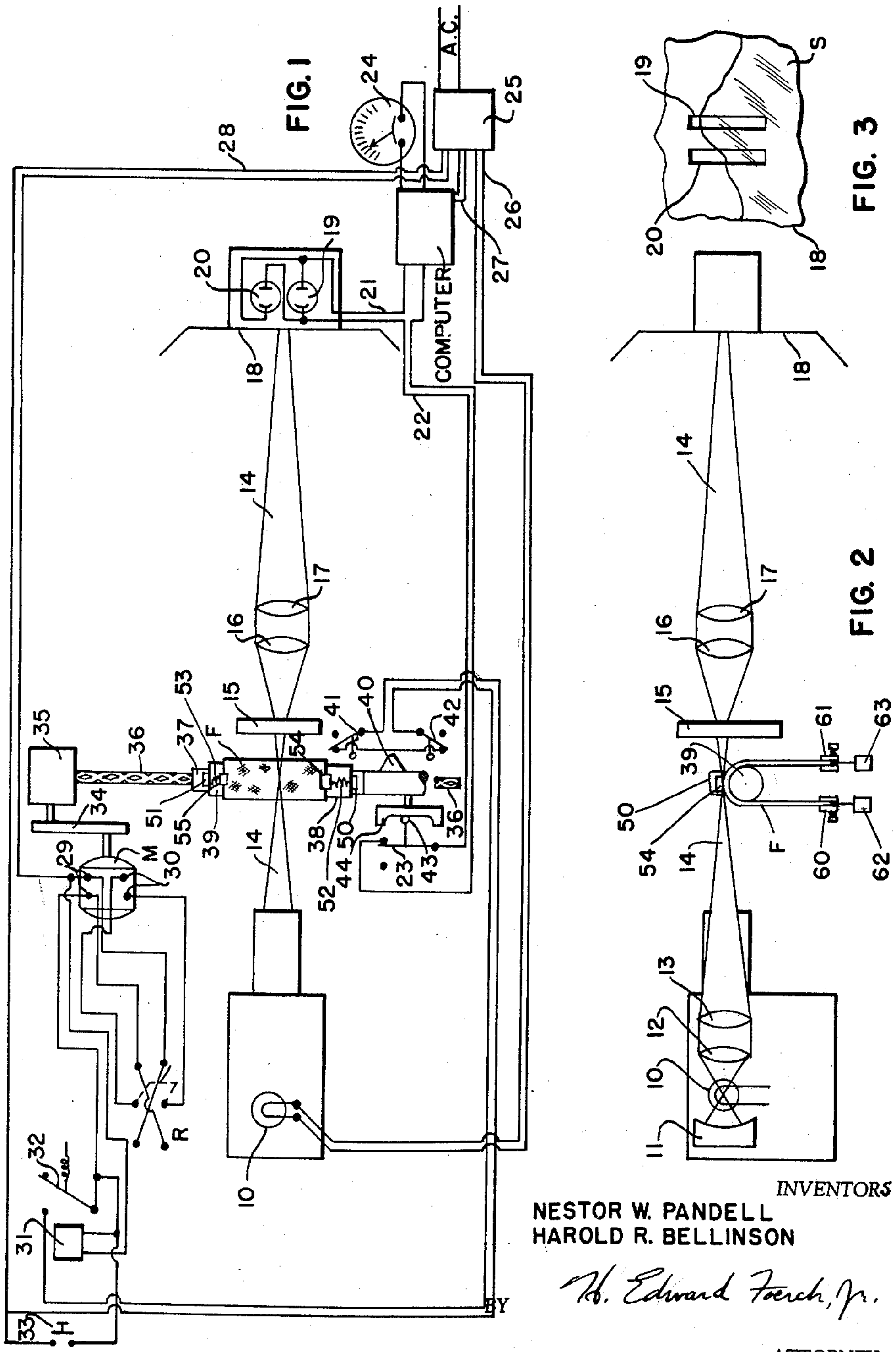
Jan. 8, 1963 N. W. PANDELL ETAL 3,072,012

WRINKLE MEASURING DEVICE

Filed April 28, 1959 2 Sheets-Sheet 1



INVENTORS
NESTOR W. PANDELL
HAROLD R. BELLINSON

BY H. Edward Foerch, Jr.

ATTORNEY

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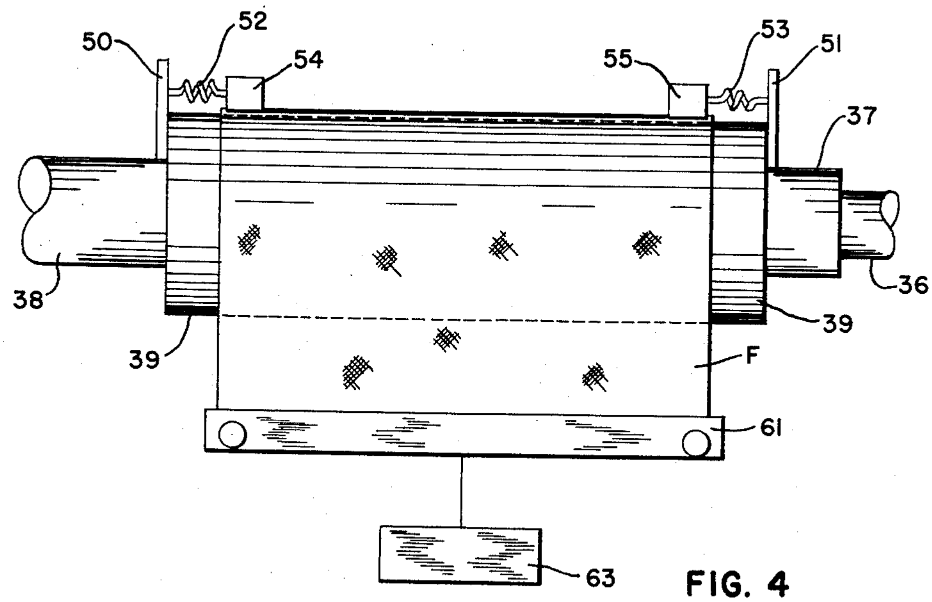

FIG. 4

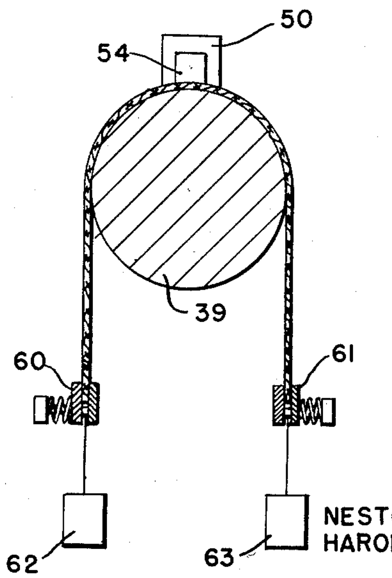

FIG. 5

INVENTORS
NESTOR W. PANDELL
HAROLD R. BELLINSON

BY H. Edward Foerch, Jr.
ATTORNEY

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WRINKLE MEASURING DEVICE

Nestor W. Pandell, Schenectady, and Harold R. Bellinson, Troy, N.Y., assignors to Cluett, Peabody & Co., Inc., Troy, N.Y., a corporation of New York
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This invention relates to a method and a device for measuring surface characteristics of a web of flexible material, and more particularly to a method and device for measuring surface irregularities such as wrinkles of a web of flexible material. The present application is a continuation-in-part of our application Serial Number 746,-808, filed July 7, 1958, and titled "Wrinkle Measuring Device," now abandoned.

With the recent growth in the wash and wear fabrics and related wash and wear clothing industry, a need has arisen for an accurate and precise standard of performance for the various fabrics described as "wash and wear," "minimum care," or "drip dry." These terms are only general indications of the characteristics of the fabric imparted to it by the finish and indicating generally that the fabric is relatively smooth and wrinkle free after washing and without ironing. The performance of these fabrics, after washing and drying without ironing, varies in that the fabrics have differing frequencies of wrinkles and differing sizes of wrinkles depending upon the particular finish used and the care with which it is applied. This variation of performance has caused some unfavorable consumer reaction and is a threat to the wash and wear industry.

To date, to the best of our knowledge, no method or device for accurately measuring surface wrinkles, or similar surface characteristics of a flexible web, is available which would permit an effective evaluation of fabrics or the establishment of a standard of performance for wash and wear fabrics. Comparisons heretofore have been made entirely by visual observations or other non-precise methods. As the method and device of the present invention were developed in connection with measuring surface irregularities or wrinkles in flexible materials for establishment of a standard of performance for wash and wear fabrics, our invention will be described in this preferred embodiment. However, it will be recognized that the present method and device are equally useful in measuring or evaluating surface characteristics other than wrinkles, and therefore that it is useful in connection with flexible webs other than fabrics, and even for measuring or evaluating characteristics of inflexible surfaces as will be explained hereinafter.

The problem presented by the increasing popularity of wash and wear garments is a problem of determining the "performance" in terms of the smoothness of the surface of the wash and wear fabric after drying and without ironing. This in turn requires that accurate standards be established and, in accordance with the instant invention, that accurate measurement of the surface irregularities in the wash and wear fabric be obtained for comparison purposes.

The present method for measuring the surface characteristics, and particularly the wrinkles, of a flexible web includes the steps of first projecting an enlarged profile of a line across the surface of the flexible web, then quantitatively measuring the irregularities continuously along the line profile, and then comparing the measurement with standard, such as a measurement of the profile with the wrinkles removed. This method provides a scientific measurement of the surface irregularities or wrinkles and eliminates errors which arise through mental calculations and comparisons. It also eliminates subjective errors

which arise because of color variations caused by shades and patterns, and by thickness or variations in the weave of the fabric. This method also eliminates the effects of long range trends such as drape or roll effects in the web from the measurement.

According to the device of the present invention, the flexible web is positioned on a mandrel having the desired curvature to obtain a crown or crest extending along a line across the surface in order to reveal an inner edge of the flexible web. A beam of light is directed from a source toward the ridge line of the crest formed across the surface to project a profile shadow of the surface of the web. A receiving screen intercepts the projected profile and includes means to record a characteristic of the surface such as the frequency and size of wrinkles, or to compare the projected profile with a standard. In the preferred embodiment, two photoelectric cells are positioned to receive two separate points on the profile and to generate a difference voltage. The projected profile is caused to move across the two receiving photoelectric cells to obtain a continuous signal along the length of the projected profile. Suitable computer means are connected to receive the generated signal and to record the continuous sum of such readings for comparison or evaluation.

We have been concerned with the so called "wash and wear" problem, and have invented a method of measuring smoothness of the fabric and believe it permits an evaluation of wash and wear performance. Thus, our device permits an accurate comparison to be made between the surface irregularities in a piece of fabric in a relaxed condition after washing and therefore containing wrinkles, and this same piece of fabric which has been tensioned to remove wrinkles. This comparison is independent of the weave or finish and eliminates large roll or drape effects from consideration. Also, construction or surface irregularities such as slubs, that is, a knot in the thread from which the fabric is woven, fuzz, lint, dust or random projections of fibers, are eliminated from the evaluation since a comparison of readings with the same fabric is made and only the wrinkles are removed by tensioning. By using the image or shadow profile of the exposed line surface of the fabric, we also have eliminated the problems of differing colors and shades or other surface effects in fabrics. This contrasts with previous suggestions concerning the use of reflected light, "see-through" optical systems, or other similar devices and is an important feature of our invention.

An object of the present invention is to measure a surface characteristic of a flexible material.

A further object of the present invention is to measure surface irregularities of a flexible web having surface irregularities of varying frequency and amplitude.

A further object of the present invention is to provide a method for evaluating wash performance of wash and wear fabrics with scientific accuracy and without regard to normal surface characteristics or to color, weave, or drape of the fabric.

Still another object of the present invention is to provide a device which will permit measurement or evaluation of surface characteristics of a flexible web without mental calculations or visual observations.

Other objects and advantages of the present invention will be apparent from the following description together with the drawing, in which:

FIG. 1 is a schematic plan view of a device for measuring surface characteristics of a flexible web in accordance with the present invention;

FIG. 2 is a side view of a device shown in FIG. 1 with some of the electrical elements deleted for clarity;

FIG. 3 is an enlarged detailed view of the irregular shadow cast by a profile of the sample of fabric and sensed by the photoelectric receiving means in accordance with our invention;

FIG. 4 is a partial side view illustrating a tensioning arrangement for the fabric specimen; and

FIG. 5 is a partial end view illustrating a tensioning arrangement for the fabric specimen.

In describing the preferred embodiment of the present invention, a familiarity with a special analytical technique of statistical method which is known as the mean square successive difference will be helpful. This is for the reason that our invention analyzes a mass of data which is in effect successive differences in the surface irregularity of a piece of fabric, by employing the said technique. Thus, in terms of statistical method, one recognized method of minimizing the effect of a long ranged trend where the variation in the mean is gradual (that is where a linear or non-linear trend is shifting the mean of a population) is to estimate the standard deviation from differences. The equation for the means square successive difference is:

$$S^2 = \frac{\sum_{i=1}^{n-1}(x_{i+1}-x_i)^2}{n-1}$$

where S^2 is the estimate of the population variance, or of the standard deviation squared and i refers to the temporal or spatial order of the observation X.

Another related analytical method found to be useful in measuring wrinkles is to obtain the sum of absolute successive difference. This is expressed by the equation:

$$\text{M.D.} = \frac{\sum_{i=1}^{n-1}|x_{i+1}-x_i|}{n-1}$$

This method of calculation can also be used to estimate, σ, the population standard deviation. Although not as efficient as the calculation involving squares, its accuracy is entirely adequate when a large number of observations is available. Its advantage in this instance is that it permits a great simplification in computer circuits.

Furthermore, if the number of observations, n, is always constant, and if the purpose of the analysis is simply to make comparisons, then it is not necessary to divide by $n-1$, and only necessary to obtain this sum.

This is the basis of the computer circuits in the preferred embodiment.

Correlating the above to our invention, the small wrinkles or surface irregularities of small magnitude are distinguished from the long range trend (drape or roll effects in the fabric) by using an analog computer which in effect calculates the mean square successive difference, or in a second instance, above, the sum of the absolute successive differences. This is believed to be logical for the reason that what the layman terms "wrinkles" are those surface irregularities which are most apparent to the human eye. These are the small wrinkles rather than the large roll, drape or similar effects.

Briefly, our inventive device permits the utilization of two separate but simultaneous observations of a piece of fabric. These observations preferably are of two adjacent areas in the shadow profile of a line across the fabric. For this purpose, the two photoelectric cells are joined electrically so as to feed to an analog computer an electric voltage which represents the difference between two observations. The analog computer in one case may electrically square this difference, and an entire series of differences, and store the sums thereof electrically in a condenser. When the sum of absolute difference is used, the voltage differences generated by the two photoelectric cells may be positive or negative and therefore a so-called "absolute value unit" is used to feed only positive values directly to the computer which sums and records them. The final summation is recorded electrically for a given piece of washed fabric in a relaxed condition. The same fabric again is measured and recorded after tensioning the fabric to remove surface irregularity caused by wrinkles and the difference between the two readings is used to establish an index of performance for the fabric. By experience, precise standards of wash and wear performance then can be related to the mathematical values of these differences. For example, a difference index between 0 and 1.0 might be excellent, whereas a difference between 10 and 20 might be poor.

With the above background in mind, reference now should be had to FIG. 1. Firstly, an electrical lamp bulb **10**, together with a mirror **11** and one or more condensing lenses such as **12** and **13**, provide a source of light the beam of which is identified by the numeral **14**. This beam of light is caused to shine tangentially across the top surface of a sample of fabric F which is draped so as to be perpendicular to the beam. The beam then progresses through a control aperture **15**, through focusing lenses such as **16** and **17**, and on to a perpendicular shadow screen **18**. As shown in FIG. 3, the shadow S which is thus formed on the screen magnifies the surface irregularities of the fabric F.

Behind the shadow screen **18**, we place two photoelectric cells, **19** and **20**. These may be either self generating selenium cells or photronic photoelectric cells, the self generating selenium cells here being the preferred embodiments selected for purposes of illustration. As shown in FIG. 3, these photoelectric cells are arranged to sense the contour of the magnified shadow S cast by the surface irregularities on the piece of fabric F.

For example, an electric circuit **21**, **22** connects the photoelectric cells **19** and **20** via a switch **23** to an analog computer. This analog computer is shown as a box because it is a common item commercially available on the market. In a device for recording the sum of the absolute successive differences, for example, the analog computer might include a D.C. power supply, a number of operational preamplifiers, a multiplier section and a number of operational manifolds to which is added an integrator for summing the successive computations which in this case comprises a capacitor for accumulating successive values. These elements are all common commercial items. The computer is of a type which has an input section and an output section. By an electrical effort, the analog computer accumulates the sum of successive electric voltages received by the input section and transmits this sum to the output section. Thus, as shown in FIG. 1, a voltmeter **24** can be joined to the output section of the analog computer and the dial of the voltmeter calibrated to yield reading directly proportional to the accumulated sum of the electric voltages which are received by the input section of the analog computer.

Referring more particularly to the photoelectric cells **19** and **20**, it will be noted that these cells are electrically connected so that the anode of one cell is joined to the cathode of the other cell. These connections cause the voltages generated by the individual cells to oppose one another. The resultant voltage transmitted through the circuit **21**, **22** thus is the difference between the voltages generated by the individual cells as hereinafter more fully will be explained.

Referring now to the electric components associated with our invention, we have indicated a source of alternating current with the letters A.C. This source of current first is passed through a voltage stabilizing device **25**. Three separate circuits are connected to the output of the voltage stabilizing device **25**. The first of these, **26**, provides a source of current for the electric lamp **10**. The second of these, **27**, provides a source of current for the computer. The third of these, **28**, actuates mechanism associated with an electric motor M to cause the previously mentioned piece of fabric F to traverse or to move perpendicularly back and forth in light beam **14** as now will be described in more detail. The electric motor M is a reversible split phase induction motor having separate start and rotor terminals **29** and **30** respectively. A double throw reversing switch R is interposed in the electric circuit for the motor M so as to allow the motor to be run in either direction in order to effect a traversal of the fabric F in either direction across the light beam **14**.

A holding solenoid **31** is provided for the normally open switch **32** in the motor circuit. In addition, a push button starting switch **33** is located in the primary electric circuit for the motor M. In general, these elements and their associated elements define means for moving the fabric F in a direction parallel to the surface of the fabric as now will be explained in more detail.

As shown in FIG. 1, the rotor of the motor M drives a pulley over which runs a belt **34**. The belt **34**, in turn, rotates a second pulley and thus actuates a gear reduction train **35**. It is the function of the gear reduction **35** to rotate a screw **36** upon which are mounted two collars **37** and **38** together with suitably mounted followers. Rotation of the screw **36** in one direction causes the collars to carry a fabric support cylinder **39** in one direction, whereas a reversal of the motor M, and thus the screw rotation **36**, will cause the collars **37** and **38** to move the support cylinder **39** in the opposite direction. It is the support cylinder **39** over which the fabric F is draped for the measurement of the surface irregularities and it is an important feature of the invention that the support provides a line exposure of the surface of the fabric to the light beam. This casts a profile type of shadow on the screen as will be appreciated.

The collar **38** carries a cam **40** which is positioned to intercept, selectively, the following wheels of the switches **41** or **42**. The latter thus define limit switches which stop the traversal of the support cylinder **39** at a preselected exact position each time a piece of fabric is scanned by the light beam.

Similarly, the normally closed switch **23** is opened through the medium of a follower wheel **43** when one end of the cam **44**, carried by the collar **38**, contacts the same. It will be recalled that the switch **23** is connected in series with the photoelectric cells **19** and **20**. The traversal of the support **39** thus also controls actuation of the photoelectric cells.

With the above explanation in mind, the operation of a typical cycle in traversal will be apparent. Thus, the push button **33** first is depressed in order to start the motor M and energize the solenoid **31**. The solenoid **31** immediately closes the switch **32** whereupon the push button **33** may be released. The motor M then will remain energized until the circuit is interrupted by one or the other of the switches **41**, **42**. Energization of the motor M causes a rotation of the pulley thereof in one direction or the other, depending upon the position of the reversing switch R. Assuming energization in a given direction, the pulley **34** and gear reduction **35** cause the screw **36** to rotate. The collars **37** and **38** then ride on the screw and cause the support cylinder **39** to carry the sample of fabric F past the light beam **14**. As this is done, the shadow S moves across the screen. Successive portions of the surface contour shadow of the piece of fabric thus are cast upon the shadow screen **18** for the benefit of the photoelectric cells **19** and **20**. When a traversal has been completed, the cams **40** and **44** are so positioned that the circuit to the motor M and to the photoelectric cells **19** and **20** both are opened. This, in turn, deenergizes the solenoid **31** and allows the normally open switch **32** to return to its open position. The circuits then are dormant until the reversing switch R is reversed and the push button **31** once again is depressed to initiate a subsequent traversal cycle.

In FIGS. 4 and 5, we have shown a simple means for tensioning the fabric F. The purpose of the tensioning means is to remove all wrinkles from the fabric F and thereby obtain a reading for the fabric which is known to be free of wrinkles. The means for tensioning the sides of the fabric F may include braces **50** and **51** attached to the supporting cylinder **39**. Resilient means such as springs **52** and **53** are attached to the braces **50** and **51**, respectively, and attached to the other end of the springs **52** and **53** are gripping means **54** and **55** which may comprise hooks or clamps or some other suitable means for gripping the fabric F. The particular means for tensioning the sides of the fabric to remove wrinkles in the fabric specimen are a matter of choice, and the tensioning means may be varied to suit the particular conditions. The tensioning means, however, must engage only the sides of the fabric F so that they do not interfere with the scanning of the fabric or modify the projected line profile of the surface.

As seen in FIG. 5, the ends of the fabric F are also tensioned to remove wrinkles and these tensioning means may include clamps **60** and **61** which are connected to weights **62** and **63**. The weights **62** and **63** are chosen such that they will remove wrinkles in a lengthwise direction of the fabric F without unduly stretching the fabric. Other tensioning means may of course be used and the particular tensioning means described are illustrated for simplicity.

As an example, we set forth below a chart showing the results obtained through the use of our method and device with respect to some samples of typical wash and wear broadcloth, print, sport denim, and other fabric.

Type of fabric	Preparation of sample	Sum of absolute successive differences as obtained from wrinkle indicator	Relaxed-tension or wrinkle index	Visual rating
Broadcloth	Pressed relaxed	8.3	8.3−8.0=0.3	"Perfect" sample no wrinkles.
Print	Pressed relaxed	6.4	6.4−5.8=0.6	Do.
	Pressed tensioned	5.8		
Sport denim	Pressed relaxed	9.6	9.6−9.5=0.1	Do.
	Pressed tensioned	9.5		
Broadcloth	Machine washed, drip dried, relaxed	17.3	17.3−14.0=3.3	"Good" sample slightly wrinkled.
	Machine washed, drip dried, tensioned	14.0		
Sateen print	Machine washed, drip dried, relaxed	24.4	24.4−19.6=4.8	Do.
	Machine washed, drip dried, tensioned	19.6		
Chambray	Machine washed, drip dried, relaxed	21.0	21.0−16.0=5.0	Do.
	Machine washed, drip dried, tensioned	16.0		
Broadcloth	Machine washed, drip dried, relaxed	22.3	22.3−12.5=9.8	"Fair" sample wrinkled.
	Machine washed, drip dried, tensioned	12.5		
Gingham	Machine washed, drip dried, relaxed	23.1	23.1−12.4=10.7	Do.
	Machine washed, drip dried, tensioned	12.4		
Skip dent	Machine washed, drip dried, relaxed	24.0	23.0−14.4=9.6	Do.
	Machine washed, drip dried, tensioned	14.4		
Broadcloth	Machine washed, spin extracted, hung to dry, relaxed	37.2	37.2−16.0=21.2	"Poor" sample badly wrinkled
	Machine washed, spin extracted, hung to dry, tensioned	16.0		
Khaki drill	Machine washed, spin extracted, hung to dry, relaxed	39.7	39.7−19.3=20.4	Do.
	Machine washed, spin extracted, hung to dry, tensioned	19.3		
Print	Machine washed, spin extracted, hung to dry, relaxed	39.6	39.6−13.1=26.5	Do.
	Machine washed, spin extracted, hung to dry tensioned	13.1		

In the chart illustrated above, the average of the absolute successive differences as indicated by the present wrinkle measuring device was recorded for samples of various type fabrics and for different preparation of the samples. Readings were recorded for each sample with the sample in a relaxed condition and then in a tensioned condition to remove wrinkles only from the sample. Construction features, such as slubs, fuzz, lint, etc., remain unchanged. The difference between these two readings were then recorded.

It will be noted that the different readings or wrinkle index for the various type fabrics produces comparable wrinkle index values which fall within defined ranges or standards of performance for the fabrics. Thus, an exact scientific evaluation of the fabric performance following washing but without ironing is obtained by measurement of the wrinkles. This measurement is independent of the construction or color of the fabric and is easily correlated to acceptable standards. It will be apparent also that the apparatus can be used to inspect or evaluate surface characteristics of any flexible web which will conform to the mandrel or semi-flexible web which can be made to conform to the mandrel.

In the chart illustrated above, readings for only a single traverse along a single line profile of the fabric were recorded. Obviously, it may be desirable to obtain readings along several line profiles at different sections or directions of the fabric sample. In this case, average readings may be obtained for evaluation of the performance of the fabric. Additionally it may be desirable to construct a wrinkle index which is a ratio of the recorded measurements rather than a difference. Either means may of course be used, although the difference index is preferred in the present embodiment.

It will be apparent that the apparatus can be used to inspect or evaluate surface characteristics of various kinds, providing the surface is of a material which can be draped over the mandrel or supporting cylinder **39** and such that the material conforms to the shape of the mandrel. The depth and uniformity of surface patterns on embossed paper or fabric, or on three-dimensional woven fabric, are characteristic of this type. Corduroy offers a specific illustration of this type of use. The esthetic value of a corduroy fabric is affected by such properties as the distance from one wale to another, the amount of open space between adjacent tufts, the height of the tufts, the presence of occasional fibers extending above the general surface, and the uniformity of these properties from one spot to another on the fabric. All of these characteristics can be detected by a beam of light shining across a suitably created "internal edge" of the fabric. The characteristics can be recorded on a chart, and observed there, or, by appropriate and well known changes in the computing circuit, these characteristics can be reported by one or several numbers.

In evaluating surface characteristics of materials other than wrinkled fabrics, it will be apparent that statistical measurement methods other than a sum of absolute successive differences may be desirable, in which case well known modifications may be made to the recording computer circuit. It will also be apparent that by use of a well known method of obtaining surface impressions of inflexible surfaces with a plastic film, the surface characteristics of an inflexible surface may also be evaluated by the present method and device. The plastic film, being flexible and being a true picture of the surface of the inflexible surface, may then be draped over the supporting cylinder **39** and evaluated or measured in the manner explained above.

In conclusion, it will be appreciated that our method and measuring device may be modified and used to obtain accurate measurements of different characteristics of flexible webs in the light of the foregoing teachings. It is therefore understood that changes may be made herein within the full intended scope of our invention as defined by the appended claims.

We claim:

1. A method of determining an index of wrinkles in a flexible web, comprising the steps of projecting a contour profile of a line portion across the surface of the flexible web, recording the sum of continuous successive height differences of two separated points along said profile with said web relaxed to include said wrinkles and with said web tensioned to remove said wrinkles, then taking the difference of said tensioned and said relaxed web sums.

2. A method of determining an index of wrinkles in a flexible web, comprising the steps of creating a crest line across the surface of said web, projecting a contour profile of a crest line, recording the sum of continuous successive height differences of two separated points along said profile including said wrinkles, recording the sum of continuous successive height differences of separated points along said profile without said wrinkles, and comparing said recorded sums to obtain an index of said wrinkles and said web.

3. A method of determining an index of wrinkles in a flexible web, comprising the steps of creating a crest line across the surface of said web, projecting a contour profile of said crest line, recording the sum of continuous successive height differences of two separated points along said profile with said web relaxed to include said wrinkles and with said web tensioned to remove said wrinkles, and then taking the difference of said tensioned and said relaxed sums to obtain an index of said wrinkles.

4. A device for determining the surface characteristics of a web of flexible material, comprising a light source directing a beam of light toward an image receiving means, means for supporting said web with a line portion perpendicular to and partially intercepting said beam of light to cast a profile shadow of said line portion onto said image receiving means, said image receiving means including adjacently spaced light sensitive means positioned to generate electrical signals respectively proportional to the height of two spaced portions of said profile shadow, said light sensitive means being connected to produce electrical signals representing the difference in said heights of said spaced portions.

5. A device for determining the surface characteristics of a web of flexible material, comprising a light source directing a beam of light toward an image receiving means, means for supporting said web with a line portion perpendicular to and partially intercepting said beam of light to cast a profile shadow of said line portion onto said image receiving means, said image receiving means including adjacently spaced light sensitive means positioned to generate electrical signals respectively proportional to the height of two spaced portions of said profile shadow, said light sensitive means being connected to produce an electrical signal representing the difference of said distances, means moving said profile shadow relative to said light sensitive means to cause said light sensitive means to view successive spaced portions of said profile shadow across said profile to obtain an index measurement of the wrinkles in said fabric.

6. A device for determining the surface characteristics of a web of flexible material, comprising a light source directing a beam of light toward an image receiving means, means for supporting said web with a line portion perpendicular to and partially intercepting said beam of light to cast a profile shadow of said line portion onto said image receiving means, said image receiving means including adjacently spaced light sensitive means positioned to generate electrical signals respectively proportional to the height of two spaced portions of said profile shadow, said light sensitive means being connected to produce an electrical signal representing the difference of said heights, traversal means for moving said profile shadow relative to said light sensitive means to cause said light sensitive means to view successive spaced portions of said profile shadow across said profile to obtain an index measurement of the wrinkles in said fabric, said traversal means

including means for tensioning said web on said supporting means along said ridge line and perpendicular thereto.

7. A device for determining the surface characteristics of a web of flexible material, comprising a light source directing a beam of light toward an image receiving means, means for supporting said web with a line portion thereof perpendicular to and partially intercepting said beam of light to cast a profile shadow of said line portion onto said image receiving means, said image receiving means including adjacently spaced photocells positioned to generate electrical signals respectively proportional to the height of two spaced portions of said profile shadow, said photocells being connected to produce an electrical signal representing the difference of said heights, means for moving said support means within predetermined limits to cause said spaced apart photocells to view successive spaced portions along said profile shadow to produce successive difference signals, and means summing said successive difference signals to obtain an index measurement of the wrinkles of said fabric.

8. A method of determining surface irregularities of flexible material, comprising the steps of producing a ridge line across the surface of said web material, projecting a profile shadow of the line portion, utilizing the projected profile shadow to obtain a sum of successive height differences of two separated points continuously along said profile shadow.

9. A method of determining an index of wrinkles removed from a web of flexible material by tensioning the material, comprising the steps of creating a ridge line across the surface of the flexible material, projecting a profile shadow of said ridge line, utilizing the projected profile shadow to obtain a first sum of successive height differences of two separated points continuously along said profile shadow, tensioning said web material to remove wrinkles therein, utilizing the projected profile shadow of said ridge line with said web in said tensioned condition to obtain a second sum of successive height differences of separated points continuously along profile shadow, and subtracting the second sum from said first sum to obtain an index of the wrinkles removed in said web material by tensioning.

10. A device for measuring surface irregularities in a web of flexible material comprising, a light source directing a beam of light towards adjacently spaced light sensitive means, support means between said light source and said light sensitive means for supporting said web with a line portion of the web surface perpendicular to and partially intercepting said beam of light to cast a profile shadow of the surface irregularities along the line portion toward said adjacently spaced light sensitive means, said adjacently spaced light sensitive means receiving spaced portions of said profile shadow and generating voltages portional to the respective heights of spaced portions of said profile shadow, means providing relative motion of said profile shadow and said light sensitive means in a direction parallel to said line portion to cast successive portions of said profile on said light sensitive means continuously across said profile, and circuit means for electrically summing continuous difference voltages as successive spaced portion of said profile as viewed by said light sensitive means to obtain a measurement of the surface irregularities in said web.

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