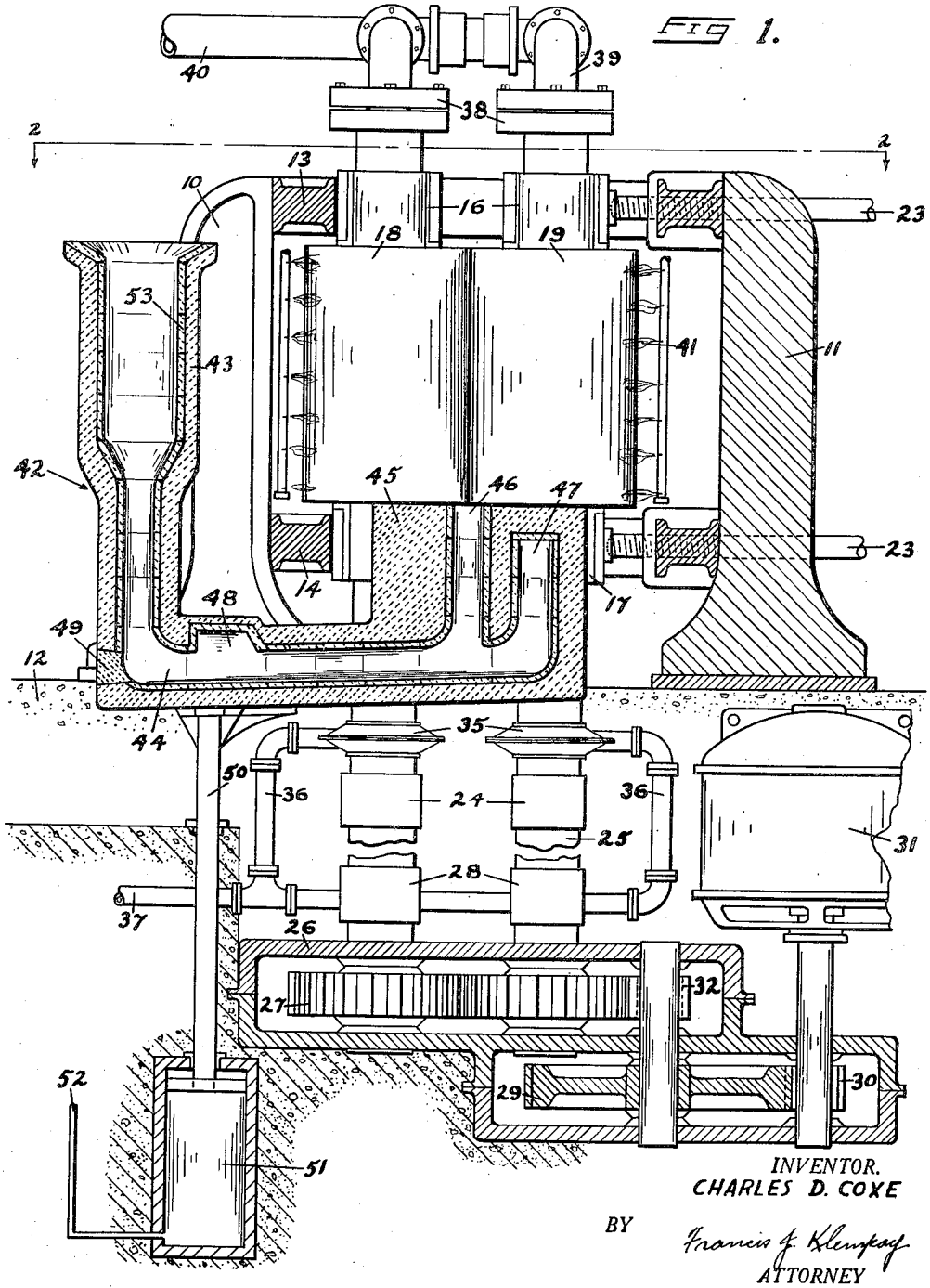
Dec. 12, 1939. C. D. COXE 2,183,010

DIRECT ROLLING OF HOT METAL

Filed Nov. 28, 1936 4 Sheets-Sheet 1

Fig 1.



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BY

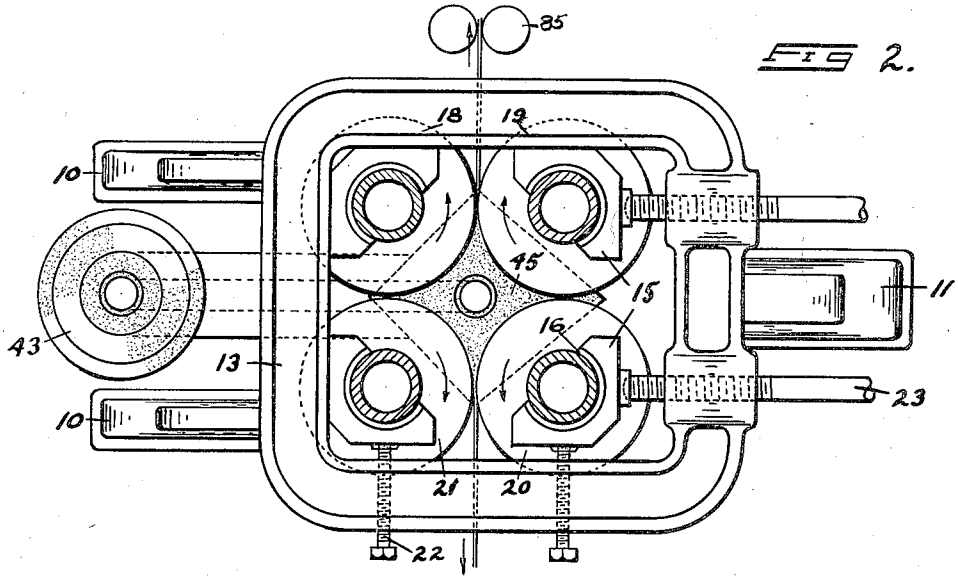
Francis J. Klempay
ATTORNEY

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DIRECT ROLLING OF HOT METAL

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Fig 2.



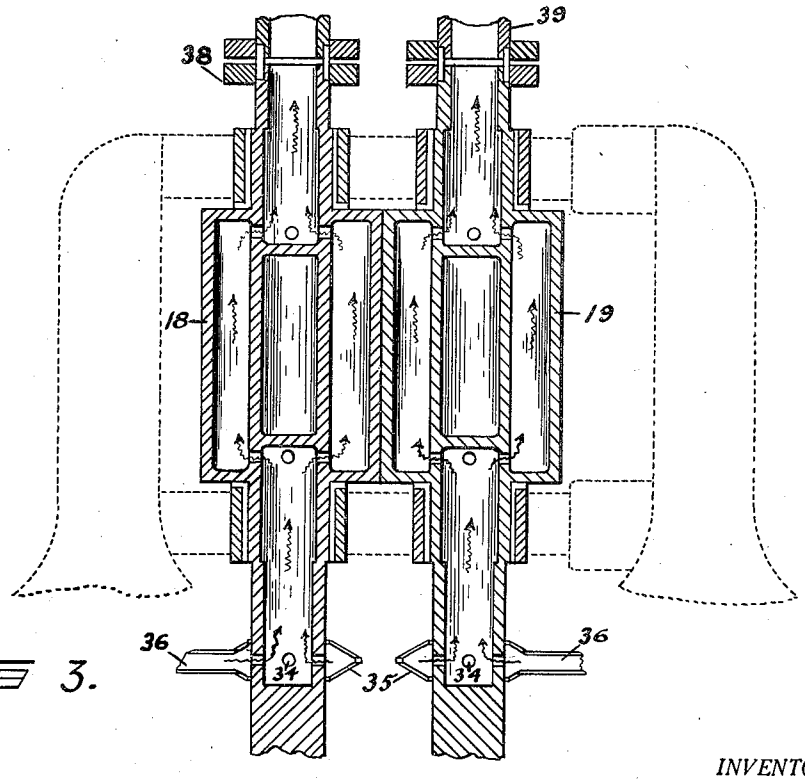


Fig 3.

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Fig 4.

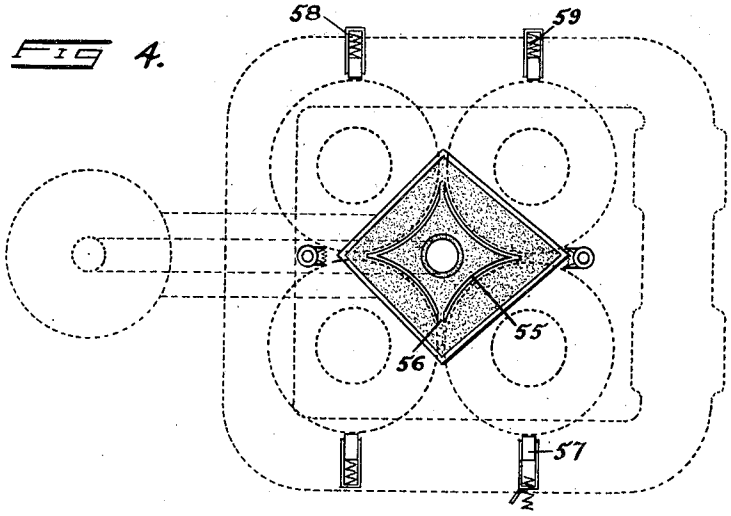
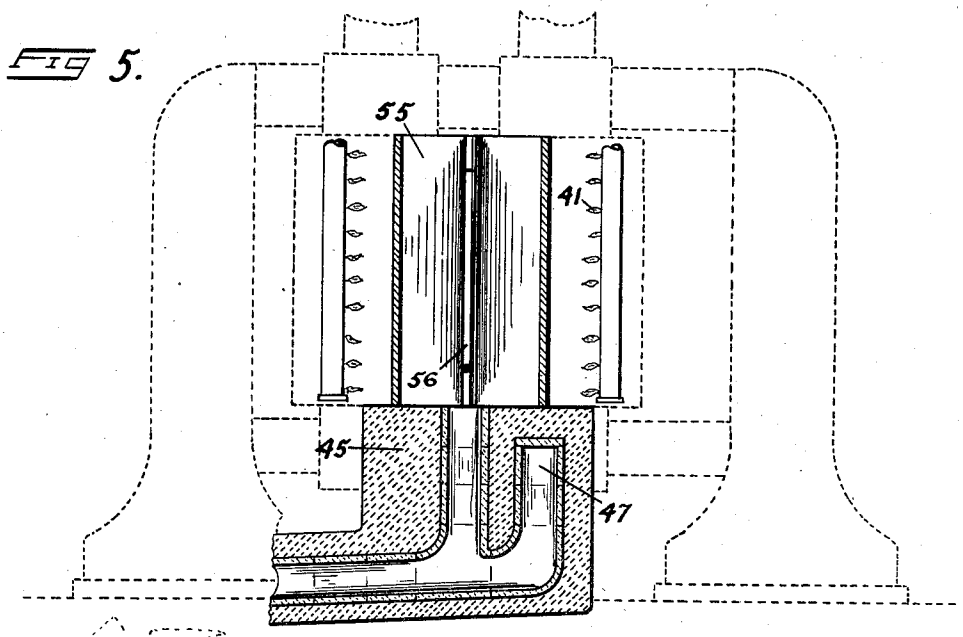


Fig 5.



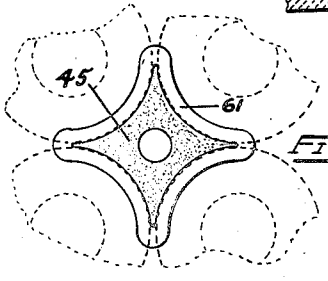
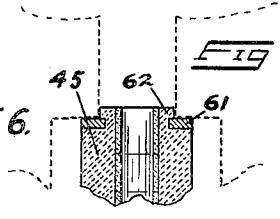


Fig 6.

Fig 7.



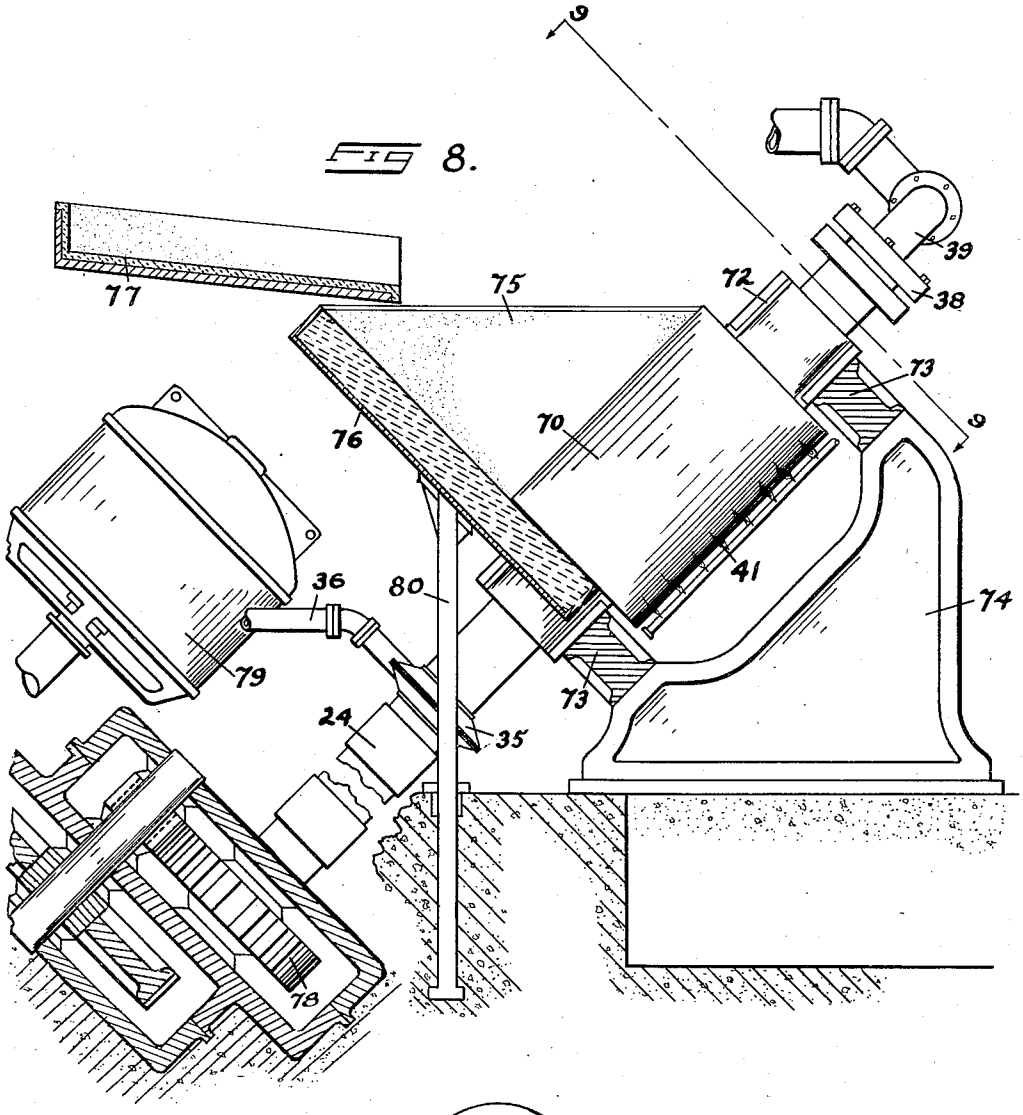
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DIRECT ROLLING OF HOT METAL

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FIG 8.



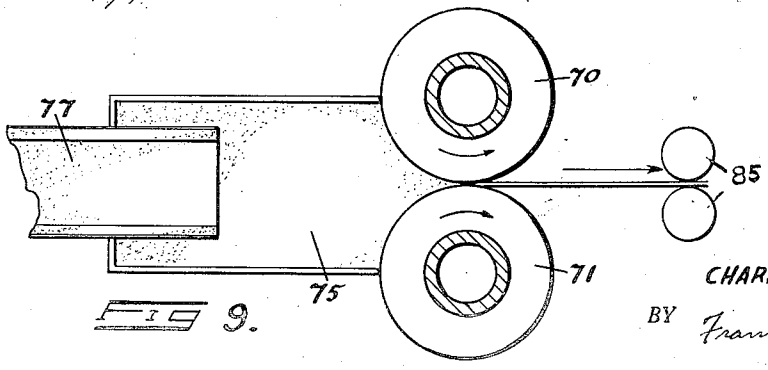


FIG 9.

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UNITED STATES PATENT OFFICE

2,183,010

DIRECT ROLLING OF HOT METAL

Charles D. Coxe, Youngstown, Ohio

Application November 28, 1936, Serial No. 113,222

10 Claims. (Cl. 22—57.5)

The present invention relates to the art of manufacturing metal plates or sheets and more particularly to method and apparatus for producing such plates or sheets directly from metal in the hot fluid state. The invention constitutes an improvement on the direct rolling method first advanced by Henry Bessemer and disclosed in Bessemer's U. S. Patent No. 49,053.

Various attempts have heretofore been made to apply the fundamental concepts taught by Bessemer to a commercially feasible and economical production system, but none have been particularly successful, especially in the production of steel sheets or strip, because of various difficulties encountered. A principal objection to the devices heretofore used is the difficulty of properly defining the edges of the formed metal. As is well known in the art, a delicate relationship must be maintained between the initial temperature and composition of the fluid metal and the temperature and speed of rotation of the extruding rolls. With devices of the prior art, these relationships are difficult to maintain. Also the forming of a satisfactory joint between the pouring means and the extruding means and thus the maintenance of a proper static pressure of the fluid metal has presented a serious problem.

The primary object of my invention is to provide means whereby the sheet or strip issuing from the extruding rolls will have sharply defined edges and will be of uniform and controllable width.

Another object of my invention is to provide novel and easily replaceable means for conveying fluid metal into the extruding area proper to eliminate any danger of injury to the apparatus and to reduce periods of inoperatability thereof.

These and other objects and advantages of the invention will become obvious from a consideration of the drawings and the following specification.

In the drawings:

Figure 1 is a vertical cross-sectional view of an apparatus constructed in accordance with my invention,

Figure 2 is a plan view of the apparatus taken along the line 2—2 of Figure 1,

Figure 3 is a vertical cross-section through the extruding rolls,

Figure 4 is a plan view of a modified form of the apparatus, certain elements being shown phantomally,

Figure 5 is a vertical section of the apparatus of Figure 4,

Figures 6 and 7 are plan and section views, respectively, of a modified form of liquid metal supplying and sealing means.

Figure 8 is a vertical section of still another modified form of apparatus, and

Figure 9 is a partial plan view of the apparatus of Figure 8 taken along the line 9—9 of Figure 8.

Referring to Figures 1 and 2, there is disclosed a supporting frame consisting generally of two spaced pedestals 10 laterally aligned along one side of the apparatus and another heavier pedestal 11 positioned centrally on the opposite side of the apparatus. These pedestals may be secured to the concrete foundation bed 12 in any suitable manner. Cradled between the pair of pedestals 10 and the pedestal 11 are the upper and lower bearing supporting rings 13 and 14 respectively, which support the chocks 15 carrying the bearings 16 and 17 for the rotatable support of the four vertically extending extruding rolls 18, 19, 20 and 21. The lower bearings 17, in addition to preventing separation of the rolls of the mill, perform the added function of a thrust bearing to carry the weight of the rolls.

The intervals between the rolls are adjustable by operation of the setting screws 22 and 23 which are in screw-threaded engagement with the frames 13 and 14 and have their ends in abutting engagement with the chocks 15. Any suitable means may be employed to rotate and indicate the position of the screws 22 and 23.

As shown more particularly in Figure 3, the rolls may be hollow and have integral therewith hollow shafts which are journaled in the bearings above mentioned. Universal joints or wobblers 24 connect the lower ends of the shafts with the spindles 25 which are, in turn, connected with the meshed driving gears 27 through the wobblers 28. Gears 27 are housed within a suitable closed case 26 and are driven by a motor 31 through pinion 30, gear 29 and pinion 32. The direction of rotation of the rolls is indicated in Figure 2.

To provide means for passing cooling fluid through the rolls, the lower hollow shafts are provided with a plurality of circumferentially spaced apertures 34, (see Fig. 3) about which are placed the slip rings 35 adapted to convey cooling fluid from the tubes 36 to the apertures 34. A common header 37 is employed to supply steam or other cooling fluid to the tubes 36. The cooling medium is exhausted from the rolls through the slip connection 38, tubes 39 and header 40. It will be observed that rotation of the rolls does not interfere with passage of the cooling medium through them. A series of gas flames 41 may be

employed to heat the rolls to bring them up to their proper initial temperatures.

I obviate many of the difficulties of the devices of the prior art by introducing the molten metal at the bottom of the apparatus, that is, by "bottom pouring", as it is termed in the art. To this end I provide a novel metal supplying device generally indicated at **42**, which consists essentially of a generally U-shaped tube which may be a fired clay product having an enlarged opening **43** constituting a pouring fountain and reservoir for the molten metal. The horizontal portion **44** of the tube has the lower surface of its opening inclined upwardly from the bottom of the pouring end of the tube. A slag trap **48** is provided in the roof of the horizontal duct which is operatable to skim off and trap slag which may be poured into the reservoir **43** along with the molten metal. A plug **49** is inserted in the side wall of the tube at its lowest point in order that all the contents of the tube may be drained when desired. The right leg of the U-shaped pouring and feeding assembly is enlarged as shown at **45** to provide a stool having a flat upper surface to fit closely against the lower end surfaces of the extruding rolls. A vertical duct **46** extends centrally through the stool and is operative to feed molten metal to the space between the rolls. A dead end duct **47** is provided in the stool to form a space for the lodgment of solid particles which may be washed in with the flow of molten metal. If desired, the end of the duct **47** may have an opening to the atmosphere to provide an escape for entrapped air. The passages through the member **42** may be lined with suitable refractory tile **53**. The pouring and feeding member **42** is supported on the standard **50** which may readily be raised and lowered by hydraulic cylinder **51** operated by fluid passing through tube **52**. It should be noted that the stool **45** is positioned between pairs of roll supporting and rotating shafts and couplings and that a portion of it extends above the lower bearings **17** and the lower frame member **14**. The hydraulic cylinder therefor performs two functions, i. e. it is operative to maintain the stool in constant engagement with the lower surfaces of the rolls and it is operative to lower the pouring and feeding assembly whereby it may readily be removed from the mill for replacement or repair.

The operation of the apparatus thus far described should be apparent. The rolls are driven in unison in the direction indicated by the intermeshing gear wheels **27** and molten metal flowing into the space between the rolls reaches its point of incipient fusion near the common plane of the axes of rolls **18** and **19** and also near the common plane of the axes of the rolls **20** and **21**. The metal is then extruded by operation of the rolls in two strips moving in opposite directions as shown. If desired, suitable means may be employed to apply tension to the issuing strips to prevent sticking between the strips and rolls. To this end I provide tensioning rolls **85** which are adapted to tightly engage the issuing strip and by having their peripheral speeds greater than the linear speed of the issuing strip apply tension to the strip.

In carrying out the method of direct rolling of metals, extreme accuracy must be maintained in the temperature and static pressure of the molten metal and in the temperature and speed of rotation of the rolls. The use of the bottom pouring device and the reservoir **43** enables me to maintain the temperature of the metal constant as it is a simple matter to add either hotter or cooler metal to the reservoir. Also by maintaining a constant level of liquid in the reservoir a constant static pressure is maintained on the metal entering the extruding space between the rolls. The cooling effect of the rolls may be varied by varying the supply of cooling fluid passing through the header **37** and the speed of rotation of the rolls may be controlled by controlling the speed of the variable speed motor **31**. If desired, thermocouples or other temperature sensing devices may be positioned adjacent the rolls and molten metal passes to aid in keeping the proper temperature balance required.

Because of the tendency of the molten metal in the pouring tube and in the space between the rolls to seek its own level, the height of the metal in the space between the rolls may be readily controlled by varying the height of the metal in the pouring fountain and reservoir **43**. The width of the extruded strips is dependent, of course, on the height of the metal in the space between the rolls. It is therefore apparent that I have provided means to easily vary and control the width of the extruded strips. It is only necessary to vary and control the height of the molten metal in the pouring fountain and reservoir to vary and control the width of the extruded strips.

Figures 4 and 5 illustrate a modified form of apparatus wherein a sheet metal container **55** is closely fitted within the space between the rolls. The container **55** is open at both ends and its side walls are bent to conform closely to the curvature of the rolls with which they are in sliding contact. The contact between the walls and the rolls insures a sufficient rate of heat conductivity to result in at least the essential partial solidification of the molten metal at the point of extrusion and prevents burning of the metal of the walls. The container is supported on the upper flat surface of the stool **45**, the orifice in which supplies the molten metal. A pair of slits **56** are provided in opposite sides of the container, arranged parallel with each other and with the axes of rotation of the rolls. These slits are positioned adjacent to but on the inner side of point of extrusion of the metal.

To provide lubrication between the rolls and the curved surfaces of the container, I provide a graphite brush **57** extending the length of each roll, the purpose of which is to deposit a small amount of graphite lubricant on the surface of the roll before it comes in contact with the surface of the container. Brushes **57** are seated within housings **58** which enclose the springs **59**, the springs **59** maintaining the brushes in contact with the surface of the rolls.

The flow of metal along the side walls of container **55** results in partial solidification thereof, or at least in sufficient cooling that when it comes in contact with the roll proper at the point of extrusion that solidification takes place there. The structure of Figures 4 and 5 provides an effective seal between the molten metal and the rolls except at the slits which are located adjacent the point of extrusion of the metal.

In Figures 6 and 7, I have illustrated a modified form of stool which is especially useful in connection with the form of apparatus disclosed in Figures 1, 2 and 3. The upper surface of the stool **45** is crowned with a metallic ring **61** of a shape to overlie the outer edge of the bottom surfaces of the extruding rolls. This is advantageous in that it provides a better wearing sur-

face between the stools and the rolls and a more effective seal for the molten metal. The stool is provided with an extended portion 62 of a shape to fit closely within the lower portion of the space betwen the rolls. This provides a further seal for the molten metal.

Figures 8 and 9 illustrate a simpler form of apparatus wherein but two rolls 70—71 are used. These rolls are mounted parallel with each other in an inclined plane and are rotatably supported in bearings 72 carried by the cross members 73 bridging the two supporting frames 74. A refractory lined hopper 75 is fitted about the set of rolls to form a reservoir for molten metal coming into the mill from the pouring spout 77. As shown, the lower surface 76 of the hopper is in the plane of the lower ends of the roll to prevent loss of metal. The hopper may be supported in any suitable manner as by the standard 80. The rolls are heated and cooled as in the other embodiments disclosed, and are driven by spindles 25 through wobblers 24 and gear train 78 by the variable speed motor 79. When the hopper is filled with molten metal at the proper temperature and the rolls are at the proper temperature and rotated at the proper speed, a strip of formed metal will issue from the apparatus as suggested by Figure 9 of the drawings.

Having thus described my invention what I claim is:

1. Apparatus for the continuous production of metal shapes comprising a set of four parallel vertically extending extruding rolls arranged in pairs, the rolls of each pair being in contact with each other but spaced from the rolls of the other pair, means to rotate said rolls, the rolls of a pair rotating in opposite directions in relation to each other and in relation to the adjacent rolls of the other pair, and means to supply metal in the fluid state to the space between the rolls.

2. Apparatus for the continuous production of metal shapes comprising two pairs of parallel vertically extending extruding rolls, the rolls of each pair being in contact with each other but spaced from the rolls of the other pair, means to rotate said rolls whereby the rolls of a pair rotate in opposite directions in relation to each other and in relation to the adjacent rolls of the other pair, means to supply metal in the fluid state to the space between the rolls comprising a U-shaped conduit having a pouring fountain on one leg and an orifice discharging into said space on the other leg.

3. Apparatus for the continuous production of metal shapes comprising a set of four parallel vertically extending extruding rolls arranged in juxtaposed position to define a space between the rolls, a container in said space having its walls bent to conform to the curvature of said rolls, the walls being in sliding contact with the rolls, a pair of slits in opposite sides of said container, said slits being parallel with each other and with the axes of rotation of the rolls and means to rotate said rolls in such manner that liquid metal within said container and issuing from said slits is caused to be extruded.

4. Apparatus for the continuous production of metal shapes comprising a pair of cylindrically shaped extruding rolls positioned on parallel inclined axes, means to rotate said rolls in opposite directions, a hopper located above said rolls, one wall of the hopper having its inner surface in the plane of the lower ends of the rolls, and means to supply metal in the fluid state to the hopper.

5. Apparatus for the continuous production of metal shapes comprising a box-like frame, four hollow extruding rolls vertically positioned in said frame and mounted on parallel axes, said rolls being rectangularly arranged to define a space between the rolls, means to rotate said rolls comprising a gear train positioned beneath said rolls, a motor for driving said train, spindles having universal joints connecting said train and rolls, means to conduct cooling fluid through said rolls comprising passages through the roll supporting and rotating shafts, outlets in said passages below and above said rolls, means to conduct cooling fluid into said passages through the lower outlets and out of said passages through the upper outlets, a pouring tube comprising a generally U-shaped structure having a pouring fountain positioned to one side of said frame, a horizontal portion extending beneath said frame and a stool having an upper flat surface to engage the lower end surfaces of the extruding rolls.

6. A metal supplying means for a direct rolling mill of a type utilizing a plurality of extruding rolls comprising a stool of refractory material having a metallic ring to slideably engage a portion of the end surfaces of the extruding rolls, an extension on said stool closely fitting between said rolls for a portion of the longitudinal distance, and a passage through said stool and extension.

7. Apparatus for the continuous and direct production of metal shapes comprising four parallel vertically extending extruding rolls rectangularly arranged to define a space between the rolls, a metal supplying means comprising a stool adapted to slideably engage the lower end surfaces of the rolls, an open-ended container supported on said stool and positioned within said space and having side walls bent to conform to the curvature of said rolls a pair of oppositely aligned slits in said container, each positioned adjacent the common plane of two of said rolls, a passage through said stool communicating with said container, means to supply liquid under pressure to said passage and container, and means to rotate said rolls whereby metal issuing from said slits will be extruded by said rolls.

8. In combination with a direct rolling mill having vertically extending extruding rolls, a metal supplying device comprising a generally U-shaped refractory lined tube, one of the legs of the tube extending above the other leg thereof and being provided in its upper portion with an enlarged cylindrically shaped space constituting a reservoir, the other leg of the tube constituting an enlarged stool having a flat upper surface to engage the lower edges of the extruding rolls, said stool including a vertical passage for the flow of metal to the extruding rolls and means to raise and lower said metal supplying device.

9. The method of producing a strip from plastic material which consists of extruding the plastic material between a pair of moving surfaces, the surfaces being composed of upwardly extending parallel linear increments, said increments movable laterally in such manner that continuously changing portions of the two surfaces move toward each other and in the direction of travel of the plastic material being extruded, and controlling the width of said strip by controlling the height of plastic material coming in contact with said surfaces.

10. Apparatus for the continuous production of metal shapes comprising a set of parallel up-

wardly extending extruding rolls arranged in juxtaposed position to define a space between the rolls, a container in said space having its walls shaped to conform to the curvature of said rolls, the walls being in sliding contact with the rolls, a slit in the side of said container, said slit being parallel with the axes of rotation of the rolls, and means to rotate said rolls in such manner that liquid metal within said container and issuing from said slit is caused to be extruded.

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