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CONTINUOUS CASTING APPARATUS HAVING SUCTION MEANS BETWEEN MOLD AND COOLING MEANS

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Fig. 1

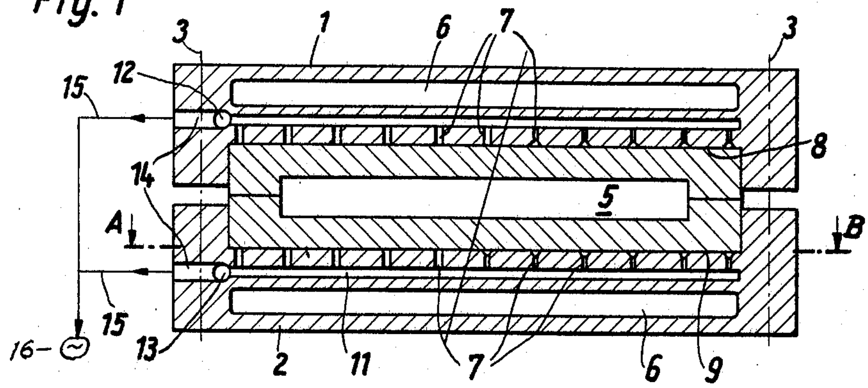


Fig. 2

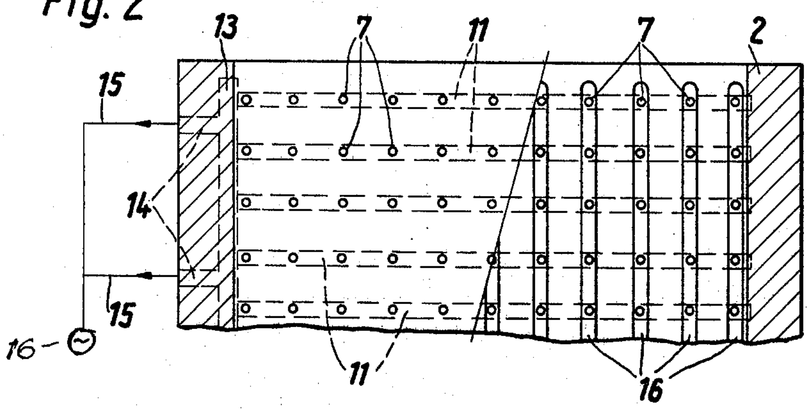
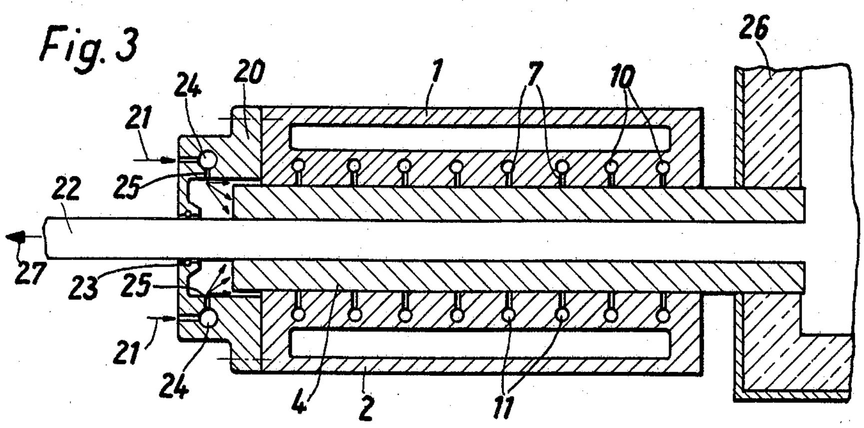


Fig. 3



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CONTINUOUS CASTING APPARATUS HAVING SUCTION MEANS BETWEEN MOLD AND COOLING MEANS

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ABSTRACT OF THE DISCLOSURE

An apparatus for maintaining intimate contact between a mold and cooling device in a continuous casting operation. The contact surface between the mold and cooling device is subjected to a reduced pressure by a vacuum transmitted through apertures in the cooling device which communicate with the contact surface. The mold can also be sealed to the atmosphere and supplied with nitrogen to prevent oxidation where graphite molds are used.

The invention relates to an apparatus and method for continuous casting of metals. More particularly, the invention relates to an apparatus and method having at least one mold cooled by a surrounding cooling device.

Heretofore, structures and methods have been known and used wherein a metal casting has been formed by a mold which has been surrounded by a cooling device. However, difficulties have risen repeatedly since it has not been possible to obtain and maintain a permanent intimate contact between the mold and cooling device. The difficulties have originated from the different temperatures to which the mold and cooling device have been subjected, for example, the molten metal within the mold can subject the mold to a temperature above 1000° C. while the cooling device is subjected to prevailing temperatures between 60° and 100° C. Because of the differences in these temperatures and also because of the non-uniformity in heat distribution in the contacting surfaces between the mold and cooling device, stresses have arisen in the mold or in the cooling device which have subsequently lead to deformation of these parts. Such deformations result in the formation of air gaps or spaces between the mold and cooling device in the plane of the contacting surfaces. This has impaired the heat transfer from the mold to the cooling device and has consequently led to interruptions in the continuous casting process so that at least the quality of the cast strand is considerably lowered.

It is an object of the invention to provide for a uniform heat transfer from a mold to a surrounding cooling device during a continuous casting process.

It is another object of the invention to maintain a continuous contact surface between a mold and a surrounding cooling device during a continuous casting process.

Briefly, the invention provides a method of maintaining the contacting surfaces of a mold and a cooling device surrounding the mold in intimate contact with each other during a casting operation. Intimate contact is maintained by producing a reduced-pressure between the surfaces of the mold and cooling device which has an effect of drawing the mold onto the cooling device. The adjacent surfaces of the mold and cooling device thus are always in complete contact so as to avoid the formation of air gaps therebetween while insuring a good uniform heat transfer during each phase of the casting operation. The method of the invention is particularly advantageous in the continuous casting of strips since the molds for

such have a large width and thus a large heat transfer surface.

The apparatus of the invention includes a cooling device for surrounding a mold of a continuous casting device wherein the contacting surfaces of the mold and cooling devices communicate through a plurality of apertures within the cooling device with a means for generating a reduced-pressure.

These and other objects and advantages of the invention will become more apparent from the following detailed description and appended claims taken in conjunction with the accompanying drawings in which:

FIG. 1 illustrates a cross sectional view of a mold and cooling device of the invention;

FIG. 2 illustrates a view taken on line A–B of FIG. 1; and

FIG. 3 illustrates a cross sectional longitudinal view of a modification of the invention.

Referring to FIG. 1, a cooling device having an upper part **1** and a lower part **2** held together, for example, by bolts (indicated by broken lines **3**) is secured around a mold **4**. The mold **4** is likewise divided into upper and lower parts to define a hollow internal longitudinal space **5** which serves to form a strip shaped cast strand. The upper and lower parts **1, 2** are each provided with chambers **6** through which cooling medium, such as water, oil or the like, flows in a manner not shown in detail.

Referring to FIGS. 1 and 2, a plurality of apertures **7** are formed in the upper and lower parts **1, 2** of the cooling device between the mold **4** and the chambers **6** in each respective part **1, 2**. The apertures **7** are uniformly distributed over the cooling device and communicate at one end with the contact surfaces **8, 9** between the mold **4** and the respective parts **1, 2** of the cooling device. The opposite ends of the apertures **7** communicate with a series of passages **10, 11** in each respective parts **1, 2** of the cooling device. The passages **10, 11** which are disposed, for example, transversely of the longitudinal axis of the mold **4** are interconnected by a respective transverse passage **12, 13** which is disposed, for example, longitudinally of the mold axis at one side of the cooling device. Each transverse passage **12, 13** is connected through a bore **14** in the cooling device and a pipe **15** (shown diagrammatically) connected to each bore **14** with a reduced-pressure generating suction means, for example, a vacuum pump **16**.

During a casting operation, the reduced-pressure generating means creates a reduced pressure, for example, of 7 p.s.i., across the contacting surfaces **8, 9** between the mold **4** and each of the parts **1, 2** of the cooling device. The effect of such a reduced-pressure is that the mold **4** is maintained flush with the parts **1, 2** of the cooling device along the contact surfaces **8, 9** so that a good uniform heat transfer from the mold to the cooling device is constantly provided. The formation of air gaps in the contact surfaces **8, 9** is prevented even if the walls of the cooling device in which the apertures **7** are formed are slightly deformed, as by bending, since the adjacent mold walls will also be subjected to similar deformation.

Each part **1, 2** of the cooling device is provided with apertures **7** which are cylindrically formed along their lengths on the left of each part, as shown in FIG. 1, and apertures **7** which are conically widened at their ends adjacent the contact surfaces **8, 9** on the right of each part, as shown in FIG. 1. The conically widened apertures provide an increase in the suction area between the contact surfaces **8, 9** so that a greater suction force per aperture is created to press the mold **4** against the cooling device. It is noted in this regard that the reduced pressure is substantially uniform in each of the apertures of the cooling device. It is further noted that since the heat transfer from the mold to the cooling medium (e.g. water) is conducted through the cross section of the metal of the cooling device, by maintaining the diameter of aperture **7** as small as possible within the parts **1, 2** and by widening the ends of these apertures, a good suction area is obtained without reducing the heat flow area within the cooling device to any great degree. In addition, the concially widened ends of each row of these latter apertures **7** communicate with each other to form grooves **16** in the parts **1, 2** extending transversely of passages **10, 11.**

The mold **4** can be formed of a material such as, graphite or a "cermet" (sintered compound of metallic and ceramic substance). Where the mold material is graphite, the invention can be advantageously improved by feeding nitrogen to the exit of a cast strand from the mold **4.**

Referring to FIG. 3, a mold of graphite which is connected to a furnace **26** is surrounded by a cooling device as described above having upper and lower parts **1, 2** with cylindrically formed apertures **7** and by a housing **20** mounted on the exit end of the mold. The housing **20** is connected to a supply of nitrogen **21** (schematically shown) and surrounds a solidified strand **22** emerging from the mold. A labyrinth seal or gland **23** is provided between an inwardly directed wall of the housing **20** and the casting **22.**

Nitrogen is supplied to a pair of passages **24** in the housing **20** which distribute the nitrogen through a plurality of ports **25** into the interior of the housing **20** over the width of the strand **22.** The nitrogen is fed under a slight excess pressure to prevent in a simple manner contact of the graphite of the mold with the atmospheric oxygen of the surrounding atmosphere so that oxidation of the graphite is avoided. Due to the gas porosity of the graphite, the supplied nitrogen passes through the mold and is drawn off by a reduced-pressure generating means acting on the mold as described above.

The molten metal or metal alloy in the furnace which is to be cast enters the mold **4** at the end connected to the furnace, solidifies under the action of the cooling device, and is continuously or discontinuously drawn out by means (not shown) from the mold in the direction indicated by the arrow **27.**

It is noted that the apertures **7** need not be formed in the walls of the cooling device. Instead, individual plates which are to be considered as componnts of a cooling device can be provided between a mold and the remainder of the cooling device. These plates are formed of heat conducting material and are provided with apertures **7** together with transverse connecting passages **10, 11** as described above. If desired, the apertures **7** can extend through the entire depth of thicknesses of the plates so that a reduced-pressure will act both on the contact surface between plate and mold as well as on the contact surface between plate and the remainder of the cooling device.

The invention provides for the simplified construction of a mold. For example, when casting broad strips, it is no longer necessary to manufacture the mold over the entire width from a simple piece. Rather, the mold of the invention can be assembled from several narrower pieces which together extend over the entire width of the strand to be produced since the mold portions lying side by side are safely and permanently held against a cooling device under the reduced-pressure created by the reduced-pressure generating means of the invention. Likewise, the same principles apply to molds for the casting

of strands which have square or rod-like cross sections rather than the cross sections of strips. In casting these square or rod-like strands, the mold can be assembled from four separate parts which bound the four sides of the square or rod-like cross section and which are then held in a surrounding cooling device by means of the reduced-pressure generating means of the invention.

Having thus described the invention, it is not intended that it be so limited as changes may be readily made therein without departing from the scope of the invention. Accordingly, it is intended that the foregoing Abstract of the Disclosure, and the subject matter described above and shown in the drawings be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A continuous casting apparatus comprising

a mold having a space therein for forming a strand therein;

a cooling device surrounding said mold for cooling a casting therein, said cooling device and mold defining a contact surface therebetween;

suction means for generating a reduced-pressure; and

means communicating said suction means with said contact surface to maintain said mold and cooling device in continuous intimate contact along said contact surface upon generation of a reduced pressure therebetween.

2. An apparatus as set forth in claim **1** wherein said means communicating said suction means with said contact surface includes a plurality of uniformly distributed apertures in said cooling device adjacent said contact surface.

3. An apparatus as set forth in claim **2** wherein at least a portion of said apertures have conically widened ends facing said contact surfaces.

4. An apparatus as set forth in claim **3** wherein a plurality of grooves interconnect the conically widened ends of said apertures facing said contact surfaces in rows.

5. An apparatus as set forth in claim **2** wherein said means communicating said suction means with said contact surface further includes a plurality of passages interconnecting said apertures in rows within said cooling device, at least a pair of transverse passages interconnecting said passages, and pipe means connecting said transvere passages with said suction means.

6. An apparatus as set forth in claim **1** further comprising a housing mounted on one end of said cooling device for surrounding a cast strand emerging therefrom in sealed relation, and means for connecting the interior of said housing to a nitrogen supply.

7. An apparatus as set forth in claim **6** wherein said mold is made of graphite.

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