BILLET ROUGHING MILL

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Filed Apr. 25, 1967, Ser. No. 633,442

Int. Cl. B21B 21/00, 13/10; B21D 41/04

U.S. Cl. 72—189

ABSTRACT OF THE DISCLOSURE

A roughing stand adapted to work substantially the entire periphery of a billet. It is provided with peripherally disposed undriven work rolls, each of which is moved in a closed curved path toward and away from the billet by synchronized drive means. The rolls are arranged in sets, each set moves as a unit displaced in time phase with respect to other each set of rolls.

This invention has to do with the rolling of metal blooms and billets. It is more particularly concerned with apparatus for effecting a large substantially symmetrical reduction of a billet in a single pass.

My apparatus is intended to effect the rough reduction of metal billets, blooms and the like. It will be described hereinafter with reference to the hot rolling of steel billets, but it is likewise adapted to the rolling of other metals. It is conveniently employed to work all faces of a billet of conventional square cross-section in a single pass and will be so described hereinafter, but it is adapted to work all faces of billets of other prismatic forms, such as those of hexagonal cross-section, or substantially the entire surface of a cylindrical billet. My apparatus as adapted to square or rectangular billets employs two pairs of work rolls, each pair consisting of oppositely disposed rolls adapted to work opposite faces of a billet. The pairs of rolls are positioned at right angles to each other so as to work all four faces of a billet in a single pass. My work rolls are freely rotatable on their bearings and are not driven by any external source of power other than the friction exerted by the work itself in the reduction of a billet. The rolls of each pair are moved toward and away from each other in a closed curved path by individual eccentrics which in turn are driven by the mill motor.

Several embodiments of my invention are illustrated in the attached figures, to which reference is now made.

FIGURE 1 is a vertical cross-section of a first embodiment of my apparatus taken at right angles to the passline on the plane 1—1 of FIGURE 2. FIGURE 2 is a side elevation of the apparatus of FIGURE 1.

In the figures the passline 1 is identified by a broken line. The apparatus of FIGURES 1 through 4 is mounted on a frame 3, which is generally elongated in the direction of the passline 1 and is supported at its ends by legs 3 and 4. Adjacent end 3, frame 2 is formed with four pairs of outwardly projecting lugs. Lugs 5—5 project upwardly, and opposite to them lugs 6—6 project downwardly. Lugs 7—7 project to one side of frame 2, and opposite them lugs 8—8 project to the opposite side of frame 2. In FIGURE 1, lugs 7—7 are on the left and lugs 8—8 on the right side of frame 2. In lugs 5—5 is journaled a rotatable horizontal shaft 9, provided at each of its ends outside lugs 5—5 with bevel gears 10—10. In lugs 6—6 is journaled a rotatable horizontal shaft 11 which is provided at its ends outside lugs 6—6 with bevel gears 12—12. Shaft 11 continues beyond one bevel gear 12 as shaft 13, which through coupling 14, is connected to gear reducer 15, which is driven by a motor or other source of power, not shown.

In lugs 7—7 is journaled a vertical rotatable shaft 16, the ends of this shaft outside lugs 7—7 being provided with bevel gears 17—17. In lugs 8—8 is journaled vertical rotatable shaft 18, the ends of which outside lugs 8—8 are provided with bevel gears 19—19. The bevel gears affixed to the ends of the horizontal shafts 9 and 11 mesh with the bevel gears affixed to the adjoining ends of the vertical shafts 16 and 18, for example, bevel gear 10 with bevel gear 17, and bevel gear 12 with bevel gear 19.

Between lugs 5—5 horizontal shaft 9 is provided with an eccentric 21. Between lugs 6—6 horizontal shaft 11 is provided with an eccentric 22. Likewise vertical shaft 18 is provided with an eccentric 23, and vertical shaft 16 is provided with eccentric 24. Positioned above passline 1 is elongated member 26, one end 27 of which surrounds eccentric 21 and provides a journal therefor. Positioned below passline 1 is elongated member 28, one end 29 of which surrounds and journals eccentric 22. Positioned to the left of the passline is elongated member 30, one end 31 of which surrounds and journals eccentric 23. Positioned to the right of the passline 1 is elongated member 32, one end 33 of which surrounds and journals eccentric 24.

The other end 35 of elongated member 26 is pivotally connected to a link 36, which in turn is pivotally connected to projection 37 of frame 2. The other end 38 of elongated member 28 is pivotally connected to a link 39, which is pivotally connected to projection 40 of frame 2. The other end 41 of elongated member 30 is pivotally connected to link 42, which is pivotally connected to projection 43 on frame 2. The other end 44 of elongated member 32 is pivotally connected to link 45, which is pivotally connected to projection 46 of frame 2.

Intermediate its ends, elongated member 26 is formed as a channel 48, between the walls of which is journaled freely rotatable work roll 49. The open end of channel 48 faces the passline 1, and the closed end forms a guard for the work roll within it. Work roll 49 is journaled in channel 48 so that its working face 50 is adjacent passline 1 and parallel to the corresponding face of the pass. In like manner rotatable work roll 51 is journaled within the channel portion 52 of elongated member 28, so that its working face 53 is opposite working face 50 of roll 49. Freely rotatable work roll 55 is journaled within the channel portion 54 of elongated member 30, so that working face 56 is parallel to one face of the pass, and work roll 58 is journaled within channel portion 57 of elongated member 32, so that its working face 59 is opposite working face 56 of work roll 55.

The operation of this embodiment of my invention will be described with respect to the foregoing description. When power is applied to shaft 13, the arrangement of
bevel gears, which has been described causes all four shafts 5, 11, 16 and 18 to rotate in synchronism. Eccentrics 21 and 22 are fastened to shafts 9 and 11 respectively, 180° out of phase with each other, so that elongated members 26 and 28 are caused to approach the passline 1 and recede from it synchronously. Eccentrics 23 and 24 are similarly affixed to vertical shafts 16 and 18 respectively, so that elongated members 30 and 32 likewise approach the passline 1 and recede from it synchronously. The link mounting of the ends of the elongated members above mentioned permits the elongated members to move in the direction of the passline, as well as perpendicular to it. As the opposite pairs of work rolls are journaled in their respective elongated members, the rolls of each pair approach and recede from the passline synchronously. The eccentrics 21 and 22 are set 180° out of phase with the eccentrics 23 and 24 respectively, so that work rolls 49 and 53 approach the pass while work rolls 55 and 58 are retreating from it and vice-versa. In this way the billet in the pass is worked first on one pair of opposite faces and then on the other pair of opposite faces, so that it is reduced on all faces in the same pass.

It will be noted that the motion of the eccentrics causes each work roll, such as work roll 49, to approach passline 1 in a curved path and retreat from it in a second curved path parallel to the passline of work roll 49 or any other work roll thus moves in a closed curved path. As work rolls 49, 52, 55 and 58 are mounted for free rotation and are not driven by the mill motor, they are free to rotate about their axes when they make contact with the work in the pass, in the direction determined by the friction of the work roll with the material being reduced and motion imparted to the workpiece by the mill feeding and withdrawing means.

FIGURES 5 and 6 illustrate the essential elements of a second preferred embodiment of my invention. The figures show the arrangement employing single eccentrics located within freely rotating undriven work rolls, but, for clearness, do not show any framing structure, gears, or driving mechanism. These elements have been described in connection with the first preferred embodiment of my invention. The mill comprises four eccentrics disposed in two planes at right angles to each other, as in the case of the embodiment of FIGURES 1 through 4. Eccentrics 60 and 61 mounted on parallel driven shafts 62 and 63 respectively constitute one such pair. The outer rim 64 of eccentric 61 is semicircular in cross-section and forms one half of the ball race. Surrounding rim 65 is a freely rotating rim 65, which constitutes the work roll, the inner surface 66 of which is also semicircular in cross-section and forms the other half of the ball race mentioned above. The rim 65 rotates freely on eccentric 61, supported by a plurality of ball bearings 67—67 which are positioned between the ball race surfaces 64 and 66. Eccentric 60 is surrounded by a like freely rotating rim 68 which moves on ball bearings in the same manner as has been described for rim 65. The working face 70 of rim 65 is positioned on one side of the passline 1 opposite to working face 73 of rim 68. FIGURE 5 illustrates one of the second pair of eccentrics positioned in a plane perpendicular to that of eccentrics 60 and 61 previously described. This eccentric 75 supports a freely rotating rim 74 on ball bearings 67—67 in the manner described. The identical eccentric and freely rotating rim mounted thereon positioned opposite eccentric 75 are not illustrated.

The apparatus illustrated in FIGURES 5 and 6 reduces the billet in essentially the same way as that of the previously described embodiment. Shafts 62 and 63 are geared together and rotated by a driving mechanism not shown. The eccentrics 60 and 61 are set on shafts 62 and 63 respectively, so as to cause the working faces 70 and 73 of freely rotating rims 65 and 68 to approach opposite faces of the work and recede therefrom synchronously. Rims 65 and 68 rotate freely around their respective eccentrics 60 and 61, supported by the ball bearings 67—67.

The other pair of eccentrics likewise provided with freely rotatable rims and positioned in the plane perpendicular to that of eccentrics 60 and 61 rotate in the same way, driven through gearing by the same driving mechanism, but the eccentrics are so set that the working faces of the work rolls carried by them approach the billet at the same time the work faces 70 and 72 of rims 65 and 68 are receding from the billet. A third embodiment of my invention is illustrated in FIGURE 7. This embodiment is identical with my first embodiment with the exception that the working face 76 of work roll 49 is grooved. The same is true of the working faces 77, 78 and 79 of work rolls 52, 55 and 58, respectively. The working faces of the work rolls define a circular pass and the mill rolls round or cylindrical billets.

A fifth embodiment of my invention is illustrated in FIGURE 9. It is not essential that the undriven work rolls of my mill be freely rotatable through the full arc of 360°. Shaft 85 and eccentric 86 mounted thereon correspond to shaft 62 and eccentric 60 of the second embodiment of my invention illustrated in FIGURE 6. Undriven roll 87 is mounted on ball bearings 89—89 to rotate on eccentric 86. Work roll 87 is provided with a larger diameter working face 88 which extends around a portion only of its circumference. Roll 87 is restrained in its rotation by spring 90 which is positioned between one shoulder 92 of the working face 88 and frame 2, and by spring 91 which is positioned between the other shoulder 93 of working face 88 and frame 2. Springs 90 and 91 yieldingly oppose rotation of roll 87 through a large arc but do not restrain its rotation through the small arc resulting from frictional engagement of the work roll by the work.

The first preferred embodiment of my invention which I have described is desirable where work rolls of relatively small diameter are to be used. The second preferred embodiment is desirable when work rolls of relatively large diameter are to be used. As the work roll surfaces which make contact with the billet are not driven but are freely rotatable in their mountings, the operation of my mill does not feed the work through the mill. For this purpose a feeding mechanism is necessary, such as a pair of pinch rolls on one or both sides of the mill. My mill will reduce work passed through it whether the work is passed in the direction of rotation of the rolls or in the direction opposite the rotation of the rolls. Because the work rolls of my apparatus are freely rotatable and are not driven, different areas of their work surfaces are brought into contact with the work at different times, and wear on the work rolls is thus equalized.

Although I have described and illustrated the third and fourth embodiments of my invention in terms of my first embodiment, those skilled in the art will appreciate that they could be realized equally well as modifications of my second embodiment. Likewise the fifth embodiment of my invention could be based on my first embodiment rather than my second. Those skilled in the art will also appreciate that my mill is not restricted to reducing a billet of square cross-section, for example, to a billet of smaller square cross-section, but can also reduce a billet of square cross-section to one of round cross-section or to other non-square cross-section, and vice-versa.

While I prefer to use eccentrics to impart the desired motion to the work rolls of my mill and have described the various embodiments of my invention in that context, I do not intend thereby to exclude other means of effect-
ing the desired motion, such as hydraulic means, for example.

In the embodiments of my invention described herein, two sets of two work rolls each are provided. Each set of rolls is positioned with the roll axes perpendicular to a plane passing through the passline, and those planes are perpendicular to each other. For hexagonal billets my invention employs three sets of two work rolls each or two sets of three work rolls each, each roll being positioned as before with the roll axis perpendicular to a plane passing through the passline, but having the planes disposed at angles of 60° to each other. The work rolls of each set are operated to approach the work and recede from it synchronously and this cycle for each set of work rolls is displaced in time phase with respect to that of each other set. This principle may be extended to the rolling of other multidimensional shapes by symmetrical sets of rolls moving against the stock in phased synchronism.

I claim:

1. Apparatus for symmetrically reducing the thickness of a ductile billet in a single pass comprising frame means, a plurality of sets of undriven rotatable work rolls supported by the frame means, the rolls of each set being disposed symmetrically around the passline with the axis of each roll perpendicular to a plane passing through the passline, those planes for each set of rolls being disposed at equal angular intervals around the passline, and the several sets being disposed symmetrically around the passline, first means attached to the frame means causing the work rolls of a set to move in identical closed curved paths in the same direction parallel to the passline and in radially opposed directions perpendicular to the passline and second means attached to the frame means causing the paths of movement of successive sets of work rolls to be displaced in time phase with respect to each other.

2. Apparatus of claim 1 in which the work rolls are restrained to permit rotation through an arc of less than 360° and their working faces extend only over that arc.

3. Apparatus of claim 1 in which the first means comprise a rotatable eccentric provided around its circumference with antifriction bearing means on which its associated work roll rotates.

4. Apparatus of claim 1 in which the number of sets of work rolls is at least two and the work roll faces are contoured to form a circular pass.

5. Apparatus of claim 1 in which the number of sets of work rolls is at least two, and the work roll faces are contoured to form a pass which is a regular polygon having an even number of sides.

6. Apparatus of claim 1 in which the first means comprise a rotatable eccentric journalized in the frame means, an element elongated in the direction of the passline, one end of that element surrounding the eccentric and the other end of that element being attached to the frame means by third means permitting movement of the element both parallel and perpendicular to the passline, the element being provided intermediate its ends with journals for a work roll.

7. Apparatus of claim 4 in which each set consists of two work rolls.

8. Apparatus of claim 5 in which the axis of each work roll is parallel to the edge of the pass adjacent thereto.

9. Apparatus of claim 5 in which the axis of each work roll is inclined to the adjacent edges of the pass adjacent thereto.

10. Apparatus of claim 5 in which each set comprises two work rolls.

11. Apparatus of claim 6 in which the third means comprise link and pin mechanism.

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U.S. Cl. X.R.

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