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MOTOR CONTROL SYSTEM

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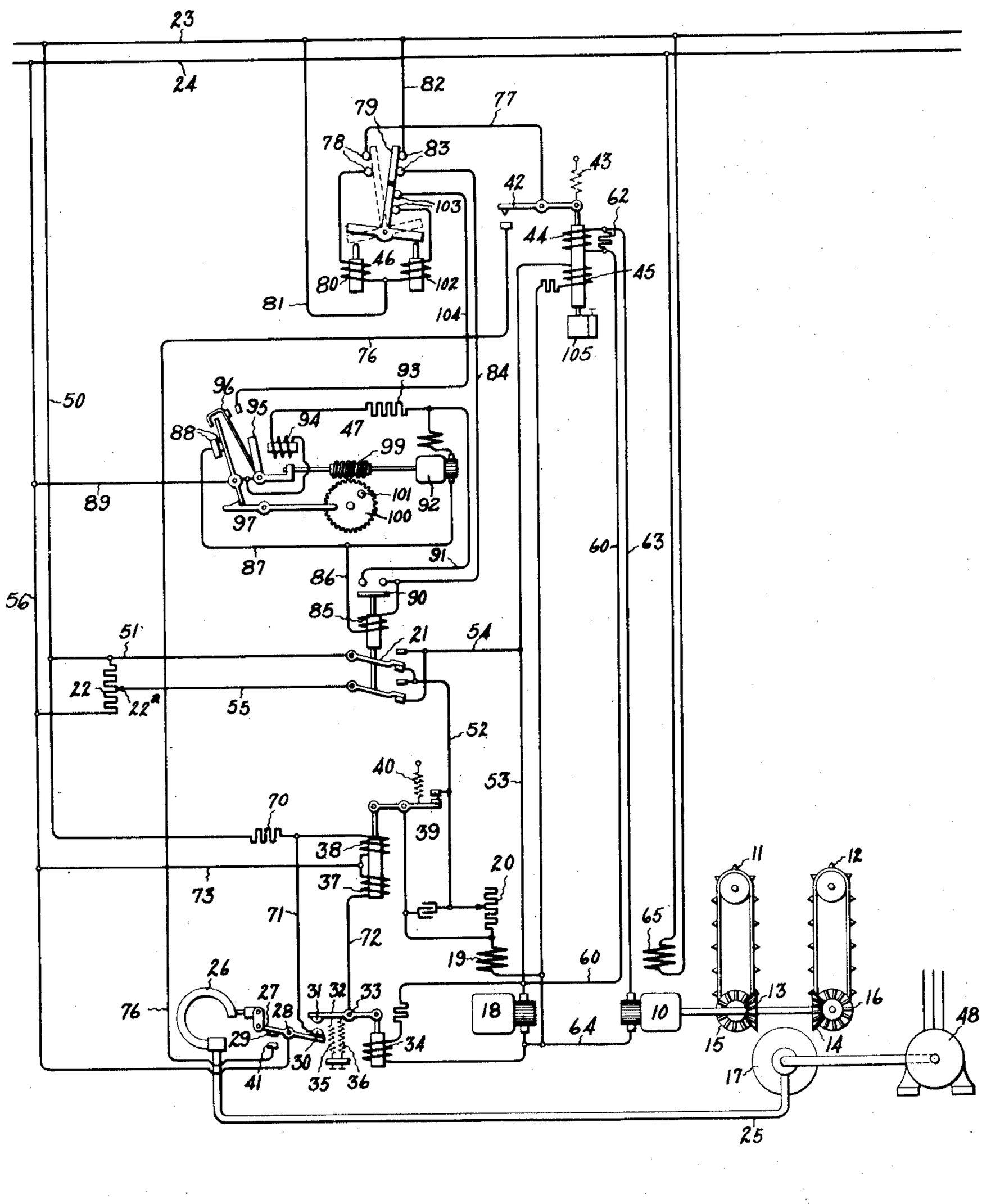

Inventors
Frank A. Byles.
Fred H. Winter,
by Charles V. Mullen
Their Attorney.

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MOTOR CONTROL SYSTEM

Frank A. Byles, Scotia, and Fred H. Winter, Schenectady, N. Y., assignors to General Electric Company, a corporation of New York

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Our invention relates to motor control systems, more particularly to systems for governing the operation of rotary grinding machines used in the production of wood pulp, and has for an object the provision of a reliable automatic system responsive to changing conditions incident to the operation of the machine for insuring a uniform product.

While our invention is not necessarily limited thereto, it is particularly applicable to the type of grinding machine employed in the production of wood pulp to be used in the manufacture of paper. A typical machine of this type consists of a grindstone carried by a rotary driving shaft to which the wood in the form of short logs is fed by a suitable feeding means. Although the surface condition of the grindstone and the amount of water supplied to the stone must be considered, the texture of the wood pulp obtained from the grinding machine is dependent to a large degree on the pressure with which the wood or logs are urged against the grindstone. By maintaining the pressure substantially constant the texture of the wood pulp is much more uniform than when the pressure varies above and below a predetermined amount. Uniformity of the wood pulp is particularly desirable since at the present time the practice is to use the wood pulp as obtained from the grinding machine for paper manufactures.

In carrying out our invention in one form, we provide for the feeding of the wood against the grindstone so that a substantially constant predetermined pressure of the wood against the grindstone is maintained. More specifically, we utilize the oil pressure at the bearings of the grindstone in conjunction with a vibratory regulator to control the drive of the feeding means for the wood. The vibratory regulator is of the type which prevents over-regulation of the feeding means and thereby insures a more uniform texture of the wood pulp.

For a more complete understanding of our invention, reference should now be had to the drawing, the single figure of which diagrammatically shows our invention applied to a control system for a wood pulp grinding machine.

Referring to the drawing, we have shown our invention in one form as applied to a Ward-Leonard control of a motor 10 arranged to drive the endless feed chains 11 and 12 through the cooperation of the gears 13 and 14 secured to the motor shaft and the gears 15 and 16, respectively, driving the feed chains 11 and 12. Billets of wood, or short logs, are introduced between the feed chains and are urged downwardly to engagement with a grindstone 17. The operations of the motor 10 are controlled by a generator 18 whose armature is connected in local circuit with the armature of the motor. A generator field winding 19 is connected to the armature of the generator and through a resistance 20, a reversing switch 21, and a resistance 22 to a separate source of direct current supply as indicated by the supply lines 23 and 24.

For the purpose of controlling the speed and direction of rotation of the motor 10, the bearing oil pressure of the grindstone 17 is transmitted through a pipe 25 to a Bourdon pressure element 26 operatively connected to a lever 27 which is pivoted at 28 and which supports on opposite sides of the pivot contacts 29 and 30. A contact 31 carried by a lever 32 pivoted at 33 is arranged to cooperate with the contact 30 which is suitably insulated from the lever 27. An anti-hunting electromagnet 34 energized by the voltage of the generator 18 is arranged to increase the distance between the contacts 30 and 31 while the springs 35 and 36 are arranged to oppose the pull of the electromagnet 34. The closing of the contacts 30 and 31 causes the energization of a coil 37 connected in opposition to a coil 38. The coil 38 normally maintains the relay 39 open, the resistance 20 thereby remaining in circuit with the field 19. It will be observed that whenever the contacts 30 and 31 close, the coils 37 and 38 neutralize each other so that a spring 40 connected to the armature of the relay 39 thereupon operates the relay to its closed position. The effect of closing the relay 39 is to shunt the resistance 20 from the field circuit causing an increase in the excitation and output of the generator 18. The resulting increased speed at which the motor 10 drives the feed chains 11 and 12 correspondingly increases the pressure of the wood against the grindstone.

The contacts 29 and 41 are arranged to be closed whenever the pressure against the grindstone drops below a predetermined amount. The contacts of a differentially operated relay 42 are connected in series with the contacts 29 and 41. The contacts of the relay 42 are closed by a spring 43 whenever the generator current responsive coil 44 neutralizes the effect of the generator voltage responsive coil 45. The circuit thereby completed serves to energize a relay 46 which operates to complete a circuit to operate the reversing switch 21 and to initiate the operation of a timing mechanism 47.

With the above identification of the elements

comprising an embodiment of our invention, the operation will be fully understood by the detailed description which follows: In the operation of our invention in the form shown it will be assumed that the grindstone 17 is being driven at constant speed by a suitable prime mover shown as an alternating current motor 48 and that short logs of wood have been introduced between the drive chains 11 and 12. It will also be assumed that the generator 18 is being rotated at constant speed by a suitable prime mover (not shown). It will be observed that the generator field winding 19 is energized from the direct current supply lines 23 and 24 through a circuit which may be traced from the supply line 23, conductors 50 and 51, the upper contact of the switch 21, conductor 52, resistance 20, field winding 19, through the armature of the generator 18, conductors 53 and 54 to the lower contact of the switch 21, conductor 55, to an adjustable tap 22a provided on the resistance 22, through a portion of the resistance 22 and by conductor 56 to the other supply line 24. The resistor 22 furnishes a small starting voltage to initiate the rise of magnetism in the generator. Thereafter the rising voltage of the generator 18 causes excitation current to flow through the field winding 19 through a circuit which may be traced from one side of the armature of the generator 18 by conductor 53, conductor 54, the lower contact of the switch 21, conductor 55, through the upper portion of the resistance 22 by conductor 51 to the upper contact of the switch 21, thence by conductor 52 and the resistance 20 through the field winding 19 and to the other side of the armature of the generator 18.

The consequent excitation of the field winding 19 causes the generator voltage 18 to build up which in turn causes the motor 10 to rotate in the proper direction to drive the feed chains and to urge the wood against the grindstone 17. The local circuit between the motor and generator armatures may be traced from one side of the generator armature by conductor 60, through a resistance 62 and a coil 44 connected in parallel with each other, thence by conductor 63 through the motor armature and by conductor 64 to the other side of the generator armature 18. The field winding 65 provided on the motor 10 is directly connected across the supply lines 23 and 24.

It will be observed that the coil 38 of the field controlling relay 39 is directly connected through a resistance 70 to the conductors 50 and 56 leading from the supply lines 23 and 24, the coil being arranged to maintain the relay 39 open. The resistance 20 is therefore normally connected in circuit with the field winding 19 causing the motor 10 to rotate at a lower speed than when the resistance 20 is short-circuited. If the pressure on the grindstone 17 decreases below a predetermined amount the Bourdon pressure element 26 closes the contacts 30 and 31, thereby energizing the coil 37 through a circuit which may be traced from the supply line 23, conductor 50, resistance 70, conductor 71, contacts 30 and 31, conductor 72, coil 37, conductor 73, conductor 56 and to the other supply line 24. Inasmuch as the coils 37 and 38 are differentially connected, the switch 39 is thereby closed by reason of the tension spring 40 connected to the armature of the switch 39. The closure of the switch 39 short-circuits the resistance 20 and thereby increases the excitation of the generator 18. The resulting voltage rise produces an increased motor speed so that the feed chains 11 and 12 driven by the motor drive the logs with greater effort against the grindstone 17. It is to be observed, however, that the increased voltage corresponding to an increased output of the generator 18 is applied to the anti-hunting magnet 34 which causes the contacts 30 and 31 to separate against the bias of the springs 35 and 36. The result is a vibratory motion of the lever 32 carrying the anti-hunting contact 31. The opening of the contacts 30 and 31 causes the opening of the relay 39 and hence the reinsertion of the resistance 20. As is well understood in the art, the excitation voltage of the generator 18 and consequently the speed of the motor 10 is dependent upon the average time that the relay 39 and the contacts 30 and 31 are closed, which average time is dependent upon the relative positions of the lever 33 and the lever 27. The net result is a vibratory action of the part of the relay 39 and the contact 31 with a consequent control of the excitation of the generator 18 which is precise and accurate and corresponds to the increased excitation necessary to cause the desired increase of pressure on the grindstone 17.

Were it not for the quick acting anti-hunting means, the regulator would tend to produce hunting with consequent periodic increases and decreases from the normal pressure of the wood against the grindstone. Thus, assuming contact 31 to be fixed, the engagement of the contacts 30 and 31 as the result of a decrease in pressure as previously described, will cause an increase in excitation of the generator 18 until these contacts again separate as a result of the pressure having returned to normal. The result will be a periodic variation of pressure on both sides of normal which will be accentuated by the time constants of the field winding of the generator and of the motor. However, with the anti-hunting means such a variation is prevented, for as the contact 30 moves in response to pressure, the anti-hunting contact 31 is actuated to prevent the increase or decrease in excitation of the generator 18 from lasting so long as to cause a material variation, so that the pressure with which the logs are urged against the grindstone remains substantially constant with a consequent greater uniformity of wood pulp.

The vibratory action of the anti-hunting means being responsive to the generator voltage and not to the field current of the machine, acts so rapidly that due to the time lag of the field winding of the generator, the current therein is held substantially constant, so that no periodic effect on the pressure is produced by this anti-hunting means. Our invention is not limited to the particular operating means for the anti-hunting contact which has been shown, and it will occur to those skilled in the art that many other ways of securing vibratory action of the contact 31 may be employed without departing from our invention in its broader aspect.

If the pressure is not increased by the regulating action which we have just described and the pressure exerted by the wood against the grindstone continues to diminish, the contacts 29 and 41 are closed after such pressure has diminished a predetermined amount. Assuming that a jam has formed between the feed chains 11 and 12, it will be apparent that the load current of the motor 10 will remain quite high, the result being that the coils 44 and 45 connected in opposition neutralize each other so that the spring 43 provided on the relay 42 closes the contacts of the

relay. An energizing circuit for the relay 46 is thereby completed which circuit may be traced from the supply line 24, conductor 56, contacts 29 and 41, conductor 76, relay 42, conductor 77, through the contacts 78 shunted by the armature 79 of the relay 46, through the operating coil 80 and by conductor 81 to the supply line 23. The coil 80 thereupon causes the plunger to strike the lower portion of the armature 79 to move it from its normal position as shown by the broken line outline to the full line position. The operating coil 85 of the reversing switch 21 is thereupon energized through a circuit which may be traced from the supply line 23, conductor 82, the upper pair of contacts 83 on the relay 46, conductor 84, operating coil 85, conductors 86 and 87, the left-hand contacts 88 of the timing means 47, and by conductors 89 and 56 to the other supply line 24.

The reversing switch 21 thereupon closes to reverse the magnetism and voltage of the generator 18 causing a reversal in the direction of rotation of the motor 10 and consequently causing the chains 11 and 12 to be driven in a direction to remove the pressure from the grindstone 17 or in the case a jam is formed, to break the jam.

When the reversing switch 21 was operated to its new position a switch 90 actuated with switch 21 was closed, establishing an energizing circuit for the timing means 47. This circuit may be traced from the supply line 23, contacts 83, conductor 84, switch 90, conductor 91, a resistance 93, the coil 94, thence by conductor 89 and conductor 56 to the other supply line 24. It will be observed that the energization of the coil 94 exerts a force on the armature 95 of switches 88 and 96, tending to move the armature in a direction to open the switch 88 and close the switch 96. This movement of the armature 95, however, is prevented by a gravity operated latch 97. The energization of the timing motor 92, which is connected in parallel circuit relation, as shown, with the coil 94 and the resistance 93, causes its armature to be rotated, and by means of the worm gear 99, carried by the armature shaft, engaging a gear 100, serves to rotate the gear 100 in a clockwise direction so that the projection 101 strikes the outer end of the catch 97 in a direction to release the armature 95, whereupon the armature is moved by the attractive effort of the coil 94. The skitch 88 is at the same time opened to break the circuit through the operating coil 85 of the reversing switch 21, and the reversing switch 21 is thereupon operated to its original position. The closing of the switch 96 establishes an energizing circuit for the coil 102 of the relay 46, which circuit may be traced from the supply line 23, coil 102, contacts 103 shunted by the armature of the relay 46, by conductor 104, the switch 96 and thence by conductors 89 and 56 to the other supply line 24. The coil 102 thereupon operates the relay 46 to its original position.

It will of course be obvious to those skilled in the art, that as soon as the reversing switch 21 was returned to its former position, the generator voltage again reversed its polarity causing the motor 10 to drive the feed chains 11 and 12 in a direction to again feed the wood downwardly against the grindstone 17.

It will be remembered that the contacts of the relay 42 were closed because the coils 44 and 45 neutralized each other. The reversal of the motor 10, as we have explained, serves to break the jam of the logs which occurs between the feed chains. As soon as the jam is broken, the motor current becomes relatively small and consequently the opposition offered by the coil 44 to the coil 45 becomes much less. The result is that the voltage responsive coil 45 opens the contacts of the relay 42. We provide a dashpot 105 on the relay 42 so that this relay may only be closed after the occurrence of an interval of time. This interval of time is important in order to prevent an immediate reversal of the generator voltage after the direction switch 21 has been operated to its first position.

If, however, the jam has not broken and the pressure remains below the predetermined amount on the grindstone 17, it will of course be understood that the contacts of the relay 42 again close, establishing the circuits as we have described them, causing the generator voltage to again reverse, hence reversing the drive of the feed chains 11 and 12.

The provision of the relay 42 causes our control system to discriminate between a condition of decreased pressure against the grindstone 17 with a corresponding decrease of motor current and the condition of a jam where the motor current is increased.

While we have shown a particular embodiment of our invention, it will be understood, of course, that we do not wish to be limited thereto since many modifications may be made, and we therefore contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of our invention.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. In a wood grinder, the combination of a grindstone provided with a shaft and bearings therefor, means for feeding wood against the stone to exert a pressure thereon, driving means for said feeding means, a pair of associated contacts, means for moving one of said contacts in response to an output characteristic of said driving means, pivoted means supporting said other contact on one side of its pivot for movement toward and away from said other contact, means responsive to the bearing pressure of said grindstone for actuating said pivoted means, control means operable by said contacts to control the speed of said feed driving means, a second pair of contacts one of which is supported on the opposite side of said pivot for engagment with the other contact upon a predetermined reduction in said bearing pressure, and reversing means operable upon engagement of said second pair of contacts for reversing said feeding means.

2. The combination with a grinding machine provided with a rotatable grindstone and feeding means for the grindstone, of a motor for driving said feeding means, a generator connected in local circuit with said motor and provided with a field winding, a regulating resistance connected in circuit with said field winding for controlling said motor, a pair of contacts, means mounting said contacts for their mutual approach and separation, connections for connecting said contacts to control said regulating resistance, means for operating one of said contacts in response to the bearing pressure of said grindstone and means for operating the other of said contacts in response to the voltage of said generator.

3. The combination with a machine having a load supporting member, feeding means associated with said member, of a motor for driving said feeding means, a supply generator provided

with a field winding for controlling said motor, a pair of contacts, connections for connecting said contacts to control the energization of said field winding, means for moving one of said contacts in response to the bearing pressure of said member, and means for moving the other of said contacts in response to a generator electrical condition which varies with the output of said generator so that said contacts by their mutual approach and separation control said generator and said motor to maintain substantially constant the load on said supporting member.

4. In a wood grinder, the combination of a grindstone, its gearing, shaft and bearings, means for feeding wood against the stone to exert pressure thereon, driving means for said feeding means, a oil film between the shaft and its bearings subject to said pressure, a pair of contacts, means mounting said contacts for mutual approach and separation, connections for connecting said contacts to control said feed driving means, means for moving one of said contacts in response to an output characteristic of said driving means, and means for moving the other of said contacts in response to the pressure of said oil film.

5. In a wood grinding machine, the combination of a grindstone, its gearing, shaft, and bearings, means for feeding the wood against the stone to exert pressure thereon, an oil film between the shaft and its bearing subject to said pressure, a movable circuit regulating element operable in accordance with the pressure of said oil film, an electric means for controlling said wood feeding means, said electric means including an electric circuit the voltage of which is regulated by said movable element, and means for modifying the operation of said movable element in response to the voltage of said electric circuit to prevent overregulation of said electric means.

6. A control system for pulp grinding machines and the like, comprising a member for carrying out a predetermined operation upon the material, means for feeding said material to said machine so that a pressure is applied to said member, a motor for driving said feeding means, a source of electrical energy for supplying said motor, control means responsive to the pressure applied to said member for increasing said electrical energy applied to said motor upon a predetermined decrease of pressure against said member, and means associated with said control means responsive to the voltage of said source for modifying the action of said means to prevent overregulation.

7. A control system for grinding machines for the production of wood pulp comprising a grindstone, feeding means for urging the wood against said grindstone, driving means for said feeding means, means responsive to the bearing pressure of said grindstone and operatively associated with said driving means for controling its speed to maintain said bearing pressure substantially constant, and means responsive to speed variations of said driving means for modifying the action of said pressure responsive means to prevent overregulation of said bearing pressure.

FRANK A. BYLES.
FRED H. WINTER.