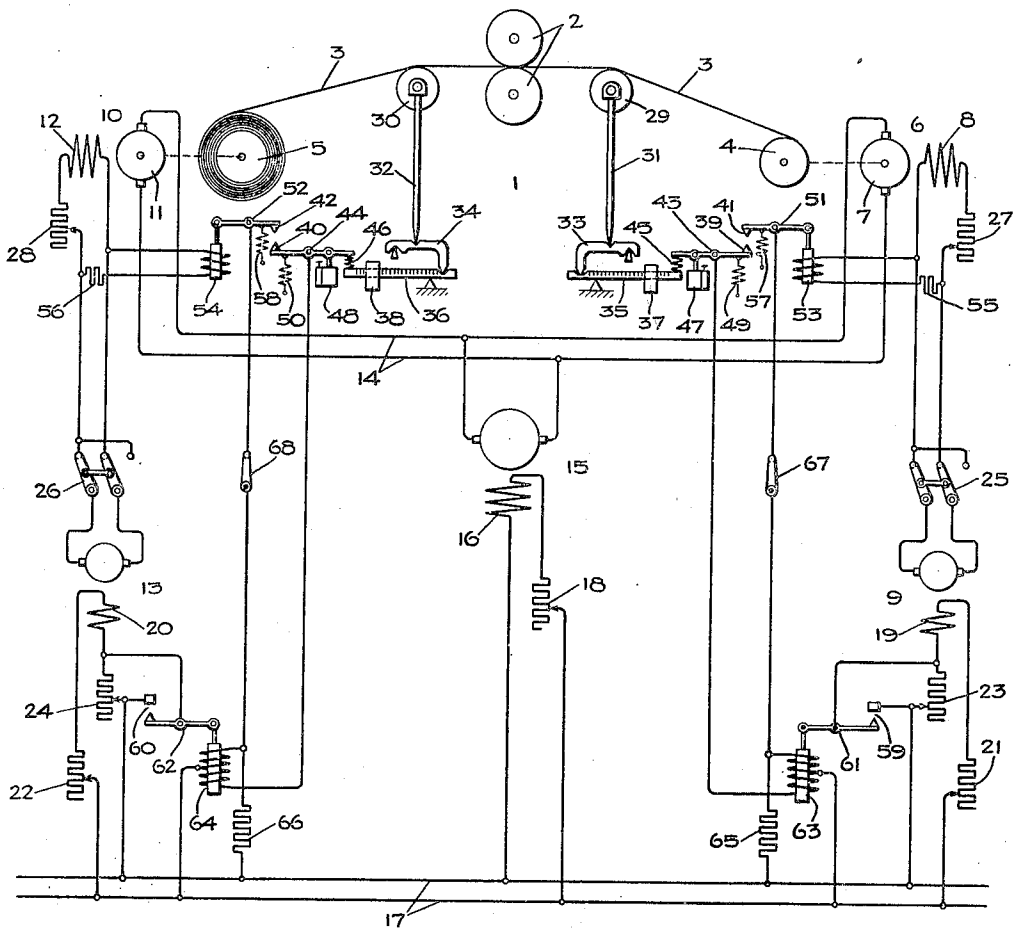
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ELECTRICAL REGULATING SYSTEM

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ELECTRICAL REGULATING SYSTEM

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My invention relates to electrical regulating systems and particularly to an electrical system for regulating the tension of materials being acted upon by reeling mechanisms.

In reeling mechanisms it is often desirable to regulate the tension of the material being reeled or unreeled in a manner to maintain this tension at a predetermined value. This is especially true in strip and wire mills where the material is drawn though die or sizing rolls, for as it requires a considerable force to pull the material through these rolls it is important that the tension of the material entering the rolls should not exceed a given value for otherwise the sum of this entering tension and the tension necessary to pull the material through the rolls may produce breakage of the material.

Due to the well-known fact that the angular speed of a reel must change in order to keep the linear speed of the reeled material constant, as the reeling or unreeling progresses, frictional devices on the reel are usually unsatisfactory as tension holding devices in cases where close limits of regulation are necessary.

In accordance with my invention I provide an electrical regulating system for the tension of reeled material which is controlled by a mechanical balance that is responsive directly to the tension of the material.

An object of my invention is to provide a new and improved electrical regulating system for the tension of reeled material.

Another object of my invention is to provide an electrical regulating system for the tension of reeled material, which employs a vibratory contact type regulator that is controlled by a mechanical balance whose equilibrium is upset by departures from a predetermined value of the tension of the reeled material.

My invention will be better understood from the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

Referring now to the single figure of the accompanying drawing, which is a diagrammatic illustration of an embodiment of my invention as applied to a strip or wire mill, 1 designates the mill generally and 2 are the sizing or die rolls for reducing the cross-section of the material 3 drawn through them. The mill which is illustrated is reversible, the material 3 being alternately passed through the sizing rolls in opposite directions by means of a pair of reversibly driven reels 4 and 5. Reel 4, which, from the disposition of the material on the reels is in a position to pull the material through the rolls, is driven by a suitable dynamo 6, acting as a motor, whose armature 7 is connected thereto. The field winding 8 of motor 6 may be energized from any convenient source, in fact it may even be a shunt field, but in the illustrated embodiment of my invention it is energized by an exciter 9. Reel 5, which is acting as the trailing reel is associated with a dynamo 10, which is arranged to act as a generator so as to provide the necessary back tension. As shown, the armature 11 of machine 10 is mechanically connected to reel 5 while the field winding 12 of this machine is energized by an exciter 13 although any other suitable source would be satisfactory.

The armatures 7 and 11 of machines 6 and 10 are connected to a circuit 14 which is energized by a suitable source of current, such as a generator 15, whose field winding 16 is energized by any suitable source, such as the constant voltage supply bus 17, through the usual adjustable field rheostat 18.

The respective field windings 19 and 20 of exciters 9 and 13 are energized from the supply bus 17 through their respective adjustable field rheostats 21 and 22 and adjustable regulating resistances 23 and 24. For controlling the direction of rotation of machines 6 and 10, reversing switches 25 and 26 are provided in the circuits of the respective field windings of these machines. The usual field rheostats 27 and 28 are also inserted in the respective field winding circuits of these machines.

For regulating the tension of the material 3, I provide a mechanical balance device which actuates an electrical regulator for controlling the excitation of the trailing dynamo and hence the back tension produced

by it. As the particular mill which I have shown is reversible, each of the machines 6 and 10 is alternately the trailing machine and hence duplicate balance devices and regulators are provided. The balance devices may be embodied in a variety of forms the ones illustrated comprising idlers 29 and 30 over which the material 3 passes, these idlers being so mounted with respect to the reels and sizing rolls that the material is swigged off in such a way that tension in the material produces a downward force on them. This force is transmitted by rods 31 and 32 to pivoted levers 33 and 34 and thence to pivoted levers 35 and 36 on which are mounted adjustable weights 37 and 38. Through this arrangement weights 37 and 38 may be adjusted so as to create a balance or state of equilibrium at any desired tension in material 3. Although these weights have been shown as being manually adjustable, it will occur to those skilled in the art that remote control means such as small electric motors and worm gearing for moving these weights may be employed without departing from my invention in its broader aspects. With such an arrangement the control of the tension may be varied from a distance. It will be seen from the arrangement of the pivoted levers that a relatively small movement of the idlers produces a relatively large movement of the weights. This has a double advantage in that relatively small weights will balance a relatively large force on the idlers and also a relatively small movement of the idlers, which will not in itself appreciably effect the tension of the material 3, will produce a relatively large motion of the adjusted ends of the levers, thus producing a sensitive control means for the regulating devices.

The regulating devices, which are controlled by the balancing devices, consist essentially of two contacts, namely, control contacts 39 and 40 and vibratory anti-hunting contacts 41 and 42. Control contacts 39 and 40 are respectively mounted on pivoted levers 43 and 44 which in turn are respectively connected by resilient connecting means, such as springs 45 and 46, to the weighted levers 35 and 36. Damping means, such as dashpots 47 and 48 and biasing means, such as springs 49 and 50, are connected to levers 43 and 44 respectively. Anti-hunting contacts 41 and 42 are mounted respectively on pivoted levers 51 and 52. These levers are moved respectively by suitable actuating means, such as solenoids 53 and 54 which are connected across the circuits of field windings 8 and 12 through suitable current limiting resistors 55 and 56. Biasing means, such as springs 57 and 58, serve to urge contacts 41 and 42 respectively to circuit closing positions.

Although the regulating devices may be made to operate directly on regulating resistances 23 and 24, it is preferable to interpose relays between the contacts of the regulating devices and the regulating resistances so as to protect, and limit the current carried by, the contacts. No particular type of relay is necessary, the illustrated embodiment being provided with differential relays which are satisfactory for the purpose. These relays comprise respectively pairs of contacts 59 and 60 which are arranged to short circuit regulating resistances 23 and 24. One contact of each pair is arranged to be moved through suitable pivoted levers 61 and 62 by differential magnets 63 and 64, one coil of each of which is energized constantly from supply bus 17, while the other coil is energized intermittently by the action of the contacts of the regulating devices from the same source. The return circuits of each of the coils of each pair being through current limiting resistors 65 and 66 respectively. The coils of each pair are so arranged that when both are simultaneously energized their magnetomotive forces are in opposition.

Switches 67 and 68 are provided for rendering their associated regulators inoperative when desired, these switches may be connected in any one of a number of ways which would be obvious to those skilled in the art and in the embodiment shown are connected to the contact circuit of their associated regulator.

The operation of the illustrated embodiment of my invention is as follows. Assume that bus 17 is energized by any suitable source of direct current and that generator 15 and exciters 9 and 13 are being driven by any suitable prime mover. As practically all the material 3 is wound on reel 5, the rotation of reels 4 and 5 during the succeeding operation of the mill will be clockwise, thereby to draw the material through the sizing rolls from reel 5 to reel 4. To do this, field rheostat 18 of generator 15 is adjusted so that the proper voltage is impressed on circuit 14, switch 67 is opened thereby to cut its associated regulator out of service, reversing switch 25 is moved to the position giving clockwise rotation of machine 6 as a motor and field rheostats 21 and 27 are adjusted so as to give machine 6 the desired speed and torque. Reversing switch 26 is moved so that machine 10 also tends to operate in a clockwise direction as a motor but field rheostats 22 and 28 are set so that the excitation of this machine is greater than that of machine 6 with the result that machine 6 through the intermediary of the reels and work operates it as a generator. Machine 10 therefore acts as a regenerative brake to maintain a back tension in the material 3. The application of my invention, however, is not limited to arrangements wherein the trailing machine acts as a regenerative brake, and it will readily occur to those skilled in the art that other ways of securing this braking action through the trailing machine are

available, for example, dynamic braking wherein the generated energy of the trailing machine is dissipated in heating a resistance.

The operation of the regulating means is as follows. If the back tension in material 3 exceeds a predetermined value, as determined by the position of weight 38, idler 30 and rod 32 will descend slightly thus causing the weighted end of pivoted lever 36 to rise which motion will be transmitted by the resilient connection 46 and pivoted lever 44 to contact 40 which will descend. This motion of contact 40 will cause it to move away from contact 42 with the result that the circuit of the lower winding of the differential relay operating magnet is broken. The upper winding of this magnet will then be unopposed and will act to separate the contacts 60 whereby all of resistance 24 is inserted in the field winding circuit of exciter 13. This will decrease the exciter voltage and consequently will decrease the excitation of machine 10 which is operating as a generator. The result of this decrease in the generator excitation will be to decrease its voltage thus decreasing its output and hence its braking effect so that the tension in material 3 is reduced.

At the same time that the excitation of machine 10 decreases the energization of anti-hunting magnet 54 decreases with the result that spring 58 overpowers the pull of magnet 54 and contact 42 engages contact 40. This energizes the lower coil of differential magnet 64 with the result that the effect of the upper coil is neutralized and contacts 60 engage to short circuit resistance 24 thereby to increase the excitation of exciter 13 and hence generator 10. However, as soon as the voltage of exciter 13 increases magnet 54 overpowers spring 58 and contact 42 leaves contact 40. This cycle is then repeated, contact 42 vibrating rapidly to hold a mean value of excitation on machine 10, depending upon the position of contact 40.

Were it not for the quick acting anti-hunting means the regulator would tend to produce hunting with consequent periodic increases and decreases from normal of the tension of the material. Thus, assuming contact 42 to be fixed, the separation of the contacts 40 and 42 as a result of an increase in tension, as previously described, will cause an increase in excitation of machine 10 until these contacts again engage each other as a result of the tension having decreased below normal. The result will be a periodic overswing of the tension on both sides of normal which will be accentuated by the time constants of the field windings of the exciter and braking machine. However, with the anti-hunting means such an overswing is prevented for as contact 40 moves in response to changes in tension the anti-hunting contact is actuated to prevent the increase or decrease in excitation of machine 10 from lasting so long as to cause an overswing, so that the balance device has a chance to return to its position of equilibrium.

The vibratory action of the anti-hunting means, being responsive to the exciter voltage and not to the field current of machine 10 acts so rapidly that due to the time lag of the field winding of machine 10 the current therein is held substantially constant so that no periodic effect on the tension is produced by this anti-hunting means. My invention, however, 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 contact 42 may be employed, such as an ordinary buzzer circuit for example wherein contacts 40 and 42 will correspond to the buzzer contacts, without departing from my invention in its broader aspects.

If the tension falls below normal, weight 38 descends, thereby raising contact 40 to increase the excitation of generator 10.

After the material has been passed through rolls 2 and is consequently mainly wound on reel 4, switch 68 is opened, switch 67 closed, reversing switches 26 and 25 operated and rolls 2 adjusted for the next operation. Machines 6 and 10 will reverse their direction of operation and the material will be drawn through the rolls in the opposite direction, the regulating devices associated with machine 6 acting to hold constant back tension in the same manner as has been described in connection with the other regulating means.

While I have shown and described a particular embodiment of my invention it will be obvious to those skilled in the art that changes and modifications may be made without departing from my invention and I, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

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

1. In combination, means adapted to produce translatory motion of a length of material, a generator, means responsive to the motion of the trailing end of said material for driving said generator whereby the energy required to drive said generator produces a back tension in said length of material, and means including a vibratory contact regulator responsive to the tension in said material for regulating the excitation of said generator.

2. In combination, a reel for a strip to be wound thereon, means for unwinding said strip from said reel, a dynamo electric machine connected to said reel for retarding the motion thereof, a vibratory contact type regulator for varying the excitation of said dynamo electric machine to control its retarding action, and means responsive to the ten-

sion of said strip for controlling said regulator.

3. In combination, a source of electrical energy, means energized by said source of electrical energy and adapted to be fastened to one end of a length of flexible material for producing translatory motion thereof, a generator, means connecting said generator to the other end of said length of material whereby the translatory motion of said material drives said generator, means for feeding the electrical output of said generator to said source of electrical energy, and means operative in accordance with the tension in said material for regulating the excitation of said generator.

4. In combination, means adapted to be connected to one end of a length of flexible material for producing translatory motion thereof, means at the other end of said length of material for opposing said motion, means including a pair of contacts for varying the degree of opposition produced by said motion opposing means, means for moving one of said contacts with respect to the other in accordance with the tension in said length of material, and means for producing a vibratory motion of said other contact.

5. In combination, a reel for material to be wound thereon, means for unwinding said material from said reel, dynamo electric means for opposing the unwinding of said reel, means including a pair of contacts for controlling the degree of opposition produced by said dynamo electric means, means for moving one of said contacts with respect to the other comprising a pivoted arm, a weight attached to said arm on one side of the pivot, a lever attached to said arm on the other side of said pivot, and means responsive to the tension in said material for actuating said lever.

6. A strip mill having in combination, a pair of reels adapted to be joined by a strip, sizing rolls through which said strip passes, independent reversible dynamo electric machines connected to each of said reels, means for operating one of said dynamo electric machines as a motor to draw said strip through said sizing rolls, means for operating the other dynamo electric machine as a generator to oppose the drawing of said strip through said sizing rolls, and means responsive to the tension of said strip before it reaches said sizing rolls for controlling the generating action of said last mentioned dynamo electric machine.

7. In combination, means including separate dynamo electric machines adapted to be connected to each end of a length of flexible material, means for energizing said machines in such a manner that one of them tends to operate at a greater speed than the other whereby the faster machine acts as a motor to produce translatory motion of said material which motion operates said other machine as a generator, means for performing a manufacturing operation on said material which produces a tension therein, separate means responsive to the tension in said material on each side of said operation performing means for regulating the excitation of said dynamo electric machines, means for rendering either one of said tension responsive regulating means inoperative, and means for reversing the operation of said dynamo electric machines.

8. In a strip mill, a reel for a strip to be wound thereon, sizing rolls, means for drawing said strip from said reel between said rolls, electrically controlled braking means associated with said reel, means including a pair of contacts for controlling the action of said braking means, means comprising a normally balanced system of forces for determining the position of one of said contacts with respect to the other, one of said forces being constant, the other of said forces varying in accordance with the tension in said strip, and anti-hunting means operated in accordance with an electrical condition of said braking means for controlling the position of the other contact.

9. A tension regulator for reeled flexible material comprising electrically controlled means for producing back tension in said material, a pair of contacts for controlling an electrical condition of said electrically controlled means, an idler pulley for swigging off a portion of said material so as to produce a force which is a function of the tension in said material, movable means connected to said idler for producing a force which opposes the force produced by said idler, means for adjusting the value of said opposing force, means responsive to an unbalance of said forces for moving one of said contacts with respect to the other, and means for vibrating said other contact.

10. A reeling mechanism having in combination a generator, means for performing a manufacturing operation on a length of flexible material, means for feeding said material to said operation performing means, means connecting said material to said generator whereby the energy required to drive said generator opposes the feeding of said material to said operation performing means, and means for varying the excitation of said generator inversely with changes in the tension in said material.

11. A strip mill having in combination, a pair of spaced reels adapted to be joined by a strip of flexible metallic material wound on said reels, a pair of sizing rolls between which said strip moves, a separate dynamo electric machine mechanically coupled to each reel, a common source of electrical energy for said dynamo electric machines, means for reversing the excitation of each of said dy-

namo electric machines, means for varying the degree of excitation of each of said dynamo electric machines, a separate vibratory contact type electrical regulator associated with the excitation circuit of each dynamo electric machine, a separate idler for swigging off a portion of said strip on each side of said sizing rolls, a separate balance device associated with each of said idlers whereby changes in tension in said strip from a predetermined value upset the balance of said device, means responsive to changes in the balance of said balance devices for controlling said regulators, and means for selectively rendering either one of said regulators inoperative.

In witness whereof, I have hereunto set my hand this 22nd day of July, 1930.

FRANK A. BYLES.