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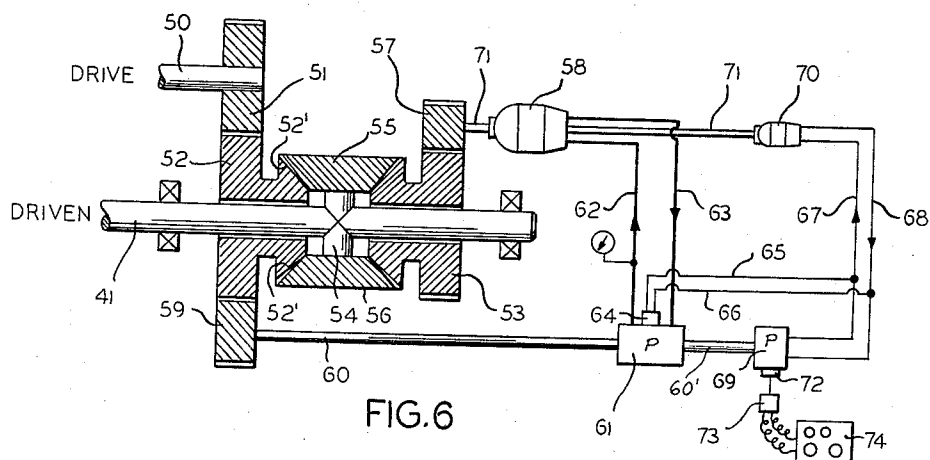
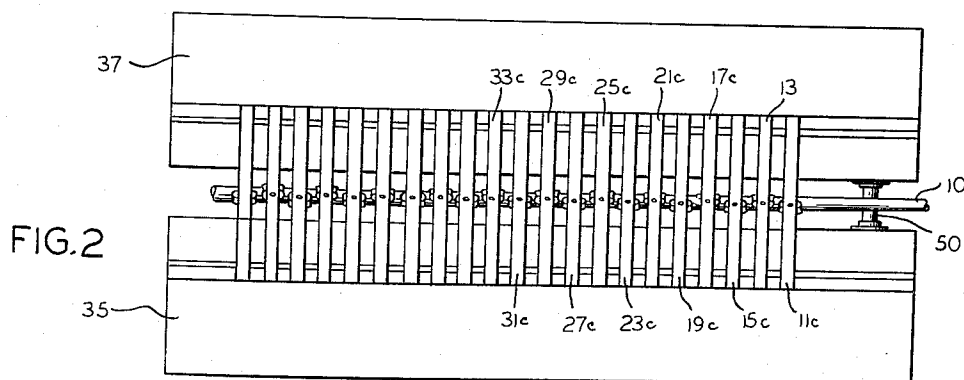
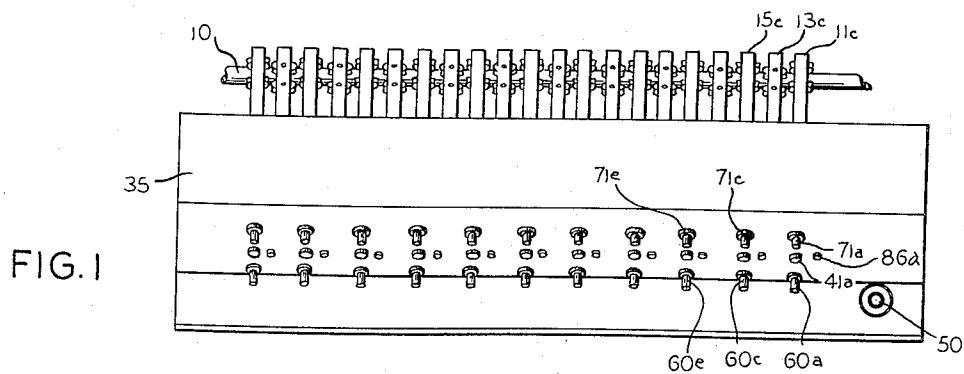
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3,013,452

DRIVE ASSEMBLY FOR METAL WORKING MILL

Filed April 20, 1959

3 Sheets-Sheet 1



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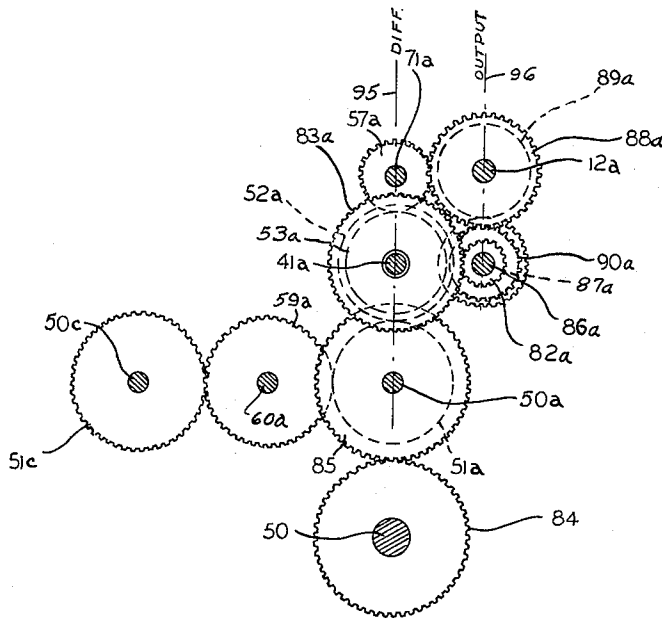
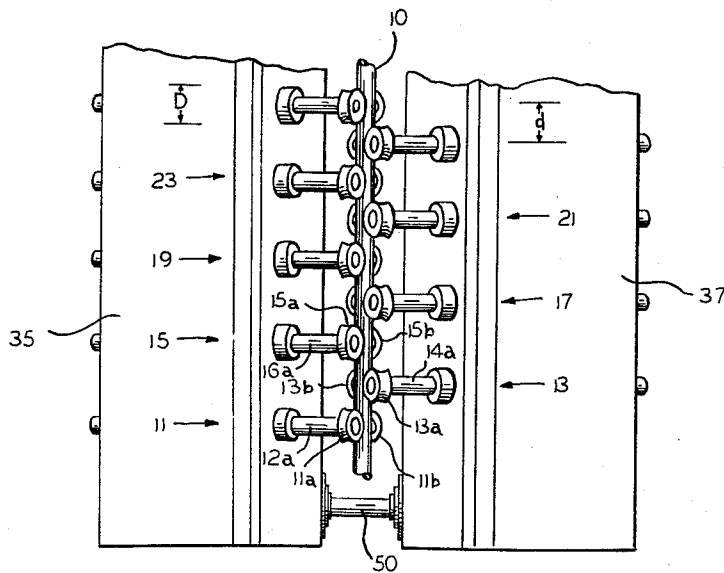
L. HORNOSTEL

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DRIVE ASSEMBLY FOR METAL WORKING MILL

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3 Sheets-Sheet 3



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DRIVE ASSEMBLY FOR METAL WORKING MILL
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Filed Apr. 20, 1959, Ser. No. 807,606
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This invention relates to a drive assembly for a metal working mill. More particularly, this invention relates to a drive assembly for a mill structure for continuous metal working mills of the type having a plurality of roll stands through which stock to be stretch-reduced is fed and wherein a particularly compact arrangement is achieved through utilizing the individual roll stand supports as casings for the individual differential drive assemblies for controlling the speed of each of the stands.

Mills such as tube mills are used to convert pierced hot cylindrical metal billets into pipe and tubing. Such mills may receive a billet which is about five to six inches in exterior diameter, is about forty feet long, and has an interior dimension of about two to three inches. This billet is reduced to elongate piping or tubing of controlled diameter and wall thickness by being drawn through the nips of a plurality of sequentially arranged roll stands of a mill. A typical mill may, for example, have from 11 to 22 such stands. In such a mill a billet of the type described above would produce about 300 feet of half-inch pipe. Of course, the size of the successive nips of the roll stand of the mill determines the outer pipe diameter whereas the relative speed ratios between successive roll stands determines the wall thickness of the pipe by determining the amount by which the original billet is stretched.

It is thus important to provide a mill wherein the drive arrangement is such that the relative speed of the various roll stands can be accurately and easily controlled. Known electric drive units are not satisfactory because when the steel reaches its yield point, as it must in each nip to facilitate working, the driving torque is so greatly reduced that the released load on the electric driving motor will speed up the motor so as to require over compensation for correction in speed. Since the metal must be worked in its yield area in the nip of each roll stand throughout the mill it is obvious that the electric drive is very expensive, unduly complicated, and never sensitive enough to meet all operating conditions and requirements. Hydraulic controls in general have a faster response than the all electric drives. However, for either electric or hydraulic types of drive assemblies, the mechanical arrangement and layout of the drive assembly has an important relationship to possible overall mill construction and operation.

Previously known mill construction have required a substantial spacing between adjacent roll stands in order to accommodate the drive control apparatus necessary to individually control the speed of each stand. This wide spacing between roll stands is extremely undesirable since the greater the distance between successive nips the greater will be the crop losses and the radiated heat loss of the tubing being processed. Such crop losses and heat loss can result in extremely inefficient operation. The larger spacing between roll stands the more difficult also is the problem of controlling the operation of the mill particularly during intermittent operation. Since two adjacent roll stands are usually required to develop enough torque to feed the metal through the mill, the crop loss is for this reason increased as the spacing between the roll mill stand increases. That is to say, the leading and trailing ends of each billet being formed will always end up as waste end plugs on the finished pipe or tube because these ends cannot be sub-

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jected to tension loads or draw as stock advances through the mill. Such crop losses, however, can in accordance with the present invention be reduced to a minimum by minimizing the spacing between roll stands. Furthermore, this is accomplished in a compact mill structure wherein the casings of the roll stand supports also serve as a housing for the speed control apparatus of the mill. These advantages are achieved along with other objects and advantages by providing a drive assembly which will accommodate closer spacing together of the mill roll stands than has heretofore been possible. In particular, it is possible in accordance with this invention to position successive sets of rolls so that the distance between their centers can be equal to or even less than the diameter of such roll. Such close spacing has not been obtainable with previously known mill constructions of the type including a readily controllable heavy drive which can deliver any power requirement needed on any roll center spacing.

In accordance with one feature of the present invention a pair of housings extend longitudinally along opposite sides of the mill. These housings serve as support members for the shafts on which the nip defining rollers of the mill are mounted. The shafts for odd numbered roll stands are supported by and protrude from one housing whereas the shafts from even numbered roll stands are supported by and protrude from the other housing, the roll stand shafts thus being arranged in alternate staggered relationship between the two housings. The housings also contain individual differential drive speed controlling units for each roll stand. The two trains of differential drives in the oppositely disposed pair of housings are each connected to be driven through meshed gearing from a common source to constant speed power. Such gear connected driving eliminates the use of slip couplings or similar devices which are necessary where a line shaft is used and accommodates the changes in length under expansion and contraction creating conditions. Furthermore, the backlash on such a gear train drive can be adjusted to prevent "wind-up" variations such as commonly occur in systems using a line shaft.

The individual differential drive assemblies in the two housings afford the means for controlling the speed of the associated roll stand. These individual drive assemblies can be easily maintained and replaced or repaired if necessary without disassembly of the entire unit. The utilization of the roll stand supports as casings for these differential drive assemblies leads to a tube mill of greater compactness and efficiency of operation than has been attainable with heretofore known mills.

It is accordingly an object of this invention to provide a continuous mill structure having the foregoing features and advantages.

It is a further object of this invention to provide a drive assembly for a continuous mill which is arranged to permit extremely close spacing of the roll stands of the mill while still affording positive flexible driving power.

It is a further object of this invention to provide a continuous reducing mill wherein a differential drive assembly is provided to control the speed of each roll stand and wherein the drive assemblies are supported in the roll stand supports and are so positioned and interrelated that successive roll stands can be positioned a distance apart which may be less than the diameter of a roll of the stand.

It is a further object of this invention to provide a continuous mill structure affording a more compact arrangement and more efficient operation than has hitherto been known.

It is a further object of this invention to provide a continuous mill structure wherein the roll stand supports are

utilized as casings for individual differential drives for the roll stands in order to achieve a compact and efficient mill.

Other objects, features and advantages of the present invention will be more fully apparent to those skilled in the art from the following detailed description taken in connection with the accompanying drawings in which like reference characters refer to like parts throughout and wherein:

FIGURE 1 is a side elevational outline view of a mill in accordance with the present invention;

FIGURE 2 is a top plan view of the structure shown in FIGURE 1;

FIGURE 3 is an enlarged end elevational view of the mill shown in FIGURE 1 and is partly broken away to show internal details of the mill;

FIGURE 4 is a diagrammatic view taken on the line IV—IV of FIGURE 3 and shows the plan of arrangement of the shafts and gearing inside the housing;

FIGURE 5 is a fragmentary plan view on a larger scale than the plan view of FIGURE 2 and with portions of the apparatus shown in FIGURE 2 broken away to show the relationship between the nip defining rollers of the various roll stands of the mill; and

FIGURE 6 is a diagrammatic view illustrating the basic components and mode of operation of a differential drive assembly such as is associated with each of the roll stands in the mill.

Turning now to the drawings and in particular to FIGURES 1, 2, 3 and 5, it will be seen that the pipe stock 10 which is to be drawn or reduced in the mill is fed sequentially through the nips of a plurality of roll stands such as the stands 11, 13, 15, 17, 19, 21, 23, 25, etc. Thus, it will be seen that the two adjacently positioned pulley-shaped rollers 11a and 11b define between them the nip of the roll stand 11 which is the last roll stand in the mill through which the pipe 10 is drawn. It will be noted that the rollers 11a and 11b are respectively mounted on shafts 12a and 12b which lie in the same transverse plane with respect to the axis of the pipe stock 10 and which make an angle of 45 degrees with the horizontal in that plane. Of course, rollers 11a and 11b respectively rotate in opposite directions about the axes of the shafts 12a and 12b so that each roller urges the pipe stock 10 in the same direction to the right as seen in FIGURES 1 and 2 and forwardly out of the plane of the paper as seen in FIGURE 3.

Immediately in back of the roll stand defined by rollers 11a and 11b is another roll stand the nip of which is defined between similar pulley-shaped rollers 13a and 13b. Rollers 13a and 13b are respectively mounted on shafts 14a and 14b as may be seen in FIGURES 3 and 5. It will be noted that the shafts 14a and 14b also lie in the same plane which plane is also transverse to the axis of the pipe stock 10 and in back of plane of the shafts 12a and 12b. The shafts 14a and 14b also make an angle of 45 degrees with the horizontal and these shafts further make an angle of 90 degrees with the shafts 12a and 12b supporting the rollers of the next adjacent roll stand. That is to say, the axis of rotation of each of the rolls of each of the roll stands is parallel to that of the other roll in the same roll stand and perpendicular to that of each of the roll stands in each of the adjacent stands.

This general arrangement may clearly be seen from FIGURE 3 and from the fragmentary detailed plan view of FIGURE 5. Of course, it will be understood that the number of roll stands in any given mill is entirely a matter of design depending upon the particular application for which the mill is intended.

In order to clarify the drawing, the shaft supporting frame 11c, 13c, 15c, etc., which support the roll bearing shafts of each roll stand have been omitted from FIGURE 5 in order that the rolls themselves may be shown in a full line view. Furthermore, in FIGURE 5 the rolls are positioned so that the central plane in which the axes of each of the shafts of each stand lies is separated from

the same central plane of the next adjacent roll stand by a distance d which is greater than the diameter of the rolls of each stand. This distance d , which may conveniently be referred to as the center-to-center nip separation distance, can, however in accordance with the present invention be easily made equal to or even less than the diameter of the roll as may be clearly seen from FIGURE 5. Thus, the diameter of an individual roll as indicated by the capital letter D in the drawing is in practice the same for each roll of the stand. However, by virtue of the fact that the shafts of adjacent roll stands are in fact at a 90° angle to each other so that the pulley-shaped rolls of adjacent stands lie in planes which are at 90° angles to each other, it will be seen that the nip separation distance d between the centers of adjacent roll stands can in fact be made even less than the diameter of the roll of each stand since the rolls may overlap into interfitted relationship to each other. Furthermore, as will be seen from the discussion below, the fact that the shafts are brought out from opposite sides of the pipe stock being worked on permits an arrangement of an associated part of the drive assembly for each stand which accommodates this extremely close spacing of the nip of adjacent roll stands and thereby reduces heat losses and crop losses in the operation of the mill.

Turning now again to FIGURES 1, 2 and 3, it will be noted that the shafts 12a and 12b which support the rolls 11a and 11b respectively, are themselves journaled in a cage or framework 11c there being one such cage or framework for each roll stand. In FIGURE 3 the cage 11c associated with the nip 11 may be seen. From FIGURES 1 and 2 it will be noted that similar cage structures are provided for each of the other roll stands. In FIGURE 5, however, these cage structures have been omitted in order to more clearly show the details of the nip defining roll structures. As may be seen in FIGURE 5, the shafts for alternate nips 11, 15, 19, etc., project from and are supported in a main left hand housing 35 which extends the full length of the mill on one side thereof. The remaining intermediate nips such as the nips 17, 21, 25, etc., have the shafts associated therewith supported by and projecting from a main right hand housing 37 which also extends the full length of the mill and is positioned opposite to the housing 35. The housings 35 and 37 are preferably upright casings generally of the shape shown in FIGURES 1, 2 and 3 and may conveniently rest on any fixed support member or directly upon the floor. The box-like frames or cages such as 11c, 13c, 15c, etc., which support the shafts for each of the roll stands are each in turn rigidly attached to both of the housings 35 and 37 in spaced relationship to each other along the length of the mill as may be seen in FIGURES 1, 2 and 3. These frameworks may be welded, bolted or attached in any convenient manner to the housings 35 and 37.

Within the housings 35 and 37, there is provided for each individual roll stand an individual speed controlling differential drive assembly, a fixed ratio reduction gear and suitable reversing gearing to assure that the two shafts of the stand rotate in opposite directions. The drive assembly for a typical roll stand may be most clearly seen from the broken away sectional portion of FIGURE 3 and from the sectional plan view of the gearing shown in FIGURE 4. The differential drive included in this assembly for each stand operates in a manner which may most clearly be seen from a consideration of the diagrammatic view shown in FIGURE 6. Hence, in order to facilitate an understanding of the operation of the apparatus the operation of the differential drive unit diagrammatically shown in FIGURE 6 will first be described as a prototype to which the differential drive assemblies for the individual roll stands each conforms.

In FIGURE 6 power output from the differential drive is indicated as being delivered through the variable

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r.p.m. output shaft 41. In order to provide this variable output power, a constant speed power input shaft 50 drives a gear 51 which in turn drives the first of two input gears of the differential. These two input gears are indicated in FIGURE 6 as the gears 52 and 53 each of which is journaled and mounted for free rotation and concentrically with and about the output shaft 41 but independently of the rotation thereof. The output shaft 41 carries a cross-shaft spider assembly 54 on which are mounted the two bevel gear pinions 55 and 56 respectively. Of course, it will be understood that the driving gear 51 is meshed in engagement with the input gear 52 of the differential. The gear 52 in turn has a bevel gear portion 52' which is meshed with the bevel gears 55 and 56 respectively. Similarly, the other input gear 53 of the differential has a bevel gear portion 53' which is also meshed with the bevel gear pinions 55 and 56 and the gear 53 is also meshed with another driving gear 57 which is rigidly mounted on the shaft 71 of a variable speed hydraulic motor 58. The input gear 52 is also meshed with a gear 59 rigidly mounted on the drive shaft 60 of a constant speed variable displacement hydraulic pump 61. Shaft 60 is in turn connected to drive shaft 60' which drives the slave pump 69. The output of pump 61 is applied through hydraulic line 62 or 63 to the input of the constant displacement variable speed hydraulic motor 58 and the hydraulic fluid is returned from motor 58 through hydraulic lines 63 or 62 to the input of pump 61. The displacement of pump 61 may be controlled by any known mechanism indicated schematically by the block 64 which is connected by pressure sensing lines 65 and 66 to the hydraulic conduits or lines 67 and 68 respectively of a slave hydraulic system comprising hydraulic pump 69 and hydraulic motor 70. The hydraulic unit 70 is a constant displacement variable speed unit. Shaft 71 integrally connected motors 58 and 70 so that they necessarily operate at the same speed. Fluid is supplied to the slave hydraulic motor 70 through line 67 or line 68 which connects the constant displacement variable speed motor 70 to the variable displacement constant speed pump 69 which is coupled integrally for corotation with pump 61. The displacement per revolution of pump 69 is controlled by means of any conventional displacement control mechanism such as a slide block indicated generally by the reference character 72 which may in turn be mechanically connected for actuation by an electric motor 73 which may be controlled by manual switch-board control 74 or by any other suitable manual or automatic means.

When the mill operator pushes one of the buttons on the control board 74 so as to rotate motor 73 in one or the other preselected directions so as to either increase or decrease the volumetric displacement of pump 69, a pressure unbalance is created in the system which results in pressure being applied through line 65 or 66 so that the displacement control 64 of pump 61 is adjusted to a new volumetric displacement rate. The adjustment of pump 61 follows that of pump 69, thereby eliminating the unbalanced condition in the system and returning it to equilibrium at a new speed ratio. Hence, adjustment of slide block 72 by motor 73 at a relatively low power level sets the speed ratio between pump 61 and motor 58 transmitting variable system power.

Considering now the overall operation of the differential unit shown in FIGURE 6, first note a hypothetical situation wherein the gear 53 is held stationary. If gear 52 is now turned, the small pinion gears 55 and 56 on the cross shaft 54 of output shaft 41 will walk on the bevel gear portion of the gear 53. The net result is that the output shaft 41 will rotate at one-half the speed of rotation of the gear 52. The same rotation of the output shaft would be produced if gear 52 were held stationary and gear 53 were rotated. It can readily be shown, in other words, that the rotation of output shaft

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41 has a speed which is equal to one-half the algebraic sum of the speed of rotation of gears 52 and 53. Of course, when gears 52 and 53 are rotating at the same speed, the output shaft 41 will also rotate at this speed in accordance with the above formula. In this later condition, the hydraulic system, which acts as a variable radio reduction coupling, has an effective coupling ratio of one to one.

Furthermore, the power transmitted to shaft 41 from gears 52 and 53 is directly proportional to the relative rotational speeds of these gears respectively. If gear 52 turns at 1000 r.p.m. and gear 53 turns at 100 r.p.m., the power input imparted to shaft 41 from gear 52 will be ten times that from gear 53. It is thus evident that if an adjustment of speed of rotation of the output shaft 41 is necessary over a relatively small range, most of the power can be transferred through gear 52 to shaft 41 from a constant r.p.m. source and that the variation in speed necessary can be accomplished by varying the speed of rotation of gear 53. Also, the amount of variable power which must be delivered to gear 53 will be small because the variation in speed required in mills of this type is in practice small. On large drives, this means that most of the power can be transmitted from a simple economical highly reliable constant speed source and that the variable power necessary can be supplied from a variable speed source of much lower horsepower rating.

The accuracy of the drive is also improved by the ratio of the variable to the constant horsepower. For instance, if the variable speed drive should vary 1% and the power input from the variable speed drive is only one-tenth of the total, the speed input from the variable drive would also only be one-tenth of the total and therefore the variation or error from the main output would only be one-tenth of one percent. Because this differential drive is essentially a simple, high quality gear drive, the operation, service factors, time ratings, etc., are those of gearing.

The variable portion of the drive is shown as being provided by the system comprising the hydraulic pump and motor which are adjustable in ratio of speed. The pump is driven at a constant speed from the main input shaft. The pump has an adjustable displacement per revolution. The hydraulic motor which is connected through gear 57 through gear 53 has a constant displacement per revolution. Setting of the displacement of the pump 61 by setting the displacement of the pump 69 through the operation of motor 74 thus sets the ratio between the r.p.m. of pump 61 and motor 58 and, as a consequence, determines the ratio between the r.p.m. of the input shaft 50 and of the shaft 71. The hydraulic system of speed control is preferred since it is not subject to overheating or temperature problems associated with entirely electrical systems. It is essentially a rigid ratio drive which may be adjusted as desired, but once set, holds a definite speed ratio between the pump and motor throughout the load range.

The same reference numerals used in identifying the component parts of the differential drive diagrammatically illustrated in FIGURE 6 have been applied in the other figures to the mechanical components in the actual embodiment of the invention which have functions similar to those of the parts to which the reference numerals were originally applied in FIGURE 6. Suffix letters have been added to the numerals where appropriate to indicate the particular roll stand in which the part occurs, the letter *a* indicating the corresponding part in stand 11, the letter *b* in stand 13, the letter *c* in stand 15, etc.

In FIGURES 1-5 the main power input shaft is indicated by the same reference character 50 as is used in FIGURE 6 since there is only one such shaft for the entire machine. Although the shaft 50 is shown in the drawings as being positioned at the outlet or right hand end of the mill, it will, of course, be understood that

the location of this shaft axially of the mill is a matter of choice or design and that the shaft could be located either at the inlet end of the mill or at the mid-point of the mill. In any arrangement, however, it will be understood that the input shaft 50 preferably lies in a horizontal plane with respect to the base of the mill and extends transversely across the feed axis of the mill so that it may transmit power to the gear coupled drives in the two casings 35 and 37 forming the left and right hand support housings of the mill. As may be seen more clearly in FIGURE 3, the shaft 50 is journaled in the walls of the housings 35 and 37 in any convenient or conventional manner. A bevel gear 84 is rigidly attached to the drive shaft 50 and is meshed with a mating bevel gear 85 which is rigidly mounted on a shaft 50a which extends through the housing 35. Also rigidly mounted on the shaft 50a and rotating concentrically and in synchronism with the bevel gear 85 is a driving gear 51a for the differential of the first stage. The gear 51a corresponds for the first roll stand in function with the gear 51 shown in FIGURE 6. Of course, it will be understood that the bevel gears 84 and 85 are used only for the single point at which the main drive shaft enters the housing. However, a shaft such as the shaft 50a occurs for each roll stand and corresponds to the shaft 50 shown in FIGURE 6. Gear 51a (and all corresponding drive gears) meshes with and drives a pump gear 59a which is rigidly mounted on a shaft 60a which projects through the housing to drive the externally positioned hydraulic pumps. That is to say, the hydraulic pumps 61 and 69 for each stand adapted to be mounted outside the housing 35 and to be driven by the shaft 60 of either adjacent pump gear in any convenient manner. In order to clarify the drawing, the connection to the pump has been indicated in FIGURE 3 only by the arrow and legend associated with the shaft 60a. Also, of course, it will be understood that pump gear 59a drives the power input gear 59c of the third roll stand and that pump and driven gears alternate along the length of each housing forming two separate power input gear trains. In FIGURE 4, the complete gearing of the first stand, the first pump gear, and only the first power input gear 51c of the third stand are shown.

It will, of course, be understood that, as may be seen in FIGURE 5, the main power input shaft 50 extends the full width across the machine and in addition to driving the train of gears for the roll stands extending along the left hand housings 35 also drives a similar train of gears extending throughout the right hand housings 37 to which every other roll stand is connected. Thus, the shaft 60a could drive the hydraulic pump for roll stand 11, the shafts 12a and 12b of which project from housing 35. Shaft 60b is not shown in the drawing but would, of course, be disposed in the right hand housing 37 and could drive the hydraulic pump associated with the differential drive for the second roll stand 13 the shafts 14a and 14b of which project from the right hand housing 37. Shaft 60c, on the other hand, is driven by gear 51c which in turn is driven through pump gear 59a from gear 51a as may be seen in FIGURE 4.

As an aid in visualizing the gear arrangement for the first roll stand, the line 95 indicates the center line on which are positioned the shafts of the differential such as shafts 50, 41, and 71 as shown in FIGURE 6, whereas line 96 indicates the center line of the power output shafts such as 12a and 12b for stand 11.

Returning now to FIGURES 3 and 4 and to a consideration of the differential for the first roll stand 11, it will be noted that the gear 51a rigidly mounted on shaft 50a meshes with and drives a gear 52a corresponding to the gear 52 in FIGURE 6. Gear 52a is journaled in any convenient manner for free rotation about the shaft 41a which lies in back of reduction gear shaft 86a seen in FIGURE 3. The gear 52a is meshed in driving rela-

tionship with the bevel gears 55a and 56a and operates these differential bevel gears in the manner discussed above in connection with FIGURE 6. The gear 52a thus supplies to the differential the major portion of its input power at a constant r.p.m. The variable r.p.m. portion of the input power to the differential, it will be recalled from FIGURE 6, is supplied through the hydraulic system discussed therein. This system is not shown in detail in FIGURE 3 since it is mounted externally of the housing 35. However, as noted above, the shaft 60a drives the hydraulic pump 61 which in turn drives an externally mounted hydraulic motor 58 which in turn drives the variable r.p.m. input shaft 71 for each stage. In FIGURE 3, it will be noted that the shaft 71a is journaled in the housing 35 and is positioned in back of the upper output shaft 12a which is also journaled in the housing 35.

The variable r.p.m. input shaft 71a drives a gear 57a rigidly mounted thereon which gear meshes with the second input gear 53a to the differential as may be seen in FIGURES 3 and 4. The gear 53a is mounted for free rotation about the shaft 41a.

Gear 83a which is rigidly mounted on the output shaft 41a of the differential drives a gear 82a which is meshed therewith and is rigidly mounted on a stub shaft 86a mounted in the housing as shown and which in turn drives a gear 87a rigidly mounted thereon at the forward end thereof. Gear 87a in turn drives a larger meshed gear 88a to afford a fixed reduction ratio in the power transmitted from the differential unit of the stage to the drive shafts of the stage or stand. The gear 88a is rigidly mounted on and drives directly the upper output shaft 12a of the roll stand 11. Also rigidly mounted on the shaft 12a is a gear 89a which meshes with and drives a gear 90a of the same diameter as gear 89a. Gear 90a is rigidly mounted on and drives the second output shaft 12b. The gears 89a and 90a reverse the direction of rotation of output shaft 12b and insures that the two outputs shafts 12a and 12b rotate oppositely with respect to their axis so that they both urge the pipe stock 10 in the same direction.

The stub shaft 86a to which the gear 82a is rigidly attached and which transmits power from the differential unit through gears 87a to 88a to the output shaft 12a is itself journaled at the rearward end in the wall of the casing and at its forward ends is journaled in a housing 81a which is supported by the inner wall of the housing 35. The rearward end of the second output shaft 12b is also journaled in the housing 81a in back of the reversing gear 90a and is of course journaled in the main wall of the housing 35 in front of the reversing gear 90.

It will be understood that there is shown in FIGURES 3 and 4 the basic layout of the gearing forming the differential drive unit, the reduction gearing therefrom, and the reversing gears by which the two shafts of each roll stand are driven, and that in the interests of clarity of illustration exact dimensions have not been shown on the drawings. Thus, the ratio of gear pairs 83—92 and 87—88 may be varied as required for any desired reduction ratio between the differential shaft 41 and the output shafts.

As noted above, the drive gear 51a of the first roll stand drives the idler gear 59a between roll stands which in turn drives the input driving gear 51c of the third roll stand which is positioned adjacent to the first on the left hand side of the mill. It will, of course, be understood that this pattern of gearing arrangement is repeated throughout the length of the mill on each side thereof so that the power from input shaft 50 and the bevelled gears 84, 85 is transmitted throughout the gear train to drive all of the roll stands on the left hand side of the mill and is transmitted transversely of the mill by the same shaft 50 which drives a similar gear train on the other side from which the intermediate roll stands are driven. As noted in the discussion above, the hydraulic system which forms a part of the speed control for each roll stand would

necessarily include the pump 61 and hydraulic motor 58 of the type discussed in connection with FIGURE 6. These components may conveniently be mounted on shelving positioned adjacent to the housings 35 and 37 so that the pump 61 may be driven from shafts 60 and the motor 58 may drive the shafts 71. The electric motor 73 and the control therefor through which the hydraulic system is adjusted to control the adjustment of the speed of each roll stand may conveniently be positioned on the same shelving which supports the hydraulic component.

Provision may be made for lubrication of the gearing in the housings 35 and 37 in any convenient or conventional manner such as by spraying oil or other lubricant over the gearing. Since such provision is deemed to be conventional it has not been illustrated in detail. Similarly, provision may also be made in any convenient or conventional manner for access to the differential drives and other gearing inside of the housings 35 and 37. Again, since it is believed that simple removability of portions of the walls of the housings would satisfy this requirement, no detailed illustration has been given for this feature.

It will be apparent from the drawings that the arrangement of the gearing comprising the reversing and reduction gears and the differential drives for each stand is such as to facilitate the above-noted close spacing together of the center of the adjacent roll stands. The fact that adjacent roll stands are driven from opposite sides of the mill affords a space equal to twice the center-to-center nip separation distance d for the gearing for each roll stand. Thus, the compact arrangement of the gearing not only eliminates line shafts with their above noted disadvantages and affords a rigid controlled drive, but also permits the nips of adjacent roll stands in the mill to be more closely spaced than has hitherto been possible. This in turn results in a considerable reduction in the heat loss in the mill and a considerable improvement in efficiency and reduction of crop losses.

While a particular exemplary preferred embodiment of the invention has been described in detail above, it will be understood that modifications and variations may be effected therein without departing from the true spirit and scope of the novel concepts of the present invention as defined by the following claims.

I claim as my invention:

1. In a continuous, stretch reduction, metal working mill, a plurality of sequentially arranged roll stands, each of said stands comprising a pair of rollers respectively mounted for rotation on a pair of parallel axis shafts, said pair of rollers being adjacently positioned to define a nip therebetween, said nips being axially aligned to receive said metal stock to be drawn in said mill, the axes of said shafts of adjacent roll stands being substantially perpendicular to each other, first and second elongated and common housings extending longitudinally of said aligned nips on opposite sides thereof, said pair of shafts of each of said roll stands being supported by one of said housings, the shafts for any adjacent pair of roll stands being supported from opposite said housings, a longitudinally extending row of a plurality of drive units in each of said housings with adjacent drive units in each row being connected to the shafts of alternate ones of said roll stands, each of said drive units including hydraulic means manually adjustable during operation thereof to vary the speed of an individual roll stand independently of the other roll stands, a common power transmitting means having two parts each comprising a train of meshed gears extending longitudinally and enclosed in one of said elongated housings to interconnect all of the plurality of drive units in said housings, positive drive means interconnecting said two trains of meshed gears and a substantially constant speed means to drive both of said two trains of meshed gears at the same speed, said drive units being materially wider than their associated

roll stands and transversely aligned therewith, and said drive units of said two rolls being alternately offset and axially overlapping to reduce the axial spacing between the roller pairs of adjacent roll stands.

2. In a continuous, stretch reduction, metal working mill, a plurality of sequentially arranged roll stands, each of said roll stands comprising nip defining roller means, the nips of said roll stands being aligned axially to receive metal stock to be drawn in a straight line in said mill, said mill having only two elongated common housings extending longitudinally of said aligned nips on opposite sides thereof respectively, a pair of shafts in each of said roll stands being supported by one of said housings, the shafts for any adjacent pair of roll stands being supported from one of said opposite housings, only two longitudinally extending rows of a plurality of drive units, each said unit including a differential gear set and a speed controlling hydraulic means, each of said rows of drive units being completely enclosed in one of said two housings, only two longitudinally extending trains of meshed gears, each being in one of said two housings and interconnecting and driving all of the drive units of the roll in said housing, and a common, positive, and transversely extending drive means intergearing said two trains of meshed gears to drive them at the same speed.

3. For use in a continuous, stretch reduction, metal working mill of the type having a plurality of sequentially arranged pairs of nip defining rollers on pairs of parallel shafts with alternate pairs being substantially relatively perpendicular to each other; a drive, housing, and support assembly comprising first and second elongated common housings extending longitudinally along the length of said mill and adapted to be positioned on opposite sides of said rollers, each said housing having means to support one of said pairs of roller shafts, a row of a plurality of individual differential drive units enclosed and mounted in each of said housings and adapted to be operatively connected to each of said pairs of roller shafts, each of said drive units including always adjustable hydraulic means to vary the speed of each said drive unit individually, two trains of intermeshed gears with one of said trains extending along the length of said mill in each of said housings, each said train interconnecting and driving all of said row of differential drive units in its said housing, a common and drive transmitting shaft extending transversely of said housings and geared to said two gear trains to supply constant speed driving power thereto.

4. For use in a continuous, stretch reduction, metal working mill of the type having a plurality of sequentially arranged and axially aligned nip defining roller means; a drive, support, and housing assembly therefor comprising two axially offset and overlapping rows of a plurality of individual differential gear drive units each having means to be operatively connected to drive each of said nip defining roller means, each said drive unit including hydraulic means to always vary the speed setting of each said unit independently of the others, two trains of meshed gears with one such train extending along the side of, and geared to drive, each of said individual drive units of its said row, only two axially elongated housings extending continuously along the axial length of said mill with one such housing enclosing and supporting one of each of said rows of individual drive units and its associated train of meshed gears, each of said housings having means mounted thereon to locate and support each one of said nip defining roller means, and only one transversely extending shaft interconnected by gears to each one of said trains of meshed gears to provide a rigid common drive having a minimum of windup.

5. For use in a continuous, stretch reduction, metal working mill of the type having a plurality of sequentially arranged and axially aligned nip defining roller means; a combined drive, frame, and support assembly comprising only two parallel, axially elongated, common housings

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spaced apart to be adapted to extend continuously along the axial length of, and on each side of, the nip defining rollers of said mill, a row of a plurality of individual drive units in each of said housings, said drive units of said two rows being alternately and axially offset and overlapping to reduce the effective axial spacing between the transversely aligned nip defining roller means to be driven thereby, each said drive unit including a transversely extending, differential gear set, each said housing including a row of a plurality of reduction gear units with one of said reduction units being aligned with, and connected to, each one of said differential sets, frames on each of said housings to support said nip defining rollers to be driven by said reduction gear sets, each said housing enclosing an axially extending train of meshed gears gear connected to drive an input of each one of said differential gear sets, a single transverse shaft gear connected to said two trains of gears to provide a common drive with a minimum of windup, two shafts extending through the outer side walls of each of said common housings for each drive unit and connected to said train of meshed gears and to the second inputs of each of said differential gear sets, and an always connected and always individually manually adjustable hydraulic speed adjusting means comprising an hydraulic pump on one said shaft and a motor on the other said shaft to be accessibly mounted on the outer, exposed walls of said axially extending common housings.

6. A continuous, stretch reduction, metal working mill, comprising a plurality of adjacent and sequentially and axially arranged pairs of nip defining rollers on parallel shafts, alternate pairs being oppositely inclined and relatively orthogonal, a plurality of roller shaft supporting frames supporting and providing bearings for said pairs of shafts on opposite sides of their rollers, only two upright, elongated and common housings adjacent to, and extending continuously along, the axial length of said mill on opposite sides of said rollers, said frames being mounted on said housings and said shafts extending out through the inner side walls of said housings, each said housing enclosing a row of a plurality of individual differential drive units, each unit including an always adjustable, hydraulic, speed setting means, said rows being axially offset, each drive unit being aligned with, and connected to drive, its corresponding pair of said shafts, only two axially extending trains of meshed gears with one such train in each of said housings adjacent to and along its opposite end wall from said shafts and interconnected between each of said drive units therein, and transverse drive means positively interconnecting said two gear trains to provide a common drive with a minimum of windup.

7. A continuous, stretch reduction, metal working mill comprising a plurality of adjacent and sequentially and axially arranged pairs of nip defining rollers on parallel

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shafts with alternate pairs being oppositely inclined and relatively orthogonal, a plurality of individual roller shaft support frames, two upright, elongated, and common housings adjacent to, and extending continuously along, the axial length of said mill on opposite sides of said rollers, alternate ones of said shaft support frames being mounted only on one of said opposite housings and said pairs of parallel shafts extending out of the inner end inside walls of said housings, each said housing enclosing a row of a plurality of individual differential drive units extending in alignment with said pairs of shafts with each including an always adjustable, hydraulic speed setting means mounted on the outer sides of said common housings and being connected therethrough, said rows of drive units being axially offset, each drive unit being connected to drive its corresponding pair of said shafts, an axially extending train of meshed spur gears in each of said housings along, and adjacent to, its opposite wall from said shafts and geared to each of said drive units therein, and only a single transversely extending shaft geared to each of said gear trains to provide a common drive with a minimum of windup.

8. A continuous, stretch reduction, metal working mill comprising a plurality of adjacent sequential, and axially arranged pairs of nip defining rollers on parallel shafts with alternate such pairs being oppositely inclined and relatively orthogonal, a plurality of drive units in two horizontally and axially extending rows adjacent to, and on opposite sides of, said rollers, each drive unit including a differential gear set inclined and substantially in alignment with each corresponding pair of rollers and having its output connected thereto, an axially extending train of meshed spur gears adjacent to, and on the outside of, each said row, alternate ones of said spur gears of each train being geared to the input of a corresponding one of said differential gear sets, two upright, floor supported, common casings extending axially along the length of said mill, the upper part of each casing being of generally rectangular cross-section, inclined to match the inclination of said roller shafts and of said differential gear sets and each enclosing one of said rows of drive units and its associated gear train, a plurality of separate hydraulic means to individually change the speed setting with each drive unit during operation thereof, each including a relatively adjustable pump and motor mounted on the outer side wall of each said casing and each gear connected to drive the second input of its associated differential gear set and gear connected to be driven by said train of spur gears, and a transverse shaft geared to each of said train of spur gears to provide a common drive.

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