United States Patent [19]

Goto et al.

[11] **3,731,069**

[45] **May 1, 1973**

[54] **APPARATUS FOR DETECTING YARN QUALITY INFORMATION**

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[22] Filed: **Aug. 27, 1971**

[21] Appl. No.: **175,485**

[30] **Foreign Application Priority Data**

Aug. 29, 1970	Japan	45/75757
Nov. 4, 1970	Japan	45/97368
Nov. 4, 1970	Japan	45/97369
Feb. 3, 1971	Japan	46/3908
Feb. 1, 1971	Japan	46/3909

[52] **U.S. Cl.** ....**235/151.3,** 28/64, 73/160, 324/71 R, 340/259

[51] **Int. Cl.** **G06g 7/66**

[58] **Field of Search**....................235/151.1, 151.3; 340/178, 259; 324/61 R, 71 R; 73/159–160; 28/64, 72 R; 250/219 WE, 219 TH; 57/81; 242/36

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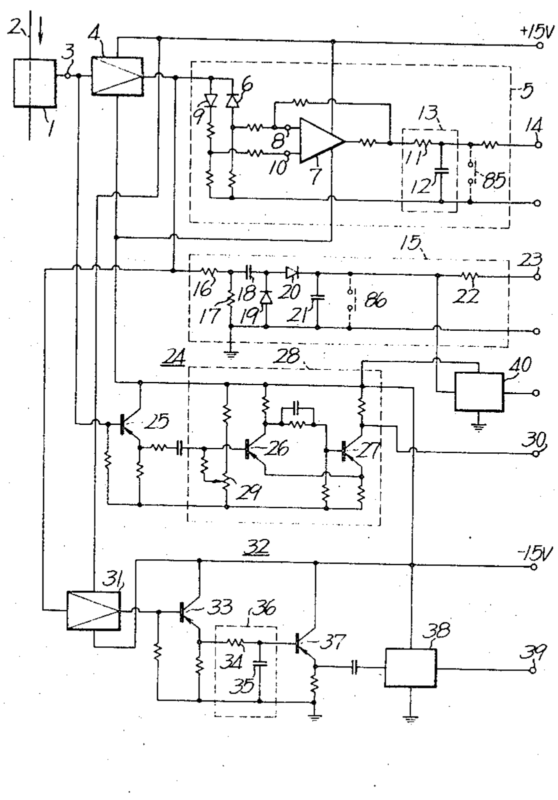
[57] **ABSTRACT**

Yarn evenness or nonuniformity in thickness or mass of filamentary or film-shaped yarns formed of synthetic polymers, natural or regenerated celluloses or the like is detected in the form of electrical deviation signals, which are applied first to an areal average detector circuit to provide an areal average, lengthwise of the yarn, of irregularities, secondly to a peak value detector circuit to provide an average of crest values lengthwise of the yarn of the irregularities, and thirdly to an abnormality detector circuit to detect abnormally thick yarn portions such as fluff or slub which occur isolatedly or to detect filament abnormalities in a multi-filament yarn which also occur isolatedly. These detected outputs are derived from a running yarn or yarns travelling through a yarn production, finishing or false twist process and are adapted to be utilized in an electronic computer for overall evaluation to determine the yarn quality.

18 Claims, 15 Drawing Figures



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5 Sheets-Sheet 1

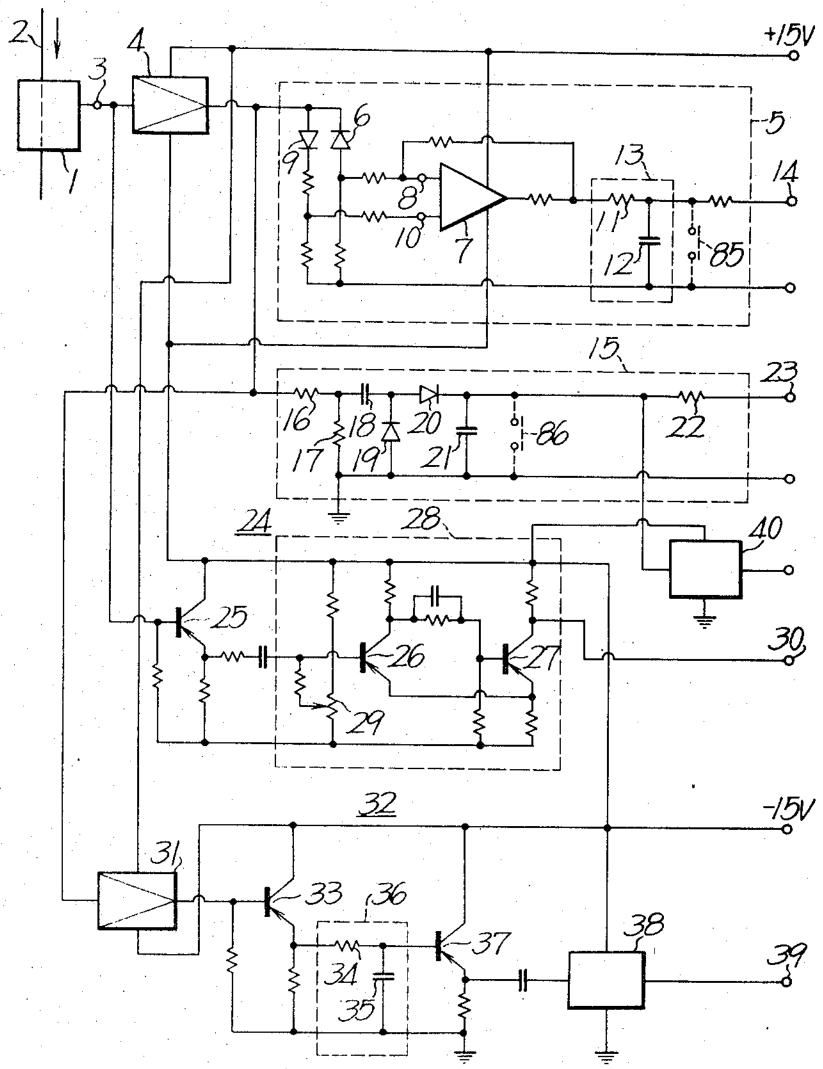

Fig. 1

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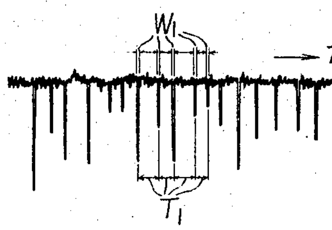

Fig. 2A

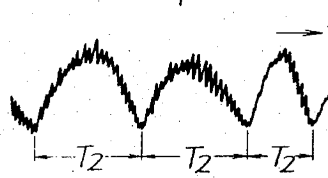

Fig. 2B

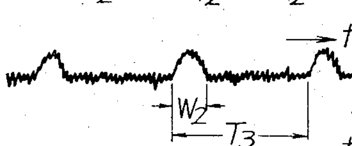

Fig. 2C

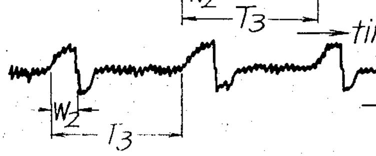

Fig. 2D

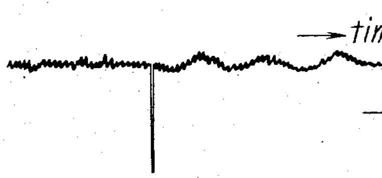

Fig. 2E

Fig. 2F

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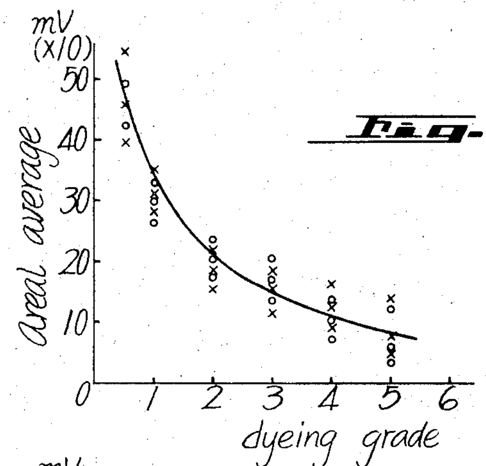

Fig. 3

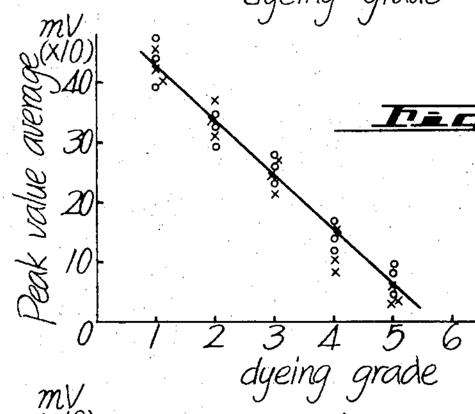

Fig. 4

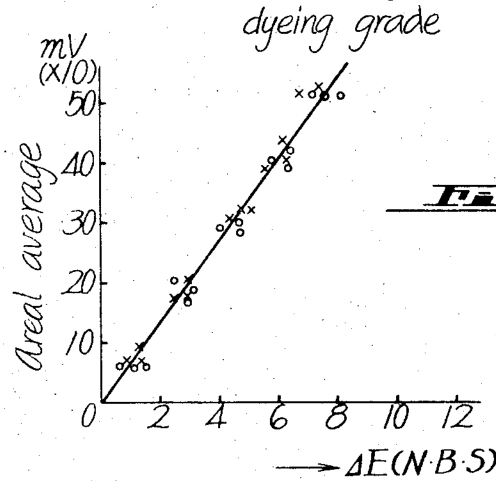

Fig. 5

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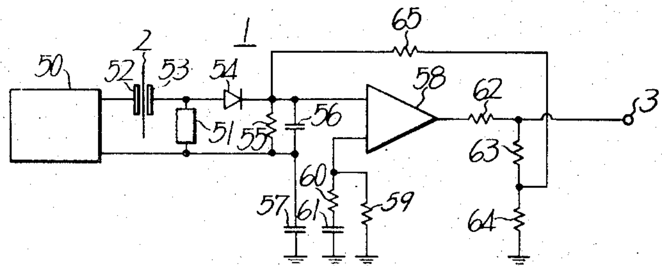

Fig. 6

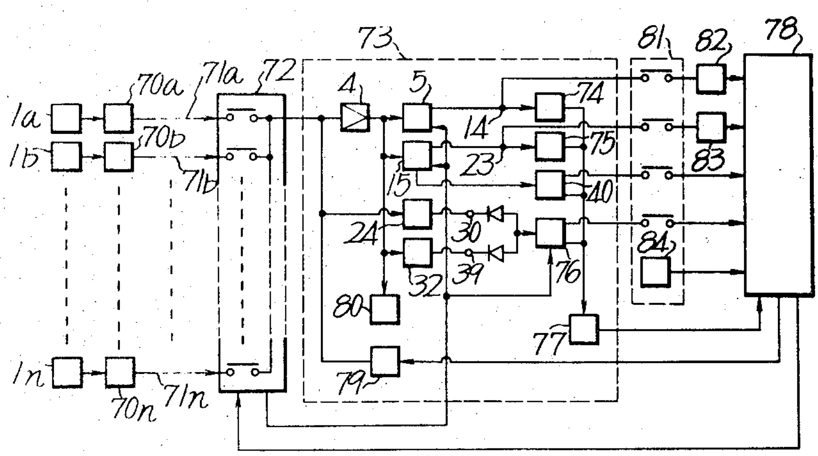

Fig. 7

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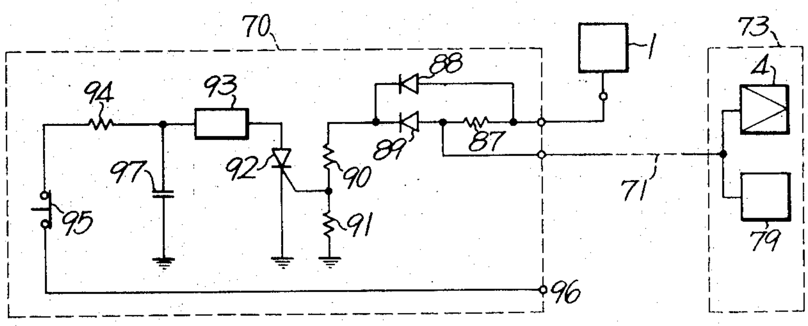

Fig. 8

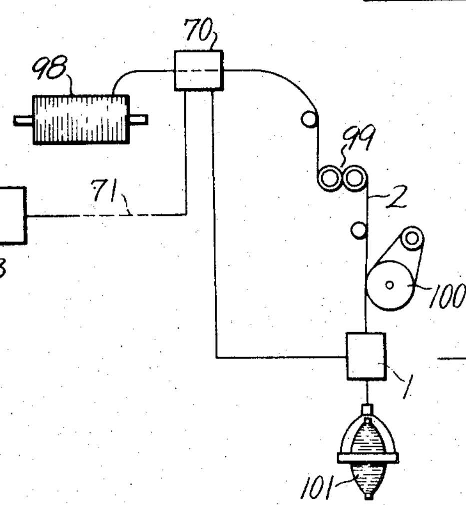

Fig. 9

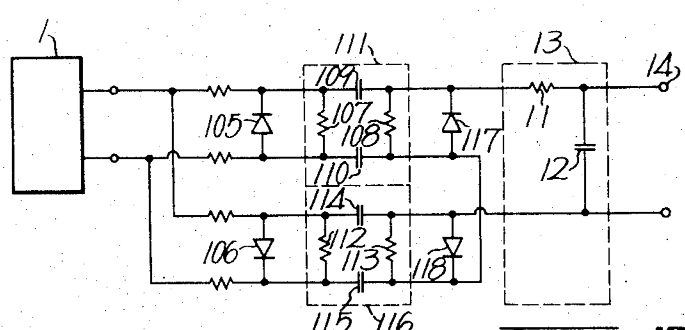

Fig. 10

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APPARATUS FOR DETECTING YARN QUALITY INFORMATION

The invention relates to an apparatus for electrically detecting nonuniformity or irregularities in thickness or mass of filamentary or film-shaped yarns formed of synthetic polymers, natural or regenerated celluloses or the like and for deriving from these electrical deviation signals information determining the quality of yarns.

The prior art practice in determining the quality of yarns involved extracting pirns on which yarns obtained from a number of spindles are wound, and weaving or knitting a cloth with a portion of yarns on the pirns for the purpose of quality control, the cloth being dyed to observe whether or not the dyeing can take place uniformly or includes shading and dyeing streak for final evaluation of the yarns from selected pirns or spindles. The appearance of the pirn was also examined to determine the yarn quality as to large irregularities such as fluffs. Such a prior art procedure for determination of yarn quality is basically a sampling inspection system which cannot provide for an accurate estimate of the overall product, and in addition requires much labor and time inasmuch as the inspection calls for a cloth to be woven or knitted, dyed and visually examined. Moreover, the visual inspection relies on the skill and/or experience of the inspectors, which renders it unavoidable that the evaluation varies from inspector to inspector, thereby resulting in a failure to provide an objective evaluation.

It is known that the most significant factor which determines the yarn quality when a filamentary or film-shaped yarn is produced or processed is nonuniformity information concerning the thickness or mass of the yarn. However, there has been no attempt to derive yarn quality information directly from such nonuniformity information while the latter is being detected in the process of yarn production or processing, without recourse to the above mentioned labor and time consuming inspection procedure. It is apparent that it is convenient to have such nonuniformity information detected in the process of yarn production or processing directly and continuously converted to a yarn quality information in order to enable an on-line production and processing control by allowing immediate actions to be taken in response to such quality information.

Therefore, it is an object of the invention to provide an apparatus for detecting yarn quality information in an accurate and rapid manner.

It is another object of the invention to provide an apparatus for detecting yarn quality information which permits continuous and immediate estimation of yarn quality in an on-line manner, i.e., during yarn production or processing steps.

It is a further object of the invention to provide an apparatus for detecting yarn quality information which is capable of providing an average value of yarn irregularities as well as an indication of detection of isolatedly occurring increased or decreased yarn thickness or cut in the yarn.

It is still another object of the invention to provide an apparatus for detecting yarn quality information having an areal irregularity average detector circuit which provides, even in the presence of a great variation of the magnitude of yarn irregularities and of their occurrence, an electrical signal which properly corresponds to an average of areas of irregularities over the yarn length.

It is a still further object of the invention to provide an apparatus for detecting yarn quality information which includes a peak irregularity average detector circuit capable of faithfully sensing the average of peak values of yarn irregularities over the yarn length.

It is yet another object of the invention to provide an apparatus for detecting yarn quality information which provides for simultaneous detection of quality information of yarns supplied from a plurality of spindles, by using a single common unit.

It is a further object of the invention to provide an apparatus for detecting yarn quality information which detects yarn irregularities of various kinds and collectively puts these information into account to determine the yarn quality.

It is a still further object of the invention to provide an apparatus for detecting yarn quality information which includes means to cut a defective yarn upon over-all determination of yarn quality.

It is another object of the invention to provide an apparatus for detecting yarn quality information which includes yarn cutting means capable of cutting a yarn from a particular spindle without adverse effect upon other spindles, that is, without cutting yarns from these other spindles.

It is still another object of the invention to provide an apparatus for detecting yarn quality information which includes yarn cutting means adapted to be controlled by a yarn cutting instruction derived from yarn nonuniformity information and controlled also directly by an electrical output representing yarn irregularities of an increased magnitude as a result of cutting of a yarn.

It is yet another object of the invention to provide an apparatus for detecting yarn quality information, including compactly constructed deviation signal emitting units which can be located in respective association with a number of yarns running parallel and relatively closely spaced to each other in a yarn production or processing step and which can provide a continuous movement of yarn irregularities with as high an accuracy as 1 to 2 percent.

According to the invention, an electrical deviation signal is continuously derived from a yarn running through a yarn production or processing step in a manner to correspond with irregularities in thickness or mass of that yarn. This deviation signal is averaged over its area to provide an areal average of yarn evenness over the yarn length. The deviation signal is a also passed to a peak value detection to provide an average of peak values of yarn evenness over the length of the yarn. Furthermore abnormally high levels in the deviation signal which occur isolatedly are detected, thereby providing detection of fluff or slub of a yarn. Abnormally low levels in the deviation signal, also occurring isolatedly, are detected from the low frequency component of the deviation signal, whereby filament abnormalities in a multi-filament yarn are detected. Substantial reduction in the rectified output of the deviation signal is also detected to give an indication of a cut in the yarn.

The areal average, peak value average and isolatedly detected abnormal levels of the deviation signal are submitted to overall evaluation to determine the yarn quality. Areal average detector, peak value detector and isolatedly occurring abnormal level detector circuits are shared in a time division scheme by deviation signals derived from yarns associated with a plurality of spindles. As a result of above mentioned over-all evaluation, the apparatus may issue a cutting instruction for cutting a defective yarn at a given position and interrupting the production or processing of that defective yarn. The cutting means responsive to such a cutting instruction is supplied with a deviation signal directly so as to be controlled additionally in response to a large variation in the deviation signal that occurs upon cutting of a yarn.

A deviation signal emitting unit provides an electrostatic conversion of a yarn evenness of a running yarn to be monitored into an electrical high frequency signal, which is in turn rectified in a circuit that is relatively free from low frequency noises. The rectified output is amplified in a negative feedback amplifier having a low output impedance and capable of providing cut-off of frequencies below a given value, the resulting output from the amplifier providing a deviation signal. The deviation signal is transmitted to a relatively remote position where it is utilized for detection of averages of areal and peak values and of the like.

Above and other objects, features and advantages of the invention will become more apparent from the following description thereof with reference to the drawings, in which:

FIG. 1 is a system block diagram, partially in circuit diagram, of an embodiment of the apparatus for detecting yarn quality information according to the invention.

FIGS. 2A to 2F graphically illustrate wave-form models of typical examples of a deviation signal,

FIG. 3 shows graphically the relation between the areal average of yarn evenness and dyeing grade,

FIG. 4 shows graphically the relation between the peak value average of yarn evenness and dyeing grade,

FIG. 5 shows graphically the relation between the areal average of yarn evenness and color difference,

FIG. 6 is a circuit diagram of a specific example of a deviation signal emitting device,

FIG. 7 is a system block diagram of another embodiment of the apparatus for detecting yarn quality information according to the invention,

FIG. 8 is a circuit diagram of a specific example of a yarn cutter,

FIG. 9 is a schematic view illustrating the disposition of a yarn cutter in a yarn-stretching process, and

FIG. 10 is a circuit diagram of another example of an areal average detector circuit.

Before proceeding with the description of specific examples of the invention, it is to be noted that corresponding parts are designated by like reference characters throughout the drawings.

Referring to FIG. 1, reference numeral 1 denotes a deviation signal emitting device through which a yarn 2 to be monitored runs and which provides an electrical signal indicative of the evenness of the thickness or mass of the running yarn 2 at an output terminal 3. The electrical signal indicative of yarn evenness or deviation signal as termed herein is amplified in an amplifier 4 before being supplied to an areal average detector circuit 5. The amplifier 4 may comprise an operational amplifier, for example, which produces a null d.c. output when no input is present. Preferably, the areal average detector circuit 5 should average out the deviation signal of opposite polarities regardless of the polarities. As an example, FIG. 1 shows that the output of the amplifier 4 having one polarity is coupled through a diode 6 to one of the input terminals, 8, of a differential amplifier with a negative feed back, or an operational amplifier 7, while the output from the amplifier 4 having the other polarity is coupled through a diode 9, poled oppositely to the diode 8, to the other input terminal 10 of the operational amplifier 7. In this manner, an amplified deviation signal of one polarity is applied to the input terminal 8 and an amplified deviation signal of opposite polarity is applied to the input terminal 10. One of these inputs is reversed in polarity while the other remains unchanged in polarity, so that the both signals are rendered to have like polarity for addition. The added output is averaged by a time constant circuit 13 comprising a resistor 11 and a capacitor 12. The circuit 13 is chosen to have a time constant which is greater than the pulse width of long duration pulses contained in the deviation signal. To give an example, the resistor 11 may have a resistance on the order of 1 megohm and the capacitor 12 may have a capacitance of the order of 2 microfarads for a deviation signal derived from a monitored yarn 2 of synthetic fiber travelling through a stretching process with a running speed of 500 to 4,000 meters per minute. However, it will be appreciated that these figures can vary with the running speed of the yarn 2 monitored. An areal average output derived from the deviation signal is obtained at the output terminal 14 of the time constant circuit 13.

The deviation signal from the amplifier 4 is also supplied to a peak value average detector circuit 15 which preferably comprises a voltage doubler as shown in FIG. 1. The detector circuit 15 shown includes a series connection of resistors 16 and 17 having one end connected to the output of the amplifier 4 and its other end grounded. The junction between resistors 16 and 17 is connected through a capacitor 18 and a diode 19 to the ground, with the junction between the capacitor 18 and diode 19 connected through another diode 20 and capacitor 21 to the ground. The diodes 19 and 20 are poled so that one diode has its anode connected with the cathode of the other. The junction between the diode 20 and capacitor 21 connected to an output terminal 23 through a resistor 22 having a high resistance such as 10 megohms. This arrangement provides rectified peak values of the deviation signal at the output terminal 23.

The deviation signal appearing at the input of the amplifier 4 is supplied to a circuit 24 which is operable to detect abnormally high levels which occur isolatedly in the deviation signal. In the example shown, the deviation signal at the input of the amplifier 4 is supplied to the base of a transistor 25 connected in an emitter follower configuration. The resulting deviation signal obtained as a low impedance output at its emitter is supplied to a Schmidt trigger circuit 28 which comprises a pair of transistors 26 and 27. Though a deviation signal involves a minor fluctuation on the order of about 1 to 2 percent as referenced to the thickness of a yarn because of electrical noises and other noises caused by mechanical vibrations, the Schmidt trigger circuit **28** is arranged such that it is triggered or switched to the opposite state in response to an input level which is by more than 10 percent, for example, in excess of the average level of the normal deviation signal. Alternatively, in terms of yarn thickness, the Schmidt trigger circuit **28** is designed to operate when the deviation signal exceeds the average level by an amount which corresponds to **10** deniers. The operative level can be established, for example, by adjustment of a variable resistor **29** connected in the base bias circuit of the transistor **26**. An abnormal high level detection output is obtained at a terminal **30**. It is noted that the deviation signal for the circuit **24** is supplied from the terminal **3** directly in view of the high levels that are to be detected by this circuit.

The output from the amplifier **4** is additionally applied to an amplifier **31** before being supplied to a circuit **32** which is operable to detect abnormally low levels in the deviation signal that occur isolatedly. To provide such a low level detection, the output from the amplifier **31** is passed through a transistor **33**, connected in an emitter follow configuration, to a low pass filter **36** of integrator type constituted by a resistor **34** and a capacitor **35**, in order to prevent a minor fluctuation of the deviation signal from operating the circuit. The filter output is supplied through an emitter follower transistor **37** to a Schmidt trigger circuit **38**. The polarity of the deviation signal is reversed in either the amplifier **4** or **31**, whereby a detection output is obtained at the output terminal **39** of the Schmidt trigger circuit **38** when the level of the deviation signal has fallen below the normal level, e.g., by 10 percent or when the thickness of the yarn has decreased by an amount corresponding to 1.5 deniers or greater.

The rectified output of the deviation signal, or in the example shown, the output obtained at the junction between the diode **20** and capacitor **21** of the peak value detector circuit **15**, is supplied to a yarn cut detector circuit **40** which comprises a Schmidt trigger circuit.

The deviation signal from the emitting device **1** assumes a number of waveforms depending upon the kind of yarn evenness. FIG. **2A** shows a relatively close succession of pulses, which corresponds, for example, to the occurrence of irregularity length or pulse width, W_1, on the order of 5 cm at an interval, T_1, on the order of 10 to 30 cm. FIG. **2B** shows a wavy variation of relatively large amplitude, the period T_2 being on the order of 1.5 to 2.0 meters. FIG. **2C** illustrates the occurrence of yarn evenness of relatively large amplitude at a long interval. The length of irregularity W_2 is about 1.0 to 1.2 meters with interval T_3 on the order of 8 meters. In this instance, thick and thin portions may occur in succession as shown in FIG. **2D**. In addition, isolatedly occurring thick or thin irregularity may occur in FIG. **2E** or **2F**, respectively, such irregularity having a length from 1 to 20 cm or greater.

When there is an irregularity such as shown in FIGS. **2A** and **2B**, the areal average detector circuit **5** of FIG. **1** will have an output which provides an indication of the average value of irregularities as appearing along the length of a yarn **2** to be monitored. The peak value average detector circuit **15** detects irregularities which cause deviation signals depicted in FIGS. **2C** and **2D** and provides the average of peak values over the length of the yarn **2** monitored. When a deviation signal as shown in FIG. **2E** is present, the abnormal high level detector circuit **24** provides an output. Such an output indicates the presence of isolatedly occurring thick yarn portions such as fluffs or slubs. For a deviation signal as shown in FIG. **2F**, the abnormal low level detector circuit **32** provides an output at its output terminal **39**, which indicates the presence of isolatedly occurring yarn irregularity of abnormally reduced thickness extending over an extent of several centimeters to several meters, which may be found with a multi-filament yarn as monofilament abnormality. When the yarn **2** monitored is cut off, the output from the peak value detector circuit **15** will become null, thereby actuating the yarn cut detector circuit **40** to provide a corresponding indication.

In this manner, by the use of the apparatus for detecting yarn quality information according to the invention, it is possible to detect the magnitude and discern the kind of irregularities for determining the yarn quality. It is found that the quality information obtained with the apparatus of the invention exhibits good coincidence with the determination of yarn quality that is obtained by the prior art method of observing dyeing results. This will be described below with reference to experimental examples. A yarn **2** being monitored was used to knit a number of cloths, which were subsequently dyed. Six dyeing grades of dyed cloths were then determined by visual comparison of these samples with a standard specimen. Dyeing grade 5 represents complete absence of shading and dyeing streak, grade 4 includes a slight amount of shading but without dyeing streak, grade 3 exhibits the presence of a slight amount of both shading and dyeing streak, grade 2 involves a slight amount of shading together with an appreciable dyeing streak, grade 1 includes a considerable amount of shading and dyeing streak, and grade 0 represents the presence of a highly intense shading and dyeing streak. These dyeing grades are plotted on FIG. **3** as abscissa against the areal average or the output of the detector circuit **5** obtained from deviation signals of corresponding yarns as taken prior to their dyeing, such average values being taken on the ordinate. The small circles on the graph correspond to yarns which comprise **24** filaments and are 50 denier thick, while crosses on the graph correspond to yarns comprising 36 filaments and 75 denier thick. It is seen that the lower the areal average output, the better the dyeing grade is rated. It is noted that there is a well defined correspondence.

The output from the peak value average detector circuit **15** for the same yarns are plotted on FIG. **4** against the dyeing grade as abscissa. Again the dyeing grade is improved with reduction in the output from the circuit **15**, and the plotted values establish a well defined correlation. Then color variation of dyed cloths was determined, not by visual inspection, but by instrument, and a difference ΔE from a standard was derived. In FIG. **5**, the difference ΔE is plotted in NBS units on the ordinate against the areal average output obtained for the deviation signals of corresponding monitored yarns. The correlation is again well defined.

An increase of the deviation signal as shown in FIGS. **2A** and **2B** or the output from the areal average detector circuit **5** results in the appearance or increase of shading effect in the corresponding dyed cloth or the so-called "deep dyed defect." It is found that an increase of the deviation signal of the type shown in FIGS. **2C** and **2D** or the output from the peak value average detector circuit **15** results in a dyeing streak in the corresponding dyed cloth.

Thus, with the apparatus for detecting yarn quality information of the invention, a deviation signal can be derived from a running yarn monitored during the yarn production or processing step to yield areal average, peak valve average and the like, all of which can be utilized to provide an objective, accurate yarn quality information directly that is comparable to that obtained by the prior art procedure, while avoiding the troublesome weaving or knitting of yarn into a cloth, dyeing the cloth and evaluating the dyeing result involved with the latter. Hence, yarn evenness information contained in a deviation signal that is derived during a yarn production or processing step can be supplied to an electronic computer, for example, to determine the grade of yarn quality automatically or to control a certain part of the instrumentation associated with that step thereby enabling an on-line control to assure an improved and uniform quality of the yarn. Where such evaluation of yarn quality or process control is effected, it is preferred that a common apparatus be shared by a number of yarns running parallel from a number of spindles. To accomplish this, it is essential that deviation signals derived from the respective yarns be collected at a single location without being influenced by noises.

A deviation signal emitting device **1** suitable for use at this end is shown in FIG. **6**. The device **1** includes a high frequency oscillator **50** which operates in a frequency range from 10 to 50 MHz. The oscillator **50** comprises a single transistor as an active element which is provided with temperature compensation, and the allowable collector loss of the transistor is chosen three to five times the actual loss or greater, with the provision of a stabilized d.c. power source, thereby assuring a high stability and low noise oscillator.

The high frequency voltage from the oscillator **50** is applied across a pair of oppositely located electrode plates **52** and **53** through an impedance element **51**. A yarn **2** to be monitored is threaded between the electrode plates **52** and **53**. It will be appreciated that any irregularity of yarn **2** will cause a change in the capacitance across the electrode plates **52** and **53**, which change will appear as a variation of the high frequency voltage across the impedance element **51**.

The high frequency voltage thus obtained across the impedance element **51** is rectified by a rectifier **54** having little low frequency noises, which may be a silicon epitaxial diode of planar type designed for high frequency applications. The rectified output is applied across a resistor **55** and a capacitor **56** connected in parallel. It will be understood that any variation or irregularity of the yarn **2** monitored will appear as a minute voltage change across the resistor **55**. For the stretching step of synthetic fibers, it is found as a result of extensive experimental work conducted over years that yarn evenness can be completely known from measurement of irregularities extending from 1 mm to 100 m lengthwise of the yarn. For this reason, when the yarn **2** monitored runs at a speed of 1,000 meters per minute, for example, the detection of signals having frequencies from about 0.1 Hz to 10 KHz is sufficient.

Consequently, only irregularity signals within such a necessary frequency band are amplified in a stable manner. At this end, the resistor **55** has its one end connected to the ground through a capacitor **57**, and its other end connected with the output and the inverse polarity input terminal of an operational amplifier **58** that is formed by a semiconductor integrated circuit and designed for constant current operation. The other input terminal to which an input of the same polarity as the output of the amplifier **58** is applied is connected to the ground by a parallel combination of a resistor **59** and a series circuit including a resistor **60** and a capacitor **61**. The output terminal of the amplifier **58** is connected to the ground through a resistor chain including resistors **62**, **63** and **64**, the junction between the resistors **63** and **64** being connected through a negative feedback resistor **65** to the inverse polarity input terminal to provide a high degree of negative feedback.

The resistors **55** and **60** have a same resistance R, the resistors **59** and **65** have also a same resistance, and the capacitors **57** and **61** have a same capacitance C. So that the lower cut-off frequency f required for amplification can be as low as a fraction of 1 hertz, these parameters are chosen to satisfy the relation:

$$1/(2RC) = f$$

In this manner, a highly stabilized high output voltage of high accuracy can be obtained at the terminal **3** connected to the junction between the resistors **62** and **63**. A low output impedance of the amplifier **58** makes it immune from the influences of external noises and makes a long distance transmission of a deviation signal possible.

In order to allow the yarn **2** being monitored to pass the space between the electrode plates **52** and **53** freely, the length of the gap therebetween should be chosen large in relation to the yarn thickness, e.g., five to more than 10 times the latter. As a result, the variation in capacitance across the electrode plates **52** and **53** in response to the irregularity of yarn passing therebetween will be very small. As an example, with a yarn **2** having thickness of 50 deniers passing between the electrode plates **52** and **53**, the rate of change of the d.c. voltage developed across the resistor **55** is about 10^{-5}, and hence, to permit a measurement with an accuracy of 1 percent, the measurement of above voltage change must be able to be effected with an accuracy of 10^{-7}. Yarn evenness can thus be measured with an accuracy of 1 to 2 percent for yarns having thickness of 20 to 300 deniers or greater, and the arrangement shown in FIG. **6** develops a deviation signal of such a high accuracy. When this deviation signal emitting device is constructed as a semiconductor integrated circuit, the device can be implemented with such a small overall size of $20 \times 60 \times 50$ mm^3, for example, so that a separate device can be located in association with each of a number of yarns at the position where they run parallel and relatively closely spaced to each other. The above arrangement permits the stable transmission of deviation signals from such position to information detection unit located at a distance of **10** meters or greater therefrom.

Referring to FIG. 7, an embodiment of the invention in which a common apparatus is used to derive yarn quality information from a plurality of yarns being monitored. A plurality of deviation signal emitting devices 1*a*, 1*b*, – – – 1*n* are located at the position where yarns from a number of spindles run parallel to each other. These devices 1*a*, 1*b* – – – 1*n* are connected to a plurality of yarn cutters 70*a*, 70*b* – – – 70*n*, respectively, which will be described more fully later, and thence to a scanning circuit 72 through a plurality of transmission lines 71*a*, 71*b* – – – 71*n*, respectively. The scanning circuit 72 multiplexes deviation signals from the devices 1*a*, 1*b* – – – 1*n* in sequence and feeds them to a primary information detection unit 73 which includes the amplifier 4, areal average detector circuit 5, peak value average detector circuit 15, abnormal high level detector circuit 24, abnormal low level detector circuit 32 and yarn cut detector circuit 40 described previously in connection with FIG. 1. In addition, the primary information detection unit 73 includes an areal average abnormality detector circuit 74 which may comprise a Schmidt trigger circuit, for example, so as to provide a detection output when the output of the areal average detector circuit 5 exceeds a given value; peak value average abnormality detector circuit 75 which operates in response to an output from the peak value average detector circuit 15 exceeding a given value and which may similarly comprise a Schmidt trigger circuit; an abnormal level detector circuit 76 which may comprise a flip-flop circuit to store any output from either the abnormal high level detector circuit 24 or abnormal low level detector circuit 32; a computer access circuit 77 responsive to an output from the yarn cut detector circuit 40, abnormality detector circuits 74 and 75 and abnormal level detector circuit 76; a circuit 79 responsive to a yarn cutting instruction issued by an electronic computer 78 for developing a yarn cutting signal; and a storage 80 for storing deviation signals from the amplifier 4 as required.

The outputs of the areal average detector circuit 5, peak value average detector circuit 15, yarn cut detector circuit 40 and abnormal level detector circuit 76 are supplied to corresponding input circuits of the electronic computer 78 through a group of switches 81. In this instance, the outputs of both the areal average detector circuit 5 and the peak value average detector circuit 15 are connected with analogue-digital conversion circuits 82 and 83, respectively, to supply their output in digital form to the computer 78.

In operation, assume now that one of the devices 1*a*, 1*b* – – – 1*n* which may be the device 1*a* is connected by the scanning circuit 72 to the primary information detection unit 73 for conveying the deviation signal from the device 1*a* thereto for a selected time interval which may be about 10 seconds, for example, in order to allow detection of various kinds of irregularities. When no irregularity has been detected, that is, when there is no output from any of the detector circuits 40, 74, 75 and 76, the scanning circuit 72 is automatically controlled to advance for connection of the next device 1*b* with the primary information detection circuit 73.

On the other hand, when there is an output from any one of the detector circuits 40, 74, 75 and 76, the access circuit 77 is operated to drive the computer 78, and a signal therefrom is applied to a switch control circuit 84 to turn on the switches of the group 81. Thereupon, outputs from the circuits 5, 15, 40 and 76 are respectively supplied to the computer 78 for information processing therein in a given manner. Subsequent to such supply of the outputs, the scanning circuit 72 is controlled by an instruction from the computer 78 to connect the next device 1*b* with the primary information detection circuit 73. In this manner, the devices 1*a*, 1*b* – – – 1*n* are connected in turn to the primary information detection unit 73 with a cyclic period of 13 minutes, for example, thereby achieving substantially continuous storage of primary information in the computer 78.

The signal to switch over the scanning circuit 72 also closes normally open switches 85 and 86 connected in parallel with capacitors 12 and 21, respectively, shown in FIG. 1, thereby clearing old information stored by the areal average detector circuit 5 and the peak value average detector circuit 15. Similarly, the abnormal level detector circuit 76 is reset each time the scanning circuit 72 is switched over.

The electronic computer 78 is coordinated with the deviation signal emitting devices 1*a*, 1*b* – – – 1*n* so that the number of occurrences and the magnitudes of irregularities can be stored in digital form for each kind of detected irregularities in order to rank the associated yarns according to the dyeing grade described with reference to FIGS. 3 to 5, and if desired, irregularities of each kind can be accorded differential weights to allow summing up the weighted irregularities for every deviation signal emitting device or corresponding yarn to provide an over-all estimate thereof for determining the quality grade. Based on such evaluation, it is possible to exercise a proper control over selected part of the production or processing step for each yarn in order to ensure uniform and excellent yarn quality. If required, a production or processing step for a particular yarn that has been determined as defective can be interrupted by feeding a yarn cutting instruction issued by the computer 78 to a circuit 79 which produces a yarn cutting signal to be passed through the scanning circuit 72 to one of the yarn cutters 70*a*, 70*b* – – – 70*n* that is then in electrical connection with the scanning circuit 72 for operating that particular yarn cutter to cut the associated yarn.

For effecting such cutting, the supply of the cutting signal may be through a separate route other than the path of supplying a deviation signal to the scanning circuit 72, but the both signals can be conveyed through the same transmission path. Where the common transmission line is used, the yarn cutter may be utilized not only to cut the yarn in response to an instruction from the computer, but also to cut a yarn, once cut spontaneously for some reason, at a given position and to retain it in order to prevent it causing additional cutting of other yarns by its cut end entangling with guide rollers or adjacent running yarns.

FIG. 8 shows an example of such an arrangement. The yarn cutter includes a resistor 87 of relatively small resistance through which a deviation signal from a device 1 passes to the primary information detection unit 73 via transmission path 71. Across the resistor 87 are connected a pair of oppositely poled diodes 88 and 89 in series, and the junction between the diodes 88 and 89 is connected to the ground through resistors 90 and 91 connected in series. The junction between the resistors **90** and **91** is connected with the gate electrode of a thyristor **92**. The thyristor **92** has its cathode connected to the ground and its anode is connected through the drive coil **93** of a yarn cutter, a current limiting resistor **94** and a switch **95** in series with a supply terminal **96**. The junction between the drive coil **93** and resistor **94** is connected to the ground through a capacitor **97**. The normal level of a deviation signal is chosen insufficient to cause conduction through the diodes **88** and **89**.

FIG. **9** schematically illustrates a stretching step wherein it is noted that a spun yarn bobbin **98** supplies a yarn **2** being monitored to a first and second stretching rollers **99** and **100** to be wound on a take-up pirn **101**. The yarn cutter **70** is positioned along the path of yarn from the bobbin **98** immediately adjacent the bobbin **98**. The deviation signal emitting device **1** is located immediately before the take-up pirn **101**.

In the arrangement described above, the deviation signal from the device **1** is normally passed through the yarn cutter **70** and the transmission path **71** to the primary information detection unit **73**. Based on the detected information from the unit **73**, the computer **78** may issue a yarn cutting instruction, and in response thereto, the circuit **79** may supply the transmission line **71** with a yarn cutting signal. The yarn cutting signal is chosen to have an appreciably high level of several volts, for example, as contrasted to several hundred millivolts for the level of the deviation signal, so that when a yarn cutting signal is present, the diode **89** conducts to provide an actuating signal to the gate of the thyristor **92**, which therefore conducts to energize the drive coil **93** for cutting the yarn **2** being monitored with the cutter. Since the thyristor, once conducts, maintains its conductive state, such state of the thyristor may be utilized to retain the cut end of the yarn, as left on the supply side, with the cutter itself or by separate means operated by the thyristor **92**. However, such retaining arrangement is not essential, since the disposition of the yarn cutter **70** or its electromagnetic blade means immediately adjacent the bobbin prevents further withdrawal of the yarn so cut. The resistance of the resistor **87** is chosen less the d.c. impedance of the negative feedback amplifier **58** within the device **1**, as viewed from the output side thereof, in order to assure positive cutting operation without the cutting signal being fed to the device **1**.

In the above arrangement, when the yarn **2** being monitored happens to be cut intermediate the stretching process, there will be no longer a yarn **2** between the electrode plates **52** and **53** of the device **1** so that the deviation signal will rapidly increase from a level of several hundred millivolts to a level of several volts in view of the high degree of negative feedback applied to the amplifier **58** as shown in FIG. **6**. The resulting higher level signal is applied to the yarn cutter **70** to cause conduction of the diode **88** and hence of the thyristor **92**, whereby the yarn **2** being monitored is cut at its supply end in the similar manner as mentioned above. Consequently, the possibility that a yarn cut intermediate its stretching process becomes entangled with rollers and other yarns to cause additional cutting of the latter is eliminated.

The areal average detector circuit **5** and the peak value average detector circuit **15** can be constructed as a full-wave rectifier for the deviation signal with time constant circuits of relatively small and large time constants being used for the former and the latter, respectively. Alternatively, the areal average detector circuit **5** may be constructed without using an amplifier, as shown in FIG. **10**. Referring to this figure, diodes **105** and **106** serve to supply a deviation signal of one polarity to a time constant circuit **111** which comprises resistors **107** and **108** and capacitors **109** and **110**, and to supply a deviation signal of the other polarity to a time constant circuit **116** which comprises resistors **112** and **113** and capacitors **114** and **115**. The signals obtained across the resistors **108** and **113**, respectively, are added together with the same polarity and averaged out by the time constant circuit **13**. The charging time constant determined by the resistor **108** and capacitors **109** and **110** as well as the charging time constant determined by the resistor **113** and capacitors **114** and **115** are chosen several times greater than the pulse widths contained in the deviation signal by using capacitors of large capacitance. The discharge time constant determined by a diode **117** connected in parallel with the resistor **108**, resistor **107** and capacitors **109** and **110** as well as the discharge time constant determined by a diode **118** connected in parallel with the resistor **113**, resistor **112** and capacitors **114** and **115** are chosen less than the time interval between adjacent occurring pulses contained in the deviation signal. With such an arrangement, positive pulses in the deviation signal will appear faithfully across the resistor **108**, and upon termination of such pulses, the charge on the capacitors **109** and **110** will be discharged rapidly. In a similar manner, negative pulses in the deviation signal will appear faithfully across the resistor **113**, and upon termination of such pulses, the charge on the capacitors **114** and **115** will be discharged rapidly. The pulses which appear across the resistors **108** and **113** are added together with the same polarity and averaged out in the time constant circuit **13** to provide an output which properly corresponds to the average of area of yarn irregularities over the length of the yarn. Both arrangements of the areal average detector circuit shown in FIGS. **1** and **10** provide a faithful detection of the average of area of irregularities even when the magnitude and the number of occurrence of irregularities are subject to a great variation.

When the peak value detector circuit of voltage doubler type shown in FIG. **1** is used as the peak value average detector circuit **15**, there will be obtained an output which, for yarn irregularities causing a succession of alternately positive and negative pulses as depicted in FIG. **2D**, namely, for a yarn having alternately and closely located portions of increased and decreased thickness, represents the sum of the respective amplitudes of the positive and negative pulses for an improved indication of yarn evenness.

In addition to the deviation signal emitting device **1** shown in FIG. **6**, other conventional devices including a device having a pair of electrode plates connected in one of branches of an a.c. bridge and disposed for passage of a yarn being monitored therebetween may be used. The yarn cut detector circuit **40** may be connected with the areal average detector circuit **5**, but its connection with the peak value average detector circuit **15** assures an improved detection free from malfunction, since the circuit **15** detect noises generated during the running of the yarn with an increased sensitivity and hence an interruption of noises is positively sensed by this circuit as indicative of a cut in the yarn. While in the above description, the outputs from detector circuits **24** and **32** which detect the presence of isolatedly occurring abnormally high and low levels, respectively, are stored in the abnormal level detector circuit **76** common to both, they may be stored separately. Also the disclosure illustrated a single detector circuit **24** to detect abnormally high levels, a plurality of such circuit may be provided. For example, by providing two of such circuits, one may be set to provide an output in response to an increase of the deviation signal above the average level by an amount corresponding to **10** deniers, for example, for detecting the presence of significant fluffs for utilizing such information for the purpose of quality evaluation and interruption control of the yarn production or processing step, while the other may be set to provide an output at a level which is by an amount of 3 to 4 deniers higher than the average level of the deviation signal, thus detecting smaller fluffs to find failure of yarn contacting members such as guide rollers or guide plates for their replacement. This allows an efficient utilization of such yarn contacting members which heretofore had to be replaced periodically.

While the prior art practice of determining yarn quality required extracting samples of a yarn, weaving or knitting them into cloths, dyeing the cloths and visually inspecting the dyed cloths for ranking the dyeing grade, the above described apparatus for detecting yarn quality information of the invention eliminates the need for such troublesome steps by deriving deviation signals from running yarns and processing the signals to produce various kinds of yarn evenness information which are totalized to predicate the yarn quality accurately. This permits immediate evaluation of yarn quality during yarn production or processing step, thereby enabling yarns of uniform and excellent quality to be obtained and labor to be saved.

It should be understood that the apparatus according to the invention can be applied in industry for determination of individual yarn qualities such as thickness or mass in various steps including both melt spinning and wet spinning, stretching and false twisting steps as well as in any other manufacturing steps for filamentary or film-shaped products.

While the invention has been described with reference to particular embodiments thereof, it should be understood that various modifications and changes are possible to those skilled in the art without departing from the spirit and scope of the invention. Therefore, it is intended that the appended claims cover all such modifications and changes as fall within the scope of the invention.

Having described the invention, what is claimed is:

1. Apparatus for detecting yarn quality information comprising a device for producing a deviation signal which varies in accordance with the irregularities in thickness or mass of a length of yarn being monitored, an areal average detector circuit responsive to an areal average of the deviation signal to produce an areal average signal representative of the average value of the irregularities occurring along the length of yarn, and a peak value average detector circuit responsive to an average of peak values of the deviation signal to produce a peak average signal representative of the average of peak values of the irregularities occurring along the length of yarn, said areal average and peak average signals being indicative of the quality of the yarn.

2. Apparatus according to claim 1, further including a circuit for rectifying the deviation signal, and a yarn cut detector circuit for detecting the reduction of the rectified output below a given level.

3. Apparatus according to claim 1, in which the areal average detector circuit comprises a circuit for detecting one polarity of the deviation signal, a time constant circuit constituted by a capacitor and a resistor to which said detected signal of said one polarity is supplied, the time constant circuit having a charging time constant which is greater than pulse widths of the deviation signal and having a discharge time constant which is chosen less than time intervals between adjacent occurring pulses, and a circuit for averaging out the signal developed across said resistor of the time constant circuit.

4. Apparatus according to claim 1, in which the areal average detector circuit comprises a first detector circuit for detecting one polarity of the deviation signal, a second detector circuit for detecting the other polarity of the deviation signal, and a circuit for adding the outputs from the first and second detector circuits together with a same polarity and averaging out the result.

5. Apparatus according to claim 1, in which the peak average detector circuit comprises a voltage doubler rectifier of the type in which a peak value is detected.

6. Apparatus according to claim 1, in which the deviation signal producing device comprises transducer means for varying the voltage of a high frequency electrical signal in a capacitive transducing fashion in accordance with irregularities in thickness or mass of the yarn, a rectifier circuit for rectifying the converted high frequency electrical signal, said rectifier circuit having a noise response which is reduced at relatively low frequencies, and an amplifier with negative feedback to which the rectified output is supplied and having a frequency response to block frequencies less than that corresponding to the length of the longest extending irregularity to be monitored.

7. Apparatus for detecting yarn quality information comprising means provided separately for a plurality of running yarns to be measured for producing a deviation signal which varies in accordance with irregularities in thickness or mass of each yarn being measured, scan means for deriving the deviation signals successively, an areal average detector circuit which is supplied with the output of the scan means, a peak value average circuit for producing an average of peak values of yarn evenness, and means for collectively evaluating the outputs of the areal average detector circuit and the peak value average circuit for each yarn to derive information concerning the quality and grade of each yarn being measured.

8. Apparatus according to claim 7, further comprising a circuit supplied with the output of the scan means

for detecting isolatedly occurring abnormal levels of the deviation signal, the output from the last mentioned circuit being also fed to the evaluating means.

9. Apparatus according to claim **7**, further comprising a filter circuit supplied with the output of the scan means for detecting low frequency components thereof, and an abnormally low level detector circuit for detecting the low frequency components below a given level, the output of the last mentioned detector circuit being also fed to the evaluating means.

10. Apparatus according to claim **7**, further comprising means for issuing a yarn cutting instruction for a yarn being measured which is determined to be of defective quality by the evaluating means, a circuit for producing a yarn cutting signal in response to the yarn cutting instruction, and means associated with each of the yarns being measured to cut a running yarn at a given location thereof in response to the yarn cutting signal.

11. Apparatus according to claim **10**, in which the yarn cutting means is interposed between the deviation signal detecting means and the scan means, the arrangement being such that a signal of high level is produced upon disappearance of the deviation signal from the deviation signal detecting means, said signal of high level being effective to operate the yarn cutting means.

12. Apparatus according to claim **7**, further comprising means for deriving from the output of the areal average detector circuit information concerning shading formed upon dyeing a cloth woven from the yarn being measured and for deriving from the output of the peak value average detector circuit information concerning dye streaking.

13. Apparatus according to claim **7**, in which the evaluating means stores the outputs of the areal average detector circuit and the peak value average detector circuit separately for each of the yarns being measured and determines the quality grade of the yarns being measured on the basis of the stored outputs.

14. Apparatus according to claim **13**, further comprising means for according to the outputs from the detector circuits differential weights according to the variety of the detector circuit before being added together, the sum being made the basis to determine the quality grade of a corresponding yarn being measured.

15. A method of measuring the quality of yarn comprising the steps of:

producing a deviation signal which varies in accordance with the irregularities in thickness or mass which occur along a length of the yarn;

averaging said deviation signal to produce an areal average signal representative of the average value of irregularities occurring along the length of yarn;

averaging the peak values of said deviation signal to produce a peak average signal representative of the average of the peak values of irregularities occurring along the length of yarn; and

using said areal average signal and said peak average signal as a measure of the quality of the length of yarn.

16. A method according to claim **15** further comprising the step of determining from said areal average and peak average signals the dyeing grade of the length of yarn.

17. A method according to claim **16** further comprising the step of determining from said areal average signal information concerning dye shading which would occur in the yarn when it is subsequently formed into cloth and dyed.

18. A method according to claim **17** further comprising the step of determining from said peak average signal information concerning dye streaking which would occur in the yarn when it is subsequently dyed.

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