Fig. 1.

Fig. 2.

Fig. 3.

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ATTORNEY
To all whom it may concern:

Be it known that I, Glen E. Stoltz, a citizen of the United States, and a resident of Wilkinsburg, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Motor-Control Systems, of which the following is a specification.

My invention relates to motor-control systems and has particular relation to such systems as are employed in connection with cold rolled strip mill operations, and the like.

One object of my invention is to synchronize the speed of a reel for winding steel strips with the speed of the mill for rolling these strips.

A second object is to insure that the speed of the reel automatically changes to correspond to any change in the speed of the mill.

Another object of my invention is to insure constant tension on the strip while the material is being rolled.

A further and very important object is to maintain tension on the strip while the mill is stopped, with the strip in the rolls, for gauging the material, so that the material will remain tightly coiled on the reel.

Still another object is to provide means for adjusting the tension on the material in accordance with different sizes of strips.

Other objects of my invention will appear in the following specification.

In rolling steel or other material into strips of uniform thickness, it is customary to wind the finished material in coil form upon a suitable reel. Efforts have been made to maintain approximately uniform tension on the finished material during the rolling process. As the strip is wound on the reel, the coil formed of course increases in diameter and, in order to maintain constant peripheral speed thereof, it is necessary to gradually reduce the speed of rotation of the winding reel. A slip clutch mechanism is commonly employed for this purpose and its limitations are well understood.

It is a purpose of my invention to eliminate the clutch mechanism and provide more suitable means for controlling the speed of the reel. In accordance with the preferred form of my invention, a direct-current adjustable-speed motor is connected for operating the reel and it receives its energy from a generator that is directly connected for rotation in accordance with the speed of the mill. The speed of the reel-motor will, therefore, synchronize with the speed of the mill.

In order to maintain constant tension on the strip, I provide a constant-current regulator for limiting the current and torque of the reel-motor. I also provide means whereby the operator may adjust the tension to suit variations in the material. It is found preferable to employ a collapsible reel whereby the material is initially tightly wound in coil form and, upon completion of the winding operation, the coil is readily removed when the reel is permitted to collapse. Occasionally during the process of finishing the material, it becomes necessary to stop and restart the mill, and my system insures proper tension during the acceleration and deceleration of the mill, and also when stopped, so that the reel cannot collapse until the winding process is completed, except in an emergency.

My invention will be described in connection with the accompanying drawing in which

Figure 1 is a diagrammatic representation of circuits and apparatus employed for controlling the reel-motor.

Fig. 2 is a diagrammatic view of circuits and apparatus employed for controlling the rolling mill and the winding reel, and

Fig. 3 is an end view of a suitable reel which may be employed in connection with my invention.

Referring to Fig. 2 of the drawing, a strip of unfinished material 1 is illustrated as having been started through a pair of rolls 2 and 3 that are driven in a familiar manner by means of a motor 4. A generator 5 is connected through suitable gearing 6 for rotation in accordance with the speed of motor 4. A reel motor 7, preferably of the direct-current, adjustable-speed type, is electrically connected to generator 5 and is geared to a collapsible reel 8. Suitable controllers 9 and 11, respectively, control the operations of motors 4 and 7.

Referring now to Fig. 3, the reel 8 comprises a spider 12 for mounting upon a shaft 13 that is driven by the reel motor 7 (Fig. 2). This spider is connected by means of links 14 to collapsible portions 15 of the reel
which are arranged to slide radially through the fixed portion 16 of the reel. When the portion 16 is momentarily restrained from rotation and the shaft 13 is rotated in a counter-clockwise direction, the spider 12 causes links 14 to straighten and move the portions 15 radially so as to increase the effective diameter of the reel. The reel is provided with a stationary jaw 17 and a second jaw 18 that is supported upon a shaft 19. A compression spring 21 provides a flexible connection between the spider 12 and jaw 18, so that on rotation of spider 12 in a counter-clockwise direction, jaws 17 and 18 are brought together. This movement is for the purpose of gripping an end of a strip of material.

As soon as the reel has begun to rotate in a counter-clockwise direction sufficiently to put tension on the strip, it is no longer necessary to restrain the member 16. It will be evident that the force exerted by the reel in a counter-clockwise direction operates against the strip tension, which is in a clockwise direction, and, therefore, the reel members 15 are maintained in their expanded positions.

In Fig. 2 I have shown the reel 8, with an end of the strip 1 inserted preparatory to commencing the winding operation, and a foot-operated mechanical brake 22 that is arranged for retarding the rotation of the reel 8 until the latter has been properly expanded, as previously described.

Reference may now be had to Fig. 1, in which armatures 23 and 24 of the generator 5 and motor 7, respectively, are arranged for connection in a loop circuit, comprising an accelerating resistor 25, a resistor 26 and a switch 27. Shunt field-magnet windings 28 and 29 are separately excited from a suitable source of energy comprising conductors 31 and 32. Auxiliary switches 30 and 43 are employed for a special purpose hereinafter described. A resistor 33 is connected in circuit with motor field winding 29 and is controlled by means of a current regulator 34 having an operating coil 35 connected across the terminals of resistor 26. A rheostat 36 provides means for adjusting the value of current traversing coil 35. An auxiliary resistor 37 is controlled by a plurality of switches 38, 39, 40, 41, 42 and 43, under special operating conditions hereinafter set forth.

Referring again to Fig. 2, a no-voltage relay 44 having an operating coil 45 is controlled by means of start and stop buttons 46 and 47, respectively, for controlling an energizing circuit for the operating coil 48 of switch 27 (Fig. 1). A transfer relay 49, having an operating coil 50, controls the operating coils 51, 52, 53, 54, 55, 56 and 57 of switches 30, 38, 39, 40, 41, 42 and 43, respectively. Master switches 58 and 59, of the dial type, are mechanically connected in a suitable manner, as by means of a bar 60, to tension rheostat 36. A double pole knife switch 61 controls the operation of main mill motor 4 and also provides an electrical connection to dial switch 59.

My invention will be best understood from a description of the operation, which is as follows.

Assuming the apparatus in its illustrated or inoperative condition, the rolling mill is started by closing knife switch 61, whereby energy is supplied to motor 4 from line conductors 31 and 32 through controller 9. Controller 9 may be of any suitable type commonly employed for service of this character. The operator next compresses the spring 63 in order to apply the brake 22, and simultaneously therewith, starting button 46 is actuated. This button may be either separate from, or mechanically connected to operate with the brake 22. Coil 45 of no-voltage relay 44 receives current from conductors 31 and 32 and, upon closure of the relay, a holding circuit is established extending from line conductor 31 through stop button 47, coil 48 and relay 44 to conductor 32. The closure of relay 44 immediately effects the energization of coil 48, and, consequently, the closure of switch 27. Since the armature 23 of generator 5 is driven by the motor 4, a voltage is applied to coil 50 of transfer relay 49, which is immediately actuated to its open-circuit position. Current from the armature 23 of generator 5 also traverses the loop circuit comprising the armature 24 of motor 7, the starting resistor 26, resistor 33, and switch 27. As soon as armature 24 rotates sufficiently to take up any slack in the strip 1, brake 22 should be released. As motor 7 accelerates, resistor 26 is gradually shunted by means of accelerating switches 63 and 64, which are closed after suitable time intervals, in accordance with any preferred known system of acceleration. The value of the motor current is now controlled by means of the current regulator 34, which operates to shunt a portion of resistor 23 when the motor current exceeds a predetermined value and to reinsert resistor 33 when the motor current falls below another predetermined value. Thus the motor current is automatically regulated by controlling the excitation of shunt field winding 29.

The relay coil 35 is responsive to variations in current traversing motor 7, since it is connected across the resistor or "shunt" 26. With tension rheostat 36 occupying its illustrated position, relay 34 operates at a relatively low current value and the torque exerted by the motor 7 is regulated accordingly, to maintain a given tension in winding the strip 1 upon the reel 8. Should it become necessary to increase the tension
on the strip, the rheostat 36 is actuated in a clockwise direction to insert more resistance in circuit with coil 35 and correspondingly raise the setting or current value at which relay 34 operates.

When it is desired to stop the rolls 2 and 3, in order to gauge the strip, knife switch 61 is opened, and as the mill motor 4 slows down and stops, the speed of the generator 5 is likewise controlled. Therefore, the motor 7 falls off in speed in accordance with the change in speed of the rollers 2 and 3 since its speed is dependent upon the voltage supplied by the generator 5. The regulator 34 continues to maintain a substantially constant current value for the motor 7. At a predetermined low speed of the generator 5, the coil 50 of transfer relay 49 becomes sufficiently deenergized to permit the relay to be restored to its normal position, thereupon establishing a circuit for switch coils 51 and 57 extending from line conductor 31 through relays 44 and 49 and the operating coils 51 and 57 to line conductor 32.

Switches 30 and 43 now close, and current is supplied to armature 24 of motor 7 for maintaining proper tension on the strip 1 when motor 7 is at rest. The circuit in question extends from line conductor 31 through switch 30, resistor 28, armature 24, resistor 37 and switch 43 to conductor 32.

In order not to interrupt the circuit of motor 7, even for a short period, which might be sufficient to cause reel 8 to collapse, switch 27 remains closed and, therefore, current also traverses the generator armature 59 by way of a shunt circuit comprising line conductor 31, switches 30 and 27, armature 23, resistors 25 and 37 and switch 43 to conductor 32. Accelerating switches 63 and 64 are opened when motor 7 is stopped. In the stop position, it is only necessary to supply sufficient current to the armature 7 to prevent reel 8 from collapsing; resistor 37 is accordingly selected of such ohmic value as to suitably limit the motor current.

As illustrated in Fig. 2, dial switches 58 and 59 are mechanically interlocked with tension rheostat 56 so that, for a certain running tension, the rheostat 56 occupies its illustrated position. Therefore, the tension with armature 24 at rest may be correspondingly regulated by dial switch 58, which in its illustrated position, will effect energization of coil 52 of switch 53 to cut out a portion of resistor 37.

When the mill is restarted, switch 61 is again closed, whereupon motor 7 is again accelerated in accordance with the rate at which the main mill motor 4 is accelerated, and, in order to maintain proper tension in strip 1, current is also supplied from line conductors 31 and 32. To obtain sufficient accelerating current it may be necessary to cut out a portion of resistor 37, which is automatically accomplished by the closure of one or more of switches 40, 41 or 42 in accordance with the setting of the dial switch 59. In the illustrated position, switch 40 only is closed, an operating circuit therefor extending from line conductor 31, through relays 44 and 49, operating coil 54 of switch 40, dial switch 59, conductor 65 and switch 61 to conductor 32.

When the voltage of generator 5 has built up to a suitable value, transfer relay 49 is again actuated, as previously described, to open the switches 30 and 43. After which motor 7 is controlled in accordance with the speed of generator 5 and its torque is limited by current regulator 34. Switches 38 to 42 are also restored to their inoperative positions.

From the above description of my invention it is evident that a winding-reel may be automatically controlled during all the necessary operations incident to handling strip steel from its rough unfinished condition until it is properly finished and coiled in accordance with various requirements. My invention clearly permits of an increase in the production and a better quality of strip material over that of any known system.

I do not claim the particular type of reel described and illustrated herein. Any suitable reel may be employed and many modifications in my system may occur to one skilled in the art. I have illustrated merely the preferred form of my invention and desire not to be limited specifically to the details disclosed herein.

I claim as my invention:

1. The combination with a strip of unfinished material and finishing means thereof, of means for winding the material in coil form, electroresponsive means for maintaining the finished material under constant tension while winding, and electroresponsive means for stopping said winding operation and for maintaining tension during stopping.

2. The combination with a strip of unfinished material and finishing means thereof, of means for winding the material in coil form, electroresponsive means for maintaining the finished material under constant tension while winding, and electroresponsive means for stopping said winding operation and for maintaining tension when stopped.

3. The combination with a strip of unfinished material and finishing means therefor, of means for winding the material in coil form, electroresponsive means for maintaining the finished material under constant tension while winding, and electroresponsive means for stopping said winding operation and for maintaining tension when stopped.

4. The combination with a strip of un-
4. finished material and finishing means therefor, of a motor for winding the material in coil form, a generator therefor driven by said means, a constant-current regulator for limiting the current supplied to said motor and means for adjusting the current traversing said regulator independently of said generator.

5. In a rolling mill for finishing a strip of metal, electro-responsive means for operating the mill, a collapsible reel for winding the strip, electro-responsive means for operating the reel in synchronism with said mill operation, and electro-responsive means for maintaining said strip under suitable tension during the starting, stopping, and running of said mill.

6. The combination with a strip of material and a motor for winding the material in coil form, of electro-responsive means for maintaining constant motor current while winding, and electro-responsive means for stopping said winding operation and for maintaining tension during stopping without interruption of the motor circuit.

7. The combination with a strip of material and finishing means therefor, of a motor for winding the material in coil form, a variable-speed generator operated by said means, electro-responsive means comprising said generator for maintaining the material under constant tension while winding, means for stopping said generator, remote controlling means for maintaining tension when stopped without interruption of the motor circuit, and means for adjusting the tension.

8. The combination with a strip of material and finishing means therefor, of a motor for winding the material in coil form, a variable-voltage generator operated by said means, electro-responsive means comprising said generator for maintaining the material under constant tension while winding, means for stopping said generator, a separate source of energy for said motor, and means for connecting said motor to said source without interruption to the variable-voltage circuit.

9. The combination with a strip of material and finishing means therefor, of a motor for winding the material in coil form, a variable-voltage generator operated by said means, electro-responsive means comprising said generator for maintaining the material under constant tension while winding, means for stopping said generator, a separate source of energy for said motor, and means for connecting said motor to said source while maintaining the generator and motor in normal circuit connection.

In testimony whereof, I have hereunto subscribed my name this first day of February, 1923.

GLENN E. STOLTZ.