United States Patent

[11] **3,575,231**

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[32] Priority **Jan. 25, 1968**
[33] **Belgium**
[31] **53,803**

[54] **METHOD AND APPARATUS FOR INJECTING THERMAL CONDUCTING IN A BAND WHEEL CONTINUOUS CASTING SHRINKAGE GAP**
7 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **164/87,** 164/89, 164/283
[51] **Int. Cl.** **B22d 11/06**
[50] **Field of Search** 164/87, 89, 278, 283

[56] **References Cited**

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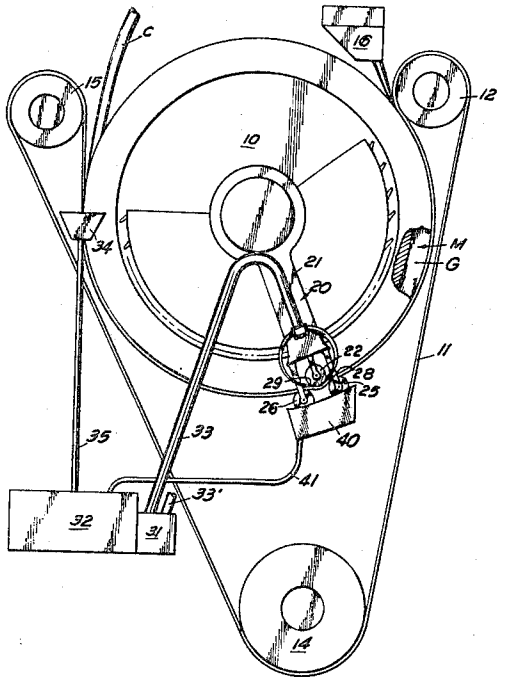
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Primary Examiner—J. Spencer Overholser
Assistant Examiner—R. Spencer Annear
Attorney—Jones and Thomas

ABSTRACT: A continuous casting method which includes solidifying a molten metal in a casting wheel and injecting a heat-conducting medium into the gap formed between the metal and the casting wheel as a result of the solidification of the metal. Casting apparatus is also disclosed and includes a casting wheel having a peripheral groove with a portion closed by an endless band to form a mold and injecting means for injecting a heat-conducting medium into the mold to fill the gap formed between the metal in the mold and the casting wheel when the metal shrinks during its solidification.



PATENTED APR 20 1971

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SHEET 1 OF 2

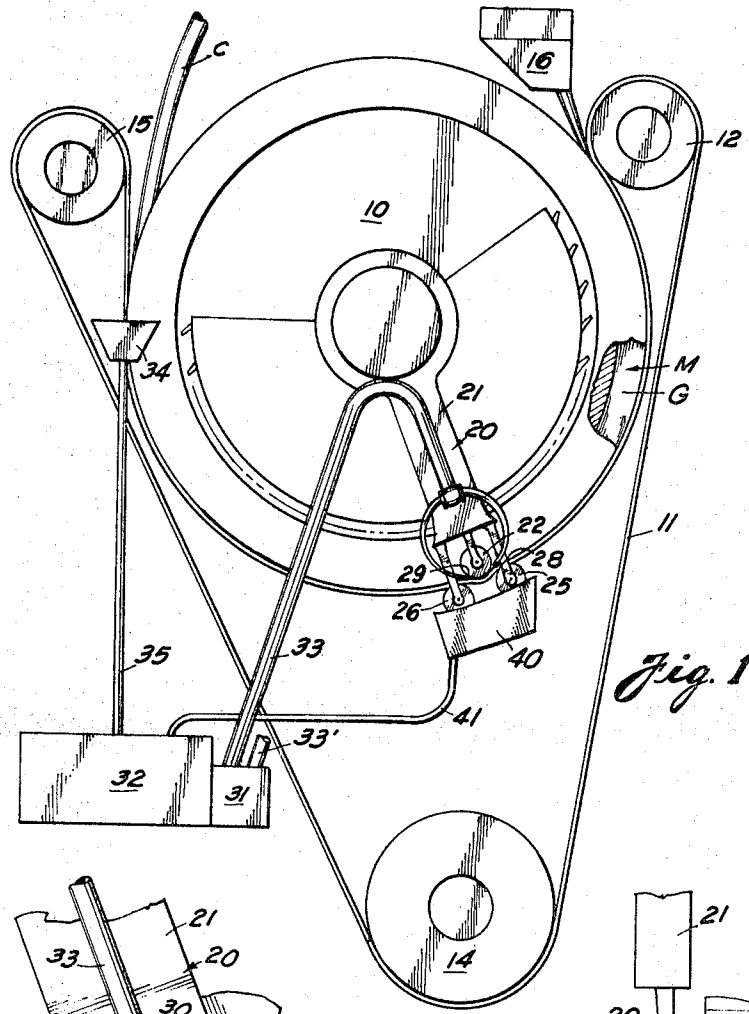


Fig. 1

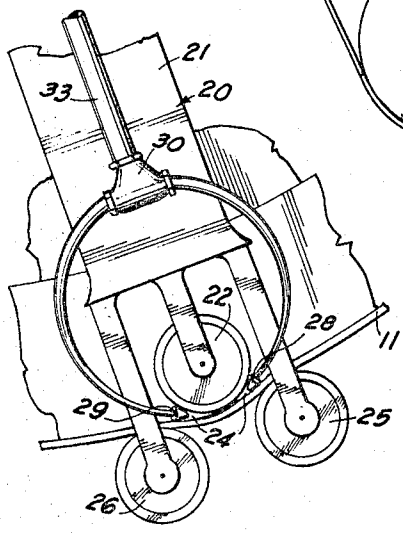


Fig. 2

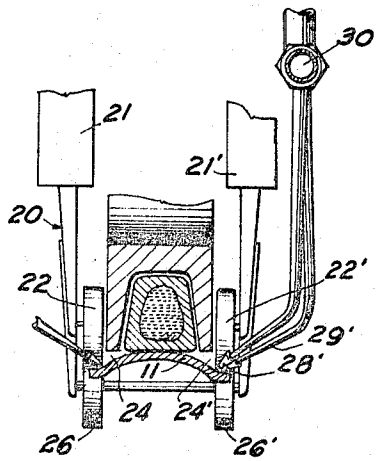


Fig. 3

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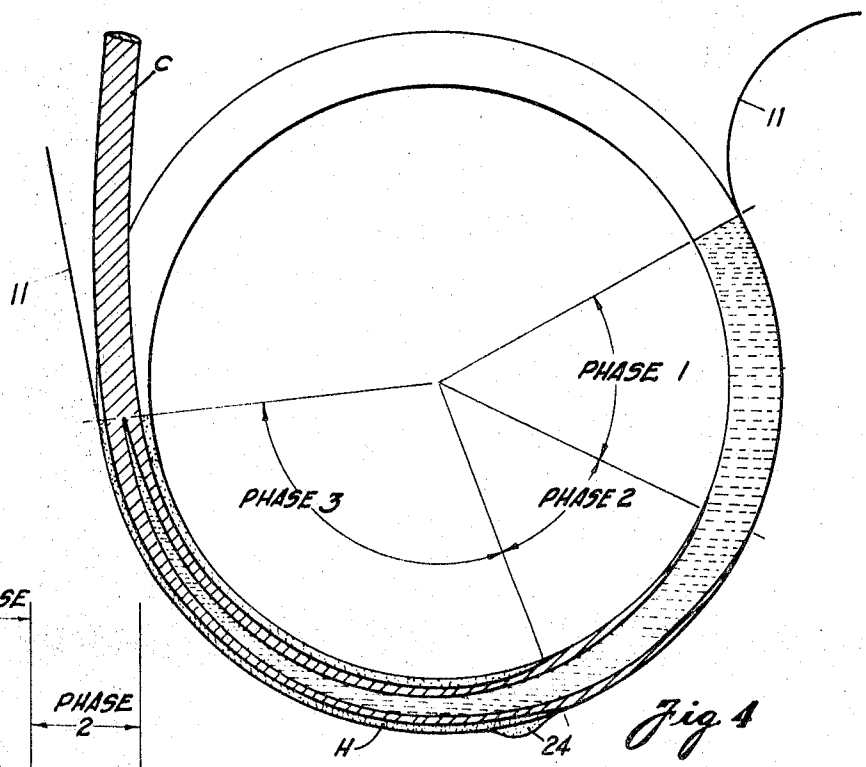

C
11
11
PHASE 1
PHASE 2
PHASE 3
H
24

Fig. 4

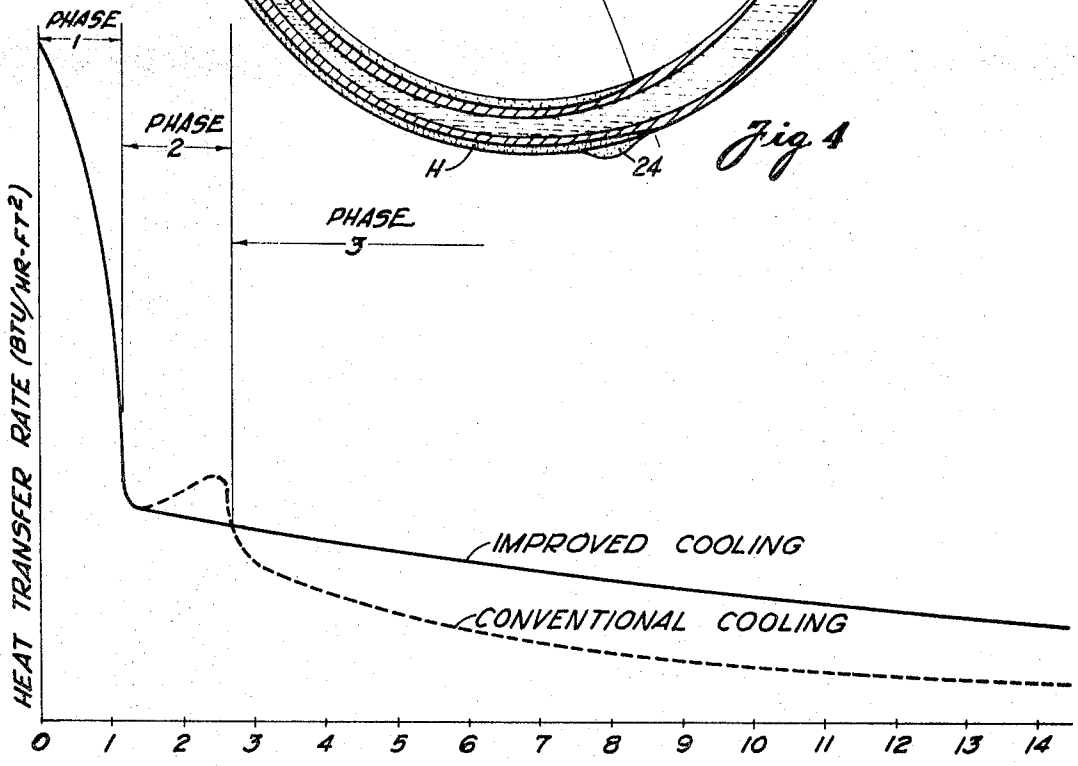

PHASE 1
PHASE 2
PHASE 3
HEAT TRANSFER RATE (BTU/HR·FT²)
IMPROVED COOLING
CONVENTIONAL COOLING
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

Fig. 5

METHOD AND APPARATUS FOR INJECTING THERMAL CONDUCTING IN A BAND WHEEL CONTINUOUS CASTING SHRINKAGE GAP

CROSS REFERENCE TO RELATED APPLICATION

This application corresponds to Belgian application Ser. No. 53,803, filed Jan. 25, 1968, now Belgian Pat. No. 709,901.

BACKGROUND OF THE INVENTION

The continuous casting of metal in a peripheral groove around a rotating casting wheel is well known in the metal foundry art. In the casting of metal in these rotating casting wheels, it has been found that, as the metal is cooled, it solidifies in three distinct phases. The first phase begins when the liquid metal is fed into the peripheral groove of the casting wheel and includes that portion of the casting process during which the metal is cooled but is completely liquid within the casting wheel so as to be in complete contact with the casting wheel. The second phase is that portion of the casting process during which the continued cooling of the metal causes an outer crust of solidified metal to form adjacent the casting wheel but during which the metal is still in substantially complete contact with the casting wheel. The third phase is that portion of the casting process beginning generally at or near the point in the solidification of the molten metal at which the continued cooling of the metal and the thickening of the outer crust of solidified metal cause the metal to shrink away from the casting wheel and form an air gap between the metal and the casting wheel. Thus, the third phase includes that portion of the casting process during which the air gap prevents complete contact between the metal and the casting wheel even though the metal is not completely solidified and requires further cooling.

It is this third phase of solidification that is most troublesome in the casting of molten metal in a prior art rotating casting wheel since the air gap formed between the cast metal and the casting wheel greatly reduces the rate of heat transfer from the metal to the casting wheel. This is because the heat must be transferred from the cast metal to the casting wheel in the third phase principally by radiation heat transfer through the air in the gap between the cast metal and the casting wheel rather than by conduction heat transfer as in the first and second solidification phases, and because less heat can be transferred by radiation heat transfer than by conduction heat transfer at the same relative temperatures.

This low rate of heat transfer during the third phase of solidification in a prior art casting wheel in turn results in limiting the maximum rotational speed of the casting wheel, hence the casting rates that can be achieved. This is because the rotational speed of a prior casting wheel must be slow enough to provide a sufficient dwell time of the metal in the casting wheel during the third phase for the metal to solidify completely in the casting wheel, and because the peripheral length of the casting wheel available for the third phase of solidification of the metal is relatively fixed.

SUMMARY OF THE INVENTION

The invention disclosed herein overcomes these and other problems associated with casting in prior art casting wheels by a casting method and a casting wheel in which a heat-conducting medium is provided in the gap between the metal and the casting wheel during the third phase of solidification. Thus, the invention results in greatly increasing the rate of heat transfer from the metal to the casting wheel during the third phase of solidification. In turn, the rotational speed of the casting wheel can be increased to provide casting rates not achieved in the prior art.

The apparatus of the invention comprises a casting wheel having a peripheral groove with a portion of its length closed by an endless band to form a casting mold into which molten metal is poured to be solidified. An injecting means is selectively positionable at that point on the casting wheel at which the third phase of solidification begins and the partially solidified metal in the mold has started to shrink away from the casting wheel to form an air gap. The injecting means serves as a means for injecting a heat-conducting medium into the mold to fill the gap formed by the shrinkage of the metal in the casting wheel so as to provide a rate of heat transfer from the cast metal to the casting wheel during the third phase of solidification which is substantially greater than that provided by air in the gap.

These and other features and advantages of the invention will be more clearly understood upon consideration of the following specification and accompanying drawing wherein like characters of reference designate corresponding parts throughout and in which:

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a side elevational view of an embodiment of the invention;

FIG. 2 is an enlarged elevational view of an injecting means for injecting a heat-conducting medium into the mold defined by a casting wheel and a band;

FIG. 3 is a cross-sectional view taken along line 3–3 of FIG. 2;

FIG. 4 is a schematic representation of the invention shown in FIG. 1 showing the position of the heat-conducting medium in the mold defined by a casting wheel and a band; and,

FIG. 5 is a graph comparing the relative cooling rates during the three phases of solidification in the embodiment of the invention shown in FIG. 1 and in a prior art casting wheel.

These figures and the following detailed description disclose specific embodiments of the invention, however, the inventive concept is not limited thereto and those skilled in the art will understand that the invention may be embodied in other equivalent forms.

ILLUSTRATIVE EMBODIMENTS

Referring to FIGS. 1, 2, and 3, it will be seen that the apparatus of the invention includes a casting wheel 10 having a peripheral groove G with a portion of its length closed by an endless band 11 carried by support wheels 12, 14, and 15. The support wheel 12 is positioned at the point on the casting wheel 10 where molten metal is fed into the casting mold M formed by the groove G and the band 11. The support wheel 15 is positioned at the opposite end of the mold M where the cast metal C is discharged after being solidified.

An injecting means such as the injection mechanism 20 for injecting a heat-conducting medium into the mold M is pivotally mounted about the central axis of the casting wheel 10 on a support 21. The support 21 rotatably carries a deflection roll 22 which engages an edge portion of the band 11 adjacent the casting wheel 10 and deflects this portion of the band 11 outwardly away from the casting wheel 10.

As will be seen from FIG. 3, a similar injection mechanism 20′ is positioned on the other side of the casting wheel 10 from the injection mechanism 20 and has a support 21′ also pivotally mounted about the central axis of the casting wheel 10. The support 21′ rotatably carries a deflection roll 22′, similar to the deflection roll 22, at its outer end to deflect this portion of the band 11 out away from the casting wheel 10.

Referring to FIGS. 1 and 2, a first depression roll 25 and a second depression roll 26 are shown as being rotatably carried by the support 21. The first depression roll 25 engages the band 11 just forward of the deflection roll 22 and holds the band 11 adjacent to the casting wheel 10 and the second depression roll 26 engages the band 11 just rearward of the deflection roll 22 and also holds the band 11 against the edge of the casting wheel 10. Thus, it will be understood that the deflection roll 22 and the depression rolls 25 and 26 will form an opening 24 between the band 11 and the casting wheel 10. Similarly, depression rolls such as the depression roll 26′ shown in FIG. 3, are rotatably carried by the support 21′ on the opposite side of the casting wheel 10 from the rolls 25 and

26 and function in the same manner as the rolls 25 and 26 to form an opening 24' between the band 11 and the casting wheel 10 at the opposite side of the band 11 from the opening 24.

An injection nozzle 28, shown in FIG. 2, is positioned just forward of the deflection roll 22 to direct a heat-conducting medium H into the mold M through the opening 24 formed between the band 11 and the casting wheel 10. A similar nozzle 29 is positioned just rearwardly of the deflection roll 22 and is also to direct the heat-conducting medium H into the mold M through the opening 24. Each of the injection nozzles 28 and 29 is connected to a manifold assembly 30 which, in turn, is connected to a pump 31 through a flexible conduit 33. A like set of nozzles 28' and 29' is positioned on the opposite side of the casting wheel 10 by the support 21' to inject the heat-conducting medium H into the mold M through opening 24' . These nozzles 28' and 29' are also connected to the pump 31 through a manifold 30' and pipe 33' so that the heat-conducting medium H will be supplied from the pump 31 to the nozzles 28' and 29' .

A catch basin 34 is positioned adjacent to the casting wheel 10 at that point from which the solidified cast metal C is discharged from the casting wheel 10. This catch basin 34 will catch any of the heat-conducting medium H being directed back into the supply tank 32 through a return pipe 35.

A second catch basin 40 is positioned under the injection mechanisms 20 and 20' as shown in FIG. 1 and is connected to the supply tank 32 by a pipe 41. The catch basin 40 will catch any splash or overflow from the nozzles 28, 28' and 29', 29.

The injection mechanisms 20 and 20' described above are positioned so that the heat-conducting medium H will be injected into the mold M at the beginning of the third phase of solidification with sufficient pressure for the heat-conducting medium H to fill the gap or space between the metal and the mold M. Since the injection mechanisms 20 and 20' are pivotally mounted, their positions can be varied depending upon the particular point on the casting wheel 10 at which the third phase of solidification begins at each particular casting rate. The pump 31 insures a sufficient continuous flow of the heat-conducting medium H through the nozzles 28, 28' and 29, 29' to keep the gap between the metal and the mold M filled with the heat-conducting medium H at all times.

However, if the heat-conducting medium H were injected into the gap formed between the metal and the mold M at room temperature, both the metal and the casting wheel 10 would be subjected to a severe thermal shock. This could result in breaking of the metal or in the formation of an undesirable grain structure in the metal as it completes solidification. To avoid this possibility, a heating means 50 in the supply tank 32 is used to raise the temperature of the heat-conducting medium H to a range wherein the metal and the casting wheel 10 will not be subjected to severe thermal shock. Also, many appropriate heat-conducting mediums will be a solid at room temperature, and the medium H must remain in a liquid state during the process.

It is to be understood that other type mechanisms may be used to apply the heat-conducting medium in practicing the invention in lieu of the injection mechanisms 20 and 20' since other embodiments or mechanisms may selectively place the heat-conducting medium H into the space between the metal and the mold M to increase the rate of heat transfer from the metal to the mold M during the third phase of solidification of the metal. For example, another mechanism that could be utilized is a mechanism capable of urging or guiding the heat-conducting medium H into the mold M from the point on the casting wheel 10 at which the cast metal C is discharged.

Numerous heat-conducting mediums may be used; however, the following table discloses some that can be used. In selecting a heat-conducting medium, there are three primary characteristics to be considered:

(1) Thermal conductivity; (2) boiling temperature; and, (3) melting temperature.

Since molten copper has a temperature of about 1,100°C., the boiling point of the heat-conducting medium should be below this to prevent vaporization of the liquid within the casting mold. The cast copper bar will emerge from the casting groove at a temperature of about 970°C. therefore, the melting temperature of the heat-conducting medium should be below this in order to maintain the medium in a liquid state.

	Melting temperature, ° C.	Boiling temperature, ° C.
Barium chloride	925	1,560
Calcium chloride	772	1,600
Copper chloride	422	1,366
Lead fluoride	855	1,290
Lithium bromide	547	1,265
Lithium chloride	613	1,353
Magnesium chloride	708	1,412
Potassium bromide	730	1,380
Potassium chloride	776	1,500
Potassium fluoride	880	1,500
Silver chloride	455	1,550
Sodium chloride	801	1,413
Sodium cyanide	563.7	1,496

OPERATION

In operation of the apparatus and in practicing the method of the invention, the casting apparatus is started by rotating the casting wheel 10 with a conventional power means (not shown) and the band 11 is positioned against the casting wheel 10 to form the mold M. The pouring pot 16 directs molten metal into the mold M and the metal begins to solidify as a result of cooling of the casting wheel 10 from conventional spray assemblies S. Depending upon the rotational speed of the casting wheel 10, the injection mechanisms 20 and 20' are selectively positioned so that they form openings 24 and 24' between the band 11 and the edge of the casting wheel 10 at substantially that point at which the third phase of solidification of the metal begins.

The pump 31 is started to force the preheated heat-conducting medium H into the mold M through the nozzles 28, 28' and 29, 29' to fill the gap formed between the metal and the mold M as is shown in FIG. 4. As the cast metal C is discharged from the casting wheel 10, some of the heat-conducting medium H is discharged with the cast metal C and drains into the catch basin 34 to be returned to the supply tank 32 and repumped through the nozzles 28, 28' and 29, 29'.

Referring more particularly to FIG. 5, the dashed line of the graph shows a typical heat transfer rate curve for a prior art casting wheel and the solid line of the graph shows a typical heat transfer rate curve for a casting wheel embodying the invention. It will be noted that the invention provides an increased rate of heat transfer during the third phase of solidification. Therefore, less dwell time for the metal in the third phase of solidification is needed to solidify the metal into the cast metal C. This allows an increase in the casting rate of the casting wheel 10 since the rotational speed of the casting wheel 10 can be increased as the required dwell time is decreased.

It will, of course, be understood that the amount of heat transferred during the third phase of solidification will be dependent on the thermal conductivity of the heat-conducting medium H selected. Therefore, it is desirable that the heat-conducting medium H have as high a thermal conductivity as possible and the heat-conducting medium H may be a liquid provided by one of the commercially available high-temperature salts. It may also be a gas such as helium or carbon dioxide if the supply tank 32 is arranged to apply suction at the catch basin 34 for drawing the gas through the mold M and into the supply tank 32.

However, it will be understood that regardless of the heat-conducting medium H selected, the heat-conducting medium H should preferably be fluid at the temperature at which the cast metal C leaves the casting wheel H and should not boil excessively at the temperature of the metal in the casting wheel 10. Moreover, it will be understood that the

characteristics of the heat-conducting medium H should not be such as to have an excessively adverse effect on the metal being cast in the mold M.

Although specific embodiments of the invention have been disclosed herein, it is understood full use of modifications, substitutions, and equivalents may be resorted to without departing from the scope thereof as set forth by the appended claims.

I claim:

1. In a process of casting molten metal the steps of feeding a molten metal into a mold formed by a peripheral groove in a rotating casting wheel and a continuous band closing a portion of the groove, cooling the mold until the said molten metal is partially solidified and shrunken due to the partial solidification, and placing a heat-conducting medium between the partially solidified metal and the mold, and continuing the cooling of the said mold.

2. The process according to claim 1 in which the placing of a heat-conducting medium is begun where a gap first begins to form between the partially solidified metal and the mold.

3. The process according to claim 2 in which the gap is completely filled by the heat-conducting medium, and is maintained full while the metal is within the mold.

4. The process according to claim 1 in which the step of placing a heat-conducting medium includes passing the said heat-conducting medium between the said continuous band and the said casting wheel.

5. Apparatus for casting a molten metal including a casting wheel having a peripheral groove, a continuous band to close a portion of the groove to form a closed mold, means to introduce molten metal into the closed mold, and means for cooling said mold to solidify the molten metal, and injecting means to fill the closed mold with a heat-conducting medium where the molten metal cools and shrinks from the mold.

6. Apparatus according to claim 5 in which said injecting means includes means to separate the said band from the said casting wheel.

7. Apparatus according to claim 6 in which said injecting means is selectively positionable along the said closed mold.