April 27, 1937. J. B. TYTUS ET AL 2,078,701

AUTOMATIC DEVICE FOR MAINTAINING AND CONTROLLING TENSION

Filed May 13, 1933 3 Sheets-Sheet 1

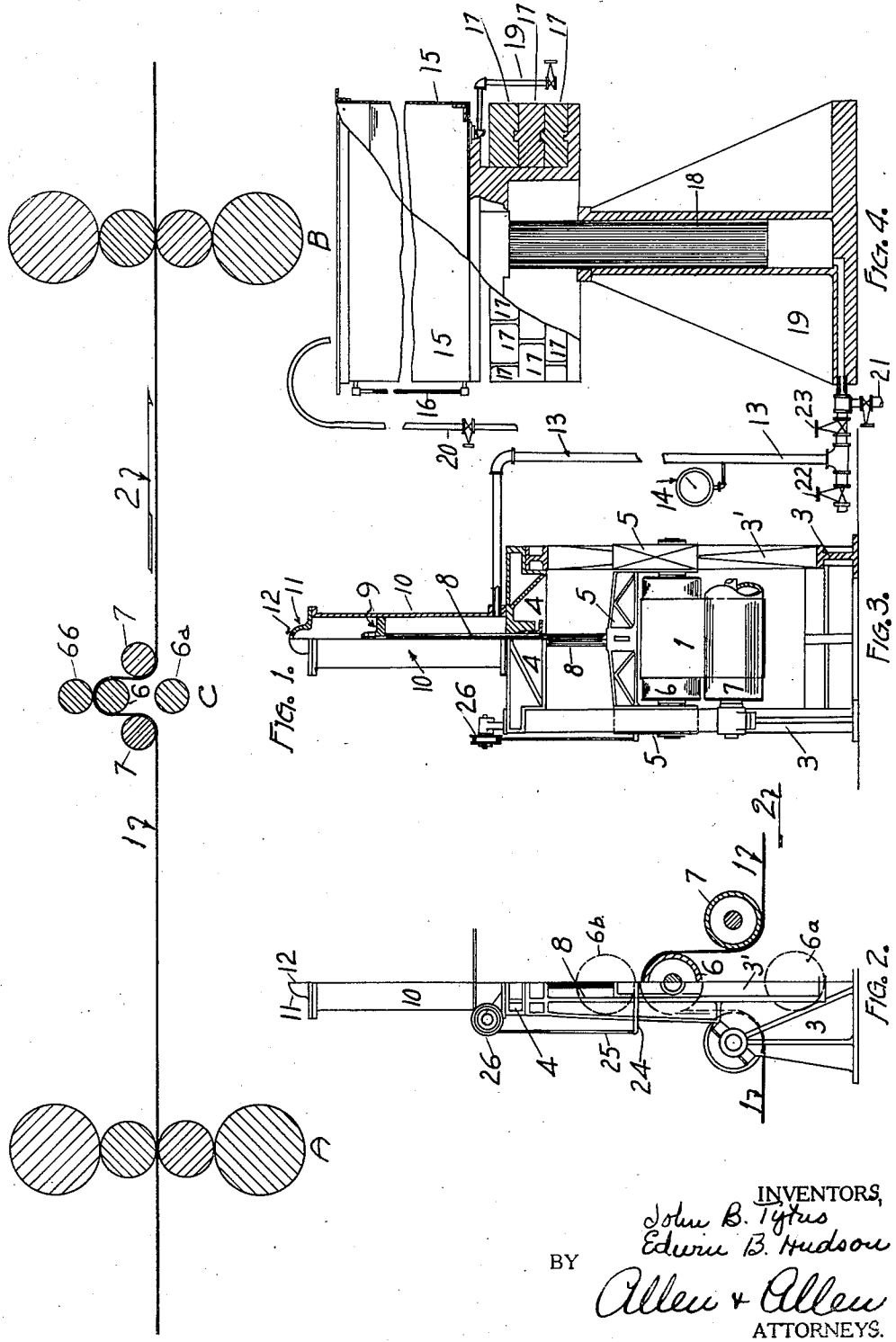


FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

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AUTOMATIC DEVICE FOR MAINTAINING AND CONTROLLING TENSION

Filed May 13, 1933 3 Sheets-Sheet 2

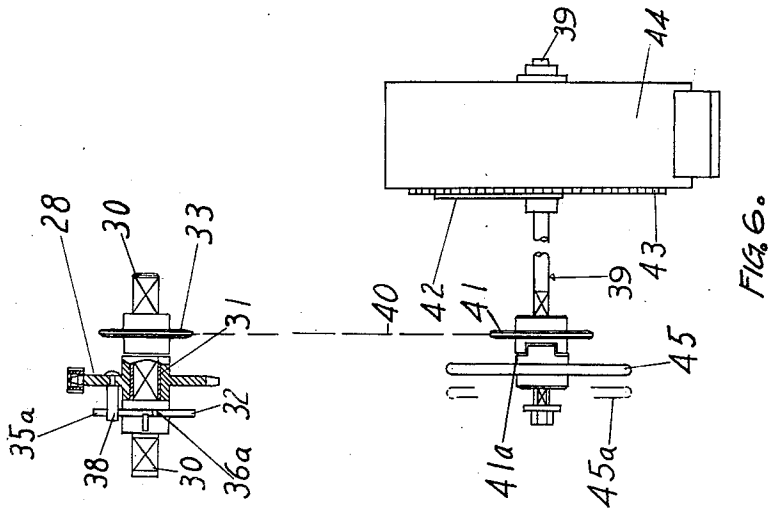


FIG. 6.

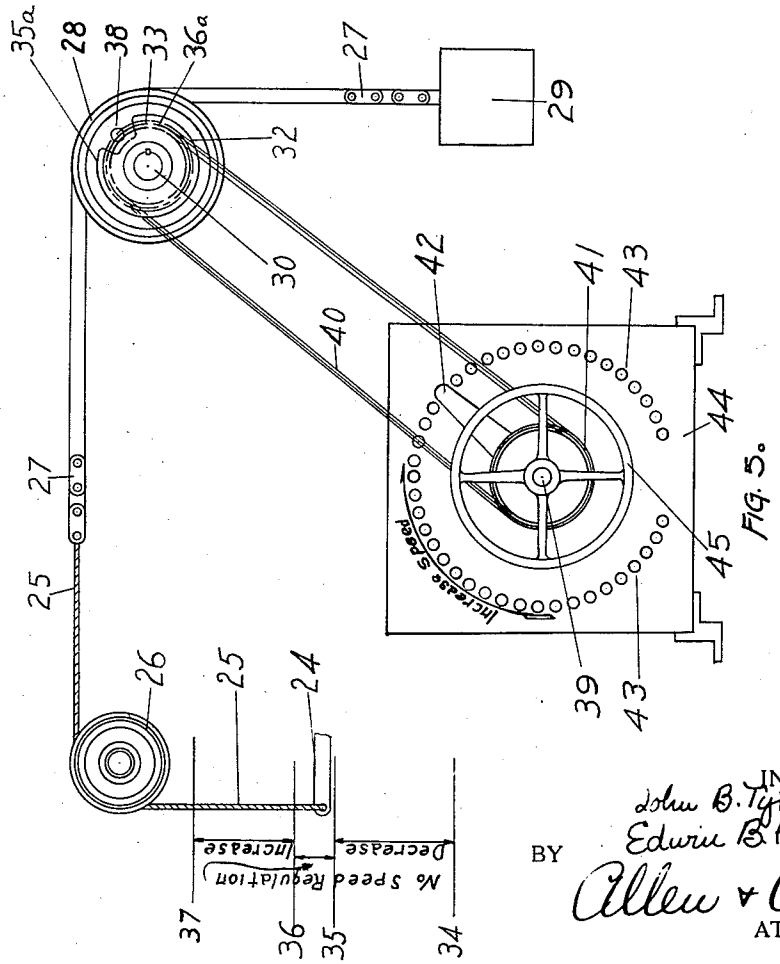


FIG. 5.

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Filed May 13, 1933 3 Sheets-Sheet 3

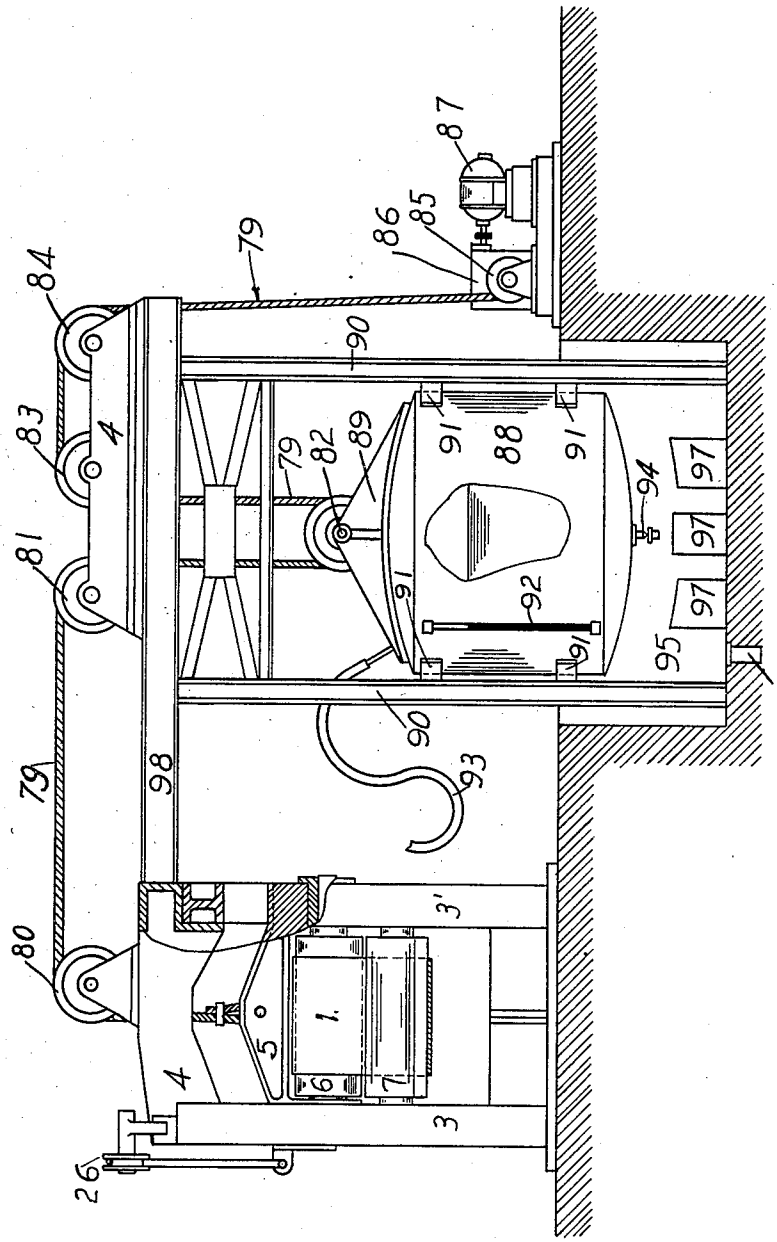


FIG. 7.

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Patented Apr. 27, 1937

2,078,701

UNITED STATES PATENT OFFICE

2,078,701

AUTOMATIC DEVICE FOR MAINTAINING AND CONTROLLING TENSION

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Application May 13, 1933, Serial No. 670,930

6 Claims. (Cl. 80—35)

Our invention has for its primary object the provision of a device which is controllable to maintain at predetermined values the tension on a strip of metal or the like in a dynamic system, such as a cold rolling system, in which a continuous strip of metal is reduced in a plurality of passes in a mill train. Our invention, however, is not limited to this field of usefulness, as will be clear.

More particularly an object of our invention is to provide a device which will take up a strip of metal under a predetermined static tension between a point at which resistance is applied to the movement of the strip and a point at which tractive effort or a pull is exerted upon the strip. Again, our object is to provide a device adapted to take up a strip under a constant predetermined static tension, which is also adapted to maintain a constant tension under dynamic conditions by controlling the forces applied to the strip by another instrumentality or instrumentalities. More specifically it is an object of our invention to provide a device which not only will maintain upon a strip a constant predetermined static tension, but will also control the speed of an antecedent or a subsequent device exerting tractive effort upon the strip in accordance with the length of strip taken up under static tension. Thus, our device is suitable for use between, for example, a braking device and a driven mill, between adjacent mills in a train, between a mill and a pulling device, etc.

Still another object of our invention is to provide a device for maintaining a static tension upon a strip and for controlling tractive effort exerted upon a strip outside of the limits of a predetermined range of strip length.

Our apparatus is of particular usefulness in the systems and in the methods of operation described in the co-pending applications of Edwin B. Hudson, Serial No. 668,101, filed April 26, 1933, and Serial No. 668,100, filed April 26, 1933, in that it permits the continuous operation of the instrumentalities described therein, with the maintenance at all times of controlled tension, irrespective of sporadic variations in the conditions of treatment of the strip. We shall therefore describe our invention in connection with the cold rolling of continuous strip metal in a plurality of stands of four-high cold mills. In a preferred operation, metal pieces are welded together to form a continuous supply, any excess of material at the line of weld is removed, the continuous supply of metal is looped to provide against interruption of the continuity of subsequent operations by reason of the discontinuous operation of welding, and the material is thereupon passed through a plurality of stands of mills, with one pulling device adapted to act continuously on the metal strip located at least at the end of the train. Other pulling devices may be located elsewhere in the train, if desired, in order to produce desired tensions and/or differential values of tension in the individual passes. In such an organization of parts, the devices for maintaining predetermined tensions, to which this application relates, will be located between each instrumentality in the train which acts to retard or advance the movement of the strip, and each following instrumentality in the train which acts to advance or retard the movement of the strip.

The objects of our invention referred to hereinabove, and other objects which will be apparent to one skilled in the art upon reading these specifications, we accomplish by that certain construction and arrangement of parts of which the following is a full, clear and exact description. Reference is now made to the drawings, wherein—

Figure 1 is a diagrammatic representation of two cold mills in the tandem train, with our tensioning device located between the mills.

Figure 2 is an elevational view of our tensioning means taken at right angles to the direction of movement of the strip.

Figure 3 is an elevational view of our strip tensioning device taken in the direction of movement of the strip.

Figure 4 shows an accumulator which may be employed for providing a constant tensioning force in our tensioning means. This figure is primarily in elevation with certain portions shown in section.

Figure 5 is a view in elevation of portions of the mechanism by which our tensioning means is adapted to control the speed of another instrumentality.

Figure 6 is an end view of the apparatus of Figure 5.

Figure 7 is an elevational view of a tensioning means and associated apparatus, in which the tensioning force is derived from a weight.

In its general aspect, one phase of our invention relates to the application of a constant predetermined static tension upon the strip, so long as the length of the strip between the mills, or other dynamic devices employed, is held within predetermined limits, and the provision of means

whereby the length of the strip between the dynamic devices referred to is maintained within the said predetermined limits by an automatic regulation of at least one of the dynamic devices. With the understanding that our invention is applicable to a like end between other dynamic devices, the description herein will concern itself with the application of our device between adjacent mills in a train, which is an exemplary application. Preferably the regulation referred to is a speed regulation, and preferably is also a regulation of the next adjacent dynamic device either preceding or succeeding the tensioning device.

The speed regulation, as indicated, may be applied either to a preceding or a succeeding mill, puller or the like. Under some circumstances it is preferable to regulate the mill or puller preceding the tensioning device. This facilitates the threading operation. It also permits the direct or indirect control of the speeds of the units in the entire train by the last puller, which has certain advantages. If the alternate arrangement is adopted, that is to say, an arrangement in which the tensioning device controls the speed of a succeeding mill or puller, the first mill in the train will directly or indirectly control the speeds of the remaining units in the train. This also is entirely operative; but it should be pointed out that the two arrangements are for most purposes alternative, since continuous control is desired throughout the train.

In Figure 1 we have shown two mills, indicated at A and B and arranged in tandem. Our tensioning device, indicated diagrammatically at C, is shown as located between the mills A and B through which the strip 1 passes for gauge reduction in the direction of the arrow 2. The tensioning device C comprises a pair of rolls over which the strip is bent at substantially a right angle, and a third movable roll engaging the loop of the strip so produced. The movable roll is acted upon by means exerting a constant force, irrespective of the movement of said roll. Consequently, within the limits of the machine the tensioning force exerted upon the strip will be constant.

The tensioning device is shown in detail in Figures 2 and 3, and comprises, in our exemplary embodiment, suitable side frame members 3 and a top cross member or head 4. The side frame members 3 are provided with guideways 3' in which a yoke member indicated at 5 is adapted to slide vertically. The movable roll 6 referred to is mounted in suitable bearings attached to the yoke 5, whereas the stationary rolls referred to and indicated at 7 in Figures 2 and 3, are suitably journaled in the frame members 3. The rolls 7 are rotatively but not slidably mounted, whereas the roll 6 can move with the frame 5 within the limits of the machine. The spacing of the rolls 7 and the roll 6 in a horizontal plane is preferably such that the roll 6 can pass between the rolls 7 with a suitable clearance for the strip. The yoke 5 is attached to a piston rod 8 which carries the piston head 9 operating in a hydraulic cylinder 10 supported by the cross head 4. The cylinder has a head 11 and a vent 12.

We have indicated in dotted lines in Figure 2 at 6a and 6b, positions of the roll 6 at the upper and lower limits of its possible travel. When the roll is in its lowermost position 6a, the strip can pass in a straight line beneath the rolls 7. When the roll 6 is in its uppermost position 6b, the greatest length of strip possible will be taken up by the machine. The manner in which the strip is engaged by the several rolls 7 and 6 will be clear from a consideration of Figures 1 and 2. The action of the hydraulic cylinder, when filled with fluid under a predetermined constant pressure, is to cause the piston rod 8 to exert continuously a pull upon the strip 1 under a predetermined and constant force, and irrespective of the length of strip taken up, until the roll 6 reaches either the upper position 6b or the lower position 6a. Fluid under pressure may be supplied to the device by an accumulator shown in Figure 4, through a pipe 13. Preferably a pressure gauge 14 will be located at a convenient point in the hydraulic system and may be calibrated to read in pounds of tension existing in the strip rather than in pounds of fluid pressure per square inch.

The accumulator may be of any well known design excepting that it preferably has provision for variable loading so that the tension on the strip 1 may be adjusted to a desired figure. We have shown means for accomplishing this variable loading, comprising a water tank 15 above the usual series of fixed weights 17. The tank 15 may be provided with a gauge 16 to indicate the water level, and this gauge may likewise be calibrated in pounds of strip tension. A conduit 20 may be employed to raise the water level in the tank 15, and a drain pipe 19 provided to lower it when desired, both pipes having controlling valves. If the segmental weights 17 are made removable, the loading on the accumulator may be varied by the removal or replacement of these weights.

Otherwise, the accumulator comprises the usual piston 18 operating in a cylinder 19 which, as shown, may be part of a base casting.

Fluid pressure may be introduced into this system by means of a hydraulic pump, not shown, through a connection 21. The system may be drained by a relief valve 22, and there may be a controlling valve 23 located between the accumulator and the conduit 13. By the proper manipulation of the valves 22 and 23 and the valve in the conduit 21, the correct relative positions of the accumulator and the piston 18 can be established. When once this position has been established, then the fluid pressure in the system will remain constant, although it can be adjusted to various desired values. Since the pressure in the system is constant, the roll 6 will tend to be moved upwardly under a predetermined constant force, and will take up the strip 1 under a constant predetermined static tension throughout the entire stroke of the piston 9 in the cylinder 10. The piston rod 8 may likewise be lowered, for threading the tensioning apparatus, by closing the valve 23 and opening the valve 22. During the operation of the tensioning apparatus the valve 22 is, of course, closed, as is likewise the valve in the conduit 21, and the valve 23 is open, whereby the accumulator is operatively connected to the cylinder 10.

In Figure 5 we have indicated the apparatus for controlling the speed of a dynamic instrumentality, such as the mill A or mill B, in accordance with the position of the roll 6. A cable 25 is attached to an arm 24 fixed to the yoke 5, so that the cable will move in accordance with the movements of the cylinder 6. The cable passes over a sheave 26 attached to the frame of our device, and is connected at some convenient point to a chain 27. This chain passes over an idler sprocket 28, and a weight 29 is suspended from the end of the chain. The sprocket 28 idles on a shaft 30, being mounted thereon by means of a bushing

31. A disc 32 is keyed to the shaft 30. The purpose of this construction is to provide for a movement of the idler sprocket 28 within predetermined limits without producing a corresponding movement of the shaft 30, to which end the disc 32 is cut away as shown so as to provide limiting shoulders 35a and 36a. A pin 38 is mounted on the sprocket 28, and is positioned to lie within the cut away portion of the disc 32. It will be clear from an inspection of Figure 5 that the sprocket 28, idling on the shaft 30, can turn in a counterclockwise direction until the pin 38 engages the shoulder 35a, after which, upon further movement, the shaft 30 will be rotated in a counterclockwise direction. Similarly, the sprocket 28 can move freely in the other direction without rotating the shaft 30 until the pin 38 engages the shoulder 36a, whereupon the shaft 30 will be rotated in a clockwise direction.

This enables us to divide the full vertical travel of the cylinder 6 into three ranges indicated diagrammatically in Figure 5. The range between the lines 36 and 35 is a central range of movement within the limits of which no speed regulation is desired. The relatively short range between the lines 36 and 37 is an upper range of movement in which speed regulation is desired for the purpose of taking up the strip. In other words, if the roll 6 rises sufficiently to cause the arm 24 to enter the range 36—37, this means that the length of the strip taken up by the tension device is becoming too long. If the tension device is arranged to control the speed of the mill B, an increase of the speed of the mill B is indicated in this range. Similarly, if the roll 6 is drawn downwardly so as to come within the range 35—34, a decrease of speed is indicated so as to permit the accumulation of a greater length of strip in the loop in the tension take-up device. The length of the central range 36—35 in which no speed control is desired, is represented on the limit disc 32 by the distance between the shoulders 35a and 36a. So long as the roll 6 stays within the central range 35—36, the sprocket 28 turns freely on the shaft 30. As soon, however, as it leaves this central range, the pin 38 engages either the shoulder 35a or the shoulder 36a, and the shaft 30 will then be rotated either in a clockwise or counterclockwise direction. If the mill A is to be controlled, the upper range will be a range requiring slower speed, and the lower range will be a range requiring increased speed, as will be understood.

We next couple the shaft 30 to a device which will vary the speed of the mill motor driving either mill A or mill B. This device may conveniently take the form of a rheostat 44 having the usual resistance elements connected to contact points 43 on an insulating panel. A rheostat control shaft 39 is provided having the usual contact arm 42 adapted to make contact selectively with any of the contact buttons 43. A sprocket 41 is rotatively mounted upon the shaft 39, and a handwheel 45 is slidably but non-rotatively mounted on the shaft. The hubs of the handwheel 45 and the sprocket 41 are provided with cooperating teeth or clutch members indicated at 41a. A sprocket 33 is journaled on the shaft 30, and a chain 40 passes over the sprockets 33 and 41. When the handwheel 45 is in the position shown in solid lines, a rotation of the sprocket 41 will produce a rotation of the shaft 39. For manual adjustment, however, the handwheel may be moved away from the rheostat to a position indicated in dotted lines at 45a. When the handwheel is in this position a rotation of the sprocket 41 will not affect the shaft 39; but the contact arm 42 of the rheostat may be adjusted as to position by means of the handwheel and/or set at a predetermined position, whereupon the handwheel may be moved to the position shown in solid lines, whereupon further movement of the shaft 39 will be controlled by movements of the sprocket 41.

In operation, as the arm 24 in Figure 5 moves into the range 37—36, the weight 29 will lower the chain 27, turning the sprocket wheel 28. When the pin 38 engages the shoulder 36, the limit disc 32 will be rotated in a clockwise direction, likewise rotating the shaft 30 and the sprocket 33. The chain 40 will transmit this motion to the sprocket 41, which will, as explained, turn the shaft 39 in a clockwise direction, which is a direction producing an increase in the speed of the motor of mill B, or alternatively a decrease in the speed of mill A. If the arm 24 is lowered into the range 35—34, the shaft 30 and the shaft 39 of the mill motor rheostat will both be moved in a counterclockwise direction to effect a decrease in the speed of the mill motor for mill B, or alternatively an increase in the speed of mill A. The limit disc 32 provides for the movement of the arm 24 throughout the range 36—35 without a corresponding movement of the mill motor rheostat or increase or decrease of the mill motor speed.

We have shown in Figure 7 a modified form of the apparatus in which the force applied to the yoke of the static tension controlling mechanism is derived from a weight. The static tension device is substantially the same as that shown in Figures 2 and 3, and like parts have been indicated by the same indicia. There is, however, no hydraulic cylinder in association with the tensioning device. Instead, a cable 79 is attached to the yoke 5 and is acted upon by a weight. We have shown adjacent the tensioning device a framework comprising uprights 90 and a cross head 98. A weight, indicated generally at 88, is slidably mounted by means of brackets 91 on the uprights 90. In the particular exemplary embodiment, this weight is shown as a tank adapted to contain a liquid, such as water. The liquid level may be raised by admitting liquid through the conduit 93, or lowered by opening a drain valve 94 in the bottom of the tank. A liquid level gauge 92 is preferably provided, and this gauge may be, if desired, calibrated directly in terms of pounds of tension on the strip. For economy of space, the lower part of this apparatus is preferably located in a pit indicated at 95, which may have drainage means 96. Blocks 97 are provided in the pit, upon which the tank 88 may rest. Suspension means 89 are attached to the tank, and a shaft 82 is journaled therein. The cable 79 may pass over a sheave 80 mounted upon the cross head 4 of the tensioning device. Thence the cable passes over a sheave 81 on the cross head 98 and downwardly to form a loop about the sheave 82, returning to pass over sheaves 83 and 84 on the cross head. Leaving sheave 84, the cable 79 passes downwardly to a motor driven sheave 85. A reversible motor 87 drives this sheave through a gear box 86 containing a self-locking worm and gear drive.

It will be clear in this arrangement that since the strip 1 is looped over the roll 6, the force applied on the yoke 5 must be twice the tension desired in the strip. Similarly, since the cable 79 is looped about the sheave 82, the weight of

the tank 88 must be twice the value of the force desired on the yoke 5. This results in the stepping up of forces and necessitates the use of a weight of considerable magnitude; but the movement vertically of the yoke 5 is only half the length of the strip portion taken up by such movement, and the movement of the tank 88 vertically is only half of the distance of movement produced in the yoke 5 thereby. Hence the effects of inertia are greatly minimized, and this system makes for exceedingly steady and constant application of force to the yoke 5 irrespective of sporadic movements thereof. If it is desired to lower the yoke 5 for threading the tension device, or for any other reason, the motor 87 is rotated in such a way as to pay out cable from the sheave 85. A tank 88 is thus lowered and comes to rest on the blocks 97. A further paying out of the cable will permit the yoke 5 to be lowered to the desired position. After threading, the motor 87 may be operated in the opposite direction, taking up cable on the sheave 85 so as to draw the yoke 5 upwardly, and afterward to raise the tank 88. In this way the position of the tank 88 may be adjusted with respect to the position of the yoke 5 in the tensioning device.

It will be clear that other forms of weight mechanism may be employed. Instead of a liquid the tank 88, or other suitable container, may be filled with shot; or instead of a tank we may employ a frame vertically movable upon the uprights 90 and upon which a series of weights may be removably positioned to adjust the total weight of the device.

Broadly our invention relates to means for taking up and paying out a strip under a predetermined tension of a constant value. To secure constant tension in the strip two conditions must be provided, first a constant force must be caused to act upon the take-up means, and second, the force must be so applied that it is constant on the strip throughout whatever range of movement of the take-up device is required by the sporadic fluctuations in the other instrumentalities in the rolling mill train. The use of a hydraulic accumulator acting in combination with a hydraulic cylinder directly connected to the take-up device is a novel step toward the attainment of the application of constant force. In this method slight inaccuracies may occur due to the cylinder packing friction. The elimination of cylinder packing by the use of lapped pistons and cylinders will reduce this friction to a negligible amount, and our invention likewise contemplates the use of such expedients. The fractional travel of the accumulator with respect to the travel of the piston of the hydraulic cylinder acting on the roll 6 reduces the acceleration and deceleration forces, and this effect can be increased by the use of an accumulator having a larger bore. The weighted device as disclosed in Figure 7 is a particularly simple and direct method of securing a constant force, and applying that force constantly to the take-up device, irrespective of its position. Friction can be reduced to a minimum by the use of roller bearings. In this form of our device the fractional travel of the weight is as advantageous as in the hydraulic method.

Other means of applying a constant upward force are, however, applicable to the uses of our invention. It is possible to employ compressed air, for example, either by using a large volume air reservoir which can be pumped up to a predetermined pressure, and which is connected to an air cylinder acting upon the roll 6, or by using air from a mill supply line and admitting it to a cylinder for controlling roll 6 through a pressure regulating valve. When so employed, the air cylinder may have a calibrated relief valve. In the use of compressed air or other elastic fluids, it is important to provide so large a supply of the pressure fluid that sporadic movements of the take-up device will not greatly affect the pressure applied to the take-up cylinder.

In our take-up device the manner in which the strip passes beneath the rolls 7 and is engaged by the roll 6 so as to be drawn out into a loop is important, since movements of the roll 6 throughout a wide range do not disturb the parallel relationship of the two arms of the loop. So long as the strip is taken up in a loop having parallel portions, a constant force can be applied thereto, irrespective of variations in the amount of strip so taken up, which would not be possible if a greater or less taking up of the strip in a tension device were to vary the angularity of parts of the strip with respect to each other, as when a pressure-driven roll is pressed transversely against an otherwise straight and taut strip. It is not necessary in our structure to provide a central range of movement of the take-up device in which no control of the speed of another instrumentality is effected. Our device works well under conditions of continuous automatic control.

It is obvious also that our device may be provided with means in addition to the control means aforesaid for stopping the mill train in the event of strip breakage.

It will be clear that modifications may be made in the mechanism shown without departing from the spirit of our invention.

Having thus described our invention, what we claim as new and desire to secure by Letters Patent, is:—

1. In a tension take-up device for strip material a framework, a pair of knee rolls journaled in said framework, a pull roll slidably mounted with respect to said framework, a yoke engaging said pull roll, and means for exerting a constant predetermined force on said yoke in a direction to cause said pull roll to take up said material, said means comprising a cable attached to said yoke and a weight adapted to act on said cable, said cable being so arranged that for a given movement of said yoke said weight will move through a lesser distance.

2. In a tension take-up mechanism the combination of a device for taking up strip having fixed and movable elements, a framework, a weight slidably mounted in said framework, a cable connected to said movable elements and suspending said weight by means of a loop in said cable, and a take-up device for said cable for controlling the positions of said movable elements and said weight.

3. In a tension take-up device, means for taking up a strip and comprising fixed and movable elements and a framework, a second framework, a weight slidably mounted in said second framework, a cable for suspending said movable elements and said weight, sheaves mounted on said frameworks for the movement of said cable, for causing said cable to suspend said weight by means of a loop and for conducting an end of said cable to a take-up device, and a take-up device attached to an end of said cable and provided with a self-locking drive.

4. In a tension take-up device, means for tak-

ing up a strip under tension in a parallel-sided loop and comprising fixed and movable elements, a driving means connected with said movable elements and comprising an element rotatively mounted on a shaft, an element fixed on said shaft and having interspaced abutments, means on said first-mentioned element for engaging said abutments selectively, and means connected with said shaft for actuating a speed control device.

5. In a tension take-up device, means for taking up a strip under tension in a parallel-sided loop and comprising fixed and movable elements, a driving means connected with said movable elements and comprising an element rotatively mounted on a shaft, an element fixed on said shaft and having interspaced abutments, means on said first-mentioned element for engaging said abutments selectively, and means connected with said shaft for actuating a speed control device and comprising a rheostat, an operating shaft for said rheostat, an element rotatively mounted on said shaft, a driving connection between said last mentioned element and said first mentioned shaft, and means for selectively connecting said last mentioned element to said rheostat shaft in a plurality of positions selectively.

6. In metal rolling apparatus, the combination of a driven mill and another device effecting the movement of a metal strip being rolled, driving means for said two devices, and intermediate said devices, a tension take-up mechanism for rendering the tension between said devices independent of variations in elongation occurring in the rolling of the metal, said tension take-up device comprising a pair of fixed knee rolls and a movable take-up roll, over all of which said strip passes and whereby said strip is taken up in a parallel sided loop, means for exerting upon said take-up roll in a direction to elongate said loop a constant predetermined force irrespective of the movements of said roll, control means for the driving means of said first two mentioned devices and an operative connection between said movable roll and the controlling means for one of said driving means, said operative connection being so arranged that said movable roll may move within a central limited zone without affecting said control means.

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