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CONTROL SYSTEM

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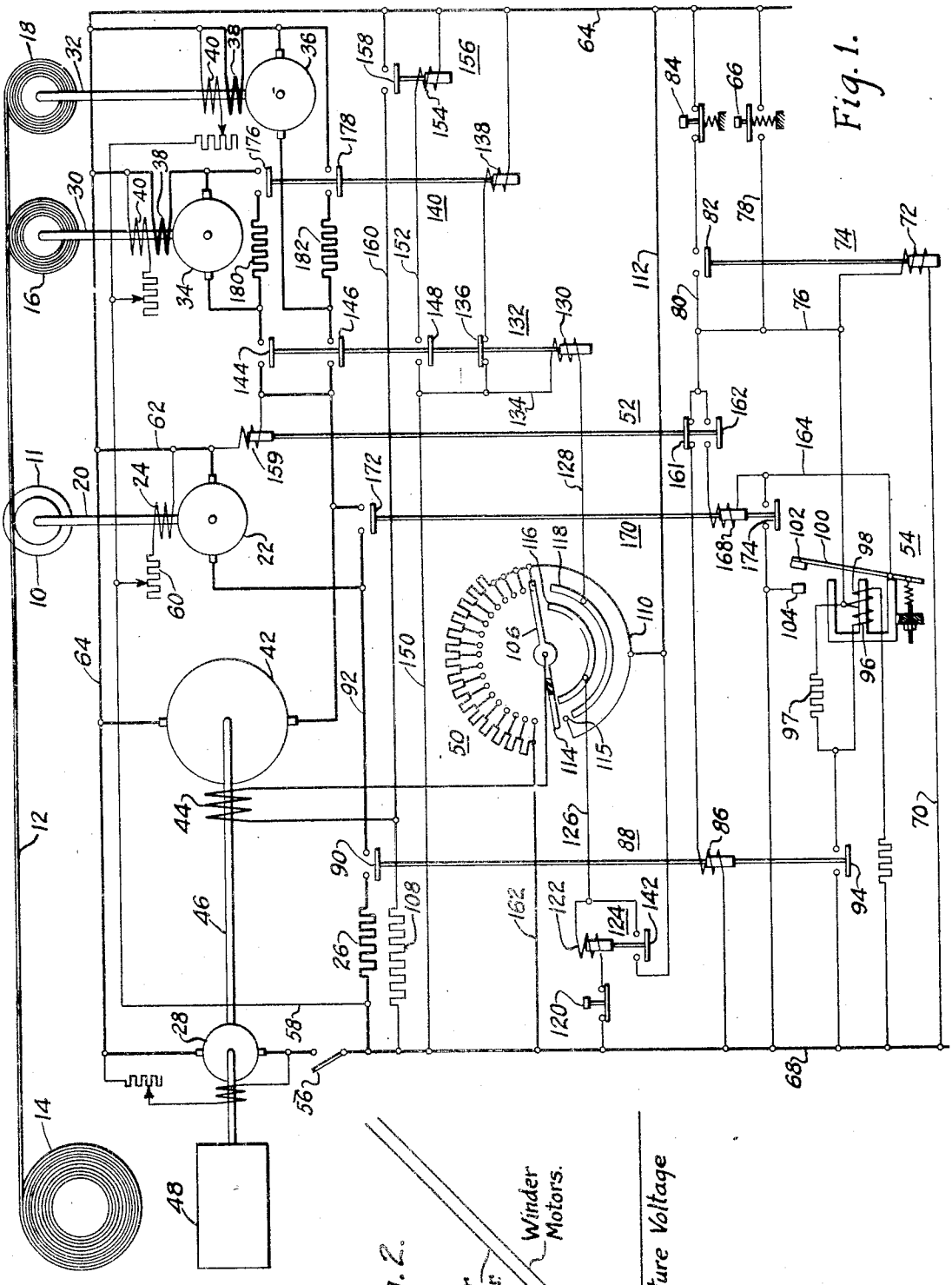

Fig. 1.




Fig. 2.

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## CONTROL SYSTEM

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This invention relates to control systems for paper mill drives.

In the manufacture of paper, it is usually made in webs that are too wide for other industries. These wide webs of paper are usually cut or slit into secondary webs of commercial size by transferring the wide web of paper from the paper machine past a roll carrying a slitter knife and adapted to rotate therewith to winder rolls upon which the secondary webs are wound. The slitter knife is carried by a roll driven at a speed approximating the speed of the winder rolls upon which the secondary webs are wound.

If the speed of the roll carrying the slitter knife is reduced or falls below that of the winder rolls, the knife does not cut the paper, but instead tears it with the result that much spoilage of the paper is encountered during the slitting operation. Such conditions are more often found during the starting and stopping of the slitting operation. This is because the rolls on which the secondary webs are wound are often started before or accelerate at a faster rate than the roll carrying the slitter knife. Further, in stopping the slitter and winder drive, the roll carrying the slitter knife sometimes stops before the winder rolls, with the result that the web tears as it is dragged past the stationary knife.

An object of this invention is to provide for starting and accelerating a slitter knife to a predetermined speed before the winder rolls are started.

Another object of this invention is to provide for starting and accelerating a slitter knife to a predetermined speed before the winder rolls are started and for maintaining the slitter knife at a predetermined speed after the winder rolls are stopped.

A more specific object of this invention is the provision for transferring a slitter motor from an exciter to a generator upon the occurrence of predetermined voltage conditions, and to transfer the slitter motor from the generator back to the exciter upon the failure of predetermined voltage conditions.

Other and additional objects of this invention will be apparent from the following description when taken in conjunction with the accompanying drawing, in which:

Figure 1 is a diagrammatic view of the control system embodying the features of this invention and

Figure 2 is a graph, the curves of which illustrate the control of the speed of the slitter and winder motors obtained in accordance with the teachings of this invention.

Referring to the drawing and Fig. 1 in particular, this invention comprises a slitter roll 10 carrying a knife 11 for rotation therewith to slit a web of paper 12 as it is transferred from a roll of paper 14 to the winder rolls 16 and 18.

The slitter roll 10 is mechanically connected by means of a shaft 20 to a slitter motor 22 disposed to be electrically connected through a high resistance 26 to an exciter 28. The slitter motor 22 is provided with a shunt field 24 disposed to be connected through a resistor 60 to the exciter 28. The winder rolls 16 and 18 are mechanically connected through shafts 30 and 32, respectively, to compound motors 34 and 36, each of which is provided with a series field 38 and a shunt field 40. The compound motors 34 and 36 are disposed to be electrically connected to a generator 42 which is provided with a field winding 44.

In order to vary the excitation of the generator 42, a master rheostat 50 is disposed to be connected in circuit relation with the field 44. The rheostat 50 may comprise any of the well known types of rheostats and is provided with a plurality of taps for connecting different portions of the rheostat in circuit with the field 44. The operation of the rheostat for varying the excitation of the generator and consequently the voltage delivered to the winder motors will be explained more fully hereinafter.

In order to transfer the slitter motor 22 from the exciter 28 to the generator 42, a relay 52 is so connected with its actuating coil in circuit with the generator 42 that upon the occurrence of predetermined voltage conditions the relay is actuated to disconnect the slitter motor 22 from the exciter 28 and to connect it to the generator 42. A time limit relay 54 of the type disclosed in Patent No. 1,753,983, issued April 8, 1930 to W. G. Cook, may be employed to insure the transfer of the slitter motor from the exciter to the generator when the actuating coil of the relay 52 is energized.

In operation, the prime mover 48 drives the exciter 28 and the generator 42. The slitter motor is electrically connected to the exciter and accelerated to a predetermined speed. The slitter motor circuit may be traced from the exciter through the knife switch 56, conductor 58, adjustable regulating resistor 60, the shunt field 24 of the slitter motor 22, conductors 62 and 64 back to the exciter. When the field of the slitter motor is energized, the start button 66 may be actuated, closing a circuit which extends from the

exciter through the knife switch 56, conductors 68 and 70, actuating coil 72 of a low voltage relay 74, conductors 76 and 78 and start button 66 to the energized conductor 64.

When the actuating coil 72 of relay 74 is thus energized, the relay 74 is actuated to a circuit closing position to close a holding circuit for the relay 74 which may be traced from the energized conductor 76 through conductor 80, contact member 82 of the relay 74, stop button 84 which is biased to a circuit closing position, to the energized conductor 64. When the holding circuit for the relay 74 is energized, a circuit is established which extends from energized conductor 68 through the actuating coil 86 of relay 88 and the contact member 161 of the relay 52 to the energized conductor 64. When thus energized, the relay 88 is actuated to a circuit closing position in which contact member 90 connects the armature of the slitter motor 22 to the exciter 28 to initially energize the slitter motor. The circuit thus established may be traced from the energized conductor 68 through resistor 26, contact member 90 of the relay 88, conductor 92, the armature of the slitter motor 22 and conductor 62 to energized conductor 64. The operating speed of the slitter motor 22 when connected to the exciter 28 is controlled by the resistor 26 which is in series with the armature of the motor. This predetermined speed is represented in Fig. 2 of the drawing by the ordinate 0—1.

When the relay 88 is actuated to connect the slitter motor 22 to the exciter 28, a circuit is also established by contact member 94 for energizing the magnetizing coil 96 of the time limit relay 54. This circuit extends from the energized conductor 68 through contact member 94 of the relay 88, magnetizing coil 96 of the time limit relay 54 and the resistor 97 in parallel therewith, to energized conductor 76. Since the magnetizing force of the coil 96 is greater than the neutralizing force of the neutralizing coil 98 of the time limit relay 54, the armature 100 is actuated to a position where a movable contact member 102 carried by the armature engages a contact member 104 and is held in a circuit closing position. The neutralizing coil 98 of the time limit relay 54 is provided for effecting a substantially constant dissipation of the residual magnetism of the core member of the relay from the maximum energized condition to zero for obtaining a prompt action of the armature 100 at any predetermined time interval in accordance with the teachings of the hereinbefore-identified Patent No. 1,753,983.

After the slitter motor 22 is started and accelerated to the predetermined speed, the winder motors 34 and 36 may be connected to the generator 42 by actuating the bridging member 106 of the rheostat 50 to close a circuit through the actuating coil of contactor 132. As shown in the drawing, a movement of the bridging member 106 to the first tap of the rheostat establishes a circuit which may be traced from the energized conductor 68, through resistor 108, field 44 of the generator 42, bridging member 106, conductors 110 and 112 to energized conductor 64. By connecting the resistor 108 in series with the field 44, any residual voltage of the generator 42 is bucked down as will be more fully described hereinafter.

A further movement of the bridging member 106 to the next tap of rheostat 50 causes segment 114 of the bridging member 106 to close a circuit which extends from the energized conductor 68 through stop button 120, actuating coil 122 of relay 124, conductor 126, bridging segment 114, contact member 115, conductors 110 and 112 to energized conductor 64. When this circuit is closed, actuating coil 122 of relay 124 is energized to actuate the relay 124 to a circuit closing position where its contact member 142 establishes a holding circuit for the relay. This circuit may be traced from the energized coil 122 through conductor 112 to energized conductor 64.

If the bridging member 106 is actuated to the third tap of the resistor 50, the segment 114 of the bridging member bridges conducting segments 116 and 118 to close a circuit which extends from energized conductor 126, through conductor 128, actuating coil 130 of contactor 132, contact member 136 of contactor 132, and coil 138 of relay 140 to energized conductor 64. The energization of coil 130 of contactor 132 causes the contactor 132 to be actuated to a circuit closing position in which contact members 144 and 146 connect the winder motors 34 and 36, respectively, to the armature of the generator 42. In this position the contact member 148 of contactor 132 closes a circuit which may be traced from energized conductor 68 through conductor 150, contact member 148, conductor 152 and actuating coil 154 of relay 156 to energized conductor 64.

When the coil 154 of relay 156 is thus energized, the relay 156 is actuated to a position where its contact member 158 closes a circuit to reverse the direction of the field 44 of the generator. This circuit may be traced from energized conductor 64 through contact member 158, conductor 160, field 44 of generator 42, rheostat 50, and conductor 162 to the energized conductor 68.

In order to increase the voltage generated by the generator 42, the rheostat 50 is adjusted to increase the strength of the field 44. As the voltage generated and delivered to the winder motors increases and consequently the speed of the motors 34 and 36 approaches the predetermined speed of slitter motor 42, represented in Fig. 2 by the ordinate 0—1, actuating coil 159 of relay 52 is energized to actuate the relay to an energized position. In this position the contact member 161 of relay 52 is in a circuit interrupting position and contact member 162 is in a circuit closing position.

When the contact member 161 is actuated to its circuit interrupting position, actuating coil 86 of relay 88 is deenergized and relay 88 drops to its deenergized position in which the contact members 90 and 94 interrupt the circuits from the exciter to the armature of the slitter motor and from the exciter to the magnetizing coil 96 of the time limit relay 54, respectively. Because of the characteristics of the relay 54 a predetermined time limit is provided in which the contact members 102 and 104 engage after the contact member 94 interrupts the circuit to the magnetizing coil. This period of delay is sufficient to permit contact member 162 of relay 52 to close a circuit which extends from energized conductor 68 through the contact members 104 and 102, armature 100, conductor 164, actuating coil 168 of relay 170, contact member 162 of relay 52, conductor 80, contact member 82, and the stop button 84 to energized conductor 64. When the actuating coil 168 is energized the relay 170 is actuated to its circuit closing position in which contact member 172 connects the armature of the slitter motor 22 to the generator 42 and contact member 174 closes a holding circuit for the relay 170.

Since each of the motors is connected in circuit relation with the generator, the speed of the motors may be controlled by adjusting the master rheostat **50** to regulate the voltage generated by the generator **42**. Since the margin of speed at a given armature voltage of the generator between the slitter motor and the winder motors as shown in Fig. 2 is fixed by the characteristics of the motors, the safety margin may be maintained over a given range of speed.

Upon a decrease in speed of the winder motors through an insertion of more of the rheostat **50** in series with the field **44** of the generator **42**, the speed of the slitter motor is decreased proportionately to the speed of the winder motors. When the voltage generated decreases and the speed of the motors is lowered to the predetermined value, the actuating coil **159** becomes deenergized and the relay **52** returns to its deenergized position. As the relay **52** drops to its deenergized position, contact member **162** drops to a circuit interrupting position to interrupt the circuit to and deenergize the actuating coil **168** of relay **170**. When the coil **168** is deenergized, relay **170** and its contact member **172** drop to a circuit interrupting position to disconnect the slitter motor from the generator. The deenergization of actuating coil **159** of relay **52** also permits contact member **161** of the relay to drop to a position where it establishes an energized circuit through the actuating coil **86** of relay **88** to actuate the relay to a circuit closing position in which contact member **90** connects the slitter motor to the exciter. Thus as the voltage generated and delivered to the winder motors **34** and **36** is further decreased, the speed of the slitter member **32** is maintained at the predetermined speed to cause the operation of the slitter knife **10** even though the winder motors stop.

In order to stop the winder motors, the bridging member **106** of the rheostat **50** is actuated to a position where the bridging segment **114** bridges the segment **116** and contact member **115** of conductor **110**. In this position the circuit through the actuating coil **130** of interlock **132** is interrupted and the interlock **132** drops to its deenergized position in which the contact members **144** and **146** disconnect the motors **34** and **36**, respectively, from the generator **42**. When the interlock **132** is in its deenergized position, the contact member **148** interrupts the circuit through the coil **154** of relay **156** causing relay **156** to drop to its deenergized position in which contact member **158** interrupts the circuit from the energized conductor **64** through the field **44** of the generator **42**. When the interlock **132** is in its deenergized position, the contact member **136** closes a circuit as hereinbefore explained, which extends from energized conductor **134** through the actuating coil **138** of relay **140** to energized conductor **64**. The relay **140** is thus actuated to its circuit closing position in which contact members **176** and **178** connect resistors **180** and **182**, respectively, in shunt circuit relation about the motors **34** and **36** to provide dynamic braking therefor.

In stopping the winder motors **34** and **36**, the speed of the motors may be decreased by actuating the bridging member **106** of rheostat **50** to its initial position where a circuit through the high resistor **108** is completed, reversing the field and bucking down any residual magnetism of the generator. The field of the generator is thus reversed from the normal excitation direction when the winder motors are disconnected from the generator and for all initial starting operations of the system. By providing for reversing the field of the generator, as described, the generator voltage is increased slowly in the proper direction as the rheostat **50** is cut out of the circuit by the bridging member **106** and a smooth starting operation of the winder motors **34** and **36** is obtained.

When desired, the winder motors may be disconnected from the generator by actuating stop button **120** to its circuit interrupting position where it interrupts the circuit through the actuating coil **130** of the contactor **132**. The operation of the contactor **132** to disconnect the winder motors **34** and **36** from the generator **42** and to close an energized circuit through relay **140** to connect resistors **180** and **182**, respectively, in shunt circuit relation about the winder motors **34** and **36** to provide dynamic braking therefor is the same as has been described hereinbefore.

The slitter motor **22** may be stopped at any time by depressing the stop button **84** to interrupt the circuit through the actuating coil **72** of relay **74** and to deenergize the actuating coil **86** of relay **88** to disconnect the slitter motor **22** from the exciter **28**.

In the operation of the control system as hereinbefore described it is evident that the slitter motor may be started and accelerated to a predetermined speed prior to the starting of the winder motors, and after the stopping of the winder motors. By this control system an improved slitting operation is obtained by maintaining a definite predetermined minimum speed of the slitter knives. Further, it is seen that the speed of the slitter motor varies in accordance with the speed of the winder motors for all speeds above a predetermined minimum speed and that operation of the slitter motor is insured even after the winder motors have ceased to function. This invention provides against damage to the web of the paper through a failure of the slitter motor to maintain a speed greater than that of the winder motors.

Although this invention has been described with reference to a particular modification thereof, it is to be understood that other and various modifications thereof are possible. This invention is, therefore, not to be restricted except insofar as is necessitated by the prior art and the scope of the appended claims.

I claim as my invention:

1. In a paper mill drive, a generator having a field winding, an exciter for the field winding, a slitter motor disposed to be connected to the exciter, a winder motor disposed to be connected to the generator, means for controlling the generator to control the voltage output therefrom, and means responsive to predetermined voltage conditions for transferring the slitter motor to the generator to control the speed of the slitter motor with respect to the speed of the winder motor.

2. In a paper mill drive, a generator having a field winding, an exciter for the field winding, a slitter motor disposed to be connected to the exciter, a winder motor disposed to be connected to the generator, means for controlling the generator to control the voltage output therefrom, and means responsive to predetermined voltage conditions for transferring the slitter motor from the exciter to the generator to control the speed of the slitter motor with respect to the speed of the winder motor, the said means being responsive upon failure of the predetermined volt-

age conditions to transfer the slitter motor from the generator to the exciter to maintain the operation of the slitter motor at a predetermined speed.

3. In a paper mill drive, a generator having a field winding, an exciter for the field winding, a slitter motor disposed to be connected to the exciter, a winder motor disposed to be connected to the generator, means for controlling the excitation of the generator to control the voltage output therefrom and thereby control the speed of the winder motor, and means responsive to a predetermined voltage output of the generator for transferring the slitter motor from the exciter to the generator to control the speed of the slitter motor with respect to the speed of the winder motor.

4. In a paper mill drive, a generator having a field winding, an exciter for the field winding, a slitter motor, means for connecting the slitter motor to the exciter to initially energize the slitter motor and operate it to a predetermined speed, a winder motor disposed to be connected to the generator after the initial energization of the slitter motor, means for controlling the excitation of the generator to control the voltage output therefrom and thereby control the speed of the winder motor, and means responsive to predetermined voltage conditions for transferring the slitter motor to the generator to control the speed of the slitter motor with respect to the speed of the winder motor.

5. In a paper mill drive, a generator having a field winding, an exciter for the field winding, a slitter motor, means for connecting the slitter motor to the exciter to initially energize the slitter motor and operate it to a predetermined speed, a winder motor disposed to be connected to the generator after the initial energization of the slitter motor, means for controlling the excitation of the generator to control the voltage output therefrom and thereby control the speed of the winder motor, and means responsive to predetermined voltage conditions for transferring the slitter motor from the exciter to the generator to control the speed of the slitter motor with respect to the speed of the winder motor, the said means being responsive upon failure of the predetermined voltage conditions to transfer the slitter motor from the generator to the exciter to maintain the operation of the slitter motor at a predetermined speed.

6. In a paper mill drive, a generator having a field winding, an exciter for the field winding, a slitter motor, means for connecting the slitter motor to the exciter to initially energize the slitter motor and to operate it to a predetermined speed, a winder motor disposed to be connected to the generator after the slitter motor is initially energized, means for controlling the voltage output from the generator and thereby control the speed of the winder motor, means responsive to a predetermined voltage output for transferring the slitter motor from the exciter to the generator for increasing the speed of the slitter motor as the speed of the winder motor increases, the said means being responsive upon failure of the predetermined voltage output to transfer the slitter motor from the generator to the exciter to maintain the operation of the slitter motor at a predetermined speed, means for disconnecting the winder motor from the generator, and means for providing dynamic braking for the winder motor when it is disconnected from the generator.

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