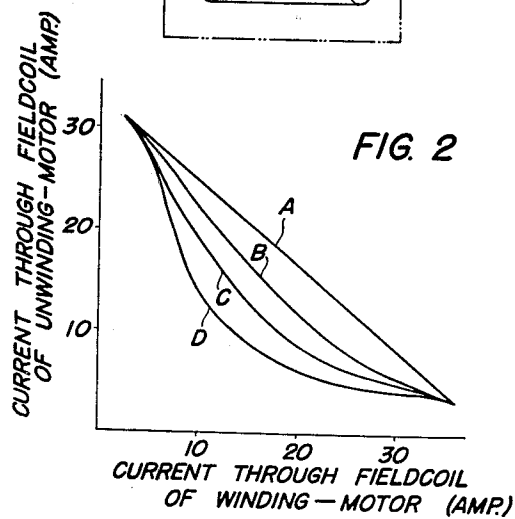
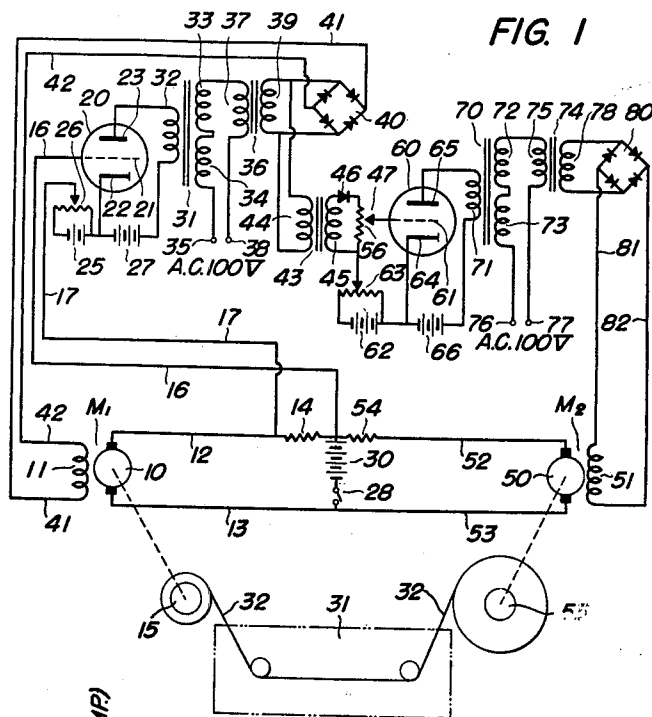


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 APPARATUS FOR CONSTANT-TENSION WINDING
 AND UNWINDING OF WEB MATERIALS
 IN DYEING APPARATUS
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APPARATUS FOR CONSTANT-TENSION WINDING AND UNWINDING OF WEB MATERIALS IN DYEING APPARATUS

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This invention relates to apparatus for constant-tension winding and unwinding of web materials in dyeing apparatus.

An object of the present invention is to provide a dyeing apparatus in which even and uniform dyeing of a continuous length of web material is accomplished under automatic control and with increased efficiency.

Another object of the invention is to provide web winding and unwinding apparatus in which both winding and unwinding drums are positively driven so that a constant tension as well as a constant linear speed of travel are assured during the whole continuous dyeing operation.

A further object of the invention is to provide electrical control means for maintaining a predetermined speed of travel of web material as well as a predetermined tensional stress in the web during the continuous dyeing operation of the web.

These and other objects and features of the present invention will best be understood from the following descriptions with reference to the accompanying drawings, in which

FIG. 1 is a diagrammatic representation of a preferable embodiment of the invention, and

FIG. 2 is a curve showing the manner of variation of voltages applied to the field windings of both winding and unwinding D.C. motors.

Referring to FIG. 1, the apparatus according to the present invention comprises a winding or take-up D.C. motor M1 and an unwinding D.C. motor M2. The motor M1 comprises an armature 10 and a separately excited shunt field winding 11, and the motor M2 comprises an armature 50 and a separately excited shunt field winding 51. The armatures 10 and 50 are connected to a common D.C. energy source 30 in parallel relation through a switch 28 by way of conductors 12 and 13, and 52 and 53, respectively. Fixed series resistors 14 and 54 are respectively included in conductors 12 and 52.

The motor M1 positively drives a winding drum 15, while the motor M2 positively drives an unwinding drum 55, respectively through direct couplings as diagrammatically shown by broken lines.

Between the two drums 15 and 55 is disposed a dyeing tank 31 in which is contained a bath of dyeing material known per se. A web of cloth 32 passes through the dyeing bath in the tank 31 from the unwinding drum 55 to the winding drum 15, and during such passage, the web material 32 is subjected to dyeing.

According to the invention, both the winding and unwinding drums 15 and 55 are positively driven respectively by motors M1 and M2 in the same direction.

In order that the dyeing may be effected in a proper manner, that is to say, the web material 32 be dyed evenly and uniformly throughout the whole length of web 32, the web should be maintained under a constant tension in the dyeing bath, and also the period of time during which each unit length of the web is in the dyeing bath should be constant.

For this purpose, the linear speed of travel of web 32 from drum 55 to drum 15 should be maintained constant in spite of the increase of outer diameter of the roll of web on the winding drum 15 with the progress of dyeing operation and the corresponding decrease of outer diam-

eter of the roll of web on the unwinding drum 55. This can be accomplished if the motor M1 is operated on the basis of a constant rate of work done regardless of the increase of outer diameter of the roll of web on the winding drum 15 or the increase of load on motor M1. In other words, the rotational speed of motor M1 should be decreased as the outer diameter of the roll of web on the winding drum 15 increases by taking up the web therearound, so that the rate of work done ($t \times \Delta L$) of the motor is constant, where t is the constant tension of the web and ΔL is the length of web taken up around the roll per unit of time.

In addition, in order to maintain the tension of web 32 constant, the unwinding motor M2 should apply a constant drag effect on the web 32 in spite of the decrease of outer diameter of the roll on the unwinding drum 55. For this purpose, the rotational speed of motor M2 should be increased as the outer diameter of the roll decreases.

According to the present invention, for accomplishing the above-outlined control of motors M1 and M2, a control system utilizing electronic tubes, saturable reactors and rectifiers are provided as described below in detail.

The voltage drop appearing across the resistor 14 is derived by conductors 16 and 17 to control a grid-controlled electronic tube or amplifier 20. The tube 20 comprises a grid 21, a cathode 22 and an anode 23. In the grid circuit, a variable grid bias consisting of parallel-connected battery 25 and variable resistor 26 is provided and connected between conductor 17 and cathode 22.

The anode circuit of amplifier 20 is completed through the direct current coil 32 of a saturable reactor 31 and a battery 27. The saturable reactor 31 comprises a three legged magnetizable core with D.C. coil 32 wound on the central leg. The reactor 31 further comprises a pair of alternating current coils 33 and 34 respectively wound on the two outer legs. The A.C. coils 33 and 34 are connected in series with the primary winding 37 of a transformer 36 to a 100-volt A.C. supply source 35-38.

The secondary winding 39 of transformer 36 is connected to energize a full-wave selenium rectifier 40, and the output of rectifier 40 is connected through conductors 41 and 42 to the field winding 11 of winding motor M1.

The output of transformer 31 is further supplied to the primary winding 44 of a step-up transformer 43, the secondary winding 45 of which is connected across a potentiometer 47 through a selenium rectifier 46.

A second grid-controlled electronic tube or amplifier 60 is provided. The tube 60 comprises a grid 61, a cathode 64 and an anode 65, grid 61 being connected to the variable tap 56 of potentiometer 47. The positive terminal of potentiometer 47 is connected to the movable tap of a variable resistor 63 which constitutes a variable grid bias of tube 60 in cooperation with a battery 62 connected in parallel with resistor 63. The rectifier 46 is so connected that variable tap 56 is of negative potential.

The amplified output of tube 60 is supplied to the D.C. coil 71 of a saturable reactor 70 similar to reactor 31, the output energy being supplied from battery 66. The reactor 70 comprises a pair of A.C. coils 72 and 73 which are connected in series with the primary winding 75 of a transformer 74 and a 100-volt A.C. supply source 76-77.

The secondary winding 78 of transformer 74 energizes a full-wave selenium rectifier 80, the D.C. output of which is supplied to the field winding 51 of unwinding motor M2.

As the dyeing operation proceeds, that is, as the web 32 on unwinding drum 55 is fed through the dyeing bath in tank 31 to the take-up drum 15, the outer diameter of the roll of web on drum 15 increases, while that of the roll on unwinding drum 55 decreases.

When the outer diameter of the roll on drum 15 in-

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creases, the load on motor M1 increases with corresponding increase in its armature current, and the voltage drop across resistor 14 increases accordingly. This increase in the voltage drop is reflected to the corresponding increase in the anode current of amplifier tube 20 through D.C. coil 32. The saturable reactor 31 (as well as 70) has such characteristics that an increase in D.C. magnetization causes a corresponding decrease in A.C. impedance, and the result is that the input in the D.C. coil is remarkably amplified in A.C. output current.

The increased A.C. output of reactor 31 is supplied through transformer 36 to rectifier 40, and the D.C. output of rectifier 40 supplied to field winding 11 is increased correspondingly, thus lowering the rotational speed of D.C. motor M1. The decrease in rotational speed of motor M1 is such that the linear speed of web 32 being taken up around the winding drum 15 is kept constant in spite of the aforementioned increase in outer diameter.

The values of various components are so chosen to accomplish the above result, and a set of practical examples of circuit constants is given below.

D.C. source	30 volts.
Resistors 14, 54	0.15 ohm.
Voltage across resistors 14, 54	about 0-4 volts.
Armature current of motors M1	about 10 amperes at light load; about 30 amperes at maximum load.
Bias source 25	10 volts.
Resistor 26	200 ohms.
D.C. output voltage of rectifier 40	5 to 30 volts.

The increase in secondary output of transformer 36 is further reflected to the amplifier tube 60 in corresponding increase in the grid bias, and results in a decrease in its anode current. This increases the A.C. impedance of saturable reactor 70, and correspondingly decreases the current through field winding 51 of unwinding motor M2 as will readily be understood.

The parts are so correlated that the unwinding linear speed of the roll of web on unwinding drum 55 is kept constant in spite of the decrease in outer diameter of the roll of web on drum 55. That is to say, the rotational speed of motor M1 is so increased by decrease in field excitation that the above result is obtained. A set of practical examples of various circuit constants may be as follows:

Transformation ratio of transformer 43	4:7.
Resistance 47	3 kilo-ohms.
D.C. source 62	50 volts.
Resistor 63	30 kilo-ohms.

It will readily be understood that the constant linear speed of web 32 may be predetermined by the settings of variable resistors 26 and 63 which determine the normal grid bias of amplifier tubes 20 and 60.

The setting of potentiometer 47 determines the relation between the voltages across separately excited field windings 11 and 51. Referring to FIG. 2, when the resistance of potentiometer 47 inserted in series with the grid circuit of tube 60 is sufficiently high, it is found that a non-linear relation D is obtained between the two field voltages. As the resistance value of potentiometer 47 is lowered, the curve approaches linearity as shown by C, B and A, successively. In order to secure the constant tension as well as the constant speed of travel of the web, it has been found that curve D should be followed. In other words, by proper adjustment of potentiometer 47, the rotational speed of unwinding motor M2 is positively changed in accordance with the change in rotational speed of winding motor M1 to secure the desired constant tension and speed of travel.

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It is to be understood that various changes and modifications may be effected without departing from the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. An apparatus for controlling a pair of D.C. motors, one for unwinding continuous web material and the other for winding said web material, each motor having a separately excited field winding, said apparatus comprising a resistor for producing a D.C. voltage drop thereacross in accordance with the armature current of said winding motor, a first electronic tube having a grid, a cathode and an anode, means for applying a variable normal bias to said grid, means for additionally applying said voltage drop to said grid, a saturable reactor including a D.C. coil connected in the anode circuit of said tube, and an A.C. output coil, a source of A.C. coupled to said coil, a full-wave rectifier energized in accordance with the output of said A.C. coil, means for supplying the D.C. output of said rectifier to said field winding of winding motor, a series-connected rectifier and potentiometer energized in accordance with said output of said A.C. coil, a second electronic tube having a grid, a cathode and an anode, means for applying a variable normal bias to said grid of said second tube, means for differentially applying the D.C. output of said potentiometer to said grid of said second tube, a second saturable reactor including a D.C. coil energized in accordance with the anode current of said second tube, and an A.C. output coil coupled to said A.C. source, a second full-wave rectifier energized in accordance with the output of said A.C. coil of said second saturable reactor, and means for supplying the D.C. output of said second full-wave rectifier to said field winding of the unwinding motor.

2. A continuous dyeing apparatus for web material, comprising a winding drum, an unwinding drum, a dyeing bath disposed between said two drums, the web passing through said bath for a dyeing operation as it is unwound from the unwinding drum and wound on the winding drum, a D.C. motor for driving said winding drum, a D.C. motor for driving said unwinding drum, each motor having a separately excited field winding, means for producing an electrical quantity representing the armature current of said winding motor, means for amplifying said electrical quantity, first means for supplying a direct current to said field winding of the winding motor in accordance with said amplified electrical quantity, and second means for supplying a direct current to said field winding of the unwinding motor in accordance with said amplified electrical quantity, said direct currents supplied to said two field windings being variable in opposite sense to each other, said first means comprising a grid-controlled amplifier tube, said tube including a grid which is controlled in accordance with said electrical quantity, means for supplying a variable normal bias to said amplifier tube, and means for producing D.C. current in accordance with the output of said amplifier tube, said second means comprising a potentiometer energized in accordance with the output of said amplifier tube, a second grid-controlled amplifier tube, means for supplying a variable normal bias to said second amplifier tube, means for additionally applying negative bias to said second amplifier tube from said potentiometer, and means producing D.C. current in accordance with the output of said second amplifier tube.

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