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H. LOHEST

3,082,361

FILAMENT WINDING APPARATUS

Filed Nov. 26, 1958

FIG. 1

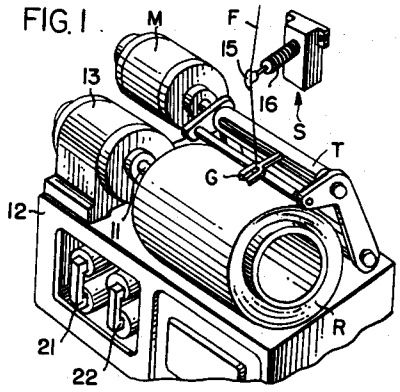


FIG. 2

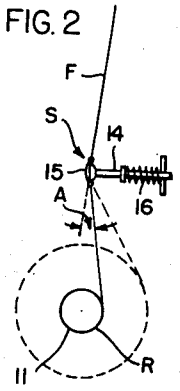


FIG. 3

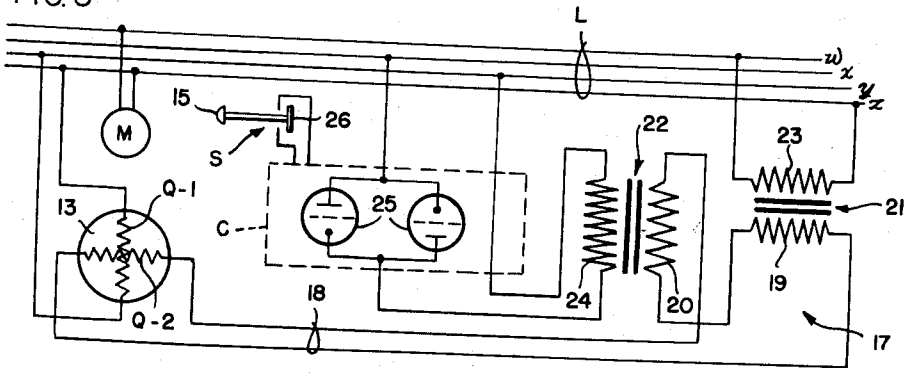


FIG. 4

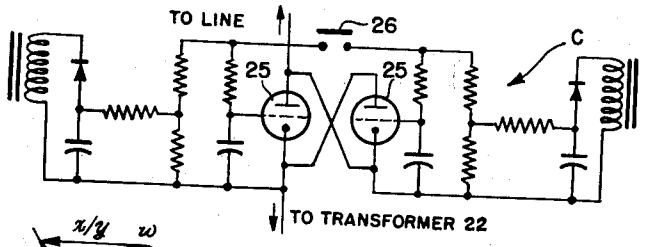
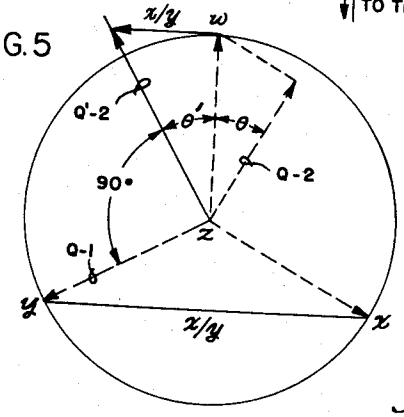


FIG. 5



INVENTOR:—

HANS LOHEST

BY:—

Marzall, Johnston, Cook & Root

ATTORNEYS

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FILAMENT WINDING APPARATUS

Hans Lohest, Remscheid-Lennep, Germany, assignor to Barmer Maschinenfabrik Aktiengesellschaft, Wuppertal-Oberbarmen, Germany

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14 Claims. (Cl. 318—6)

The present invention relates in general to the winding and reeling of flexible filamentary material, and has more particular refrence to the winding of such material upon spools, bobbins, reels and similar filament receivers. The invention pertains specifically to the provision of improved means for regulating the rate of turning movement of the winding reel so that the speed at which the filament is applied upon the reel may at all times correspond with the rate of delivery of the filament to the reel, whereby the winding operation is accomplished under substantially uniform filament tension; and the present disclosure relates to improvements in the apparatus described in a copending application for U.S. Letters Patent on the invention of Hans Lohest in Filament Winding Apparatus, Serial No. 600,331, filed July 26, 1956.

In winding devices of the character mentioned, it is conventional to provide for the adjustment of filament winding speed in response to the changing size of the spool as filamentary material is wound thereon, or in response to tension variations in the filamentary material as it is applied to the reel. Such devices, however, do not react instantly, but have an inherent lag which can not be tolerated at the high winding speeds required in modern winding apparatus. Conventional winding speed regulating arrangements commonly apply undesirable tensions in the thread and thereby tend to cause thread breakage, especially where thin, lightweight filaments are involved.

Arrangements wherein the winding speed control devices are caused to react to the tension of the material being wound rather than to the winding diameter of the spool have the advantage not only of precisely maintaining uniform winding conditions as the winding diameter of the reel increases during the winding operation, but also of adjusting the device in response to momentary variations in tension which may occur at random in the filamentary material during the winding operation. On the other hand, filament tension variations are often so infinitesimally small, especially in thin, fragile filaments, that such variations have to be amplified for transmission to the control device, necessitating the provision of expensive amplifying equipment.

Control mechanisms of the sort heretofore known, which operate to switch the spool driving motor off and on, in order to maintain a desired filament tension, can not be successfully used for high speed winding operations because of the violent disruptive sparking which develops at the make and break contacts of the associated switches.

To provide for regulating the speed of a filament winding spool or reel while avoiding the foregoing shortcomings and disadvantages, the aforesaid earlier filed copending application for U.S. Letters Patent proposed a speed control arrangement embodying an alternating current motor having a short-circuited rotor, preferably provided with increased rotor resistance, or a Ferraris motor, electrically energized with alternating current power supplied, at potentionals varying with filament tension, through transformers having secondary windings interconnected in series and including a principal power supply transformer and a regulating transformer operable to modulate the potential, at which energy is supplied to

the motor, in response to variations in thread tension, the electrical potential delivered through the regulating transformer being varied with threat tension to thereby constitute the regulating transformer either as a supplementary potential source, to increase the potential applied on the motor, or as a choke coil for potential reducing purposes, in order thus to control or regulate the speed of the reel driving motor very precisely and economically, such arrangement being particularly effective where the regulating transformer is controlled by an electronic switching circuit connected in its primary circuit to control the supply of energizing power thereto under the control of a thread tension feeler.

Where a single phase alternating current motor is controlled in the manner taught in the aforesaid copending application for U.S. Letters Patent, one winding of the motor is connected to the controlled energy source through an operating condenser. Such a condenser, however, when especially fine threads are being wound, under low thread tension, is unable to accommodate the highly variable operating requirements, such as large variations in the rate of rotation which become necessary as the winding reel is filled from empty to completely wound condition. A condenser of selected size will provide for optimum operation only at a particular speed. Furthermore, the output differences of a motor driven at constantly varying speed are insufficient to accommodate the opposing torque requirements of the winding reel where large differences in winding diameter are involved. The torque yield of the motor toward the end of the winding operation is insufficient to maintain the desired pull on the thread being wound, which consequently decreases to an undesirable extent. Moreover, the condenser required in such winding drives is an excessively expensive item, the cost of which it is now proposed to eliminate.

An important object of the present invention is to provide improved control means for regulating the speed of a filament winding reel while avoiding the above noted shortcomings and disadvantages of apparatus heretofore provided for the purpose; a further object being to provide for controlling the speed of a winding reel driving motor by energizing the same at variable voltage fluctuating above and below a base potential supplied by a principal power transformer; a still further object being to provide for increasing or decreasing such base potential in accordance with variations in the tension of a filament being wound upon a reel driven by the motor.

Another important object is to control the speed of a reel driving motor by connecting one winding of the motor directly with a source of energizing power, while energizing another motor winding at a variable voltage which fluctuates above and below the base potential of a power supply source in accordance with variations in the tension of a filament being wound on a motor driven reel; a further object being to connect one winding of an alternating current motor directly with a source of alternating current power, while connecting another winding of the motor with an alternating current power source and an associated voltage modulating device for motor speed regulating purposes; a still further object being to supply alternating current power at varying potential upon a winding of an alternating current motor by connecting said winding with the secondary windings of a pair of transformers energized from alternating current power sources relatively displaced as to phase, including means operable to control the delivery of energizing power to one of the transformers in accordance with momentary tension conditions prevailing in a filament being wound on the motor driven reel.

Another important object is to provide for regulating the operating speed of an alternating current motor by

connecting one of its windings with a suitable power source, such as a phase of a polyphase power supply line, while connecting another winding of the motor in circuit with the series connected secondary windings of a pair of transformers, the primary winding of one of which is energized from another phase of the power supply line, the other transformer being energized from still another phase of the supply line through switching means operable in accordance with the motor speed variations to be accomplished.

The foregoing and numerous other objects, advantages and inherent functions of the invention will become apparent as the same is more fully understood from the following description which, taken in connection with the accompanying drawings, discloses a preferred embodiment of the invention.

Referring to the drawings:

FIG. 1 is a perspective view of filament winding apparatus embodying the present invention;

FIG. 2 is a diagrammatic view of a portion of the apparatus shown in FIG. 1;

FIG. 3 is an electrical wiring diagram of a motor control system embodying the invention;

FIG. 4 is a wiring diagram showing the details of switching circuitry indicated generally in the diagram comprising FIG. 3; and

FIG. 5 is a vector diagram for the circuit arrangement illustrated in FIG. 3.

To illustrate the invention the drawings show winding apparatus comprising a winding spindle **11** adapted to support and drivingly turn a thread winding receiver R, such as a tube, mandrel, spool, reel or bobbin. Conventional bearing means of any suitable or preferred character may be employed for supporting the shaft for turning movement, as on a support frame or base **12**. The base may also support an electrical motor **13** drivingly connected with the spindle **11** and operable to turn the receiver R at desired speed for winding a filament upon the receiver. In accordance with the present invention, filamentary material, such as a thread F, may be delivered from a supply source, such as a storage reel (not shown), or directly from a spinning machine, through a thread guide G, for winding upon the receiver R as the same is turned on and by the motor driven spindle **11**. The guide G may be of any suitable or preferred character; and it may be actuated by conventional translation mechanism T driven by a motor M, in order to cause the thread guide G to travel back and forth longitudinally of the receiver R at desired speed. The spindle and guide driving motors are preferably caused to operate in synchronism; and, of course, the guide actuating device T, if desired, may be drivingly connected directly with the receiver driving motor **13**. By using a separate motor M, however, the receiver driving motor **13** will be free from the guide driving load, and hence will be fully available for the task of driving the winding receiver. As a consequence, it may have a relatively low power rating, and hence will be more sensitive to regulation in accordance with the teachings of the present invention.

The filament F is preferably delivered upon the winding receiver at as near constant delivery speed as possible. The filament may be delivered to the receiver past a sensing device S which may conveniently comprise an axially movable stem **14** carrying a grooved filament engaging head **15** and a spring **16** arranged to yieldingly urge the stem **14** in a direction to press the head **15** laterally against the filament as it passes to the receiver. The thrust of the spring may be adjusted to correspond with the filament tension under which it is desired to accomplish the winding operation. As the diameter of the wound filamentary material increases on the receiver R during a winding operation, it will be seen that the direction of the thread changes as it passes from the head of the sensing device S toward the receiver, the deflection angle A progressively increasing toward a maximum value, as clearly shown in FIG. 3 of the drawings, as the reel becomes filled with wound material. As a consequence, the pressure of the thread upon the sensing device will progressively increase as the receiver becomes filled; and, even when the thread is under relatively slight tension, its force component upon the sensing device is sufficient to activate the same.

The driving motor **13** may conveniently comprise an alternating current short-circuit rotor motor having augmented rotor resistance, or the motor may comprise a Ferraris slip-bushing motor. In accordance with the teachings of the present invention, one winding Q–**1** of the motor **13** may be considered as the main motor winding and may be connected either directly, as shown, or through a suitable transformer, across a phase of a power supply line L embodying the phase conductors W, X and Y and a neutral conductor Z, the main winding Q–**1** being shown connected directly across the phase Y—Z of the power line. Another motor winding Q–**2**, which for convenience in reference may be called an auxiliary winding, is electrically connected in a power supply system **17**, including a motor energizing circuit **18** connected with the auxiliary winding Q–**2** and with means operable normally to supply electrical power in the circuit **18** at a value which lies between the maximum and minimum power requirements of the motor. Means is provided for increasing and decreasing the power delivered to the auxiliary winding Q–**2** in accordance with the action of the sensing device S under the influence of variant tension conditions which occur in the filament F as it is delivered for winding upon the receiver R.

To these ends, the secondary windings **19** and **20** of transformers **21** and **22** are interconnected in the circuit **18** in series with the auxiliary winding Q–**2**. The transformers **21** and **22** respectively embody primary windings **23** and **24** energized from unlike phases of the supply line L, the primary winding **23** being connected with the phase W—Z of the power supply line L, while the primary winding **24** is connected between the phase conductors X and Y of the line through switching means C controlled by the sensing device S. In multiple arrangements, in which a plurality of coil winding machines are disposed in side-by-side or adjacent relationship, the principal power supply transformer **21** may be interconnected with the driving motors and regulating transformers **22** of the several machines arranged in parallel in order to supply all of them with power at the same basic potential.

The switching circuitry C, which controls the supply of energy to the auxiliary or voltage modulating transformer **22**, is shown in detail in FIG. 4 of the drawings; and it operates under the control of the sensing device S to vary the delivery of energy in the motor energizing circuit **18** by regulating the control transformer **22** in order to adjust the electrical energy delivered to the motor through the circuit **18** precisely to that required to drive the motor **13** at desired winding speed. The switching means C functions not only to accomplish the choking of the basic potential down to a minimum operating level, but also to increase the potential in the motor energizing circuit up to a maximum desired value. Accordingly, it will be seen that the principal transformer **21** may deliver power at a predetermined basic potential in the supply circuit **18**, while the control transformer **22** may function to regulate the intensity or duration, or number of successive power impulses required to be added or subtracted in order at all times to drive the motor **13** at desired speed.

As shown more particularly in FIG. 4 of the drawings, the control system C may comprise a pair of thyratron valves **25** interconnected, in relatively reversed parallel relationship, in series with the primary winding **24** of the transformer **22** between the phase conductors X and Y of the power supply line L, whereas the primary winding of the principal transformer **21** is connected between the phase conductor W and the neutral conductor Z of

the power line. It should be noted also that the main winding Q–1 of the motor **13** is energized from still another phase Y—Z of the power line. The control grids and cathodes of the thyratron valves **25** may be connected with suitable power sources for the purpose of actuating the valves, and a switch **26** may be provided for interconnecting the control grids of the valves in order to render the same electrically conductive, such switch being controllably connected with the stem **14** of the sensing device so that the switch may be normally urged toward closed position by action of the spring **16** and will become open when tension in the filament F exceeds a selected value. So long as the switch **26** remains open, the control transformer **22** will remain inactive and will function merely as a choke in the circuit **18**.

Accordingly, electrical energy at reduced potential will be supplied to the motor **13**, which, consequently, will operate with considerable slippage until filament tension is relaxed, thereby allowing the spring **16** to close the switch **26**. Upon activation of the thyratrons, power delivered through the control transformer **22** will be applied to modify or modulate that supplied in the circuit **18** through the principal transformer **21**, to thereby regulate the speed of the motor **13** in desired fashion. When the spring **16** causes the switch **26** to close, thereby igniting the thyratrons **25**, the motor will run faster than when the switch is open. The system is so sensitive, even at high filament delivery speeds, that variations in thread tension are held at an exceedingly low level. Because of the character of the control transformer **22**, a relatively high potential can be employed in its primary circuit, whereby current delivered through the thyratron valves may be of relatively low value. The regulating impulse amplifier, accordingly, may have a low power rating. Any other suitable switching circuitry, including those disclosed in the aforesaid earlier filed and copending application, may of course be employed for controlling the operation of the voltage varying transformer **22**.

As shown more particularly in the vector diagram comprising FIG. 5, the main winding Q–1 is connected between the phase conductor Y of the power line and the neutral conductor Z, while the auxiliary winding Q–2 is connected between the phase conductor W and the neutral conductor Z of the power line, and, at intervals, between the phase conductors X and Y of the power line. When the switch **26** is open, the transformer **22** is inactive but functions to choke down the potential at which energy is delivered in the circuit **18** by the transformer **21**. The magnitude and phase position of potential in the circuit **18**, when switch **26** is open, is indicated with its appropriate displacement angle θ with respect to the potential applied on the transformer **21** from the line conductors W—Z.

As shown, the potential applied in the circuit **18** when the switch **26** is open trails the potential applied to energize the basic transformer **21** by an angle θ of about 30°, as indicated by the dotted vector line marked Q–2, the dotted vector line marked Q–1 indicating the potential applied upon the other winding of the motor. Accordingly, the phase displacement of potential applied to the two motor windings amounts to $120°+30°=150°$. Since the motor is designed for operation with a potential phase displacement of 90° in the energy components applied on the windings Q–1 and Q–2, it will operate at relatively low torque output, when the switch **26** is open. Furthermore, as indicated in the vector diagram, the potential applied upon the auxiliary winding Q–2 of the motor, when switch **26** is open, is sharply reduced by the choking effect of the secondary winding of the transformer **22**.

Upon closure of the switch **26**, the summation of the potentials at which energy is applied in the circuit **18**, by the secondary windings of the transformers **21** and **22**, is indicated by the vector line labelled Q'–2, the same being the summation of the voltage vector Z—W, repre-

senting the voltage applied in the circuit **18** through the transformer **21**, and the vector X—Y extending in a direction normal to the vector Z—W and representing the voltage applied in the circuit **18** through the transformer **22**. The potentials applied in the line **18** by the two transformers **21** and **22** are displaced by an angle of 90° and the angle of displacement θ' between the potential Z—W, applied through the transformer **21**, and the potential applied upon the auxiliary winding Q–2 of the motor, when the switch **26** is closed, is of the order of 30°. The relative phase displacement of potentials applied on the motor windings Q–1 and Q'–2, consequently, is of the order of $120°-30°=90°$, thereby developing optimum torque in the motor, when the switch **26** is closed. It will be noted also that the vector line labelled Q'–2 indicates the application of energy on the motor winding at a voltage somewhat greater than the phase voltage Z—W applied through the transformer **21**.

It is thought that the invention and its numerous attendant advantages will be fully understood from the foregoing description, and it is obvious that numerous changes may be made in the form, construction and arrangement of the several parts without departing from the spirit or scope of the invention or sacrificing any of its attendant advantages, the form herein disclosed being a preferred embodiment for the purpose of demonstrating the invention.

The invention is hereby claimed as follows:

1. A speed regulating system for an electric motor having a main and an auxiliary winding, comprising means for energizing said winding from separate sources of electrical power cyclically fluctuating at selected frequency and relatively displaced as to phase, and means operable at intervals to superimpose on said auxiliary winding regulatory electrical energy fluctuating at like frequency and displaced as to phase with respect to the energizing power applied thereon.

2. A speed regulating system for an electric motor having a main and an auxiliary winding, comprising means for energizing said windings from separate sources of electrical power cyclically fluctuating at selected frequency and relatively displaced as to phase by an angle of the order of 120 degrees, and control means for alternately increasing and decreasing the phase displacement of energy applied on said auxiliary winding with respect to that applied on the main winding.

3. A speed regulating system as set forth in claim 2, including means for alternately decreasing and increasing the voltage at which energy is applied upon a said winding as the phase displacement of energy applied upon the windings is increased and decreased.

4. A speed regulating system as set forth in claim 2, wherein said control means serves to alter the phase displacement of energy applied upon the windings between angles of the order of 120 ± 30 degrees.

5. A speed regulating system for controlling the winding speed of a filament receiver comprising an electric motor drivingly connected with the receiver, said motor having a main and an auxiliary winding, means for energizing said windings on separate sources of electrical power cyclically fluctuating at selected frequency and relatively displaced as to phase, and control means operable at intervals in response to variation in tension prevailing in the filament being applied on the receiver to superimpose upon said auxiliary winding regulatory electrical energy fluctuating at like frequency and displaced as to phase with respect to the energizing power applied thereon.

6. A speed regulating system for an electric motor having a plurality of windings, including a main winding and an auxiliary winding, comprising means for connecting the main winding with a source of energizng power fluctuating at selected frequency, a circuit for delivering energizing power to the auxiliary winding, means con-

nected in said circuit for applying electrical power fluctuating at selected frequency and displaced as to phase with respect to the energy applied on the main winding, and means for delivering in said auxiliary circuit regulatory energy of fluctuating character and displaced as to phase with respect to the energizing power delivered in said auxiliary circuit.

7. A speed regulating system as set forth in claim 6, wherein the phase displacement of energizing power in the main and auxiliary windings is of the order of one hundred twenty degrees.

8. A speed regulating system as set forth in claim 6, including means operable to vary the voltage at which energy is applied on a said winding as the phase displacement of energy applied on the windings is increased and decreased.

9. A speed regulating system as set forth in claim 6, wherein the phase displacement of energizing power in the main and auxiliary windings is of the order of one hundred twenty degrees, and wherein the regulatory energy applied in said auxiliary winding has a phase relationship such that the resultant energy produced in said auxiliary winding is displaced by an angle of the order of thirty degrees with respect to the energizing power applied therein.

10. A speed regulating system for an electric motor having a plurality of windings, including a main winding and an auxiliary winding, comprising means for connecting the main winding with a phase of a polyphase power supply line, a principal transformer adapted for connection with another phase of said line, an auxiliary transformer and switch means for connecting the same with still another phase of the line, and means for connecting the secondary windings of said transformers in series circuit with said auxiliary winding.

11. A speed regulating system as set forth in claim 10, wherein said principal and auxiliary transformers are interconnected with unlike phases of the polyphase line so as to energize the same with alternating current power displaced as to phase by an angle of the order of 90 degrees, and wherein the main winding of the motor is connected with the line to receive energy therefrom displaced as to phase by an angle of the order of 120 degrees with respect to the energy applied on said principal transformer.

12. A speed regulating system as set forth in claim 10, wherein the motor is drivingly connected with a filament winding receiver, and the switch means for connecting said auxiliary transformer with the power line is controllingly connected with sensing means responsive to tension variations in the filament whereby to control winding speed in accordance with tension conditions prevailing in the filament during the winding operation.

13. A speed regulating system as set forth in claim 10, wherein the switch means for controlling the auxiliary transformer comprises an electronic switching system interconnected with the primary winding of said auxiliary transformer means.

14. A speed regulating system as set forth in claim 10, wherein said switch means comprises an electronic switching system embodying a pair of thyratron valves connected in relatively reversed parallel relation and connected between the auxiliary transformer and the power supply line, and a switch controllingly associated with said thyratron valves and operable selectively to disable and to condition said valves for operation.

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