

Dec. 4, 1934.

F. MOHLER

1,983,387

METHOD OF WORKING METAL

Filed June 15, 1931

Fig. 1

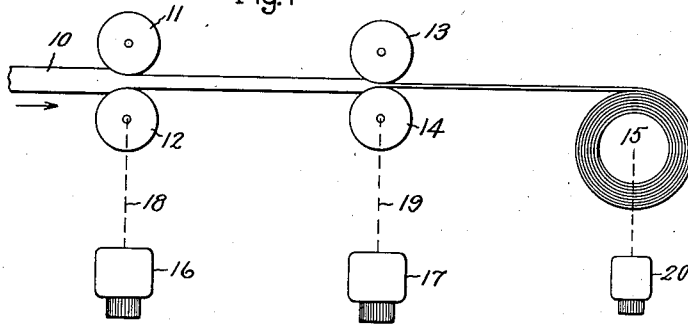
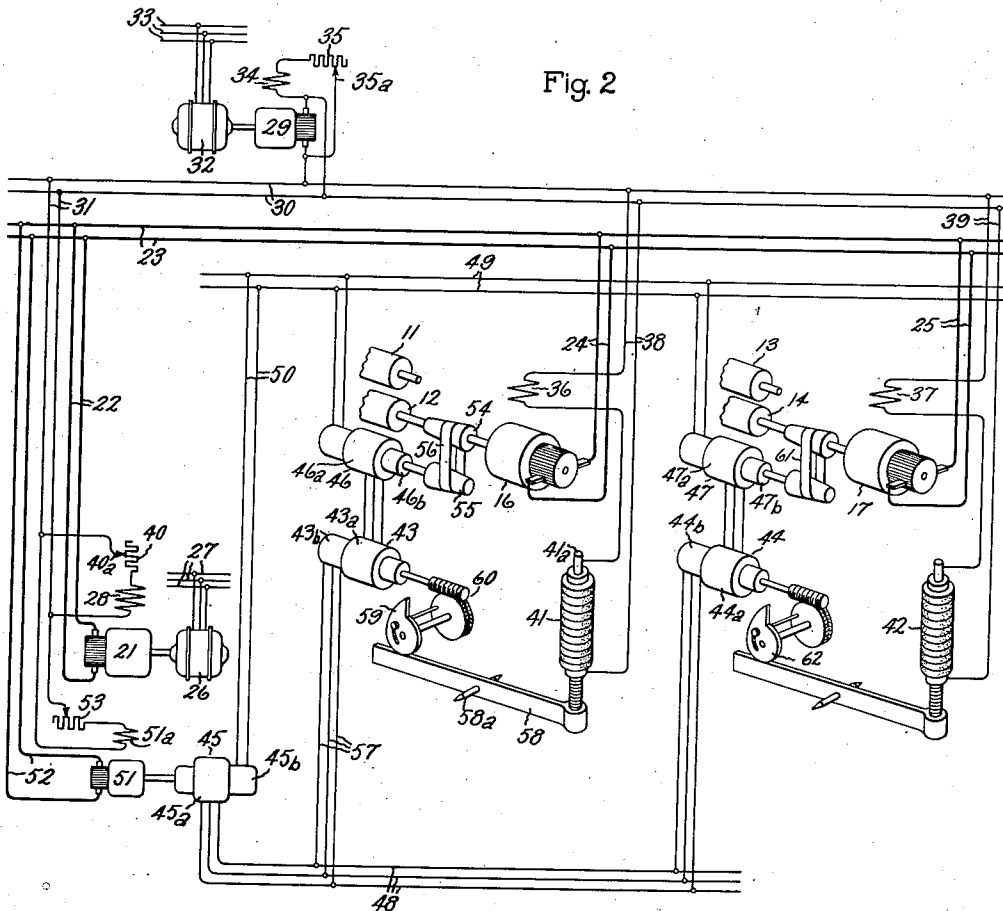


Fig. 2



Inventor:
Francis Mohler,
by *Charles E. Tuller*
His Attorney.

UNITED STATES PATENT OFFICE

1,983,387

METHOD OF WORKING METAL

Francis Mohler, Schenectady, N. Y., assignor to
General Electric Company, a corporation of
New York

Application June 15, 1931, Serial No. 544,520

6 Claims. (Cl. 80—60)

This invention relates to metal working, more particularly to the production by the cold rolling process of exceedingly thin steel strip, such for example as commercial tin plate, and it has for an object the provision of an improved method for effecting substantial uniformity of thickness or "gauge" in the finished strip.

Cold strip steel is usually rolled in a continuous mill having a plurality of tandem disposed sets of reducing rolls and a take-up roll upon which the finished strip is wound; each set of rolls and the take-up roll being driven by a suitable driving means, such for example as an electric motor.

Heretofore, it has been believed desirable and even necessary to maintain constant tension in the strip between the successive stands of the mill during the rolling process in order to obtain uniformity of gauge in the finished strip. In accordance with this belief, the reducing rolls of the several stands of the mill have been reinforced by large backing rolls so as to apply a large compressional force to effect the necessary reduction in gauge, and the separate stand driving motors have been compounded for a drooping speed characteristic in order to maintain the tension in the strip between stands substantially constant. Constant tension regulators, in reality constant current regulators, have also been employed to maintain constant input to the motors and constant tension in the strip by varying the speed of the motors in response to changes in the load thereon.

Up to the present time, however, it has not been possible with the known methods of tension control in cold rolling in a continuous rolling mill to produce finished strip in the thinner gauges of material, e. g., commercial tin plate, having a uniformity of gauge within the desired limits.

The cold strip, prior to the cold rolling operation, is a product of a hot strip mill and the undesirable unevenness or non-uniformity of gauge of the finished cold strip is believed to be due to the presence of relatively hard and soft or thick spots which form in the material during cooling of the hot strip, and which during the cold rolling operation cause the cold strip mill rolls to "spring" and the bearings to "give" when a hard spot enters the rolls. If there were no spring in the rolls of the cold strip mill the gauge of the finished strip would necessarily be absolutely uniform. As long as the material which enters the rolls of a cold strip mill is of uniform thickness and hardness, the spring of the rolls is likewise uniform and the gauge of the finished rolled strip is also uniform. However, when a hard or thick spot strikes the rolls, the rolls spring to a greater or lesser degree depending upon the degree of hardness and the

size of the hardened area. The rolls commonly employed in a cold strip rolling mill are approximately twenty inches in diameter and these in turn are reinforced by backing rolls as large as forty-eight inches in diameter. Further increase in the size or weight of the rolls would therefore appear to be decidedly impractical and consequently little if any improvement in the uniformity of gauge of the finished strip can be expected from improvements in the structure of the rolls.

I have definitely determined that variations in the tension applied to the strip during the rolling operation greatly affect the gauge of the finished strip.

Accordingly a further object of this invention is to control the tension of the strip during the rolling operation so as to produce uniformity in gauge of the finished cold strip. In carrying the invention into effect in one form thereof, a tensional force is applied to the strip and this tensional force is varied in accordance with the degree of hardness of the strip.

More specifically a relatively small tensional force is applied to the strip as it passes through the rolls at the successive stands of the mill and this tensional force is increased at the instant that a hard spot in the strip strikes the rolls at any particular stand.

For a better and more complete understanding of the invention, reference should now be had to the following specification and to the accompanying drawing in which Fig. 1 is a diagrammatical illustration in very simplified form of a continuous cold strip rolling mill; and Fig. 2 is a simple diagrammatical representation of an embodiment of a controlling and regulating system for the motors employed in carrying out the invention.

Referring now to the drawing, a cold strip of steel 10 is shown as passing in the direction of the arrow through the reducing rolls 11, 12 at one stand of a cold strip rolling mill. The gauge or thickness of the strip 10 is materially reduced as it passes between the rolls 11, 12 and the strip is then passed between the rolls 13, 14 at the next succeeding stand of the mill where the gauge is still further reduced after which the finished strip is shown as being wound upon a take-up roll 15. Although but two stands have been illustrated in the drawing, it will, of course, be understood that a greater number of stands is usually employed in actual practice.

The reducing rolls 11, 12 and 13, 14 are driven by any suitable driving means, such for example as electric motors 16 and 17 to the drive shaft of which the pairs of rolls 11, 12 and 13, 14 are respectively connected by any suitable speed reducing means represented in the drawing by the dotted lines 18, 19. Similarly the take-up reel

15 is driven by means of an electric motor 20 to which it is suitably connected as illustrated in the drawing.

The motors 16, 17 and 20 are preferably direct current motors of the shunt wound type and are designed to have very slight drooping speed characteristics with respect to wide variations in load thereon.

Although the motors 16, 17 and 20 may be supplied from any suitable source of power, they are preferably supplied from a Ward-Leonard supply generator 21 to the armature of which the armatures of the motors 16, 17 are connected in a closed loop by means of the conductor 22, supply busses 23 and supply leads 24 and 25 respectively. The Ward-Leonard generator 21 is driven at a speed which is preferably substantially constant by any suitable driving means such for example as the alternating current motor 26, which, as shown, is supplied from any suitable source of power such for example as that represented in the drawing by the three supply lines 27.

The generator 21 is provided with the usual field winding 28 which is supplied from any suitable source of excitation such for example as the exciter 29, the armature of which is connected to excitation busses 30 to which the field winding 28 is also connected by means of the conductors 31 as shown.

Exciter 29 is driven at a speed which is preferably substantially constant by any suitable means such for example as the alternating current motor 32 supplied from a suitable source of power represented in the drawing by the three supply lines 33, which source may be, and preferably is, the same as that represented in the drawing by the three supply lines 27.

As shown, the exciter 29 is provided with a self-excited field winding 34 connected across its armature terminals with a variable resistance 35 included in circuit therewith. The voltage generated by the exciter 29 and supplied to the excitation busses 30 is adjusted to any desired value by altering the position of the movable contact 35a on the variable resistance 35 as is well understood by persons skilled in the art.

The stand driving motors 16 and 17 are respectively provided with field windings 36 and 37 which are supplied from the excitation busses 30 to which they are respectively connected by means of the connections 38 and 39.

A variable resistance 40 is included in circuit with the field winding 28 of the Ward-Leonard supply generator 21 and, as is well understood, the voltage generated by the generator 21 may be controlled at will by varying the position of the movable contact 40a on the resistance 40 to increase or decrease the degree of excitation of the field winding 28 depending upon whether the movable contact 40a is moved in a direction to increase or decrease the amount of the resistance 40 in circuit with the field winding 28. Since the speed of the stand driving motors 16 and 17 vary in accordance with the voltages supplied to their armatures, it will be seen that these motors may be accelerated from rest to full speed and likewise decelerated from full speed to rest simply by altering the position of the movable contact 40a upon the resistance 40 in the field circuit of the Ward-Leonard supply generator 21.

Although any suitable form of speed regulating devices may be employed for maintaining the speed of the stand driving motors 16, 17 substantially constant at any desired value, the dif-

ferential motion transmission system shown in the drawing is preferably employed because of the high degree of accuracy with which it functions to maintain the desired speed. In this system variable resistances 41 and 42 respectively connected in circuit with the field windings 36, 37 of the stand driving motors 16, 17 are respectively controlled by electrical differential motion devices 43 and 44 which in turn are actuated in accordance with the speed of a master motion transmitting device 45 and individual motion transmitting devices 46 and 47 respectively associated with the stand driving motors 16 and 17.

The master motion transmitting device 45 comprises a stator member 45a which is provided with a polycircuit winding (not shown) which is physically similar to a polyphase alternating current winding and a rotor member 45b which is provided with a single phase winding (not shown) arranged in inductive relationship with the stator winding; the terminals of the polycircuit winding being connected to the busses represented in the drawing by the three conductors 48, and the single phase winding on the rotor 45b being supplied with single phase alternating current from any suitable source such as that represented in the drawing by the two supply lines 49 with which its terminals are connected by means of the conductors 50. The rotor member 45b of the master device 45 is rotated at a speed which is proportional to the speed at which the stand driving motors 16 and 17 rotate, by means of a small electric motor 51 the armature member of which is supplied from the Ward-Leonard supply generator 21 to the supply busses 23 of which the motor 51 is connected by means of conductors 52. In order that the initial speed of the master motor 51 may be made to correspond accurately with the speed of the stand driving motors 16 and 17, a variable resistance 53 is included in circuit with the field winding 51a which as shown is supplied from the excitation busses 30.

The individual motion transmitting device 46 which is associated with the stand driving motor 16 is in all respects similar to the master motion transmitting device 45 and consists of a stator member 46a provided with a polycircuit winding (not shown) and a rotor member 46b which is provided with a single phase winding (not shown) arranged in inductive relation with the polycircuit winding on the stator member 46a and supplied from the same single phase source 49 as that from which the single phase winding on the rotor member 45b of the master motion transmitting device is supplied. As shown in the drawing, the rotor member 46b is driven from the shaft of the stand driving motor 16 to which it is mechanically coupled by means of a suitable variable speed transmission device shown in the drawing as consisting of a cone pulley 54 on the drive shaft of the motor 16 and a similar but oppositely arranged cone pulley 55 mounted on the shaft of the rotor member 46b, together with a belt 56 which is arranged to be slid in one direction or another along the surfaces of the cone pulley so that the speed of rotation of the rotor member 46b can be made to accurately correspond with the speed of the rotor member 45b of the master motion transmitting device 45 when the stand driving motor 16 is rotating at the desired speed.

The electrical differential motion device 43 associated with the stand driving motor 16 com-

prises a stator member 43_a which is provided with a polycircuit winding (not shown) the terminals of which are connected to the terminals of the polycircuit winding arranged on the stator member 46_a of the individual motion transmitting device 46, and a rotor member 43_b which is likewise provided with a polycircuit winding (not shown) arranged in inductive relationship with the polycircuit winding on the stator member 43_a and connected to the busses 48 by means of conductors 57. Since the single phase winding on the rotor member 46_b of the individual motion transmitting device and the winding on the rotor member 45_b of the master motion transmitting device are supplied with an alternating voltage, it will be understood that alternating voltage will be induced in the polycircuit winding on the stator member 46_a of the individual device and the winding on the stator member 45_a of the master device and that these alternating voltages are respectively supplied to the polycircuit winding on the stator member 43_a and the polycircuit winding on the rotor member 43_b of the differential device.

Persons skilled in the art will understand that as long as the electrical axes of the single phase winding on the rotor members of the individual motion transmitting device 46 and the master motion transmitting device 45 are in angular agreement, the voltages supplied to the polycircuit winding on the stator member 43_a and on the rotor member 43_b will balance each other, i. e., they will be exactly equal and opposite and consequently there will be no tendency for the freely rotatable rotor member 43_b to move with respect to the stator member 43_a.

Although the variable resistance 41 in the field circuit of the stand driving motor 16 may be of any suitable type a pressure responsive resistance, such for example as the stack of carbon discs illustrated in the drawing is preferably employed. The carbon pile 41 is arranged between a suitable stop 41_a and one extremity of a lever 58, the opposite extremity of which is turned in either direction about the fulcrum 58_a by means of a cam 59 which as shown is connected to the rotor member 43_b of the differential device 43 by any suitable connecting means such for example as the worm and the worm wheel 60.

As is evident from the drawing, the speed regulating device for the stand motor 17 is in all respects identical with that just described and it is, therefore, believed to be unnecessary to repeat a detailed description of the regulating device for motor 17.

In operation the mill motors 16, 17 are accelerated from rest by varying the field excitation of the Ward-Leonard supply generator 21 and after the mill motors 16, 17 have been brought up to speed the strip 10 is threaded between the rolls 11, 12 and then carried along by the operator and threaded into the rolls 13, 14 of the finishing stand. The excitation of the motor 51 which drives the master motion transmitting device 45 is increased until the speed of the rotor 45_b corresponds accurately with the speed of the rotors 46_b and 47_b of the individual motion transmitting devices 46 and 47 respectively; this condition of speed correspondents being indicated by the rotor members 43_b and 44_b of the differential devices coming to rest.

In order that only a very small tensional force shall exist in the strip 10 between the pairs of

stand rolls 11, 12 and 13, 14 a large loop may be formed in the strip 10 after it has been threaded through the rolls 11, 12 and before it is threaded into the finishing rolls 13, 14. An ammeter placed in the armature circuit of the stand driving motor 17 may be read to ascertain the current necessary to reduce the gauge of the strip at this point solely by the compressional force exerted on the strip by the rolls 13, 14. Similar observation taken at the other stands of the mill under similar circumstances will indicate the amount of current input to each stand driving motor necessary to reduce the strip at each particular stand solely by the compressional force exerted on the strip by the rolls and without the aid whatsoever of any tensional force in the strip. Thereafter when the rolling process has begun, the belts 56 and 61 are shifted in one direction or the other upon the cone pulleys of the speed regulating devices until the readings of the ammeters correspond with the readings previously taken under the condition of no tension in the strip 10 and the reduction thereof being affected solely by the compressional force of the rolls at the various stands.

In actual practice the belts 56 and 61 of the speed regulating devices are shifted until the input to the various stand driving motors 16, 17 are slightly higher than those observed under the condition of no tension in the strip, and this will insure a slight tension in the strip between the rolls of the various stands which is of course materially less than the elastic limit of the material, but which is nevertheless sufficient to maintain a certain desirable tautness in the strip during the rolling operation.

As long as the texture, i. e., the degree of hardness of the strip 10 entering the rolls 11, 12 is uniform the reduction of the gauge of the strip by the rolls 11, 12 will be done principally by the compressional force exerted by these rolls and the gauge of the strip leaving the rolls will for all practical purposes be substantially uniform. However, if a portion of the strip 10 entering the rolls 11, 12 is considerably harder than adjacent portions thereof, the rolls 11, 12 will tend to spring apart slightly and as a result the elongation of the strip at this point will tend to decrease, i. e., the forward linear speed of the strip 10 at the nip of the rolls 11, 12 is slightly retarded. This retardation in the speed of the strip 10 at the rolls 11, 12 imposes an increased load on the motor 17 which drives the rolls 13, 14 at the next succeeding stand and, as a result, the speed of the motor 17 tends to decrease slightly. As the speed of the motor 17 tends to decrease, the angular correspondence between the electrical axes of the rotor members 45_b and 47_b of the master and individual motion transmitting devices respectively is disturbed, and consequently the voltages supplied to the polycircuit windings of the differential device 44 become unbalanced, thus causing the rotor member 44_b to rotate relatively to the stator member 44_a, thereby causing the cam 62 to be rotated in a direction to relieve the pressure on the carbon pile resistance 42 so as to weaken the field of the motor 17 and to increase its speed. When the speed of the motor 17 has been restored to its former value the electrical axes of the rotor members 45_b and 47_b will again be in correspondence and the regulating action will cease.

The above described regulating action takes

place exceedingly rapidly, in fact almost instantaneously, and consequently the speed of the motor 17 is for all practical purposes maintained constant continuously at the desired value.

5 Since the speed of the motor 17 is held constant and cannot decrease in response to the increased load when a hard spot in the strip strikes the rolls 11, 12, the input to the motor 17 naturally must increase in order to sustain 10 the increased load and this increased input increases the tensional force in the strip between the rolls 11, 12 and the rolls 13, 14. The increased tension force in the strip is most effective at the point in the strip which is subjected to the compressional force between the 15 rolls, i. e., is most effective at the hard spot in the strip, and this increased tensional force taken in combination with the compressional force due to the rolls 11, 12 is sufficient to reduce 20 the hard spot, so that the gauge of the strip emerging from the rolls 11, 12 is of the desired value, despite the tendency of these rolls to spring as the hard spot in the strip enters.

The increased input to the motor 17 and the 25 increase in tensional force in the strip is directly proportional to the texture of the strip, i. e., the degree of hardness thereof, and thus the elongation of the strip is substantially constant and the gauge of the strip as it emerges from the 30 rolls 11, 12 has the desired uniformity.

After the hard spot in the strip has been reduced, the load on the motor 17 is decreased and the speed of this motor naturally tends to increase above normal value. The speed regulating mechanism, however, responds to this 35 tendency to increase in speed and functions in the reverse manner to that previously described, to increase the field current of the motor so as to maintain its speed at normal value. As a result 40 the input to the motor is lessened and the tensional force applied to the strip is likewise decreased in proportion.

Since similar constant speed regulators are provided for the motors at all the stands in the 45 mill, the above-described operation also takes place at other sections of the mill when a hard spot in the strip strikes a pair of rolls at any particular stand.

It will thus be clear that as long as the texture, i. e., the degree of hardness of the strip is 50 uniform, the reduction in gauge at the various stands is accomplished primarily by the compressional force of the rolls and that the tensional force in the strip between any two successive stands is maintained at a value which is 55 considerably less than the elastic limit of the metal and which is for all practical purposes negligible, whilst when a hard spot or portion of the strip engages the rolls at any particular 60 stand, the tensional force in the strip between this stand and the next succeeding stand is increased in proportion to the degree of hardness of this hard spot or portion of the strip.

Persons skilled in the art will understand that 65 due to the inherent tendency of a shunt wound machine to maintain constant speed despite variations in load, the above described operations and results can be approximated though not 70 equalled, without using any special constant speed regulating apparatus simply by employing shunt wound motors designed to have an almost negligible drooping speed characteristic for driv-

ing the rolls at the various stands of the mill.

Although, in accordance with the provision of the patent statutes, I have described the invention as embodied in concrete form and as being 80 carried out in a specific manner, I would have it understood that the description is merely illustrative and that the invention itself is by no means limited thereto since alterations and 85 modifications will readily suggest themselves to persons skilled in the art without departing from the true spirit of the invention as set forth in the annexed claims.

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

1. The method of working cold metal that 90 comprises applying to said cold metal a tensional force and a substantially constant compressional force, and passing the cold metal through thickness reducing means at substantially constant 95 speed, thereby to vary said tensional force in accordance with variations in the texture of the metal.

2. The method of working cold metal that comprises applying to said metal while cold a 100 relatively large compressional force and a relatively small tensional force, and passing said metal while cold through thickness reducing rolls at substantially constant speed to increase 105 said tensional force with increasing hardness of the portion of the metal engaged by the rolls.

3. The method of working cold metal that comprises applying to said metal while cold a 110 compressional force and a relatively small tensional force, passing said metal while cold through reducing rolls, and maintaining the speed of said rolls substantially constant, thereby 115 to materially vary said tensional force in accordance with variations in the texture of the metal.

4. The method of working cold metal that 115 comprises applying to said metal while cold a compressional force in the neighborhood of the elastic limit of the metal and a tensional force materially less than the elastic limit thereof, 120 passing said metal while cold through gauge reducing rolls, and materially increasing said tensional force when a relatively hard portion of the metal enters said rolls by maintaining 125 the speed of said rolls substantially constant.

5. The method of working cold metal that 125 comprises applying a compressional force and a tensional force to said metal while cold, passing said metal while cold through the reducing rolls of each of a plurality of successive stands, 130 and materially varying the tensional force between successive stands when a relatively hard portion of the metal enters the rolls of one of said stands by maintaining the speeds of the 135 rolls of all of said stands substantially constant.

6. The method of working cold metal that 135 comprises applying to the metal while cold a relatively large compressional force and a relatively small tensional force, passing the metal while cold between reducing rolls of a plurality 140 of successive pairs of rolls, and maintaining the speeds of all of said pairs of rolls substantially constant to materially increase said tensional force between one stand and a succeeding 145 stand when a relatively hard portion of the metal enters the rolls of said one stand.

FRANCIS MOHLER.