.

Starch*	Stormer Viscosity	C. P. R. No.	Smoothness Factor	Mean Deviation
A	75	2	0.6395	0.0209
B	170	1	0.5459	0.0152
C	38	45	1.0724	0.0262

*40 grams of starch per liter of water.

SUMMARY

Methods are described for evaluating starches for use on fabrics; these include methods for judging the starch mixtures from a processing or plant operating viewpoint and methods for evaluating the quality of starched fabrics. The former may be used for measuring the stickiness of starch mixtures during ironing, and the penetration of such mixtures; the latter may be used to measure the transparency of starch films, and to determine the smoothness, stiffness, and resistance to crushing of starched fabrics.

These methods may also be used to advantage in evaluating other sizing or finishing agents.

LITERATURE CITED

(1) Furry, M. S., U. S. Dept. Agr., Tech. Bull. 284 (March, 1932).
(2) Laundry Owners' National Assoc. of U. S. and Canada, Joliet, Ill., Special Rept. 80.
(3) Mercier, A. A., Natl. Bur. Standards, Research Paper 196 (August, 1930).
(4) Peterson and Dantzig, U. S. Dept. Agr., Tech. Bull. 108 (April, 1929).

This work was carried out by the Carbohydrate Unit, Agricultural Chemical Research Division, Bureau of Agricultural Chemistry and Engineering, in cooperation with, and in the laboratories of the Engineering Experiment Station of the Alabama Polytechnic Institute. Contribution No. 157 from the Carbohydrate Unit, Agricultural Chemical Research Division, Bureau of Agricultural Chemistry and Engineering, U. S. Department of Agriculture.