July 6, 1937. L. IVERSEN 2,085,981

METHOD AND APPARATUS FOR SHEARING METAL STRIP

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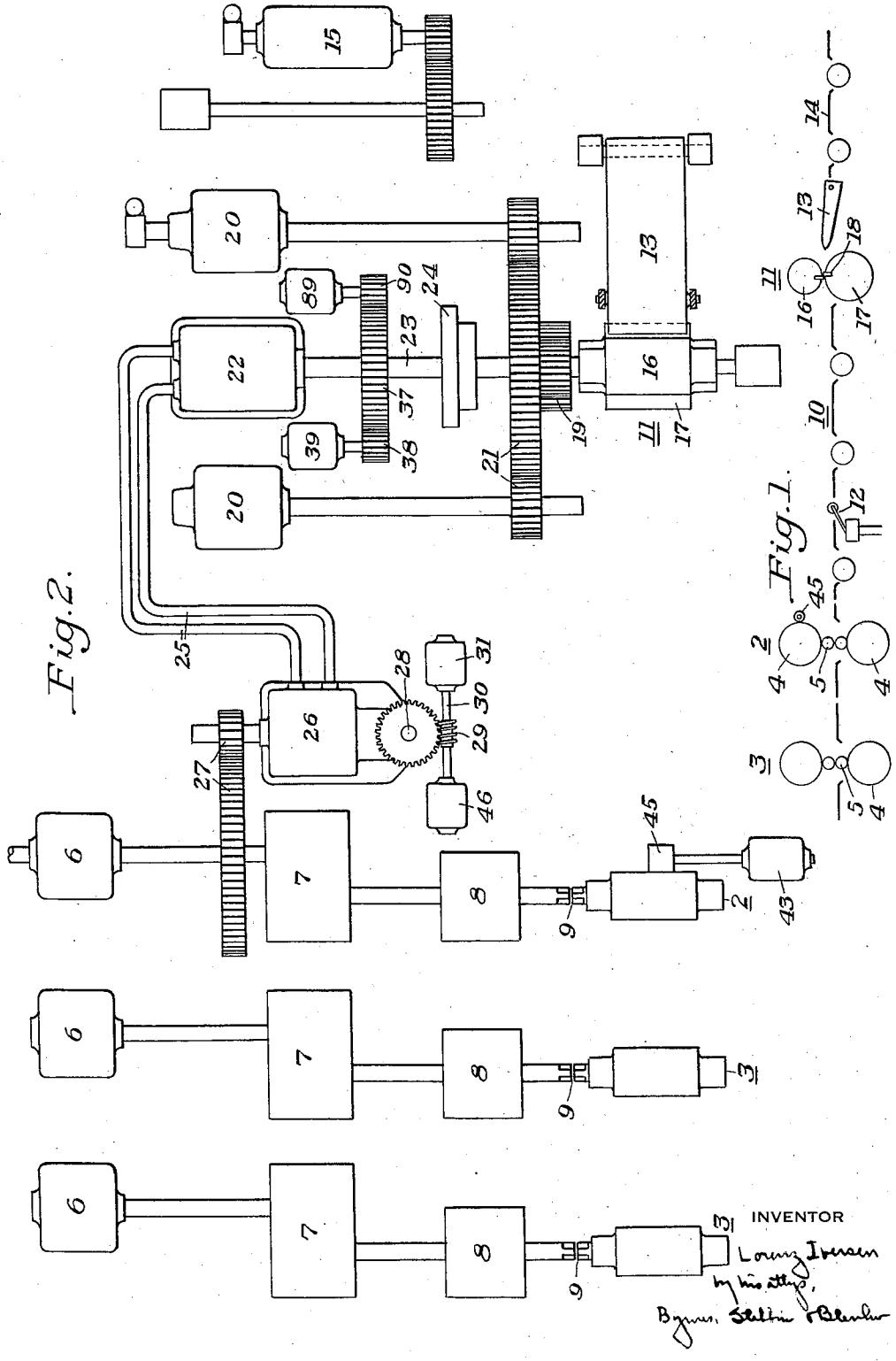



Fig. 2.

Fig. 1.

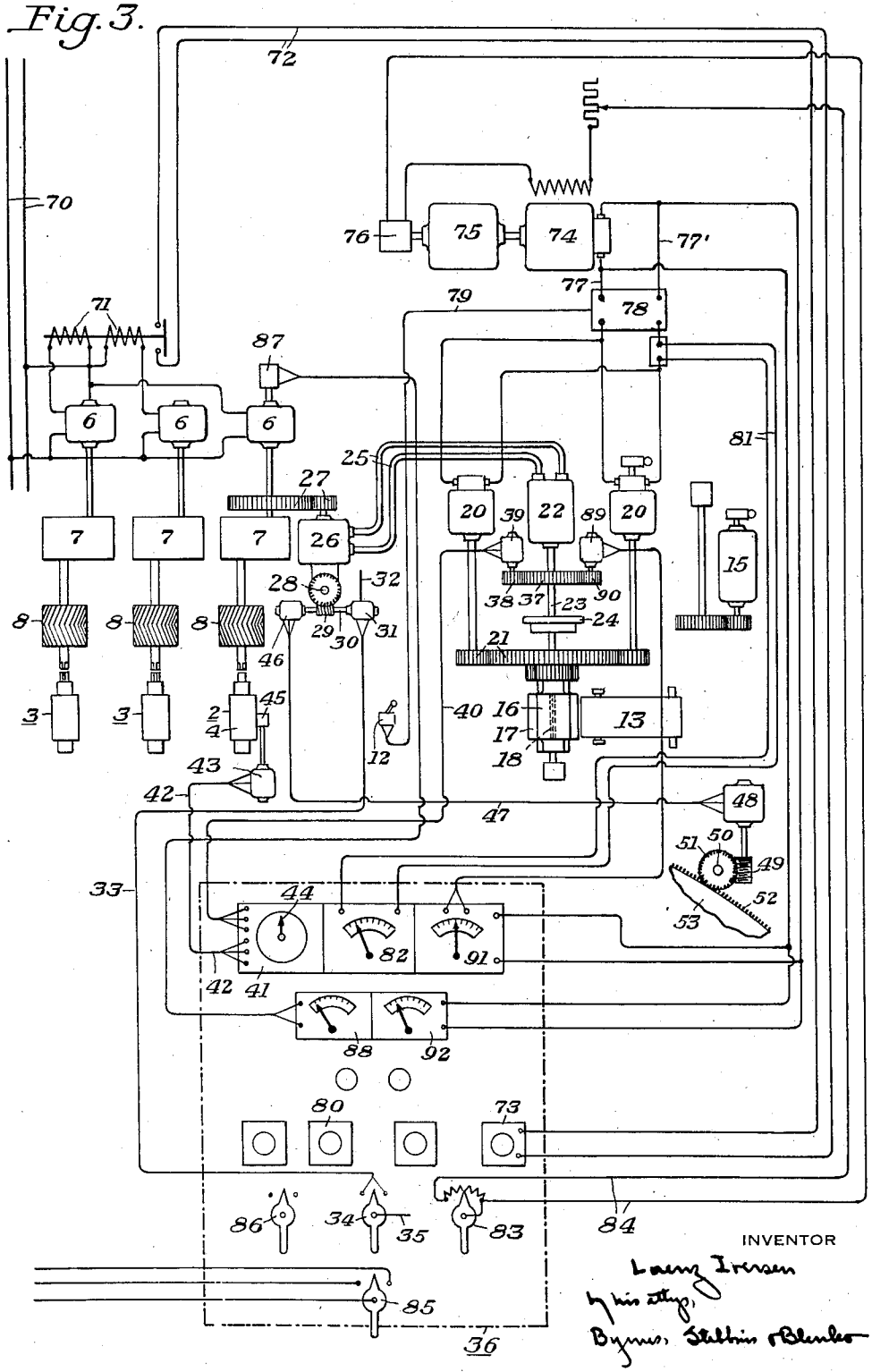
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METHOD AND APPARATUS FOR SHEARING METAL STRIP

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Fig. 3.




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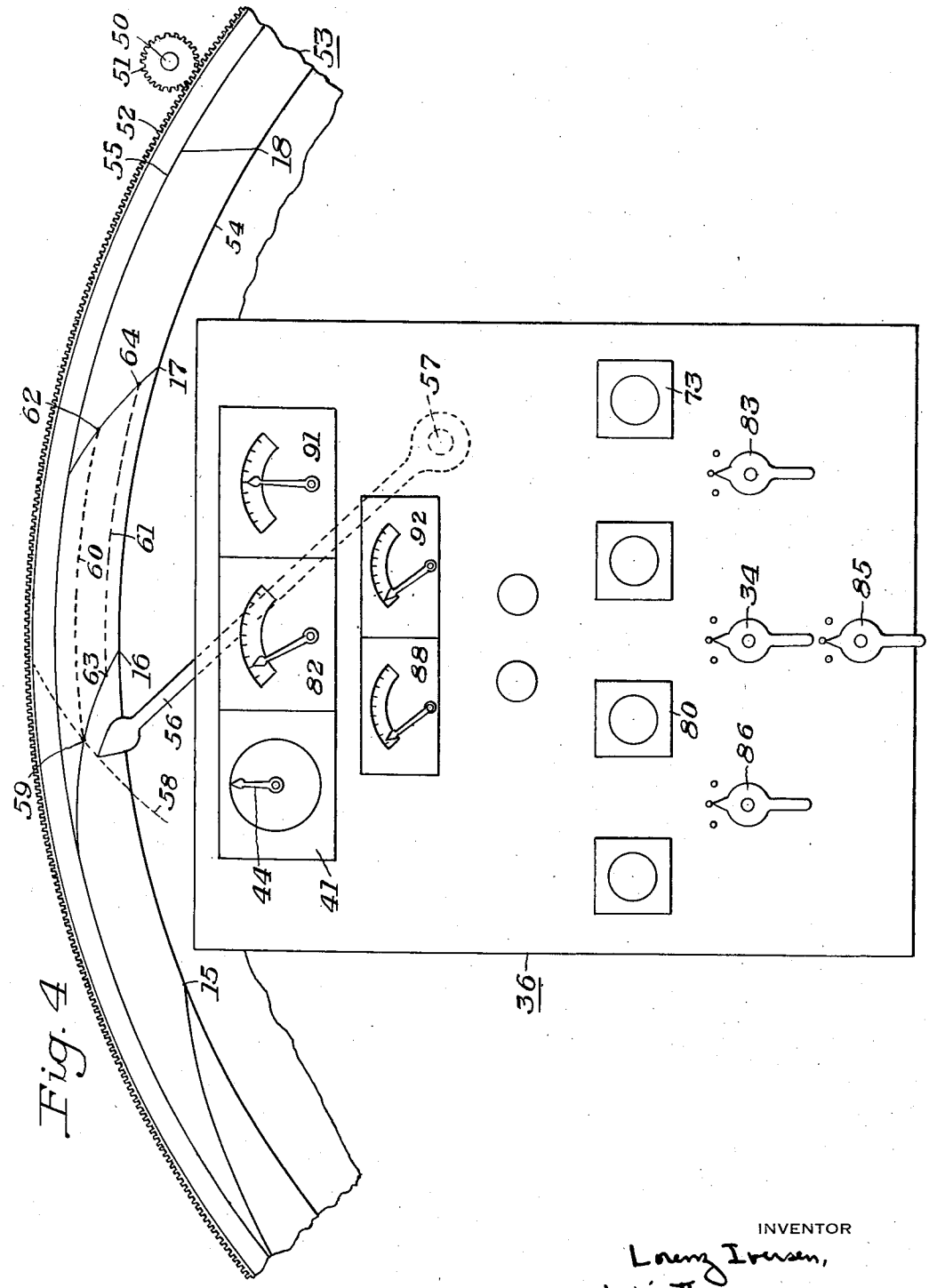



Fig. 4

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# UNITED STATES PATENT OFFICE

2,085,981

## METHOD AND APPARATUS FOR SHEARING METAL STRIP

Lorenz Iversen, Pittsburgh, Pa., assignor to Mesta Machine Company, Pittsburgh, Pa., a corporation of Pennsylvania

Application April 4, 1935, Serial No. 14,611

21 Claims. (Cl. 164—68)

This invention relates to a method and apparatus for shearing metal strip and is herein particularly described as applied to a structure embodying a continuous mill for the rolling of wide strip, and a rotary shear for cutting the same into lengths as it is delivered from the continuous mill.

I have heretofore developed shears of the rotary type which function very satisfactorily for such purpose. They are shown, for example, in my prior Patents 1,876,456 and 1,890,221. I have also developed heretofore a control system for shears of this type in which the shear is interconnected with the roll stand from which strip is delivered to the shear so that their rotative speeds bear a fixed relation to one another. Provision is made for adjusting this relation so as to correspondingly adjust the length of the cut. Such a combination is more fully described and claimed in my copending application Serial No. 628,878, filed August 16, 1932. Briefly stated, it comprises in its preferred embodiment a fluid pump and a hydraulically connected fluid motor, these units being connected one to the feed rolls and one to the shear. The pump and motor are of the well-known Waterbury type and by a simple adjustment the output of the pump may be varied over wide limits. This effects a corresponding variation in the speed of the motor, thus changing the speed relationship between the rolls and the shear and correspondingly changing the length of the pieces cut by the shear. Further refinements of this general combination are hereinafter described.

A practical difficulty arises in the commercial use of the structure above described due to the fact that different lengths must be cut requiring an adjustment of the apparatus, and further due to the fact that fairly frequent replacements of the work rolls in the last stand of the continuous mill are required. These rolls act to feed the strip to the rotary shear, and even a minute difference of diameter between the rolls of one pair and the rolls which they replace has a very marked effect on the cut length of the product. The rolls must be changed with reasonable frequency because their surface deteriorates in use and adversely affects the surface qualities of the product. It is customary to keep several sets of rolls on hand near the mill so that a rapid substitution can be made. After the rolls have been thus withdrawn from service they are re-ground and thus again made ready for use in the mill, but such regrinding necessarily reduces their diameter. It follows that the successive pairs of rolls employed in the finishing stand may vary considerably from one another in diameter, and this affects the accuracy of the shear unless due compensation is made.

With the apparatus heretofore available it has been impossible to compensate rapidly and accurately so as to take into account the factors just described. In consequence, the adjustments have resulted in a loss of mill time and in certain cases inaccurate cutting to length of some of the product. The difficulties are enhanced by the fact that the delivered strip is at high temperature and provision must be made for its shrinkage. In addition, the strip is delivered with such rapidity that cut and try methods of determining the length necessarily waste a great deal of strip as well as delay the mill operation.

The present invention provides a method and apparatus whereby all of these difficulties are obviated and the length of the cut pieces is accurately determined, taking into account the variable introduced by roll changes.

I provide indicating means which take into account the factor of feed roll diameter and give the operator a direct reading index whereby he can accurately adjust the speed relation between the feed rolls and the shear so as to cut any desired length. It is important to note that a change in the diameter of the feed roll requires a change in the amount of adjustment for effecting any stated change in the length of the cut strip. To illustrate, if the feed roll be 16.0 inches in diameter, the amount of adjustment of the Waterbury gear necessary to increase the cut length by two feet differs from the amount of adjustment required if the feed roll is say 16.1 inches in diameter. In consequence, there must be provided a series of scales comprehending all roll diameters within the desired range and all cut lengths within a desired range for each such roll diameter. This indicating apparatus is preferably located in the control pulpit of the mill and a control apparatus for adjusting the Waterbury gear is also located in the pulpit so that the entire mill operation is thus centralized. This materially simplifies and speeds up the operation of the mill as a whole. As above stated, even a minute change in the diameter of a feed roll has a marked effect on the cut length of the strip, and in order to eliminate the necessity for calipering the rolls and to insure against errors on this account, I preferably employ in conjunction with the above described apparatus means for measuring the peripheral speed of the feed rolls without regard to their angular velocity.

This enables me to effect a base adjustment of the shear directly in accordance with the linear speed of the strip and thus establish a rotative speed relationship between the feed rolls and the shear, which compensates for and takes into account the diameter of the feed rolls. I thereafter effect such adjustment of the shear as may be necessary to meet the mill requirements for pieces of different length.

In the accompanying drawings which illustrate the present preferred embodiment of the invention,

Figure 1 is a diagram showing the last stands of a continuous mill and a rotary shear in conjunction therewith;

Figure 2 is a top plan view of the apparatus shown in Figure 1 with certain details of the shear and the drive also illustrated;

Figure 3 is an electrical diagram showing the interconnection between the several parts; and

Figure 4 is a view showing the control panel and a portion of the length indicating dial.

The mill illustrated in Figures 1 to 3 is of the continuous type consisting of a series of stands all in alignment and adapted to act successively on a slab or ingot to reduce it to a long continuous strip. In the drawings only the last stands of the mill are shown, these being of the now well known 4-high type. The finishing stand is indicated at 2 and preceding stands are shown at 3. The stands have backing rolls 4 and working rolls 5 of smaller diameter. The backing rolls require replacement only at relatively infrequent intervals, but the working rolls 5 must be changed quite often in order to maintain the proper surface on the delivered strip. The surfaces of the working rolls deteriorate fairly rapidly under the severe conditions to which they are subjected, and it is common practice to keep a number of pairs of working rolls on hand so that a replacement can be made quickly and without undue loss of mill time. Roll changes are particularly frequent in the finishing stand 2 because of the fact that the wear is the greatest at this stand.

The working rolls are driven from motors 6 through speed reducers 7, pinion stands 8, and wobbler connections 9 as is well known. It will be seen that for any given speed of one of the motors 6, the working rolls 5 will have a definite angular velocity and hence the peripheral speed of the roll will depend on its diameter. The delivery speed of the strip is substantially the same as the peripheral speed of the rolls 5 in the finishing stand 2, and it follows that the delivery speed will likewise be dependent on the diameter of the rolls 5.

As material issues from the stand 2 it passes over a roll table 10 to a rotary shear 11. A flag switch 12 is arranged in the table 10, this flag switch controlling the initial starting up of the shear. The front end of the strip is cropped and is diverted downwardly by a switch member 13, which switch member is then lowered so as to constitute the forward end of a delivery table 14 by which the strip is carried away from the shear. The switching member 13 is set by a motor 15 through connections not shown. This apparatus constitutes no part of the present invention, although advantageously used in connection therewith. It is more fully described and claimed in my copending application Serial No. 754,607, filed November 24, 1934.

The shear 11 comprises rotors 16 and 17 having cutting blades 18 thereon. The rotors are geared together at 19 and are driven by motors 20 through gearing 21 whose control is hereinafter described in greater detail. The maximum speed at which the motors 20 may drive the shear rotors is limited by a hydraulic motor 22 whose shaft 23 is connected to the shear through an over-running clutch 24. This mechanism permits the motors 20 to drive the shear at any speed less than the maximum determined by the hydraulic motor 22, the cooperating members of the clutch 24 simply over-running during this operation. However, when the shear is cutting to length the motors 20 will be supplied with sufficient energy to cause them to run the shear just as fast as the hydraulic motor 22 will permit. This over-running clutch mechanism is more fully described and claimed in my said application Serial No. 754,607.

The hydraulic motor 22 is connected by fluid conductors 25 to a hydraulic pump 26 which is connected through gearing 27 to the drive shaft of the finishing stand 2. The pump 26 and motor 22 are of the well-known Waterbury type and run always in a definite speed relationship to one another. This relationship may be varied by rotating a control shaft 28. The mechanism so far described permits of maintaining an adjusted relationship between the angular velocity of the working rolls 5 in the finishing stand 2 and the rotors of the shear 11. In order to obtain the desired results contemplated by this invention, it is necessary to first make a base adjustment of the fluid pump 26 so as to establish a definite relationship between the linear speed of the delivered strip and the rotative speed of the shear 11. In view of what has been said above as to the effect of roll diameter on strip speed, it is necessary to correlate the rotative speed of the shear with the peripheral speed of the rolls 5 regardless of their angular velocity. This is done by mechanism which will now be described.

The shaft 28 is connected through worm gearing 29 to a drive shaft 30 which is actuated by a reversible motor 31. The motor 31 draws current from a line wire 32 and is connected through a multiple wire control cable 33 to a manual switch 34 and thence to a line wire 35. The manual switch 34 is mounted on a control panel 36 in the operator's pulpit, and the motor 31 may be driven to rotate the shaft 30 and turn the shaft 28 in one direction or the other, at the will of the operator. The switch also has an intermediate position at which the motor 31 stands still. This is its normal condition when the mill is in operation, the motor 31 being actuated when a shear adjustment is to be made. Any adjustment of the shaft 28 affects the rate at which the fluid pump 26 circulates fluid through the hydraulic motor 22 and hence changes the rotative speed of the shaft 23. The shaft carries a gear 37 which meshes with a pinion 38 on the shaft of a generator 39. The generator 39 is connected through a multiple wire cable 40 to a speed matching tachometer 41. The speed matching tachometer is also connected through a cable 42 to a generator 43. The tachometer is of well known type, and is provided with an indicating pointer 44 which stands still if the generators 39 and 43 are running at the same speed, or moves in one direction if the generator 43 is rotating at higher speed than the generator 39, and moves in the other direction if the generator 43 is rotating at a lower speed than the generator 39. This mechanism provides a means whereby the rotative speed of

the shear can be compared with the linear speed of the strip. To this end the generator **43** is provided with a friction pulley **45** and is so mounted that the pulley bears against the upper backing roll **4** of the finishing stand **2**. The backing roll **4** is rotated by frictional engagement with its working roll **5** and hence has the same peripheral speed. It follows that the peripheral speed of the friction pulley **45** is the same as the linear speed of the strip, and by suitably designing the apparatus so that the friction pulley **45** is of the proper size and the gears **37** and **38** are of the proper ratio, the apparatus will, when so adjusted that the pointer **44** stands still, be in condition to cut a strip of convenient length. It is important to note that the speed matching obtained by the apparatus before described is between the rotative speed of the shear and the linear speed of the strip. If successive pairs of work rolls of identical diameter were employed in the mill, an initial adjustment of this sort would suffice; but in practice the various sets of working rolls employed, if not initially differing one pair from another in diameters, will inevitably attain different diameters after a few grindings. As a matter of fact, the difference of only a few thousandths of an inch in the diameter of the working rolls will materially affect the length of the pieces which are cut by the shear **11**, so that for practical purposes an adjustment of this sort is of the highest importance.

The base adjustment is thus a very simple thing, it merely being necessary for the operator to manipulate the control switch **34** until the pointer **44** stands still. Thereafter this particular adjustment need not be again called into play until a roll change or unless it is desired to check the adjustment during the run of a pair of rolls in the mill. The apparatus may, as stated, be designed so that the base adjustment provides a convenient cut length, say, for example, 16 feet. This adjustment having been made, the apparatus will thereafter cut to 16 foot lengths until and unless some change in the setting of the shaft **28** in the hydraulic pump **26** is effected. In order to meet the demands of the trade, it is necessary that the shear be easily adjustable to cut accurately to length over a wide range. The amount of adjustment of the shaft **28** required to effect a given change, say 2 feet in the length of cut, is dependent upon the diameter of the working rolls **5**, and hence a different scale in length adjustments must be used every time the working rolls **5** are changed. The present invention provides a convenient way of taking into account the various factors involved and giving a direct reading to the operator of the shear setting in terms of the length to be cut. The mechanism for doing this is shown diagrammatically in Figure 3 and in greater detail in Figure 4.

Referring first to Figure 3, it will be seen that the shaft **30** is connected to a Selsyn unit **46** connected through a multiple wire cable **47** to a corresponding Selsyn unit **48**. As is well known, the Selsyn units **46** and **48** rotate together and always at the same speed. The Selsyn unit **48** is connected through worm gearing **49** to a shaft **50** carrying a pinion **51** meshing with teeth **52** on the periphery of a large dial **53**. The dial **53** is provided with a band lying between circumferential lines **54** and **55**, and this band is marked with scale lines as shown. A pointer **56**, pivotally mounted at **57**, is arranged to sweep over the scale band. This pointer is adjusted by hand and there is sufficient friction in its pivotal mounting that it stays in any adjusted position.

It has been stated above that the mechanism for making the base adjustment will, unless modified, serve to effect cutting of the strip always to a predetermined length, and for the sake of example I have given this length as 16 feet because this is a convenient intermediate length. It will be seen that any adjustment of the hydraulic pump **26** acts through the Selsyn units to adjust the position of the rotatable scale dial **53**, and that such dial will stand still until a further adjustment of the fluid pump is made. The dial will occupy different positions after the making of such base adjustment, depending on the diameter of the working rolls **5**. The 16 foot marker on the dial will occupy a position within the sweep of the pointer **56**, but the scale line will not necessarily be coincident with the line swept out by the pointed **56**. I have indicated this latter line at **58** in Figure 4. Regardless of the position assumed by the dial **53** on the making of the base adjustment as above described, the procedure next to be followed is to manually adjust the pointer **56** until it touches the scale line corresponding to the base adjustment, which, in this case, is the 16 foot line. As shown in Figure 4, the pointer will be adjusted to the point **59** for the position of the scale dial shown. The scale lines on the dial are of different geometrical shape and hence corresponding points on successive lines will be different angular distances apart. This is shown by the circumferential lines **60** and **61** which have been drawn on Figure 4 between the 16-foot and 17-foot scale lines. The line **60** intersects the 16-foot line at the point **59** and intersects the 17-foot line at the point **62**. The line **61** intersects the scale lines at the points **63** and **64**, respectively. Radii drawn from the center of the disc through the points **59** and **62** enclose a greater angle than radii drawn through the points **63** and **64**. It follows that if the base adjustment is such that the pointer **56** lies over the point **59**, a greater angular rotation of the disc **53** will be required in order to bring the point **62** beneath the tip of the pointer **56** than would be required if the point **63** originally lay under the tip of such pointer and an adjustment were made to bring the point **64** thereunder. In each case the adjustment is for the purpose of increasing the cut length of the strip but one foot, and the difference in the amount of adjustment required to effect this change in the cut length is occasioned by the different size of the rolls **5**. The dial **53** may be considered as an infinite number of circular scales, any one of which may be utilized, depending upon the initial positioning of the pointer **56**. It will be understood that the dial may be otherwise formed or marked and specifically that circular lines may be drawn thereon corresponding to different roll diameters. This type of dial will be of particular value where the matching apparatus is omitted.

In order to give a complete understanding of my invention, the remaining control apparatus illustrated in the drawings will be briefly described. The several motors **6** are connected to power lines **70**. The shear motors **20** are driven from a generator **74** constituting a part of a motor generator set having a driving motor **75** and an exciter **76**. The motors **20** are supplied with current from the generator **74** through a bus **77**. A control box **78** is interposed in the bus **77** and is connected through a control cable **79** to the switch **12**. Timing relays **80** are shown on the control panel **36**. These are controlled by load relays **71** connected in the circuits of the

motors 6 through the circuit 72. The relays 80 are connected into the shear motor circuit in a well-known manner to control the time in which the shear is brought from rest up to full speed, thus controlling the length of the crop which is sheared from the leading end of a strip. The connection between the relays 80 and the circuit for the motors 20 is omitted for the sake of clarity in illustration. A shunt 77' in one side of the bus 77 is connected by leads 81 to an ammeter 82 on the control panel for indicating the load on the shear motors. The voltage of the generator 74 is governed by a controlling rheostat 83 connected to the field winding of the generator 74 through a circuit 84. The shear is hand started and stopped by a switch 85 on the panel which is connected to a starting panel, the details of which are known, and a selector switch 86 is provided for controlling the shear in case it is desired to use it for automatic cropping or continuous cutting to length.

For the further information of the operator, a tachometer 87 is driven by the motor 6 for the delivery stand 2, and is connected to an indicating voltmeter 88 on the control panel 36 to indicate the speed at which material is delivered by the last stand 2. A generator 89 having a pinion 90 meshing with the gear 37 on the shaft of the fluid motor 22 is connected to a differential voltmeter 91 on the panel 36. The other winding of the volt meter 91 is subject to the voltage of the generator 74. The voltmeter 91 thus indicates the difference between the actual shear speed and the speed which the generator voltage is adjusted to produce. A voltmeter 92 connected across the generator 74 indicates what the linear speed of the shear knives will be when the motors 20 are brought up to the speed corresponding to the indicated voltage of the generator 74.

While I have illustrated and described the present preferred embodiment of my invention, it will be understood that it is not limited thereto but may be otherwise embodied and practiced within the scope of the following claims.

I claim:

1. In the method of shearing metal strip accurately to length with an apparatus comprising a pair of feed rolls and an adjustable flying shear, the steps consisting in advancing the strip by the feed rolls measuring the peripheral speed of a feed roll without regard to the angular velocity thereof, and adjusting the flying shear in accordance therewith.

2. In the method of shearing metal strip accurately to length with an apparatus comprising a pair of feed rolls and a rotary shear rotatable at different angular velocities to obtain different cut lengths, the steps consisting in measuring the linear velocity of the strip delivered by the feed rolls without regard to the angular velocity of the feed rolls, and operating the shear at an angular velocity adjusted in accordance with the thus-determined linear velocity of the strip.

3. In the method of shearing metal strip accurately to length with an apparatus comprising a pair of feed rolls and an adjustable flying shear, the steps consisting in measuring the linear velocity of the strip delivered from the feed rolls without regard to the angular velocity of the feed rolls, effecting a base adjustment of the flying shear in accordance with such linear velocity, and thereafter effecting further adjustments of the flying shear so as to change the cut length of the strip.

4. In the method of shearing metal strip accurately to length with an apparatus comprising a pair of feed rolls and a rotary shear, the steps consisting in measuring the linear velocity of the strip delivered from the feed rolls without regard to the angular velocity of such rolls, effecting a base adjustment of the angular velocity of the rotary shear in accordance with the linear velocity of the strip, and thereafter further adjusting the angular velocity of the rotary shear to adjust the cut length of the strip.

5. In the method of shearing metal strip accurately to length with an apparatus comprising a pair of replaceable feed rolls and a rotary shear, the steps consisting in feeding strip through the rolls to the rotary shear, cutting it into lengths by such rotary shear, substituting for the feed rolls another pair of feed rolls, measuring the linear velocity of the strip as delivered from the substituted feed rolls, and effecting an adjustment in the angular velocity of the rotary shear to compensate for the difference in diameter of the substituted feed rolls and the diameter of those rolls which have been replaced.

6. In the method of shearing metal strip accurately to length with an apparatus comprising a replaceable feed roll and a rotary shear, the steps consisting in feeding strip by means of said feed roll to the rotary shear, cutting the strip into lengths therein, replacing the feed roll, effecting a base adjustment in the angular velocity of the rotary shear to compensate for differences in the diameter of the substituted feed roll and the diameter of the roll it has replaced, and thereafter adjusting the angular velocity of the rotary shear so as to change the cut length of the strip, the last-mentioned adjustments being in predetermined amounts and in accordance with the diameter of the substituted feed roll.

7. In the method of shearing metal strip accurately to length with an apparatus comprising a replaceable feed roll and a rotary shear, the steps consisting in feeding strip by means of said feed roll to the rotary shear, cutting the strip into lengths therein, replacing the feed roll, effecting a base adjustment in the angular velocity of the rotary shear to compensate for differences in the diameter of the substituted feed roll and the diameter of the roll it has replaced, selecting a length adjusting scale corresponding to the diameter of the substituted feed roll, and adjusting the angular velocity of the shear in accordance with the scale so selected.

8. In the method of shearing metal strip with apparatus comprising a feed roll adapted for replacement and a shear driven in timed relation therewith, the steps consisting in measuring the peripheral speed of the feed roll and adjusting the speed relation between the feed roll and the shear whereby to compensate for differences in diameter between successive feed rolls employed.

9. In the method of shearing metal strip with apparatus comprising a feeder having a delivery roll adapted for replacement and a rotary shear driven in timed relation therewith, the steps consisting in predetermining the relative angular speed of the feed roll and the shear to cut different strip lengths, and for feed rolls of different diameters, placing a feed roll of suitable diameter in the feeder, adjusting the relative speed of the feed roll and the shear so as to establish for the feed roll and the shear the angular speed relationship theretofore determined, and then feeding strip by the feed rolls to the shear and cutting the same therein accurately to the desired length.

10. Apparatus for shearing metal strip comprising a pair of feed rolls, a shear, means for measuring the peripheral speed of the feed roll without regard to its angular velocity, and means for adjusting the shear in accordance with such measurement.

11. Apparatus for shearing metal strip comprising a feed roll, a rotary shear, means maintaining a timed relation between the angular velocity of the feed roll and the angular velocity of the shear, means for determining the linear velocity of the strip, and means for effecting a corresponding adjustment in the relative angular velocity of the feed roll and the shear.

12. Apparatus for shearing metal strip comprising a feed roll, a shear, means driven from a peripheral surface of the feed roll, and means for adjusting the speed of the shear in accordance with the speed of such driven means.

13. Apparatus for shearing metal strip comprising a feed roll, a rotary shear, means driven from a peripheral surface of the feed roll, and means for adjusting the angular velocity of the shear in accordance with the velocity of such driven means.

14. Apparatus for shearing metal strip comprising a feed roll, a rotary shear, a variable speed mechanism connecting the feed roll and the shear and determining their relative rotative speeds, means for establishing a base setting of the variable speed mechanism in accordance with the linear speed of strip delivered by the feed roll to the rotary shear, and means for adjusting the variable speed mechanism from such base setting.

15. Apparatus for shearing metal strip comprising a feed roll, a rotary shear, a variable speed mechanism connecting the feed roll and the shear and determining their relative rotative speeds, means for indicating the appropriate relative angular velocity of the feed roll and the shear for cutting different strip lengths and for feed rolls of different diameter, and means for adjusting the variable speed mechanism to procure the relative speed so indicated.

16. Apparatus for shearing metal strip comprising a feed roll, a rotary shear, a variable speed mechanism connecting the feed roll and the shear and determining their relative rotative speeds, means for indicating the appropriate relative angular velocity of the feed roll and the shear for cutting different strip lengths and for feed rolls of different diameter, said means being readable directly in terms of the strip length, and means for adjusting the variable speed mechanism to procure the relative speed so indicated.

17. Apparatus for shearing metal strip comprising a feed roll, a rotary shear, a variable speed mechanism connecting the feed roll and the shear and determining their relative rotative speeds, means for establishing a base setting of the variable speed mechanism in accordance with the linear speed of strip delivered by the feed roll to the rotary shear, indexing means for determining the amount of adjustment of the shear speed in order to cut predetermined lengths with different diameters of feed rolls, and means for selecting an indexing means corresponding to the diameter of the feed roll being employed.

18. Apparatus for shearing metal strip comprising a feed roll adapted for replacement, a rotary shear, a variable speed mechanism connecting the feed roll and the shear and determining their relative rotative speeds, indexing means determining the amount of adjustment of the variable speed mechanism necessary for cutting different cut lengths of material and taking into account the diameter of the feed roll then employed, and means for determining the indexing means which corresponds to the feed roll in use.

19. Apparatus for shearing metal strip comprising a feed roll adapted for replacement, a rotary shear, a variable speed mechanism connecting the feed roll and the shear and determining their relative rotative speeds, a scale having a face of substantial width and comprising a multiplicity of scales different from one another and severally indicating the amount of adjustment of the variable speed mechanism required for cutting different strip lengths, different scales corresponding to different feed roll diameters, and means for correlating the feed roll employed with its corresponding scale.

20. Apparatus for shearing metal strip comprising a feed roll adapted for replacement, a rotary shear, a variable speed mechanism connecting the feed roll and the shear and determining their relative rotative speeds, and indexing means determining the amount of adjutment of the variable speed mechanism necessary for cutting different cut lengths of material and taking into account the diameter of the feed roll then employed.

21. Apparatus for shearing metal strip comprising a feed roll adapted for replacement, a rotary shear, a variable speed mechanism connecting the feed roll and the shear and determining their relative rotative speeds, and a scale having a face of substantial width and comprising a multiplicity of scales different from one another and severally indicating the amount of adjustment of the variable speed mechanism required for cutting different strip lengths, different scales corresponding to different feed roll diameters.

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