July 31, 1934. W. R. CARROLL 1,968,670

METHOD OF AND APPARATUS FOR ROLLING RODS

Filed Dec. 5, 1929 5 Sheets-Sheet 1

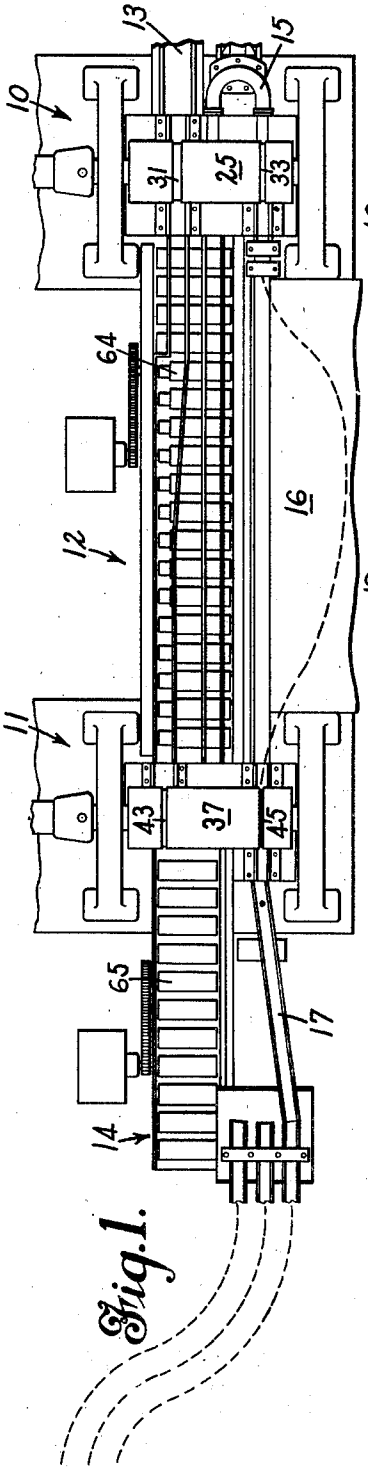


Fig. 1.

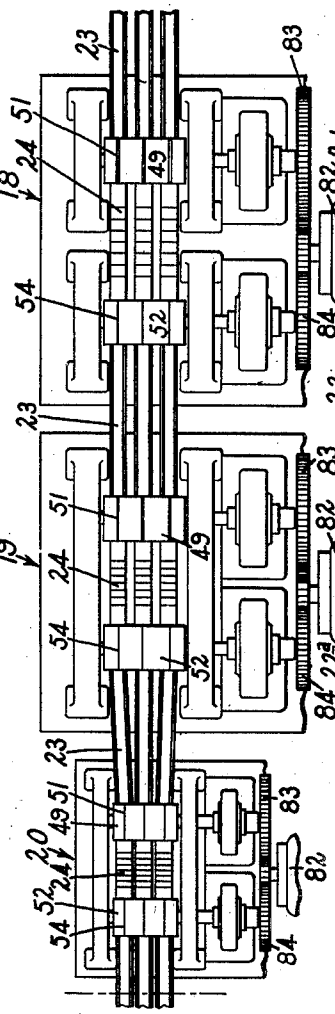


Fig. 2.

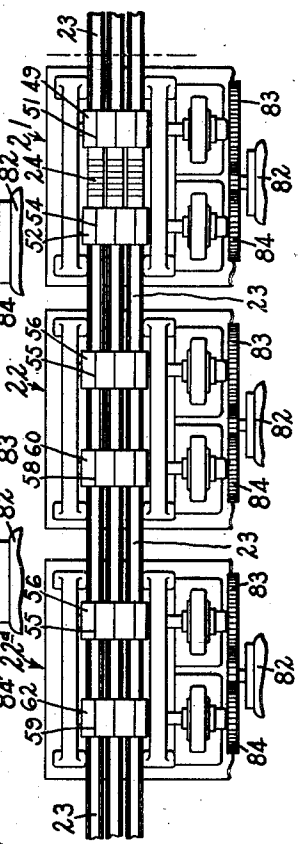


Fig. 3.

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METHOD OF AND APPARATUS FOR ROLLING RODS

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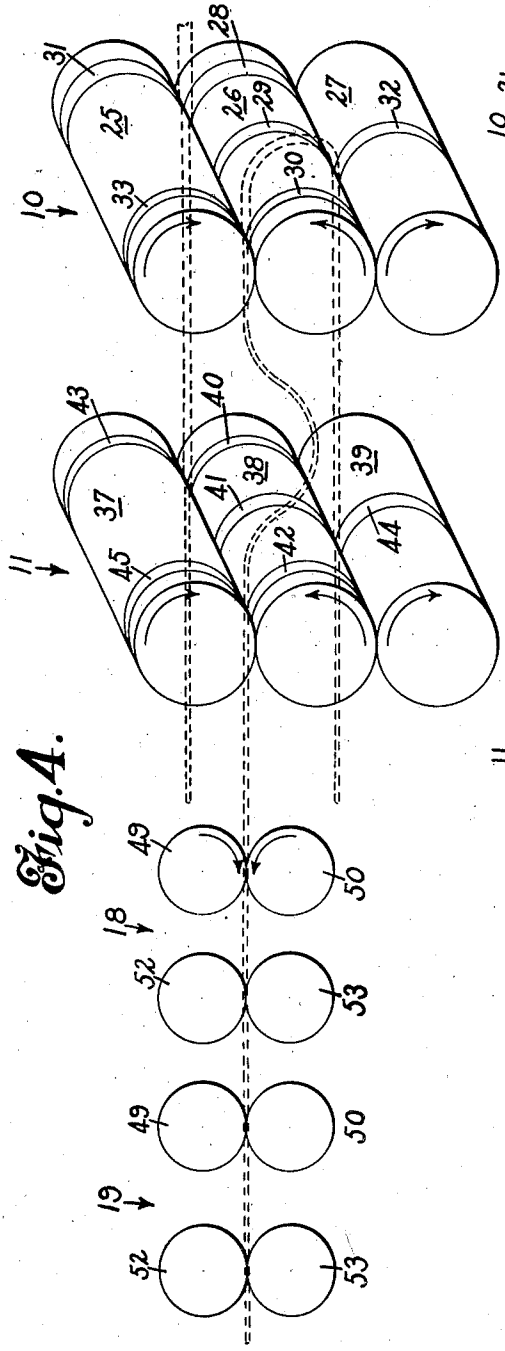


Fig. 4.

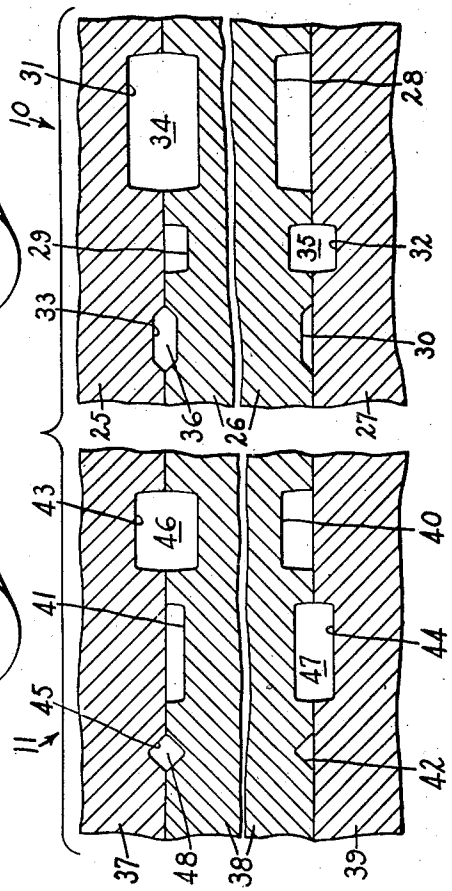


Fig. 5.

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METHOD OF AND APPARATUS FOR ROLLING RODS

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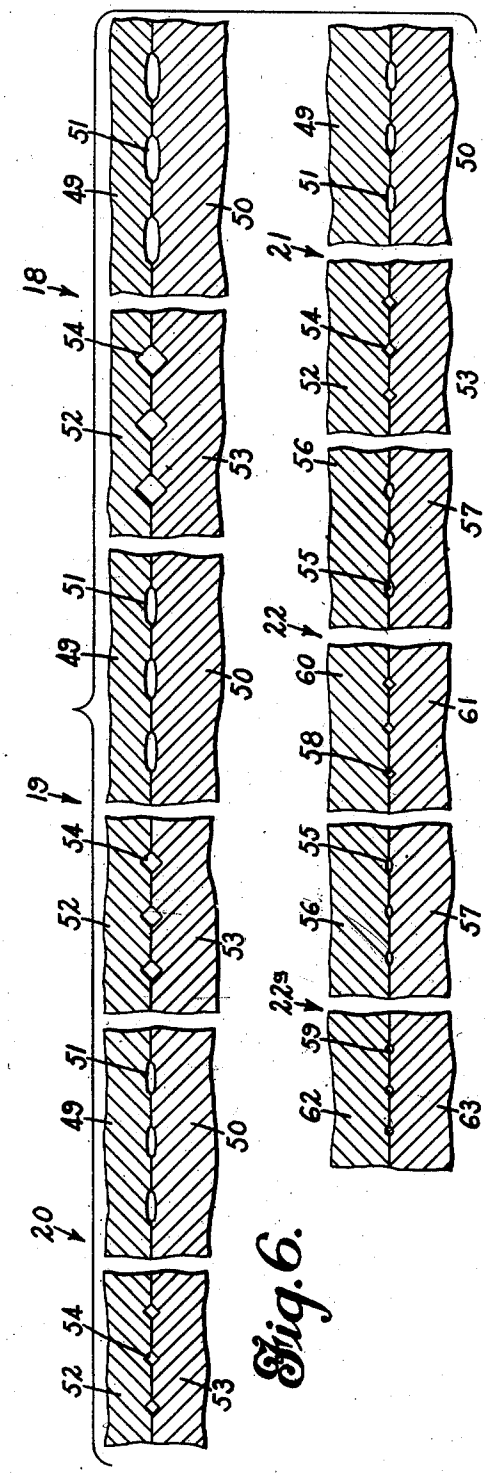


Fig. 6.

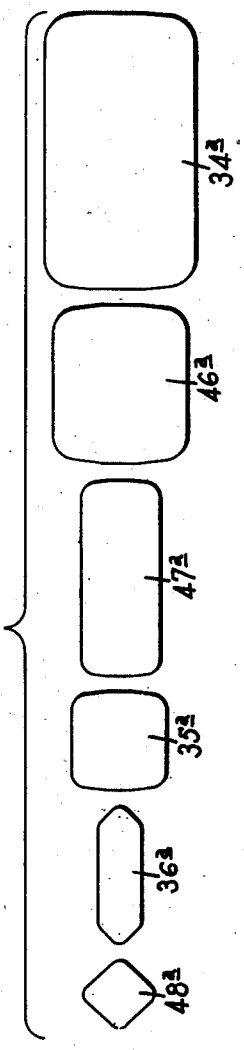


Fig. 7.

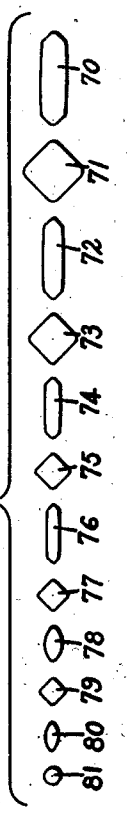


Fig. 8.

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METHOD OF AND APPARATUS FOR ROLLING RODS

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Fig. 15.

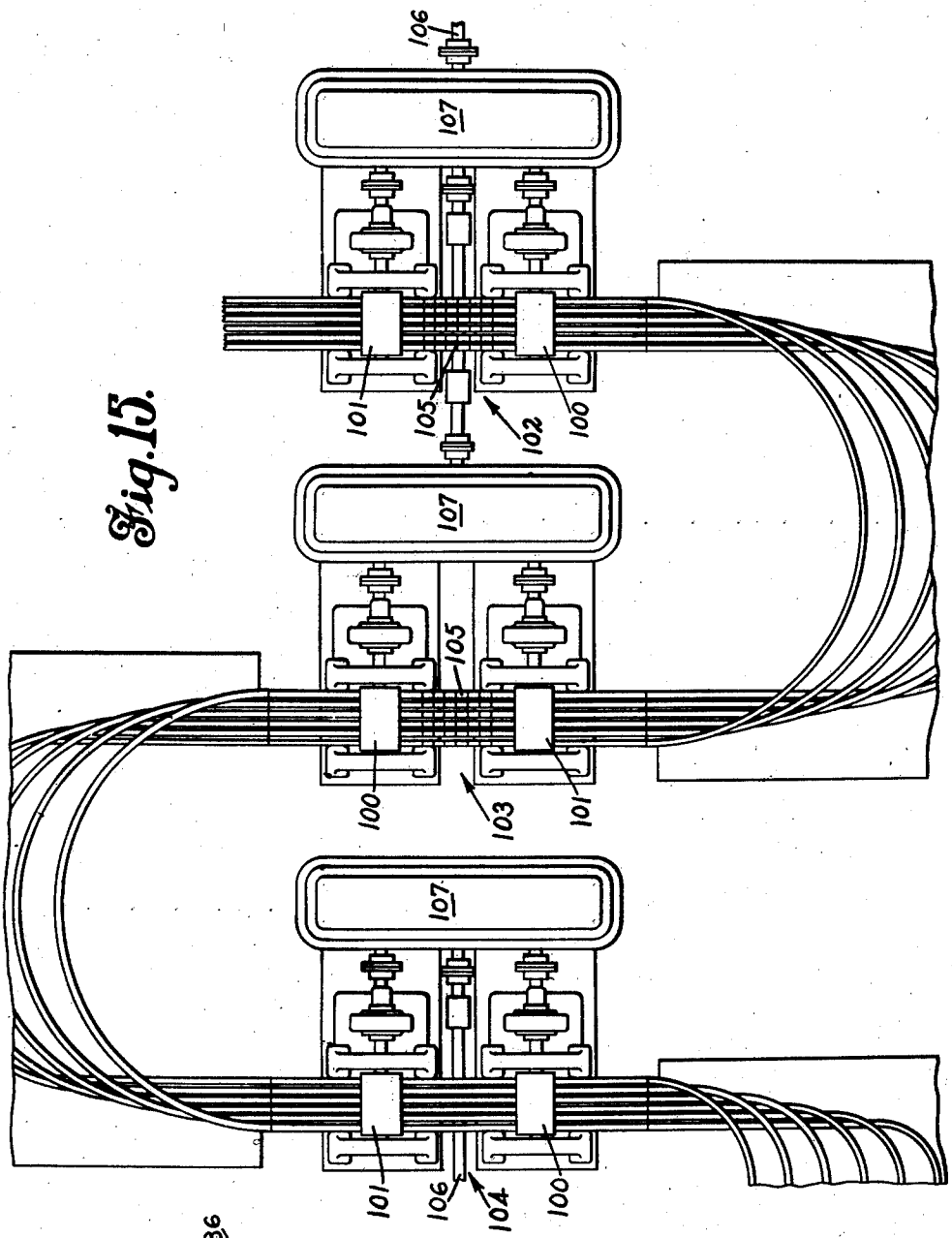
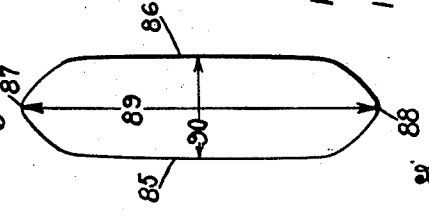


Fig. 9.



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Fig.10.

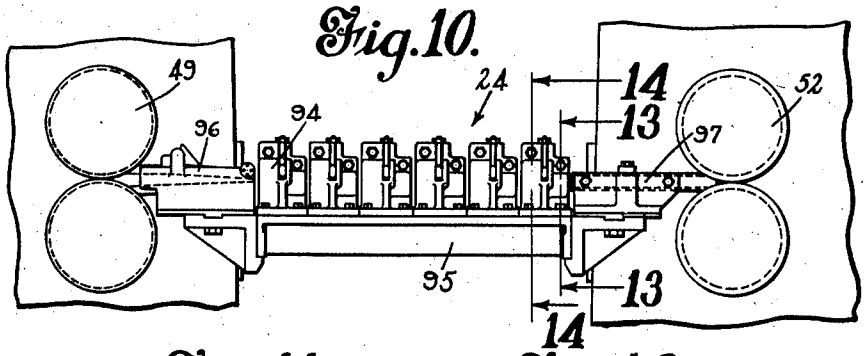


Fig.11.

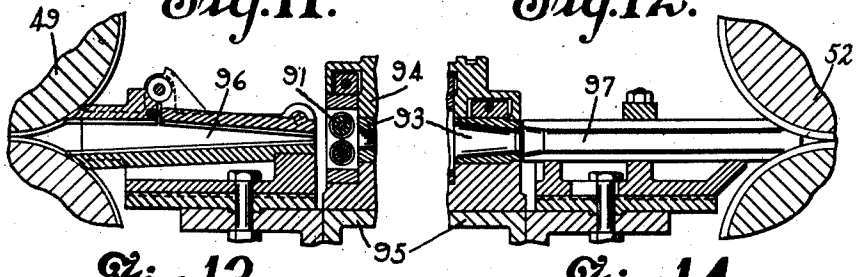


Fig.12.

Fig.13.

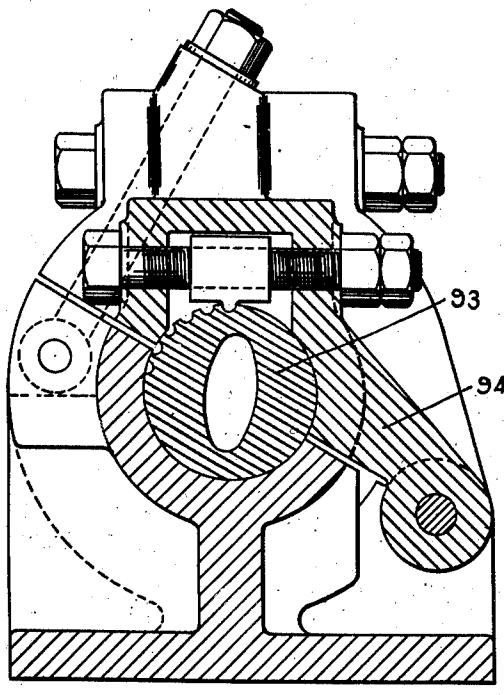
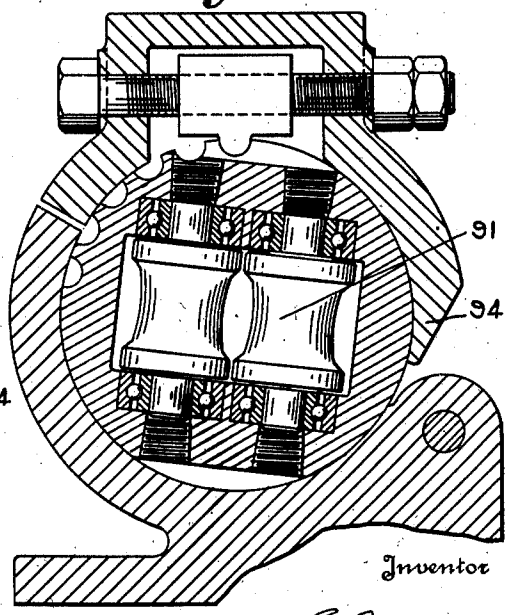


Fig.14.



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UNITED STATES PATENT OFFICE

1,968,670

METHOD OF AND APPARATUS FOR ROLLING RODS

Willard R. Carroll, New Haven, Conn., assignor to Farrel-Birmingham Company, Inc., Ansonia, Conn.

Application December 5, 1929, Serial No. 411,825

55 Claims. (Cl. 80—63)

This invention relates to rod rolling, and more particularly to a method of and apparatus for reducing a billet of metal, comparatively large in cross-sectional area, to a rod comparatively small in cross-sectional area.

The method of rolling a rod from a billet embodying the features of this invention, is particularly characterized by the fact that the bar emerging from a billet breaking-down unit, is directed substantially in a straight line between a series of pairs of cooperating rolls without looping the bars between any one of the pairs of rolls, and in the fact, that a special form of bar cross-section is provided between certain of the pairs of rolls which permits a larger reduction in the cross-sectional area of the bar by said rolls than has heretofore been possible and facilitates the movement of the bar through the mill. Certain features of the method of this invention, however, are applicable to a modified form of mill, in which loops are permitted between certain of the adjacent pairs of rolls, the bar being directed between other pairs in a straight line and without looping.

By the use of the method of rolling rods of this invention, the efficiency of a rolling mill is greatly increased, especially in respect to its capacity, simplification of its operation, increase in speed, greater reduction in cross-sectional area of the bar between adjacent sets of rolls, and a reduction in the number of pairs of rolls required, all of which tends to reduce the production cost of the product and tends to provide a comparatively large improvement in the quality of the rod produced. The formation of a particularly novel cross-sectional shape of bar by certain of the cooperating rolls, largely assists in the obtainment of the above results and particularly in the comparatively large reduction in cross-sectional area that is obtainable by the application of this method to the art of rolling rods.

One of the objects of this invention is to provide an improved method of rolling rods or the like, of comparatively small diameter from a billet of comparatively large diameter.

A further object is to provide a novel form of cross-section for a bar being rolled whereby the reduction in cross-sectional area of the bar during subsequent rolling operations thereon will be greatly facilitated.

To these and other ends, the invention consists in the novel features and steps to be hereinafter described and claimed.

In the accompanying drawings:

Fig. 1 is a plan view of a breaking-down unit of a rolling mill in which the operations of the method of this invention may be performed;

Figs. 2 and 3 together show in plan view the running down and finishing units of the rolling mill;

Fig. 4 diagrammatically illustrates the passage of a bar through the break-down unit shown in Fig. 1, and through the first four sets of rolls shown in Fig. 2;

Fig. 5 is a pair of vertical sections through the sets of rolls of the break-down unit, showing the cooperating grooves thereof;

Fig. 6 is a series of vertical sections through the various cooperating rolls of the secondary section, and showing the cooperating grooves thereof;

Fig. 7 is a series of views showing the cross-sectional shape of the product as it passes through the cooperating grooves of the break-down unit;

Fig. 8 is a series of views showing the cross-sectional shape of the bar as it passes through the cooperating grooves in the rolls of the rolling mill;

Fig. 9 is a detailed cross-sectional view of the bar during the rolling thereof;

Fig. 10 is a side elevation of a bar turning mechanism;

Fig. 11 is a vertical section of bar guiding means associated with the bar turning mechanism;

Fig. 12 is a vertical section of another bar guiding means;

Fig. 13 is a section on line 13—13 of Fig. 10;

Fig. 14 is a section on line 14—14 of Fig. 10; and

Fig. 15 is a plan view of a slightly modified form of rolling mill.

The method of rolling rods embodying the features of this invention may be performed by a rolling mill such as illustrated in Figs. 1, 2 and 3, wherein the various units thereof are arranged in alignment with the axes of the rolls in parallel.

The rolling mill illustrated by way of example generally comprises a three-high breaking-down mill unit (see Fig. 1), in which two three-roll sets of rolls 10 and 11 are provided between which is disposed suitable bar guiding means 12. A billet guiding means 13, a bar receiving table 14, a bar turning means 15, a bar loop receiving table 16, and a bar selecting and directing means 17, also form part of the breaking-down unit. Following the breaking-down unit is a secondary section comprising a series or tandem of roll units, 18, 19, 20, 21, 22 and 22^a, each comprising two sets of two cooperating rolls. Suitable bar guideways 23 are provided to direct the bar from one

unit of this continuous mill to the next. In this instance, the rolls of the duel units are each provided with three grooves to adapt them to roll three bars simultaneously, the break-down unit being of sufficient capacity to provide material therefor, the bars emerging from the break-down unit being selected and directed into the proper guideway 23 by means of the selector 17. Each of the units 18, 19, 20 and 21 is provided with a bar turning mechanism 24, which is disposed between the pairs of rolls thereof and is adapted to turn the bar gradually through approximately 90° as it traverses the space between said pairs of rolls. The bar turning mechanism is more clearly shown in Figs. 10 to 12, inclusive.

The set of rolls 10 of the breaking-down unit, comprises an upper roll 25, an intermediate roll 26, and a lower roll 27. The intermediate roll 26 is provided with grooves 28, 29 and 30, that cooperate respectively with a groove 31 in the upper roll 25, a groove 32 in the lower roll 27, and a groove 33 in the upper roll 25, to form passes 34, 35 and 36 (see Fig. 5), through which the bar is drawn during the rolling operation. The set of rolls 11 of the break-down unit comprises an upper roll 37, an intermediate roll 38, and a lower roll 39. The intermediate roll 38 of this set is provided with grooves 40, 41 and 42, that cooperate respectively with grooves 43 in the upper roll 37, 44 in the lower roll 39, and 45 in the upper roll 37 to form passes 46, 47 and 48 (see Fig. 5).

In the case illustrated there are four rolls provided in each of the tandem sets 18 to 21 inclusive, one pair or set 49 and 50 being the receiving rolls for that set and being provided with grooves 51. The other pair of rolls 52 and 53 of each set or unit are the delivery rolls thereof and are provided with grooves 54. The receiving rolls 56 and 57 of units 22 and 22ª are provided with cooperating grooves 55, and the delivery rolls 60 and 61 of the unit 22 are provided with cooperating grooves 58, while the delivery rolls 62 and 63 of the unit 22ª are provided with cooperating grooves 59. The cooperating grooves 51 formed in the receiving rolls of units 18 to 21 inclusive, are formed to shape the bar passing therethrough into a certain flattened cross-sectional form, as hereinafter more particularly pointed out, and the cooperating grooves 54 of the delivery rolls of these units are formed to shape the bar passing therethrough into a cross-sectional form which is substantially a square. Grooves 55 of the receiving rolls of units 22 and 22ª form a bar having a cross-sectional shape of an ellipse, and grooves 58 and 59 of the delivery rolls of units 22 and 22ª are square and round respectively.

The rolling mill illustrated in Figs. 1, 2 and 3, is operated by feeding a billet of material through guide 13, toward and into the pass 34 formed by cooperating grooves of rolls 25 and 26 of the break-down unit, wherein it is reduced in cross-sectional area and formed into a bar substantially rectangular in cross-section but with rounded corners, as shown at 34ª in Fig. 7. As this bar leaves the rolls 25 and 26, it falls upon the rollers 64 of the guiding means 12, and during its passage along the same is turned over upon its narrower edge before it enters pass 46, formed by grooves of rolls 37 and 38 respectively, wherein it is further reduced in cross-sectional area and is fed out over rollers 65 of the receiving table 14. While passing through the pass 46 the bar is given a cross-sectional shape that is substantially square but has rounded corners, as shown at 46ª in Fig. 7. The bar is then returned and entered into the lower pass 47 between rolls 38 and 39, and feeds along rollers 64 toward rolls 26 and 27 and into lower pass 35. As the bar passes through pass 47, it is further reduced in cross-sectional area and given a rectangular shape 47ª and as it passes through pass 35 it is given a square shape 35ª while being further reduced in cross-sectional area (see Fig. 7). As the bar emerges from pass 35 it is received in bar turning device 15 and directed forwardly into upper pass 36 whereby it is further reduced in cross-sectional area and given an elongated form 36ª, having substantially parallel sides and blunt angularly pointed ends. (See Fig. 7.)

At this point in the breaking down of the billet, the bar, due to the repeated reductions in cross-sectional area, is of considerable length and is, therefore, permitted to form a loop which extends out over table 16, as it passes from pass 36 into upper pass 48, between rolls 37 and 38. As the bar passes through pass 48 it is further reduced and again given a square cross-sectional shape 48ª, but it still has slightly round corners (see Fig. 7). The bar after passing through pass 48, enters the bar selecting and directing means 17, which is designed to direct the bar into whichever guideway 23 is empty at this time.

From any of the guideways 23, the bar is directed toward the corresponding cooperating grooves 51 in the receiving rolls 49 of the tandem unit 18. From the rolls 49 the bar passes successively through the corresponding cooperating grooves 54 of rolls 52 and 53, and grooves 51 and 54 of tandem units 19, 20 and 21, being successively formed into a flattened cross-sectional shape as at 70, and then square as at 71, and the changes in shape being continued and alternated as shown at 72 to 77 inclusive, in Fig. 8. After passing through the series of units 18 to 21 inclusive, and while it is of square profile, the bar is fed into rolls 56 and 57 of unit 22 and given an oval or elliptical cross-sectional form 78, into rolls 60 and 61 of said unit and given a substantially square form 79, into rolls 56 and 57 of unit 22ª and given an oval or elliptical form 80, and into rolls 62 and 63 of said unit and given a round form 81. After passing rolls 62 and 63, the bar may be collected in any suitable manner, as upon reels, for further disposition as required.

During its passage through the units 18 to 22ª, inclusive, the bar is forced to travel substantially in a straight line without being permitted to loop between the various sets of rolls. This is partly due to the novel arrangement of the several pairs of rolls. Each of the units 18 to 21, inclusive, comprises two pairs of rolls 49 and 50, and 52 and 53, respectively, said pairs being driven by a common motor 82 through gears 83 and 84, respectively. Gears 83 and 84, while acting as speed reducers for the rolls, are also adapted to drive one pair of rolls, for instance rolls 52 and 53, faster than rolls 49 and 50. The speed ratio between these pairs of rolls is such that the bar passing from one to the other will remain substantially taut, the preference being to permit a small per cent. of slippage of the rolls 52 and 53 upon the bar rather than to permit the bar to loop between these pairs of rolls. The speed ratio between the pairs of rolls is determined by the relative reduction in cross-sectional area of the bar. A certain reduction in area takes place between the rolls 49 and 50, whereby the bar is increased in length. This increased length necessitates that the rolls 52 and 53 rotate faster in order to pass this extra length of bar without

permitting it to loop. By arranging the rolls in sets of two pairs and operating them as above stated it is only necessary to maintain four rolls in exact diameter with each other. The bar is not permitted to loop between units or tandems due to an arrangement in the control mechanism of the various motors whereby the speed of the rolls of one unit may be automatically increased or decreased and without changing the ratio between the pairs of rolls thereof, in order to maintain a bar passing from one unit to the other in a taut condition, slight slippage of the receiving pair of rolls of each unit upon the bar being permitted if desired.

The bar emerging from the several receiving pairs of rolls 49 and 50 of the units 18 to 21 inclusive, is of a novel elongated or flattened cross-sectional shape, the shape being such that the bar may be readily and efficiently turned, from the position in which it emerges from these rolls, (in this particular case with its major axis substantially horizontal) substantially 90° before it enters between the next pair of rolls 52 and 53, and such as to facilitate its entering between said rolls. This cross-sectional shape is illustrated in Fig. 9 and generally comprises an elongated figure or form having substantially flat sides 85 and 86 and blunt pointed ends 87 and 88. Broadly considered, this form approaches a rectangular shape with V-shaped pointed ends. More specifically, the bar cross-section has a shape wherein the length of the major axis 89 is approximately three times that of the minor axis 90, the longer sides of the figure being substantially flat and disposed generally parallel to each other, although in the preferred form the sides are cambered or very slightly crowned. The blunt pointed ends 87 and 88 are defined by lines preferably V-shaped, the arms of the V's being substantially at right angles to each other. The arms of the V are, however, preferably cambered or slightly crowned and the apex is slightly rounded and the ends of the V merge into the sides 85 and 86. The axes of the V's are in alignment with the median line of the bar and with each other and substantially parallel to the bar faces. The substantially parallel faces of the bar make it easier to guide the same between adjacent sets of rolls and the change from the square to the elongated shape and vice versa during reduction can be very readily effected and secures a comparatively large reduction economically and efficiently.

It will be observed that the alternate changes of cross-section shown in Figs. 7 and 8 can be effected very readily and with a minimum lateral displacement of metal. The passes are such as to produce maximum elongation with minimum spread. It will be noted that in changing from cross-section 35^a to cross-section 36^a, the bar is compressed in a vertical direction (Fig. 7) to spread it and form the pointed side edges that are substantially right angled. In the change from 36^a to the square 48^a, the rectangularly angled corners or blunt V-shaped edges are preserved, the principal change in cross-section being in condensing and relatively thickening the middle part of the bar body. Similar operations take place in changing from shape 70 to shape 71, and so on, it being merely necessary to twist the bar through 90° between the production of the flattened sections and the production of the squares, and it being unnecessary to twist the bars intermediate the formation of the squares and the formation of the flattened sections immediately following. The changes from flats to squares take place (in the intermediate mill section in this instance) in the dual units of the tandem where the rolls of the dual units are geared together and under positive control, preferably such as to exert tension on the bar; whereas between the dual units the bar is square, which enables it to be very readily and effectively guided by simple mechanical means from one unit to the next without any special equipment for turning it upon its axis. As it emerges from the square-forming rolls the square bar, having one of its diagonals vertically disposed, has a tendency to turn and does turn of itself through 45° so that in entering the next unit two of its sides will be substantially horizontal. In the process described it will be observed that the bar is rolled alternately into a square cross-section and into an elongated cross-section having two substantially rectangularly angled pointed side edges and substantially parallel upper and lower faces, and two opposite rectangularly angled portions of the cross-section are maintained substantially unchanged in contour in rolling from one of said cross-sections to the other, whereby the spread of the metal is decreased as compared to other processes and considerably increased elongation can be obtained.

The flattened parallel sides 85 and 86 of the bar greatly facilitate the guiding of the bar through the turning mechanism 24, which is provided between the pairs of rolls of each unit, and the pointed ends 87 and 88 facilitate the entering of the bar into the bite of the subsequent pair of rolls, the particular shape as a whole lending itself especially well to the accomplishment of unusually large reductions in relatively few passes.

By the use of the cross-sectional shapes above described, reductions of 40% and in some cases as high as 63% in the cross-sectional area of a bar, have been obtained under conditions wherein a reduction of 20% had previously been considered the limit.

The bar turning mechanism 24 preferably consists of a guide disposed between adjacent sets of rolls and presenting a straight passageway for the material from one set to the other, said guide having adjustable parts enclosing the bar and conforming to it in profile. The turning mechanism may comprise a plurality of pairs of angularly adjustable rollers 91, each pair having an angularly adjustable guiding member 93 associated therewith, each pair of rollers and its associated guiding member being mounted in a separate housing section 94. The sections 94 are mounted in alignment upon a beam 95 extending between the adjacent sets of rolls 49 and 52 of each unit. Each pair of rollers 91 and each member 93 is individually adjustable about its longitudinal axis so that a bar entering the first set of these devices will be slightly turned and while passing between the rollers and guiding members of subsequent sets will be progressively turned or twisted about its axis until it reaches a position substantially 90° from its initial position in the guideway. The peripheries of the rollers 91 are grooved to substantially fit the cross-sectional shape of the bar, especially at its flattened sides 85 and 86, this form being relatively easy to provide and maintain upon the rollers 91, it being important that the opening between the rollers substantially fits the bar to prevent relative movement therebetween other than the longitudinal movement of the bar therethrough, in order not to affect prejudicially the condition of the bar surface. Bar guiding members 96 receive the bar from one set of rolls

49, and guide it toward the first set of turning devices, and after passing through the several sets, the bar is directed by a bar guide 97 into the bite of the set of rolls 52. This guide mechanism, as I prefer to construct it, is described and claimed in my copending application, Serial No. 411,826 filed December 5, 1929, but other turning mechanism may be used, or the turning effected manually in some cases.

In the modified form of mill shown in Fig. 15, the bar is permitted to loop between the delivery rolls 100 and the receiving rolls 101 of each of the tandems 102, 103 and 104. The bar has a cross-sectional form of a square between the tandems where it is permitted to loop (the square form being easily handled) but is given a cross-sectional shape similar to that above described and shown in Fig. 9, by the receiving rolls 101, being directed in a straight line from these rolls to rolls 100 without permitting it to loop. The bar of special elongated cross-section when passing from rolls 101 to rolls 100 is readily turned as in the former case 90° by the use of turning guides 105. The advantage in the use of such a cross-sectional shape for the bar may, therefore, be provided in a loop mill especially one in which the rolls are arranged in units of two pair each, through which the bar is fed in a straight line. The rolls of each of the tandems 102, 103 and 104 are driven by means of a common drive 106 operating through gearing similar to that above described, which is housed in gear housings 107. A definite ratio of speed is provided between the pairs of rolls of each tandem by this gearing in order to maintain the bar taut between the receiving rolls 101 and the delivery rolls 100.

I do not claim herein the particular construction of the turning guides or other features claimed in my application, Serial No. 411,826, above identified.

While I have shown and described a preferred manner of carrying out my invention, it will be understood that it is not to be limited to all the details shown but is capable of modification and variation within the spirit of the invention and the scope of the appended claims.

What I claim is:

1. The method of rolling a rod from a billet, which comprises passing the billet through the rolls of a break-down unit to form a bar and then passing the elongated bar so formed between sets of rolls to give the bar by one set of rolls a cross-sectional shape having substantially flat parallel sides and blunt pointed ends and by another set of rolls a shape substantially rectangular in cross-section with two of its corners formed by said blunt pointed ends.

2. The method of rolling a rod from a billet, which comprises passing the billet through the rolls of a break-down unit to form a bar and then passing the elongated bar so formed successively in approximately a straight line through a series of pairs of cooperating rolls to alternately give the bar a cross-sectional shape having substantially flat parallel sides and blunt pointed ends, and a square shape.

3. The method of rolling a rod from a billet, which comprises passing the billet through the rolls of a break-down unit to form a bar and then passing the elongated bar so formed successively in approximately a straight line through the rolls of a series of units, each comprising pairs of rolls, to give the bar an elongated cross-sectional shape having substantially flat parallel sides when the same enters said units and a substantially square cross-sectional shape when emerging from said units.

4. The method of rolling a rod which comprises breaking down a billet of rod material into a bar substantially square in cross section, and changing the cross-sectional shape of this bar to an elongated form having substantially parallel sides, the major axis of which is greater than the diagonal across the corners of the preceding square form and then repeating the alternation in cross-section as the reduction progresses.

5. The method of rolling a rod which comprises breaking down a billet of rod material into an elongated bar, and then alternately changing the cross-sectional shape of this bar from an elongated to substantially a square form and having substantially parallel sides and blunt pointed ends, the major axis of which is greater than the diagonal across the corners of the preceding square form while passing the bar substantially in a straight line and without permitting it to loop between the rolls.

6. The method of rolling a rod which comprises breaking down a billet of rod material into an elongated bar, and changing the cross-sectional shape of this bar from a substantially square form to an elongated form having a major axis approximately three times the length of its minor axis, with the long sides thereof substantially flat and parallel to each other, and blunt pointed ends.

7. The method of rolling a rod which comprises breaking down a billet of rod material into an elongated bar, and changing the cross-sectional shape of this bar from a substantially square form to an elongated form having a major axis approximately three times the length of its minor axis, with the long sides thereof substantially flat and parallel to each other, and with its end portions of V-shape.

8. In the method of rolling rods, the step which consists in rolling a bar substantially square in cross-section into an elongated cross-sectional form whose major axis is approximately three times the length of its minor axis, the long sides being substantially flat and parallel to each other, and said form having blunt pointed ends, and then further reducing the bar.

9. In the method of rolling rods, the step which consists in rolling a bar substantially square in cross-section into an elongated cross-sectional form, the wide opposite sides of which are slightly convex, with V-shaped ends slightly rounded, and then further reducing the bar.

10. The method of rolling a rod which comprises rolling a bar from substantially a square cross-section to an elongated cross-sectional form having substantially parallel sides and blunt pointed ends, one of its axes being greater in length than the diagonal across the corners of the preceding square form and then rolling that shape into a square.

11. The method which comprises rolling a bar from a square cross-section having rounded corners to an elongated substantially parallel sided cross-sectional shape in which two of the rounded corner shapes reappear in the elongated shape and wherein one of the axes thereof is greater in length than the diagonal across the rounded corners of the preceding square cross-section.

12. The method which comprises rolling a cross-sectional shape which is square, and then rolling the square into a flat that is longer than the diagonal across the corners of the preceding square shape and in which two of the corner

shapes of the square appear at the respective edges of the bar.

13. The method of rolling a rod which comprises breaking down a billet into a bar, rolling the bar into square cross-sectional shape, rolling the square into an elongated cross-section, and then rolling the elongated cross-section back into a square and maintaining tension on the bar during the rolling of the elongated cross-section.

14. The method of rolling a rod which comprises rolling a bar whose width is approximately three times its thickness, with substantially right-angled edges whose apices are in line with the median line of the bar, and rolling the bar into a square cross-section while substantially maintaining the contour of the edge portions.

15. The method of rolling a rod which comprises rolling a substantially parallel faced bar whose width is approximately three times its thickness, with substantially right-angled edges whose points are in the median line of the bar, and rolling the bar into a square cross-section while substantially maintaining the contour of the edge portions, by engaging such edge portions in opposite roll grooves and compressing the bar.

16. The method which comprises producing a bar presenting four substantially right-angled corners, and then elongating the bar cross-section by exerting rolling compression on two opposite faces to maintain substantially parallel faces and shaping the edges to right angular bevels, the compression of the bar section being continued until it has a width more than twice its thickness.

17. The method of rolling which comprises entering a bar between rolls which give it an elongated substantially parallel faced cross-section, then, while the bar is still engaging the first rolls, entering it between rolls which form it into a square cross-section, and twisting the bar through substantially 90° as it passes from the first to the second rolls.

18. The method of rolling which comprises entering a bar between rolls which give it an elongated flattened cross-section, then, while the bar is still engaging the first rolls, entering it between rolls which form it into a square cross-section, and maintaining tension upon that part of the bar intermediate the two sets of rolls.

19. The method of rolling which comprises entering a bar between rolls which give it an elongated flattened section with the elongation substantially in the line of the roll bite, twisting the bar through substantially 90° while it is still engaged with the first rolls, entering it in the bite of a second pair of rolls which engage the edges of the flat shape and condense it into substantially square shape, and maintaining tension on that portion of the bar which is being twisted.

20. The method of rolling which comprises rolling a bar into square cross-section, introducing this section into a flattened roll pass and elongating the cross-section to form a flat while creating opposite rectangularly angled corners, twisting the emerging bar through substantially 90°, and entering its end into a roll pass which compresses the bar, by acting on opposite corners of the flat while substantially preserving the contours of such corners, to form a square.

21. The method of rolling rods which comprises rolling a bar into square cross-section, introducing this section into a flattened roll pass and elongating the cross-section to form a flat while creating rectangularly angled corners at the bar edges, twisting the emerging bar through substantially 90°, and entering its end into a roll pass which compresses the bar, by acting on opposite edges of the flat while substantially preserving the contours of such edges, to form a square, the twisting being effected while the bar still engages the first roll pass, and maintaining tension on the bar during the twisting.

22. The method of rolling a rod which comprises breaking down a billet by alternately rolling flats and squares and repeating the alternation a number of times after the billet has been broken down into a bar, a number of the flats presenting V-shaped edges and substantially parallel faces, then rolling one of the squares into an oval and the oval into a round.

23. The method of rolling a rod which comprises alternately rolling rectangles and squares, rolling a square into a flat having V-shaped edges substantially rectangularly angled, rolling this flat into a square and the square back into a smaller but similar flat cross-sectional shape, continuing this alternation a number of times, and finally rolling a square into a round.

24. The method of rolling a rod which comprises alternately rolling rectangles and squares, rolling a square into a flat having V-shaped edges, rolling this flat into a square and the square back into a similar flat cross-sectional shape, and continuing this alternation a number of times and finally rolling a square into a round by operations which include the formation of relatively small ovals.

25. The method of rolling a rod which comprises alternately rolling rectangles and squares, rolling a square into a flat having V-shaped edges, rolling this flat into a square and the square back into a similar flat cross-sectional shape, and continuing this alternation a number of times and finally rolling a square into a round by operations which include the formation of relatively small ovals, several of the flats preceding the ovals having substantially parallel faces merging into the pointed edges.

26. The method of rolling a rod which comprises rolling a billet to form alternately rectangles and squares, rolling one of the squares into a flat having pointed side edges, rolling this flat into a square, rolling the square into a flat and that flat into a square and continuing the alternation of flats and squares a number of times until a square of considerably reduced cross-section is formed, and rolling that square into an oval and the oval into a round, a number of the flats of smaller cross-section having side edges which are pointed and present substantially right angles.

27. The method which comprises rolling a bar from a square cross-section having rounded corners to a cross-sectional shape having substantially rectangularly angled side edges and which is longer in one dimension than the diagonal across the rounded corners of the preceding square cross-section, and then rolling that cross-section back into a square while substantially preserving the contours of the rectangularly angled edges.

28. The method which comprises rolling a bar of a cross-section having substantially rectangularly angled pointed side edges and which is larger in one dimension than in the other into a square cross-section the diagonal across the corners of which is longer than the small dimension of the preceding cross-section while substantially preserving such rectangularly angled side edges.

29. The method of rolling a rod which comprises breaking down a billet into a bar, rolling the bar into square cross-sectional shape, rolling the square into an elongated cross-section having substantially right-angled pointed edges, by pressure upon opposite sides of the square shape, turning the elongated shaped bar about its axis, and then rolling the elongated cross-section back into a square by pressure upon its pointed edges.

30. The method of rolling rods which comprises rolling a bar cross-section of elongated shape having substantially rectangularly angled pointed edge portions disposed symmetrically with respect to the median line of the cross-section, then turning the bar about its axis, and engaging the edge portions in opposite roll grooves and condensing the bar section to form substantially a square cross-section while maintaining the contour of such edge portions substantially unchanged.

31. The method of rolling a rod which comprises rolling a bar into an elongated cross-sectional form having substantially flat faces and substantially rectangularly angled pointed side edges, rolling that form into a square while maintaining the rectangularly angled side edges so that they constitute the corners of the square, and then rolling the square back into an elongated cross-section having substantially flat faces and substantially rectangularly angled pointed edges by exerting pressure on opposite faces of the square to spread it laterally and form rectangularly angled side edges thereon.

32. The method of rolling a rod which comprises rolling a bar into a square cross-section and then flattening the square by pressure on opposite faces thereof to change the bar cross-section into an elongated shape having pointed side edges, and then rolling the elongated shape into a square.

33. The method of rolling rods which comprises rolling a bar cross-section of elongated shape having rectangularly angled pointed edge portions disposed symmetrically with respect to the median line of the cross-section, engaging the edge portions in opposite rolling grooves and condensing the bar section to form a square while maintaining the contour of such edge portions substantially unchanged, and then exerting pressure on opposite faces of the square to laterally elongate the cross-section and form substantially rectangularly angled edges at the sides of the flattened bar.

34. The method of rolling rods which comprises rolling a bar alternately into a square cross-section and into a laterally elongated cross-section having substantially rectangularly angled pointed side edges and substantially parallel faces by alternately engaging the opposite pointed side edges and opposite faces of the square and applying pressure thereon.

35. The method of rolling rods which comprises forming a bar cross-section of substantially rectangular shape, feeding the bar between rolls that engage and press the bar upon opposite faces thereof to flatten the same and increase the dimension between the other opposite faces thereof, and which form rectangularly angled side edges on and reduce the cross-sectional area of the bar, turning the bar upon its longitudinal axis, and then engaging the rectangularly angled side edges and by pressure thereon bulging out the flattened sides of the bar to form a square cross-section while again reducing the cross-sectional area of the bar.

36. The method of rolling rods which comprises forming a bar cross-section of substantially rectangular shape, feeding the bar between rolls having shallow elongated grooves therein which engage and press the bar upon opposite faces thereof to flatten the same and increase the dimension between the other opposite faces thereof, and which form rectangularly angled side edges on and reduce the cross-sectional area of the bar, turning the bar upon its longitudinal axis, and then feeding the bar between rolls having opposing V-shaped grooves therein which engage the rectangularly angled side edges and by pressure thereon bulge out the flattened sides of the bar to form a square cross-section while again reducing the cross-sectional area of the bar.

37. The method of rolling a rod which comprises rolling a bar into an elongated cross-sectional form having substantially flat faces and substantially rectangularly angled pointed side edges, turning the bar about its axis and rolling that form into a square by pressure upon and while maintaining the rectangularly angled side edges so that they constitute corners of the square, and then rolling the square back into an elongated cross-section having substantially flat faces and substantially rectangularly angled pointed edges by exerting pressure on opposite faces of the square to spread it laterally and form rectangularly angled side edges thereon.

38. The method of rolling rods which comprises rolling a bar cross-section of elongated shape having rectangularly angled pointed edge portions disposed symmetrically with respect to the median line of the cross-section, turning the bar about its axis, and engaging the edge portions in opposite rolling grooves and bulging the bar at the sides thereof to form a square shape while maintaining the contour of such edge portions substantially unchanged, and then exerting pressure on opposite faces of the square to elongate the cross-section and form a flattened bar having substantially rectangularly angled edges.

39. The method of making a rod or like article which involves the rolling of a bar of square cross-section upon opposite flat sides thereof to form a bar at least twice as wide as it is thick, having flattened faces and pointed edges, and then rolling that shape back into a square.

40. The method of making rods and like articles which comprises passing a bar of square cross-section through a roll bite with two sides of the square parallel to the roll axes and thereby forming a thinner wider bar, twisting the emerging end of the bar through approximately 90°, and then introducing it in that position into another roll bite and rolling the bar into another smaller square cross-section.

41. The method of making a rod or like article which comprises passing a bar through a roll bite so that it emerges as a square having two of its opposite corners substantially in a line parallel to the roll axes, permitting the bar to turn so that one flat face is uppermost and another lowermost, and then exerting rolling pressure on the upper and lower flats of the square and producing a wider thinner shape having pointed side edges.

42. The method of making a rod or like article which comprising rolling a bar to produce a square issuing from the rolls having one diagonal substantially at right angles to the roll axes, permitting the bar to turn itself to a position in which two opposite flats are substantially parallel

to said axes, and in that position introducing the bar between rolls which flatten and widen it.

43. The method of making a rod or like article which comprises rolling a bar to produce a square issuing from the rolls having one diagonal substantially vertical, permitting the square to turn itself to a position in which two opposite flats are substantially vertical, and in that position introducing the bar between horizontal rolls which flatten and widen it by exerting rolling pressure on the other flats and pointing up the lateral margins.

44. The method of reducing a billet to a rod or other shape of small cross-section which involves the repeated alternation of rolling a square section by exerting pressure in opposite directions on opposite parallel faces thereof into an elongated section of considerable width relatively to its thickness, and the rolling of such elongated section back into a square section.

45. The method of reducing a billet to a rod of small cross-section which involves the repeated alternation of the following steps, to wit, rolling a square cross-section into an elongated cross-section by exerting pressure upon opposite faces of the square and compressing it until its width is at least twice its thickness, and turning the emerging end of the bar and entering it between rolls which exert pressure on its opposite side edges so as to roll the elongated cross-section back into a square.

46. The method of rolling a rod from a billet, which comprises passing a bar through a series of pairs of cooperating rolls to alternately give the bar a square shape and an elongated cross-sectional shape whose width is at least twice its thickness and having substantially flat parallel sides and pointed side edges.

47. A rolling mill for reducing a billet to a bar of small cross-section, comprising a plurality of sets of roll tandems which alternately roll a square cross-section into a flat and a flat into a square cross-section, each tandem comprising a receiving pair of rolls which roll the flats and a discharging pair of rolls which roll the squares, the rolls of each tandem being so geared together that the stock passes from the receiving rolls of each tandem to the discharging rolls thereof under tension, and separate prime movers for driving said tandems independently.

48. A rolling mill for reducing a billet to a rod of small cross-section, comprising a number of roll tandems, each having a receiving pair of rolls and a discharging pair of rolls, the discharging rolls of one tandem adapted to feed the stock to the receiving rolls of the next tandem, the receiving rolls of each tandem being adapted to roll flats and the discharging rolls of each tandem being adapted to roll the flats into squares, and means intermediate the receiving and discharging rolls of each tandem for turning the advancing end of the bar on its axis so that the flattened bar is turned through substantially 90° before being presented to the square-forming rolls.

49. A rolling mill comprising a plurality of sets of roll tandems, each tandem having a pair of receiving rolls and a pair of discharging rolls, the discharging rolls in one tandem adapted to feed the stock to the receiving rolls of the next tandem, said rolls being grooved so that the receiving rolls flatten a square cross-section and the discharging rolls square a flattened cross-section.

50. A rolling mill comprising a plurality of sets of roll tandems, each tandem having a pair of receiving rolls and a pair of discharging rolls, the discharging rolls in one tandem adapted to feed the stock to the receiving rolls of the next tandem, said rolls being grooved so that the receiving rolls flatten a square cross-section and the discharging rolls square a flattened cross-section, and turning guides interposed between the receiving rolls and the discharging rolls of each tandem.

51. A rolling mill comprising a plurality of sets of roll tandems, each tandem comprising a pair of receiving rolls and a pair of discharging rolls, the receiving rolls of each tandem being geared to the discharging rolls thereof, but the rolls of each tandem being free of connection with the other tandems, separate prime movers for driving the tandems independently, turning guides interposed between the receiving rolls of each tandem and the discharging rolls thereof, and straight guides interposed between the tandems for conducting the bar from one tandem to the next.

52. A rolling mill for reducing a billet to a bar of small cross-section comprising a plurality of sets of roll tandems, each tandem comprising a receiving pair of grooved rolls which roll a square rod section into a flat and a discharging pair of grooved rolls which roll the flats into squares, the axes of the receiving rolls being parallel to the axes of the discharging rolls, the rolls of each tandem being so geared together that the stock passes from the receiving rolls to the discharging rolls under tension, and separate prime movers for driving said tandems independently.

53. A rolling mill for reducing a billet to a bar of small cross-section comprising a plurality of sets of roll tandems, each tandem comprising a horizontally disposed grooved receiving pair of rolls which roll square rod sections into flats and a horizontally disposed grooved discharging pair of rolls which roll the flats into squares, the rolls of each tandem being so geared together that the stock passes from the receiving rolls to the discharging rolls under tension, turning guides between the receiving and discharging rolls respectively of each tandem which twist the bar, straight guides between the tandems for guiding the bar from one tandem to another, and separate prime movers for driving the tandems independently.

54. The method which comprises rolling a bar of a cross-section having substantially rectangularly angled pointed side edges and which is at least twice as wide as it is thick into a square cross-section by exerting pressure on the bar edgewise, turning the bar, and then rolling the square cross-section back into a cross-section which is the same as the first-mentioned cross-section but smaller by exerting pressure upon opposite parallel faces of the square and pointing up the side edges of the thinned bar.

55. The method of rolling a rod which comprises exerting pressure in opposite directions upon opposite parallel faces of a bar of rectangular cross-section and simultaneously shaping up the resulting side edges of the thinned bar into points.

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