Oct. 6, 1942. G. E. STOLTZ 2,297,812

DRAFT CONTROL SYSTEM

Filed June 30, 1939 3 Sheets-Sheet 1

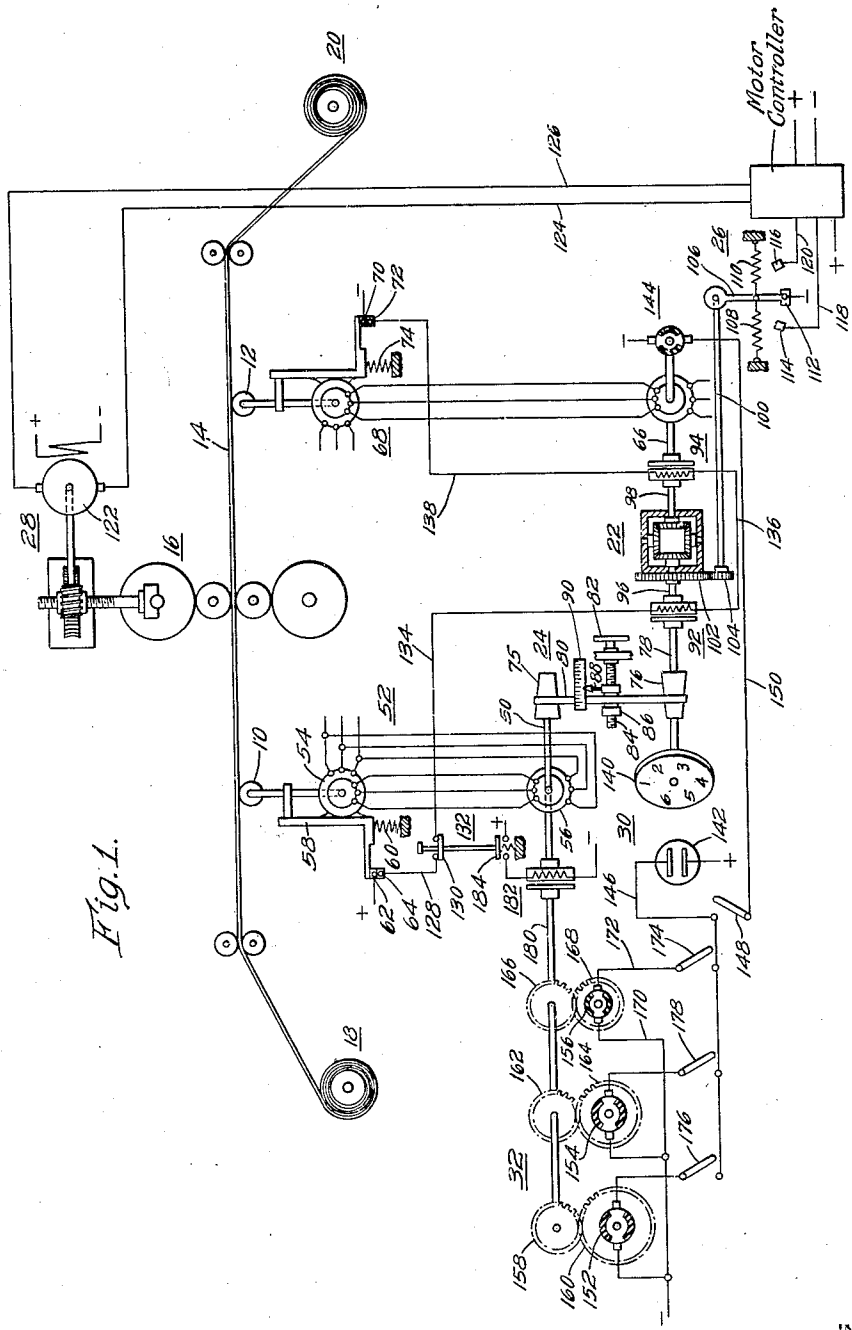


Fig. 1.

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DRAFT CONTROL SYSTEM

Filed June 30, 1939 3 Sheets-Sheet 2

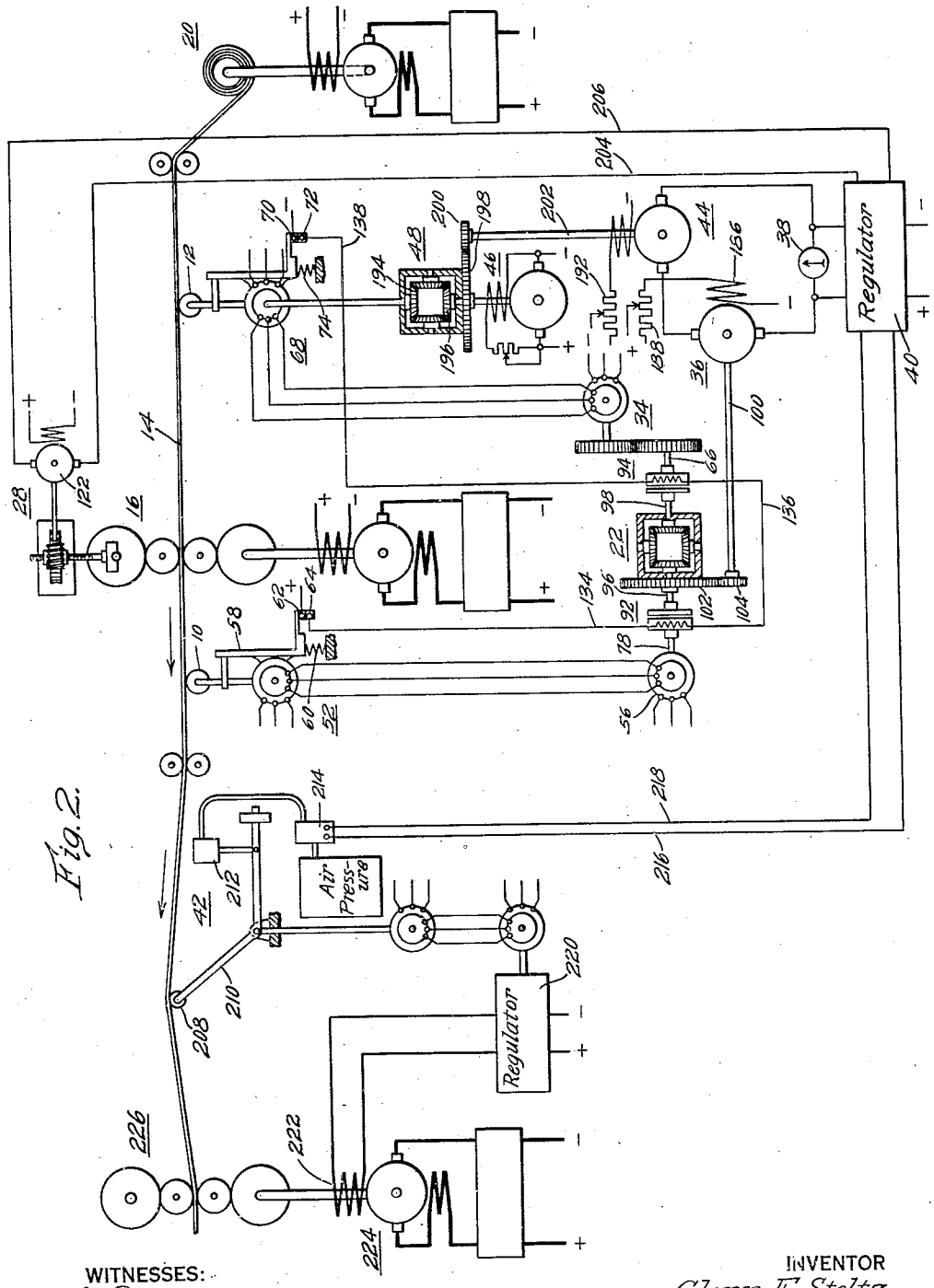


Fig. 2.

WITNESSES:
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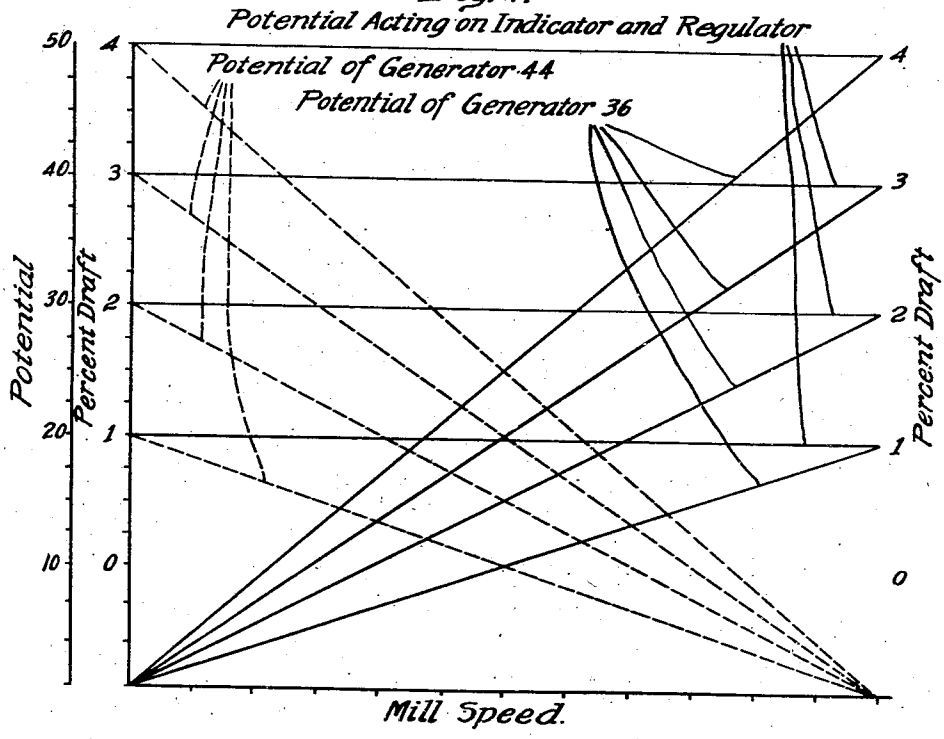
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Filed June 30, 1939 3 Sheets-Sheet 3

Fig. 4.



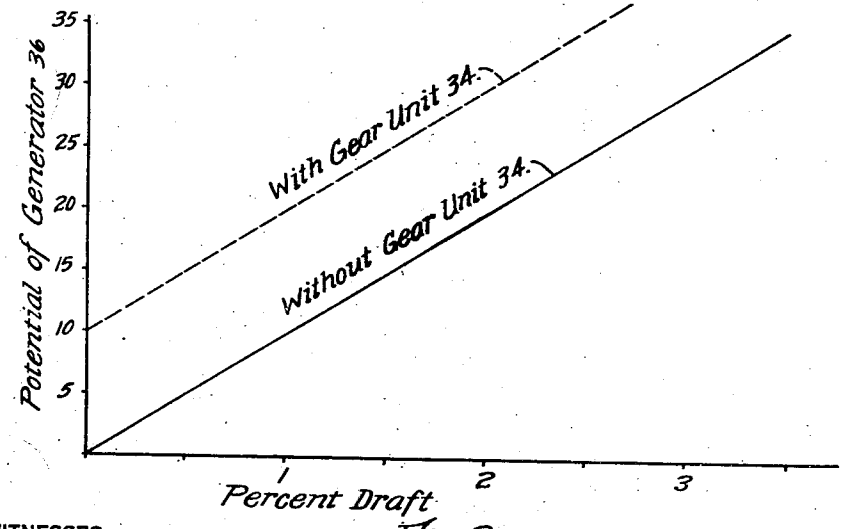


Fig. 3.

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Patented Oct. 6, 1942

2,297,812

UNITED STATES PATENT OFFICE

2,297,812

DRAFT CONTROL SYSTEM

Glenn E. Stoltz, Pittsburgh, Pa., assignor to Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., a corporation of Pennsylvania

Application June 30, 1939, Serial No. 282,197

13 Claims. (Cl. 80—32)

My invention relates, generally, to draft control systems for rolling mills, and, more particularly, to systems for controlling and indicating the draft taken on strip material as it passes through a rolling mill.

In the operation of rolling mills, and particularly strip rolling mills, it is necessary that the amount of reduction of the material being rolled, commonly known as the draft, be indicated and very closely controlled so that the rolled product will have a uniform thickness or gauge.

An object of my invention is to provide a draft control system which shall function to indicate and control the draft taken on a length of material as it passes through the reducing rolls of a rolling mill.

A further object of my invention is to provide a draft control system for a rolling mill which shall function to accurately indicate and control the draft taken by the reducing rolls, which shall be adjustable to take any desired predetermined draft and which shall automatically compensate for variations in the mill speed.

Another object of the invention is to provide a draft indicating and control system which shall be simple and efficient in operation and which shall be inexpensive to manufacture, install, and maintain.

These and other objects and advantages of the invention will be apparent from the following detailed description taken in connection with the accompanying drawings in which like reference characters designate identical or similar elements and in which:

Figure 1 is a diagrammatic view of a strip rolling mill and draft control means therefor embodying the principal features of a preferred embodiment of my invention;

Fig. 2 is a diagrammatic view of a strip rolling mill and draft control means therefor embodying the principal features of another embodiment of my invention; and

Figs. 3 and 4 are graphs illustrating the operating characteristics of certain parts of the embodiment of the invention shown in Fig. 2.

In practicing the preferred embodiment of my invention I provide a pair of rollers 10 and 12 which bear upon the strip 14 on opposite sides of the reducing roll stand 16 as it passes between the reducing rolls and between the reels 18 and 20. The rollers 10 and 12 are driven by the strip and their motion is transmitted to opposite sides of a speed-differential responsive device 22. A variable-ratio transmission device 24 is interposed between the roller 10 and its associated side of the speed-differential responsive device 22 to compensate for the difference in the speeds of the strip on the opposite sides of the mill due to reduction of the strip in the mill.

A control device 26 responsive to the speed-differential responsive device 22 functions to control the screw-down actuating mechanism 28.

A stroboscopic device 30 functions to indicate any deviation of the draft from that determined by the setting of the variable speed-ratio transmission device 24. A series of contact devices 32 is provided for calibrating the variable speed-ratio transmission device 24 and for verifying its calibration.

In the embodiment of the invention shown in Fig. 2, one side of the speed-differential responsive device 22 is driven in accordance with the rotation of the roller 10 and the other side is driven in accordance with the rotation of the roller 12 through a reduction gear unit 34. The speed-differential responsive device 22 drives a generator 36 which is connected to energize a draft indicator 38 and a regulating device 40. The regulating device 40 functions to control the screw-down actuating mechanism 28 and a strip tensioning device 42. Variations in the speed of the mill are compensated for by a generator 44 whose output potential is made to vary inversely with the speed of the strip on the entry side of the mill. The generator 44 is driven at a speed proportional to the difference between the speed of the roller 12 and a constant speed motor 46 through a differential mechanism 48.

The graph of Fig. 3 indicates the effect of the reduction gear unit 34 in the system.

The curves of Fig. 4 represent the output potentials of the generators 36 and 44 at the different strip speeds and the resultant potentials acting on the indicator 38 and the regulator 40 at the different degrees of reduction of the strip in the mill.

Referring again to Fig. 1 for a more complete description, the shaft 50 of the variable speed-ratio transmission device 24 is driven by the roller 10 through a synchro-tie system 52 which has a transmitting element 54 driven by roller 10 and a receiving element 56 connected to drive the shaft 50. The roller 10 is mounted upon a frame 58 which is mounted for a vertical movement against the bias of a spring element 60. A contact element 62 is mounted on the frame 58 and is positioned to engage fixed contact element 64 when the frame 58 is pushed downward against the bias of this spring 60 by the engagement of the strip 14 with the roller 10.

In a similar manner a shaft 66 is driven by the roller 12 through a synchro-tie system 68 and movable and fixed contact elements 70 and 72 are positioned to engage when the roller 12 and its supporting frame are moved downward against the biasing of a spring 74 by engagement of the strip 14 with the roller 12.

The variable speed-ratio transmission device 24 comprises a cone pulley 75 mounted on a shaft 50 and a cone pulley 76 mounted on a shaft 78 and a belt 80 extending in driving relation between the cone pulleys. The position of the belt 80 along the pulleys determines the speed ratio of the pulleys and the positioning of the belt may be manually controlled by an adjusting wheel 82 which drives a screw 84. The screw 84 has screw-threaded engagement with a belt guide 86 which moves longitudinally of the screw 84 upon actuation of the screw to thus adjust the position of the belt 80 with respect to the cone pulleys 74 and 76. An indicator pointer 88 is mounted for movement with the belt guide 86 and cooperates with a scale 90 to indicate the adjustment of the transmisison device. Scale 90 may be calibrated in terms of per cent reduction so that the variable speed-ratio transmission device 24 may be set to produce any desired reduction of the strip 14.

The driven shafts 78 and 66 are connected by means of electrically operated clutches 92 and 94 to drive the shafts 96 and 98. The shafts 96 and 98 drive the opposite sides of the speed-differential responsive device 22 which operates a shaft 100 through the gear members 102 and 104. The control device 26 comprises an operating arm 106 which is mounted upon the shaft 100 for rotation by the shaft through the arc between the contact elements 114 and 116 and which is biased to a central neutral position, as indicated, by means of spring members 108 and 110. A contact element 112 is mounted upon the arm 106 to be moved by rotation of the arm 106 into engagement with fixed contact elements 114 and 116. The contact elements 112, 114 and 116 operate through the conductors 118 and 120, as indicated, to actuate the motor controller which in turn controls actuation of and the direction of rotation of the armature 122 of the drive motor for the screw-down actuating mechanism 28 through the conductors 124 and 126. The motor controller indicated may be any suitable controller and may take the form of the controller shown in Fig. 7 of the patent to Lamb No. 2,154-946.

The sets of cooperating contact elements 62—64 and 70—72 control the actuation of the clutches 92 and 94 through a circuit which extends from one side of a suitable source of electrical energy as indicated through the contact elements 62 and 64, the conductor 128, the contact element 130 of a pushbutton switch 132, the conductor 134, the winding of the clutch 92, the conductor 136, the winding of the clutch 94, the conductor 138, and contact elements 72 and 70 to the other side of the source of energy.

The stroboscopic device 30 comprises a disc 140 mounted for rotation by the shaft 78 and an illuminating device 142 positioned to illuminate the disc 140 when energized. The illuminating device 142 may be any suitable device commonly used for this purpose, such as a grid-glow tube. A circuit interrupter 144 is mounted to be driven by the shaft 66 and is connected to intermittently energize the illuminating device 142 through a circuit which extends from one side of a suitable source of electrical energy through the illuminating device 142, a conductor 146, a circuit control element 148, a conductor 150, and the circuit interrupter 144 to the other side of the source of energy.

In the operation of the system, as the strip is passed through the mill and extends between the reels 18 and 20, it will bear upon the rollers 10 and 12 to close the control circuit for the clutches 92 and 94 thus causing engagement of the clutches. The rollers 10 and 12 will be driven at speeds proportional to the speeds of the strip on the opposite sides of the mill. The speeds of the strip on the opposite sides of the mill will be different, and their ratio will depend on and will be proportional to the amount of reduction of the strip 14 as it passes through the reducing rolls. The adjusting wheel 82 will be manipulated to adjust the variable speed-ratio transmission device 24 to produce a speed ratio of the device corresponding to the ratio of the speeds of the strip on the two sides of the mill which will exist when the desired amount of reduction in the mill is being produced. With the desired reduction being produced in the mill, it will be seen that the drive connection between the roller 12 and the shaft 98 which drives one side of the speed-differential responsive device 22 and the drive connection between the roller 10 and the shaft 96 which drives the other side of the speed-differential responsive device 22 will produce rotation of the shafts 96 and 98 at equal speeds, and no rotation of the shaft 100 to actuate the control device 26 will occur. If, for any reason, a different degree of reduction of the strip 14 than that corresponding to the setting of the variable-speed-ratio transmission device 24 is produced, there will be a difference in the speeds of rotation of the shafts 96 and 98 and this differential motion will be transmitted to the shaft 100 which in turn will cause the control device 26 to actuate the screw-down actuating mechanism to so adjust the screw-down setting of the mill as to produce the desired degree of reduction of the strip 14.

The stroboscopic device 30 will function to give a visual indication of any variation of the degree of reduction of the strip from the desired predetermined amount. With the circuit control device 148 in the closed circuit position, it will be seen that the illuminating device 142 will be energized to intermittently illuminate the disc 140 at a frequency proportional to the speed of the strip 14 on the right-hand side of the mill. The disc 140 being driven by the shaft 78 will be rotating at a speed corresponding to the speed of the strip on the left-hand side of the mill multiplied by the speed ratio of the variable-speed-ratio transmission device 24. If then the amount of reduction in the strip is such that the ratio of the speeds of the strip on the opposite sides of the mill is the same as the ratio of the variable-speed-ratio transmission device 24, then the speed of rotation of the disc 140 will correspond to the frequency of illumination of the disc 140 by the illuminating device 142, and the disc will appear to be standing still. However, if the degree of reduction of the strip in the mill is not such as to produce a ratio between the speeds of the strip on the opposite sides of the mill corresponding to the speed ratio of the variable-speed-ratio transmission device 24, the motion of the disc 140 will not correspond to the frequency of illumination of the disc by the illuminating de-

vice 142, and the disc 140 will appear to be moving.

The series of contact devices 32 provided for calibrating the variable-speed-ratio transmission device 24 and for verifying its calibration comprise circuit interrupters 152, 154 and 156 driven by gears 158—160, 162—164, and 166—168, respectively. The ratios between the sets of gears 158—160, 162—164, 166—168 have definite fixed values. The interrupter 156 may be connected to energize the illuminating device 142 through a circuit which extends from one side of a suitable source of electrical energy through a conductor 170, the interrupter 156, the conductor 172, the circuit-control device 174, the conductor 146, and the illuminating device 142 to the other side of the source of energy. The interrupters 152 and 154 may be connected to control the energization of the illuminating device 142 in a similar manner by means of the selectively actuable-circuit-control device 176 and 178.

The sets of gears may be driven by a shaft 180 which may be connected to the shaft 50 by means of an electrically actuated clutch 182 which is controlled by a contact element 184 of the pushbutton switch 132.

In the operation of the device for calibrating the variable-speed-ratio transmission device 24, the circuit control element 148 is moved to the open circuit position and the circuit control element 174 is moved to the closed circuit position. The pushbutton switch 132 is then operated and this will cause the deenergization of the clutches 92 and 94 by moving the contact element 130 to open circuit position and the energization of the clutch 182 by moving the contact element 184 to closed circuit position. The operating wheel 82 may now be actuated to make the disc 140 appear to stand still thus indicating that the speed ratio of the transmission device 24 is the same as the speed ratio of the gears 166—168. The indication on the scale 90 may thus be verified since the speed ratio of the gears 166—168 is known, or in calibrating this scale 90 the indication may be marked on the scale. In a similar manner other settings of the transmission device 24 may be calibrated or verified by the selective actuation of the circuit control element 176 and 178 to render the interrupters 152 and 154 operative at their respective known speeds. As many of the interrupter devices as desired may be provided so that as many points on the scale 90 as desired may be calibrated or verified.

In the embodiment of the invention shown in Fig. 2 in which like reference characters designate the corresponding elements common to the embodiments of the invention of Figs. 1 and 2, the strip moves through the mill in the direction indicated by the arrows and the motion of the strip on the delivery side of the mill is transmitted from the roller 10 through the synchro-tie system 52, the shaft 78, the clutch 92, and the shaft 96 to one side of the speed-differential responsive device 22, and the motion of the strip on the entrance side of the mill is transmitted from the roller 12 through the synchro-tie system 68, a set of gears 34, the shaft 66, the clutch 94, and the shaft 98 to the other side of the speed-differential-responsive device 22. The shaft 100 whose speed is governed by the speed-differential of the shafts 96 and 98 is connected to drive a generator 36 whose field winding 186 is connected through a rheostat 188 to any suitable source of direct current power. Thus, it will be seen that the output potential of the generator 36 will vary with the difference in the speeds in the strip on the entry and delivery sides of the mill. The set of gears 34 has a very small speed ratio, such as approximately 98/100. This provides a normal potential bias of the generator 36 so that it will have an appreciable potential at the low degrees of reduction of the strip 14 thereby assuring more accurate readings on the indicator 38. This functioning of the gear unit 34 is best illustrated by the graph of Fig. 3 in which the output potential of the generator 36 is plotted as a function of the per cent draft taken by the mill, comparing the conditions of the operation with the gear unit 34 and without the gear unit 34. By reference to Fig. 3, it will be seen that without the use of the gear unit 34 with a small per cent draft such as .5% the potential output of the generator 36 will be approximately 5 volts. With the gear unit 34 in use, however, with a draft of .5% the potential output of the generator 36 will be approximately 15 volts. Since electro-responsive indicators and regulators cannot be accurately calibrated and controlled at lower potentials, it will be seen that this potential bias supplied by the use of the gear unit 34 will result in much more accurate draft indications and regulation at the lower percentages of draft.

In order to compensate this system for variations in speed of the mill, the generator 44 is connected in circuit with the generator 36 and is driven at a speed inversely proportional to the speed of the mill so that its output potential will be inversely proportional to the speed of the mill. The generator 44 is provided with a field winding which may be energized by direct current energy as indicated. The generator 44 is driven through a differential mechanism 48 having a sun-gear 194 driven by the roller 12 and a sun-gear 196 driven at a constant speed by the motor 46. The differential speed as determined by the differential mechanism 48 is transmitted through the gears 198 and 200 and a shaft 202 to the generator 44. The regulator 40 is connected by means of conductors 204 and 206 to control the energization of the armature 122 of the drive motor for the screw-down actuating mechanism 28.

The tensioning device 42 comprises a roller 208 mounted upon a crank 210 which is actuated to cause the roller 208 to deflect the strip 14 from its normal pass line and thereby subject it to tension. The crank 210 may be actuated by a fluid operating piston and cylinder arrangement 212, the force applied by the piston being automatically regulated by a suitable electrically adjustable regulating valve 214. The amount of tension applied to the strip may be controlled by the regulator 40 through conductors 216 and 218 connected to the pressure regulating valve 214. The deflection of the strip by the tension device 42 may be kept within predetermined limits by means of a regulator 220 actuated in accordance with the deflection of the strip by the tensioning device 42 and acting upon the field winding 222 of the drive motor 224 for the roll stand 226 to regulate the amount of slack in the strip by control of the speed of the roll stand 226. The amount of strip reduction for a given screw-down setting is a function of the tension applied to the strip as it passes through the reducing rolls.

In the operation of the embodiment of the invention shown in Fig. 2, it will be seen that the output potential of the generator 36 will be pro-

portional to the difference between the speeds of the strip on the entry and delivery sides of the mill. With the mill operating at a constant speed, the output potential of the generator 36, therefore, should be a measure of the reduction of the strip in the mill. However, should the speed of the mill vary, the output potential of the generator 36 would not be a true indication of the draft taken in the mill, although it would be a true indication of the difference in the speeds in the strip on the entry and delivery sides of the mill. With the generator 44 operating at a speed proportional to the difference between the speeds of the strip on the entry side of the mill and the motor 46, this output potential will be inversely proportional to the speed of the mill. Thus for a given per cent draft the potential of the generator 44 will tend to compensate for the variations in the output potential of the generator 36 due to variations in the speed of the mill and the sum of the output potentials of the generators 36 and 44 will be an accurate indication of the draft taken in the mill. This functioning of the generator 44 to compensate for variations in the speed of the mill is illustrated by the graph in Fig. 4. It will be seen that for a given per cent draft the potentials of the generators 36 and 44 will be adjusted by means of the rheostats 188 and 192 so that the sum of their potentials throughout the range of variation of the strip speed will be constant. For 1% draft, for instance, the potential of the generator 36 will be adjusted to vary from zero to 20 volts and the potential of the generator 44 will be adjusted to vary from 20 volts to zero through the range of strip speed from zero to the speed attained at the maximum speed of the mill. Thus the sum of the potentials of generators 36 and 44 will always equal 20 volts when 1% draft is being taken regardless of the mill speed. Any variation of the draft, however, with the variation of the speed of the mill will cause a variation of the output potential of the generator 36 and this variation will be observed on the indicator 38 and will actuate the regulator 40 to vary the screw-down setting of the rolls and to vary the tension applied to the strip by the tension device 42.

When it is desired to produce a different percentage draft in the mill, the rheostats 188 and 192 will be varied to produce the potential indicated by the graph of Fig. 4 corresponding to the desired draft, and the regulator will be adjusted to maintain the screw-down setting and tension on the strip which will produce the desired draft.

It is to be understood that tension devices such as the tension device 42 described in connection with the embodiment of the invention shown in Fig. 2 may be applied on both sides of the mill stand in the system of Fig. 2 and that the regulator may be made to control the tension of the strip only or the screw-down setting only or both the tension and the screw-down setting, either together or in sequence, and that the tension device may be used either with the screw-down setting control of the embodiment of the invention of Fig. 1 or instead of the screw-down setting control, and that the tension device may be used on either or both sides of the mill stand in the system of Fig. 1.

It will be seen that I have provided a draft control system for a strip rolling mill which functions to indicate and control the draft taken on a length of material as it passes through the mill, which shall be adjustable to take any desired predetermined draft, which shall automatically compensate for variations in the mill speed, which shall be simple and efficient in operation and shall be inexpensive to manufacture, install, and maintain.

In compliance with the requirements of the patent statutes, I have shown and described herein the preferred embodiments of my invention. It is to be understood, however, that the invention is not limited to the constructions shown and described herein but is capable of modification by one skilled in the art, the embodiments shown herein being merely illustrative of the principles of my invention.

I claim as my invention:

1. In a draft control system for a strip rolling mill, means applying a tension to the strip as it passes through the mill, and means responsive to the difference between the entry and delivery speeds of the strip for causing said tension applying means to control the tension applied to the strip.

2. In a draft control system for a strip rolling mill, means applying tension to the strip as it passes through the mill, a differential gear unit having its respective sun-gears connected to be actuated in accordance with the entry and delivery speeds of the strip as it passes through the mill, and means responsive to the difference between the entry and delivery speeds of the strip as measured by said differential gear unit for causing said tension applying means to control the tension applied to the strip.

3. In a draft control system for a strip rolling mill, means applying tension to the strip as it passes through the mill, a mechanical speed-differential responsive device actuated in accordance with the entry and delivery speeds of the strip as it passes through the mill, and means responsive to the difference between the entry and delivery speeds of the strip as measured by said differential device for causing said tension applying means to control the tension applied to the strip.

4. In a draft control system for a strip rolling mill, in combination, means for controlling the screw-down setting of the reducing rolls of the mill, means applying tension to the strip as it passes through the mill, a mechanical speed-differential responsive device actuated in accordance with the entry and delivery speeds of the strip as it passes through the mill, and means responsive to the difference between the entry and delivery speeds of the strip as measured by said speed-differential device for controlling said tensioning means and said screw-down setting control means.

5. In a draft control system for a strip rolling mill, in combination, a mechanical speed-differential responsive device, drive means including a clutch for connecting the strip on the entry side of the mill in driving relation with one side of said speed-differential responsive device, drive means including a clutch for connecting the strip on the delivery side of the mill in driving relation with the other side of said speed-differential responsive device, and means responsive to the engagement of the strip with both of said drive means for effecting engagement of said clutches.

6. In a draft control system for a strip rolling mill, in combination, a mechanical speed-differential responsive device, means including a roller engaging the strip and an electromagnetic clutch

for connecting the strip on the entry side of the mill in driving relation with one side of said speed-differential responsive device, means including a roller engaging the strip and an electromagnetic clutch for connecting the strip on the delivery side of the mill in driving relation with the other side of said speed-differential responsive device, and circuit control means responsive to the engagement of the strip with said rollers for effecting the energization of said clutches only when the strip is in driving relation with both of said rollers.

7. In a draft control system for a strip rolling mill, in combination, two stroboscopic members comprising a rotatable member and a circuit make-and-break device, means connecting the strip on one side of the mill in driving relation with one of said stroboscopic members, means including a selectively adjustable variable speed-ratio transmission device connecting the strip on the other side of the mill in driving relation with the other of said stroboscopic members, a light producing device disposed to illuminate said rotatable member, and means connecting said circuit make-and-break device to control the energization of said light producing device, said variable speed-ratio transmission device comprising speed-ratio adjusting means, and auxiliary make-and-break means connected to intermittently energize said light producing device at selectable frequencies that bear predetermined ratios to the speed of the driven side of said variable speed-ratio transmission device, whereby the said speed-ratio adjustment indicating means may be calibrated and its calibration verified.

8. In a draft control system for a strip rolling mill, in combination, two stroboscopic members comprising a rotatable member and a circuit make-and-break device, means connecting the strip on one side of the mill in driving relation with one of said stroboscopic members, means including a selectively adjustable variable speed-ratio transmission device connecting the strip on the other side of the mill in driving relation with the other of said stroboscopic members, a light producing device disposed to illuminate said rotatable member, means whereby said make-and-break device controls the energization of said light producing device, differential-speed responsive means responsive to the difference between the speeds of said two stroboscopic members, and means responsive to said differential-speed responsive means for varying the reducing forces applied to the strip.

9. In a draft control system for a strip rolling mill, in combination, a speed-differential responsive device, means connecting the strip on one side of the mill in driving relation with one side of said speed-differential responsive device, means including a variable speed-ratio transmission device connecting the strip on the other side of the mill in driving relation with the other side of said speed-differential responsive device, means responsive to said speed-differential responsive device for controlling the reducing forces applied to the strip by the mill, a stroboscopic device, and means connecting said stroboscopic device to be actuated in accordance with the speeds of the two sides of said speed-differential responsive device, whereby the stroboscopic device may indicate variations of the degree of reduction of the strip in the mill from a predetermined degree of reduction determined by the adjustment of said variable speed-ratio transmission device, said variable speed-ratio transmission device comprising a manually operated speed-ratio adjusting means and means for indicating the adjustment of the speed-ratio, auxiliary stroboscopic control means for calibrating said speed-ratio indicating means and verifying its calibration, and means for simultaneously rendering said speed-differential responsive device inoperative and rendering said auxiliary stroboscopic control means operative.

10. In a draft control system for a strip rolling mill, in combination, a speed-differential responsive device, means connecting the strip on one side of the mill in driving relation with one side of said speed-differential responsive device, means connecting the strip on the other side of the mill in driving relation with the other side of said speed-differential responsive device, means for maintaining slightly different ratios between the speeds of the strip on the two sides of the mill and the corresponding sides of the speed-differential responsive device, a generator, means for controlling the output potential of said generator in accordance with the speed differential measured by said speed-differential responsive device, and means responsive to the output potential of said generator for indicating the draft taken by the mill.

11. In a draft control system for a strip rolling mill, in combination, a speed-differential responsive device, means connecting the strip on one side of the mill in driving relation with one side of said speed-differential responsive device, means connecting the strip on the other side of the mill in driving relation with the other side of said speed-differential responsive device, means for maintaining slightly different ratios between the speeds of the strip on the two sides of the mill and the speeds of the corresponding sides of the speed-differential responsive device, a generator, means for controlling the output potential of said generator in accordance with the speed-differential measured by said speed-differential responsive device, and means responsive to the output potential of said generator for controlling the reducing forces applied to the strip.

12. In a draft control system for a strip rolling mill, in combination, a speed-differential responsive device, means connecting the strip on one side of the mill in driving relation with one side of said speed-differential responsive device, means connecting the strip on the other side of the mill in driving relation with the other side of said speed-differential responsive device, means for maintaining slightly different ratios between the speeds of the strip on the two sides of the mill and the corresponding sides of the speed-differential responsive device, a generator, means for controlling the output potential of said generator in accordance with the speed-differential measured by said speed-differential responsive device, means responsive to the output potential of said generator for indicating the draft taken by the mill, and means responsive to the speed of the strip on the entry side of the mill for compensating the said draft indicating means for variations in the operating speed of the mill.

13. In a draft control system for a strip rolling mill, in combination, a speed-differential responsive device, means connecting the strip on one side of the mill in driving relation with one side of said speed-differential responsive device, means connecting the strip on the other side of the mill in driving relation with the other side

of said speed-differential responsive device, means for maintaining a slightly different ratio between the speeds of the strip on the two sides of the mill and the corresponding sides of the speed-differential responsive device, a generator, means for controlling the output potential of said generator in accordance with the speed-differential measured by said speed-differential responsive device, a second generator, means for varying the output potential of said second generator inversely with the speed of the strip on the entering side of the mill, and an electro-responsive device connected in circuit with said generators.

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