June 29, 1954 D. G. C. HARE 2,682,144

CONTROL METHOD AND MEANS

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Fig. 1.

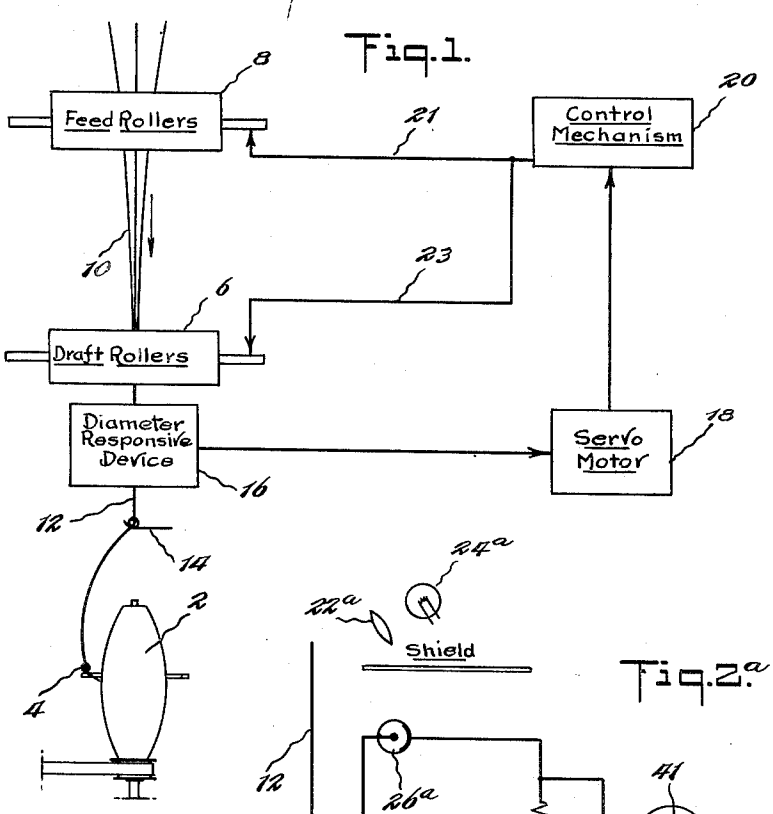
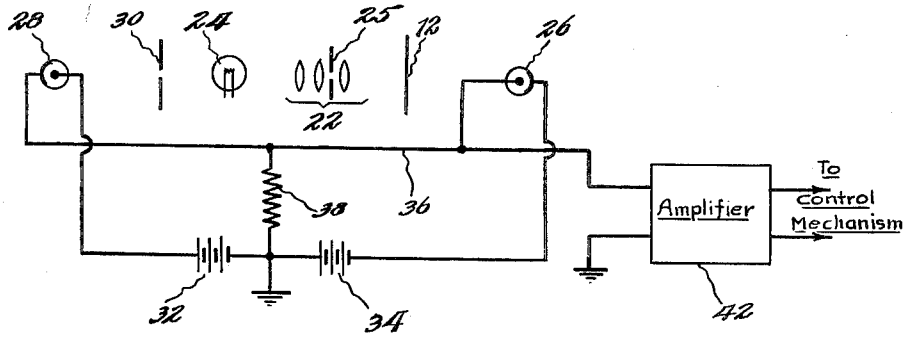


Fig. 2a.

Fig. 2.



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Fig. 3.

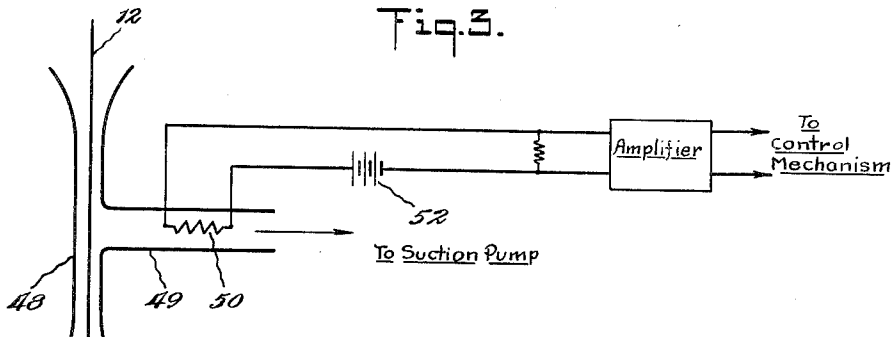


Fig. 4.

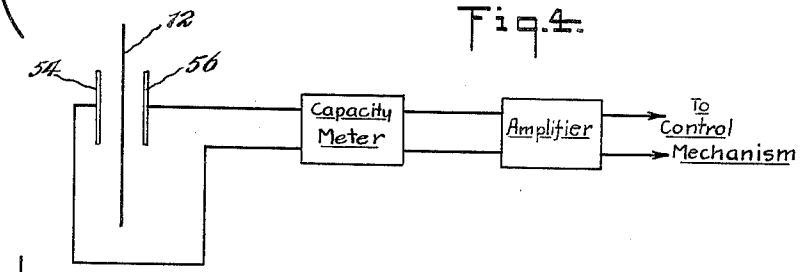


Fig. 5.

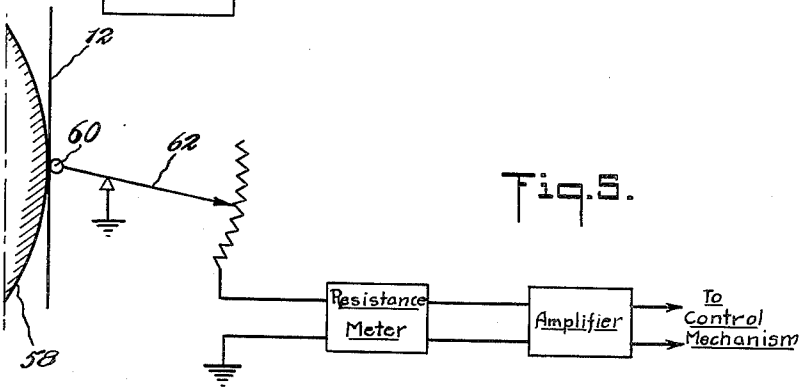
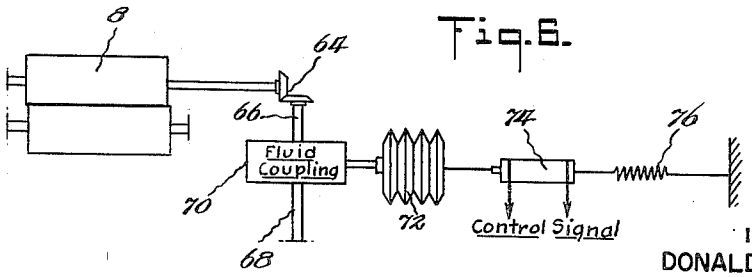


Fig. 6.



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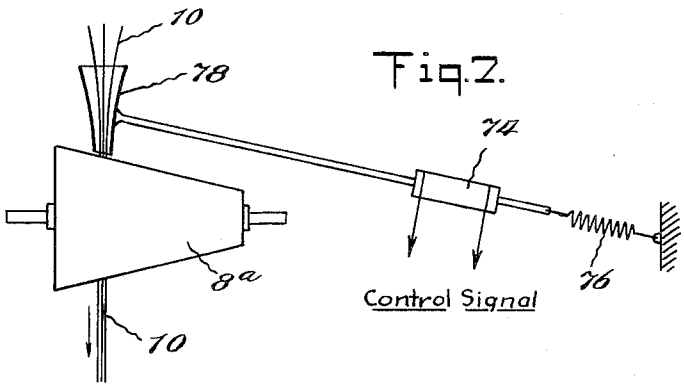


Fig. 2.

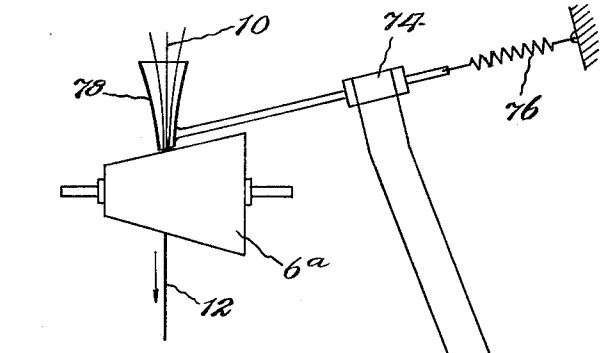
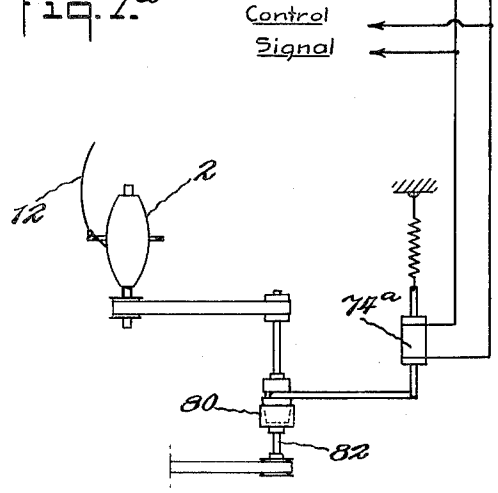


Fig. 2a



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Fig. 8.

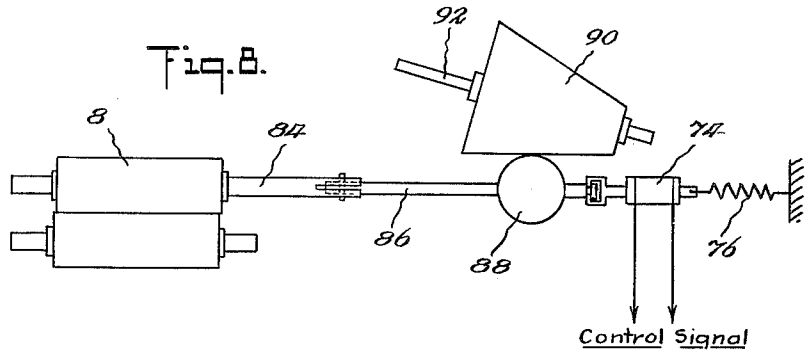


Fig. 8.a

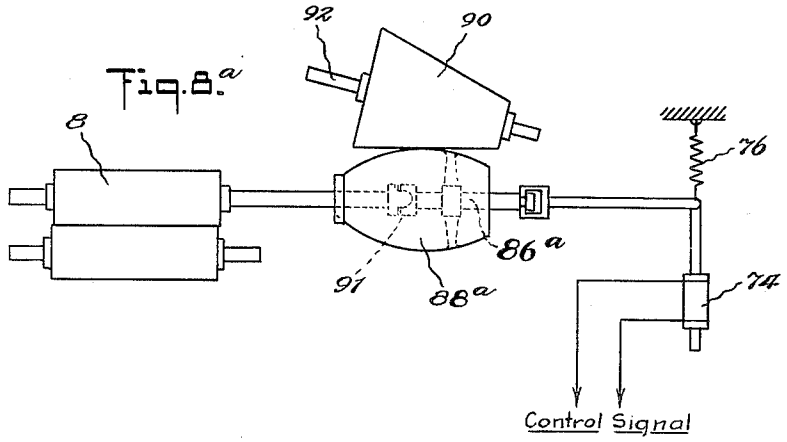
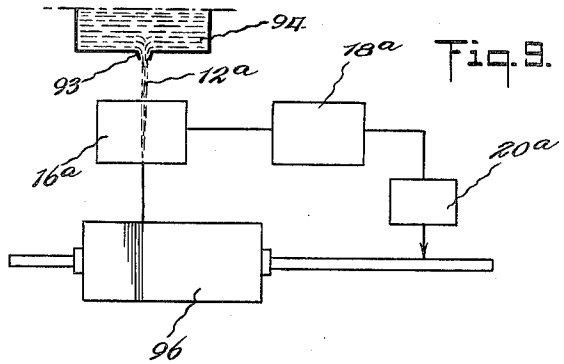


Fig. 9.



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CONTROL METHOD AND MEANS

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Application March 18, 1947, Serial No. 735,457

7 Claims. (Cl. 57—97)

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My present invention relates to methods and means for control of dimensions of materials during manufacture. My invention is particularly adapted for continuous control of yarn diameter during the spinning operation but the broad features of the invention have a much wider application, as will be apparent as the description proceeds. The invention, as applied to yarn diameter control, is applicable to any type of yarn, whether formed from staple fibers or from continuous filament, and may be employed to control the spinning operation of direct tow-to-yarn as well as of the usual roving to yarn spinner.

Workers in the textile industry have devised various mechanisms for measuring and recording yarn diameters but so far as I am aware no one has heretofore suggested or disclosed how such mechanisms could be used to insure substantial uniformity in yarn diameter. In accordance with the preferred embodiment of the present invention, as applied to yarn diameter control, I utilize any suitable means that is responsive to yarn diameter variations to control, through a suitable servo-mechanism, an element of the yarn spinning mechanism that affects the diameter of the yarn being spun. More specifically, and as applied to the usual spinning mechanism wherein roving is drawn by draft rollers from feed rollers rotating at a lower speed than the draft rollers and the yarn is wound on a rapidly rotating spindle, I position the yarn diameter responsive device preferably between the draft rollers and spindle and control from that device the draft ratio, that is, the ratio of the peripheral speed of the draft rollers to that of the feed rollers. Various means may be utilized for adjusting the draft ratio to control yarn diameter and various yarn diameter responsive devices may be employed. In the accompanying drawings I have indicated more or less diagrammatically various types of mechanisms suitable for carrying out the method of the invention.

Fig. 1 is a diagram indicative of apparatus embodying the invention and operative to control yarn diameter;

Figs. 2, 2*a*, 3, 4, and 5 are diagrams illustrating alternative yarn diameter responsive devices suitable for use as one element of the equipment of Fig. 1;

Figs. 6, 7, 7*a*, 8 and 8*a* are diagrams illustrating alternative mechanisms for controlling the draft ratio of the spinning mechanism of Fig. 1;

Fig. 9 is a diagram illustrating the invention as applied to control of diameter of continuous filaments.

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In Fig. 1 a conventional unit of a spinning machine is indicated as comprising the spindle 2, with its traveller 4, the draft rollers 6 and feed rollers 8. Only one roller 6 and one roller 8 is shown in the drawings but it will be understood that the draft rollers comprise one driven roller and one idler roller between which the rovings 10 pass and emerge as yarn 12 and similarly the feed rollers comprise one driven and one idler roller between which the rovings 10 pass. In accordance with the preferred embodiment of the invention, the yarn 12 during its travel from the draft rollers 6 to the yarn guide 14 passes through a device 16 which responds to variations in the diameter of the yarn and which operates, upon departure of the yarn diameter from a predetermined value, to actuate a servo-motor 18. The motor 18 in turn operates to actuate a control mechanism 20 to adjust the draft ratio in a direction to return the yarn diameter to the predetermined value or range. Mechanism 20 may adjust the draft ratio by adjustment of the rate of delivery of the feed rollers as indicated by the line 21 or by adjustment of the rate of delivery of the draft rollers as indicated by the line 23, or by both such adjustments. Preferably, mechanism 20 controls the rate of delivery of the feed rollers.

Various mechanisms could be used for the device 16 of Fig. 1, and examples of suitable devices are illustrated diagrammatically in Figs. 2 through 5.

In Figs. 2 and 2*a*, photoelectric means responsive to yarn diameter are illustrated. In Fig. 2 a photocell 26 is positioned to receive light from a suitable source 24 after its passage through a lens system 22; a slot 25 being positioned between parts of the lens system. The yarn 12 passes between the photocell 26 and lens system 22 so as to intercept some of the light. A second, or balancing, photocell 28 is positioned to receive light from source 24 after passage through a slot 30. The positive terminal of a battery 32 is connected to the anode of cell 26, and the negative terminal of that battery is connected to ground and to the positive terminal of a battery 34, of equal voltage, and of which the negative terminal is connected to the cathode of cell 26; the cathode of cell 28 and anode of cell 26 being connected together by a lead 36. A resistor 38 has one end grounded and its other end connected to lead 36. An amplifier 42 is connected across the resistance 38. With the above described arrangement, when the current through the photocells are equal, no current flows through the resistor 38, and no potential difference appears across the input terminals of the amplifier. Suitable adjustment, as of

the distance of cell 28 to the light source 24, or of the size of slot 30, or the like, may be made to insure equal current through the photocells when the diameter of the yarn 12 is that desired. If then, the diameter of the yarn increases at any time, the current through cell 26 decreases with the result that the potential of lead 36 will be positive with respect to ground and current will flow through resistor 38, and a potential difference of a magnitude depending upon the change in yarn diameter will be applied across the amplifier input terminals. The amplified voltage appearing across the output terminals of the amplifier can then be used, as hereinafter described in connection with Figs. 6 to 8*a* inclusive, to increase the draft ratio until the voltage across resistor 38 returns to zero, indicating a return of yarn diameter to the desired diameter.

Conversely, when the yarn diameter is less than that desired, the current through photocell 26 exceeds that through cell 28 and the potential of lead 36 becomes negative, causing application of potential difference across the amplifier input terminal in a direction to cause reduction in draft ratio.

Instead of arranging photocells to respond, as in Fig. 2, to the direct light from a source, the response could be by reflected light as indicated diagrammatically in Fig. 2*a*. In this embodiment of the invention, light from a source 24*a*, after passage through a lens 22*a*, illuminates the yarn 12 and a photocell 26*a* is positioned to receive light reflected from the yarn surface. A resistor 38*a* and battery 34*a* are connected in series with the cell 26*a*. Thus the current through the cell is dependent upon the diameter of the yarn and variations of such current from a value corresponding to the desired yarn diameter can be utilized to control draft ratio. For example the indicating needle 41 of a voltmeter 43 connected across the resistor 38*a* could close one circuit of a reversible motor 46 when the voltage across resistor 38*a* increases to a predetermined value and could close the other circuit of the motor when the voltage drops to a predetermined figure; rotation of the motor in one direction, that caused by excess current through the cell 26*a* operating to increase the draft ratio and rotation of the motor in the other direction caused by too little current through the cell 26*a* operating to decrease the draft ratio.

In Fig. 3 the yarn diameter responsive device includes a capillary tube 48 through which the yarn passes, and from which air is drawn by suction applied to a branch tube 49. A resistor 50 is positioned in the branch pipe 49 and is supplied with current from a battery 52. If a constant suction is applied to the pipe 49, the air flow past the resistor 50 will vary with the diameter of the yarn and consequently the temperature of resistor 50 and hence its resistance will vary accordingly. Variations in current through the resistor 50 can be suitably amplified and utilized for control of draft ratio.

In Fig. 4 control in response to variations in capacity resulting from yarn diameter variations is indicated; the yarn 12 passing between plates 54 and 56 of an air condenser so as to affect the capacity thereof.

Fig. 5 illustrates diagrammatically a contact method of determining yarn diameter. In this arrangement the yarn 12 passes between a fixed surface 58 and a light roller 60 carried on one end of a pivoted rod 62. The roller will follow variations in thickness of the yarn and cause rotation of lever 62. Such rotation may be utilized to vary a resistance as diagrammatically illustrated. Such resistance variations, after amplification can be made to generate suitable control signals.

Various yarn diameter responsive devices have now been briefly described in connection with Figs. 2 to 5 inclusive. The invention in its broadest aspect is not concerned, however, with the particular device employed as any device which responds to yarn diameter variations while the yarn is moving would be suitable for use as the device 16 of Fig. 1. Nor is the particular type of control signal obtained from the responsive device important as electrical, mechanical, pneumatic or hydraulic control signals could readily be utilized by those skilled in the art for control of the draft ratio of the spinning unit of Fig. 1. For this reason, and for simplicity, the alternative mechanisms, illustrated diagrammatically in Figs. 6 to 8*a* inclusive and now to be described have been indicated as solenoid actuated but other types of actuation could as readily be employed.

In Fig. 6 control of draft ratio is effected by varying the rate of rotation of the driven feed roller 8. The driven roller 8 is driven through spur gears 64 by a shaft 66, which shaft is coupled to a drive shaft 68 through a fluid coupling 70. The liquid level within the coupling 70, and therefore the degree of coupling or slip between shafts 66 and 68 is controlled by expansion and contraction of a bellows 72 which in turn is controlled by the solenoid 74 acting in opposition to a spring 76. Thus variations in yarn diameter transmitted as control signals to the winding of coil 74 operate to change the rate of rotation of the feed roller 8 in directions and by amounts sufficient to eliminate the variations.

Instead of changing the rate of rotation of the driven feed roller as indicated in Fig. 6, the arrangement indicated diagrammatically in Fig. 7 could be employed. In this case, the driven feed roller 8*a* is of tapered diameter and is driven at a constant rate of rotation. The rovings 10 as they pass to the feed rollers are collected in a trumpet 78 and the position of this trumpet longitudinally along the feed roller 8*a* is controlled by the solenoid 74 in response to the control signal. When the trumpet 78 moves the rovings to that end of roller 8*a* having the largest diameter and hence the highest peripheral speed, the draft ratio is at a minimum and conversely when the trumpet 78 moves the rovings to the other end of roller 8*a*, the draft ratio is a maximum.

In Fig. 7*a* the same type of control, as just described, namely the use of a trumpet for moving the roving longitudinally along tapered rollers is indicated as applied to the draft rollers 6*a*. In this case, as the draft ratio is controlled by adjustment of the draft rollers, the rate of delivery of the yarn 12 will vary with changes in the position of the trumpet 78. If it is desired to avoid corresponding variations in the number of turns of yarn per unit length on the spindle the rate of rotation of the spindle 2 can be varied concurrently with change in trumpet position, as, for example, by control of a friction clutch 80 from a solenoid 74*a* connected in parallel with solenoid 74; the clutch 80 serving to couple the spindle to the constant speed driven shaft 82.

In Fig. 8, as in Fig. 6, the draft ratio is controlled by control of the rate of rotation of the driven feed roller 8. In this embodiment of the

invention the shaft 84 of the driven roller 8 is coupled to a shaft 86 by a connection permitting relative longitudinal motion of the two shafts. For example, the shaft 84 may be tubular and be provided with a plurality of longitudinal slots and the shaft 86 may extend into the shaft 84 and be provided with pins extending into the longitudinal slots. Shaft 86 has fixed thereto a generally spherical member 88 for frictional engagement with a conical roller 90 driven at a constant rate by drive shaft 92. With this arrangement, the rate of rotation of feed roll 8 depends upon the diameter of the roller 90 at the point of contact with member 88 and hence control of draft ratio is effected by longitudinal movement of shaft 86 under control of solenoid 74; the angular position of shaft 92 relative to shaft 86 being such as to insure engagement of member 88 at any desired diameter of roller 90.

In Fig. 8a another form of variable coupling between the conical roller 90 and the shaft of feed roller 8 is indicated. In this arrangement the shaft of roll 8 is connected by a suitable universal coupling 91 to a shaft 86a to which is keyed a member 88a of varying diameter. The angular position of shaft 86a relative to the shaft of the roll 8 controls the point of engagement of member 88a with conical roller 90 and hence the rate of rotation of the roll 8; the angular position of shaft 86a being controlled by the solenoid 74.

The invention as applied to yarn diameter control has now been described with reference to a unit of a conventional machine for spinning yarn from rovings. Obviously the invention is equally applicable for the control of yarn diameter by control of draft ratio in a machine for spinning yarn directly from tow. The invention is applicable also to the control of diameter of drawn filaments such as glass, and such application of the invention is diagrammatically illustrated in Fig. 9.

In Fig. 9, 93 represents a nozzle through which the filament 12a is drawn from the molten bath 94 by the rotation of a drum 96; the rate of rotation of the drum, assuming constant temperature of the bath, determining the elongation and hence diameter of the filament. In accordance with the invention, the filament 12a is passed through a diameter responsive device 16a, which may be of the type indicated in Figs. 2 through 4 inclusive. Device 16a operates through a suitable servomotor 18a to control, through a control mechanism 20a, the rate of rotation of the drum 96. The device 16a may be responsive to the diameter of a single filament or to the average of a plurality of filaments if desired. The same type of control, namely of the rate of rotation of the receiving drum to vary the tension on the filament in response to filament diameter could be utilized for the control of the diameter of extruded filaments.

In the foregoing description of the invention as applied to maintenance of substantial constancy of diameter of yarn or of filaments, nothing has been said about insurance against hunting of the regulators, as anti-hunting regulation is well known and specific illustration of devices to prevent over travel of the control means in any particular device is not deemed necessary.

In some instances it might be desired to change the diameter of a yarn or filament at regular or irregular intervals and at the same time insure correct diameter during such intervals. To effect this result, if the periodicity of the desired changes in diameter are large compared to the rate of travel of the yarn or filament it would only be necessary to change the bias of the diameter responsive device, that is, the value corresponding to the desired diameter, at a rate corresponding to the periodicity of the desired diameter changes. Such an arrangement might be advantageously employed in wire drawing operation to vary die size periodically and thereby obtain a wire of diameter changing in accordance with any desired pattern, or in yarn manufacture to produce a slubby yarn.

The invention has now been described with reference to various embodiments thereof. The invention is of particular utility in the textile industry and particularly important when used to control diameter of worsted yarns. Many expensive and time consuming doubling operations are ordinarily practiced on worsted rovings in an attempt to insure uniform roving diameter. By means of the present invention, most, if not all, of these doubling operations may be omitted. Rovings of non-uniform diameter may be delivered to a spinning machine equipped with apparatus of the invention and automatic control of draft ratio will insure yarn of substantially uniform diameter, irrespective of the diameter of the rovings.

Although I prefer, when controlling yarn diameter, to position the diameter responsive device between the draft rollers and the spindle, this is not essential as the diameter of the roving in the ratch varies with the diameter of the yarn and hence, measurement of roving diameter could be utilized in control of yarn diameter. Thus, the diameter responsive device could be positioned in the ratch, between the feed and draft rollers, or diameter measurement could be made directly at the nips of the draft rollers.

By "filamentary material" in the accompanying claims I intend to include yarn and rovings, as well as wire, glass or other synthetic filaments to which the term is more often applied.

I claim:

1. The method of controlling a yarn spinning machine to maintain substantially constant yarn diameter which comprises automatically adjusting the draft of the machine in response to variations in the diameter of the drafted yarn while maintaining a constant relationship between the rate of feed of yarn and rotation of the spindle.

2. The method of controlling a yarn spinning machine to maintain substantially constant yarn diameter which comprises automatically adjusting the rate of feed of the draft rollers in response to variations in the diameter of the drafted yarn and simultaneously adjusting the rate of rotation of the spindle to maintain constant relationship between the rate of feed of yarn and rotation of the spindle.

3. The combination with a yarn spinning machine having driven feed and draft rollers and a driven spindle for twisting the drafted material of a device responsive to variations in diameter of drafted material at a point in its path between the said draft rollers and the spindle and adapted to produce an electrical control signal upon departure of the diameter of the material from a predetermined value, means for amplifying the signal produced by said device and means actuated by said amplified control signal for adjusting the rate of delivery of the draft rollers in a direction to compensate for the departure in material diameter initiating said signal and for

simultaneously adjusting the rate of rotation of said spindle to maintain a constant relationship between the rate of feed of yarn and rotation of the spindle.

4. The combination according to claim 3 wherein said last mentioned means operates upon actuation to change the rate of rotation of the draft rollers.

5. The combination according to claim 3 wherein the draft rollers are of conical contour and said last mentioned means operates, when actuated, to vary the location along the draft roller at which the rovings are fed.

6. The combination with a yarn spinning machine having draft and feed rollers and a spindle of a device responsive to variations in diameter of the yarn being spun, and means controlled by said device for maintaining a constant relationship between the rate of feed of yarn and rotation of said spindle.

7. The combination with a yarn spinning machine having draft and feed rollers and a spindle of a device responsive to variations in diameter of the yarn being spun, and means controlled by said device for adjusting the rate of speed of said draft rollers and simultaneously adjusting the rate of rotation of said spindle to maintain constant relationship between the rate of feed of yarn and rotation of the spindle.

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