

Jan. 12, 1971

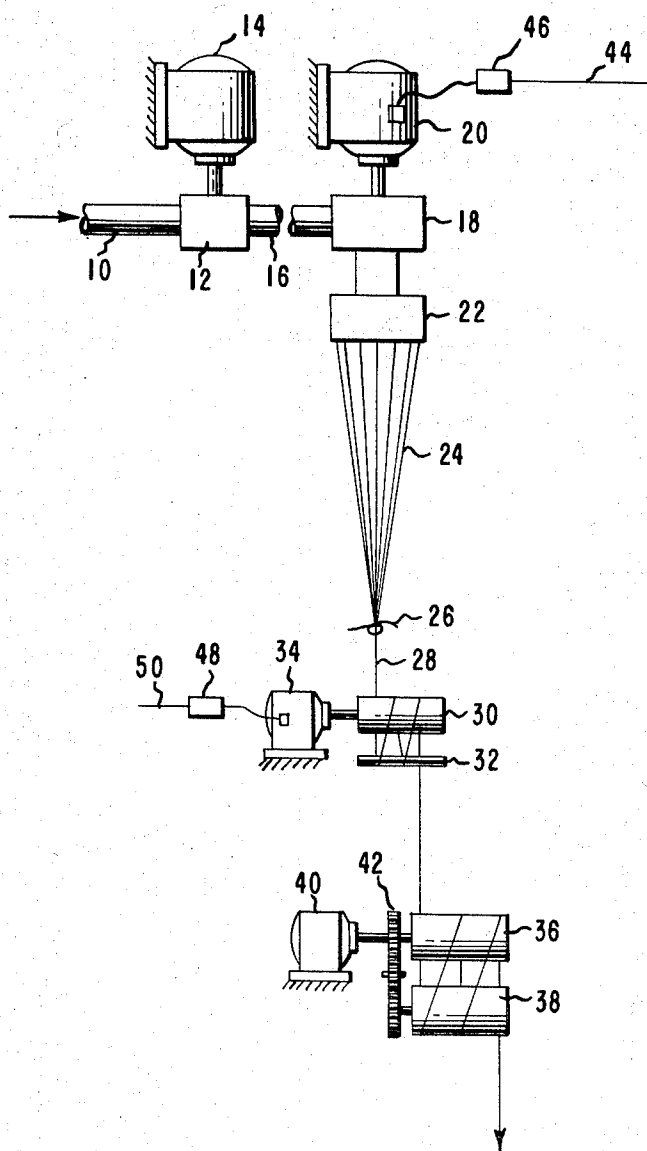
W. T. WINDLEY
METHOD FOR MONITORING PROPERTIES OF POLYMER AND
YARN PRODUCED THEREFROM

3,555,537

Filed Dec. 22, 1967

3 Sheets-Sheet 1

FIG. 1



INVENTOR
WILLIAM THOMAS WINDLEY

BY *Howard P. West Jr.*
ATTORNEY

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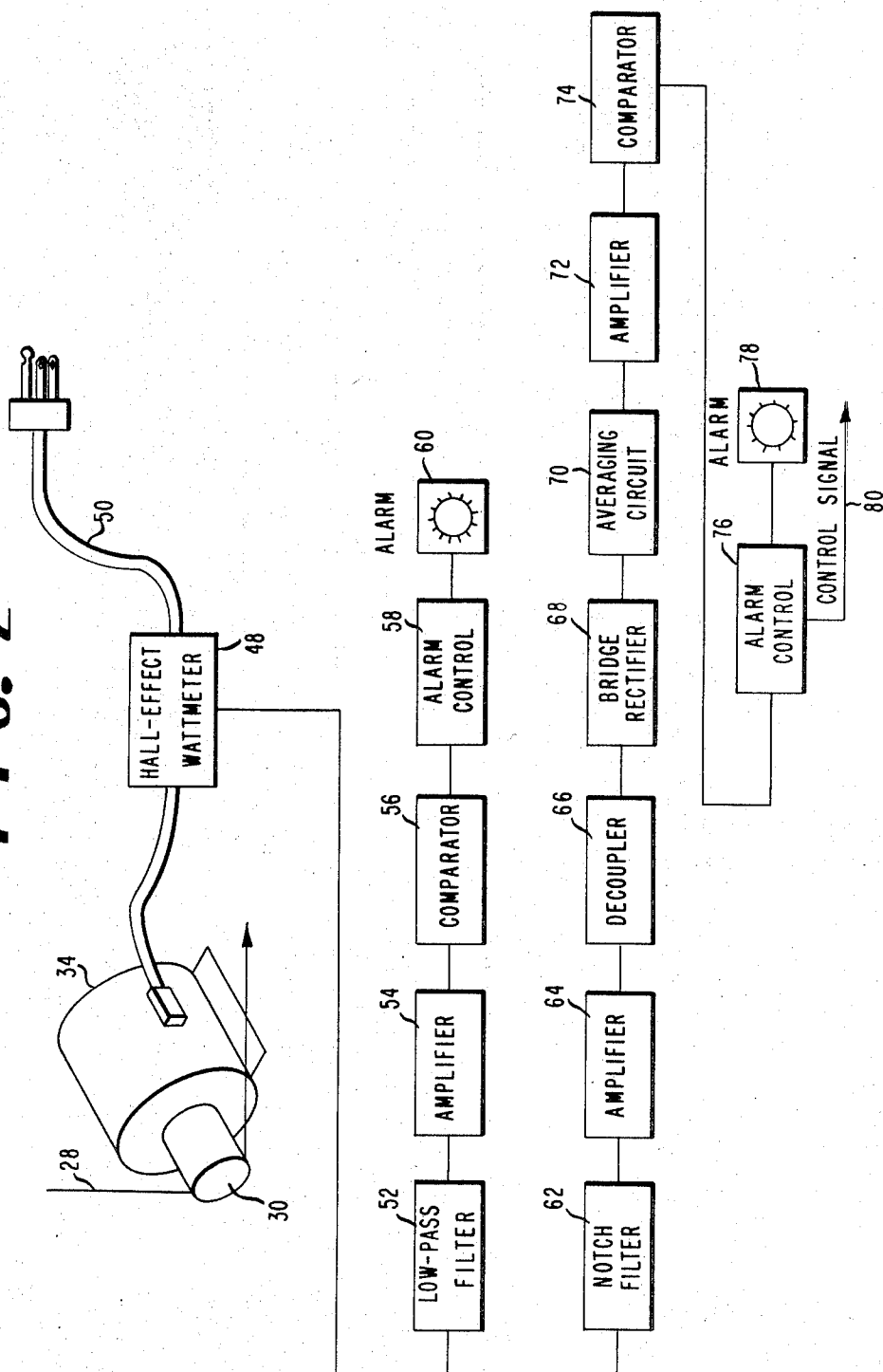
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3 Sheets-Sheet 2

FIG. 2



INVENTOR
WILLIAM THOMAS WINDLEY

BY *Howard P. West Jr*
ATTORNEY

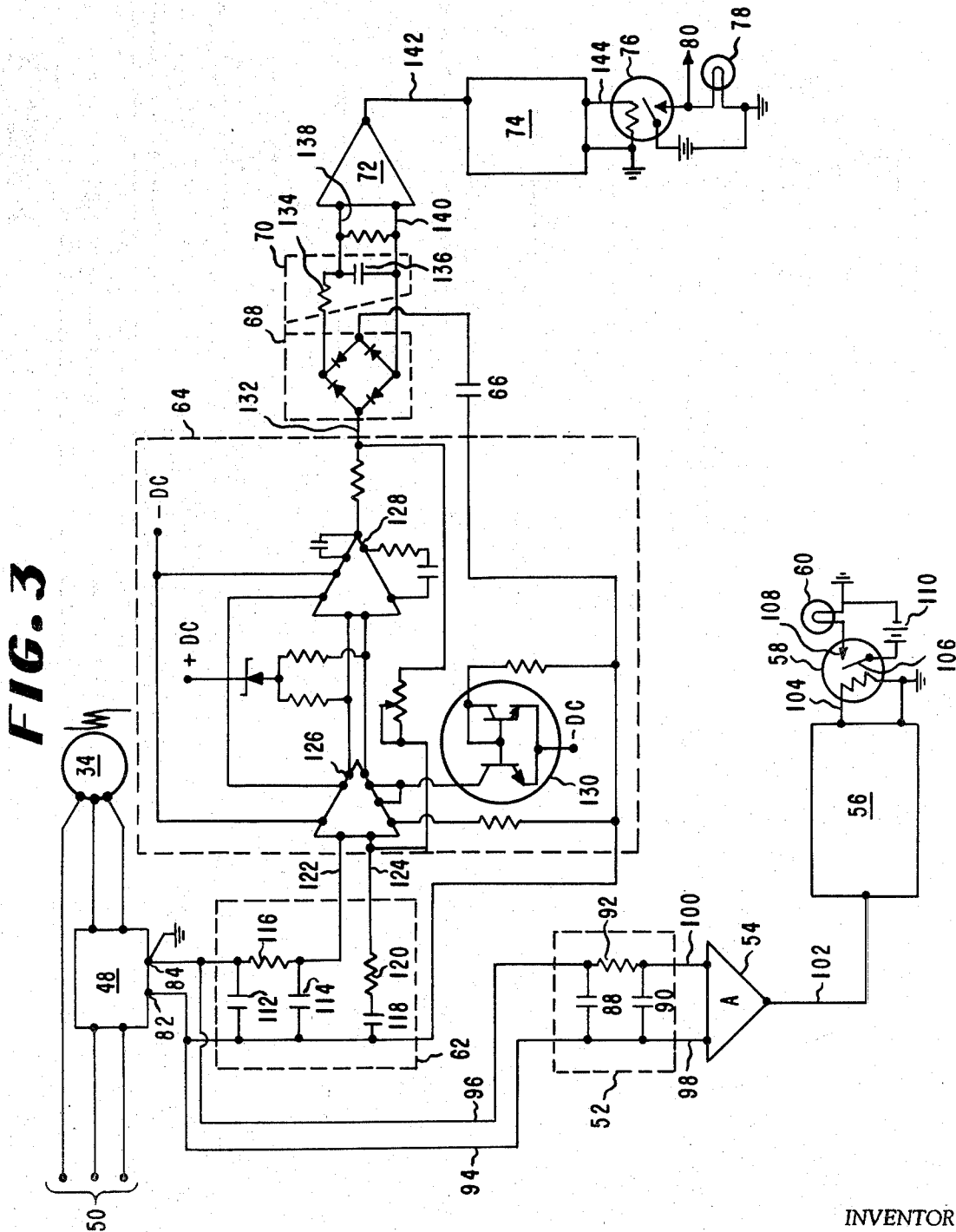
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INVENTOR
WILLIAM THOMAS WINDLEY

BY Howard P. West Jr.

ATTORNEY

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**METHOD FOR MONITORING PROPERTIES OF
POLYMER AND YARN PRODUCED THEREFROM**
William Thomas Windley, Seaford, Del., assignor to E. I.
du Pont de Nemours and Company, Wilmington, Del.,
a corporation of Delaware

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U.S. Cl. 340—259

6 Claims

ABSTRACT OF THE DISCLOSURE

In a process for producing or modifying yarn from synthetic polymer wherein, under desired operating conditions, electrical power is utilized at an essentially constant level in at least one step of the process, a method for determining deviations in polymer and yarn properties from a desired level. Variations in the electrical power utilized, corresponding to deviations in process operating conditions, are detected, characterized and compared to known characteristics representative of desired operating conditions which have been correlated to desired polymer and yarn properties.

BACKGROUND OF THE INVENTION

This invention relates to processes for the making of yarn from synthetic polymer and/or modifying the yarn. It particularly relates to monitoring these processes to insure that a desired product property is kept constant. It has been found that wattmeters measuring the electrical power utilized by "product moving" motors are sensitive to variations in product properties, e.g., denier, dyeability, etc. Variations in the output of the wattmeter are used to signal deviations in a product property.

The term yarn is meant to include single filaments as well as bundles of filaments.

There is an increasing need to obtain more uniform yarn. Variations in product properties such as denier, dye depth, modulus, etc., show up as variations in the end products, e.g., carpets, fabrics, etc. It is necessary to know when such variations occur so that the poor yarn can be segregated until the cause of the variation is corrected. These variations can be caused by malfunctioning equipment or variations in the product supplied.

In the past, yarn property tests were made in a separate area away from the producing machine. Frequently, many hours, and sometimes days, passed before the test results were available and appropriate corrective action could be taken. In the meantime, excessive amounts of low-grade yarn were produced. Some of this could inadvertently be released as good yarn and cause problems in later processing steps. At other times, the problem causing the poor yarn would be self-correcting and good yarn would be downgraded. In either case, the costs would be excessive.

It has been long recognized that it would be ideal to be able to know instantly when product properties start varying. Attempts have been made to place monitoring instruments near or touching the yarn. Such instruments have been expensive, both in initial cost and maintenance costs. Further, such instruments frequently damaged the product.

SUMMARY OF THE INVENTION

This invention encompasses all stages of yarn production, starting with the manufacture and moving of molten polymer to the final stages of yarn production, whether these steps are done in one continuous operation or in separate groups of one or more steps and relates to a method for determining deviations in polymer or yarn

properties from a desired level. In those steps of yarn producing or yarn modifying processes wherein under desired operating conditions electrical power is utilized at an essentially constant level, as for example, by a product moving element driven by a motor, it was discovered that certain characteristic variations in power utilized in such a step correlated to variations in product properties. According to the method of this invention, the power utilized in such a step is measured by a wattmeter which simultaneously detects variations in the measured power from the essentially constant utilization level. These variations are then characterized, by means of electrical circuits, according to polymer and yarn properties which correspond to operating conditions and the characterized variations are compared in a comparator with similar known characteristic levels corresponding to desired polymer and yarn properties. Differences of a predetermined magnitude resulting from such a comparison indicate the occurrence of deviations from desired operating conditions and from corresponding desired polymer and yarn properties. Such occurrences can be signalled visually or audibly so that an operator can take corrective action.

Further, part of the invention can include indicating the proper corrective action.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a schematic illustration of a spinning process.

FIG. 2 is a block diagram of a monitor connected to a feed roll motor.

FIG. 3 is a schematic of the electrical circuitry of FIG. 2.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENT

FIG. 1 shows a line diagram of a typical spinning process. Molten polymer is supplied through supply pipe 10 to transfer line pump 12 which is driven by electrical motor 14. Transfer line pump 12 forces the molten polymer through transfer line 16 to one or more metering pumps 18. Only one is illustrated. Metering pump 18 is driven by electrical motor 20 and meters the supply of molten polymer to the spinning head 22 to form filaments 24 which can be quenched in the normal manner. Filaments 24 are gathered by convergence guide 26 to form a thread bundle 28. Thread bundle 28 is wrapped several times around feed roll 30 and its companion separator roll 32 to prevent slipping. The feed roll 30 is driven by an electric motor 34. The speed of the feed roll 30 determines the spinning speed of filaments 24.

It is well known that the best physical properties of synthetic yarns are only obtained after further processing steps, such as drawing, heat setting, relaxing, etc. FIG. 1 shows in outline form only a drawing step, which comprises a pair of draw rolls 36 and 38 which are driven by an electric motor 40 through gearing 42. Threadline 28 then is sent to further processing steps or wound into a package.

Electrical power to drive motor 20 is supplied through a power supply line 44. Inserted in this line is wattmeter 46 which measures the amount of electrical power utilized by this motor to drive the metering pump 18. In a similar manner, wattmeter 48 measures the power utilized by motor 34 in controlling the speed of feed roll 30. Under some conditions, the electrical power utilized by motor 34 is a braking force and the power on power supply line 50 is negative; or power is supplied into rather than removed from power supply line 50. Synchronous electric motors are used to enable accurate control of their speeds. This can be done by accurately controlling the frequency of the electrical power supplied to the motors.

In one embodiment of this invention, the electrical power utilized by motor 34 to drive the feed roll 30 is

measured by a Half-effect wattmeter 48. It has been found that denier variations along the threadline 28 are caused by low frequency and high frequency process upsets. Both types produce poor product and must be corrected. Tests on a spinning machine producing 66 nylon textile yarns showed that there is a direct correlation between the electrical power utilized by motor 34 and the denier of threadline 28. The low frequency changes are normally caused by changes in polymer throughput, etc., while the high frequency variations are caused by equipment malfunction or poor quenching, etc.

A block diagram of the control system used to determine these variations and to characterize which type are occurring is shown in FIG. 2. As mentioned above, particularly in a drawing process, the feed roll 30 will be a holdback roll and motor 34 will serve as a brake and will generate electrical power rather than using it. Thus, the power utilized through line 50 may be positive or negative as measured by wattmeter 48.

As shown in FIG. 2, the output of the Hall-effect wattmeter 48 is fed to a low-pass filter 52 to amplifier 54 through comparator 56 which provides an output signal when the amplitude of the low frequency signal is above a desired setpoint. This signal operates the alarm control 58 and sounds an audible or visible alarm 60.

In a similar manner, the output of wattmeter 48 is fed to a notch filter 62. Its output is amplified and decoupled by amplifier 64 and decoupler 66. Bridge rectifier 68 takes the varying plus or minus signal and converts it to a positive signal which is averaged by the averaging circuit 70, again amplified by amplifier 72. This amplified signal is compared to a setpoint in comparator 74. When it exceeds the setpoint, an alarm control 76 sounds an audible or visual alarm 78. In addition, a control signal 80 can be supplied.

Referring to FIG. 3, the power lines 50 are connected through the wattmeter 48 to motor 34. The output from the Hall-effect wattmeter 48 is supplied on terminals 82 and 84.

A π filter, comprising capacitors 88 and 90 and resistor 92, functions as the low-pass filter 52. The output signal of wattmeter 48 is connected to the low-pass filter by leads 94 and 96 from terminals 82 and 84, respectively. By appropriate values of these components, all variations in the output of wattmeter 48 above 1-2 cycles per second are cut out and only low frequency signal or steady-state signals are permitted to reach amplifier 54 on leads 98 and 100. The output of amplifier 54, which can be a Sanborn amplifier Model 8803A, is fed to comparator 56 by lead 102. Comparator 56, which can be a Sensitak comparator Model 12-A, compares the signal on lead 102 with a pre-set level. If the signal on lead 102 is below this desired level, there is no output of comparator 56 on lead 104. When the input signal on lead 102 is above the setpoint, there is an output signal on lead 104. It has been found that there are momentary upsets which give spurious signals and it is not desirable to alarm for these upsets. Such things are power line transients due to the starting of motors, etc. cause these momentary upsets. Consequently, alarm control 58 (Amperite, Model 12N010T) has a thermal time delay incorporated in it. After the appropriate time delay, arm 106 touches contact 108, completing the circuit and connecting power source 110 to the alarm light 60. Alarm 60 can either be a visual light or an audible alarm. Thus if there is any sustained change in the power utilized by motor 34, alarm 60 will so indicate.

Notch filter 62 has a π filter comprising capacitors 112 and 114 in combination with resistor 116. The values of these electrical components are different from the values in the low-band-pass filter 52. This has a higher threshold frequency than the low-pass filter 52, e.g., 20 cycles per second. In addition, capacitor 118 and resistor 120 remove the D.C. component from the wattmeter

signal which is supplied from terminals 82 and 84. Thus, the output signal of notch filter 62, which is supplied on leads 122 and 124, consists only of the variations in the wattmeter output signal which is above a certain frequency but below a second level of frequency i.e., a band width of frequency. Amplifier 64 comprises disposable monolithic silicon microcircuit amplifiers 126 and 128 and transistor assembly 130. The output of amplifier 64 is on lead 132. This signal is decoupled by decoupling capacitor 66. This signal is then put on the bridge rectifier 68; supplied to the averaging circuit 70 comprising an RC network, resistance 134, and capacitor 136. The bridge rectifier 68 converts the plus and minus signals on lead 132 to all plus signals. The averaging circuit 70 smooths or averages this series of plus pulses into a level signal. This level signal is fed to amplifier 72 on leads 138 and 140. An amplified signal is supplied on lead 142 to comparator 74. Amplifier 72 can be identical to the amplifier 54 and comparator 74 can be identical to comparator 56. The signal on lead 142 expresses, as a magnitude signal, the amount of cyclic variations between the two frequency thresholds determined by the notch filter 62. If the magnitude of these variations exceeds a pre-set point in comparator 74, a signal is provided on lead 144 to the alarm control 76. This also can be identical to the alarm control 58 and incorporates a thermal time delay set appropriately. It operates in similar manner to alarm control 58 and when the signal has been of sufficient magnitude for the time period desired, a signal is provided which controls alarm 78 and supplies the control signal 80.

In operation, it has been found that when the machine is spinning good yarn i.e. within desired property levels, there are very few fluctuations in the power utilized on motor 34 and detected by wattmeter 48. However, if either alarm 60 or alarm 78 is operated, the operator knows that poor quality yarn is being produced and it should be segregated immediately. Depending upon which alarm is activated, he takes the appropriate corrective action to remedy the cause of the poor yarn production.

When used to produce 66 nylon textile yarns, it has been shown that the equipment can be adjusted so that the low frequency alarm 60 will be activated when the average denier deviates outside of desired limits. The high frequency alarm will be activated when there are short-term variations in denier, even though the average denier of the thread bundle is within the desired limits.

The improved method of this invention has been extremely useful in the production of heavy (1,000-4,000) denier BCF (bulk continuous filament) yarns, particularly those used to produce carpets. In this situation, one of the most important product properties is dyeability. Both short-term dye variations and major dye level shifts show up in the final carpet and cannot be tolerated. Consequently, it is very important to know, while the yarn is being produced, if the yarn is within the desired limits of dye level and dye variations. The present method of insuring that all the yarn going into one carpet will dye the same, without streaks, is very time consuming and costly. It consists of making dye depth measurements on a large number of the packages produced and segregating the packages into different dye groups depending upon the results of the dyeing tests. The improved method of this invention eliminates these costly operations.

A Hall-effect wattmeter 46 is placed on motor 20 driving metering pump 18 (FIG. 1) on a spinning machine producing heavy denier BCF carpet yarns. Tests have demonstrated that dye level and dye variability correlate with the electrical power utilized by motor 20. Circuitry similar to that shown in FIGS. 2 and 3 is used to characterize the variation in the electrical power utilized. Whenever the low frequency signal or the high frequency signal exceeded pre-selected limits, yarns with excessive dye variations were being produced. Such production is segregated until proper corrective action is taken. Since corrective action is normally taken very soon after the

alarm is given, only small amounts of yarn are downgraded.

It has been ascertained that in the production of 66 nylon BCF carpet yarns, a malfunction of metering pump 18 will show up as low frequency (1 cycle every 2 to 4 minutes), low amplitude, cyclic variations in the watt-meter signal. In contrast, a malfunction, e.g. channeling, of the filtering elements in spinning head 22 will show up as even lower frequency (1 cycle every 10 to 30 minutes), high amplitude, erratic or transient variations. As the melt-filtering elements become loaded with removed particles, the over-all average level of power utilized increases. These low frequency variations are superimposed on the long-term change. It is possible, by using one low-pass filter 52 and two notch filters 62 (each sized appropriately), to be able to characterize and distinguish the different types of variations. By appropriate alarms, the spinning machine operator can segregate yarn with poor dye characteristics and then take appropriate corrective action as indicated by the alarm system.

It should be obvious to one skilled in the art that many types of variations can be characterized. Such variations as a change in slope in the power-utilized curve which may be characterized by means of a very high frequency band pass filter or electronic differentiator; counting the number of times the power utilized goes outside, either above or below, a desired band, etc., can be characterized to characterize a product variable.

While the embodiments described above all used analog signals, digital computers can easily be used. A single computer-scanner could sample the power utilized by all the equivalent motors on the various positions on a large, multi-position spinning machine. By using appropriate storage and comparison steps, it would be possible to characterize variations within a single position as well as variations between positions.

All of the embodiments have been illustrated on a spinning machine. The improved method can easily be applied to separate yarn modifying steps when electric power is utilized to modify a yarn property, e.g., draw, heat set, stabilize, etc.

It is apparent that many changes and modifications can be made without departing from the spirit of the present invention, which is intended to be limited only by the scope of the appended claims.

What is claimed is:

1. In a process for producing yarn from synthetic polymer in one or more steps wherein under desired operating conditions electrical power is utilized at an essentially constant level in at least one step, the method of indicating deviations from at least one desired operating condition, corresponding to deviations from a desired level in a yarn property, said method comprising the machine implemented steps of:

- (a) measuring the electrical power utilized in at least one of said yarn producing steps;
- (b) detecting variations in the measured power from the essentially constant level;

(c) characterizing said variations according to the desired yarn property level; and

(d) comparing the characterized levels of variations with similar known characteristic levels corresponding to desired yarn properties.

2. The method of claim 1 including the following additional step:

signalling a deviation of a predetermined magnitude of said characterized levels of variations from said similar known characteristic levels, thereby indicating deviations from desired operating conditions and from corresponding desired polymer and yarn properties.

3. The process as defined in claim 1, said variations being transient.

4. The process as defined in claim 1, said variations being cyclic.

5. The process as defined in claim 4, said cyclic variations being characterized according to frequency related to yarn property levels related to corresponding to operating conditions.

6. In a process for producing yarn from synthetic polymers in one or more steps wherein under desired operating conditions electrical power is utilized at an essentially constant level in at least one step, the method of indicating deviations in desired operating conditions represented by a set point amplitude, said deviations corresponding to deviations in polymer and yarn properties from a desired level, comprising:

- (a) continuously detecting the electrical power utilized in said one step;
- (b) generating equivalent electrical signals corresponding to variations from said essentially constant level;
- (c) segregating said signals according to frequency into a plurality of frequency bands;
- (d) comparing the amplitude of said signals in said band to said set point amplitude; and
- (e) signalling when said signal amplitude exceeds said set point amplitude, thereby indicating deviations from desired operating conditions and from corresponding desired polymer and yarn properties.

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THOMAS B. HABECKER, Primary Examiner

D. L. TRAFTON, Assistant Examiner

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