METHOD FOR THE CONTINUOUS CASTING OF METAL STRIP, AND STRIP CASTING PLANT FOR CARRYING OUT THE METHOD

Filed Sept. 18, 1957 2 Sheets-Sheet 1

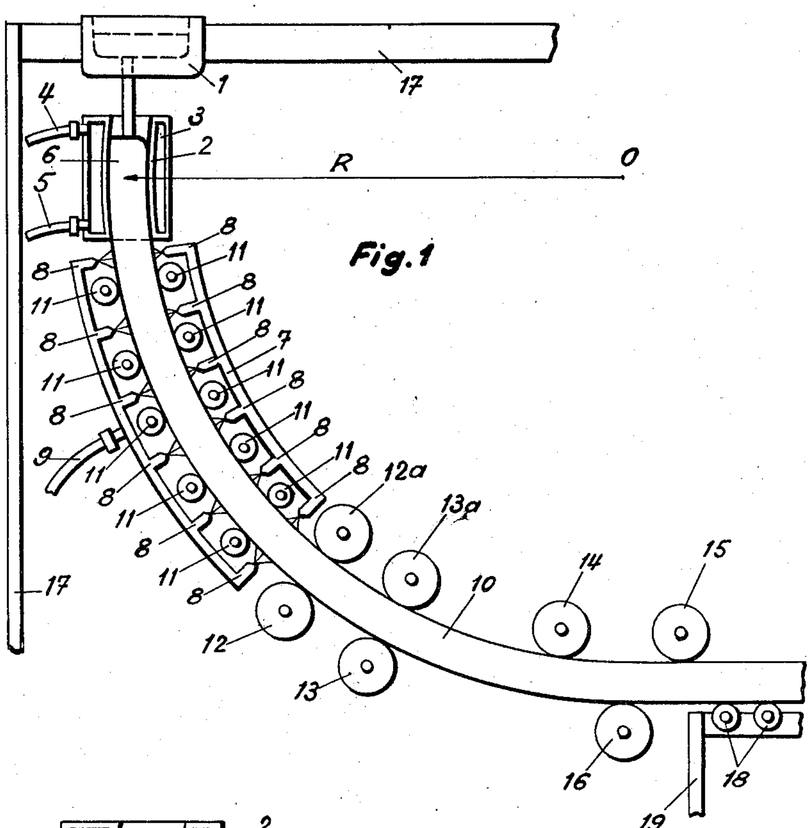

Fig.1

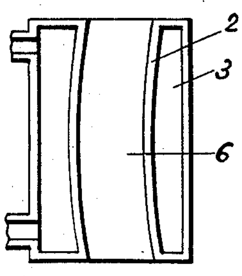

Fig.2

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2 Sheets-Sheet 2

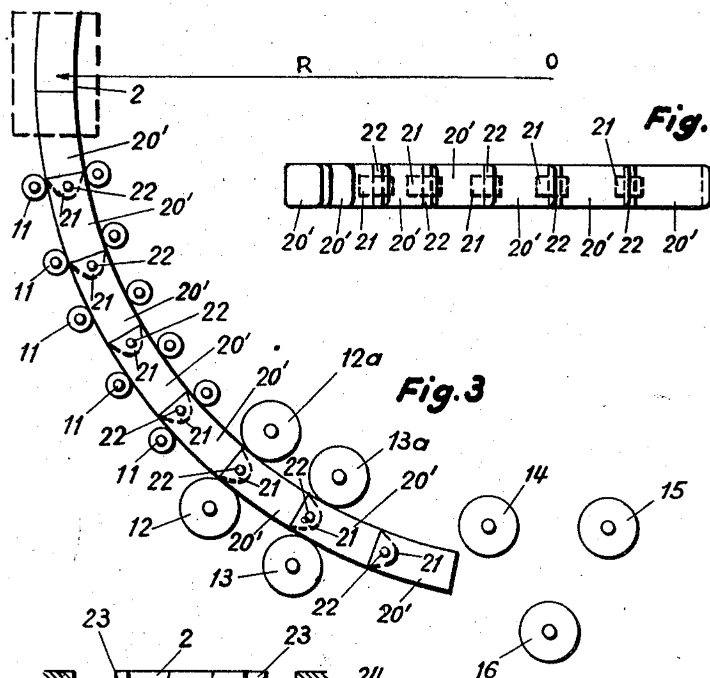

Fig.4

Fig.3

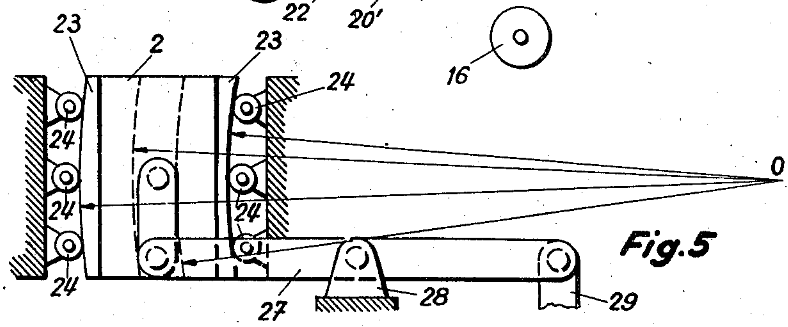

Fig.5

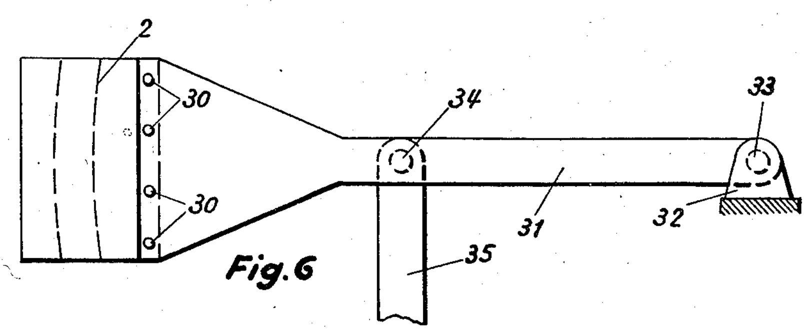

Fig.6

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METHOD FOR THE CONTINUOUS CASTING OF METAL STRIP, AND STRIP CASTING PLANT FOR CARRYING OUT THE METHOD

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5 Claims. (Cl. 29—417)

The continuous casting of metal strips and in particular of iron or steel strips is preferably effected in a water-cooled flow-through mould for abstracting as much heat as possible already in the chill from the metal strip. The strip discharged from the mould is then submitted to further cooling with suitable cooling agents such as water, air, which are sprayed or blown directly onto the surface of the metal strip for completing its solidification.

As the cooling and the concomitant solidification of the metal strip discharged from the vertical chill cannot be achieved in a short time, and its cutting into billets of the desired length demands the solidification throughout of the metal, the strip casting plant must have a considerable height. Such vertical strip casting plants by reason of their great height have the disadvantage that very often they cannot be accommodated in existing casting houses. For the uninterrupted feeding of the hopper mounted above the chill-mould, craneways are required for transporting the ladles from which the molten metal is poured and this increases still further the overall height of the installation. Consequently a strip casting plant even for such small sections as for example 25 to 50 cm.^{2}, assuming that the billets have a length of 3 m., has a height of at least 14 to 16 m., and the craneways must be mounted above the plant.

Recently an attempt has been made to reduce the height of such strip casting plant, so that the cast strip discharged from the flow-through mould and passed over the lowering rollers is bent in a horizontal direction and straightened later. Such procedure allows a reduction in the height of the plant, and affords the advantage that the billets can be cut in any desired length from the horizontal strip. However, it has been found that the bending of the metal strip must not be started before complete solidification of the metal has been effected, otherwise detrimental stresses arise between the outer layers and the core of the strip. The travel distance of the strip for solidification is determined by the cross-section of the strip, and the rate of pouring, so that the distance becomes longer for larger sections and also for increased pouring rates. For this reason the suggested bending of the metal strip only leads to a height reduction of the strip casing plant by about 20%, so that it still remains inconveniently high.

The main purpose of the invention is to provide means for avoiding the disadvantages referred to.

The invention relates to a method for the continuous casting of a metal strip in a water-cooled flow-through mould in which the metal strip is cast in the chill in the shape of the segment of a circular annulus, and after discharge from the mould is passed onto a guideway consisting of support and guide rollers forming a track in the shape of a circle segment, the medium radius of curvature of the track corresponding to the medium radius of curvature of the circular annulus segment formed by the metal strip, in such manner that the strip is cooled and drawn from the flow-through mould by

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take-off rollers, whereupon the completely solidified metal strip deflected at the desired angle is straightened and the straight strip transported on a straight track for cutting the strip into billets of the required length.

There is no necessity to bend the cast metal strip, as the strip is produced in the form of a circular annulus segment and after travelling a certain distance is solidified sufficiently for straightening.

The invention furthermore, relates to a plant for carrying out the continuous strip casting method according to the invention.

The accompanying drawings illustrate preferred embodiments of the strip casting plant according to the invention. Details are shown schematically.

Figure 1 is a side view of a part of the metal strip casting plant.

Figure 2 is a vertical cross-section on an enlarged scale of the flow-through mould used in the metal strip casting plant.

Figure 3 is a side view of the guide track for the cast metal strip supplied with the starting strip, serving as closure for the flow-through mould during commencement of casting. The cooling device is not shown.

Figure 4 is a top view of the starting strip according to Figure 3.

Figure 5 is a side view of a first embodiment of a device for imparting alternating movements to the flow-through mould.

Figure 6 is a side view of a second embodiment of a device for imparting alternating movements to the mould.

The hopper **1** is fed continuously with molten metal from the ladle transported by a crane (not shown). Below hopper **1** the flow-through mould **2** is mounted, which is provided with a cooling jacket **3** to which cooling water is fed by the flexible pipe **4** and drained by the flexible pipe **5**. The flow-through mould **2** is provided with a casting chamber **6** in the shape of an annulus sector, the bisector of its cross-section having the radius R. This radius R corresponds to the desired median radius of curvature of the metal strip to be cast in relation to the centre O. Below the flow-through mould **2** a reference cooling device **7** with coolant nozzles **8** is provided. The cooling device **7** can be supplied for example with water from the pipe **9**. The coolant nozzles **8** are arranged in parallel rows to the cast metal strip, bent to form the arc of a circle, in such a manner that the cooling medium is supplied equally to the whole circumference of the metal strip **10**. Support and guide rollers **11** for the not completely solidified metal strip **10** are mounted to be freely rotatable inside and outside between the coolant nozzles **8**. Below the cooling device **7** two successive pairs of take-off rollers **12**, **12*a*** and **13**, **13*a*** are provided between which the metal strip **10** travels. These rollers **12**, **12*a*** and **13**, **13*a*** are driven in such a manner to draw the metal strip **10** out of the flow-through mould **2** at a speed conforming to the pouring rate. For such purpose the peripheral speed of the take-off rollers **12** and **13** on the outer side of the bent metal strip **10** must be greater than that of the take-off rollers **12*a*** and **13*a*** on the inner side of the metal strip **10**. The support and guide rollers **11** together with the two take-off pairs of rollers **12**, **12*a*** and **13**, **13*a*** provide a track forming the arc of a circle, having the median radius of curvature R for the metal strip **10**. In the drawing the case is shown in which the track is extended to approximately 90°, so that the metal strip **10** after passing the take-off roller **13**, **13*a*** has practically assumed a horizontal direction. Behind the rollers **13**, **13*a*** a straightening device with direction rollers **14**, **15** and **16** converts the deflected and throughout solidified curved metal strip **10** into a straight strip. The hopper **1**, the cooling device **7**, the support and guide rollers 11, the take-off roller pairs 12, 12*a* and 13, 13*a* and the direction rollers 15, 16 are all mounted on the housing frame 17, which is indicated only in Figure 1.

The straightened metal strip 10 passing the direction rollers 14, 15 and 16 is taken up by a series of support rollers 18 which undertake the further transport of the strip. These support rollers 18 are mounted on a frame 19, only part of which is shown in Figure 1. The metal strip 10 is conveyed by the support rollers 18 to a cutting-off machine of conventional type (not shown in the drawing) for the separation into billets of the desired length.

According to present conditions the guide track for the metal strip 10 can be constructed in such manner that the strip is deflected 90° or less, and is conveyed from the guide track to the straightening device, subsequently travelling on a straight track formed by the transport rollers. This straight track can be horizontal or inclined, it can rise upwards or slope downwards.

For starting the strip casting the outlet of the flow-through mould 2 must be closed. For such purpose a starting strip 20 is employed, which may consist of a single curved piece introduced on the guide track for the cast metal strip and withdrawn at the commencement of strip casting at a speed corresponding to the pouring rate.

As shown in Figures 3 and 4 the starting strip can also consist of several comparatively short bent parts 20′ detachably connected to each other in such a manner that the curvature of the starting strip corresponds to that of the guide track. These parts 20′ have adjacent ends that are supplied with grooves and tongues 21 that interlock and are connected to each other by the bolts 22, passed through each groove and tongue.

This subdivision of the starting strip 21 affords the advantage that the individual pieces 20′ facilitate the handling of the starting strip. They can be introduced into the guide track, for example as shown between the take-off roller 13 and the direction roller 16, separately, connected to each other in the guide track, and removed from the guide track in similar manner.

The described process for the continuous casting of a metal strip and the strip casting plant according to the invention make possible a considerable reduction of the overall height in comparison to hitherto known strip casting plants. A further advantage of the plant according to the invention is the cutting of the billets from the straightened metal strip on a horizontal or on a slightly inclined track, which permits the production of larger billets without increasing the overall height of the strip casting plant. This advantage can prove valuable in a subsequent rolling of the billets. The reduced overall height of the strip casting plant not only has the advantage of enabling erection in existing casting houses, in which the known plants cannot be placed by reason of their much greater height, but furthermore reduces accidents.

It is well known that the strip casting of metals can be carried out with flow-through moulds that are provided with an oscillating movement in the direction of the metal strip, for preventing the sticking of the metal strip in the chill. This is also possible for the strip casting plant according to the invention. However, in such case, the flow-through mould must not be moved to and fro on a straight line but on the arc of a circle corresponding in curvature to that of the annular segment formed by the cast metal strip 10. This requirement is achieved as follows:

Figure 5 shows a device for moving the flow-through mould 2, in which the mould 2 is provided with guide ledges 23 having guide-faces bent in the form of the segment of a circle, the centre of curvature of the guide-faces coinciding with the centre of curvature O of the cast metal strip. The guide ledges 23 run on the guide rollers 24 mounted on fixed axles that form a track in the shape of a circle section, with the radius E on which the flow-through mould can be moved to and fro. The one end of the guide 26 is pivoted to the axle arm, projecting laterally from the flow-through mould 2, and the other end of the guide 26 is mounted in a bearing at the end of the one arm of the double-armed lever 27. The lever 27 is pivoted in the fixed bearing block 28, and a thrust rod 29 acting on its other arm moves the lever 27 to and fro.

A second embodiment of a device for moving the flow-through mould 2 is shown in Figure 6. The device is rigidly secured by means of the bolts 30 to the broadened end of the lever 31. The lever 31 is pivoted on the axle 33 mounted in the bearing block 32 and the axle 33 passes through the centre of curvature of the cast metal strip. The lever 31 is provided with an axle 34 on which the one end of a thrust rod 35 which imparts oscillating movements to the lever 31, is mounted.

The drive means which impart to levers 27, 31 respectively, over the thrust rod 29, 35 the oscillating movement are not shown in Figures 5 and 6. They may consist of optional mechanical, hydraulic, pneumatic or electromagnetic drives.

Instead of the starting strip 20 composed of individual parts 20′ connected to each other detachably, it is also practicable to employ a starting strip made of flexible material such as rubber, plastic flexible compositions, textile that is supplied with a metallic head-piece for scaling the casting chamber of the flow-through mould on starting the strip casting.

What we claim is:

1. A method for continuous casting of elongated metal bodies in a water-cooled flow-through mould, comprising the steps of casting liquid metal into a curved mould having a mould cavity substantially in the shape of a segment of a circular annulus; oscillating said mould along a curved path having a median curvature substantially equal to the curvature of said circular annulus; guiding the elongated metal body as it leaves the mould over a curved track having substantially the shape of a circular segment, the median curvature thereof corresponding substantially to the curvature of said circular annulus of said mould; cooling said elongated metal body as it is passed over said track so as to completely solidify the metal body; continuously feeding the solidified body so that the metal is continuously withdrawn from the mould and transported over the track; deflecting the solidified metal body at a desired angle; passing the deflected metal body onto a straightening device so as to straighten the curved metal body into a substantially straight elongated metal body; and cutting the straightened metal body into billets of required length.

2. A casting apparatus for continuous casting of elongated metal bodies of relatively heavy cross-section comprising, in combination, a water cooled flow-through mould including a casting chamber in the shape of a segment of a circular annulus, the walls forming said casting chamber being stationary with respect to the remainder of the mould; means for pouring metal into said casting chamber; curved track means located below said mould and including a plurality of guide rollers spaced from each other and arranged in two groups along two concentric circles, with the innermost portion of said guide rollers in the two groups of guide rollers in direct contact with opposite sides of the cast metal body emanating from said mould, respectively, and respectively located on two concentric circles having a median radius of curvature corresponding to the median radius of curvature of said casting chamber; cooling means arranged in the vicinity of said curved track means; additional track means mounting said mould for oscillating movement along a curved path having a median radius of curvature corresponding to the median radius of curvature of said casting chamber; drive means for imparting

an oscillating movement to said mould along said additional track means; at least one pair of take-off rollers arranged in a position in which the cast metal body is deflected; and straightening means for converting the cast curved body into a substantially straight elongated body.

3. A casting apparatus as defined in claim 2 in which said mould is formed with a pair of curved outer guide faces forming each a segment of a circle and being respectively guided by said additional track means.

4. A casting apparatus for continuous casting of elongated metal bodies of relatively heavy cross-section comprising, in combination, a water cooled flow-through mould including a casting chamber in the shape of a segment of a circular annulus, the walls forming said casting chamber being stationary with respect to the remainder of the mould; means for pouring metal into said casting chamber; curved track means located below said mould and including a plurality of guide rollers spaced from each other and arranged in two groups along two concentric circles, with the innermost portion of said guide rollers in the two groups of guide rollers in direct contact with opposite sides of the cast metal body emanating from said mould, respectively, and respectively located on two concentric circles having a median radius of curvature corresponding to the median radius of curvature of said casting chamber; cooling means arranged in the vicinity of said curved track means; drive means for imparting an oscillating movement to said mould, said drive means including a lever fastened to said mould, axle means for pivotally supporting said lever and passing through the center of curvature of said casting chamber, and means for oscillating said lever about said axle means; at least one pair of take-off rollers arranged in a position in which the cast metal body is deflected; and straightening means for converting the cast curved body into a substantially straight elongated body.

5. A casting apparatus for continuous casting of elongated metal bodies of relatively heavy cross-section comprising, in combination, a water cooled flow-through mould including a casting chamber in the shape of a segment of a circular annulus, the walls forming said casting chamber being stationary with respect to the remainder of the mould; means for pouring metal into said casting chamber; curved track means located below said mould and including a plurality of guide rollers spaced from each other and arranged in two groups along two concentric circles, with the innermost portion of said guide rollers in the two groups of guide rollers in direct contact with opposite sides of the cast metal body emanating from said mould, respectively, and respectively located on two concentric circles having a median radius of curvature corresponding to the median radius of curvature of said casting chamber; cooling means arranged in the vicinity of said curved track means; at least one pair of take-off rollers arranged in a position in which the cast metal body is deflected; straightening means for converting the cast curved body into a substantially straight elongated body; and starting strip means insertable in said track means for sealing said casting chamber and movable along said track means for starting the casting of an elongated metal body, said starting strip means including a plurality of relatively short and curved parts, each having a median radius of curvature corresponding to the median radius of curvature of said casting chamber, and means for detachably connecting said short parts to each other.

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