

April 5, 1949.

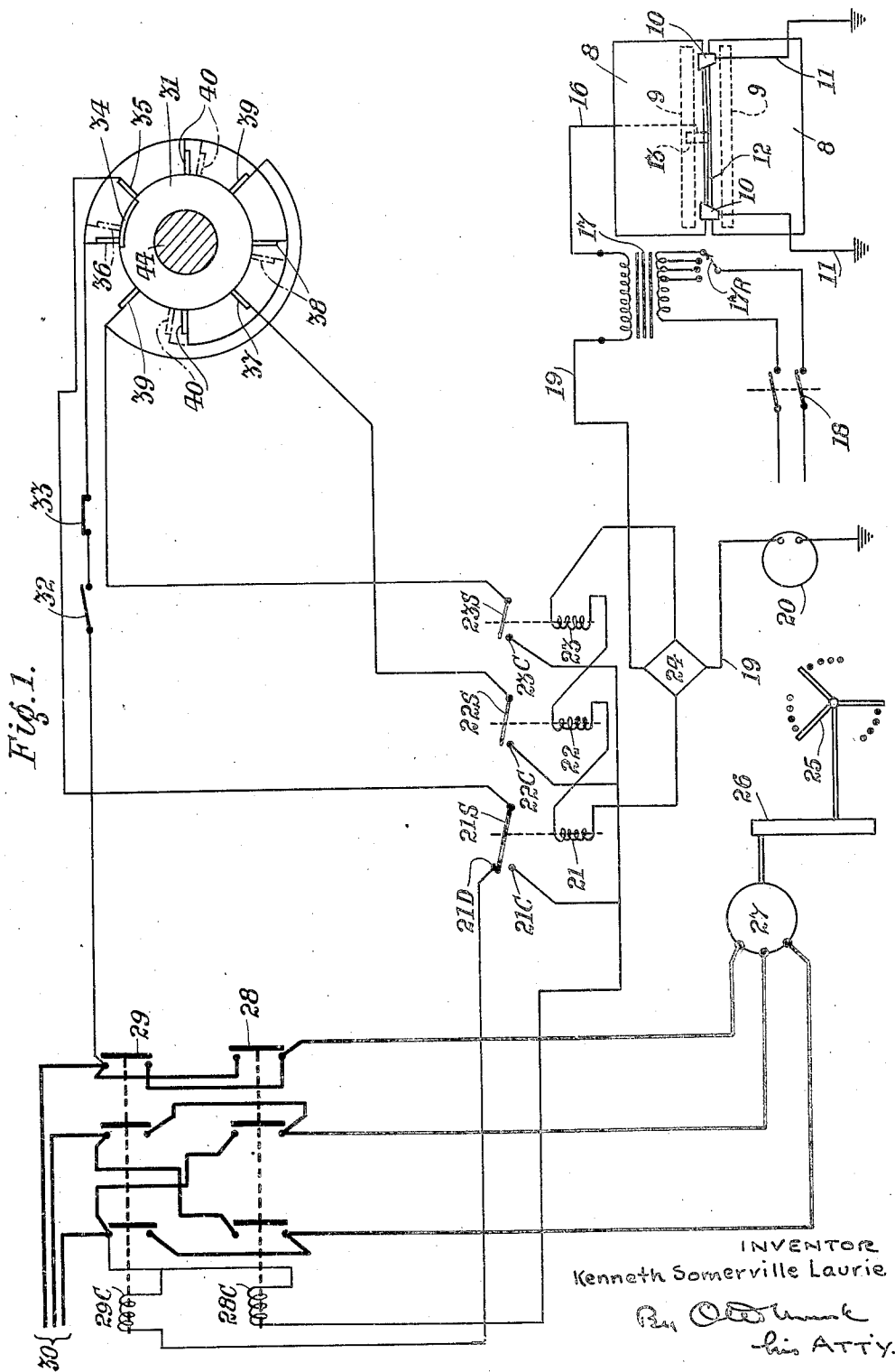
K. S. LAURIE

2,466,446

ELECTRIC CONTROL APPARATUS IN FABRIC DRYING MACHINE
HAVING MEANS FOR CONVEYING THE FABRIC

Filed July 7, 1944

3 Sheets-Sheet 1



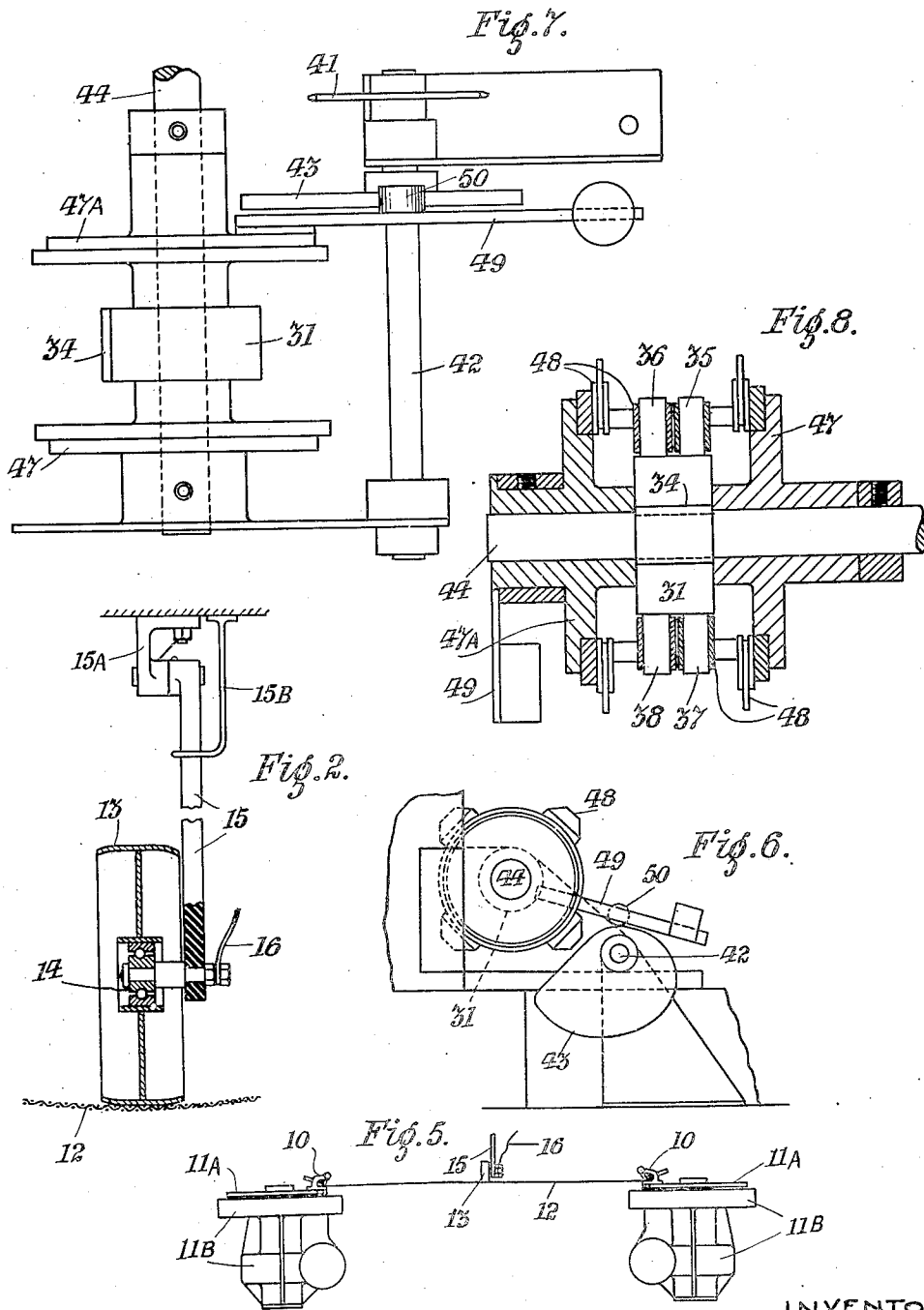
April 5, 1949.

K. S. LAURIE
ELECTRIC CONTROL APPARATUS IN FABRIC DRYING MACHINE
HAVING MEANS FOR CONVEYING THE FABRIC

2,466,446

Filed July 7, 1944

3 Sheets-Sheet 2



INVENTOR
Kenneth Somerville Laurie
By *[Signature]*
His ATT'Y.

April 5, 1949.

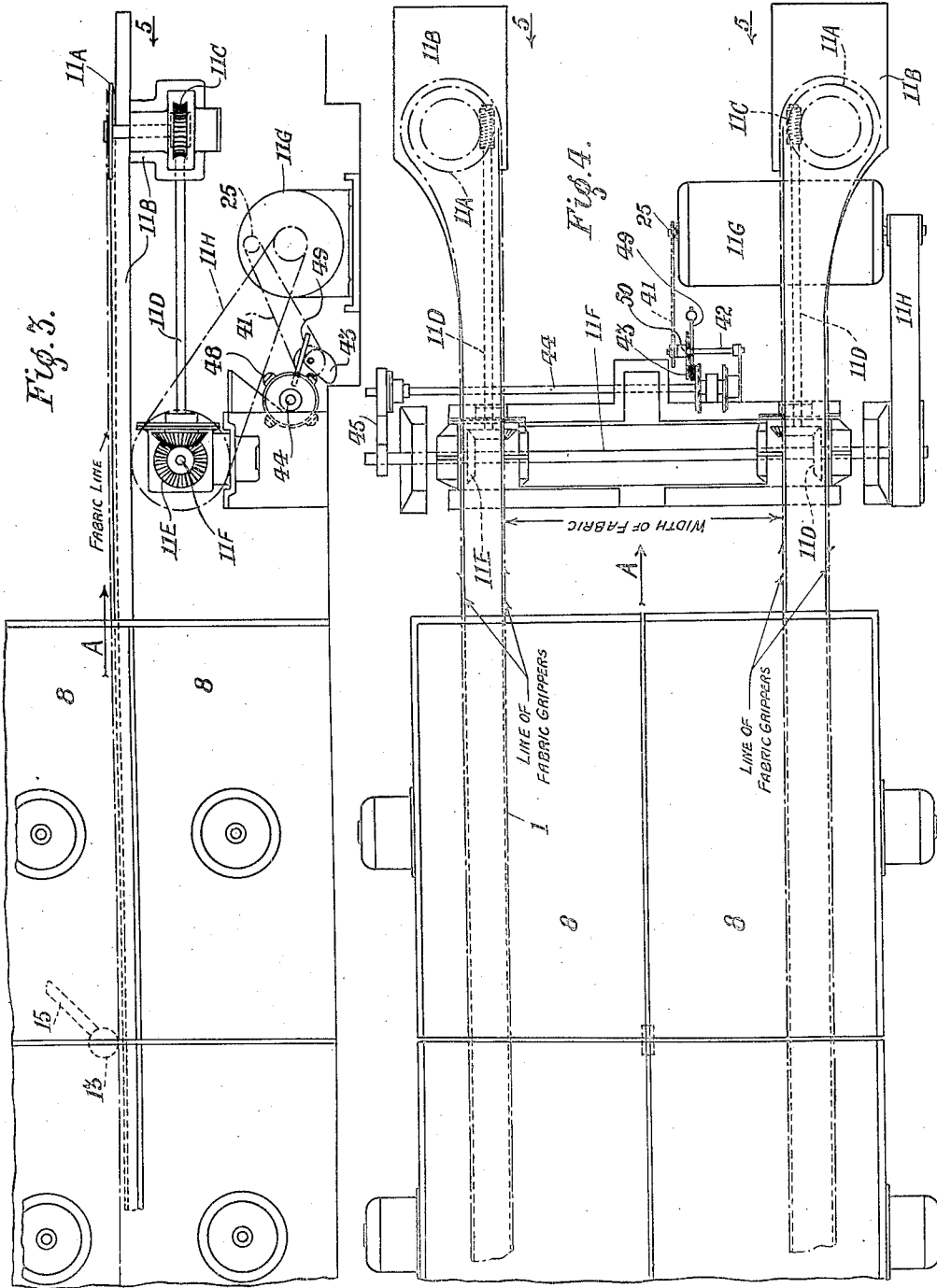
K. S. LAURIE

2,466,446

ELECTRIC CONTROL APPARATUS IN FABRIC DRYING MACHINE
HAVING MEANS FOR CONVEYING THE FABRIC

Filed July 7, 1944

3 Sheets-Sheet 3



INVENTOR
Kenneth Somerville Laurie
By *[Signature]*
his ATT'Y.

UNITED STATES PATENT OFFICE

2,466,446

ELECTRIC CONTROL APPARATUS IN FABRIC
DRYING MACHINE HAVING MEANS FOR
CONVEYING THE FABRICKenneth Somerville Laurie, Glasgow, Scotland,
assignor to John Dalglish, Glasgow, ScotlandApplication July 7, 1944, Serial No. 543,831
In Great Britain October 1, 1942

6 Claims. (Cl. 34—52)

1

This invention relates to the drying of travelling fabrics.

In various processes involved in the manufacture and/or finishing of fabrics, an initially wet or moist fabric travels through a machine to a place where it is drawn off in a dry condition. For example, in operation of a stentering machine, an initially moist woven fabric travelling through the machine is simultaneously stretched and dried in its passage. Hereinafter a machine in which a fabric is dried is referred to as a "drying machine."

In connection with drying machines it is known to use apparatus for controlling the drying in relation to the moisture content of the fabric; and in such apparatus it is known to pass an electric control current through a portion of the travelling fabric at a selected place in the run of the fabric in order to utilise the varying electric resistance of the said portion, such resistance being a measure of the moisture content to vary the control current, thereby to operate the controlling apparatus; apparatus of this type will be hereinafter and in the claims referred to as electric drying control apparatus of the type aforesaid. In certain electric drying control apparatus of the type aforesaid previously proposed for regulating the dryness, a fabric speed controller is continuously under the influence of the control current. In such circumstances some extent of "hunting" is inevitable. That is to say, supposing that a fabric is excessively moist at the selected place in the run, the control apparatus would set about the work of increasing the drying by reducing the fabric speed. When the desired state of dryness should be reached, the increased drying effect would continue for some appreciable time, and the fabric would become overdry, before the opposite corrective regulation could be started by the control apparatus. Therefore a continuous swinging would occur above and below the desired dryness level due to over-regulation in both directions, and the limits of such swinging would become seriously higher and lower than the desired level.

An object of this invention is to effect control of the drying with freedom from hunting by providing an apparatus which performs the work of regulation stepwise, and independently of the fabric speed such apparatus to make regulating adjustments of the drying in steps, the direction of each step being determined at the start of the step by the current in an electric control circuit whose resistance varies with the moisture content of the fabric. In use of such apparatus the dry-

2

the effect is increased when the moisture content is greater than a determinate datum value and decreased when the moisture is less than said value.

The term "step" is used herein to mean an action complete in itself, which has its start, its duration and its stop. It is thought to be by virtue of the recurrent stops which are independent of the fabric speed that hunting is avoided.

Another object of this invention is thus to start dryness-regulating adjustment steps at regularly recurring instants in the drying operation.

Another object of this invention is to make extra steps between the regularly recurring steps when the moisture content is outside normal limits.

Other objects of the invention will be apparent from the following description with reference to the accompanying drawings and from the appended claims.

In the drawings:

Fig. 1 is a diagram of an example of electric drying control apparatus of the type aforesaid according to the invention and by which the drying of a travelling fabric is performed by regulating the fabric speed.

Fig. 2 is a sectional view of a roller which is a component of the apparatus and which presses as an electric contact upon the travelling fabric.

Fig. 3 is a side elevation showing part of a stentering machine to which the apparatus according to the invention is applied, said machine being shown in a semi-diagrammatic manner as it belongs to a well known kind of machine and as its constructional details are not material to the present invention.

Fig. 4 is a plan corresponding to Fig. 3.

Fig. 5 is a view of the stentering machine grippers as viewed in the direction of the arrows 5 in Figs. 3 and 4.

Fig. 6 is a detail view showing parts seen in Fig. 3 to a larger scale; Fig. 7 is a plan corresponding to Fig. 6; and Fig. 8 is a section approximately on the line 8—8 of Fig. 6.

The stentering machine to which the apparatus of the present invention is shown applied incorporates fabric-drying means. In the example, the drying means is shown conventionally as comprising upper and lower casings 8, and in these casings there are provided heaters 9 consisting of ducts from which hot air is ejected to effect the drying operation. The stentering machine also includes fabric grippers 10, represented conventionally in Fig. 1 and shown with greater

particularity in Fig. 5. These grippers are earthed, or grounded, through the frame of the stentering machine. The machine frame is represented from the electrical standpoint in Fig. 1 by earth connections 11, 11. The machine frame is represented from the mechanical standpoint in Figs. 3, 4 and 5, the grippers at both sides of the machine travelling in tracks the lines of which are represented in Fig. 4. The grippers are driven by horizontal chain-wheels 11A in side frame members 11B, the chain wheels being rotated by worm-gearing 11C through side shafts 11D, bevel gearing 11E and a cross-shaft 11F. A main electric motor 11G drives the cross-shaft 11F through a belt-and-pulley drive 11H. In operation of the stentering machine, the fabric is caused to travel in a stretched condition, gripped at its selvages by the grippers 10, through the drying means 8 in the direction of the arrow A, Figs. 3 and 4.

In Figs. 1, 2 and 5 the fabric is denoted by 12. At full width the stenter grippers will ordinarily be spaced to deal with fabrics 36 or 48 inches wide.

An electric contact roller 13 presses against the fabric, in the example at a place midway between the lines of grippers. The roller is made of sheet metal (say brass). As Fig. 2 shows, the roller is journaled on a ball bearing 14 carried by an arm 15. An electric lead 16 is connected to the bearing 14. The arm 15 is made of or incorporates electricity insulating material and is pivotally supported by a bracket 15A on the frame of the machine, and the arm 15 is pressed by a spring 15B to hold the roller firmly upon the fabric in order to make good electric contact therewith. Thus it will be clear that there is connection for electric current from the lead 16, through the roller 13, across the full width of the fabric 12 and through the frame 11, 11 (Fig. 1) to earth.

The apparatus includes a step-up transformer 17 (Fig. 1) whose primary is connected to an A. C. mains switch 18 and whose secondary is connected in a control circuit 19 that includes the lead 16. The transformer output voltage is variable, say between the limits 5,000 and 10,000 volts. There may be interposed in the control circuit 19 an ammeter 20 designed to measure currents up to a very small fraction of an ampere, say one-half to two milliamperes, and calibrated to indicate percentages of moisture content. An electro-magnetic relay assembly including relay coils 21, 22 and 23 is also connected to the control circuit 19 through the intermediary of a rectifier 24. The relay assembly will be described hereinafter.

The electric motor 11G which drives the stentering machine is a variable speed motor, and the rotor speed is governed by a controller 25 turnable through reduction gearing 26 by a small auxiliary 3-phase A. C. motor 27 which may be called a pilot motor. In Fig. 1 the controller 25 is represented conventionally as a rheostat. However, the controller in the example may be any appropriate speed controller; and the controller 25 shown in Fig. 4 may be regarded as representing a brush-shifter applied to the motor 11G in well known manner. In Fig. 5 the pilot motor 27 is not shown, and neither is the gearing 26 nor the electrical apparatus leading from the roller 13 to the pilot motor.

The setting of the controller 25 and therefore the speed of the stenter-driving motor 11G and therefore the speed at which the fabric 12 travels

through the drying means and therefore the rate of drying the fabric are controlled by the assembly of relay coils 21, 22 and 23 (Fig. 1). These coils operate relay switches 21S, 22S and 23S adapted to close against contacts 21C, 22C and 23C when the associated coils are energized effectively. The coils are arranged as a progressive series, a predetermined minimum current being sufficient to energize coil 21, a greater current being necessary to energize coil 22 also, and a still greater current being necessary to energize coil 23 also. Thus it will be clear that when the fabric is moist to a predetermined minimum degree, or slightly more moist, the resistance of the fabric will be such as to pass through the control circuit 19 a current strong enough to energize effectively the first coil 21 alone. If the fabric is moister to a predetermined degree, or slightly more, the second coil 22 also will be energized. If the fabric is still moister to a further predetermined degree, the third coil 23 also will be energized.

The switch 21S, when its coil 21 is insufficiently energized, closes against a second contact 21D. The switches 22S and 23S are open when their coils are insufficiently energized.

The pilot motor 27 has a starter which comprises two switches 28 and 29 interposed between 3-phase mains 30 and said motor. The switch 28 is a "slow-down" switch and the switch 29 is a "speed-up" switch. That is to say, when the starter is operated to close switch 28 (or switch 29) the controller 25 is turned, and keeps turning for the period that the switch remains closed, to reduce (or increase) the speed of the stenter-driving motor and therefore to increase (or reduce) the rate at which the fabric is being dried for the time being. The switches 28 and 29 are operable by relay coils 28C and 29C which when energized close the respective switches. The slow-down coil 28C is connectible through the contacts 21C, 22C and 23C and the switches 21S, 22S, and 23S with a rotary timing switch 31. The speed-up coil 29C is connectible through the contact 21D and switch 21S also with the rotary timing switch. The coils 28C and 29C, the switches 21S, 22S and 23S and their contacts, and the rotary timing switch 31, are connected across two of the mains 30. There are also interposed in the connection a main switch 32 and a link 33, which may be a so-called "cloth-switch" (that is, a switch that automatically opens when there is no fabric 12 in the stentering machine).

The rotary timing switch 31 is a device which functions stepwise to determine the time when the slow-down switch or the speed-up switch is to close and the length of the period during which the switch that has been closed is to remain closed. Such a switch is desirable in order that changes of speed of the stenter-driving motor may be in accordance with the moisture content of the travelling fabric. By way of further explanation suppose that the contact roller 13 (Figs. 3 and 4) is situated at a selected point along the length of the stentering machine. Suppose also that a change in current through the circuit 19 causes a slight change in speed of the motor 11G in the proper direction. It follows that the change of moisture content of the fabric due to the change in speed will not reach a settled value until the part of the fabric entering the machine at the time of the change has reached the point where the roller contacts. Therefore it may be contrived that under normal conditions no further speed change takes place until this time has

elapsed. This condition is fulfilled by the rotary timing switch in cooperation with the switch 21S (as distinct from the switches 22S and 23S).

The rotor of switch 31 in the example is rotated by the stentering machine driving motor 11G at such a speed that it performs one revolution in the time previously described (namely, the time taken by an entering part of the fabric 12 to reach the roller 13). That is to say, the switch rotor speed is a constant function of the stentering machine speed. The rotor 31 has a contact segment 34 which in the example co-operates with a brush 35 connected to the switch 21S and with another brush 36 connected through switch 32 and link 33 (both assumed closed) to the mains 30. Therefore, for the short period that the segment bridges the brushes 35 and 36 either the slow-down switch or the speed-up switch will be closed as determined by the strength of the current in the control circuit 19. That is to say, in so far as switch 21S is concerned, at spaced times in the operation of the machine steps are automatically taken either to slow-down or speed-up the stenter according to the moisture content of the fabric and each of said steps has its start, its duration and its stop as determined by the segment 34 in co-operation with the brushes 35 and 36.

By virtue of the stepwise action of the control apparatus, each stoppage at the end of each step brings the apparatus to a state of rest. Therefore there is no danger of hunting (that is of continuous swinging to and fro by the apparatus in its work of regulation) and therefore serious over-regulation is avoided.

It is considered that, in so far as concerns fabrics dried to a greater degree than the desired average level, speeding-up steps of substantially constant duration taken at regular times will suffice for all conditions met in practice. However, conditions may be met under which the fabric is excessively moist and which require the drying effect to be greater than got from the single relay switch 21S and the two contacts 35 and 36. Therefore, in order to provide for extra speed-reducing steps in case of excessive moisture in the fabric, one or more extra relays can be arranged. In the example there are the two extra relay switches 22S and 23S. To co-operate with these relays, additional brushes 37, 38, 39 and 40 are provided.

The brushes 35, 37 and 39 constitute a single mechanically interconnected set. The other brushes 36, 38 and 40 also constitute a single mechanically interconnected set, and they are all electrically connected to the mains.

The brush 37 is connected to the relay switch 22S and is located diametrically opposite to brush 35, and to co-operate with brush 37 the second mains-connected brush 38 is provided opposite to the brush 36. By virtue of these brushes 37 and 38, when the fabric is moist enough to cause both of the relay coils 21 and 22 to be effectively energised, slowing-down of the stenter-driving motor is effected for an extra period mid-way between the time when the brush 35 is active (i. e. bridged with the mains brush 36 by the segment 34).

There are two interconnected brushes 39 for the relay switch 23S, each midway between the brushes 36 and 37; and to co-operate with the brushes 39 there are two mains brushes 40 midway between and connected to the brushes 36 and 38. By virtue of the two pairs of brushes 39 and 40, when the fabric is so moist as to

cause all three relay coils 21, 22 and 23 to be effectively energised slowing down of the stenter-driving motor is effected for either or both of two extra periods midway between the times when the brushes 35 and 37 are active.

In sum, under normal conditions (i. e. conditions of average or nearly average moisture content) the relay 21 in combination with the rotary timing switch cause a driving impulse to be imparted to the pilot motor 27 in either the slowing-down or speeding-up direction once in each revolution of said switch; under conditions which may be regarded as outside normal limits or abnormal (i. e. conditions of excessive moisture content) by virtue of the additional relays 22 and 23 two, three or four impulses in the slowing-down direction are caused to be imparted in each revolution of the timing switch to the pilot motor.

Provision is made whereby the operator can regulate the apparatus to leave approximately any desired degree of moisture content in the outgoing fabric. In the example, such regulation is provided for by using a variable transformer 17, the regulating means being conventionally shown at 17A in Fig. 1 as a variable tapping.

Provision is made to govern the duration of the steps of speed change (i. e. the duration of the impulses) in relation to the speed of the stenter-driving motor so that the speed changes will be substantially constant in spite of variation of the original speed of the machine when the change was initiated. Such provision is made because in absence thereof when said motor was speeded up or slowed down, the steps would become shortened or lengthened as the case might be; and it is desirable that the steps should be varied in substantial conformity with the fabric speed. In the example, the governing means include the set of brushes 36, 38 and 40, these brushes being fixed angularly in relation to one another but being adjustable as a set in relation to the stationary set of brushes 35, 37 and 39. By angularly adjusting the adjustable set of brushes 36, 38 and 40, the duration of the period that each pair of brushes (namely: 35 and 36; 37 and 38; and 39 and 40) is bridged by the segment 34 is lengthened or shortened. In Fig. 1 the adjustable brushes are shown in dot-dash lines in a different setting. In Fig. 8, for convenience of illustration, the brushes 35 and 36 are shown side-by-side and so are the brushes 37 and 38.

Adjustment of the set of brushes 36, 38 and 40 is effected by an operative connection with the controller 25, said operative connection including a cam which displaces said set of brushes in accordance with the setting of the controller 25. One form of adjustment means is shown in Figs. 3, 4, 6, 7 and 8. As shown, the controller 25 is connected by a chain-and-sprocket or equivalent drive 41 to a camshaft 42 having an adjustment cam 43 (Fig. 6). The rotor 31 of the timing switch is secured to a shaft 44 that is driven by a belt-and-pulley or equivalent drive 45 from the rotary cross-shaft 11F. The stationary set of brushes (namely: 35, 37 and 39) is secured to a stationary ringlike member 47 in whose hub the switch rotor shaft 44 rotates. The adjustable set of brushes 36, 38 and 40 are secured to a similar but adjustable ringlike member 47A (Fig. 8). The brushes of both sets are each fitted into a brush-holder 48 secured to the associated ringlike member 47 or 47A. The ringlike member 47A

has a weighted arm 49, a roller 50 on which bears upon the cam 43, the arrangement being such that the setting of the member 47A and the set of brushes 36, 38 and 40 thereon varies with the setting of the controller 25. In this way the period that each set of brushes is bridged by the segment 34 is lengthened or shortened, by means of controller 25 and cam 43, in correspondence with increase or decrease of the speed of fabric conveyance, whereby the resultant change in speed of the machine is maintained substantially constant in spite of variation in the original speed of the machine prior to such change.

For clearness of illustration, the brushes 35 to 40 and their holders 48 are omitted from Fig. 7.

The rotary cross-shaft 11F may be conveniently regarded as the driving shaft of the machine, the linear speed of conveyance of the fabric 12 varying in proportion to the rotational speed of said shaft; that is to say, the fabric speed is proportional to the machine speed.

The relay 21 which is continuously in operation under the influence of the current in the control circuit 19 may be regarded as the main or normal relay; and the relays 22 and 23 may be regarded as extra relays which come into operation only when the current conditions in the control circuit are abnormal, as hereinbefore explained. The circuit or system in which the relay switches 21S, 22S and 23S, the timing switch contacts 35 to 40 and the starter coils 28C and 29C are all connected may be regarded as the operating circuit of the apparatus.

The apparatus ensures that a machine can be run to give the maximum output commensurate with adequate drying, over-drying thus being avoidable. More especially, in drying a fabric of varying texture in which certain lines or zones of material tend to remain more moist than others, the apparatus can be set to ensure that such material will be satisfactorily dried without substantial over-drying of the remainder of the fabric.

In the example the drying effect is regulated by varying the speed of the travelling fabric through the heater of the stentering machine.

In the example, the drying machine referred to is a stenter. The invention however is applicable to machines in general in which a travelling fabric is dried. For instance, the invention is applicable to drying machines in which the fabric passes round large drums. In such a machine one of the drums may be used as an electric contact, or two longitudinally spaced drums may be used as electric contacts of greatly different electric potential.

In the example, the stenter grippers are used as electric contacts. Instead, the contacts may consist of spaced wheels or equivalent of greatly different electric potential.

In a drying machine where wheel contacts or the equivalent are used, they may be spaced apart either weftwise or warpwise or diagonally.

In the example, the extra relays 22 and 23 are provided to give extra control steps when the fabric is excessively or abnormally wet; corresponding extra provision may be made to give extra control steps when the fabric is excessively or abnormally dry.

In the example, control steps are automatically taken at regular intervals of time even under condition when change in the drying is unnecessary—that is to say, even when the fabric has the proper moisture content. Provision may be made whereby no control steps are taken unless neces-

sitated in one or other direction by over-moistness or over-dryness of the fabric.

I claim:

1. In a fabric drying machine including means for conveying the fabric through the machine, means for driving said conveying means at variable speed, means for drying the fabric during its conveyance through the machine; electric drying control apparatus of the type aforesaid comprising: means for passing an electric control current through a portion of the fabric, switch means under the influence of the control current, an electric operating circuit to which said switch means is connected, controller means influenced by the current in said operating circuit and adapted to control the driving speed of the machine, a timing switch also connected to said operating circuit, a driving connection from said machine to said timing switch which connection operates said timing switch at a speed proportional to the machine speed so that said timing switch co-operates with said switch means to close said operating circuit at spaced instants for periods of time and to open said operating circuit after each of such periods, and adjusting means connected to said timing switch and operated from said controller for automatically varying the duration of said periods to compensate for changes in the speed of operation of said timing switch responsive to changes in the machine speed.

2. In a fabric drying machine including means for conveying the fabric through the machine, means for driving said conveying means at variable speed, means for drying the fabric during its conveyance through the machine; electric drying control apparatus of the type aforesaid comprising means for passing an electric control current through a portion of the fabric, a plurality of normal and extra electromagnetic switch devices under the influence of the control current, an electric operating circuit to which said devices are connected, controller means influenced by the current in said operating circuit and adapted to control the driving speed of the machine, whenever said circuit is closed, a timing switch having a plurality of normal and extra contacts also adapted electrically to connect to said operating circuit, means operable by said driving means and driving said timing switch so that its normal contacts close the operating circuit to said normal devices in response to said control current at spaced instants for periods of time and so that said extra contacts close the operating circuit to said extra devices in response to abnormal conditions of said control current at extra spaced instants for extra periods of time and so that all of said contacts in turn open said operating circuit after each of such periods, and means driven by said controlling means for automatically varying the setting of the controlling means and thus compensating the duration of said periods and extra periods whereby the resultant change in speed of the machine is maintained substantially constant in spite of variation in the original speed of the machine prior to such change.

3. In a fabric drying machine including means for conveying the fabric through the machine, means for driving said conveying means at variable speed, means for drying the fabric during its conveyance through the machine; electric drying control apparatus of the type aforesaid comprising: means for passing an electric control cur-

rent through a portion of the fabric, electromagnetic switch means under the influence of the control current, an electric operating-circuit to which said switch means is connected, said switch means being operable under the influence of the control current to selectively energize alternative circuits in order either to slow down the machine when said current is above a predetermined datum or to speed up the machine when said current is below such datum, and said switch means being connected to said operating circuit for operation only when said circuit is closed, a timing switch also connected to said operating circuit, means operable by said driving means and driving said timing switch to cooperate with said switch means to close said operating circuit at spaced instants for periods of time and means connected to said driving means for varying the setting of said timing switch under the influence of the speed of conveyance of the fabric in order to vary the period before opening of said operating circuit whereby the resulting speed-changes of the machine are maintained substantially constant in spite of variation of the original speed of the machine.

4. In a machine for conveying fabric past fabric-drying means and having apparatus as defined in claim 1 said apparatus also including connections to a source of pulsating electric current and a transformer whose primary winding is connected with said connections and whose secondary winding imposes a high voltage in the circuit of said control current.

5. In a fabric drying machine including means for conveying the fabric through the machine, means for driving said conveying means at variable speed, means for drying the fabric during its conveyance through the machine; electric drying control apparatus of the type aforesaid comprising: means for passing an electric control current through a portion of the fabric, a control circuit applied to said portion of the fabric so that the current in said circuit is responsive to variations in the moisture-content of said portion, a relay operable under the control of said control circuit, a rotary switch operable by said driving means, contacts with which said rotary switch co-operates, a controller turnable in either of two directions in one of which the controller serves to decrease said speed of conveyance and in the other of which the controller serves to increase said speed, a pilot motor for turning said controller, a starter for starting said motor in one or other direction, and an operating circuit with which said relay and said contacts and said starter are all connected, said relay being designed to set the operating circuit for operation of the starter either to decrease or increase the

speed of conveyance according as the control circuit current is above a predetermined datum or is below such datum and said rotary switch serving to close and open the operating circuit and thus to put the pilot motor in operation for spaced periods of time, and means driven by said controller to adjust automatically the position of said contacts relative to said rotary switch so as to lengthen the period with increased speed of conveyance of the fabric and vice-versa.

6. In a fabric-drying machine, means for passing an electric control current through a portion of the fabric, means for conveying the fabric through the machine, means for driving said conveying means at variable speed; and apparatus that comprises a control circuit making electric contact with the fabric so that said circuit contains said fabric, a controller adapted to control the speed of said driving means and thus regulate the speed of conveyance of said fabric, a motor operatively connected to said controller, switch means to start said motor in one or other direction according to the strength of electric current produced in said circuit to pass through said fabric, such strength being determined by the moisture-content of the fabric and such motor acting in the speeding-up direction when the moisture-content is low and in the slowing-down direction when the moisture-content is high, a timing switch which co-operates with said switch means to start said motor, means which connects said timing switch with said means for driving the conveying means and thus rotating said timing switch in timed relationship with said speed of conveyance, said timing switch comprising a continuously rotating bridge member, contacts bridged by said member to effect closure of the timing switch in each revolution thereof and means connecting one of said contacts to said controller for adjustment of that contact in relation to the other in order to regulate the period of switch closure.

KENNETH SOMERVILLE LAURIE.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,194,937	Hawkins	Mar. 26, 1940
2,219,213	Swain	Oct. 22, 1940
2,244,722	Norcross	June 10, 1941
2,270,732	Jones	Jan. 20, 1942
2,303,081	Krogh	Nov. 24, 1942
2,311,673	Lilja	Feb. 23, 1943
2,346,437	Krogh	Apr. 11, 1944
2,358,338	Lilja et al.	Sept. 19, 1944