United States Patent

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[54] **CONTINUOUS CASTING MOLD WITH CORRUGATED SURFACE MANDREL**
6 Claims, 3 Drawing Figs.

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[50] **Field of Search** 164/85, 283, 273; 249/175

[56] **References Cited**
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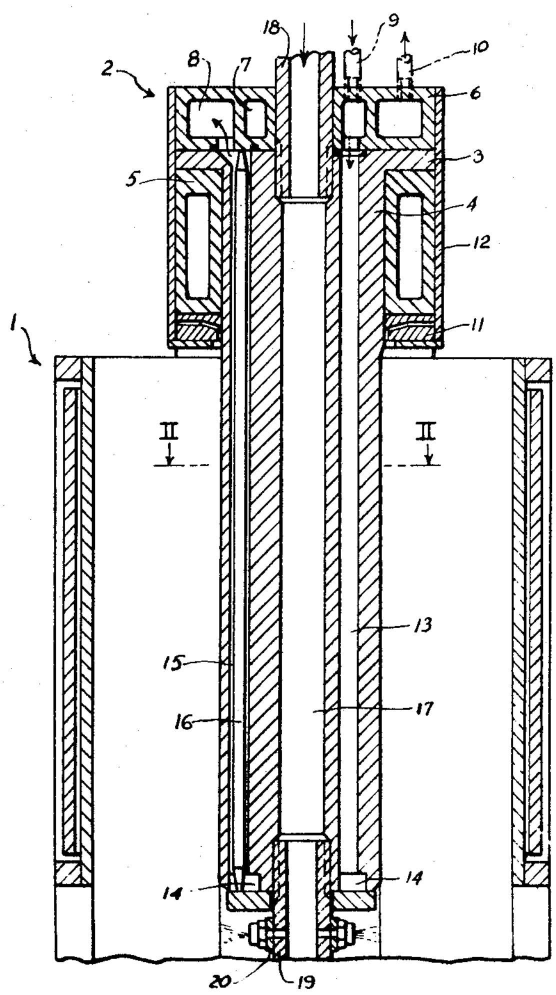
ABSTRACT: Apparatus for continuously casting tubes consists of a cooled mandrel extending into a continuous casting mold. The portion of the surface of the mandrel extending into the mold has longitudinal depressions therein substantially parallel to the longitudinal axis of the mandrel. In a preferred form, the depressions are spaced around the mandrel forming a corrugated surface with regular and equally curved ridges and hollows. Cooling channels are preferably provided in the ridges between the depressions. Jets are preferably provided at the end of the mandrel for applying coolant to the interior of a tube formed by the mandrel. The mandrel may also be conical in the direction of tube travel.



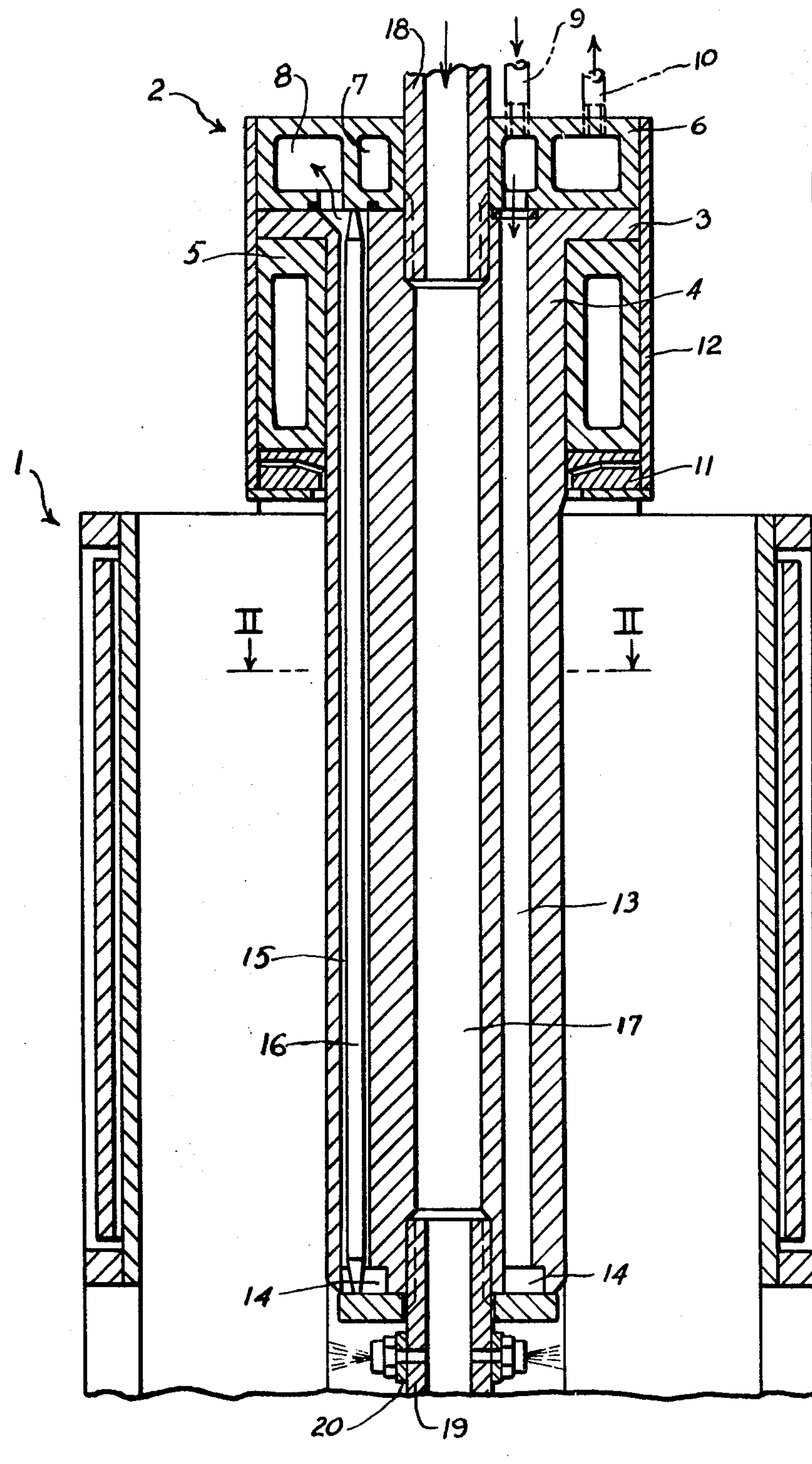


FIG. 1

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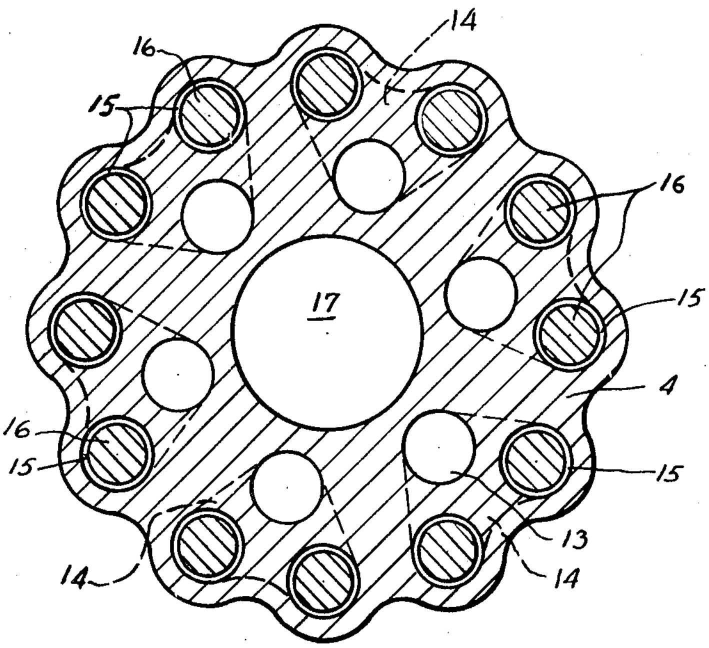
FIG.2



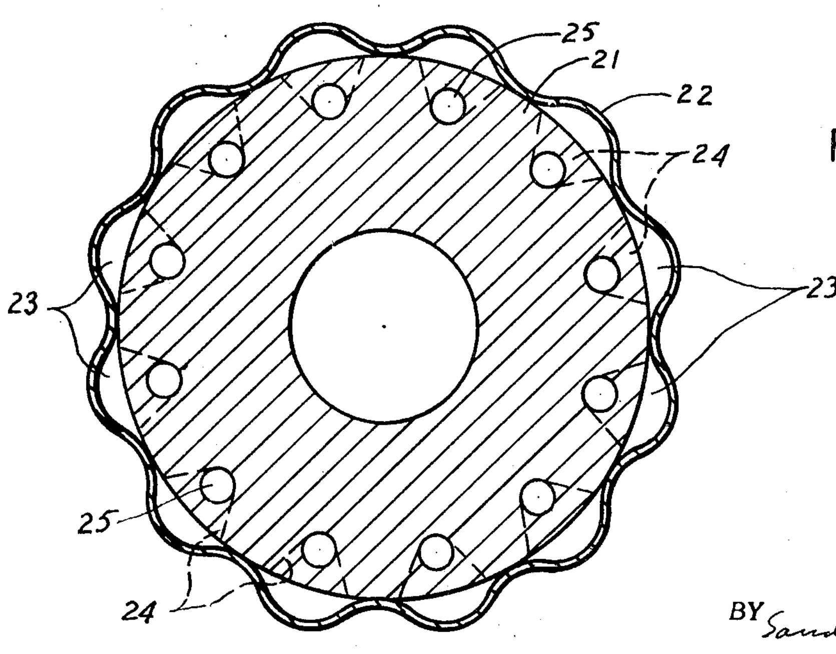


FIG.3

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CONTINUOUS CASTING MOLD WITH CORRUGATED SURFACE MANDREL

The present invention relates to a mandrel which extends into a continuous casting mold for the continuous casting of tubes. It is known in the art to circulate coolant in mandrels in order to obtain solidified skins of the same thickness on both the outside and the inside of the tubes. It is also known to give the mandrel a conical shape in order to prevent the tube from shrinking on the mandrel.

The shrinkage gap between the mold wall and the outside of the tube increases during the cooling of the casting. This results in a decrease of the heat transfer between the mold wall and the outside of the tube, which in turn decreases the cooling rate of the strand. This stable condition between shrinkage and heat transfer does not apply to the relationship between the mandrel and the inside of the tube, because here the shrinkage causes an increase in the heat transfer, which in turn increases the shrinkage and so on. This process accelerates itself and results in a shrinking of the tube on the mandrel. It can only be prevented by using a mandrel which is so extremely conical, that the tube could not shrink on it, despite the above described mutually accelerating relationship between shrinkage and heat transfer. However, the provision of such a large shrinkage gap would greatly reduce the heat transfer and therefore the casting speed.

A principal object of the present invention is to provide a mandrel which prevents the tube from shrinking on it, while the shrinkage gap is kept at a minimum, thereby insuring good cooling of the tube. According to the invention this is accomplished by having longitudinal depressions in the surface of the mandrel which run substantially parallel to the axis of the mandrel. In a preferred form, the surface of the mandrel has straight, parallel, regular and equally curved ridges and hollows, similar in configuration to commercial corrugated iron.

The solidified skin on the inside of the tube, which results from the cooling process, follows the curved ridges and hollows in the surface of the mandrel in a band around the mandrel, and as the shrinkage increases, the circumference of this band shortens and pulls those segments of the solidified skin that protrude into the hollows out of the hollows. This decreases the contact area between the solidified skin and the mandrel, thereby decreasing the heat transfer and hence the shrinkage. The unstable condition on the mandrel surface thus becomes a stable condition by eliminating the previously described mutually accelerating relationship between shrinkage and heat transfer.

Further improvement can be obtained by making the ridges and hollows on the mandrel conical in the direction of the strand travel.

Cooling channels located in the protruding parts of the mandrel assure equal cooling of the casting for all of the mandrel surface.

In another preferred embodiment of the invention, the mandrel consists of a shaft having cooling water connections and being enveloped by a corrugated sheet in such a way that the vertical cavities, which are formed by the shaft and the ridges of the corrugated sheet, are connected to the cooling water, thereby providing excellent cooling.

In order to provide further cooling for the inside of the tube after it has left the mandrel, a cooling device fitted with jets is attached to the lower end of the mandrel and supplied with coolant by a duct in the mandrel.

Illustrative embodiments of the invention are shown in the accompanying drawings in which:

FIG. 1 is a vertical longitudinal section through a mandrel of this invention protruding into a mold;

FIG. 2 is an enlarged section on line II—II of FIG. 1; and

FIG. 3 is an enlarged cross section through another embodiment of a mandrel of this invention, which mandrel has a corrugated outer sheet.

Referring to the drawings, a mandrel support 2 is located above the inlet end of a continuous casting mold 1. A mandrel 4 extends downward into the mold and together with the walls of the mold forms a ring-shaped casting cavity. A flange 3 of the mandrel 4 rests on the cooling duct 5 of the mandrel support.

The top of the mandrel support 2 is formed by a water box 6 and an inner duct 7 of said water box has a cooling water inlet connection 9, while an outer duct 8 has a cooling water outlet connection 10. The bottom of the mandrel support 2 is formed by a lubricating oil inlet ring 11. An asbestos cover 12 provides heat and splash protection for the mandrel support.

Water channels 13 located in the mandrel 4 are supplied by the inner duct 7 and conduct the cooling water by way of a connecting duct 14 into the outer cooling channels 15 which are connected to the outer duct 8, where the water is discharged. Rods 16 located in the cooling channels 15 increase the water velocity for pushing away gas bubbles from the walls and also to prevent the formation of scale.

A cooling water inlet pipe 18 is connected to a central channel 17 in the water box 6 and the mandrel 4. A pipe 19 which carries jets 20 for spray cooling of the inside of the cast tube is connected to the lower end of the central channel 17.

The lower portion of the surface of the mandrel 4 which extends down in the mold, is corrugated. As shown in FIG. 2, the cooling channels 15 are located in the ridges of this corrugated surface.

In an alternative embodiment shown in FIG. 3, the mandrel comprises a cylindrical shaft 21 which is covered by a corrugated outer sheet 22. Each ridge of the corrugated sheet forms a separate cooling channel 23 with the surface of the cylindrical shaft 21 and lateral ducts 24 connect water supply channels 25 with the cooling channels 23.

The above-described two alternative mandrels might, in addition to the foregoing features, also be shaped conically in the direction of the tube travel.

During the casting a solidified skin is first formed in the upper sections of the mandrel. This solidified skin follows the hollows and ridges of the corrugated mandrel surface. During the downward movement of the strand, the thickness of the solidified skin increases, in which turn results in a shrinkage of its circumference. In order to shorten the circumference, the solidified skin pulls back from the hollows of the mandrel. This decrease in contact area between the solidified skin and the mandrel decreases the heat transfer and thereby further shrinkage. In this manner, at stable relationship between heat transfer and shrinkage has been obtained.

What is claimed is:

1. In combination with a continuous casting mold, an internally cooled mandrel extending into the mold for the casting of a tube characterized by that portion of the external surface of the mandrel extending into the mold having uniformly distributed longitudinal depressions therein substantially parallel to the longitudinal axis of the mandrel, said depressions adapted to allow a tube skin solidified thereon to pull back therefrom during shrinkage to decrease the contact area between said skin and the mandrel.

2. The combination of claim 1 wherein the depressions are spaced around the circumference of the mandrel with the depressions and the longitudinal portions between them shaped to form regular an equally curved ridges and hollows around the circumference of the mandrel.

3. The combination of clam 1 in which the mandrel is conical in the direction of tube travel.

4. The combination of claim 1 including channels for coolant in the portions of the mandrel between the depressions.

5. The combination of claim 1 wherein said mandrel comprises a shaft, a corrugated sheet enveloping the shaft for the cavities in the exterior of the sheet to provide said depressions and for interiors of the exterior ridges of the sheet to form vertical channels with the surface of the shaft, said shaft having ducts for coolant opening into said vertical channels.

6. The combination of claim 1 which includes a duct for coolant therein connected to a pipe at the end of the mandrel which extends into the mold for conducting coolant to the pipe, said pipe having jets being directed for applying said coolant to the interior surface of a tubular casting formed in the mold by the mandrel.