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[54] **METHOD OF AND APPARATUS FOR REGULATING THE SPEED OF RING OR SPINDLE RAILS ASSOCIATED WITH TEXTILE MACHINES**

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[51] **Int. Cl.** **D01h 1/24,** D01h 1/36

[58] **Field of Search** 57/54, 93, 95, 98, 99, 100, 57/156; 242/26.1, 26.2, 26.3, 26.4

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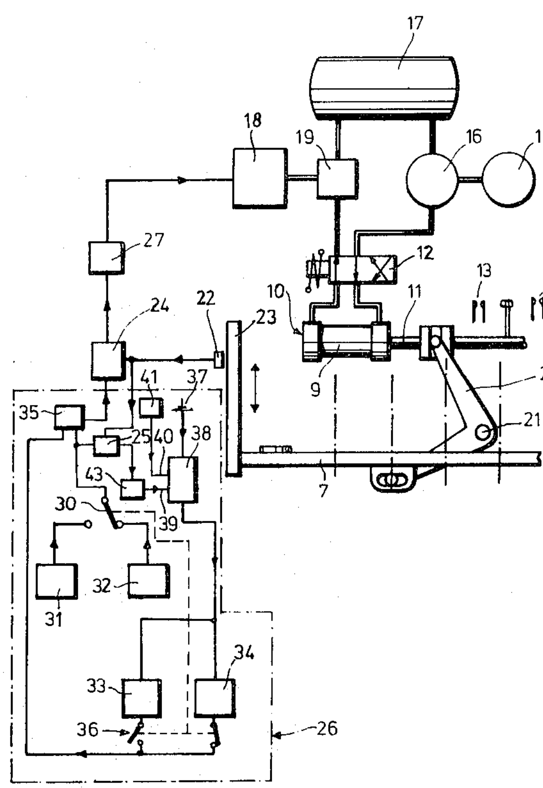
[57] **ABSTRACT**

In textile machines, for obtaining a more uniform wound package on a bobbin supported by a spindle, the motion of the reciprocating ring rail is controlled in such a manner that the level of the desired speed designed for the rail travel after reversal of direction, is temporarily increased for the duration of the deceleration and acceleration phases in and about the upper and lower reversal points of the ring rail travel.

11 Claims, 4 Drawing Figures



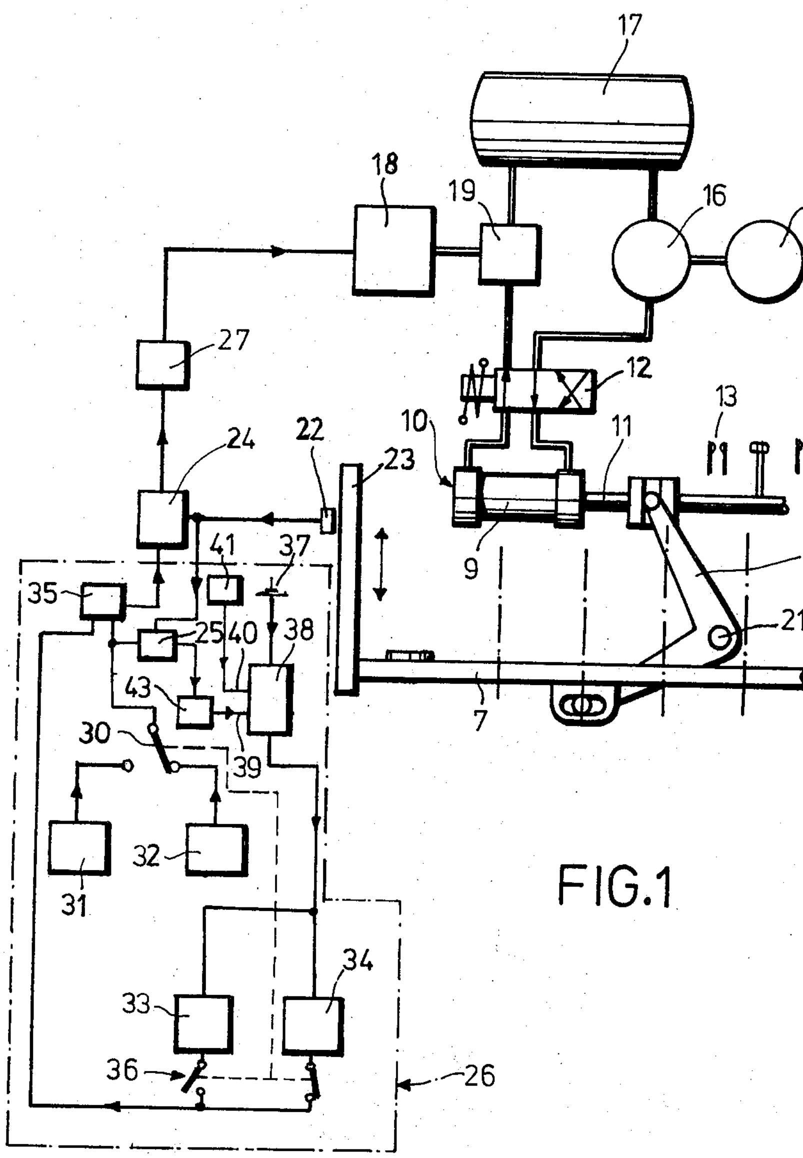


FIG.1

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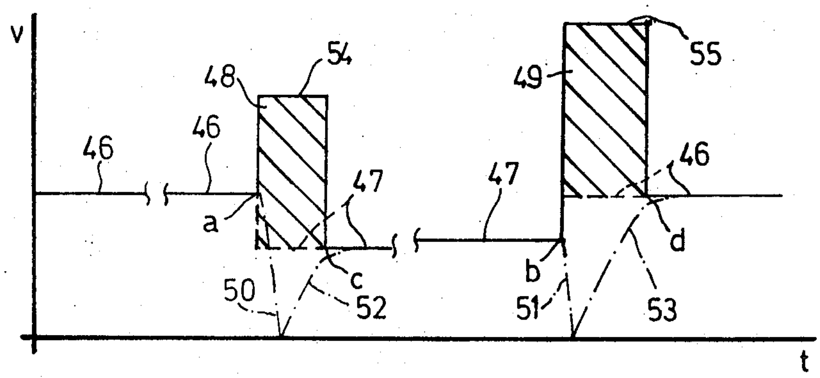

FIG.2

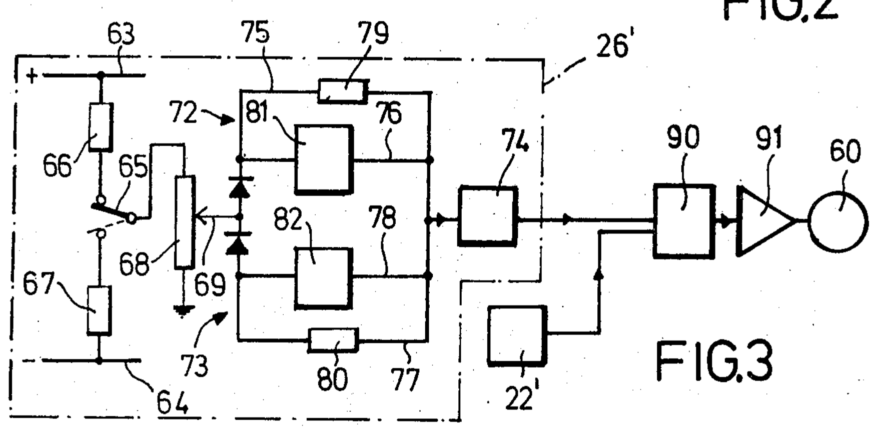

FIG.3

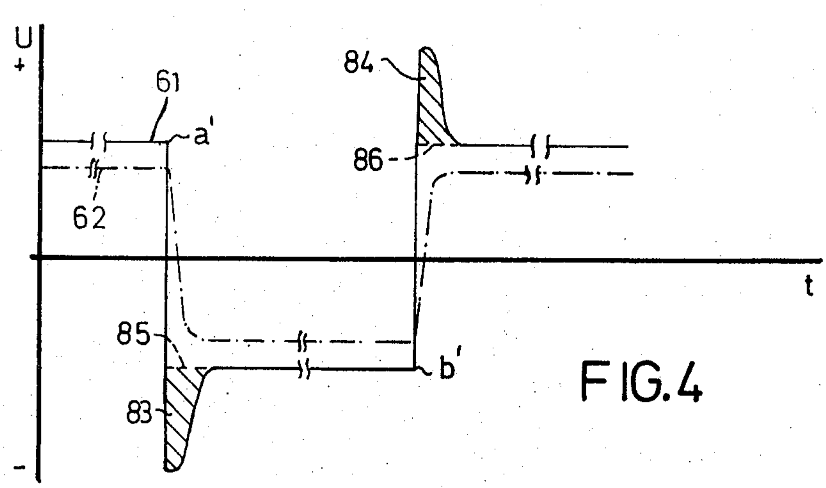

FIG.4

METHOD OF AND APPARATUS FOR REGULATING THE SPEED OF RING OR SPINDLE RAILS ASSOCIATED WITH TEXTILE MACHINES

BACKGROUND OF THE INVENTION

This invention relates to a method of and apparatus for the regulation of speed of ring or spindle rails which are reciprocated vertically by drive means and which are associated with textile machines. The signals determining the rail speed are automatically set to values that are directly proportionate to the positive difference between the actual value and the desired value of the rail speed.

In textile machines in which yarns, threads, twisted yarns and the like are wound on bobbins or spools inserted on spindle shafts of textile spindles, at each winding station the yarn is wound by means of a traveler orbiting on a spinning or twisting ring while the spindle shaft carrying the bobbin or spool executes a rotary motion. The spindle or twisting rings are mounted on so-called ring rails, whereas the spindles are mounted on so-called spindle rails. In order to effect the necessary relative motion between the spindle rail and the ring rail for the winding of the yarn into a yarn package, in most instances it is the ring rail which is continuously reciprocated up and down parallel to the axis of the spindles. In some cases, however, it is expedient to vertically reciprocate the spindle rail instead. In order to obtain a uniform wound package, it is known to control the vertical reciprocating speed of the spindle rail or ring rail. Such a speed regulation is particularly important in draw twisting machines in which endless synthetic yarns or twisted yarns are wound on a bobbin. The regulation is effected in a known manner by predetermining a desired value (which may be constant, or which may be different for the upward motion and the downward motion or which may be varied in time) and continuously sensing the actual momentary values of the rail speed, for example, by means of a tachometer. The difference between the desired value and actual value constitutes the deviation to be compensated and thus, signals representing this deviation are applied to the input of a regulating apparatus, at the output of which there appear regulating signals which affect a setting mechanism for adjusting or changing the rail speed in a sense in which the above-noted deviation will be decreased. Most often, the regulating apparatus is a PI or PID regulator. For driving the rail, usually hydraulic cylinder-and-piston units are used. The reversal of the direction of motion of the piston is effected by limit switches which are actuated when the rail reaches the reversal points of its motion and which, at the same time, may set the constant or timely variable desired value assigned to the new direction of rail motion. The speed of the ring rail is set by means of a known servo valve which controls or regulates the flow rate of the hydraulic liquid entering into or flowing out of the cylinder. The invention, however, is not limited to the aforenoted hydraulic drive means, but may find application in any type of arrangement adapted for reciprocating the rails.

During each reversal of the rail motion, the rail speed is first gradually reduced to zero, and then gradually increased until the desired speed value in the new direction is reached.

Since rails of the aforenoted type and their driving mechanisms have a substantial inert mass, the afore-mentioned phases of deceleration and acceleration may have such a long duration that disadvantageous irregularities in the wound package may appear at the height of the reversal points. These irregularities may be more pronounced as the rail speed increases. In addition, the regulating apparatus, because of technical considerations, is usually designed as a PI or as a PID regulator in which the periods of deceleration and acceleration are particularly long.

OBJECT AND SUMMARY OF THE INVENTION

It is an object of the invention to provide an improved method of and apparatus for decreasing the duration of the deceleration and acceleration phases at the lower and/or upper reversal points of the rail travel particularly in systems which incorporate a PI or PID regulation of the rail speed.

Briefly stated, according to the invention, from the moment of switching of the drive means to the new direction of rail motion, the desired value is increased during the deceleration and acceleration phases at the lower and/or upper reversal points with respect to the desired speed value designed for the new direction of rail motion and effective after the termination of the deceleration and acceleration phases.

More particularly, the maximum increase of the desired value is at least 60–100 percent, preferably at least 140 percent of the non-increased desired value effective after the termination of the increase of the desired speed value.

By practicing the aforeoutlined method, the duration of the deceleration or acceleration phase of the rail is substantially decreased, for example, to less than one-half of the duration required when an increase of the desired value is not effected. Thus, tests with a draw twisting machine having a maximum ring rail stroke of 450 mm and a minimum stroke duration of 6 seconds, yielded the following values:

The duration of the deceleration and acceleration phases without an increase of the desired value was approximately 200 milliseconds. In a second test, during the deceleration and acceleration phases the new desired value was increased approximately 140 percent of the normal (non-increased) desired value. The duration of the deceleration and acceleration phases was then approximately 80 milliseconds.

The desired value of the ring rail speed may be set in a known manner for both the upward motion and the downward motion of the ring rail. The desired value may be constant or may slowly change as a function of time.

The invention will be better understood, as well as further objects and advantages become more apparent, from the ensuing detailed specification of several exemplary embodiments taken in conjunction with the drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic view of a drive means for a ring rail of a draw twisting machine and a block diagram of a first embodiment of a speed regulating apparatus associated with said drive means;

FIG. 2 is a diagram illustrating the mode of operation of the regulating apparatus according to FIG. 1;

FIG. 3 is a block diagram of a second embodiment of a regulating apparatus according to the invention; and

FIG. 4 is a diagram illustrating the mode of operation of the embodiment shown in FIG. 3.

DESCRIPTION OF THE EMBODIMENTS

Turning now to FIG. 1, the drive means reciprocating a fragmentarily shown ring rail **7** includes a hydraulic piston-and-cylinder unit **10**, the cylinder **9** of which is stationary and the piston of which, together with the associated piston rod **11** may be changed in its direction of motion by means of a switch valve **12** controlled by limit switches **13, 14.** By virtue of the alternate actuation of these switches, in the work chambers of the cylinder **9** there is alternately admitted hydraulic liquid drawn from a tank **17** and pressurized by a pump **16** driven by a motor **15.** The hydraulic liquid leaving the momentarily non-energized work chamber of the cylinder **9** flows through the switch valve **12** and, through a quantity control valve **19** controlled by a setting mechanism **18,** back into the tank **17.** The setting of the quantity control valve **19** determines the speed of the piston of the piston-and-cylinder unit **10** and thus the stroke speed of the ring rail **7** which is moved by the piston rod **11** through a bell crank lever **20** pivotably held at **21** in a stationary bearing. For the purpose of changing the reversal point of the ring rail motion, the limit switches **13, 14** may be shifted parallel to the axis of the piston rod **11.** Thus, the position of the limit switch **14** determines the location of the upper reversal point of the ring rail **7,** whereas the position of the limit switch **13** determines the location of the lower reversal point of the ring rail **7.** The speed of the ring rail is continuously sensed by means of an actual value transmitter **22** which measures the speed by means of a bar **23** affixed to and moving as a unit with the ring rail **7.** The actual value transmitter **22** may be, for example, an inductive speed measuring device or a tachometer which is connected in such a manner that its output signal, independently from the direction of the ring rail travel, always has the same polarity and is thus proportionate to the absolute value of the ring rail speed. The output of the actual value transmitter **22** is applied to a differential stage **24** generating the deviation to be compensated and further, to another differential stage **25,** the function of which will become clear as the specification progresses.

The regulating apparatus further has a desired value transmitter device generally indicated at **26** and a continuous regulator **27** which is designed expediently as a PI or a PID regulator or, in simpler cases as a P regulator. To the input of the regulator **27** there is applied in a known manner the signal characterizing the deviation to be compensated which, as a function of the polarity and the magnitude of said deviation, generates at its output a regulating signal which is applied to the setting device **18** of the quantity control valve **19.**

The greater the positive deviation to be compensated, the greater the extent to which the quantity regulating valve **19** is opened and, accordingly, the greater will be the automatically adjusted speed of the ring rail. Conversely, the greater the negative deviation to be compensated, the more the return of the hydraulic liquid is throttled by means of the quantity regulating valve **19** and, accordingly, the more is the ring rail speed decreased, since the deviation to be compensated equals the difference which exists between the actual value and the desired value of the ring rail speed and which is to be eliminated by the regulating apparatus.

The desired value transmitter device **26** has two main desired value transmitters **31** and **32** alternately energizable by means of a switch **30.** The desired value transmitter **31** generates the desired value for the speed of the downward rail motion, whereas the desired value transmitter **32** generates signals for the speed of the upwardly moving ring rail. Further, there are provided two additional desired value transmitters **33, 34** which serve for the generation of additional desired values. The latter, during the deceleration and acceleration phases of the ring rail appearing at and about the reversal points of its traveling path are added as increased desired values in an adding stage **35** to the desired values generated by the desired value transmitters **31** and **32.** The additional desired value transmitter **33** generates the additional desired value at the upper reversal point of the traveling path of the ring rail, whereas the desired value transmitter **34** generates the additional desired value at the lower reversal point of the ring rail travel. The two additional desired values may thus be set to different values. This possibility is advantageous, since it takes into account the different physical conditions of the speed reversal at the upper and lower reversal points.

The outputs of the two additional desired value transmitters **33, 34** are, by means of the switching device **36** controlled by the limit switches **13, 14,** alternately connected to the adding stage **35.** Each additional desired value transmitter **33, 34** generates an output signal of the constant, adjustable magnitude every time a voltage of a DC voltage source **37** is applied to its input. The voltage source **37** is connected to the input of a gate stage **38** which blocks the transmission of the DC voltage of the voltage source **37** to the input of the additional desired value transmitters **33, 34** every time both of its control inputs **39, 40** have no voltage thereon. Conversely, the gate stage **38** is opened every time one or both of the control inputs **39, 40** are energized. The control input **40** is connected to a pulse transmitter **41** which, every time one of the limit switches **13, 14** is actuated, transmits an output signal of constant, preferably adjustable duration so designed that it corresponds approximately to the duration of the deceleration phase at the upper and lower reversal point of the ring rail motion. The other control input **39** of the gate stage **38** is connected to the output of a threshold stage **43** which delivers an output voltage for maintaining the gate stage **38** open every time the difference, formed in the differential stage **25** between the desired value delivered by the momentarily operational main desired value transmitter **31, 32** and the actual value delivered by the actual value transmitter **22** exceeds a predetermined, preferably adjustable, positive magnitude. As long as this difference remains below the threshold value of the threshold stage **43,** the output terminal of the latter has no voltage thereon.

The mode of operation of the aforedescribed regulating apparatus will be further explained with reference to the diagram illustrated in FIG. **2.** Here, the abscissa t indicates the duration and the ordinate v indicates the desired and actual speed values of the rail motion. The curve in solid lines represents the output signal of the adding stage **35** of the desired value transmitting device **26.** The curves shown in broken lines indicate the non-increased desired values delivered by the main desired value transmitters 31, 32 and applied to the input of the adding stage 35 during the increase of the desired value.

The dash-dot curves 50-53 represent the actual value of the ring rail speed during the deceleration and acceleration phases of the ring rail 7 at the reversal points of their traveling path.

During the reversal of motion of the rail 7 initiated at points *a* and *b*, first the rail speed is decelerated to zero; the descending dash-dotted curve portions 50 and 51 of the actual value of the rail speed illustrate the deceleration phase. After passing through the zero speed value, the rail 7 is accelerated to the new desired value 46 or 47, respectively; the ascending dash-dotted curve portions 52, 53 illustrate the acceleration phase of the rail 7. In order to shorten the duration of the deceleration and acceleration phases 50, 52 and 51, 53, during these phases, the new respective desired value 46, 47 is increased by virtue of an additive superposition of the associated additional desired value 48 and 49 (shown as a hatched area), so that the effective desired value corresponds to the curve ranges 54, 55.

The curve ranges 46 correspond in this example to the desired value of the rail speed during the downward motion thereof. This desired value is higher than the desired value 47 set for the upward motion of the ring rail. The desired value 46 is constant, whereas the desired value 47 is continuously increased by a small value during the period of upward motion of the ring rail. The aforenoted continuous increase is not visible in the diagram since the latter shows only very short time periods.

When the ring rail 7 has reached its lower point of reversal as indicated at *a* in FIG. 2, the limit switch 13 is activated. Thereupon, the switching valve 12, the switch 30 and the switching device 36 are simultaneously reversed, so that the main desired value transmitter 32 and the additional desired value transmitter 34 are connected to the adding stage 35. The activation of the limit switch 13 simultaneously also excites the pulse transmitter 41 for the generation of a pulse which, for example, may last for 50 milliseconds. As a result, the gate stage 38 is opened and the additional desired value transmitter 34 is energized, so that to the desired value 47 (FIG. 2) applied by the main desired value transmitter 32 to the adding stage 35, there is added an additional desired value 48 of constant magnitude. Consequently, at the output of the adding stage 35 there appears an increased desired value 54, whereby in the differential stage 24 there is formed the difference between the increased desired value and the actual value of the rail speed. Signals representing this difference are applied to the regulator 27 which, in turn, in view of the large positive deviation to be compensated, generates a regulating signal which opens the quantity control valve 19 to a correspondingly large extent. Thus, the ring rail speed is first very rapidly decelerated, as shown at 50 in FIG. 2, and then is very rapidly accelerated in its new diection of motion, as shown at 52. When the output voltage of the pulse transmitter 41 turns zero, there has already been set a substantial difference between the desired value 47 appearing at the output of the main desired value transmitter 32 and the actual value 50, 52 of the rail speed since at this moment the rail speed is close to its zero value. Thus, the threshold stage 43 delivers an output voltage which maintains the gate stage 38 open, so that the increased level of the desired value is maintained. During the acceleration phase 52 the input voltage of the threshold stage 43 decreases fast because of the rapid acceleration of the ring rail, and when the said input voltage falls below a predetermined small value, no voltage will prevail on the output of the threshold stage 43. Consequently, the gate stage 38 closes and the output of the additional desired value transmitter 34 will have zero voltage as shown at *c* in FIG. 2. From this moment on it is only the new desired value 47 delivered by the main desired value transmitter 32 which is effective and the speed of the upward motion of the ring rail is therefore determined solely by the desired value 47 of the main desired value transmitter 32.

When the ring rail 7 reaches its upper reversal point as shown at *b* in FIG. 2, the limit switch 14 is actuated. As a result, the switch valve 12, the switch 30 and the switching device 36 are simultaneously reversed so that now the main desired value transmitter 31 and the additional desired value transmitter 33 are connected with the adding stage 35.

Simultaneously, the pulse transmitter 41 generates a pulse which opens the gate stage 38, so that the desired value transmitter 33 generates the additional desired value 49 which, by virtue of the cooperation between the components 41, 25, 43 and 38 is maintained until point *d* shortly prior to the termination of the deceleration and acceleration phases.

The aforedescribed increases in the desired values are repeated at each reversal of the ring rail motion. The increased levels 48, 49 of the desired values at the lower and upper reversal points of the ring rail motion are different to permit their adaptation to the desired values of different magnitude.

Turning now to FIG. 3, the regulating apparatus shown therein is designed for a ring rail or spindle rail drive means which, instead of the valves 12 and 19 shown in FIG. 1, has a sole servo valve 60 which combines the functions of the aforenoted two valves 12, 19 by setting the downward or upward direction of the rail motion automatically as a function of the polarity of the desired value voltage 61 (FIG. 4). The greater the desired value voltage of the corresponding polarity, the greater the speed setting for the rail.

The regulating apparatus according to FIG. 3 includes an actual value transmitter 22' for the actual value 62 (FIG. 4) of the rail speed and a desired value transmitter device 26' which generates DC voltage signals which, in the one direction of the rail motion are always positive, while in the other direction of rail motion are always negative.

The desired value transmitter device 26' has conductors 63 and 64 each being on a constant positive and negative potential, respectively, which, by means of a switch 65 controlled by limit switches disposed at the reversal points of the ring rail may be connected through resistances 66, 67 alternately to the same side of a potentiometer 68. By means of a slider 69 different ratios of the magnitudes of the desired speed values for the two directions of rail motion may be set. In the central position of the slider 69 both desired values are of equal magnitude. To the slider 69 there are connected through rectifiers two circuits 72, 73, the outputs of which are coupled to a desired value amplifier 74. The two rectifiers ensure that dependent upon the position of the switch 65, one or the other of the two circuits 72, 73 is energized, so that in the one direction of motion, the desired value of the ring rail speed is determined by the circuit **72**, while in the other direction the desired value of the rail speed is determined by the circuit **73.** Each circuit **72, 73** has two parallel circuit branches **75, 76** and **77, 78,** respectively. The branches **75, 77** contain resistances **79, 80,** while the branches **76, 78** include non-linear function transmitters **81, 82,** respectively. The latter serve for the generation of the desired value increases **83, 84** (FIG. **4**) and may each include an RC circuit which, subsequent to each energization of the switch **65,** generate a short, decaying voltage pulse by means of differentiating the steep increase of the new desired value voltage. This voltage pulse which effects the desired value increments **83, 84,** is additively superposed on the constant, non-increased desired value voltage **85, 86** applied through the resistance **79** or **80** to the desired value amplifier **74.** After the decay of the voltage pulse **83** or **84** generated by the non-linear function transmitter **81** or **82,** respectively, the circuit branch **76** or **78** which contains the function transmitter, becomes inactive so that upon termination of the desired value increase, the effective desired value is determined solely by the voltage applied to the desired value amplifier **74** through the circuit branch **75** and **77,** respectively. The output signals of the desired value amplifier **74** and those of the actual value transmitter are applied to a regulator amplifier **90** having PI characteristics. From the difference between the two signals there is generated a regulator signal which, after being amplified in a power amplifier **91,** controls the servo valve **60** in such a manner that the rail speed is regulated to correspond to its predetermined desired value.

All the amplifiers **74, 90** and **91** of this regulating apparatus are DC voltage amplifiers, the output voltages of which have, in a stationary condition, the same polarity as their input voltages.

In FIG. **4** the DC voltages applied to the input of the regulator amplifier **90** are shown in graph form. The desired value voltage is indicated at **61,** while the actual value voltage is shown at **62.** The abscissa is the time axis t. A switch to reverse from the upward stroke of the rail to a downward stroke occurs at a', while a switch to reverse from a downward stroke to an upward stroke takes place at b'.

Subsequent to each switching step, the new desired value is immediately applied, that is, either the circuit **72** or the circuit **73** will be at a positive or negative voltage. The thus appearing steep voltage increase causes, as described, by means of the associated function generators **81** and **82,** respectively, the short-period voltage increases **83** and **84.** The amplitude and the course of the associated voltage increase is so designed that there is obtained the desired shortening of the period of the deceleration and acceleration phases. Expediently, the individual function generator **81, 82** may be designed in such a manner that the amplitude of its voltage signal is proportionate to the magnitude of any predetermined desired value voltage appearing after its decay. For example, the function generator may have an adjustable resistance which automatically, together with the slider **69** of the potentiometer **68,** is shifted in the required manner for the generation of the aforenoted linear function. The duration of the voltage pulse generated by the function generator **81** or **82,** respectively, is so designed that it corresponds approximately to the duration of the deceleration and acceleration phase of the rail at the reversal points of its path of motion. Expediently, the voltage pulse generated by the function generators is set in such a manner that there is obtained, independently from the magnitude of the desired value, an approximately constant duration of the deceleration and acceleration phases.

As it may be observed from FIG. **4,** the regulating apparatus according to FIG. **3** is so designed that in both directions of rail motion there is regulated a constant difference between the desired value voltage and the actual value voltage.

It is noted that for any desired speed value there is automatically obtained a desired value increment, the magnitude of which is proportionate to that of the desired speed value which is designed to prevail subsequent to the termination of the desired voltage increase. As a result, the greater the ring rail speed, the greater the automatically set output to be delivered by the drive means for changing the direction of the ring rail travel. It is also noted that the desired value increment may be adapted to any desired value in such a manner that the duration of the deceleration and acceleration phases is independent from the magnitude of the desired values.

In a modification (not shown) of the regulating apparatus according to FIG. **3,** in the circuit branches **76** and **78,** instead of the function generators **81** and **82,** there are arranged resistances and an electronic switch in series for opening and closing the associated circuit branch. Further, with each electronic switch there is associated a threshold device, for example, a monostable trigger circuit which, as a function of the difference between the desired value and the actual value of the rail speed, opens and closes for the closing and opening of the appropriate electronic switch. These components are so designed that the electronic switch in the individual circuit branch is closed by means of the threshold device for activating the desired value increase as long as the difference between the desired value and the actual value is above a predetermined limit value. The latter is determined so that the desired value increment is automatically removed by opening the electronic switch shortly before the termination of the deceleration or acceleration phase of the rail.

That which is claimed is:

1. In a method of regulating the speed of a rail associated with the spindles of a textile machine and reciprocated vertically with a speed having assigned thereto a desired value for each direction of reciprocation, the said method including the known step of initiating a reversal of the rail motion towards the end of each stroke to introduce, in succession, a deceleration phase and, in the new direction of travel, an accleration phase, the improvement comprising the step of increasing at least part of the time, the new desired speed value of the rail motion for the duration of said deceleration and acceleration phases at least at one end of the vertical reciprocating motion of the rail, said new desired value being designed for said rail motion at approximately the moment said reversal is initiated, said increase resulting in a level of desired speed value that is above the level of the desired speed effective for said new direction of travel upon termination of the acceleration phase.

2. A method as defined in claim **1,** including the step of predetermining at will the amplitude of said increase.

3. A method as defined in claim 1, including the step of predetermining at will the course in time of said increase.

4. A method as defined in claim 1, wherein said increase has a different value for the upper and the lower reversal points of the rail travel.

5. A method as defined in claim 1, wherein for any desired speed value the increase automatically assumes a magnitude that is a direct function of the desired value prevailing after removal of said increase.

6. A method as defined in claim 1, including the step of adapting said increase to each desired value so that the duration of said deceleration and acceleration phases is substantially independent from the magnitude of the effective desired speed value.

7. A method as defined in claim 1, including the steps of rendering effective said new desired speed value simultaneously with the initiating of said reversal of motion and temporarily superposing on said new desired speed value an additional desired value for obtaining said increase of said new desired speed value.

8. A method as defined in claim 7, including the step of differentiating the increase in time of said new desired value to obtain said additional desired value.

9. A method as defined in claim 1, including the steps of rendering effective said increase simultaneously with the initiating of said reversal of motion and discontinuing said increase when, during the acceleration phase, the difference between the new desired speed value and the actual speed value of the rail motion falls below a predetermined magnitude.

10. A method as defined in claim 9, wherein said increase is automatically rendered effective as a function of the difference prevailing between the new desired speed value and the actual speed value of the rail motion upon initiating said reversal of motion.

11. In a regulating apparatus for controlling the speed of the reciprocating motion of a rail associated with the spindles of a textile machine, said rail being moved by a drive means, the improvement comprising,

A. a desired value transmitter connected to said drive means,

B. an additional desired value transmitter connected to said drive means and

C. means responsive to the end positions of said rail and connected to said additional value transmitter for causing the latter to temporarily apply an additional desired value to said drive means for the duration of the reversal of motion of said rail.

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