May 12, 1964 V. S. ARATA 3,132,545

CYCLOIDAL ROLLING MILL

Filed May 20, 1960 4 Sheets-Sheet 1

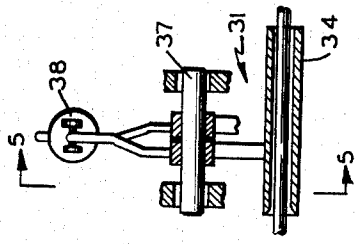


FIG. 4

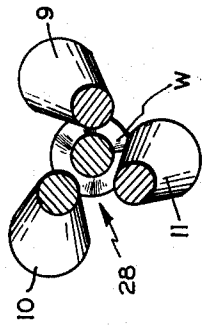


FIG. 3

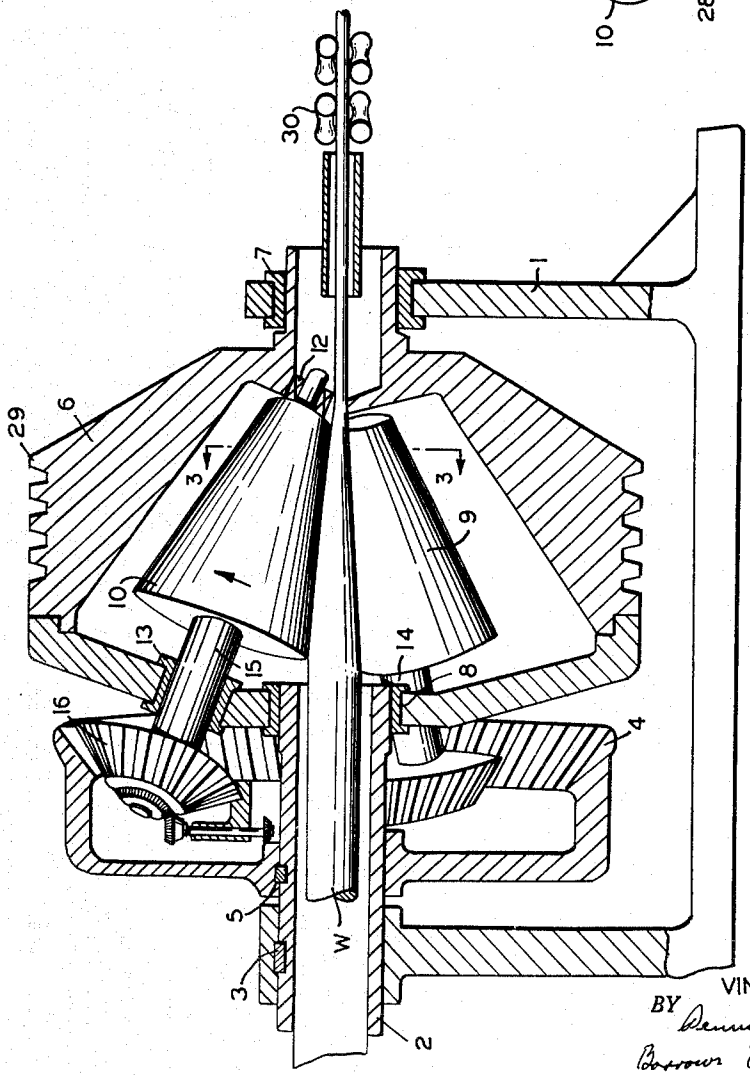


FIG 1

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CYCLOIDAL ROLLING MILL

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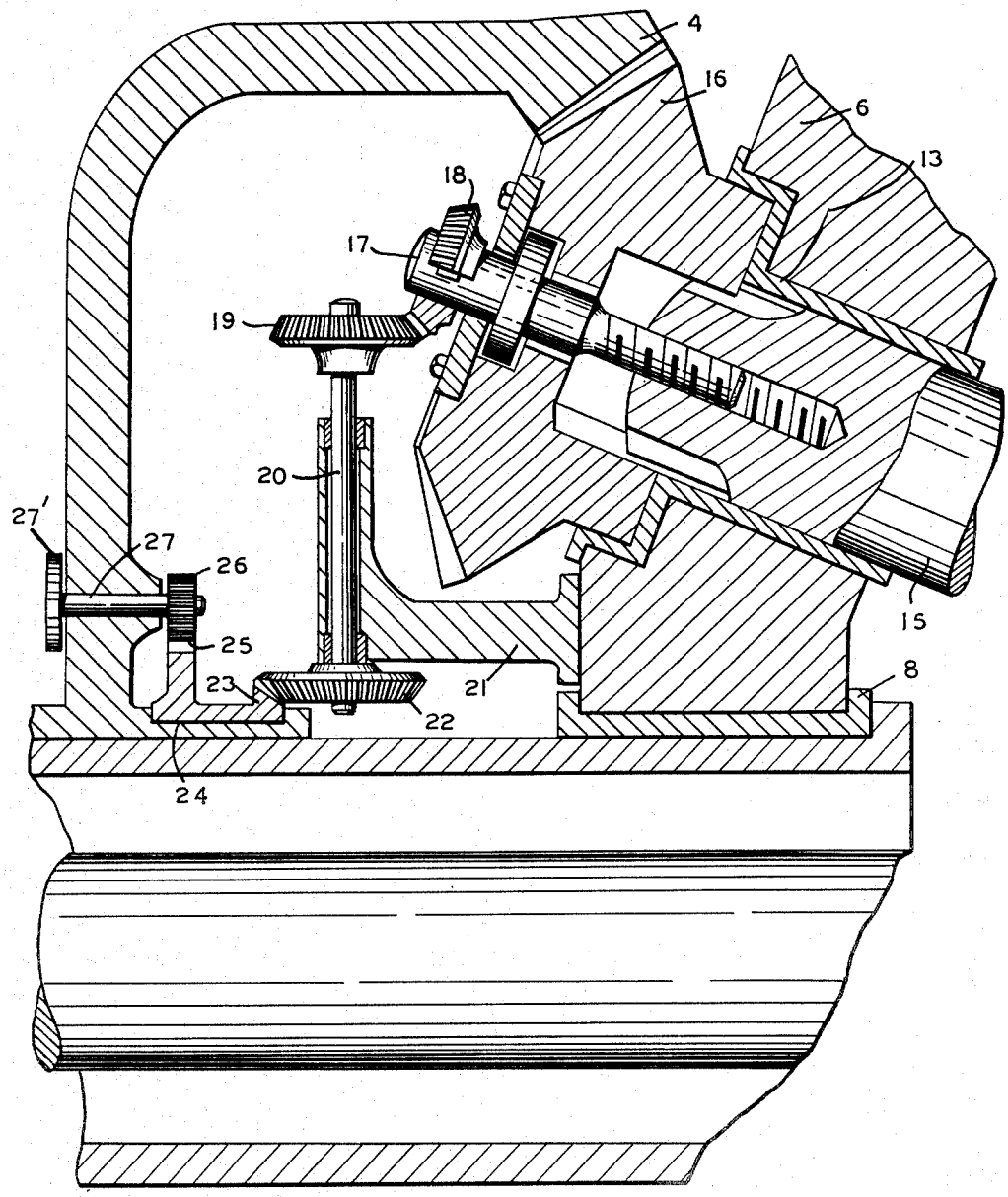


FIG. 2

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CYCLOIDAL ROLLING MILL

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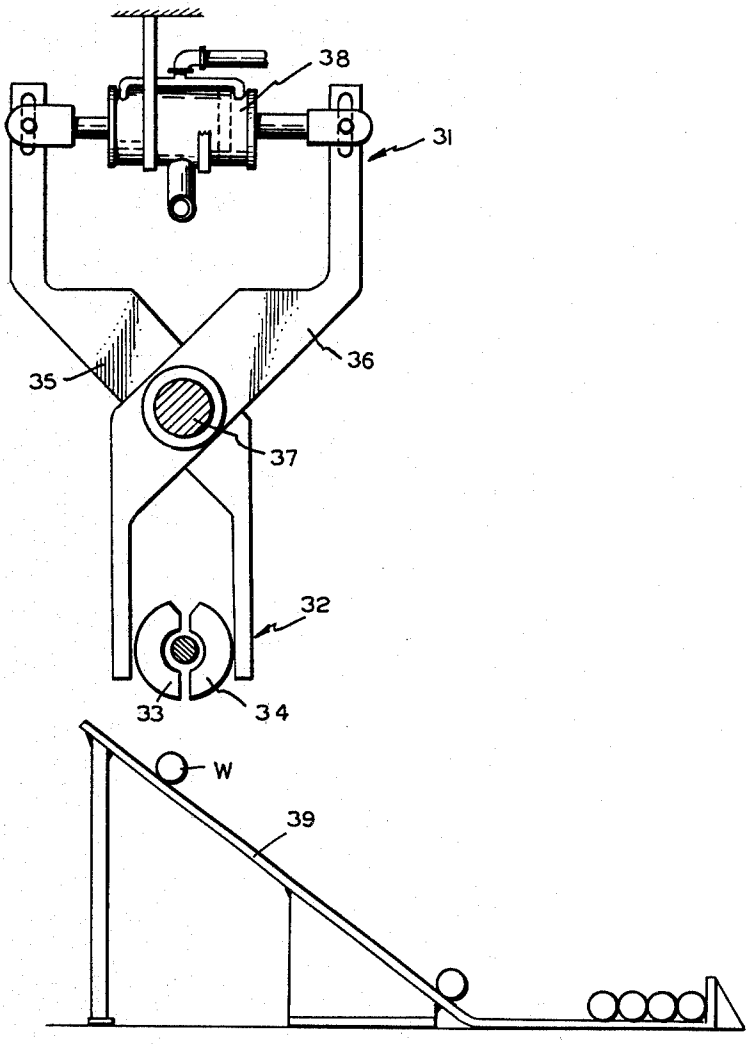


FIG. 5

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CYCLOIDAL ROLLING MILL

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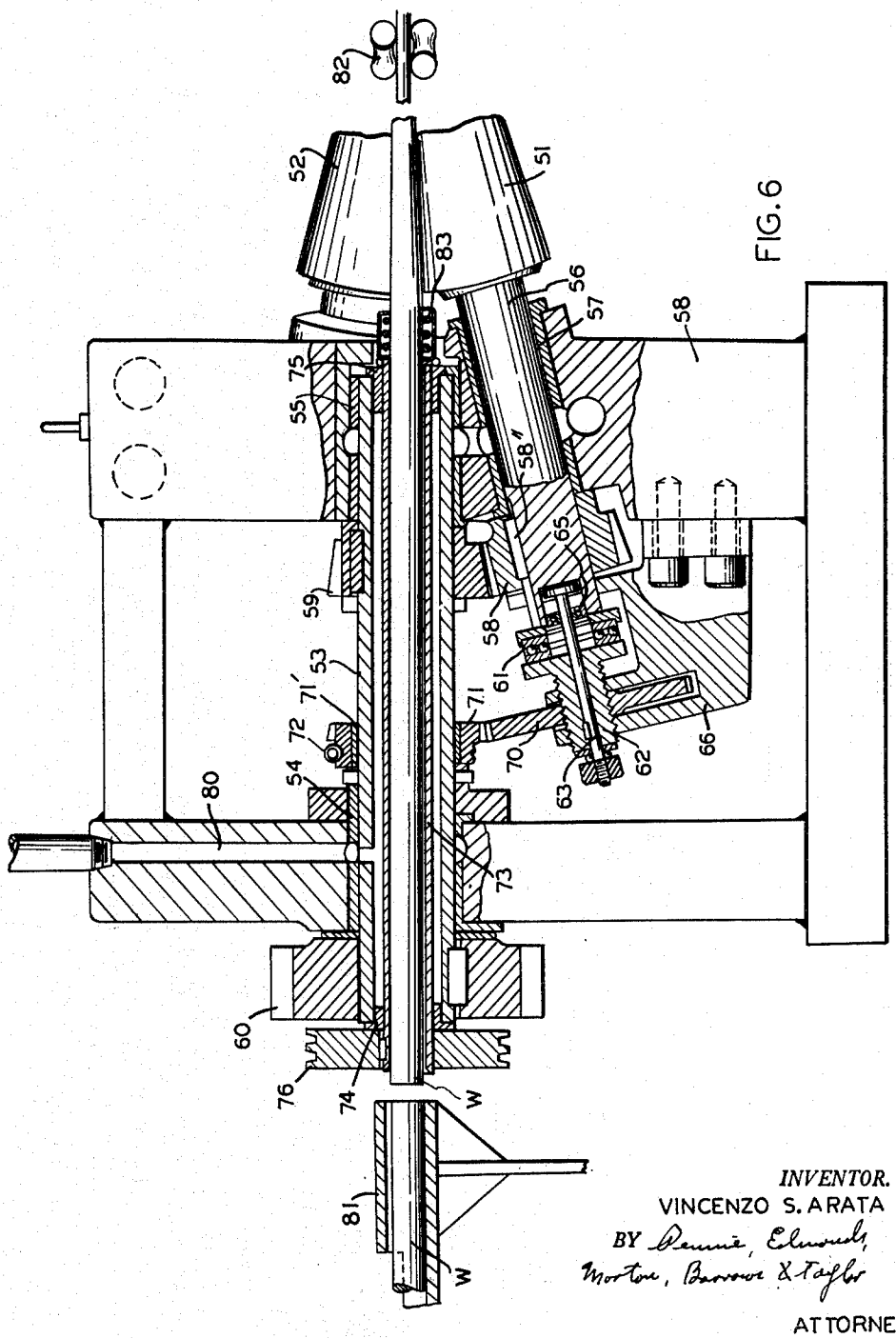


FIG. 6

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3,132,545

CYCLOIDAL ROLLING MILL

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6 Claims. (Cl. 80—22)

This invention relates to a cycloidal rolling mill for reducing the diameter of tubes or bars and more particularly to a rolling mill which will reduce the bars and tubes in a continuous manner in one pass through the mill.

It is desirable in producing bars and tubes from billets that the forming be done quickly with a minimum of passes through a rolling mill and that the reduction in diameter of the bar or tube be smooth and uniform in order to prevent any detrimental transverse forces being imparted to the bar or tube as well as to prevent any twisting of the bar or tube. Further it is desirable to have means whereby the diameter of the finished product may be readily varied without extensive adjustment to the mill.

In conventional rolling mills, it is necessary to pass the workpiece or billet through the mill a number of times and upon each pass reduce the diameter of the workpiece a set amount, which amount must be small enough to prevent a rupture or tear in the workpiece. Articles formed in such mills and the mills themselves are necessarily more expensive than if the articles could be completely formed on one pass through a different type mill.

It is, therefore, an object of my invention to provide for a rolling mill which will give a continuous even reduction of diameter of the workpiece as it passes through the mill and whereby the workpiece may be completely formed on one pass. Further I propose to provide a rolling mill whereby the diameter of the finished workpiece as it leaves the mill may be readily varied with a minimum of adjustment to the mill.

Broadly, my rolling mill comprises a plurality of substantially cone-shaped rotatable forming rolls which are bunched together to define a forming station through which the workpiece is passed and reduced in diameter. The rolls are so positioned that their longitudinal axes are skew with one another and inclined and skewed with the forming station which they define. Further the taper of the cone-shaped rolls is made such that the diameter of the rolls taken along various sections perpendicular to the longitudinal axis of the forming station will be in the same ratio with the diameter of the forming station taken along the same sections. It is then possible, by rotating the rolls with respect to the workpiece, to reduce the diameter of the workpiece in one pass through the forming station without any twist forces being imparted to the workpiece and so that the reduction in diameter is continuous throughout the complete length of the station. The skewing of the axes of the rolls with respect to the forming station will cause the workpiece to be pulled through the forming station so that it is not necessary to exert a pushing force on the workpiece or a pulling force on the workpiece as it leaves the forming station.

In addition, I propose to make the forming rolls movable longitudinally along their axes so that the forming station which they define may be readily varied in cross section thus varying the cross section of the finished workpiece.

In addition, I propose to include a receiving station in my mill whereby the workpiece which may be rotating may be easily supported as it leaves the forming station and whereby the workpiece may be easily removed from the receiving station. Broadly, the receiving station comprises a series of supporting and smoothing rollers followed by a split tubular member which surrounds the workpiece. Means are provided for separating the tubular halves after the workpiece has been cut into desired lengths so that the workpiece may drop therefrom.

While I am aware that tube reducing mills are themselves old in the art, as for example the structures illustrated in United States Patent No. 2,650,509, issued September 1, 1953 and United States Patent No. 2,358,307, issued September 19, 1944, I am not aware of any tube reducing mills wherein the forming rolls are skew with each other and inclined and skewed with the forming station; have the forming rolls tapered so that their diameters taken in any section perpendicular to the longitudinal axis of the forming station have the same ratio with the diameter of the forming station taken in the same sections; and have means for moving the rolls longitudinally along their axes in order to vary the cross-sectional area of the forming station.

Referring to the drawings in which preferred embodiments of my novel rolling mill are shown,

FIG. 1 is a cross-sectional view of a cycloidal rolling mill constructed according to my invention;

FIG. 2 is an enlarged view of a portion of FIG. 1 illustrating details of the roll regulation means;

FIG. 3 is a cross-sectional view of FIG. 1 taken along lines 3—3;

FIG. 4 is a cross-sectional view of a receiving station for receiving a workpiece from the mill of FIG. 1;

FIG. 5 is an enlarged end view of FIG. 4 taken along lines 5—5; and

FIG. 6 is a cross-sectional view of a different embodiment of my rolling mill from that shown in FIG. 1.

Referring in greater detail to the drawings and particularly to FIG. 1, 1 illustrates the frame of a rolling mill having therein a hollow shaft 2 which is held fixed to the frame by key 3. Shaft 2 in turn has mounted thereon an internal ring gear 4 held fixed to the shaft by key 5. A rotatable member 6 is journalled in bearing 7 carried on the frame 1 at one end and at the other end in the bearing 8 mounted on the shaft 2.

Rotatable member 6 in turn has journalled therein forming rolls 9 and 10. For clarity, a third forming roll 11 which is carried in this embodiment of the invention, has been omitted from FIG. 1; however, it defines with rolls 9 and 10 a forming station in which the workpiece is reduced in diameter. The rolls are so positioned that their longitudinal axes are inclined and skew to each other and to the longitudinal axis of shaft 2 which is also the longitudinal axis of the mill. The rolls are journalled in bearings 12 and 13 carried in the rotatable member 6 through shaft extensions 14 and 15. The rolls themselves are so tapered that their diameters taken in any section perpendicular to the longitudinal axis of the forming station have the same ratio with the diameter of the forming station taken in the same sections.

A bevel gear 16 is connected to each forming roll by means of a shaft 17 which is journalled in the bevel gear and which threadingly engages the extension 15 as best seen in FIG. 2. Threaded shaft 17 in turn has a first bevel gear 18 mounted on the end thereof which meshes with a second bevel gear 19 carried on an end of rotatable shaft 20. Shaft 20 in turn is journalled in bracket 21 connected to the rotatable member 6.

A third bevel gear 22 is mounted on the end of shaft 20 and meshes with an external ring bevel gear 23 which is in turn rotatably mounted in slot 24 carried by the gear member 4. The ratio between gears 22 and 23 is the same as between gears 4 and 16. Bevel gear 23 has a spur gear portion 25 which meshes with gear 26 which is carried on shaft 27 rotatably journalled in member 4. Shaft 27 in turn has thereon a dial member 27' by which it may

be turned. Gears 26, 25, 23, 22, 19 and 18 and shafts 20 and 17 all comprise a roll regulation means whereby a roll may be moved longitudinally along its axis to vary the cross-sectional area of the forming station 28 defined by the sides of rolls 9, 10 and 11. While the roll regulation means for only one roll has been illustrated and explained, it must be remembered that each roll has a similar regulation means with the parts 23—27' inclusive, being common to all. It is obvious that upon turning of the dial 27', all the rolls would be moved axially the same amount.

The rotatable member 6 has on its outer periphery grooves 29 which receive a drive belt (not shown) and which extends to a drive motor (not shown). A workpiece or billet W is initially inserted through the hollow shaft 2 so that it contacts the ends of the forming rolls. As the workpiece leaves the forming station, it is carried by supporting and smoothing rolls 30 from whence it passes on to a receiving station 31 as hereinafter explained.

As the rotatable member 6 is rotated by the drive means (not shown), the rolls 9, 10 and 11 will progressively grip the workpiece W and because of the skew of their axes with the longitudinal axis of the mill, they will pull the workpiece into the mill. Since the rolls will in turn be rotating about the workpiece, the workpiece will be caused to be squeezed or rolled to a smaller diameter which will increase its length. This reduction of diameter of the workpiece will be smooth, continuous and without any unevenness on the surface because the forming rolls themselves define essentially a solid of revolution while they are rotating with respect to the workpiece, and because there is a constant angular speed of rotation of the workpiece in any section due to the constant ratio between the diameter of the rolls and forming station in any section.

As the member 6 rotates, the shaft 20 will likewise rotate about gear 23 and since the ratio between gears 22 and 23 is the same as that between 4 and 16, there will be no relative rotation of shafts 15 and 17. If it is desired to reduce or enlarge the cross-sectional area of the workpiece as it leaves the forming station 28, the dial 27' is rotated in the desired direction which will in turn cause the rolls to be moved longitudinally along their axes and thus vary the cross-sectional area of the forming station. It is seen that it is not necessary to stop the mill in order to make this adjustment.

The machine as shown is capable of large reduction of metal workpieces without undue stretching of the metal. For example, if the diameter of the forming rolls is 4 times the diameter of the workpiece W along any vertical section of the forming station and the diameter of the ring gear 4 is 4 times that of the beveled pinion gear 16, then if the member 6 is rotated at 200 r.p.m., the gear 16 will be caused to rotate at 200×4 or 800 r.p.m. The workpiece in turn will then be rotated at 800×4 or 3200 r.p.m. If the skew of the rolls with respect to the workpiece is such to cause the workpiece to feed $\frac{1}{32}$ of an inch at the large diameter end of the forming station per revolution of the bar, then the feeding will be $\frac{1}{32}\times3200$ or 100 inches per minute with a total reduction of diameter of the workpiece from 4 to 1.

Upon leaving the forming station, the workpiece passes through a series of supporting and smoothing rolls 30 into a receiver station 31. Receiver station 31 comprises a split tubular member 32 having halves 33 and 34. Halves 33 and 34 in turn are carried by forks 35 and 36 which are pivotable about pin 37. A hydraulic actuator 38 provides a means for moving the forks 35 and 36 to cause the tubular halves 33 and 34 to open and close.

After the workpiece leaves the support and smoothing rolls 30, it passes into the tubular member 32. When the desired length of workpiece is in the member 32, a cutter (not shown) is actuated to sever the workpiece from the mill. Actuator 38 then operates to separate halves 33 and 34 to allow the completed workpiece to fall onto an inclined plate 39 where it is straightened by rolling down to a storage rack.

Referring to FIG. 6 in which another embodiment of my invention is shown and which also includes means for varying the cross-sectional width of the forming station, 50 denotes a frame in which are mounted a plurality of forming rolls 51 and 52. While only two rolls are shown in the figure, it is to be understood that a third roll is included which, because of the sectional view, is not shown. The frame 50 has a rotatable drive shaft 53 journalled in bearings 54 and 55 and which is concentric to the longitudinal axis of the frame. The forming rolls are inclined and skew with respect to each other and with respect to the longitudinal axis of the frame in the same manner as the embodiment shown in FIG. 1.

The roll 51 has in one end thereof an extension 56 which is journalled in a bearing 57 carried in the frame for both rotational and longitudinal movement. A bevel gear 58 is keyed to the extension by key 58' and meshes with a bevel gear 59 fixed on the drive shaft 53. Drive shaft 53 in turn has thereon a gear member 60 which is connected to a drive motor (not shown).

The extension 56 has mounted on one end thereof a thrust bearing assembly 61 which joins to a threaded shaft 62 that is keyed to a bracket 66 which in turn is mounted on frame 50. Threaded shaft 62 is held to extension 56 by means of a tie bolt 63 which is keyed to the shaft 62 and which is rotatably affixed to extension 56 by means of thrust bearing assembly 65. Shaft 62 threadingly engages a bevel gear 70 which meshes with a bevel gear 71 journalled onto shaft 53 by bearing 71'. A worm gear 72 in turn meshes with a corresponding spur section on gear 71 so that as the worm gear 72 is rotated, it will cause the gears 71 and 70 to rotate to move the threaded shaft 62 and the attached forming rolls longitudinally along their axes. In this manner, the cross-sectional area of the forming station defined by the forming rolls may be varied while the rolling mill is in operation.

The workpiece W is supported in the rolling mill by means of a rotatable tubular support 73 which is journalled in bearings 74 and 75 carried in the tubular drive shaft 53. A pulley wheel 76 is mounted on the end of the support member 73 so that the workpiece and support member 73 may be rotated to compensate for the driving force exerted on the workpiece by the forming rolls.

In addition, the rolling mill shown in FIG. 5 has therein a lubricating passage 80 in which a lubricant may flow to lubricate the various bearings 54, 55, 74, 75 or 57 and also to cool the tubular support 73. Where plastic bearings are used, the lubricant may be water. Also a support flange 81 is provided to hold the workpiece before it is inserted into the support member 73 and conventional smoothing rolls 82 are provided to support the workpiece as it leaves the forming station and enters into a receiving station (not shown) similar to that shown in FIGS. 4 and 5. The workpiece is reduced in diameter in the forming station in the same manner as in the embodiment shown in FIG. 1.

Where a mill is used such as that shown in FIG. 6 for reducing small diameter bars, it may be desirable to reheat the billets immediately before they enter into the forming station. For this reason, a high frequency electrical heating coil 83 is attached to the frame so that it surrounds the billet immediately before it enters into the forming station and so that it may reheat the billet as it moves through the mill.

It is to be understood that the mills illustrated may be changed in structural details such as adding backing rolls to provide a bearing against the forming rolls and still come within the scope of my invention which is to be limited only by the claims.

I claim:

1. A cycloidal rolling mill for reducing round work-

pieces comprising a plurality of rotatable substantially cone-shaped forming rolls bunched together to define a longitudinal extending tapered forming station with the taper of said rolls extending in the direction of passage of a workpiece through the forming station and the taper of said rolls being such that their diameters taken in first sections perpendicular to their longitudinal axes have a constant ratio with the diameters of said forming station taken in second sections perpendicular to the axis of the forming station wherein the first and second sections intercept along the edge of the forming station the longitudinal axis of each said forming roll being inclined and skew with each other and with the longitudinal axis of said forming station, rotation means for rotating said rolls to cause a workpiece to be pulled through said forming station, and roll regulation means for moving said forming rolls along their longitudinal axes to vary the cross-sectional area of said forming station.

2. A cycloidal rolling mill for reducing round workpieces comprising a frame, a beveled ring gear fixed to said frame, a rotatable member journalled in said frame concentric with said ring gear, a plurality of cone-shaped forming rolls rotatably journalled in said rotatable member, said rolls defining together a tapered forming station having a longitudinal axis concentric with said ring gear and said rotatable member and the taper of said rolls being such that their diameters taken in first sections perpendicular to their longitudinal axes have a constant ratio with the diameters of said forming station taken in second sections perpendicular to the axis of the forming station wherein the first and second sections intercept along the edge of the forming station, said rolls being mounted in said rotatable member so that their longitudinal axes are inclined and skew with each other and the longitudinal axis of said forming station, bevel gears mounted on the end of each said roll and meshing with said ring gear, drive means for rotating said rotatable member to cause said forming rolls to rotate and to pull a workpiece through said forming station, and roll regulation means for moving said rolls along their longitudinal axes to vary the cross-sectional area of said forming station.

3. A cycloidal rolling mill according to claim 2 wherein said roll regulation means comprises a first rotatable shaft threadingly inserted in an end of each said roll and extending through said bevel gear mounted on each said roll, a first regulation bevel gear mounted on the end of each said rotatable shaft, a second rotatable shaft carried in said rotatable member, an external bevel ring gear rotatably mounted on said frame concentric with the longitudinal axis of said forming station, a second regulation bevel gear mounted on said second rotatable shaft and meshing with said first regulation bevel gear, a third regulation bevel gear mounted on said rotatable shaft and meshing with said external bevel ring gear, and external bevel gear rotation means for rotating said external bevel

gear; said external bevel gear, said first and second rotatable shafts, and said first, second and third bevel gears all forming a gear train whereby when said external bevel gear is rotated by said rotation means, said first shaft will be caused to rotate and move said roll to which it is attached in a direction parallel to its longitudinal axis.

4. A cycloidal rolling mill for reducing round workpieces comprising a frame, a plurality of substantially cone-shaped forming rolls rotatably mounted in said frame with their longitudinal axes inclined and skew with each other, a tubular drive shaft rotatably mounted in said frame, a first gear mounted on said tubular drive shaft, drive gears mounted on each of said forming rolls and meshing with said first gear, said forming rolls together defining a forming section concentric with said tubular drive shaft and skew with the longitudinal axis of each said forming roll with the small end of each said cone-shaped forming roll extending in the direction of passage of a workpiece through said rolling mill and the outer peripheries of said rolls being such that their diameters taken in first sections perpendicular with their longitudinal axes have a constant ratio with the diameters of said forming section taken in second sections perpendicular to the axis of the forming section wherein the first and second sections intercept along the edge of the forming section, drive means for rotating said drive shaft to cause said forming rolls to rotate and pull a workpiece through said forming section and forming roll adjusting means for moving said forming rolls longitudinally along their axes to vary the cross-sectional area of said forming section.

5. A cycloidal rolling mill according to claim 4 wherein said forming roll adjusting means comprises a screw shaft rotatably mounted on the end of each said forming roll, a threaded bore in said frame meshing with said threaded shaft, and rotating means for rotating said shaft to cause it to move with respect to said frame.

6. A cycloidal rolling mill according to claim 4 having in addition a tubular workpiece support member rotatably mounted within said tubular drive shaft for supporting a workpiece and support member rotation means for rotating said support member in said frame.

References Cited in the file of this patent

UNITED STATES PATENTS

513,218	Tasker	Jan. 23, 1894
605,027	Stiefel	May 31, 1898
1,753,767	Asbeck	Apr. 8, 1930
1,970,121	Becker	Aug. 14, 1934
2,650,509	McGray	Sept. 1, 1953

FOREIGN PATENTS

13,760	Great Britain	Oct. 11, 1887
18,028	Great Britain	July 23, 1903