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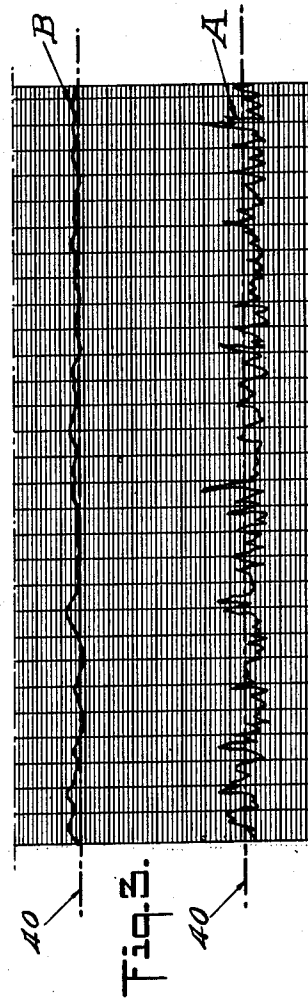
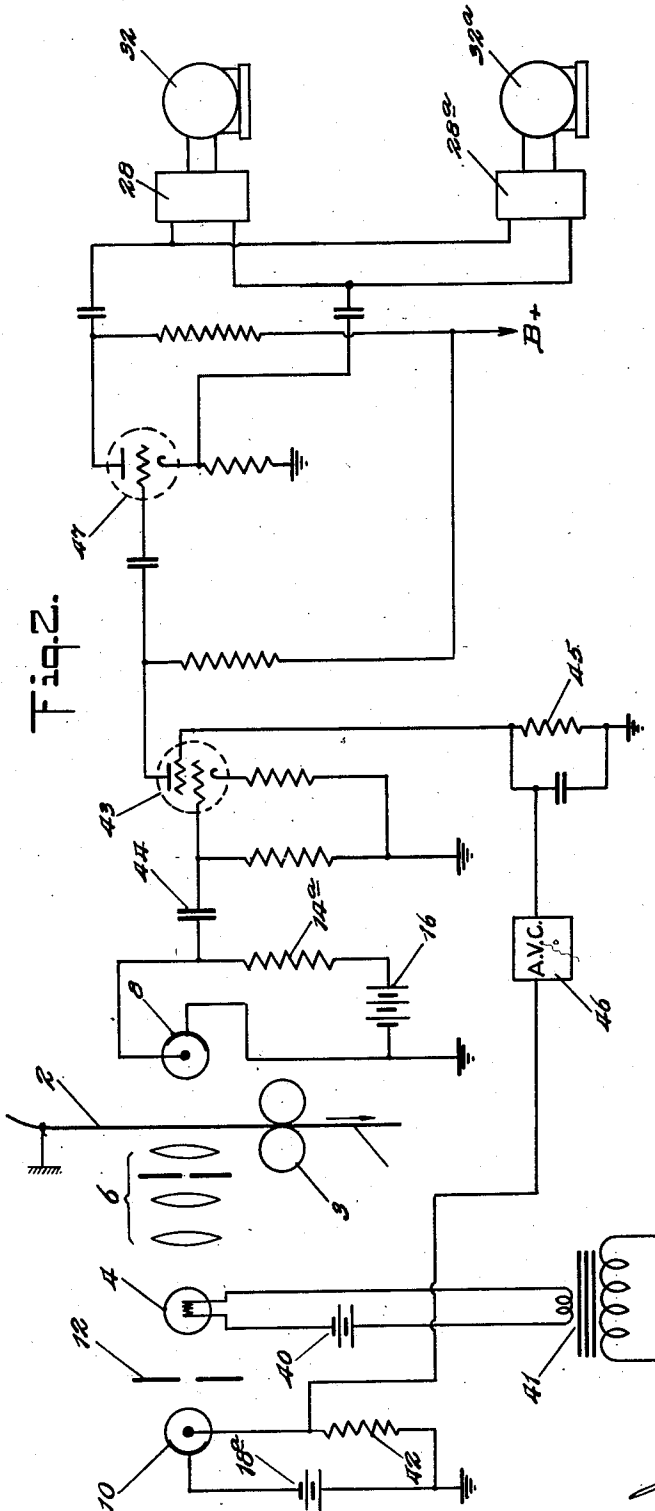
F. P. STROTHER

2,641,960

INDICATING AND RECORDING DEVICE FOR YARN DIAMETERS

Filed May 14, 1947

3 Sheets-Sheet 2



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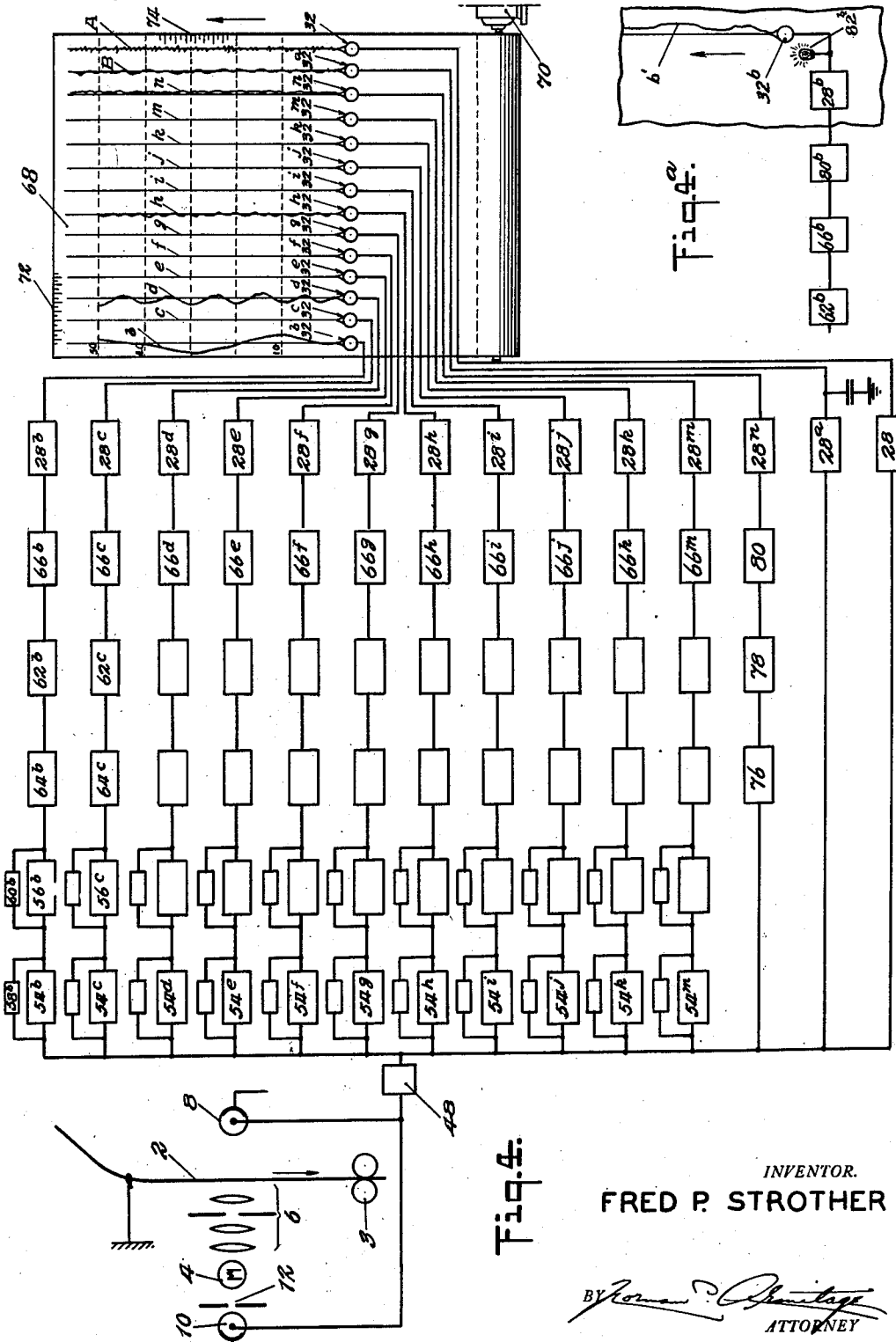
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3 Sheets-Sheet 3



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INDICATING AND RECORDING DEVICE FOR
YARN DIAMETERS

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The present invention relates to measurement and recording of textile filament or fiber diameters and comprises novel apparatus whereby diameter variations may be readily analyzed and the source of unwanted variations determined. When the diameter of yarn varies substantially, fabric woven therefrom is unsatisfactory; periodic change of yarn diameter causing banding in the woven fabric.

The source of yarn diameter variations may be in any one of a number of machines through which the slivers and rovings pass in the process of yarn production. For example, uneven or worn rollers in the sliver lapping machine, or the sliver drafting or long draft roving machines or in the yarn spinning machine itself, will cause periodic variations in yarn diameter, as will irregularities in the builder motion of the ring spinning machine. If there is faulty operation of two or more of the machines, yarn diameter variations of a corresponding number of periodicities will result. As a general rule, because of the series of drafting operations, the longer the periodicity of the diameter variations, the further back into the history of the processing of the yarn will be found the source of the trouble. When two or more periodicities occur simultaneously, a corresponding number of faulty machine elements may be expected. Thus, if yarn diameter variations can be recorded and analyzed so as to determine the number of different periodicities of the deviations occurring in the yarn, the source or sources of the deviations may be located and corrected before the yarn is woven into fabric, thus affording a substantial saving in material, time and labor.

An object of the invention is, therefore, to provide accurate means for continuously measuring and recording yarn diameter.

Another object of the invention is to provide means for obtaining a record of yarn diameter which discloses periodic diameter variations.

A further object of the invention is to provide means for analyzing and recording yarn diameter variations in accordance with their periodicity.

Other objects of the invention will become apparent as the description proceeds.

For an understanding of the invention reference may be had to the accompanying drawings of which:

Fig. 1 is a diagram of a yarn diameter measuring and recording device embodying the invention;

Fig. 2 is a diagram similar to Fig. 1 but illus-

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trating an alternative form of measuring circuit;

Fig. 3 is a diagram showing the type of records obtained with the device of either Fig. 1 or Fig. 2;

Fig. 4 is a diagram of a yarn diameter measuring, analyzing and recording device embodying the invention; and

Fig. 4a is a diagrammatic view illustrating an alternative arrangement for a part of the device of Fig. 4.

In Fig. 1, the yarn 2, the diameter of which is to be measured, is moved at a constant speed in the direction of the arrow as by rollers 3. The yarn 2 passes through a beam of light which issues from a source 4 and is directed by a lens and aperture system 6 toward a photocell 8 positioned to respond thereto. A balancing photocell 10 is positioned to respond to the light from source 4 after passage through a slit or light valve 12. In the particular measuring circuit shown in Fig. 1, the anode of cell 10 and the cathode of cell 8 are connected together and to one end of a resistor 14. The other end of resistor 14 is connected to the negative terminal of a battery 16 and to the positive terminal of a battery 18; the positive terminal of battery 16 being connected to the anode of cell 8 and the negative terminal of battery 18 being connected to the cathode of cell 10. With this arrangement, batteries 16 and 18 being of equal voltage, no current will flow through resistor 14 when the currents through the cells 8 and 10 are equal. By any suitable adjustment, as of the light valve 12, these currents may be made equal for any desired diameter of yarn 2. Departure of the yarn diameter from the desired value causes current to flow through resistor 14, the direction of the current depending upon increase or decrease of yarn diameter and the magnitude of the current depending upon the magnitude of the yarn diameter variation. The potential difference across resistor 14 resulting from unbalance of the photocell currents due to yarn diameter variations is amplified and used to control recording devices. In the particular circuit of Fig. 1, amplification of the potential difference across resistor 14 is effected by tubes 20 and 22, which may be 6AG5 tubes. As shown, these tubes have their control grids connected across resistor 14, their plates connected through a resistance 24, the mid-point of which is grounded, and their cathodes tied together and connected through a resistor 26 with the negative terminal of the power supply, indicated as B—; the control grid of tube 22 being also connected to B—. With the above described amplifier, an amplified potential

difference appears across resistor 24 when current flows through resistor 14 due to change in the yarn diameter from the predetermined value. This amplified potential difference across resistor 24 is applied to the input terminals of a power amplifier shown within the dashed enclosure 28 as a cathode follower. The double triode 29 of the power amplifier, which may be a 6AS7G, has its control grids connected to opposite ends of resistor 24, its cathodes connected by a center grounded resistor 34, and its plates connected to the power supply, indicated by B+. A winding 30, of a motor 32 is connected across resistor 34. Thus, motor 32 is energized only when the yarn diameter departs from the desired value, energization being in one direction when the yarn diameter increases, and in the other direction when the yarn diameter decreases. Motor 32, which may be, and preferably is, a pen motor, thus responds up to the limit of its sensitivity to each change in yarn diameter and hence a complete record of yarn diameter variations may be made upon a chart moved beneath the motor pen in timed relation with the feeding of a length of yarn past the photocell 8.

In Fig. 3, a graph, typical of the record obtainable by the motor 32, is indicated at A. The graph A is a record of all diameter variations of sufficient magnitude and duration to energize the motor 32. With the above described measuring and amplifying circuits, the apparatus may be made sufficiently sensitive to measure diameter variations of as little as one ten thousandth of an inch. The minimum duration of the diameter variations sufficient for accurate response of the motor depend, of course, upon the rate at which the yarn is fed through the meter. With a feed of yarn of ten feet per second, the motor can be sensitive enough to portray diameter variations of one-half inch or more duration.

To record average diameter variations, a second motor 32a is provided, the winding 30a of which is energized through a power amplifier 28a connected to the output of amplifying tubes 20 and 22, isolating resistors 36 being inserted in the leads to the control grids of the power amplifier, and damping condensers 38 being connected across the winding 30a. With this arrangement, the motor 32a integrates the variations and yields a graph such as B on Fig. 3. Motors 32 and 32a are preferably, but not necessarily, arranged to trace their respective graphs on the same chart.

In the particular measuring circuit disclosed in Fig. 1, variations in intensity of the light source at any moment will not unbalance the photocell currents as they will be equally affected. However, if the light intensity varies from time to time, the same magnitude of change in yarn diameter at different light intensities will show up in the graphs A and B as deviations of different magnitudes from their respective base lines 40. In order to insure that deviations of the graph A of equal magnitude correspond to equal diameter variations, irrespective of variations of light intensity, the cell 10, instead of being connected as a balancing cell for the cell 8 could be connected through an automatic volume control device to the amplifier circuit. Such an arrangement is illustrated in Fig. 2. Fig. 2 illustrates also an alternating rather than direct current type of measuring circuit.

In Fig. 2, the filament of lamp 4 is connected in series with a battery 40 across a suitable source

of alternating current, indicated as the secondary winding of a supply transformer 41. Photocell 8 is connected in series with a resistor 14a across the battery 16a, and photocell 10 is connected in series with a resistor 42 across the battery 18a. The control grid of an amplifier 43 is connected through a condenser 44 with the low potential end of resistor 14a, and the suppresser grid of amplifier 43 is connected to ground through a resistor 45. The potential across resistor 45 is controlled through an automatic volume control device, indicated diagrammatically at 46 from the circuit of cell 10. The output circuit of amplifier 43 is connected through a phase inverter 47 to the inputs of cathode followers 28 and 28a for energization of motors 32 and 32a. With this arrangement, motors 32 and 32a are energized continuously and an increase and decrease of yarn diameter from a predetermined value causes increase and decrease, respectively, in the motor current. The base lines 40 of Fig. 3 thus correspond, for the embodiment of Fig. 2, with energization of the motors occurring when the yarn diameter is that desired. Because of the provision of the automatic volume control in the suppresser grid lead of amplifier 43, graphs traced by the motors 32 and 32a will be independent of light intensity variations.

The scale of the chart of Fig. 3, in the particular embodiment of the invention illustrated, is such that one horizontal division corresponds to two feet of yarn and one vertical division corresponds to .001 inch. From graphs A and B, the pattern of diameter variations of the first fifteen horizontal divisions can be recognized in the second fifteen horizontal divisions and hence periodicities of diameter variations of not more than thirty feet are indicated in the particular sample of yarn tested. Periodicities of substantially less than thirty feet are also indicated by the graphs and could be specifically determined by careful analysis of curve A. The closely spaced deviations of graph A indicate short period variations such as slubs, etc. From graph B it is apparent that the average diameter variations of any length of the yarn do not exceed .0005 plus or minus.

In Fig. 4 a complete yarn diameter meter, analyzer and recorder is illustrated. In the particular embodiment of the invention illustrated in Fig. 4, the analyzer is equipped to detect and record eleven different periodicities as well as the presence of periodicities of over a given value. The measuring circuit is only diagrammatically indicated in Fig. 4. It may be assumed to be that of either Fig. 1 or that of Fig. 2. The output from amplifier 48 controls, through power amplifiers 28 and 28a, the pen motors 32 and 32a, respectively. Amplifier 48 may be assumed to be the direct current amplifier comprising the tubes 20 and 22 of Fig. 1 or the amplifier 43 and phase inverter 47 of Fig. 2. In order to analyze the graph produced by motor 32, the amplifier 48 is connected to eleven similar analyzing circuits each arranged to select and pass a different frequency component of the amplifier output and each arranged to control the energization of a pen motor. To simplify the description, specific frequencies corresponding to definite periodicities for a speed of yarn through the meter of ten feet per second will be described. The analyzer circuit of pen motor 32b passes current of .25 cycle, corresponding to diameter deviations recurring at forty-foot intervals; the circuit for motor 32c passes a current of .5 cycle;

that for motor 32*d*, 1 cycle; for motor 32*e*, 2 cycles; motor 32*f*, 4 cycles; motor 32*g*, 7.5 cycles; motor 32*h*, 15 cycles; motor 32*i*, 30 cycles; and for motors 32*j*, 32*k* and 32*m*, 60, 120 and 240 cycles, respectively. This gives an analyzing range of periodicities from one-half inch to forty feet and has been found to be sufficient to detect practically every periodic diameter variation normally encountered in yarn manufacture. In addition, there is provided one pen motor 32*n* which indicates roughness of the yarn, its analyzing circuit passing frequencies above 480 cycles. In Fig. 4, the analyzing circuit for motor 32*b*, includes two series connected amplifiers 54*b* and 56*b* bridged by feed back elements 58*b* and 60*b*, respectively. Amplifiers 54*b* and 56*b* may each be a 6AG5, and elements 58*b* and 60*b* are parallel T networks having constants such that the maximum response of amplifier 54*b* is to a frequency slightly less than .25 cycle, and the maximum response of amplifier 56*b* is to a frequency slightly higher than .25 cycle. The output from amplifiers 54*b* and 56*b* is amplified by an amplifier 62*b*, which may be a 6SJ7, after passage through a high band pass filter 64*b* and is then delivered, through a low band pass filter 66*b*, to the power amplifier or cathode follower 28*b*; the filters 64*b* and 66*b* being constructed to have overlapping pass bands in the region of .25 cycle. Thus, if diameter deviations in the yarn 2 recur at intervals of 40 feet, the pen of motor 32*b* will trace the curve *b* on the moving chart 68. The chart 68 is driven at constant speed by a motor 70, and the chart is provided with a graduated transverse scale 72 so that the magnitude of the diameter deviations may be read directly from the scale. A graduated longitudinal scale 74 may be provided, if desired, for ready interpretation of the curves A and B traced by pen motors 32 and 32*a*. A study of curve *b* indicates not only that diameter deviations do recur at 40 foot intervals in the yarn under examination but that the magnitude of such recurrent deviations is not constant. (Compare the amplitudes of the curve *b* at the antinodes).

The circuits for each of motors 32*c* to 32*m* are like that described for motor 32*b* except that each is designed to pass the selected frequency heretofore specified. The corresponding curves *c* to *m* on chart 68 indicate that in the particular stretch of yarn just analyzed, there are periodicities, in addition to the forty-foot periodicity indicated by curve *b*, of ten feet, and of eight inches. These periodicities are indicated by the curves *d* and *h*, and the absence of other periodicities is indicated by the fact that the pens of motors 32*c*, 32*e*, 32*f*, 32*g*, 32*i*, 32*j*, 32*k* and 32*m* have traced straight lines along their respective base lines.

The circuit of motor 32*n* comprises a high band pass filter 76, designed to pass frequencies above 480 cycles, an amplifier 78, a rectifier 80, which may be a 6H6 tube, for converting the alternating current from amplifier 78 to direct current, and the power amplifier or cathode follower 28*n*. From the displacement of curve *n* from its base line, it is apparent that the yarn 2 is fuzzy, as diameter deviations occurring at intervals of one-fourth inch or less are indicated.

In Fig. 4, the pen motors, except pen motor 32*n*, respond oppositely to opposite half cycles of the energizing current, and hence, trace curves such as curves *b*, *d* and *h* on chart 68. If unidirectional response of the pen motors is desired,

it is only necessary to convert the alternating current output from filters 66*b*, 66*c*, etc., to direct current by insertion of, for example, a 6H6 tube between the filters 66*b*, etc., and the cathode followers 28*b*, etc., as indicated in Fig. 4*a* for the circuit of pen motor 32*b*. In Fig. 4*a*, the 6H6 converting tube is indicated diagrammatically at 80*b* and the curve traced by motor 32*b* at *b'*. Also, if desired, indicator lamps, may be provided for each channel, as indicated at 82*b* in Fig. 4*a*.

The above described analyzer of Fig. 4, with or without the modification illustrated in Fig. 4*a*, and designed for the determination of the before specified eleven periodicities, in addition to the roughness indicator, will ordinarily be sufficient for the indication of all periodicities apt to occur in yarn manufacture. In fact, fewer frequency channels could be employed with satisfactory results. On the other hand, even without increasing the number of frequency channels, the apparatus could be made to respond to different periodicities by changing the rate of feed of the yarn through the meter. For example, if the yarn speed is doubled, the periodicities indicated by the respective pen motors will likewise be doubled.

The information obtained from the operation of the apparatus of Fig. 4 is valuable in locating the source of the yarn diameter deviations. For example, the curve *h* showing periodicity of eight inches, indicates that there may be faulty operation of the yarn spinner, probably of one or the other or of both of the draft rolls and these parts should be checked. The curve *d*, showing periodicity of ten feet, indicates probable irregular drafting operation in the machine immediately preceding the yarn spinner. Knowing the peripheries and rotating speeds of the various rolls used in the production of the yarn, the location of the source of this periodicity can be fairly accurately estimated. Similarly, the curve *b* showing a periodicity of forty feet indicates that the source of the trouble should be sought still further back in the processing of the yarn. In any given mill utilizing the apparatus of Fig. 4 or 4*a*, a chart can be compiled, either on the basis of calculation or as a result of use of the apparatus, telling where to look for faulty operation according to each periodicity indicated by the apparatus.

The invention has now been described with reference to the relatively simple meter and recorder of Fig. 1, the modification of Fig. 2, and the complete meter, analyzer and recorder of Fig. 4. Although the information given by the system of Fig. 4 is more readily interpreted, much of it could be obtained from a study of the graphs obtained by the more simple, and hence less expensive apparatus of Figs. 1 and 2. Although the complete analyzer of Fig. 4 has been indicated as having twelve specific frequency channels, obviously the invention is not limited to this particular number of channels nor to the specific selected frequencies. Various changes in the various circuits could be made without departing from the spirit of the invention, and parts of the system could be employed without employment of other parts, as will be apparent to those skilled in the art. Although the meter, analyzer and recorder of the invention is particularly adapted for use in the textile industry and for measurement of yarn diameter variations, obviously apparatus embodying the invention could be advantageously employed in other industries and for measurement and recording

of diameter variations of filamentary material other than yarn, as for example, wire, glass or the like.

The following is claimed:

1. A diameter meter and recorder for travelling yarn comprising a resistor, photoelectric means for creating a potential difference across said resistor varying with departures of the yarn diameter from a predetermined value, means for amplifying said potential difference, a pair of power amplifiers each connected to said amplifying means, a device energized by one of said power amplifiers for continuously recording said amplified potential difference in terms of yarn diameter variations, and a second device and damping means therefor energized by said second power amplifier for continuously recording said amplified potential difference in terms of average variations of yarn diameter, said devices including styli positioned to produce in juxtaposed relation traces representing diameter variations in the same section of yarn.

2. A yarn diameter meter and recorder according to claim 1 including a plurality of frequency responsive circuits connected in multiple to said amplifying means, each of said circuits being responsive to a different frequency and one of said circuits being responsive to all frequencies above a predetermined value, and a plurality of recording devices, one connected to each frequency responsive circuit, said plurality of recording devices including recording styli positioned to produce an array of juxtaposed traces, each trace representing a different periodicity in yarn diameter variations in the same section of yarn.

3. A yarn diameter meter and recorder comprising a resistor, photoelectric means for creating a potential difference across said resistor varying with departure of yarn diameter from a predetermined value, an amplifier connected across said resistor, a cathode follower connected to said amplifier, diameter recording means connected to said cathode follower so as to be energized in accordance with departures of the yarn diameter from a predetermined value, a second cathode follower connected to said amplifier, a diameter recording means connected to said second cathode follower so as to be energized thereby and damping means between said second cathode follower and the recording device energized thereby, whereby average yarn diameter variations are recorded by said last mentioned device, said recording means including recording styli positioned to produce in juxtaposed relation traces representing diameter variations in the same section of yarn.

4. A yarn diameter meter and recorder comprising in combination, a source of light, a pair of photoelectric cells positioned to receive light from said source, means for passing yarn, diameter variations of which are to be recorded, between said source and one of said cells, a pair of series connected sources of energy, one having its positive terminal connected to the anode of one of said cells and the other having its negative terminal connected to the cathode of the other of said cells, a resistor having one end connected to the other terminal of each of said sources and its other end connected to the other electrode of each of said cells, means for amplifying potential differences appearing across said resistor and recording devices controlled by said amplifying means, said recording devices including a pair of pen motors one connected for rapid response to variations in magnitude and

direction of the amplifier output and the other damped for slower response to the amplifier output, and a chart driven in timed relation with the movement of yarn past the light source for receipt of graphs traced by the pens of said motors.

5. A yarn diameter meter and recorder comprising in combination a lamp, an alternating current source for said lamp, a battery interposed between said source and said lamp, a photocell positioned to receive light from said lamp, means for moving yarn, variations in the diameter of which are to be recorded, between said lamp and said cell, a circuit for said cell including a source of energy, an alternating current amplifier coupled to said circuit, and recording devices controlled from said amplifier, said recording devices including a pair of pen motors one connected for rapid response to variations in magnitude of the amplifier output and the other damped for slower response to the amplifier output, and a chart driven in timed relation with the movement of yarn past the light source for receipt of graphs traced by the pens of said motors.

6. A filament diameter analyzer comprising in combination photoelectric means for creating a potential difference responsive to changes in filament diameter from a predetermined value, means for feeding a filament continuously past said responsive means, means for amplifying the potential difference created by said responsive means, a plurality of circuits responsive to different frequencies connected in multiple to said amplifying means and indicating means connected to said circuit whereby the output of the amplifier may be analyzed to determine periodic recurrences of filament diameter variations.

7. The filament diameter analyzer according to claim 6 wherein said indicating means comprise a plurality of recorders each controlled by one of said frequency responsive circuits and having a common chart driven in timed relation with said filament feeding means and positioned for simultaneous recording thereon.

8. The analyzer according to claim 6 wherein each of said frequency responsive circuits includes means for converting alternating current flowing in the circuit to direct current, a power amplifier in each circuit for amplifying the converted current and wherein said indicating means comprise a recording device associated with each circuit and energized by the output from the respective power amplifier.

9. A filament diameter analyzer comprising in combination electronic diameter responsive means energized in accordance with changes in filament diameter from a predetermined value, means for feeding a continuous length of filament past said responsive means, a plurality of circuits responsive to different frequencies connected in multiple to said responsive means, and indicating means connected to each of said circuits whereby the output of said responsive means may be analyzed to determine periodic recurrences of filament diameter variations.

10. The analyzer according to claim 9 wherein said indicating means comprises a plurality of recorders, each controlled by one of said frequency responsive circuits for recording the different periodicities detected thereby.

11. A filament diameter analyzer comprising in combination electronic diameter responsive means energized in accordance with changes in filament diameter from a predetermined value, means for

feeding a continuous length of filament past said responsive means, a plurality of frequency detecting means connected to said responsive means for determining recurrences of filament diameter variations of a number of different periodicities, a plurality of recording devices controlled by said frequency detecting means for recording the different periodicities detected thereby, a recording device controlled from said diameter responsive device so as to record diameter variations irrespective of periodicity, a damped recording device controlled from said diameter responsive device so as to record average diameter variations, said recording devices including a common chart moved in timed relation with the feed of the filament and positioned for simultaneous recording thereon of the different periodicities of diameter variations, of diameter variations irrespective of periodicities and of average diameter variations.

12. Apparatus for detecting specific periodicities in yarn diameter variations comprising in combination a photoelectric yarn diameter meter for creating a control current varying with the diameter of yarn traveling past the meter, an amplifier for the created control current, a plurality of circuits connected in multiple to the output of said amplifier, frequency selective means in each circuit, each frequency selective means being adapted to pass a frequency corresponding to a different specific periodicity to be detected, and means for recording the currents passed by each of said frequency selective means.

13. A device for measuring and recording yarn

diameter during movement of said yarn, diameter responsive means associated with said moving yarn for detecting diameter variations from a predetermined value, means coacting with said diameter responsive means operative to translate said yarn diameter variations into an electric signal of varying strength, means for amplifying said electric signal, a pair of power amplifiers each connected to said amplifying means, a device energized by one of said power amplifiers for continually recording said amplified electric signal in terms of yarn diameter variations and a second device including damping means energized by said second power amplifier for continually recording said amplified electric signal in terms of average variations of yarn diameter, said devices being arranged to produce in juxtaposed relation traces representing diameter variations in the same section of yarn.

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