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[54] **MANDREL FOR CONTINUOUS CASTING OF HOLLOW INGOTS**

[76] Inventors: **Vitaly Yakovlevich Genkin,** Sirenevy bulvar, 27, korpus 3, kv. 27; **Vladimir Borisovich Gankin,** Ulitsa N. Maslovka, 8, kv. 203; **Alexandr Georgievich Budkevich,** Svobodny prospekt 22, korpus 2, kv. 113; **Vladimir Efremovich Sirota,** Volgogradsky prospekt, 115, korpus 2, kv. 9, all of, Moscow, U.S.S.R.

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[52] **U.S. Cl.**................ **164/273 R;** 164/85; 249/175

[51] **Int. Cl.**^{2}.. **B22D 11/02**

[58] **Field of Search**............ 164/82, 85, 273 R, 282, 164/283M; 249/116, 135, 175

[56] **References Cited**

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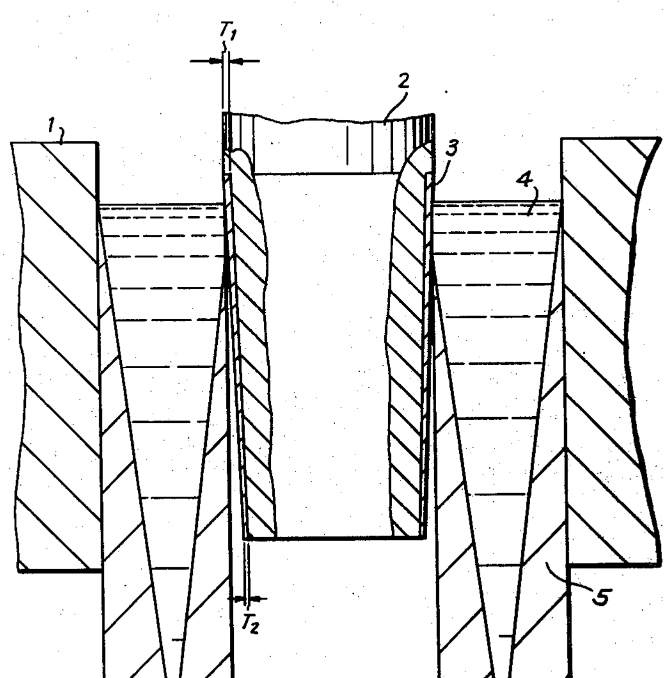
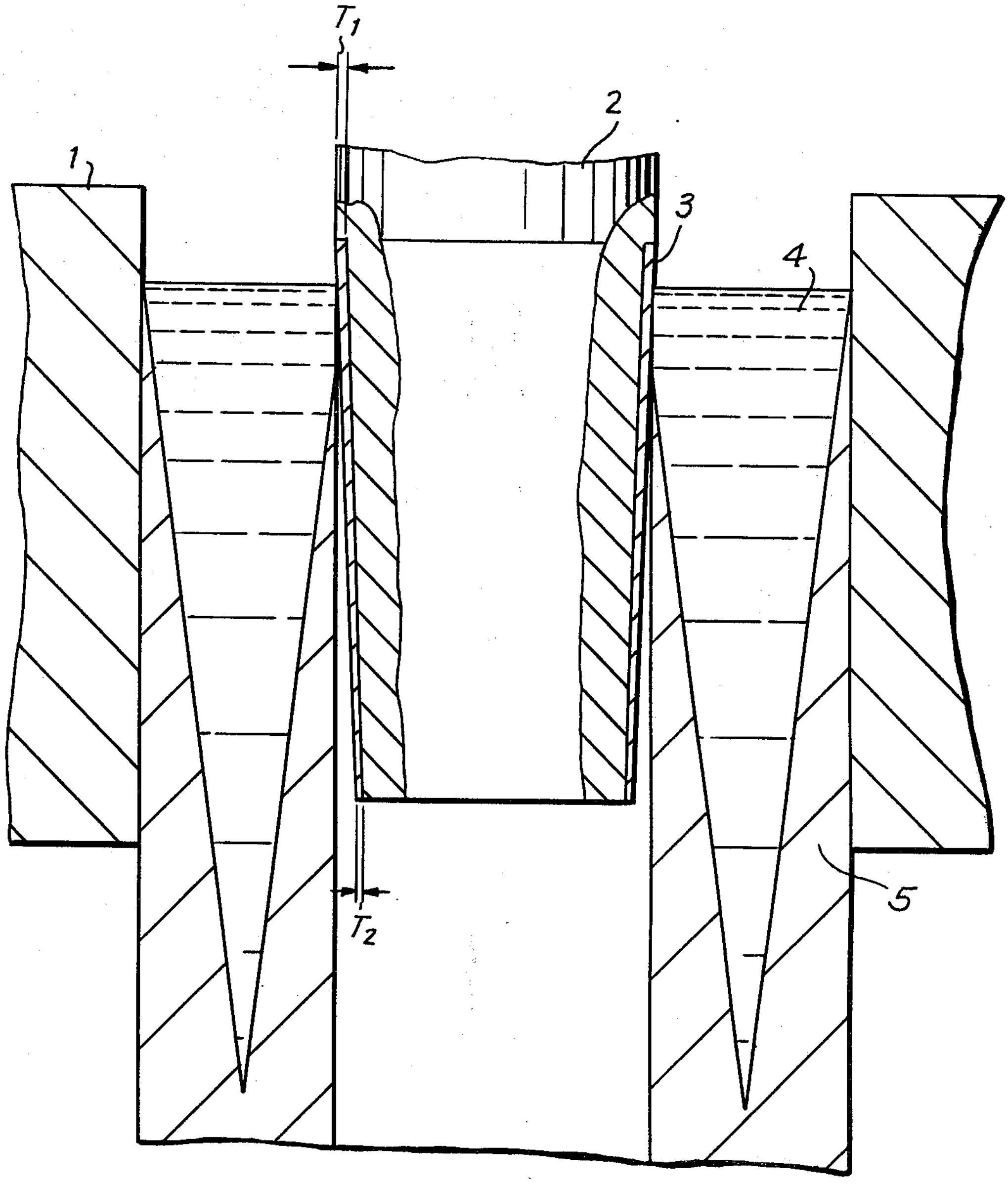
Primary Examiner—R. Spencer Annear
Attorney, Agent, or Firm—Haseltine, Lake & Waters

[57] **ABSTRACT**

A downwardly tapered section of a mandrel is given a coating of a metal whose coefficient of thermal conductivity is lower than that of the metal from which the mandrel is manufactured. The thickness of the coating diminishes uniformly downwardly along the length of the tapered section the mandrel in the direction of motion of a downwardly conveyed ingot, the ratio of the thickness of the coating at the upper end of the tapered section relative to the thickness of the coating at the lower end thereof ranging from 1:50 to 1:150.

1 Claim, 1 Drawing Figure





T_1
2
1
3
4
5
T_2

MANDREL FOR CONTINUOUS CASTING OF HOLLOW INGOTS

The present invention relates to metallurgy and, more particularly, to the continuous casting of metals and alloys and may prove useful in casting hollow ingots.

When producing hollow metal ingots on continuous casting machines an ingot space is shaped with the help of an internal mould (a mandrel). Between the walls of the external mould and mandrel there is provided an annular space wherein liquid metal is admitted. On freezing solid it forms a hollow metal blank.

Known in the art are mandrels with a working surface having a tapered or curved profile. In all the known cases the profile of the longitudinal section of the mandrel is chosen under the assumption that solidification and shrinkage of the internal ingot skin progress with time in accordance with a certain law. In an ideal case a change in the profile (a decrease in height of a mandrel radius) will match the rate of shrinkage. However, under actual conditions usually the taper or curvature are set with a certain margin, insofar as the shrinkage depends on a plurality of variables (chemical composition of the metal, its temperature, casting rate). Thus, a mandrel with a multistep taper is known (cf. GDR Patent No. **49965509, 1965**). The taper of each underlying step is chosen so that it will be slightly less that the preceding one with the step length being selected in such a manner that the skin shall fit the mandrel in the top section of each step, setting off from the mandrel as it descends. This is made to enable a periodic decrease in heat removal and to reduce the stresses arising in the skin.

A disadvantage of the parabolic or multistep tapered mandrels resides in a rapid drop in temperature of the primary ingot skin at the first instant when liquid metal comes in contact with the mandrel and in a maximum shrinkage rate which takes place at this moment. As shown by experiments, at a distance as small as **20–30** mm below the meniscus the skin sets off from the mandrel. In this case heat removal is disturbed, the rate of the building-up of the skin reduces sharply and variations in its thickness become manifest which may lead subsequently to distortion of the internal space and on some occasions to melting-off and to the bleeding of the liquid core into the ingot space. Moreover, friction between the internal skin of the ingot and the mandrel arising when the skin is pulled off the mandrel results in the origination of the skin stresses and may lead to tears or to the hanging of the skin on the mandrel.

The object of the present invention is to provide a mandrel for the continuous casting of hollow ingots whose inherent design would offer a reduction in the rate of heat removal from an internal skin of the hollow ingot, being formed, at the first instant of solidification (near the meniscus) and in the coefficient of friction between the ingot skin and mandrel.

The above object is accomplished by providing a mandrel for the continuous casting of downwardly conveyed hollow ingots having a downwardly tapered section in the zone of contact with liquid metal, wherein, according to the invention, the tapered section of the mandrel is given a coating of a metal whose coefficient of thermal conductivity is lower than that of the metal from which the mandrel is manufactured, with the coating decreasing uniformly in thickness along the length of the tapered section the mandrel in the direction of motion of the ingot with the ratio of the thickness of the coating at the upper end of the tapered section relative to the thickness of the coating at the lower end thereof ranging from **1:50** to **1:150.**

The inherent design of the mandrel **2** would offer a reduction in the rate of heat removal and shrinkage rate of the internal skin of the ingot, enabling the friction between the internal skin and mandrel to be reduced in the course of solidification.

Given hereinbelow is a specific embodiment of the invention having reference to the single FIGURE of the accompanying drawing.

The tapered section of a mandrel **2** made from copper is given a diffusion chrome or molybdenum coating **3.** The coating is applied in such a way that its thickness diminishes uniformly downwardly along the length of the mandrel in the direction of motion of the ingot from a thickness T_1 at the upper end of the tapered section to a thickness T_2 at the lower end thereof.

The ratio of limit thicknesses of the coating at the relative tapered section ends varies over a range of **1:50–1:150**. Thus, if the thickness of the mandrel coating amounts to **1** mm at the beginning or upper end of the tapered section, its thickness should range within from **20** to **7** mm at the lower end of the section.

The herein-disclosed device operates in the following manner.

An internal mould - a mandrel **2** - is installed in a continuous casting machine of a vertical type so that it is aligned axially with an external mould **1.** The working part of the mandrel has a tapered section to which the above-described coating **3** is applied.

Owing to shrinkage processes which take place during solidification of a continuous hollow ingot **5,** cast from molten metal **4,** an internal ingot space being shaped tends to "seize" the mandrel. It does not happen in practice, insofar as the coating applied on the working part of the mandrel reduces heat extraction and, accordingly, the rate of shrinkage of the internal skin.

As the internal skin of the ingot is being built-up, heat transfer from the internal skin to the mandrel shall be increased when the ingot is pulled off the mandrel, for which purpose the mandrel coating must decrease uniformly in thickness toward the end of the working part of the mandrel.

The use of the thus-made mandrel would offer a reduction in the rate of shrinkage of the primary internal skin of the ingot being shaped and would make it possible to increase the duration of contact between said ingot skin and the heat-absorbing surface of the mandrel.

Additionally, the presence of the coating on the mandrel surface descreases the coefficient of friction between the internal ingot skin and mandrel by means of which a smaller force is needed to pull the ingot off the mandrel while decreasing the probability of the skin adhering to the mandrel.

What we claim is:

1. A mandrel for the continuous casting of downwardly conveyed hollow ingots comprising a downwardly tapered section located in the zone of contact with liquid metal and having a coating of a metal provided on the tapered section whose coefficient of thermal conductivity is lower than that of the metal from which said mandrel is manufactured, with the thickness of said coating diminishing uniformly from the upper end of the tapered section along the length of the mandrel to the lower end thereof in the direction of downward motion of the ingot, the ratio of the thickness of the coating at the upper end of the tapered section relative to the thickness of the coating at the lower end thereof ranging from **1:50** to **1:150.**

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