March 13, 1951 J. F. JORDAN 2,544,837

APPARATUS FOR THE CONTINUOUS FORMATION OF METAL IN SHEETS

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FIG. 1

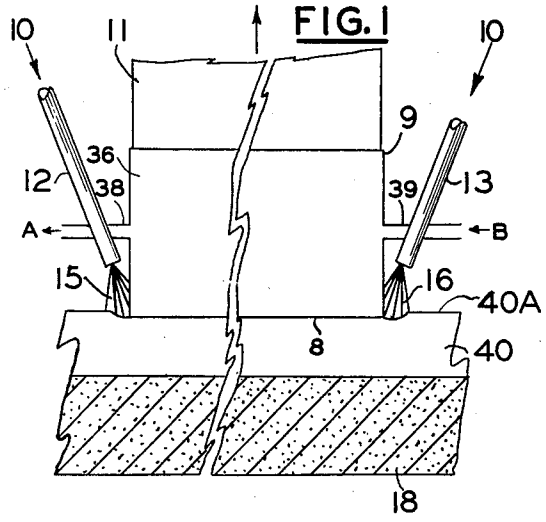


FIG. 2

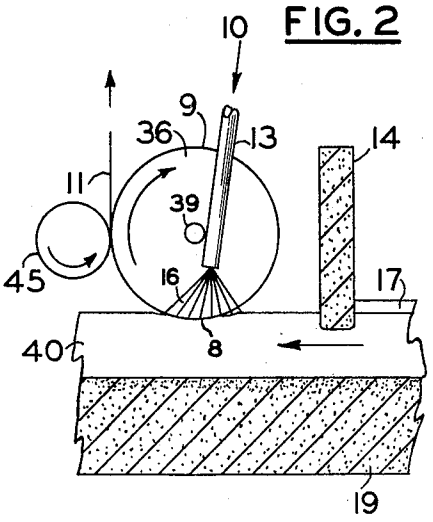
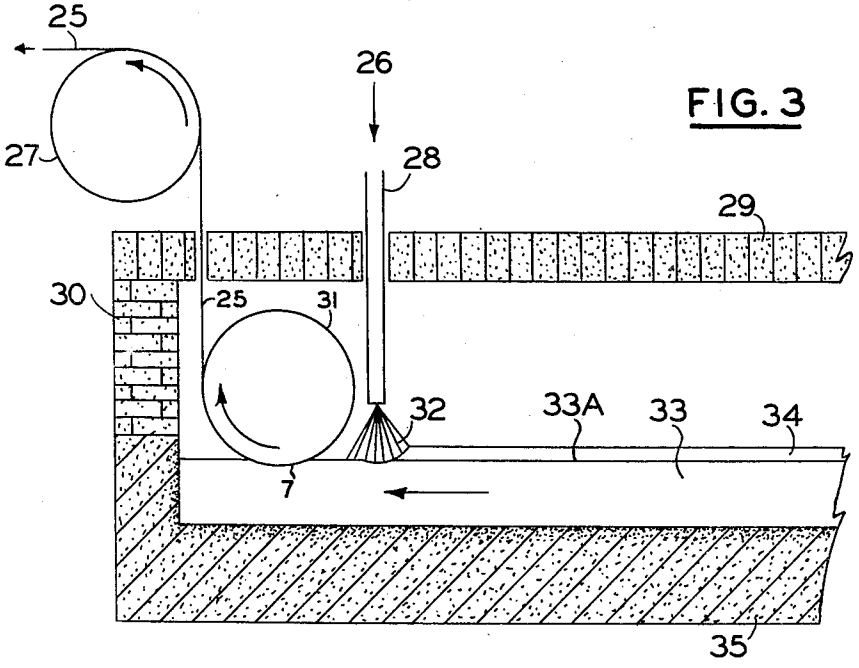


FIG. 3



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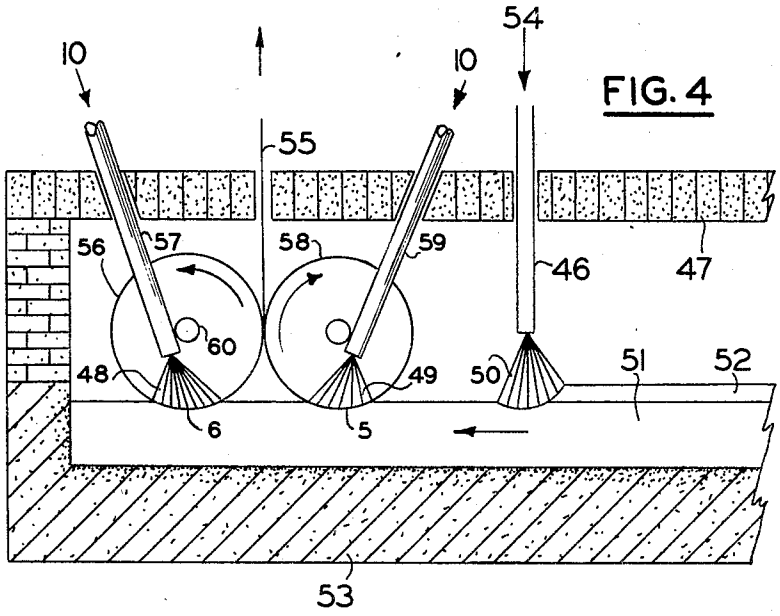


FIG. 4

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APPARATUS FOR THE CONTINUOUS FORMATION OF METAL IN SHEETS

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Application October 27, 1949, Serial No. 123,960

2 Claims. (Cl. 22—57.3)

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My invention relates to the conversion of a molten metal into sheets.

Numerous attempts have been made to continuously cast metal strip and metal sheet. Two outstanding difficulties arose during these attempts: (1) product cleanliness, due to the oxidation of the formed product and due to entrained slag and/or dross; and (2) the formation of the edges of the sheet proved troublesome. With regards to the latter, when the sheet was formed by dipping a revolving water-cooled drum into a bath of the molten metal, the molten metal lapped around the edges of the drum, resulting in the formation of a sort of channel, instead of the desired simple sheet. As the formed "channel" solidified and shrunk, the cast product became locked to the revolving drum, resulting in either a hot-tear or in the impossible situation wherein the formed product could not be stripped off of the drum.

My invention concerns an improved casting drum wherein the molten metal is prevented from lapping around said drum by means of a barrier of gas situated at both ends of said drum.

Figure 1 shows my casting drum with said barriers of gas in position.

Figure 2 shows one end of the drum of Figure 1.

Figure 3 shows an arrangement of my drum, in combination with a dynamic weir.

Figure 4 shows two of my drums, cooperating to produce one sheet.

In Figure 1, revolving water-cooled drum 9 is shown contacting molten metal bath 40, thereby continuously producing metal sheet 11. Said drum 9 is cooled by the circulating body of water 36 with which it is filled, said circulation being achieved as cold water B enters drum 9 via the hollow drum shaft 39 and the warmed water A leaves said drum 9 via the hollow drum shaft 38. Casting face 8 is immersed beneath surface 40A of molten metal bath 40, and the molten metal in said bath 40 is prevented from lapping up around the ends of said drum 9 by dynamic weirs 15 and 16. Weirs 15 and 16 are barriers of high-velocity gas which press down upon surface 40A to form an indentation in said surface 40A of sufficient depth to exceed the depth to which casting surface 8 is immersed beneath said surface 40A. Said indentations in said surface 40A, being located at each end of said drum 9, prevent bath 40 from lapping around said ends of drum 9, and thus prevent the formation of solidified metal on said ends of drum 9. As sheet 11 forms and leaves said drum 9, the level of surface 40A is maintained as bath 40 flows towards said drum 9 along hearth 18.

Weirs 15 and 16 are formed by directing orifices 12 and 13 towards the junctions of said surface 40A and said ends of drum 9. Said orifices 12 and 13 are connected to a source of high-pressure

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gas (not shown). The pressure exerted by weirs 15 and 16 upon surface 40A, and the depth of the resulting indentation in said surface 40A, may be varied by varying the pressure of gas 10 against orifices 12 and 13, or by varying the distances between said orifices 12 and 13 and said surface 40A. The size of said indentation may be increased in area by increasing the distances between said orifices and said surface 40A—followed by increases in the pressure exerted by gas 10 against said orifices, or said area of indentation may be increased by increasing the size (area) of said orifices—followed by increases in the pressure exerted by gas 10 against said orifices. The area of indentation must be at least sufficient to adequately cover the area of contact of said drum 9 with said surface 40A—see Figure 2.

The gas employed in said weirs 15 and 16 should be at least neutral to the metal being cast—that is, non-oxidizing. With steel, nitrogen, carbon monoxide and helium may be employed; with copper, carbon monoxide is preferred.

Figure 2 shows the drum of Figure 1, looking at one end of said drum 9. Refractory dam 14 is shown skimming off slag layer 17 as bath 40 flows towards drum 9. Stripping drum 45 is shown revolving with and pressing against drum 9, said drum 45 being here employed to provide the deformation that is sometimes necessary in order to strip sheet 11 off of drum 9, said drum 45 also being here utilized to smooth out the outside surface of sheet 11.

Figure 3 shows an arrangement of my casting drum wherein sheet 25, produced by drum 31, is led out of the casting apparatus by drum 27. The arrangement of Figure 3 does not show the stripping drum—such as drum 45 in Figure 2—although such a stripping drum will in most cases be required. Figure 3 shows drum 31 in cross section, and, accordingly, does not show the weirs which are positioned at each end of said drum 31. Barrier of gas 32 is an elongated column of gas that is impinged towards molten metal bath 33 in order to block off slag layer 34 from the casting operation, said barrier being caused to extend entirely across the bath of metal 33 that is flowing towards casting face 7. The function of said barrier of gas 32 is simply to dam slag layer 34. Said barrier is formed by orifice means 28 that passes thru roof 29 and directs gas 26 towards bath 33. Gas 26 is supplied to said orifice means 28 by a high-pressure source (not shown). Bath 33 is shown flowing towards drum 31 on refractory hearth 35.

Figure 4 shows a further modification. Here, two casting drums 56 and 58 are shown casting the metal of bath 51, said drums 56 and 58 being rotated in opposite directions in pressing contact with each other, so that the two metal sheets which are formed at casting surfaces 5 and 6 are

pressed together at the point of contact between drums 56 and 58, said two cast sheets being welded together at said point of contact to form sheet 55 that leaves the casting apparatus by passing up thru roof 47. Said drums 56 and 58 are rotated in opposite directions, each of said drums being rotated in that direction which constitutes the shortest distance between each drum's casting surface and the point of pressing contact between said drums 56 and 58.

The pressing contact between the two casting drums 56 and 58 results in the welding together of the two sheets to produce the single sheet 55, each of said drums 56 and 58 acting as a stripping roll for the other drum; furthermore, due to the fact that the surface of the sheet that lies next to the casting surface will always be smoother than the surface that lies away from said casting surface, the arrangement of Figure 4 will produce a much smoother sheet than when only one casting drum is being employed—the rough surface of each sheet being turned in to form the center of sheet 55.

As with Figure 2, Figure 4 shows the use of my barrier of gas 48 and 49 at each end of both of the casting drums, said barriers 48 and 49 being formed as orifices 57 and 59 direct gas 10 towards the junctions of the surface of molten metal bath 51 and said ends of drums 56 and 58, said barriers being caused to press said metal surface down at said drum ends until said surface is just equal to, or below, the depth of immersion of casting surfaces 5 and 6, so that molten metal 51 will not lap around said drum ends.

As with Figure 3, Figure 4 shows the use of another barrier of gas 50 to hold back slag layer 52, so that said layer 52 does not enter the casting operation. Barrier 50 is formed by means 46 which is fed by high-pressure gas 54.

In the arrangement shown in Figure 3, three barriers of gas are acting—one at each end of drum 31 and one to hold back slag 34. In Figure 4, five barriers of gas are employed—one at each end of each casting drum and one to hold back slag 52. When casting sheet steel, the high-pressure gas employed in these barriers of gas should be carbon monoxide, for this gas will protect the surface of bath 51 and the newly-formed sheet 55 from oxidation. Other non-oxidizing gases may be employed in these barriers—nitrogen, argon, helium or a mixture of CO and CO_2, for example.

Gas barriers 15, 16 and 32 may be composed of a preheated gas if the circumstances require; that is, if said barriers tend to cause the molten metal in baths 33 or 40 to solidify, said barriers may be preheated sufficiently to prevent this solidifying action.

When casting a metal with strong shrinkage characteristics, casting faces 5, 6, 7 and 8 should be slightly concave, so that when the cast sheet draws in from the ends of the casting drum, the casting surface will offer no resistance to the movement of the relatively-weak sheet. The axis of said concavity of the casting face of the drum must be parallel to the direction of rotation of said drum.

The expression "sheet," as employed in the claims, denotes metal sheet or metal strip.

Having now described and shown several forms of my invention, I wish it to be understood that my invention is not to be limited to the specific form or arrangement of parts herein disclosed and shown, except insofar as such limitations are specified in the appended claims.

I claim as my invention:

1. In a continuous casting apparatus, a vessel adapted to hold a pool of molten metal, a casting drum rotatably mounted in said vessel with a portion of its circumference extending below the normal molten metal level in said vessel, nozzles positioned above the molten metal and at each end of the casting drum, said nozzles being directed so as to cause a barrier of gas to press down into the surface of said molten metal at each end of said casting drum and at the point where said molten metal contacts said ends of said casting drum, and means for supplying said nozzles with gas under sufficient pressure to cause said barriers of gas to press down into the surface of said molten metal to a depth at least equal to the depth of immersion of said casting drum in said molten metal, so that said molten metal is prevented from contacting and solidifying on said ends of said casting drum.

2. The apparatus according to claim 1 in which the casting face of said casting drum is concave, so that the solidified metal may shrink in contact with said casting drum without gripping said casting drum.

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