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AUTOMATIC SCREW-DOWN CONTROL

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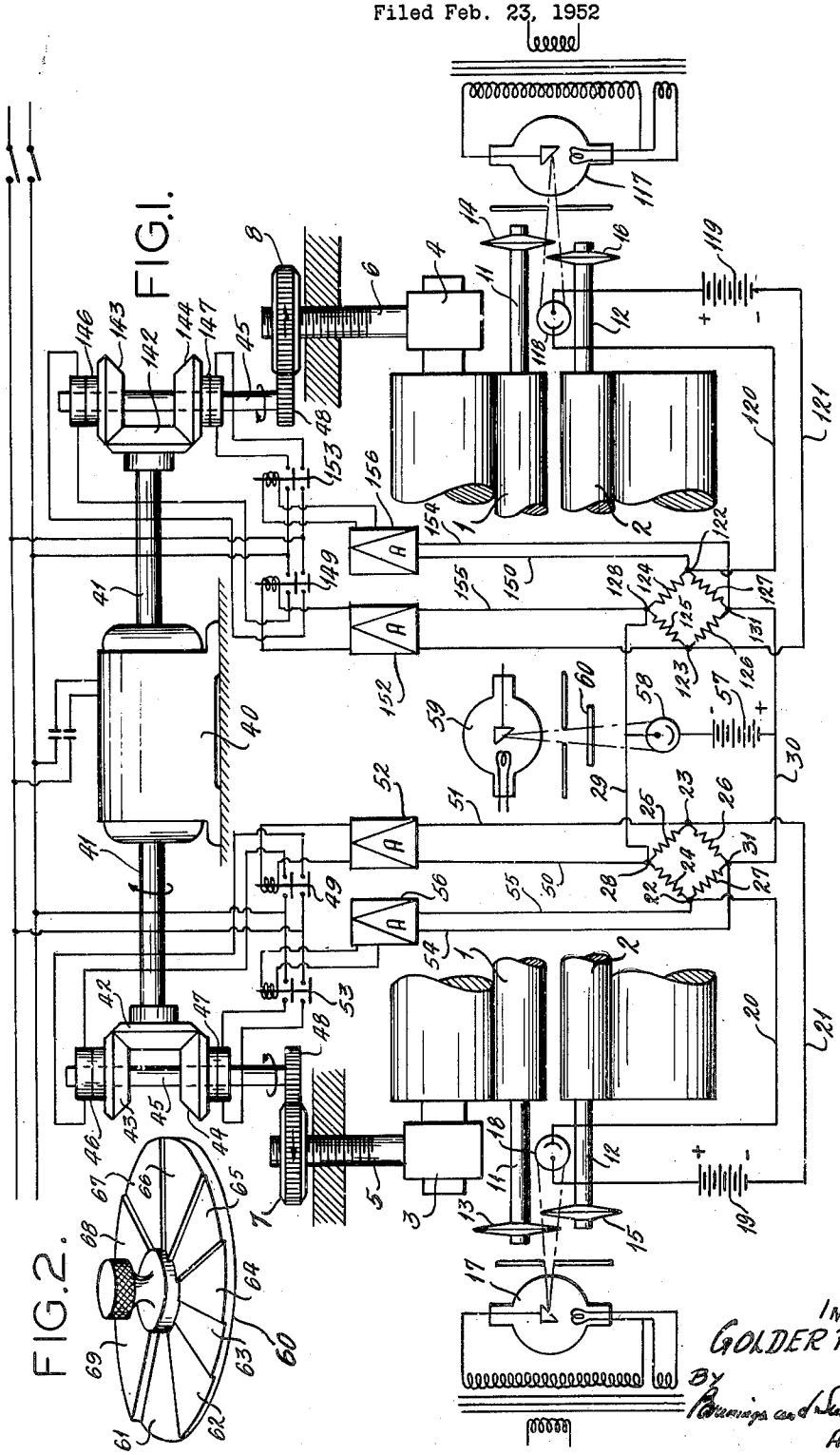


FIG. 1.

FIG. 2.

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AUTOMATIC SCREW-DOWN CONTROL

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1

This invention relates generally to automatic adjustment of the screwdown on a stand of rolls of the character utilized in strip mills, so as to control the gauge thickness of the strip being rolled.

In rolling mill stands of the character above referred to, some difficulties have heretofore been encountered in maintaining the upper and lower work rolls' level, so that the pinch between them is the same from end to end of those rolls. Gauges of the character heretofore proposed, which measure the thickness of the rolled strip, at is emerges from the roll necessarily involve a considerable waste of strip, because, by the time the off-standard strip makes its appearance at the gauge, a substantial increment of such off-standard strip has already passed through the rolls; and, furthermore, by the time the gauge has set into motion those contrivances necessary to readjust the work roll, a further substantial increment of strip will have passed through the rolls.

The object of the present invention, generally stated, is to provide an automatic screwdown system wherein the wastage aforesaid is substantially limited.

In accordance with the present invention, generally stated, the screwdown mechanism at each end of a stand of rolls is motivated by one or more continuous-moving sources of rotational movement, such as electric motors; and a clutching arrangement is provided for selectively connecting the screwdown shaft at either end of the stand of rolls with the appropriate prime mover, as and when it is desired to make adjustment at one or both ends of the stand of rolls. The invention further contemplates that the selective engagement of the several clutches, as aforesaid, be actuated by a gauge which is sensitive to variation in the inter-axial distance between the work rolls, as distinguished from being sensitive to the strip emerging from between the rolls.

While it has heretofore been proposed in the patent to Zeitlin, No. 2,332,289, to signal the level or out-of-level condition of the rolls by projecting light through the space between them, at opposite ends thereof, the arrangement therein proposed is impractical for many reasons. With the light projectors and photo-electric cells so arranged, the indication becomes inaccurate almost immediately when, as is usually the case, the region around the mill stand is foggy with oil mist, steam, or water. In practice oil is thrown helter-skelter during the rolling operation, and the deposit of a drop on either the projector or

2

the receptor has the same light intensity-reducing effect as if the rolls moved closed together.

A further object of the present invention is, therefore, to measure the displacement between the axes of the work rolls in a manner which avoids the aforesaid objections. The present invention accomplishes this by the provision on each end of each work roll shaft, of a disc whose axial thickness varies progressively from its center to its periphery. At least one of such discs has a diameter sufficiently in excess of the work roll diameter as to assure overlapping of the upper and lower discs (at each end) throughout on the operative range of pinch variation between the work rolls. The degree of overlap between the discs is used as the determinant for setting in motion the automatic controls for establishing or restoring the desired condition. Such overlap of the discs may be accurately gauged while they are in motion by making the discs of X-ray absorbent material, and projecting an X-ray beam through the region of overlap. The intensity of the X-rays emerging from the discs is an accurate measure of their overlap, because the X-rays are absorbed to a greater or lesser extent by the discs, depending upon whether the discs overlap merely adjacent their periphery (where they may be relatively thin), or nearer their centers (where the discs may be relatively thick). In the former event, there will be less absorption of X-rays than in the latter event; and, accordingly, by arranging a source of X-rays on one side and an X-ray sensitive device on the other side of the overlapped discs, the intensity of the X-rays reaching the sensitive device is inversely proportional to the thickness of the overlapped portions of the discs which the X-rays transversed. By the provision of one such set of overlapped discs at each end of the roll stand, and the provision there-adjacent of equivalent X-ray sources and X-ray sensitive devices, it becomes readily possible to provide a comparator circuit which, when out of balance, actuates a control device and initiates movement of one or the other screwdown shafts in a direction such as to establish uniformity of interaxial spacing at opposite ends of the work rolls. Instead of X-rays, beta rays, or any other equivalent, may be used, it being understood that in any event the discs must be made of material which absorbs some of the wave energy.

It is also possible, and the invention contemplates, that the comparator circuit aforesaid be further controlled by interconnection with a source of electromotive force whose potential is

determined by a standard gauge, thus controlling the degree of pinch between the rolls and assuring that in operating to restore a leveled condition the screwdown shafts operate in the proper direction. Such a standard gauge may also be, and preferably is, of the character involving a source of X-rays and an X-ray sensitive device, arranged so that there may be interposed between them a standard gauge plate of X-ray absorbent material, whose thickness is so coordinated with the characteristics of the discs at the opposite ends of the working rolls, that the pinch between the rolls is controlled by the thickness of the specimen used as a standard gauge.

Other objects and advantages of the invention will become apparent to those skilled in the art when the following description is read in connection with the accompanying drawings, in which:

Figure 1 is a schematic view of a rolling mill stand equipped with the gauges and control devices of the present invention.

Figure 2 is a perspective view of a suitable standard gauge for use in connection with the present invention and providing a plurality of pinch adjustments for the work rolls.

In the accompanying drawings a single, continuously rotating unidirectional electric motor is utilized as the prime mover for the screwdown mechanism of a rolling mill stand, but it will be understood that a plurality of motors, preferably continuously operating, such as one motor to drive the screwdown shafts in one direction and the other motor to drive them in the opposite direction, may be utilized in lieu of the motor and clutching arrangement hereinafter to be described in detail.

The invention is illustrated in connection with a four-high stand of rolls, including upper work roll 1 and lower work roll 2. The respective rolls are mounted in the conventional bearings and are movable vertically in a suitable frame, not shown, all in accordance with the usual practice. Likewise, in accordance with the usual practice, the bearings 3 and 4 at opposite ends of the topmost roll of the stands are interconnected with the usual screwdown shafts 5 and 6. The screwdown shafts 5 and 6, respectively, make threaded engagement with gears 7 and 8, so that upon rotation of said gears in one direction the bearings 3 are pressed downwardly, but upon rotation of the gears 7 and 8 in the opposite direction, the bearings 3 are drawn upwardly. The aforesaid parts 1 to 8, inclusive, constitute per se no part of the present invention, as they represent the conventional construction of one type of rolling mill stand and are described merely to illustrate the operation of the present invention in association with them.

The present invention contemplates that the upper work roll be provided with a shaft 11 extending outwardly beyond the usual frame at each end thereof. Likewise, the lower work roll 2 is provided with a shaft 12 extending outwardly beyond the frame at each end thereof. On the outwardly extending portion of shaft 11, a pair of discs 13 and 14 are secured, and, likewise, on the outwardly extending portion of shaft 12 a pair of discs 15 and 16 are secured. In the embodiment shown, the discs 13, 14, 15 and 16 are tapered so that their axial thickness is greater near their centers than at their edges, but the reverse taper can be utilized. These discs are made of X-ray absorbent material, such as iron, or brass and are mounted concentrically upon the respective shafts, so that one disc is adjacent the other, but sufficiently disaligned therewith that as the pinch between work rolls 1 and 2 increases and decreases, the discs remain in overlapped relationship but do not wear against each other.

Arranged, so as to project X-rays through the overlapped region of the discs 13 and 15, is an X-ray tube 17. Arranged, so as to receive the X-rays which emanate from tube 17 and traverse the overlapped portion of discs 13 and 15, is an X-ray sensitive device such as a photocell 18. The arrangement is such that when the work rolls 1 and 2 are close together, a greater thickness of both discs 13 and 15 must be traversed by the X-rays emanating from tube 17, while, when the work rolls 1 and 2 are far apart, a lesser thickness of the discs is traversed by such X-rays before they reach the X-ray sensitive device 18. The X-ray sensitive device 18 is preferably disposed fairly close to the discs 13 and 15, but, of course, is fixedly mounted, as on the frame of the roll stand or an auxiliary frame not shown. The X-ray sensitive device 18 is essentially of a character capable of generating an electromotive force whose potential varies according to the intensity of the X-rays impinging upon it. The output potential of the X-ray sensitive device 18 is delivered into a circuit which includes a source of fixed potential, illustrated as a battery 19. The circuit includes conductors 20 and 21 and extends to opposite terminals 22 and 23 of a comparator circuit consisting of balanced resistances 24, 25, 26, and 27.

Associated with the discs 14 and 16 at the opposite ends of work rolls 1 and 2, an identical arrangement of X-ray source, X-ray sensitive device, source of fixed potential and comparator circuit is provided, the components of which are designated by reference characters in the one hundred series but whose last two digits correspond to the parts above described, it being important in this respect that the physical characteristics of the components at the opposite ends of the work rolls be identical.

In order to maintain the same separation between the work rolls 1 and 2 at each end thereof, the respective comparators are interconnected at their mid-points. That is to say, that from a terminal 28, between resistors 24 and 25, a conductor 29 extends to a terminal 128 between resistors 124 and 125. Similarly, a conductor 30 extends from a terminal 31 between resistors 26 and 27 to a terminal 131 between resistors 126 and 127. With such an arrangement, when the overlap between discs 13 and 15 is the same as the overlap between discs 14 and 16, the potential at corresponding points in the two comparators at terminal circuits is the same, and no current will flow through conductors 29 and 30. If, however, due to creepage in the machine parts, or for other reasons, the overlap between discs 13 and 15 becomes less than the overlap between discs 14 and 16, the output potential of X-ray sensitive device 18 becomes greater than the output potential of X-ray sensitive device 118, and a potential difference occurs between the corresponding terminals of the two comparators. This potential difference at the terminals of the comparators may be utilized after appropriate amplification to actuate the instrumentalities, which move screwdown shaft 5 in a direction such as to balance the overlap between discs 13 and 15 with the overlap between discs 14 and 16.

The instrumentalities for moving the screwdown shafts consist, in the embodiment shown, of

an electric motor 40 which is preferably continuously rotating in one direction, such as that shown by the arrow. The motor 40 has a shaft 41, on one end of which a bevel gear 42 is secured, and on the other end of which a bevel gear 142 is likewise secured. The bevel gear 42 is permanently engaged, in the embodiment shown, with cooperating upper bevel gear 43 and with lower bevel gear 44. The bevel gears 43 and 44 are normally free-running on a shaft 45, so that one may turn in one direction and the other in the other on said shaft. A magnetic clutch 46 is provided, which, when energized, engages bevel 43 so as to turn with shaft 45. Similarly, a magnetic clutch 47 is provided so that when energized, it causes bevel gear 44 to turn with shaft 45. When clutch 46 is energized, shaft 45 is driven by motor 40 in the direction of the arrow shown on said shaft 45, and through pinion 48 rotates gear 7 in the direction of the arrow shown thereon to move screwdown shaft 5. Similarly, when clutch 47 is energized, the shaft 45 and its adjunct parts are moved in the opposite direction.

Corresponding parts 143 to 148, inclusive, are provided for cooperation with bevel gear 142.

The selective energization of the respective clutches 46, 47, 146, and 147 depends upon the existence of a difference in potential between the various terminals of the comparators above described; clutch 46 being energized when the potential different between terminals 23 and 28 is above a datum value; and clutch 47 being energized when the potential difference between terminals 22 and 31 is below a datum value; and, likewise, with the corresponding parts having the identical last two digits but in the one hundred series. To accomplish this, the supply of energy to clutch 46 is controlled by a magnetic switch 49. The magnetic switch 49 is normally, i. e., when the comparators are balanced, in open circuit position, but is moved to its closed circuit position when the coil thereof is energized. Energization of the coil of magnetic switch 49 occurs pursuant to the existence of an abnormal potential difference between terminals 23 and 28. From said terminals conductors 50 and 51, respectively, extend to an amplifier or electronic generator 52. The device 52 may be of any well-known type capable of producing an output potential sufficient to actuate switch 49 pursuant to the impression of a very small potential difference upon conductors 50 and 51.

Similarly, energization of clutch 47 is controlled by a magnetic switch 53 which is normally in open circuit position, but which is moved to closed circuit position upon the existence of an abnormal potential difference between terminals 22 and 31 in the manner above described in connection with switch 49, and through a circuit consisting of conductors 54 and 55 and an amplifier 56 corresponding to amplifier 52. As previously, the corresponding parts, whose reference numerals are in the one hundred series, are identical with the parts described, and in the same way control clutches 146 and 147.

When it is desired to control the pinch of the work rolls from a standard specimen, a circuit including a battery 57 and a photo-sensitive cell 58 is provided between conductors 29 and 30. The photo-sensitive cell 58 is arranged to be impinged by X-rays emanating from an X-ray tube 59 through a standard gauge 60. The standard gauge 60 may, if desired, be of the character shown in Figure 2, wherein a plurality of sectors 61 to 69 inclusive are of progressively increasing

thickness with a sharp break at the bounding edges of the respective sectors. It will be understood, of course, that in lieu of such a sectored standard gauge, individual specimens of different thickness may be employed for selective disposition between X-ray tube 59 and cell 58. In this connection, it is to be observed that the thicker the standard gauge specimen 60 the closer work rolls 1 and 2 will be moved together, as the increasing thickness of standard gauge specimen 60 corresponds to increasing the degree of overlap between discs 13 and 15 and electrical balance is maintained in the comparator circuits (when the elements 57, 58, and 59 are identical in characteristics with the elements 19, 18, and 17, respectively) when the thickness of the standard specimen 60 corresponds to the thickness of discs 13 and 15, which are traversed by the X-rays. Consequently, when the rolling mill stand is operating in balanced condition sector 61, disposed between X-ray tube 59 and cell 58 and it is desired to decrease the space between work rolls 12 and 2, the standard gauge may be moved so as to interpose one of the thicker sectors, such as 68, between X-ray tube 59 and the cell 58. When such a change in the standard gauge occurs, the output potential of cell 58 decreases and a potential difference immediately occurs between terminals 28 and 31.

In the embodiment shown in the drawings, the arrangement is such that the battery 57, together with the X-ray sensitive device 58, normally maintains the potential at terminals 28 and 128, the same as at terminals 23 and 123 when the system is in balance. Likewise, the potential at 31 and 131 is maintained the same as the potential at terminals at 22 and 122, when the system is in balance. When, however, some variation from the balanced condition occurs, balance is automatically restored by operation of the screwdown devices appropriately. For example, if work rolls 1 and 2 creep apart at the left end, the creepage will be reflected by an increase in the output potential of the photo-sensitive device 18, with the result that the potential at terminal 22 will become higher than the potential at 31. The amplifier 56 is sensitive only to currents flowing from terminal 22 to terminal 31, and, consequently, when some current flows in that direction, the magnitude thereof is amplified to an extent sufficient to actuate magnetic switch 53, in turn engaging magnetic clutch 47, and operating screwdown shaft 5 in the direction which moves the work roll 1 downwardly to restore the balanced condition.

If, on the other hand, the work rolls 1 and 2 move closer together at their left ends than at their right ends, and closer than is indicated by the particular test specimen 60, the potential output of photo-sensitive device 18 is less than normal, and, consequently, a potential difference is established between terminal 23 and terminal 28, tending to cause current to flow from the former toward the latter. The amplifier 52 is sensitive only to currents flowing from conductor 51 to conductor 50, and, when, as aforesaid, currents flow in that direction, the amplifier 52 amplifies them to an extent sufficient to actuate magnetic switch 59, closing the circuit to magnetic switch 56, and moving screwdown shaft upwardly in the direction indicated by the arrows until balance is restored.

While the operation of the device has been described, with reference to the left end of the work rolls 1 and 2, it will be apparent that when

the right end of those rolls departs from the selected spacing, the same sequence of operations occurs with the parts whose reference characters are designated by numerals in the one hundred series.

With the opposite ends of the system already in balance, any increase in the potential output of the circuit embracing battery 57 and photo-sensitive device 58, as by the replacement of test specimen 60 with a thinner one, will result in an effective lowering of the potential of terminals 28 and 128 relative to terminals 23 and 123, and will effect a closing of switches 49 and 149 to elevate work roll 1. On the contrary, a decrease in the potential output of photo-sensitive device 58 will, in effect, lower the potential of terminals 31 and 131 relative to terminals 22 and 122, and cause a current to flow from the latter toward the former through amplifiers 56 and 156, thus effecting closure of switches 53 and 153 and lowering both ends of the work roll 1.

From the foregoing description, those skilled in the art should readily understand that the invention accomplishes its objects and not only provides means for maintaining the rolls horizontal, but also a gauge for measuring the thickness of the rolled metal, as well as a means for rolling a perfect flat strip. In addition it enables the practical use of X-rays for gauging in the rolling of relatively thick strips, because the X-rays do not have to penetrate the thickness of the same metal being rolled. The latter is facilitated by making the discs 13, 14, 15, and 16, as well as the gauge 60, of lower atomic weight material (such as aluminum or magnesium) than the metal being rolled (such as copper, brass, or iron). While it has heretofore been considered impractical to use X-ray gauges in the rolling of strips of copper and brass at thicknesses in excess of 0.150" because an X-ray source capable of penetrating such thickness is prohibitively expensive, the X-ray gauge of this invention will at even lesser capacity control the rolling of thicker strips.

While one complete embodiment of the invention has been disclosed in detail, such disclosure is to be considered as merely illustrative, and not limitative upon the scope of the invention. Obviously, various modifications, variations, and adaptations thereof will present themselves to those skilled in the art without departing from the spirit of this invention, and it is, therefore, to be distinctly understood that the invention is not limited to the details of the foregoing disclosure, save as indicated in the appended claims.

Having thus described the invention, what is claimed and desired to be secured by Letters Patent is:

1. In combination with a rolling mill stand having a pair of work rolls and screwdown mechanism at each end of said stand for varying the pinch between said work rolls, said work rolls having on each end thereof a concentrically-mounted disc of X-ray absorbent material, said discs having a diameter such as to overlap each other throughout the range of normal pinch variation of said rolls, and at least one of said discs having a cross section tapering through the radius of overlap, an X-ray source arranged to direct its rays through the radius of overlap of said discs, a radiant energy-sensitive device disposed in line with said X-ray source but on the opposite side of said discs from said X-ray source, and means responsive to said sensitive device to actuate said screwdown mechanism.

2. The apparatus of claim 1 wherein both ends of said work rolls are provided with discs, X-ray sources, and radiant energy-sensitive devices, and means responsive to a differential in radiant energy reaching said devices, to actuate said screwdown mechanism in a direction tending to eliminate said differential.

3. In combination with a rolling mill stand having a pair of work rolls and screwdown mechanism at each end of said stand for varying the pinch between said work rolls, a continuously rotating motor for driving said screwdown mechanism, a plurality of electro-responsive clutches at each end of the stand between said motor and said screwdown mechanism, and means responsive to a differential in the pinch at opposite ends of said rolls to energize selected ones of said clutches to move said rolls relatively and eliminate said differential.

4. The apparatus of claim 3 wherein the means responsive to pinch comprises a source of radiant energy, a radiant energy-sensitive device, and a screen mounted for rotation coaxially with one of said rolls, said screen being partially opaque to the radiant energy emitted by said source, and said screen having its opacity quotient progressively varying along a radius thereof.

5. In combination with a rolling mill stand having a pair of work rolls and screwdown mechanism at each end of said stand for varying the pinch between said work rolls, said work rolls having on each end thereof a concentrically-mounted disc of X-ray absorbent material, said discs having a diameter such as to overlap each other throughout the range of normal pinch variation of said rolls, and at least one of said discs having a cross section tapering through the radius of overlap, a pair of X-ray sources each arranged to direct its rays through the overlapped radius of the discs at one end of said rolls, a pair of X-ray intensity measuring devices each mounted in line with one of said X-ray sources and on the opposite side of said radially overlapped discs therefrom, said measuring devices indicating by their output voltage the extent of overlap at said discs associated therewith, and means responsive as the output voltage of one measuring device exceeds that of the other measuring device to increase the relative radial overlap of said discs associated with said one measuring device, an auxiliary source of X-rays, an auxiliary intensity measuring device, an X-ray absorbent gauge standard between said auxiliary source and measuring device, and a means responsive as the output voltage of said auxiliary measuring device exceeds that of the other measuring devices to decrease the radial overlap of said discs.

6. Apparatus for selectively operating screwdown mechanism on a rolling mill stand from a continuously rotating shaft comprising, clutches interconnecting said shaft with screwdown mechanism at each end of the stand, said clutches being electro-responsive, a roll gauge producing an output voltage proportional to the magnitude of the roll pinch, a thickness gauge producing an output voltage proportional to the roll pinch desired, and means for electrically energizing said clutches to screw the rolls together when the output voltage of said thickness gauge is less than the output voltage of the roll gauge.

7. The combination of claim 6 wherein the shaft rotates in one direction only, there are two

clutches between said shaft and each screwdown mechanism, one of said clutches when energized increasing and the other decreasing the pinch between said rolls.

8. The combination with the work rolls of a rolling mill stand of X-ray absorbent discs, one mounted concentrically with each work roll, and radially overlapping each other, the radially overlapping portion of at least one disc being of gradually diminishing axial thickness.

9. In combination with a rolling mill stand having a pair of work rolls and means providing first and second variable voltages responsive to the spacing between the work rolls at the ends thereof; a pair of selectively-energizable control devices for moving an end of one of said work rolls toward and away from the other work roll, a second pair of selectively-energizable control devices for moving the other end of said one work roll toward and away from the other work roll, adjustable means providing a relatively constant

reference voltage, a first control circuit for comparing the first variable voltage against the reference voltage, and a second control circuit for comparing the second variable voltage against the reference voltage, said first control circuit being connected to alternatively energize said first pair of control devices when the first variable voltage increases and decreases relative to the reference voltage, said second control circuit being connected to alternatively energize and de-energize said second pair of control devices when the second variable voltage increases and decreases relative to the reference voltage.

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