Aug. 15, 1939. T. SENDZIMIR 2,169,711

ROLLING MILL ADJUSTMENT

Filed July 16, 1935 7 Sheets-Sheet 1

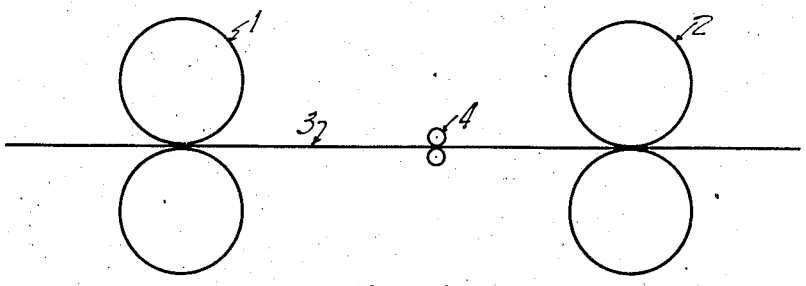


FIG. 1.

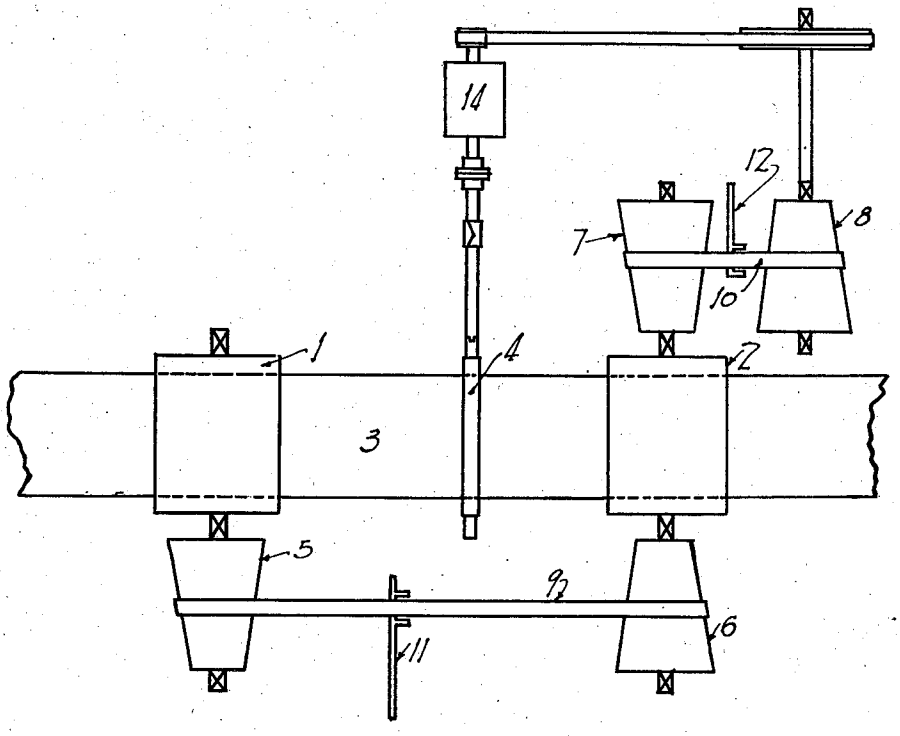


FIG. 2.

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Aug. 15, 1939. T. SENDZIMIR 2,169,711

ROLLING MILL ADJUSTMENT

Filed July 16, 1935 7 Sheets-Sheet 2

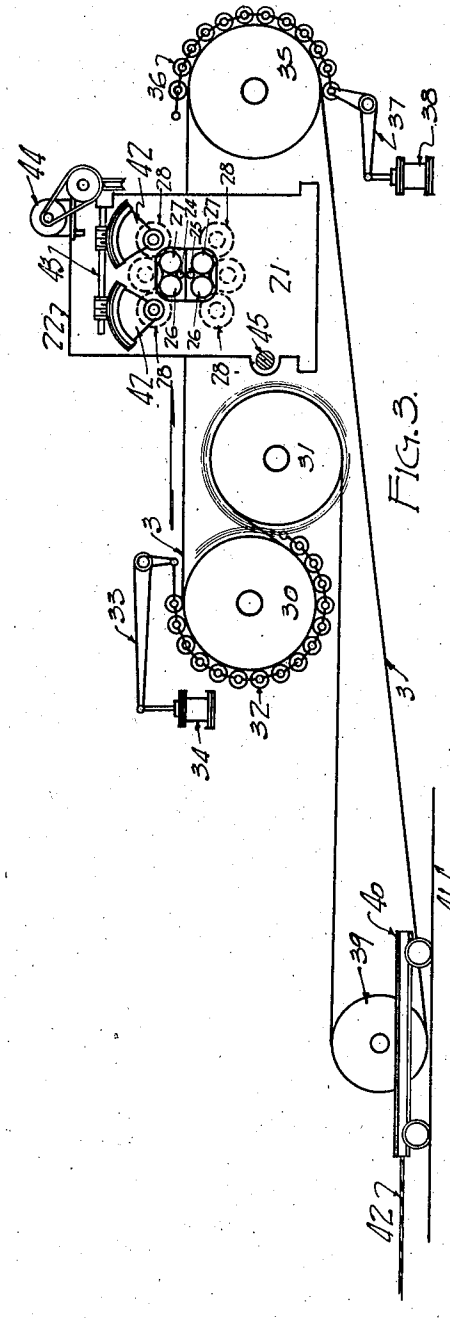


FIG. 3.

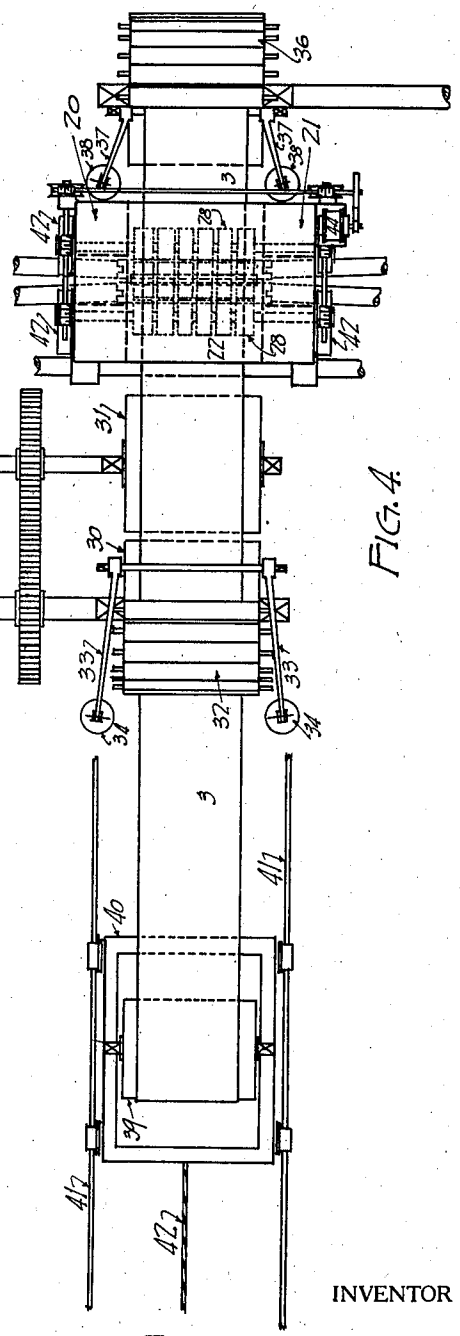


FIG. 4.

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Aug. 15, 1939. T. SENDZIMIR 2,169,711

ROLLING MILL ADJUSTMENT

Filed July 16, 1935 7 Sheets-Sheet 3

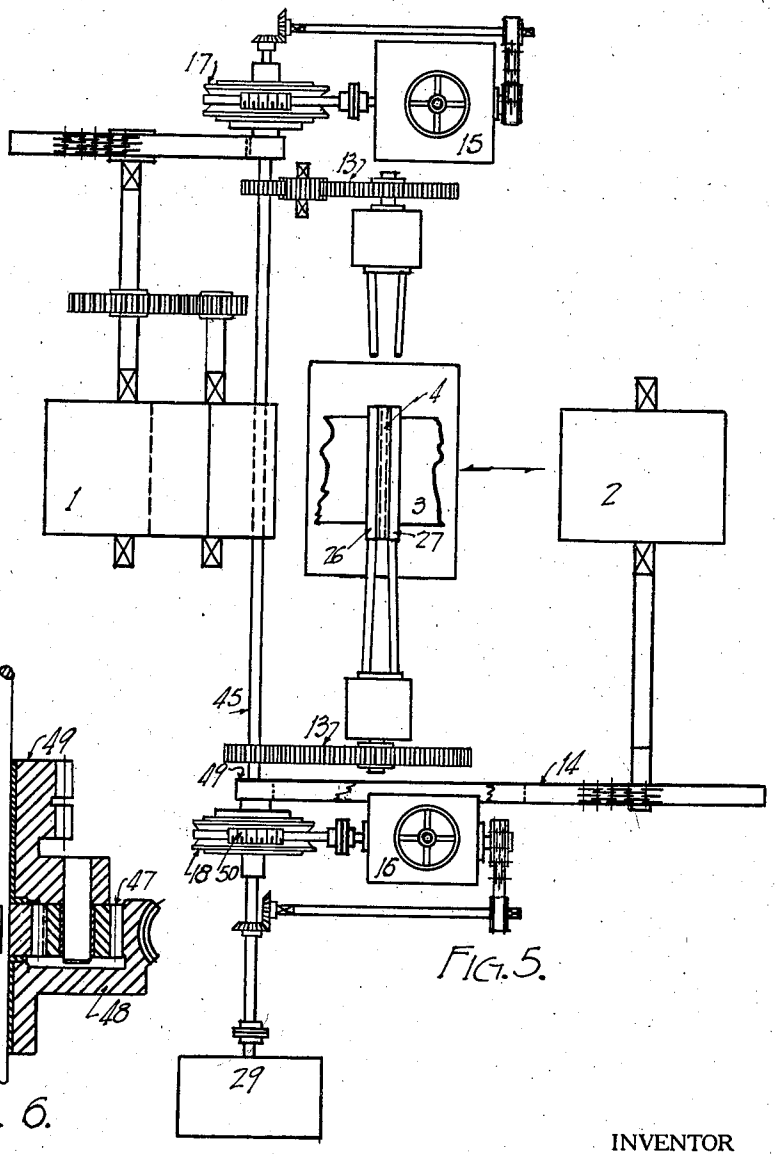


FIG. 5.

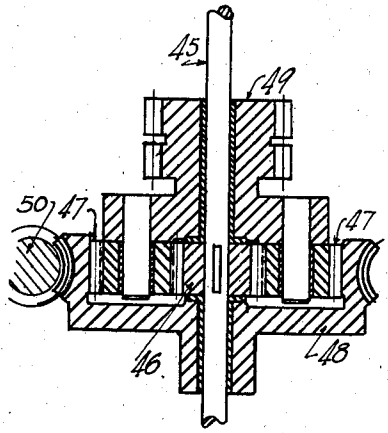


FIG. 6.

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Aug. 15, 1939. T. SENDZIMIR 2,169,711

ROLLING MILL ADJUSTMENT

Filed July 16, 1935 7 Sheets-Sheet 4

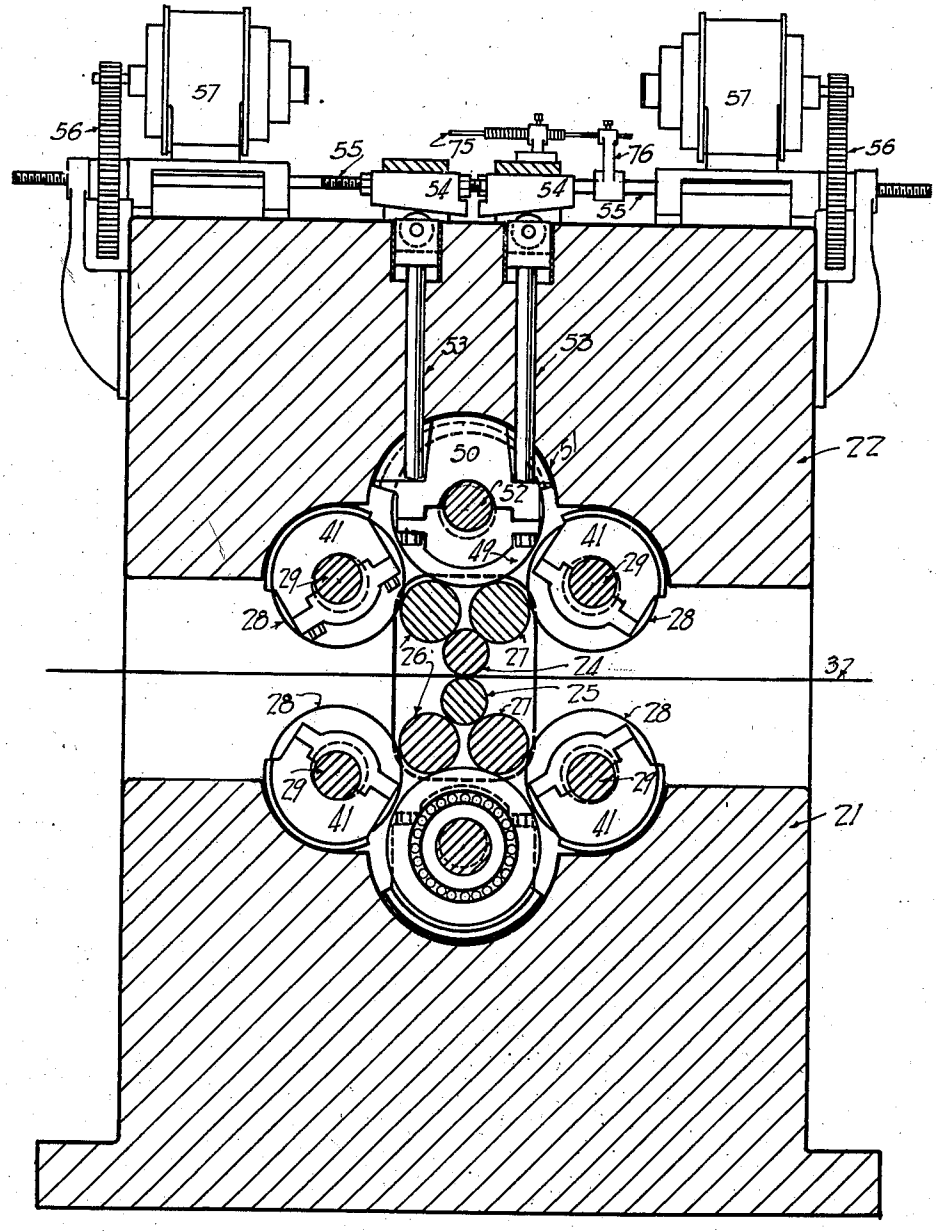


FIG. 7.

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ROLLING MILL ADJUSTMENT

Filed July 16, 1935 7 Sheets-Sheet 5

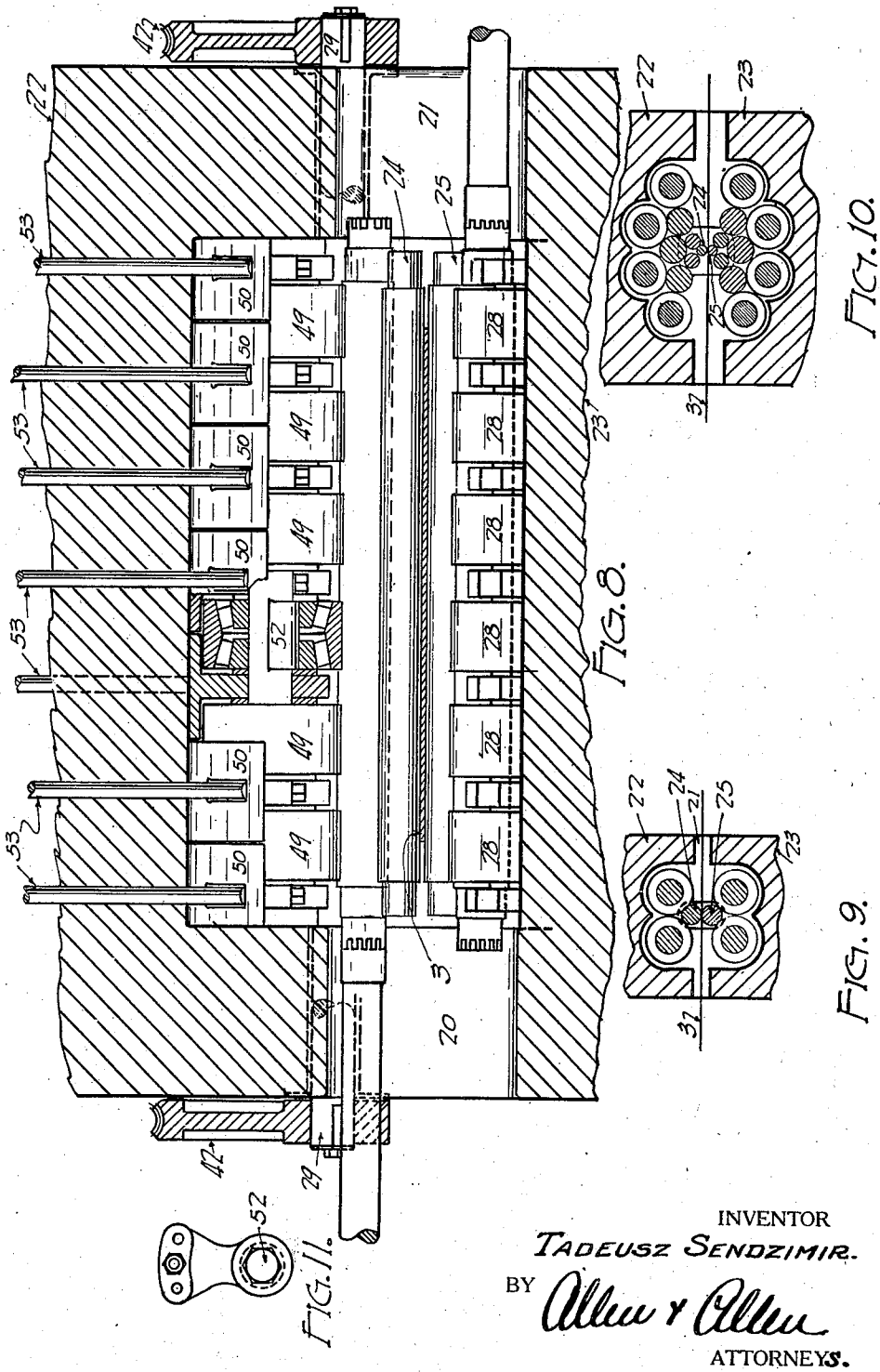


FIG. 8.

FIG. 10.

FIG. 9.

FIG. 11.

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Aug. 15, 1939. T. SENDZIMIR 2,169,711

ROLLING MILL ADJUSTMENT

Filed July 16, 1935 7 Sheets-Sheet 6

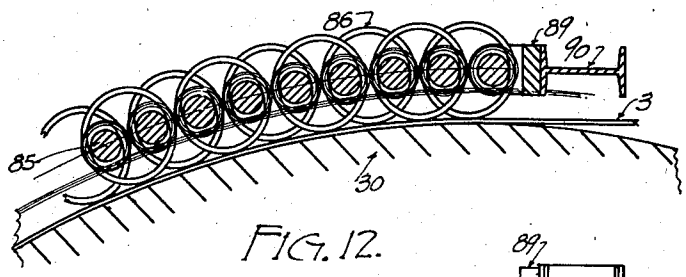


FIG. 12.

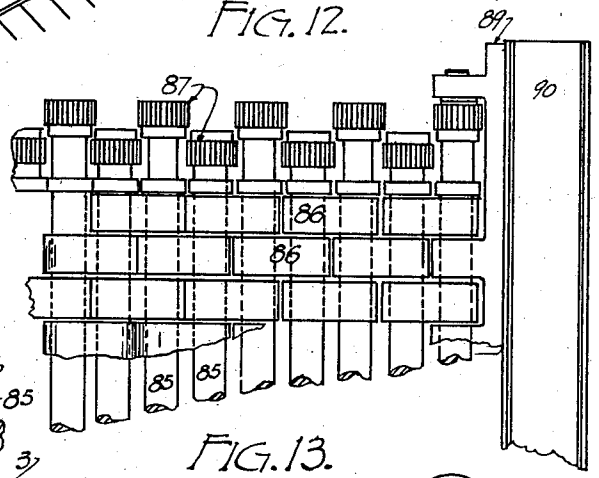


FIG. 13.

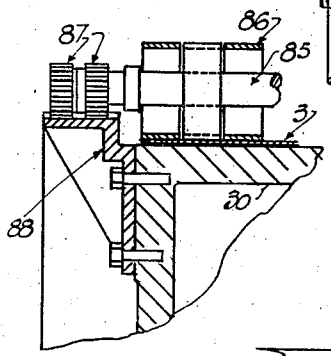


FIG. 14.

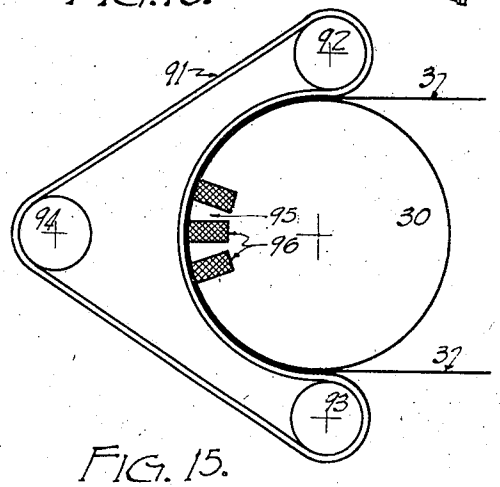


FIG. 15.

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ROLLING MILL ADJUSTMENT

Filed July 16, 1935 7 Sheets-Sheet 7

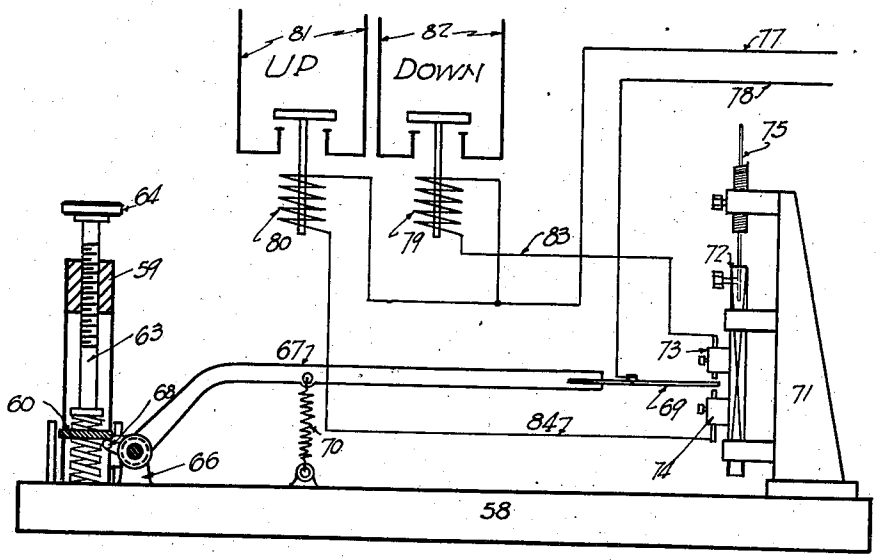


FIG. 16.

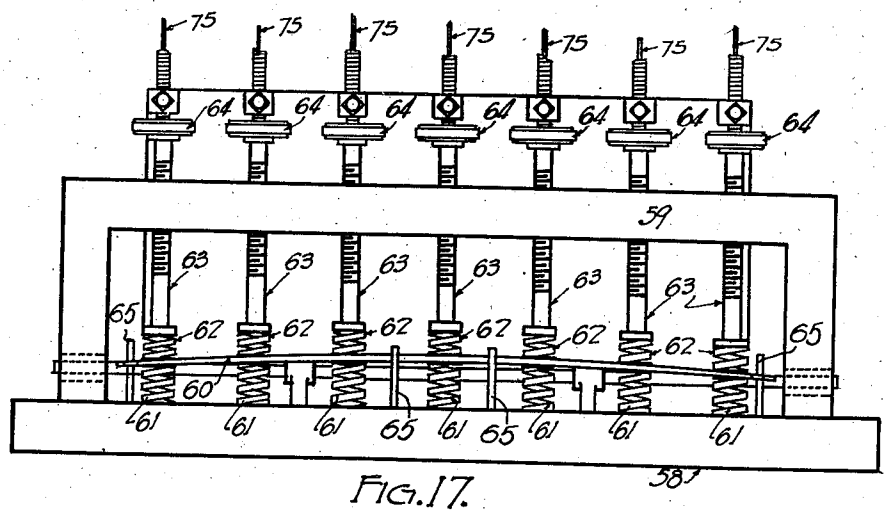


FIG. 17.

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Patented Aug. 15, 1939 2,169,711

UNITED STATES PATENT OFFICE

2,169,711

ROLLING MILL ADJUSTMENT

Tadeusz Sendzimir, Katowice, Poland, assignor to The American Rolling Mill Company, Middletown, Ohio, a corporation of Ohio

Application July 16, 1935, Serial No. 31,697

14 Claims. (Cl. 80—38)

My invention relates to the rolling of metal strips of a wide variation in widths and thickness, in which tension applied to the piece is either part or all of the working force applied thereto. My application Serial No. 31,698, filed of even date herewith, is a division hereof.

It is the object of my invention to provide a tension rolling practice in which the metal strip is extended during each pass by a definite amount in length, irrespective of the pulling force applied thereto. I am thus enabled safely and regularly to apply tensioning forces which could not be applied according to existing practice, and also I avoid defective operations incident to non-uniform material used as a starting material.

It is evident that if a metal strip is permitted to pass toward a pair of working rolls, either idle or driven at a definite speed per minute, and the piece is drawn out of the working rolls at a definite speed per minute, that the difference between the entering speed and the exit speed is an absolute measure of the elongation of the strip.

I will further describe the general aspects of my method by reference to diagrams, and will describe mechanisms suitable for carrying out my method, the inventive features of my invention being set forth in the appended claims.

In the drawings:

Figure 1 is a diagram in section illustrating my practice.

Figure 2 is a diagram in plan view illustrating the same.

Figure 3 is an elevational view of an apparatus suitable for the practicing of my invention.

Figure 4 is a plan view thereof.

Figure 5 is a plan view more clearly showing the drives for the various mechanisms.

Figure 6 is a sectional view of a planetary arrangement which may be employed in connection with the drives.

Figure 7 is a vertical sectional view of a mill which I prefer to use, the section being taken transversely to the mill in the direction of rolling.

Figure 8 is a vertical sectional view of the same mill taken across the direction of rolling.

Figures 9 and 10 are sectional views of modified forms of mills taken in the direction of rolling.

Figure 11 shows a locking means for adjustment of eccentric on shaft 52.

Figure 12 is a sectional view of an exemplary form of feeding device.

Figure 13 is a plan view thereof.

Figure 14 is a partial transverse section.

Figure 15 illustrates another type of pulling device in semi-diagrammatic elevation.

Figures 16 and 17 are respectively end and front elevations of a controlling and indicating device for roll contour.

In carrying out my invention I roll a metal strip in such a way that the elongation thereof remains constant. To this end, in the apparatus aspect of my invention, I provide a strip reducing and elongating device, such as a mill, and a positive feeding-in device therefor, as well as a positive feeding-out device, the two last mentioned devices being positively driven with a ratio of motion corresponding to a predetermined elongation. The combination of the two feeding devices, positively geared together, by way of example, and acting concurrently at different speeds on the same strip, the speeds increasing in the direction of movement of the strip, is a combination which will exert tension on the strip. Since pure stretching or elastic elongation is to be avoided as much as possible, the operation of the system depends upon the elongating device, namely, the mill, adapted to exert transverse pressure on the strip. Such a mill will have both a forward and a back tension exerted upon it through the action of the feeding-in and feeding-out devices. Since these devices operate in a predetermined ratio of motions, to give a desired elongation, the system is operative so long as the mill produces an elongation substantially equivalent to that predetermined.

It is well known that strip for cold rolling as commercially produced, is subject to sporadic variations both as to temper and gauge. In the manufacture of finished stock, particularly for automotive and like uses, it is imperative that gauge variations originally occurring in the starting pieces be not exaggerated in the finished product. An operative situation is attained if gauge variations in the finished piece, considering its thinness, are not substantially more than proportional to gauge variations in the starting piece, considering its thickness. An ideal situation would be approached more closely by the securing of a finished piece in which the gauge variations were less than the proportional relationship referred to.

My system is self-compensating as respects these factors. If the elongation produced by the mill tends to increase, as by the rolling of a spot of softer temper in the strip, the tension between the mill and the feeding-out device will decrease, thus tending to lessen the forces producing elongation. If the elongation produced

by the mill tends to decrease, as when a thicker spot of the strip or a spot of harder temper reaches the mill, the tension will increase, thus tending to increase the elongation. The back tension tends to vary with the forward tension, as will be clear, to complete the compensation aforesaid. The relationships between tension, screw pressures in the mill, and elongation, are known. Thus it will be obvious that with the variations in tension which occur as aforesaid, the compensatory effects take place in the mill. These compensatory effects counteract the normal tendencies for thinner or softer parts of the strip to be elongated more than in proportion to the general elongation, and for harder or thicker parts of the strip to receive less than their proportional elongation.

Nevertheless, because the elongation is constant, as determined by the organization of apparatus to which I have referred, the tension variations which permit uniform elongation are controlled so that the danger of breaking the strip is avoided. It would not be possible by any other system of which I am aware, artificially to produce varying tensions in the strip without serious danger of breakage. In my system the specific elongation directly affects the tension, the general elongation remaining constant, so that I do not encounter the difficulties which arise when strip moving instrumentalities are attempted to be controlled as to speed in accordance with measurements of a variable condition. A primary one of such difficulties is to be found in the fact that the response of the controlled apparatus is delayed so that the controlling condition frequently has altered by the time the compensatory effect comes into play. In my system the active devices are so correlated that there is no intermediary agency between cause and effect in the controlling and controlled agencies.

Referring to Figure 1, the devices 1 and 2, shown as pinch rolls, are intended to represent means which feed a strip without reducing its thickness, the peripheral velocity of which means will equal the linear velocity of the strip being fed by them. If now the devices 1 and 2 are caused to operate on a strip 3, with the device 1 having a velocity V, and the device 2 a velocity V_1 which is greater than V by a definite percentage and remains so, then the strip passing through the device 1 must be lengthened by the time it has passed the device 2 by this same percentage, if the strip is to move at all. As long as the ratio of velocity of the two pinching devices 1 and 2 is less than a certain figure which is quite definite for each material, and termed its "elongation", the strip 3 will stretch or elongate, without rupture, and its thickness will be reduced in like proportion, as there is very little reduction in width, in such an operation.

If at some place between the devices 1 and 2, which are preferably close enough together to avoid any substantial effect of elastic elongation, I bring pressure to bear against the strip, as, for instance, by a pair of hard and polished rods or rolls 4, and adjust the speed relation of the two pinch rolls to accommodate the increased reduction that takes place, I am able to concentrate all of the gauge reduction in the piece to the zone of engagement thereof by the rolls. This is true although the pressure applied by the rolls is comparatively slight, and does not exceed say one-fifth of the tensioning force representing the difference between the velocities of the two feeding devices or pinch rolls.

Furthermore, I am thus able to obtain an increase in length of the piece when applying the rolls to it, that is far greater in a single pass than the "stretching" of the piece would permit if pulling only were done.

Another distinctive feature of this treatment is that the progressive increase in tensile strength of the metal that is characteristic of cold working by any method, goes on very slowly and, at a certain point, which for mill steel corresponds to a reduction of about five times (say from .25" down to .05"), stops entirely, so that the strip may be further reduced practically without limit, without the metal becoming harder or more brittle. The highest figure the tensile strength attains is at the point above-mentioned, corresponding to an elongation of about five times, and is, for mild steel, from 60% to 80% higher than the tensile in annealed condition. A corresponding figure for austenitic steels, like the 18—8 chromium nickel alloy, is a maximum tensile strength from 80 to 90% higher than that of the metal in the annealed condition.

In order to accomplish a given reduction in as few passes as possible, and also to obtain other benefits, as explained below, I prefer to drive the rolls 4, and to do so in a given ratio with one of the feeding devices, preferably the exit or feeding-out apparatus, so that there always is a definite ratio between the velocity V_2 of the rolls 4 and the velocity V_1 of the pinching apparatus 2, though such ratio may be made adjustable. The velocities V_1 and V_2 differ by only a few per cent and the corresponding adjusting apparatus becomes much smaller if located between the mill and the feeding device 2, than if located between the feeding device 1 and the mill.

The rolls 4 may be driven only slightly, the degree being easily adjustable during running, so as to prevent too much stretching from taking place on the exit side of the rolls 4 and transfer a bigger proportion, than would otherwise be the case, to the entrance side.

I have illustrated diagrammatically in Fig. 2 how the relative speeds of movement of the several devices of Fig. 1 may be definitely related. In this diagram the pinch roll device 1 has its speed with relation to the pinch roll device 2 regulated by cone pulleys 5 and 6 on the shafts of said pinch rolls coupled by a belt 9 which can be adjusted to vary the speed ratio, as indicated, by the fork 11. The device 2 is driven in turn from a cone pulley 7 which is coupled by a belt 10 with the cone pulley 8. The cone pulley 8 is in turn driven from the source of power 14 that drives the working rolls 4. The belt shifter 12 is indicated as a means of adjusting the speed of the exit puller 2.

This diagram, Figure 2, shows in simple form the basic plan of my arrangement. Of course, if the rolls 4 are not to be driven, the drive of the two pinch roll elements will be the only ones linked together.

So far as the broad process aspect of my invention is concerned, there is no particular necessity for using a mill of any given type, or pulling devices of any given type, or drives intermediate the same of any given type. The necessities are that the strip be caused to move, or to be fed in, at a given linear speed by the feeding-in device, and caused to move, or to be fed out, at an increased linear speed of definite and main-

tained relation to the entering speed, by the exit feed device.

My method is adapted for operating on a succession of flat rolled strips welded end to end, or to operation on a single piece, the advancing rolled end of which is welded to the entering end, making up a continuous band. It is also applicable to a reversing mill, although in such a case the feeding-in and feeding-out devices should be independent of the coilers or accumulating means. I do not know of any coiler in which sufficiently accurate compensation could be made for the increasing and decreasing diameters of the coils, so that definite linear speeds could be maintained.

I have illustrated as an embodiment of a device suitable for my practice, a mill having as its housing a single casting forming vertical columns **20**, **21**, and cross members **22** and **23**. The working rolls **24**, **25**, are to be driven, and the thrust upon them is transmitted by a pair of idler rolls **26** and **27**, two for each working roll, to backing up devices in the form of a series of shafts with rollers upon them, generally indicated at **28**. As described in my application Ser. No. 31,698 the shafts may be supported on a series of journal members whose outer peripheries are curved eccentrically to the journals and seated in similarly curved channels in the frame cross members. By adjustably rocking these journal members the mill is adjusted as to its pass.

I preferably employ a single power source for both pullers and for driving the rolls. This is indicated as a motor **29**, in Fig. 5, which is geared to the rolls, as at **13**, to drive them in opposite directions. This motor is also directly coupled to the exit pulling device as at **14**; and the exit pulling device is thus coupled to the entrance pulling device. In the coupling of the feeding-in and feeding-out devices, I employ adjustable change gear mechanisms **17** and **18**, preferably in the form of a differential gear, the planetary elements of which are controlled by oil-operated motor-generator devices, **15** and **16** respectively.

The entrance pulling device need not be so heavily constructed as the exit pulling device, since the function of the former is more to restrain movement of the strip than to impart movement, and since the back tension on the mill is preferably generally less than the forward tension. There should be no slip in either device, and no reduction of thickness of the strip in either device.

As an entrance feeding device, I have illustrated in Fig. 3 two drums **30** and **31** close together, the drum **30** being driven and the strip **3** passed three-quarters around each of them. The drums may be faced with friction material, and geared together if desired. The function of the drum **31** in the particular embodiment shown is that of causing the material to wrap about the surface of the drum **30**, and to change its direction for the purpose of the arrangement shown in Fig. 3. In order to increase the frictional engagement of the strip **3** with the drum **30**, I provide a sheath **32**, fixed at one end to a suitable immovable support, and having means at the other end to draw it tightly about the surface of the cylinder **30**. Exemplary means are indicated more or less diagrammatically in Fig. 3, as a bell crank **33**, and a fluid pressure cylinder **34** for operating it. As an exit feeder I have illustrated a mechanism, the essential detail of which is a driven drum **35**, with a sheath or chain of rollers **36** about its periphery, which chain can be tightened around the drum by the power mechanism **37**, **38**, and the rollers of which are driven by being geared to the drum.

The strip **3** passes from the feeding-in device, through the mill and through the feeding-out device. If the strip is an endless strip, there may be provided a take-up means consisting of a drum **39** mounted on a carriage **40**, operating on tracks **41**. The strip **3** passes around this drum, and the carriage has applied to it a tensional force through a cable **42**, by some suitable means not shown. Since the tensioning of the strip as it is being actively worked in the mill is accomplished by the feeding-in and feeding-out devices, it is not necessary to exert any tension on the strip at either end of the mill beyond these devices, excepting such tension as may be required to take up the strip, or to help to hold it against the frictional driving means of the feeding-in and feeding-out devices.

The differential gearing device is shown in my application Ser. No. 742,075, filed Aug. 30, 1934. I have indicated the gearing in general for driving the exit puller as **16**, and the gearing for driving the entrance puller **15**. I have shown also in connection with each set of gearing an oil pump and oil motor device for controlling the differential element. I will now briefly describe these parts.

Each differential includes a pinion **46** fixed on the drive shaft, driving a series of planetary pinions **47**, which in turn mesh with an internal gear **48**, which is loose on the shaft **45**, the external teeth of which form part of the drive. The planetary pinions are mounted on the web of a sprocket **49**, idle on the shaft of the pinion **46**. The gear **48** is held fast or driven by a worm **50**, which is, in turn, driven by the oil motor generator transmission.

The oil device includes two similar elements, one pumping oil and the other driven by the oil pumped. The pump element is driven from some element of the drive which is convenient. A good form of device is one in which a series of pistons are driven around in a frame having cylinders for the pistons. Whether the pistons move in and out depends on the position of an eccentric ring that can be brought into contact with the piston rods. Devices of this character are known in the art.

The worm **50** either holds the gear member stationary, or drives it in one direction or the other. This controls the speed of motion transmission between the drive shaft **45** and the gear **49**. The shaft **45**, as shown in Fig. 5, is the drive shaft from the motor **29**, and in the respective planetary gear arrangements the gear **49** is the gear which is coupled, as by a chain drive, to the feeding-in or feeding-out devices.

Having thus described the general arrangement of an exemplary organization of apparatus, I will come now to a more particular description of certain elements.

As to the mill, I have indicated that the working rolls **24** and **25**, which are the rolls driven, as explained, in connection with Figs. 3, 4 and 5, are backed by rolls **26** and **27**. These rolls bear against the roll supports or backing rollers **28**, journaled on shafts **29**. These shafts have eccentric portions, as shown in Fig. 7, mounted in fixed holding members on the frame of the mill. A rotation of the shafts **29** therefore will vary the position of the backing rollers **28**, and through them will control the position of the working rolls **24** or **25**. This is the way in which a control of the screw down is effected in my mill, and

ordinarily I accomplish this as illustrated in Fig. 3 by mounting gear segments 42 on the ends of the shafts 29, and having these simultaneously controlled by a worm shaft 43, which may, if desired, be driven by a motor 44.

In Fig. 7, I have shown a number of the shafts 29, any or all of which may be controlled in this way to effect screw down.

I also preferably provide in my mill means for controlling the effective contour or crown of the rolls. It will be noticed that the exemplary mill which I have illustrated is a cluster type of mill, having relatively very small working rolls. These rolls are so small that they must be supported throughout their length for the transmission of the necessarily heavy rolling pressures. I have already indicated how the position of the supporting means may be varied to vary the effective screw down. Since, however, I am using interspaced and relatively small rollers for supporting the secondary rolls of the mill, I can control the spring of the rolls, and through this the contour of the rolling pieces, so as to control the degree of "crown", if any, in the rolling piece. I do this by mounting at least one series of the supporting rollers, indicated in Figure 7 at 49, on supporting members 50, which, instead of being fixed on the frame, are rockable in semi-circular channels 51 therein. The shaft 52, upon which the rollers 49 are mounted, is disposed eccentric of the semi-circular channel 51, so that the particular position of any of the small rollers 49 in this group can be varied by rocking the supporting means 50 adjacent thereto in its portion of the channel 51. To accomplish this rocking motion, I provide operating plungers 53, one on either side, extending through perforations in the mill housing, and bearing against abutments on the supporting member 50. These plungers operate against wedge means 54, and are provided at their upper ends with rollers for this purpose, as shown. The wedge means are driven forwardly or backwardly in a horizontal direction in Figure 7 by means of shafts 55 which are non-rotatably mounted in bearing members. Gear members 56 are threaded on these shafts, and as these gear members are driven by motors 57, the rotation of the gears 56 serves to draw the shafts 55 inwardly or outwardly. Since, in order to rock the supporting members 50, the motion of the two wedges 54 should be concurrent, but one of the motors 57 and associated wedge driving means need be provided for each pair of wedges. There should be at least as many of the motors and cooperating wedge driving means as there are supporting members 50 to be rocked throughout the length of the mill. By rocking any of the supporting members 50, the effective contour of the working rolls 24 and 25 may be changed, as will be readily understood.

I preferably provide an indicating and controlling means for roll contour, which means is illustrated in Figures 16 and 17. This means serves not only visually to indicate the contour of the roll, but also to control automatically the several supporting members 50 in accordance with a desired roll contour. I have illustrated a base 58 and an overlying supporting means 59. A resilient piece of metal 60, representative of the roll 24, is supported from the base on spring members 61. Other spring members 62 lie between this metal strip and a series of threaded shafts 63, each representative of one of the controlling devices for the supports 50 on the mill. Each of the threaded shafts is surmounted by a handwheel 64. At intervals throughout the length of the strip 60, there may be suitable scales 65, so that its contour may be gauged. It will be seen that the contour of the strip 60, taken as representative of the contour of the roll 24, may be varied at will by operating the several handwheels 64. It is my purpose so to couple up the mill with this indicating device that a change of the contour of the strip 60, as effected through operation of the handwheel 64, will be reflected in a corresponding change in the mill. To this end, I mount upon the base 58, supporting and pivoting means 66, to which I pivot arms 67 of bell crank shape, having a portion 68 bearing against the strip 60. The long arm bears a contact element 69. There is a controlling spring 70, tending to keep the member 68 against the strip 60. I mount an upright member 71 on the base 58, and slidably journal thereon an element 72 carrying interspaced contact members 73 and 74, between which the contact member 69 lies. I vary the position of the slidable member 72 in accordance with the actual conditions of the mill by coupling it to the wedge means 54 by some effective drive. I have indicated a flexible thrust drive or Bowden wire connection at 75, and I have shown at 76 in Figure 7 how this is connected to the wedge shafts. The power leads to the device of Figure 16 are shown at 77 and 78. The lead 77 is connected to solenoids 79 and 80 for controlling the contacts of relays for forward and reverse circuits to the motors 57, indicated at 81 and 82. The other ends of the solenoids 79 and 80 are connected respectively by leads 83 and 84 to the contact members 73 and 74. The power lead 78 is connected to the contact member 69.

If one of the handwheels 64 in Figure 16 is turned so as to depress a portion of the strip 60, the arm 67 will move upwardly, carrying with it the contact member 69. If the motion is sufficient, member 69 will contact the member 73, and will therefore energize the "down" circuit of the appropriate contour motor 57. This motor will then operate, as has previously been explained, to rotate the supporting member 50 so as to depress the roll 24. As this occurs, the motion of the wedges 54 will be transmitted to the sliding member 72 in Figure 16, through the action of the wire connection 75. Thus the contact 73 will tend to move upwardly; and the operation of the contour motor 57 will continue only until the contact 73 has backed away from the contact 69 and the relay circuit has been broken. The contact 69 is purposely made resilient, so that the bar 60 may be moved to any extent desired.

It will be appreciated that if one of the supporting members 50 in my mill is to receive adjustment to alter the contour, unless this adjustment is very slight in amount, there should be a concomitant adjustment of other adjacent supporting members. This is accomplished through the agency of the strip 60 in the controlling device. To this end I provide as many of the arms 67 as there are rockable supports 50 across the width of the mill, and I locate each arm adjacent one of the threaded shafts 63. As the strip 60 is raised or depressed, through the action of any of the handwheels, due to the stiffness of the strip, its position with respect to adjacent threaded shafts will change against the resiliency of the springs 61 or 62. When this occurs, if the change is sufficient to cause adjacent ones

of the arms 67 to come into contact with contact members on adjacent ones of the sliding members 72, appropriate changes will occur in adjacent ones of the contour motors 57. Thus it is only necessary to determine on the scale 65 the correct contour of the rolls, and to position the strip 60 to coincide with this contour. When this is done, all changes in the mill necessary to effect the predetermined contour will occur automatically.

I have illustrated in Figures 9 and 10 some other forms of mills in which these same principles may be embodied. Particular description of these mills is not necessary. Figure 9 shows a simpler type of cluster mill, in which each of the working rolls 24 or 25 is directly supported by an opposed pair of the supporting rollers. Figure 10 illustrates a more complex type of cluster mill, in which the working rolls 24 and 25 are each supported by two supporting rolls which, in turn, are supported by a series of three supporting rolls. These rolls, in turn, are supported by two series of four sets of the supporting rollers.

In Figures 12 to 15, inclusive, I have illustrated certain forms of pulling devices. Referring to Figures 12, 13 and 14, the numeral 30 illustrates a feeding drum. The strip is again illustrated at 3. The sheath or device for holding the strip tightly against the drum 30 comprises a series of shafts 85. These shafts are formed into a chain-like structure by being interlinked at intervals throughout their length by means of ring members 86. These ring members alternately couple adjacent shafts. Preferably these shafts bear gear members 87 at their ends, which mesh with a gear member 88, bolted or otherwise fastened to the roll 30. Thus these shafts tend to rotate as the drum 30 rotates, and through their rotation to impart movement to the rings 86. This sheath arrangement is supported at one end in journaling means 89 for the last shaft, which journaling means are attached to a fixed support 90. The other end is similarly provided with journaling means attached to the power tensioning arrangement indicated at 33 and 34, or 37 and 38 in Figure 3. As the sheath is tensioned in this way, the ring members 85 tend to become elongated. Great pressure may thus be exerted in holding strip 3 against the drum 30, without at the same time building up frictional resistance to the movement of the strip 3 with the drum 30.

I have shown in Figure 15 another type of feeding device, in which the drum 30, around which the strip 3 passes, is provided with a flexible external sheath 91, which is endless, and which passes over rotative sheaths 92 and 93 adjacent the drum 30, and a sheath 94 interspaced therefrom, which sheath is mounted both for rotation and for sliding movement. The sheath member 91 may be tensioned against the drum 30 by pulling outwardly upon the sheath 94 in the direction of the arrow. While great pressure may be exerted upon a drum in this way, the sheath 91 is adapted to move with the drum so as not to retard the movement of the strip 3.

Other types of feeding devices may likewise be employed. By way of example, the drum 30, as indicated at 95, may be shaped to provide core sections, with windings 96 positioned therein so as strongly to magnetize the surface of the drum. This alone has been found sufficient to hold the strip 3 strongly thereto, where the strip 3 is fairly thick. Where the strip 3, however, is relatively thin, there may not be a sufficient mass of the metal in the strip to be held to the magnetized drum with sufficient strength for my purpose. Where a magnetized feeding device is to be used with thin strip therefore, I prefer to make the sheath member 91 of magnetizable metal, having a relatively heavy mass. This can be accomplished by using for the sheath member 91, iron or steel link chain of the type used in chain link drives.

In the specific embodiments of my invention which I have herein described, I have illustrated the rolling of an endless band of metal. It will be understood that my invention is not restricted thereto. It will be understood that my arrangement is equally as well adapted for the rolling of continuous supplies of metal which are not endless, in the sense that opposite ends are joined together. Thus in feeding my mill, separate strips or sheets may be welded together before the material is fed to the mill, and finished pieces may be cut off after the material has passed through the mill. The forward and reverse rolling may, of course, be practiced upon any length of material in the mill, and the mill may then be set up and operated for the rolling of discontinuous lengths of metal. However, it will be understood that in the rolling of discontinuous lengths, there is bound to be some end wastage, for which reason I prefer to roll a continuous supply, at least so far as the mill and feeding devices are concerned. Different types of pulling devices may be employed, and with different types of pulling devices the exertion of such tension on the strip ahead of the feeding-in device and beyond the feeding-out device, as may be necessary for the operation of the pulling devices, will be within the skill of the worker in the art to provide.

In the companion application I have claimed the process aspects of rolling, as respects the matter of keeping the elongation constant, as well as certain broad apparatus aspects having to do with this particular feature. In this application I intend to cover certain of the mechanical elements and combinations. Inasmuch as modifications may be made in my invention without departing from the spirit thereof, it will be understood that the appended claims are not limited otherwise than by their express terms.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. In combination in a mill, a pair of working rolls, backing means for said working rolls comprising other rolls of equivalent length and supporting means for said backing rolls, said supporting means comprising interspaced rollers of less than equivalent length, means for varying the position relative to the mill housing of a plurality of said supporting means simultaneously to vary the effective screw down of said mill, and means for varying the position of certain of said supporting means simultaneously to vary the effective crown of said working roll.

2. In combination in a mill and housings, upper and lower housing members extending therebetween, a pair of working rolls, backing means for said working rolls and contour controlling means for controlling the effective shape of said working rolls, said last mentioned means comprising interspaced rollers contacting said backing means, a shaft for supporting said rollers, interspaced supporting means for said shaft journaled in a semi-circular groove in said upper and lower

housing members, said shaft being located eccentrically of said semi-circular groove, and means for rocking said supporting members in said groove.

3. In combination in a mill and housings, upper and lower housing members extending therebetween, a pair of working rolls, backing means for said working rolls and contour controlling means for controlling the effective shape of said working rolls, said last mentioned means comprising interspaced rollers contacting said backing means, a shaft for supporting said rollers, interspaced supporting means for said shaft journaled in a semi-circular groove in said upper and lower housing members, said shaft being located eccentrically of said semi-circular groove, and means for rocking said supporting members in said groove, said means comprising operating means impinging on said supporting means at opposite sides of a vertical plane passing through the axis of said shaft, and means for concurrently raising and depressing opposed pairs of said operating means.

4. In combination in a mill and housings, upper and lower housing members extending therebetween, a pair of working rolls, backing means for said working rolls and contour controlling means for controlling the effective shape of said working rolls, said last mentioned means comprising interspaced rollers contacting said backing means, a shaft for supporting said rollers, interspaced supporting means for said shaft journaled in a semi-circular groove in said upper and lower housing members, said shaft being located eccentrically of said semi-circular groove, and means for rocking said supporting members in said groove, said means comprising operating means impinging on said supporting means at opposite sides of a vertical plane passing through the axis of said shaft, and means for concurrently raising and depressing opposed pairs of said operating means, said last mentioned means comprising a motor and a connection between said motor and said operating means.

5. In combination in a mill and housings, upper and lower housing members extending therebetween, a pair of working rolls, backing means for said working rolls and contour controlling means for controlling the effective shape of said working rolls, said last mentioned means comprising interspaced rollers contacting said backing means, a shaft for supporting said rollers, interspaced supporting means for said shaft journaled in a semi-circular groove in said upper and lower housing members, said shaft being located eccentrically of said semi-circular groove, and means for rocking said supporting members in said groove, said means comprising operating means impinging on said supporting means at opposite sides of a vertical plane passing through the axis of said shaft, and means for concurrently raising and depressing opposed pairs of said operating means, said last mentioned means comprising a motor and a connection between said motor and said operating means, there being as many of said motors as there are supporting means in said structure and automatic means for controlling adjacent motors in connection with a variation of one of said operating means.

6. In combination with a mill having means for varying the contour of working rolls to conform to a predetermined profile by means effective thereon at intervals, controlling means comprising means representative of the effective contour of a roll, means for varying the effective contour thereof, and means for automatically transmitting said variation to said variable means on said mill.

7. A controlling device comprising a support, means representative of a mill roll resiliently mounted thereon, means for varying the contour of said representative means, and means controlled by the contour thereof for transmitting said variation to a device to be controlled, in order to obtain a predetermined roll contour.

8. In combination with a mill having working rolls and interspaced means throughout the length of said working rolls for varying the effective contour thereof, a controlling device comprising a support, means resiliently mounted on said support representative of one of said rolls, means for varying the contour thereof, and means for establishing a plurality of electrical circuits to transmit said variation selectively to said interspaced contour controlling elements in said mill.

9. In combination with a mill having working rolls and interspaced means throughout the length of said working rolls for varying the effective contour thereof, a controlling device comprising a support, means resiliently mounted on said support representative of one of said rolls, means for varying the contour thereof, and means for establishing a plurality of electrical circuits to transmit said variation selectively to said interspaced contour controlling elements in said mill, and connections between said mill and said controlling device effective for breaking said electrical circuits when said variations have been so transmitted.

10. In combination a mill having working rolls and means interspaced throughout the length thereof for varying the contour of said working roll, a controlling means comprising a support, means resiliently mounted on said support representative of one of said rolls, means for varying the contour of said representative means, means connected therewith for moving a series of electrical contact means, cooperating electrical contact means movably mounted with respect to said support for coaction with said first mentioned contact means, and a connection between said movable contact means and said interspaced contour controlling means on said mill.

11. In combination a mill having working rolls and means interspaced throughout the length thereof for varying the contour of said working roll, a controlling means comprising a support, means resiliently mounted on said support representative of one of said rolls, means for varying the contour of said representative means, means connected therewith for moving a series of electrical contact means, cooperating electrical contact means movably mounted with respect to said support for coaction with said first mentioned contact means, and a connection between said movable contact means and said interspaced contour controlling means on said mill, electrical means for moving said contour controlling elements on said mill and forward and reverse circuits for said electrical means connected, respectively, to said contact means.

12. In combination in a mill, a pair of working rolls, backing means for said working rolls comprising other rolls of equivalent length and supporting means for said backing rolls, said supporting means comprising interspaced rollers of less than equivalent length, means for varying the position relative to the mill housing of a plurality of said supporting means simultane-

ously to vary the effective screw down of said mill, and means for varying the position of certain of said supporting means simultaneously to vary the effective crown of said working roll, said screw down being operable both separately and simultaneously with the control for varying the effective crown of said rolls.

13. In combination in a mill having a frame, and beams forming part thereof, a pair of working rolls, and supporting means for said rolls, said supporting means comprising rollers of less length than said rolls, spaced along the length of said rolls and supported by said beams, means for varying the position relative to said beams of a plurality of said supporting means simultaneously to vary the effective screw-down of said mill, and means for varying the position relative to said beams of certain of said supporting means simultaneously to vary the effective crown of said working rolls.

14. In combination in a mill having a frame, and beams forming part thereof, a pair of working rolls, and supporting means for said rolls, said supporting means comprising rollers of less length than said rolls, spaced along the length of said rolls and supported by said beams, means for varying the position relative to said beams of a plurality of said supporting means simultaneously to vary the effective screw-down of said mill, and means for varying the position relative to said beams of certain of said supporting means simultaneously to vary the effective crown of said working rolls, said screw-down being operable both separately and simultaneously with the control for varying the effective crown of said rolls.

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