May 14, 1963 A. W. SCRIBNER 3,089,208

CONTINUOUS CASTING PROCESS

Filed Sept. 2, 1959 2 Sheets-Sheet 1

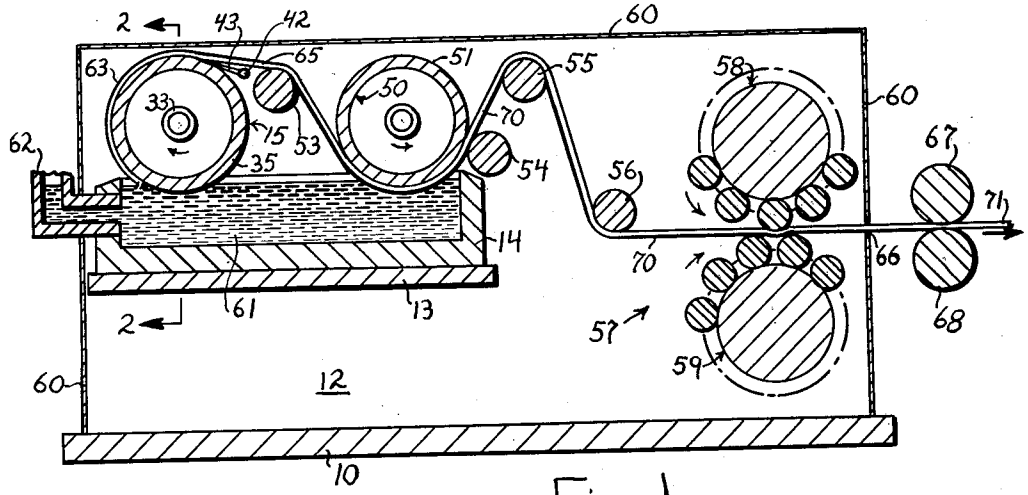



Fig. 1

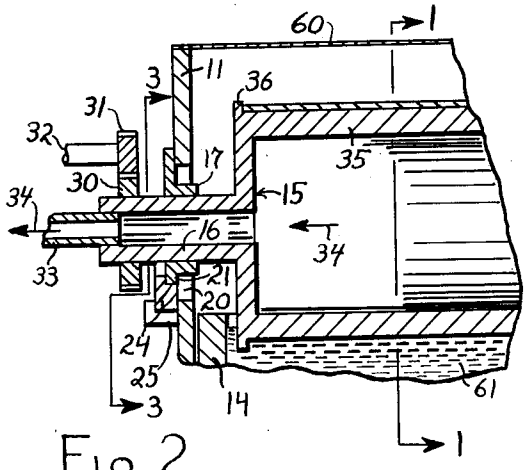



Fig. 2

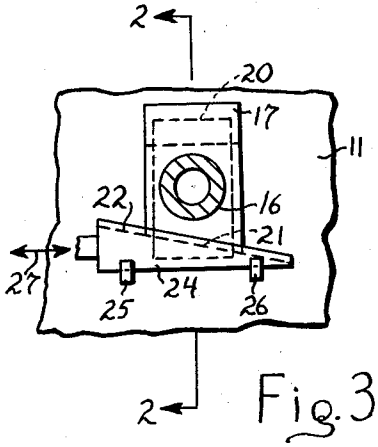



Fig. 3

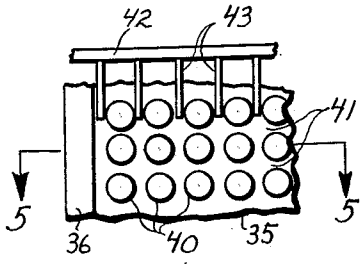



Fig. 4

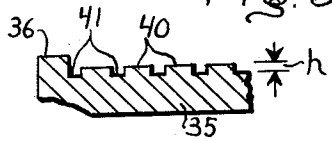



Fig. 5

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CONTINUOUS CASTING PROCESS

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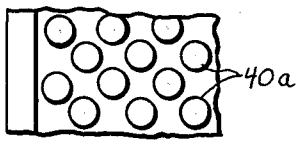



Fig. 6

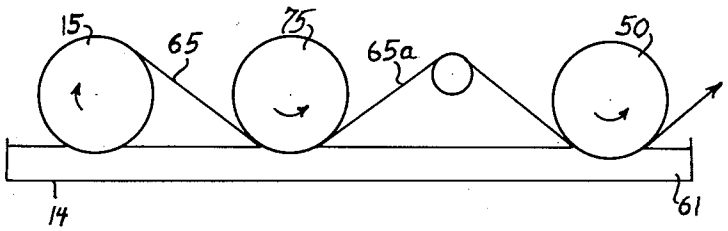



Fig. 7

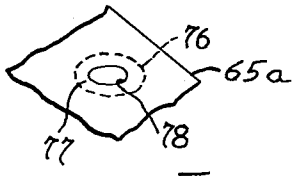



Fig. 8

Albert W. Scribner

United States Patent Office 3,089,208 Patented May 14, 1963



3,089,208

# CONTINUOUS CASTING PROCESS

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1 Claim. (Cl. 22—200.1)

This invention relates to the continuous forming of strip material and more particularly relates to the continuous casting of strip metal.

One object of the invention is to provide a method and apparatus for continuously casting strip metal by utilizing the capillary action of the molten work metal.

Another object of the instant invention is to provide a method and apparatus for continuously forming strip material by providing a web having apertures therein which are progressively filled to provide an elongated strip.

Another object of the invention is to provide a novel method and apparatus for continuously casting strip material whereby a plurality of communicating interstices are constructed and arranged to receive molten material and to retain the latter therein by capillary action, said molten metal when cooled forming a web having apertures therein which may be subsequently filled with additional material to thereby form an elongated strip.

Another object of the instant invention is to provide a novel method and apparatus for continuously casting strip material whereby a plurality of communicating interstices of predetermined size are arranged to receive molten metal and retain the same by the capillary action of the molten metal so as to form a web having apertures of predetermined size therein which may be subsequently filled with molten metal that is also retained therein by capillary action thereby forming a continuous metal strip.

Another object of the invention is to provide a novel method and apparatus for continuously casting strip material whereby a web is provided having apertures therein that are filled with molten material which, when cooled and in combination with the web material, defines an elongated strip.

Another object of the invention is to provide a novel method and apparatus for continuously casting metal strip whereby a metal web is formed having apertures of predetermined size which are successively filled with molten metal that is retained in said apertures by capillary action, the web and the molten metal when cooled forming a continuous metal strip.

Another object of the invention is to provide a novel method and apparatus for continuously casting metal strip whereby a metal web is formed having apertures of predetermined size, each of which is progressively filled with molten metal that is retained therein by capillary action.

Another object of the invention is to provide a novel method and apparatus for continuously casting strip metal whereby two cumulative and complemental casting operations are used; the first operation forming an initial fractional part of the desired strip and the subsequent second operation forming a complemental fractional part of the strip; said parts cumulatively defining the integral and substantially homogeneous elongated desired strip.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings in which like reference numerals designate like parts throughout the figures thereof and wherein:

FIGURE 1 is a longitudinal side elevational view in partial section showing the general organization of the instant apparatus.

FIGURE 2 is a partial front elevational view taken along section line 2—2 of FIGURE 1.



FIGURE 3 is a side elevational view taken along section line 3—3 of FIGURE 2.

FIGURE 4 is a fragmentary plan view of the developed cylindrical surface of the casting roll.

FIGURE 5 is a fragmentary front elevational view taken along section line 5—5 of FIGURE 4.

FIGURE 6 is a fragmentary view similar to that in FIGURE 4 and illustrates an alternate pattern of distribution for the casting roll projections.

FIGURES 7 and 8 are diagrammatic sketches illustrating another embodiment of the invention.

Referring to FIGURES 1 and 2 there is shown a base 10 on which is mounted a pair of parallel side frames 11 and 12. Secured to the side frames is a horizontally disposed member 13 which supports a rectangular shaped molten metal container 14. Rotatably mounted in said side frames and disposed immediately above the container 14 is a large diameter tubular web forming casting roll 15. In that the construction, support and operation of one end of said roll corresponds to that for the other end thereof, only said one end need be discussed in detail here. The left end, as seen in FIGURE 2, of roll 15 is provided with a tubular neck 16 which is rotatably mounted in the bearing block 17. Block 17 is slidably mounted in the vertical slot 20 formed in the side frame 11. A depending projection 21 formed on the lower end of the bearing block 17 is disposed in a correspondingly shaped elongated notch 22, FIGURE 3, formed along the inner upper sloping edge of the roll positioning wedge 24; the latter being supported for horizontal sliding movement by the L-shaped brackets 25 and 26 fixed to the machine side frame 11. As will be apparent the roll adjusting movement 27, FIGURE 3, of wedge 24 may be utilized to vertically displace the casting roll 15 to the desired position. Fixed to the roll neck 16 is a gear 30 which meshes with a pinion 31 secured to the drive shaft 32.

Any suitable coolant conducting means such as 33 may be operatively connected to each outer end of the necks of roll 15 so as to permit the flow 34 of coolant into, through and out of said casting roll. Each axial end of the operative cylindrical body portion 35 of roll 15 is provided with an annular flange such as 36, FIGURES 2 and 4, while the outer cylindrical surface of said body portion is provided with a reticulated pattern of radially extending projections 40, FIGURES 4 and 5, which cooperatively define a plurality of laterally communicating open ended interstices 41. Secured between side frames 11 and 12 is a cross rod 42, FIGURES 1 and 5, having stripping fingers 43 fixed thereto, the ends of which extend between the respective projections 40 and slidably engage to periphery of the roll body portion 35.

A second or finish casting roll 50 is rotatably mounted on side frames 11 and 12 and is constructed and supported in a manner similar to that just described for roll 15 except that here the cylindrical periphery of the roll body portion 51 is smooth. A plurality of work guide rollers 53, 54, 55 and 56, disposed in the positions shown in FIGURE 1, are rotatably mounted in the machine side frames. Supported on the same or a separate frame is a planetary rolling mill arrangement 57 having cooperating upper and lower roll heads 58 and 59 which are constructed and operated in a manner similar to those shown and described in U.S. Patent 2,059,993. A suitable cover 60 extending between the tops and ends of the side frames provides a closed space which may be filled with an inert gas thereby furnishing a nonreducing atmosphere for the continuous casting operation.

In the operation of the instant apparatus the container 14 is filled and kept full with molten metal 61 through a suitable conduit 62, and the drive shaft 32 is slowly rotated. The roll positioning wedges 24, FIGURE 3, are

then adjusted so that the lower periphery of the roll body portion 35 dips a short distance into the molten metal while the body portion 51 of roll 50 is out of the molten metal 61. The rotation of roll 15 will cause the interstices 41 of the immersed portion of the roll 15 to become successively filled with said molten metal which will be suspended and retained therein by capillary action after said interstices have successively moved above the surface of the molten metal reservoir. The molten metal which is thus continually "picked up," suspended and retained by the said interstices moves upwardly with the roll surfaces and in so doing is cooled by the flow 34 of coolant through the casting roll. By the time this cooled work material progressively engages and is stripped from the roll 15 by the operative ends of said fingers 43 it will have to be hardened sufficiently to form a cohesive self-supporting matrix or web 65 having a plurality of holes or apertures therein which corresponds in size and relative spacing to that of the respective projections 40. After passing over guide roller 53 web 65 engages and passes around the lower periphery of the now elevated casting roll 50 and over the successive rollers 54, 55 and 56. The work material then advances through the planetary mill 57 and in doing so will be mechanically kneaded. The work finally passes out through an appropriate aperture 66 in the cover 60 and through a pair of suitably supported conventional type work rolls 67 and 68. After the web 65 has been thus threaded through the machine the casting roll 50 is lowered by the means above described so that a lower portion of its periphery and the contacting portion of said web are immersed a short distance in the said reservoir of molten metal 61. This action will cause the apertures in the continuously moving web 65 to be successively filled with additional molten metal which is then retained in said apertures by capillary action after the web is progressively moved out of the reservoir. As the web together with the additional molten metal in said apertures moves upwardly between the roll 50 and guide roller 54 it will be progressively cooled by the above described circulation of coolant through the roll and will thereafter cooperatively define a continuous integral and substantially homogeneous elongated metal strip 70. As the strip 70 is progressively and repetitively kneaded in the mill stand 57 the successive worked portions of the strip will partake of rapid upward and downward transverse shear strains which serve to maintain the work material at hot working temperatures and to fully fuse and integrate all of the original web material and the material filling said apertures to a roughly uniform gage. The reducing rolls 67, 68 and if desired similar additional reducing roll stands, progressively reduce and trim the rough gaged strip to the final desired thickness and width to thereby form the finished continuous strip 71.

For a given rotative speed of roll 15, the rate of coolant circulation, the temperature of the molten metal 61 and/or the depth of immersion of the casting rolls 15 and 50 are adjusted to give the desired operational characteristics, e.g. the thickness of the web 65 and strip 70 to be formed. The casting rolls 15 and 50 are driven by their respective drive shafts such as 32, FIGURE 2, so as to have substantially the same peripheral speeds and the web 65 and hence the strip 70 will be continuously formed so that the subsequent kneading and reducing operations in the above described roll stands may also be conducted on a continuous basis. The process may be terminated at any time by elevating the casting roll 15.

For a 42 inch diameter roll 15, an exemplary size for the projections 40 is .08 to .25 inch in radial height *h*, FIGURE 5; .10 to .30 inch in diameter; and .14 to .52 inch between centers. The diagonal distance, FIGURE 4, between centers is substantially twice the diameter of said projections. The roll projections may be disposed in diagonal columns and rows as shown at 40*a* of FIGURE 6 rather than in the horizontal and vertical rows and



columns respectively, as shown in FIGURE 4, in which case the stripping fingers 43, FIGURES 1 and 4, are eliminated. Likewise said projections may have various shapes other than the circular configuration illustrated; for example said projections may be oval or polygonal in profile or may be formed so as to provide an aligned or staggered array of elongated slots in the web. Further, if desired, one or more additional casting rolls similar in construction and operation to that at 50 may be provided on the machine frame so that the strip 70 may be redipped in the elongated molten metal reservoir thereby insuring that no unfilled apertures remain in said strip 70.

Another embodiment of the invention is illustrated in the diagrammatic sketches of FIGURES 7 and 8. Here the construction and operation of the casting rolls 15 and 50 are the same as before, however an additional intermediate casting roll 75 is provided on the machine frame. Roll 75 is constructed, supported and operated in the same manner as that described for roll 15, the only difference here being that the peripheral projections thereof although having the same dimensional pattern of distribution as projections 40 are smaller than the latter and thereby can progressively mesh with the apertures of web 65 in a manner corresponding to the cooperating action of a chain and sprocket. In that the projections on roll 75 will then be sectionally smaller than the respectively associated apertures 76, FIGURE 8, in the web the unfilled space 77 of each of said apertures may be filled with molten metal as it progressively moves with the roll 75 and beneath the surface of the molten metal reservoir. Upon being stripped from roll 75 the web 65*a* will have smaller holes 78 therein corresponding in size to that of said projections on roll 75. The remaining metal forming steps may be the same as above described. By utilizing one or more intermediate casting rolls, such as 75, the interstices in roll 15 do not have to be as close together, i.e. the apertures in web 65, FIGURE 8, may be initially larger than that maximum size which will retain all the necessary molten metal by capillary action in the FIGURE 1 arrangement. Thus the arrangement of FIGURE 8 permits a progressive filling in of each web hole by successive alternate capillary retention and cooling operations.

While several embodiments of the invention have been shown and described, it will be apparent to those skilled in the art that numerous variations and modifications may be made in the particular construction without departing from the underlying principles of the invention. It is therefore desired, by the following claim, to include within the scope of the invention all such variations and modifications whereby substantially the results of the invention may be obtained by the use of substantially the same or equivalent means.

The invention claimed is:

A method of continuously casting strip metal; comprising the steps of providing a bath of liquid work metal, disposing a cylindrical body comprising on its periphery a plurality of laterally adjacent and laterally communicating open-ended interstices partially within said bath of liquid metal, said interstices being sized and mutually arranged so as to be capable of retaining work metal therein by a capillary action, rotating said cylindrical body within said bath of liquid work metal thereby progressively admitting portions of said liquid work metal to said interstices, permitting the liquid work metal admitted to said interstices to be retained therein by said capillary action until hardened sufficiently to form a cohesive web having a plurality of predetermined apertures therein that are complementary in shape with said interstices, removing the hardened web metal from said interstices, filling said web apertures with additional amounts of said liquid work metal, and cooling said additional amounts of work metal to a hardened state, said additional amounts of hardened work metal together with

the previously hardened web metal cumulatively defining an elongated substantially homogeneous strip.

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