

April 14, 1942.

J. H. McELHINNEY

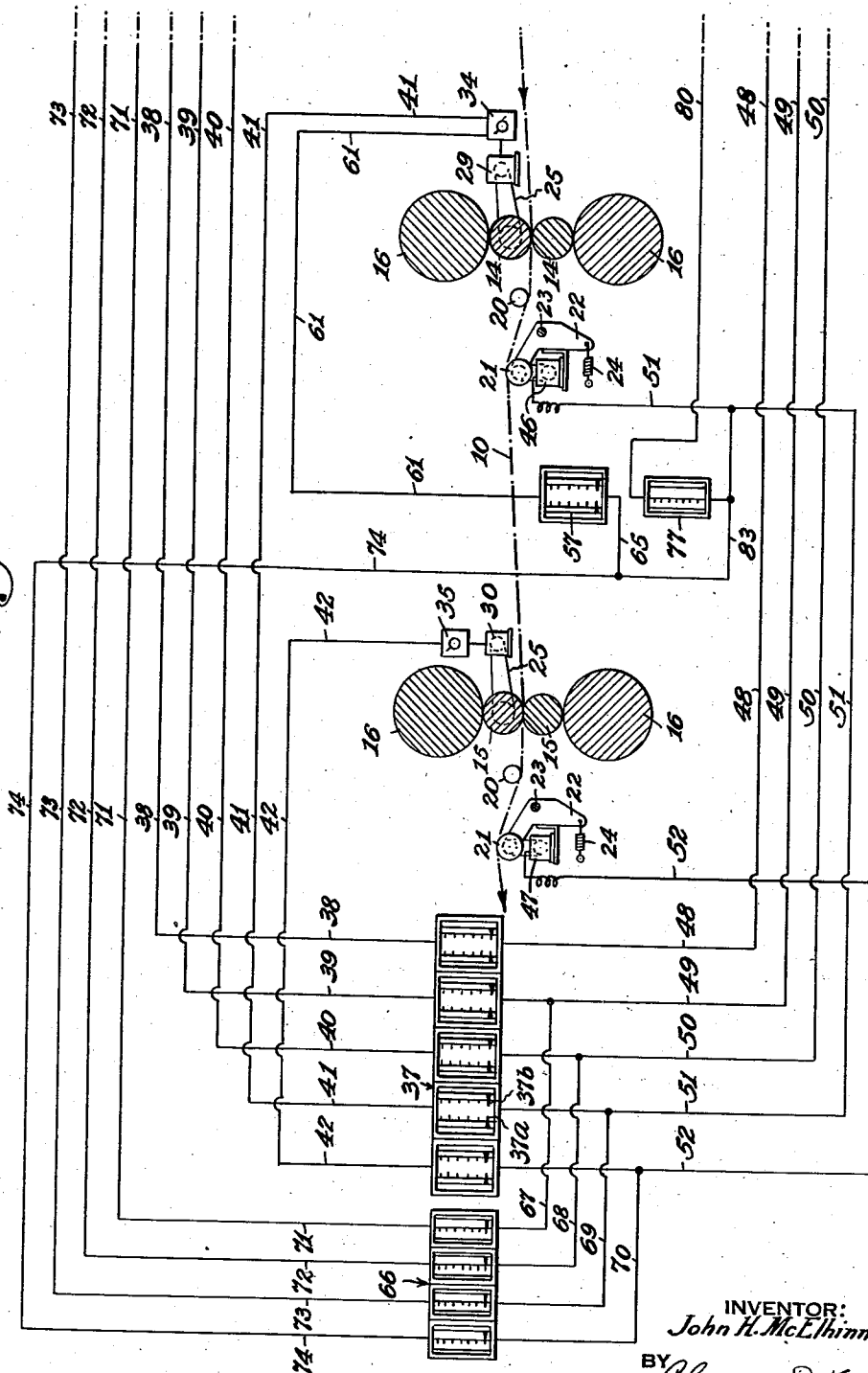
2,279,579

METAL ROLLING

Filed June 5, 1939

6 Sheets-Sheet 1

Fig. 1.



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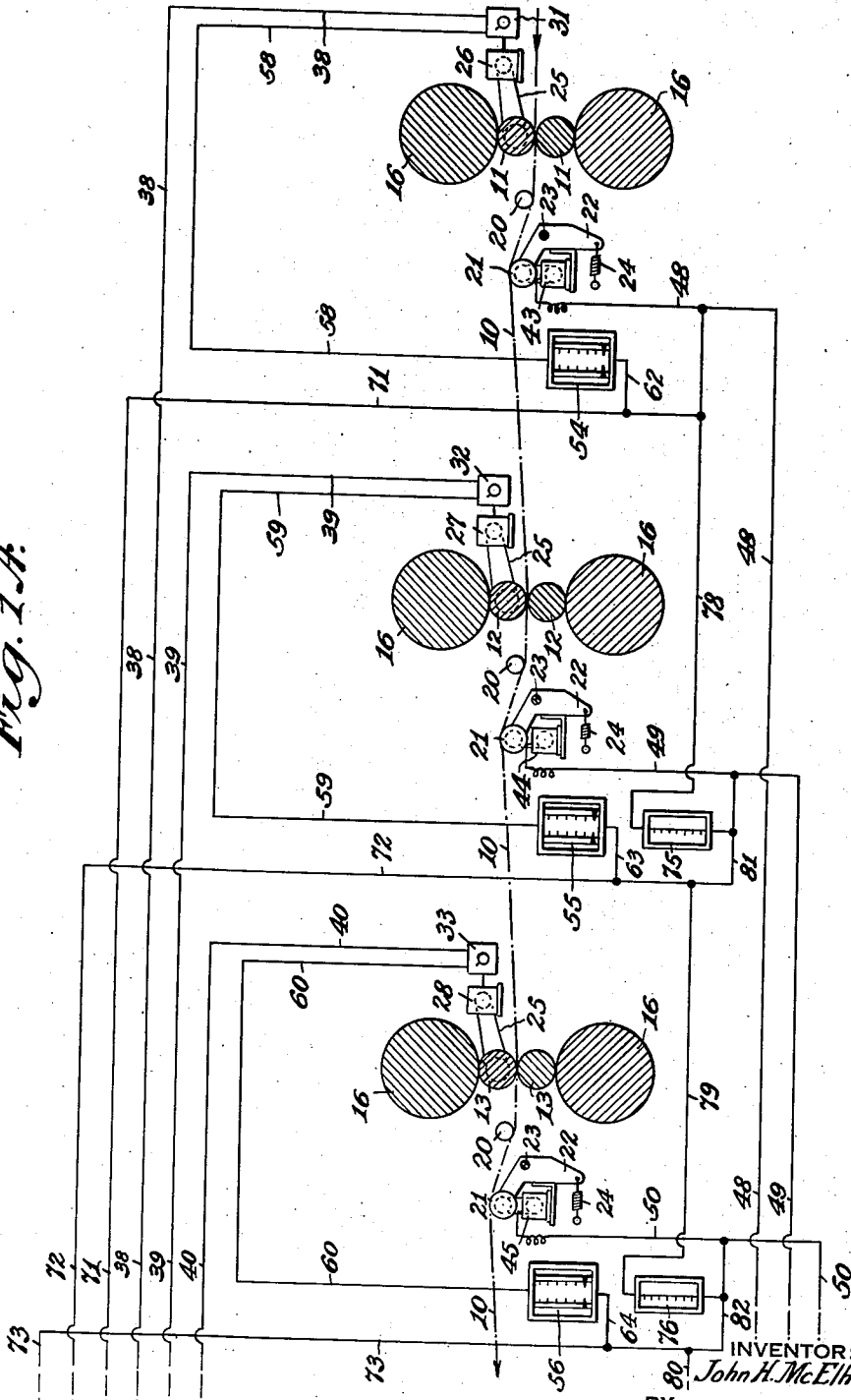
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6 Sheets-Sheet 2

Fig. 1A.



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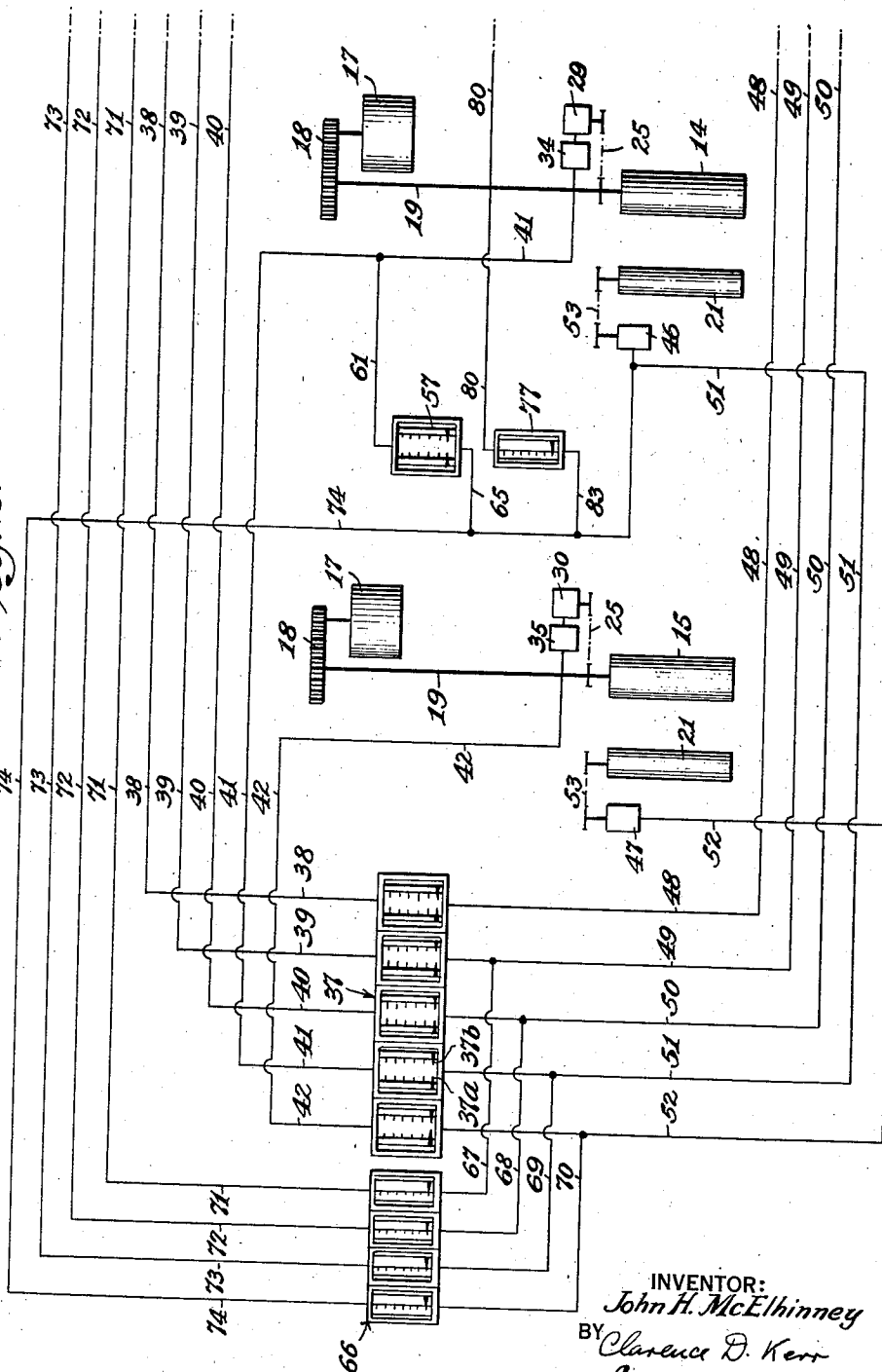
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Fig. 2.



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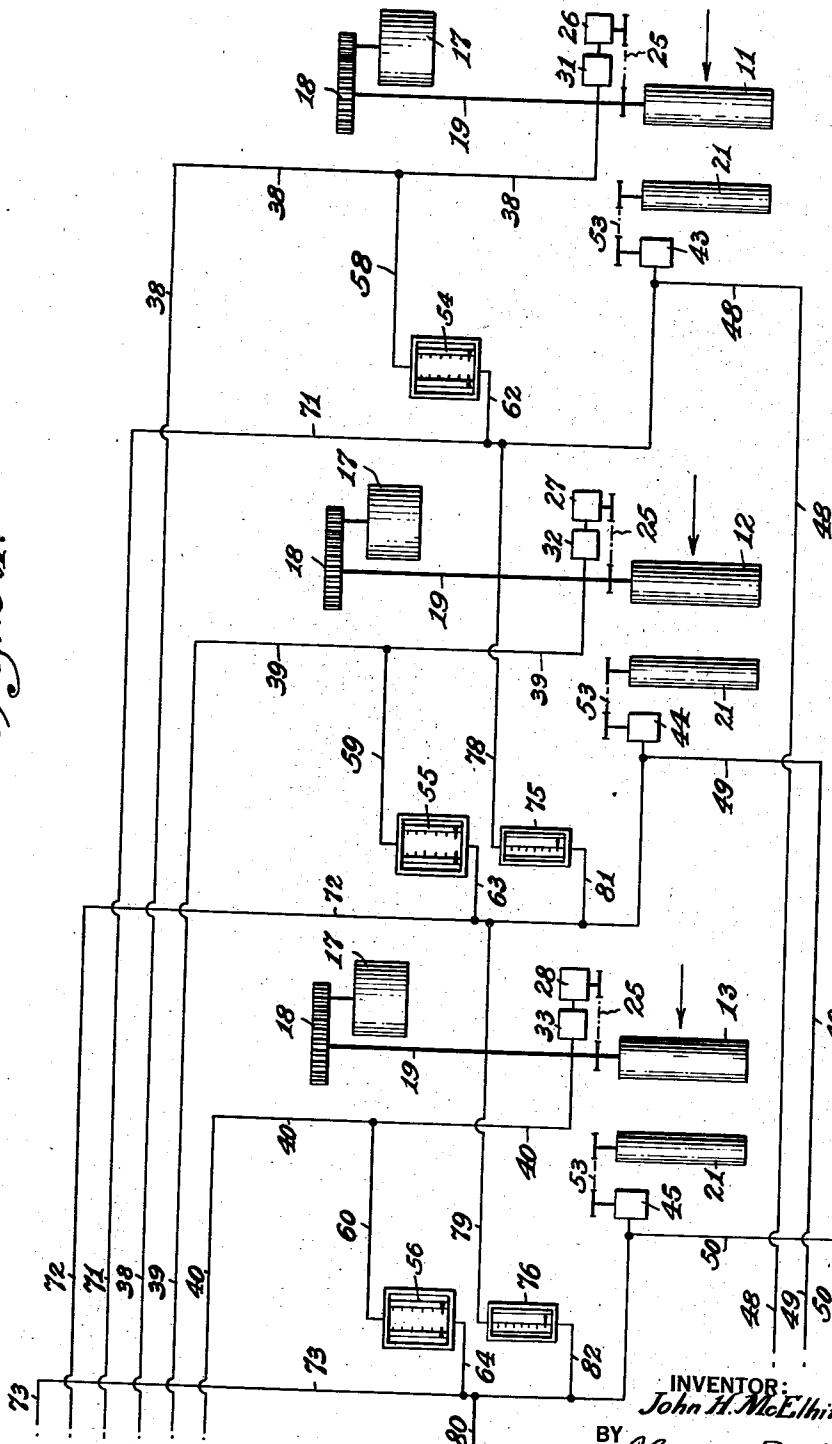
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METAL ROLLING

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Fig. 2 A.



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METAL ROLLING

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Fig. 5.

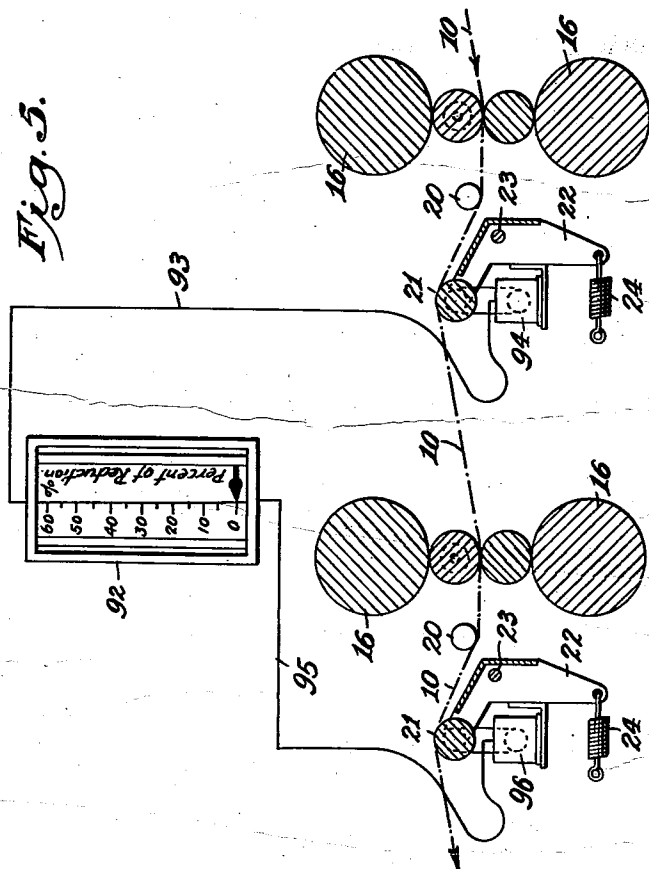


Fig. 6.

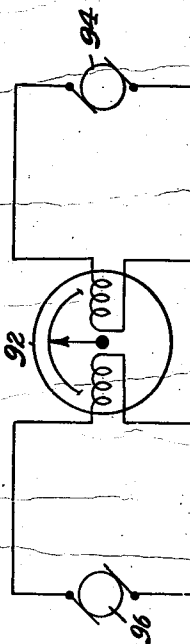


Fig. 3.

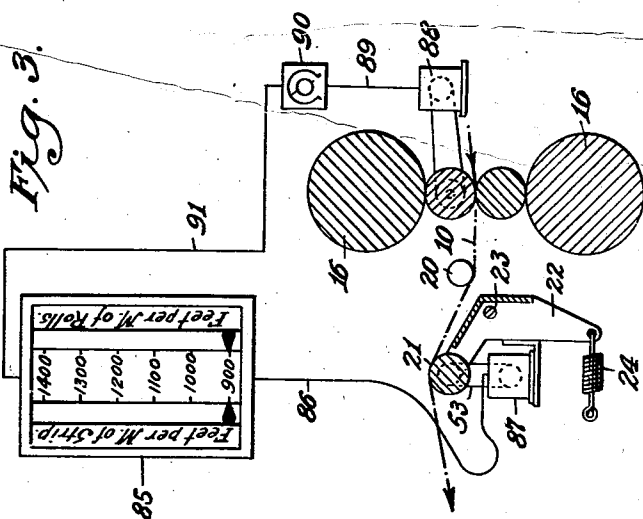
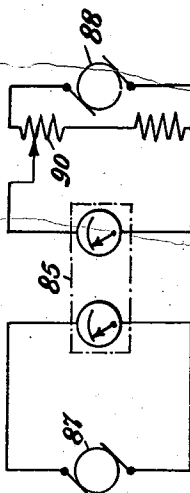


Fig. 4.



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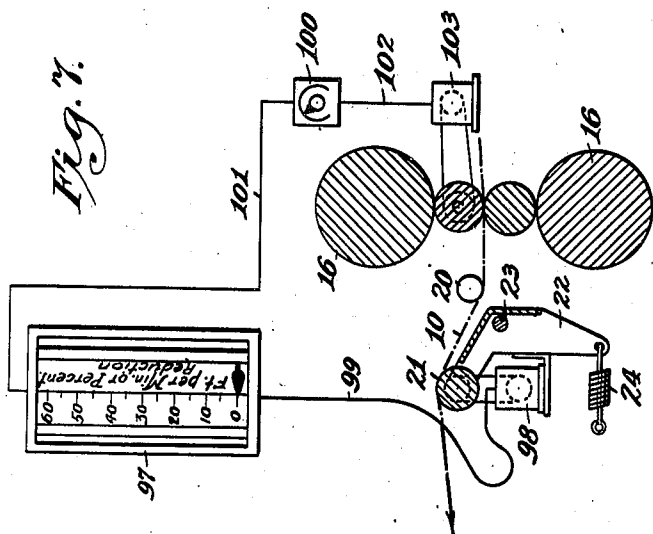


Fig. 9.

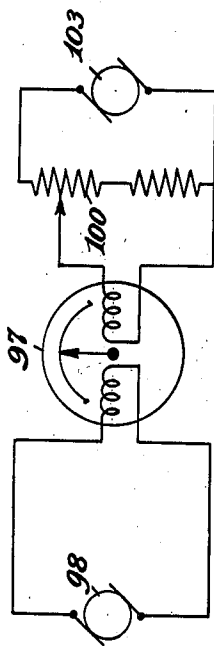
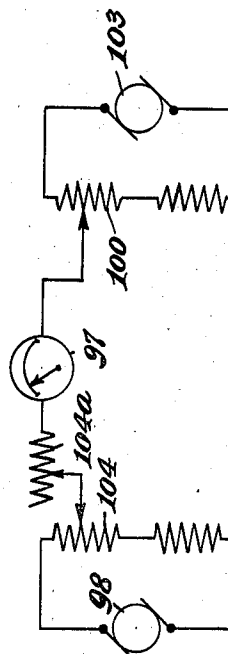


Fig. 8.



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UNITED STATES PATENT OFFICE

2,279,579

METAL ROLLING

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Application June 5, 1939, Serial No. 277,345

11 Claims. (Cl. 80-60)

This invention relates to metal rolling and is particularly useful in producing wide, thin material of substantially uniform dimensions and character by continuous cold rolling.

I have observed that in the cold rolling of strip or sheet metal there is a wide variation in surface, contour, thickness, edges, hardness, etc., not only between strip produced on different mills but also between successive strip rolled from the same stock on the same mill and even between different parts of the same strip.

Analysis of the situation indicates that a roller has the following variables to reconcile in trying to cold roll successfully:

Analyses of the metal and segregation of impurities therein; its hardness and ductility, which are particularly affected by the final finishing temperature at which the rolling of the metal was completed on the hot mill and the method of cooling from such temperature; condition of the metal as to flatness, crown, edges, surface, etc.; wear of rolls; condition of roll surfaces; swelling or shrinkage of rolls due to change of roll temperature; application of cooling or heating mediums to rolls and work; application of lubricant between rolls and work; fluctuation in roll speeds—in one stand, and in successive stands; stretch of mill housings; width and gauge of strip and tension thereon.

A roller or mill operator attempts largely by intuition to allow for and reconcile all of the foregoing variables. Correct decision and instant action are of extreme importance because the strip travels at speeds which in some mills exceed 2000 feet per minute. But the fact that one roller may produce 40% more of satisfactory finished product than another from the same run of stock and on the same mill in a given period and that even a skilled roller does not properly reconcile the several varying conditions indicates that the modern practice of cold rolling of strip or sheet is just as much an art as pack rolling.

I have also observed that frequently inability to judge the net average effect of these several variables results in the work moving either too slowly or too fast with reference to the roll face. For instance in recording the actual working performance of skilled rollers I have found that the relation of strip speed to the roll face speed varied as much as from 5% slower to 15% faster. Both conditions cause excessive and detrimental slippage of the rolls upon the work, which results in an inferior product, broken metal, roll damage and increased power consumption. Thin steel such as steel cold reduced for tin plate can be buckled to unusable height by a very small amount of heat. It is important therefore, to keep the friction between the steel and the rolls at a minimum.

I have discovered that all of the variables re-

ferred to above affect the relative speeds of the rolls and of the work, and that if these relative speeds are brought into proper relationship the conditions of mechanism and of the work that are within the mill operator's control will be those which are necessary for turning out a satisfactory product. For the purpose of giving the operator instantaneous indications of this speed of travel relationship, which in effect tells him whether he has sufficiently reconciled the variable conditions which lie within his control, I prefer to employ indicating or recording means at one or more of the roll stands which indicate the speed of one of the working roll faces and of the work adjacent to or at such roll stand or stands. Such means indicate to the operator what such speeds are and permit him to bring the speed of travel of work and of roll faces into proper relationship by such adjustments of tension, of roll pressure and of roll revolutions, etc., as may be necessary to compensate substantially for the continuously changing variables encountered. With the information obtained from such means applied to a tandem mill, the roller can change or regulate the speeds of the rolls so as to maintain the desired speed relationship at each stand.

Proper correlation of these factors result in the control of the quality and quantity of the output. A further advantage of my invention is that the differential between the strip speeds at successive stands shows the percentage of reduction in metal thickness at individual stands.

It is an object of my invention to measure the relative speeds of the roll surfaces and of the work at a given cold rolling station or stand and to adjust the operation of the rolling mill to maintain a predetermined relationship between these speeds.

Another object is to provide apparatus for measuring these relative speeds and for providing simultaneously thereby a measurement of the percentage of reduction in thickness of the work at a given cold rolling stand.

Other objects and advantages in addition to those referred to above will be described and will become apparent from the following description of certain apparatus illustrated in the drawings and embodying measuring means in accordance with my invention.

Figures 1 and 1A together illustrate diagrammatically a five stand tandem continuous cold rolling mill in side elevation showing the rolls in section and single line wiring connections, each single line representing a cable carrying two wires.

Figures 2 and 2A illustrate a diagrammatic plan view of this rolling mill with a single line wiring connections.

Figure 3 illustrates diagrammatically in elevation apparatus for measuring the relative

speeds of the work roll surfaces and of the emerging strip being rolled at a given stand.

Figure 4 is a schematic wiring diagram for the measuring apparatus in Figure 3.

Figure 5 is a vertical sectional diagrammatic view of one form of apparatus for measuring percentage reduction in the work at a given rolling stand.

Figure 6 is a schematic wiring diagram of the measuring apparatus in Figure 5.

Figure 7 is a vertical sectional view illustrating a modification of apparatus for measuring percentage reduction of the work at a given rolling stand.

Figure 8 is a schematic wiring diagram for the apparatus in Figure 7.

Figure 9 is an alternative schematic wiring diagram for the apparatus in Figure 7.

The invention is illustrated and will be described as applied to a five stand tandem cold rolling mill in which the work rolls at the different stands are individually driven. The metal strip to be rolled may be supplied to the mill from any suitable source (not shown) such as an unwind stand or coil box. This strip is indicated in Figures 1, 1A, 3, 5 and 7 by the dot and dash lines 10, and in each case the strip is moved in the direction of the arrows from right to left of the figures.

Referring more particularly to Figures 1, 1A, 2 and 2A, the strip is first passed between the work rolls 11 of the first stand or rolling station and thereafter proceeds successively between the pairs of work rolls 12, 13, 14 and 15 of the other four rolling stands and is then coiled for further treatment or cut directly into sheets as desired. The work rolls may be provided with the usual backing rolls 16 and one or both of the work rolls at each stand may be driven by individual motors 17, or from other suitable sources of power through the gearing 18 and shafting 19, or by other suitable connections between the sources of power and the work rolls.

As the metal strip 10 emerges from between each pair of work rolls it passes under an idler roll 20 and over a second idler or tension roll 21. Idler rolls 20 are not necessary but assist in maintaining a constant and uniform contact between the metal strip and the idler rolls 21. Rolls 21 may be journaled in brackets 22 which are pivotally secured to the framework of the mill as at 23. A spring 24, or group of springs or other suitable force, may be employed to press the rolls 21 firmly against the metal strip 10.

I prefer to measure the various speeds to be determined by means of electrical tachometers comprising essentially small generators supplying current to suitable meters. One of the work rolls at each stand may be connected by chains and sprockets or other suitable driving means 25 to the small generators 26, 27, 28, 29 and 30, respectively. Each of the generators 26, 27, 28, 29 and 30 is connected electrically to the respective potentiometers 31, 32, 33, 34, 35, which in turn are connected electrically to various meters. A bank of meters 37 located in a group at any convenient place near the rolling mill may be employed for indicating directly and instantaneously the relative speeds of the work roll surfaces and of the material emerging from the work rolls at each rolling station or stand. For this purpose, the potentiometers 31, 32, 33, 34 and 35 are each connected to one of the instruments in the bank 37. The lines 38, 39, 40, 41 and 42 indicate cables each carrying two wires

connecting the potentiometers to the respective instruments. The lines connecting the generators with their respective potentiometers likewise indicate cables, each carrying two wires.

The instruments in the bank 37 may also be connected to the generators 43, 44, 45, 46, and 47 by the cables 48, 49, 50, 51 and 52, each of which carries two wires for this purpose. The tachometer generators 43, 44, 45, 46 and 47 are preferably supported on the brackets 22 and are suitably connected to and driven by the idler rolls 21 through chains and sprockets 53. Thus each instrument in the bank of meters 37 may be equipped with two separate indicating pointers 37a and 37b, or other means for indicating, and/or recording if desired, the relative speeds of the work roll faces and the work emerging from each rolling station or stand.

In addition, extra meters for indicating these relative speeds may be provided at each stand where they are needed. When the bank of meters 37 is located near the last rolling station of the mill, it is only necessary to provide the meters 54, 55, 56 and 57 at the first four rolling stands. These four meters may be connected to the potentiometers 31, 32, 33 and 34 by pairs of wires in the cables 58, 59, 60 and 61. These meters may also be connected to the generators 43, 44, 45 and 46 by wires carried in the cables 62, 63, 64 and 65.

The foregoing measuring and indicating apparatus is all that is needed to operate the mill in accordance with my invention. It is easily possible, however, and I prefer to use this measuring apparatus also to provide a direct indication of the percentage of reduction in the work in a simple manner at each of the last four stands or rolling stations of the mill. If desired, the percentage reduction can be measured at the first stand in a similar manner by providing a generator driven by a roll in contact with the work before it enters the first pair of work rolls. This is generally unnecessary, however, since the work at this point is moving sufficiently slowly to enable the operator to easily determine or estimate the percentage of reduction at the first stand by the usual methods.

In order to provide an instantaneous measurement of percentage reduction on the last four stations of the rolling mill, a bank of percentage reduction meters 66 may be provided adjacent the bank of relative speed indicating meters 37 or at any other convenient location. In the rolling of metal under tension, the metal is precluded from spreading sideways to any great extent and consequently the elongation of the metal strip during rolling at a given stand is a direct function of the percentage of reduction in thickness effected by the work rolls at this stand. Similarly, the differential between the speeds of the strip entering and leaving the work rolls is also a direct function of the percentage of reduction in thickness at such a stand. The bank of meters 66 thus indicate the percentages of reduction at the different stands directly by measuring the differential in speeds of the strip immediately before and after each stand. For this purpose, the meters 66 are connected to different pairs of the generators 44, 45, 46 and 47. For example, the meters 66 on one side are connected to the generators 44, 45, 46 and 47 through the wires in the cables 49, 50, 51 and 52 by means of the wires in cables 67, 68, 69 and 70. The other sides of these meters 66 may be connected to the generators 43, 44, 45 and 46, respectively,

by means of the wires in the cables 71, 72, 73 and 74.

Provision may also be made for additional meters such as meters 75, 76 and 77 indicating percentage of reduction and located at the second, third and fourth stands of the mill, alongside of the relative speed meters 55, 56 and 57. Meters 75, 76 and 77 are connected by wires in the cables 78, 79 and 80 to the generators 43, 44 and 45, and also by wires in the cables 81, 82 and 83 to the generators 44, 45 and 46, respectively.

These relative speed and reduction meters and the electrical connections thereof preferably comprise complete circuits which are not grounded, each line indicating wiring connections in Figures 1, 1A, 2 and 2A representing a cable carrying two wires. This is desirable to avoid leakage of currents and to provide thus a more accurate measurement. However, each meter and each generator may be suitably grounded to the machine, in which case the lines of these figures would indicate single wires. In a grounded system, fewer wiring connections would be needed but it would be difficult to maintain the instruments in a calibrated condition to provide accurate measurements.

Figures 3 and 4 illustrate in more detail the connection of a relative speed or slippage indicating meter for indicating the relative speeds of a work roll face and the emerging work at any given rolling station, together with the electrical connections therefor. It will be seen that the indicating device 85 is connected by two wires in cable 86 to the generator 87 mounted in one of the supporting brackets 22, while the other generator 88 driven by one of the work rolls at the rolling stand is connected by wires in the cable 89 to a potentiometer 90 or other variable resistance and thence by wires in the cable 91 to the other side of the instrument 85. In effect, the instrument 85 comprises a pair of independent volt meters calibrated to indicate the speeds to be measured directly on the same scale. These two meters are preferably mounted in the same housing for purposes of convenience and the rolling mill operator after determining the optimum conditions has only to adjust the mill to maintain a certain predetermined variation between the speeds indicated by the two pointers. The potentiometer 90 or other variable resistance is useful in calibrating the system by varying the voltage balance in that portion of the circuit to compensate for wear on the rolls, changing of a work roll and other variable factors that might otherwise cause an inaccurate reading of the speed of the work roll face during different operations of the mill.

Figures 5 and 6 indicate one manner of connecting a percentage reduction meter 92 to indicate directly the percentage reduction. One side of the instrument is connected by wires in the cable 93 to the generator 94 in advance of a given rolling station and the other side of the meter is connected by wires in the cable 95 to the generator 96 driven by the work emerging from this rolling station. In this instance, the pointer of the meter is moved in one direction or the other a greater or lesser amount, depending upon the voltage balance between the wires carried by the two cables 93 and 95. Since the work will always be traveling at a greater speed as it emerges from the rolling stand, generator 96 will be driven at a faster rate and will generate more voltage than the generator 94. Fixed resistances

may be interposed in either side of the circuit to calibrate the instrument. Thus, percentage reduction will be indicated on the meter, since the needle of the meter will always be deflected in one direction.

Another way of measuring percentage of reduction at a given stand with apparatus employed in accordance with my invention is illustrated in Figures 7, 8 and 9. In this modification, the percentage of reduction may be indicated directly on the instrument 97 which may be connected on one side directly to the generator 98 through wires in the cable 99, and on the other side to the potentiometer or other variable resistance 100 through the wires in the cable 101. The potentiometer in turn may be connected by wires in the cable 102 to the generator 103 driven by one of the work rolls. The voltage differential between these two generators will likewise be a function of the percentage of reduction in work thickness after due allowance is made for slippage taking place between the work roll faces and the work. The potentiometer 100 is useful in adjusting the meter to compensate for variations in the work roll due to wear and the like. If desired, the circuit illustrated in Fig. 8 may be employed with another variable resistance 104a used to adjust the sensitivity of the meter or in other words to vary the extent of needle deflection under different working conditions. Resistance 104 may be used for calibration if desired.

While the arrangement in Figs. 5 and 6 is preferred for measuring percentage reduction, the device of Figs. 7, 8 and 9 has the advantage of making it possible to measure instantaneously the percentage of reduction at the first stand of a rolling mill without providing a generator driven by the work before it enters the first stand. The arrangements shown in Figs. 7, 8 and 9 may be used as alternate methods of measuring the differences between speed of the strip and roll surface.

As set forth above there is some one preferable per cent of slippage for a given reduction of any particular type of metal, but for rolling the soft steels of commerce, I have found that exceptionally satisfactory results are obtained if the speed of the strip issuing from the working rolls is maintained at approximately from 2 to 10% faster than the surface speed of such rolls, the best conditions I have observed being when the strip speed is about 5% faster than the surface speed of the rolls from which the strip has just issued. It is to be understood that this particular speed relationship has been found very satisfactory for cold rolling 0.05 to 0.20% carbon steel on the five stand tandem mill described above, said steel having an initial Rockwell hardness of 50 to 70 on the B scale, an initial thickness of .062" to .109" gauge and a finished gauge of .007" to .037" produced by successive reductions on the five stands as follows:

	Stand				
	No. 1	No. 2	No. 3	No. 4	No. 5
Min. reduction, per cent.	8	23.1	28.3	25	15
Max. reduction, per cent.	50	49.7	45	36.9	31.7

The low minimum reduction for No. 1 stand is occasioned by using a very light pass at this stand when rolling steel to heavier finished gauges.

With other rolling conditions, the foregoing speed relation between issuing work and work roll surface may be varied to obtain the optimum results. Having once established the best speed relationship for a given set of operating conditions, a less skilled worker can, by adjustments of the mill settings, such as roll speed, roll pressure and tension on the strip maintain such relation with assurance that he is producing a high grade and satisfactory product.

This invention is not limited to the rolling of steel or to the use of tandem mills although it is particularly adapted to these conditions. In general, it facilitates rolling operations where rolling is carried out with the work under tension and the work rolls are driven. The invention has been described as carried out by the measuring of the relation between the speeds of rolled work and the work roll surfaces, but the same principle may also, of course, be utilized by measuring the relation between the speeds of work roll surfaces and work entering such rolls.

While electrical speed measuring devices have been illustrated and described, it is to be understood that the work and work roll surface speeds may be measured by other means. Recording devices may also be employed.

The terms and expressions which I have employed are used as terms of description and not of limitation, and I have no intention, in the use of such terms and expressions, of excluding any equivalents of the features shown and described or portions thereof, but recognize that various modifications are possible within the scope of the invention claimed.

I claim:

1. In a process of rolling under tension an approximately flat strip of a substantially uniform contour from end to end to reduce the thickness thereof, the steps of measuring the relationship of the speed of the strip to the speed of a work roll surface, and controlling the rolling operation in accordance with said measurement to maintain the relationship between said speeds within predetermined limits.

2. In a process of rolling strip metal under tension to reduce the thickness thereof between a pair of driven work rolls, the steps of measuring the relationship of the speed of the strip to the surface speed of said rolls, and regulating the rate of driving said rolls to maintain said speed relationship within predetermined limits.

3. In a process of rolling under tension in a tandem mill an approximately flat strip of a substantially uniform contour from end to end to reduce the thickness thereof, the steps of measuring the relationship of the speed of the issuing strip to the speed of a work roll surface, and con-

trolling the rolling operation in accordance with said measurement to maintain the relationship between said speed within predetermined limits.

4. In a process of rolling under tension an approximately flat strip of a substantially uniform contour from end to end to reduce the thickness thereof, the steps of measuring the relation of the speed of the issuing strip to the speed of one of a pair of work roll surfaces, and maintaining the speed of the strip as it issues from said working rolls approximately 2 to 10% faster than the surface speed of said rolls.

5. In the cold rolling of strip steel under tension with driven work rolls, the steps of measuring the relationship of the strip speed to the surface speed of an adjacent work roll, and controlling the rolling operation to maintain said speed relationship within predetermined limits.

6. In the process of cold rolling strip metal under tension in a tandem mill with driven work rolls, the steps of measuring the relationship of the speeds of the strip at each rolling stand to the surface speeds of the working rolls at the respective stands, and controlling the driving of the work rolls to maintain said speed relationship at each stand within predetermined limits.

7. In the process of cold rolling strip metal under tension in a tandem mill with driven work rolls, the steps of measuring the relationship of the speeds of the strip emerging at each rolling stand to the surface speeds of the working rolls at the respective stands, and controlling the driving of the work rolls to maintain said speed relationship at each stand within predetermined limits.

8. A process as defined in claim 7 in which the speed of the strip emerging from each rolling stand is maintained approximately 2 to 10% faster than the respective surface speed of the work rolls from which the strip emerges.

9. A process as defined in claim 7 in which the speed of the strip emerging from each rolling stand is maintained approximately 5% faster than the respective surface speed of the work rolls from which the strip emerges.

10. A process as defined in claim 6 in which the percentage of reduction in the strip is also computed from the measurement of strip speeds.

11. In a process of rolling continuous strip metal under tension in a tandem mill having driven work rolls, the steps of measuring continuously the relationship of the speed of the adjacent strip to the surface speed of a work roll at each stand of the mill, and controlling the operation of the rolls at each stand to maintain the speeds of the strip approximately 2 to 10% faster than the surface speeds of the rolls from which the strip issues.

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