CONTINUOUS CASTING WHEEL WITH IMPROVED COOLING ARRANGEMENT

Filed Jan. 8, 1968 4 Sheets-Sheet 1

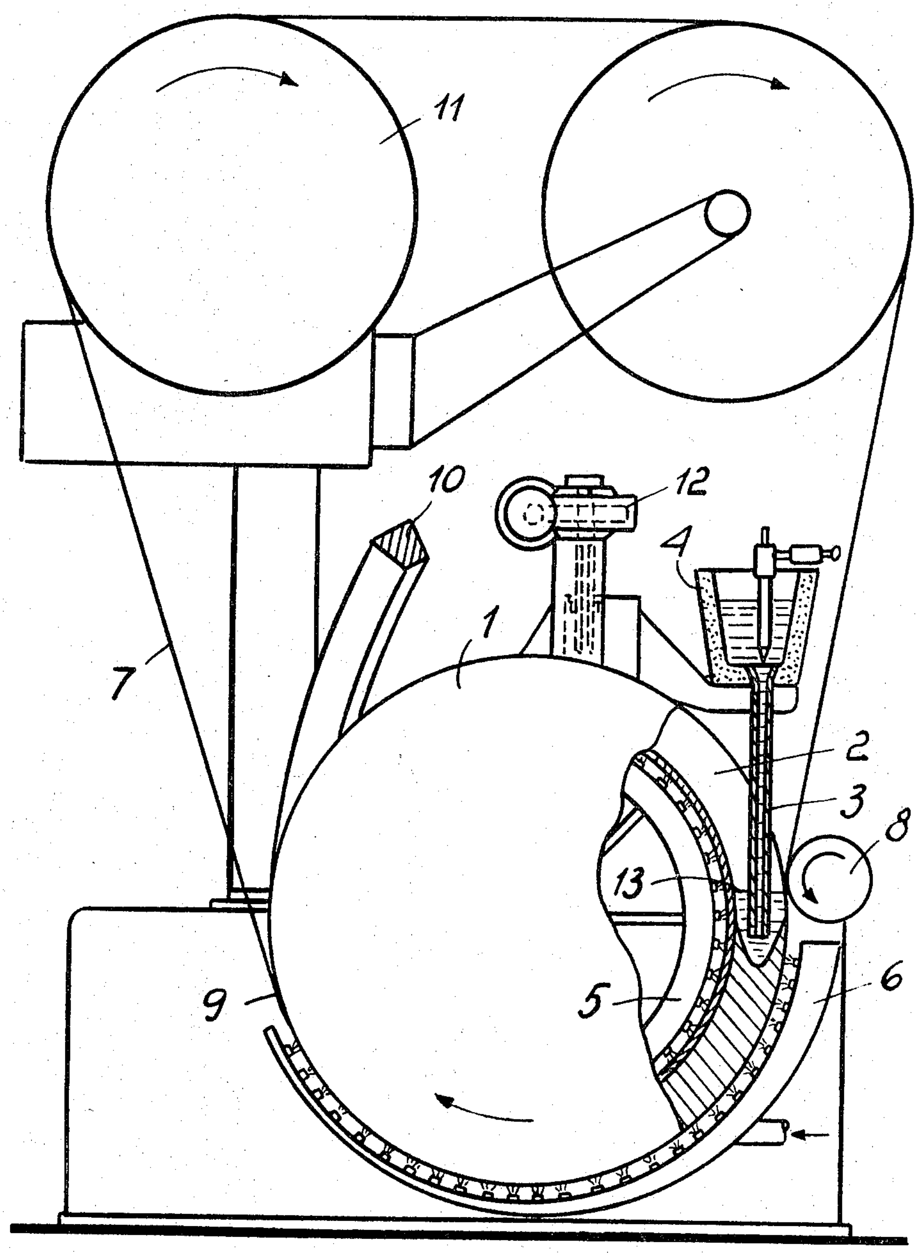

Fig. 1

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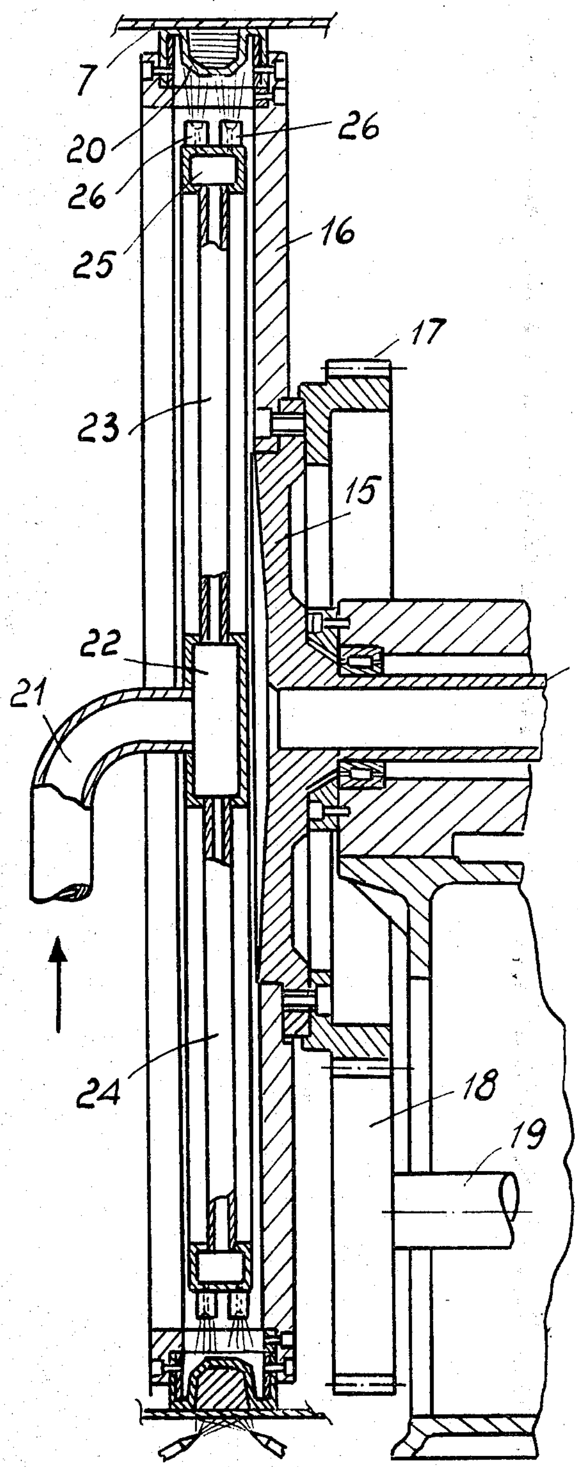

Fig. 2

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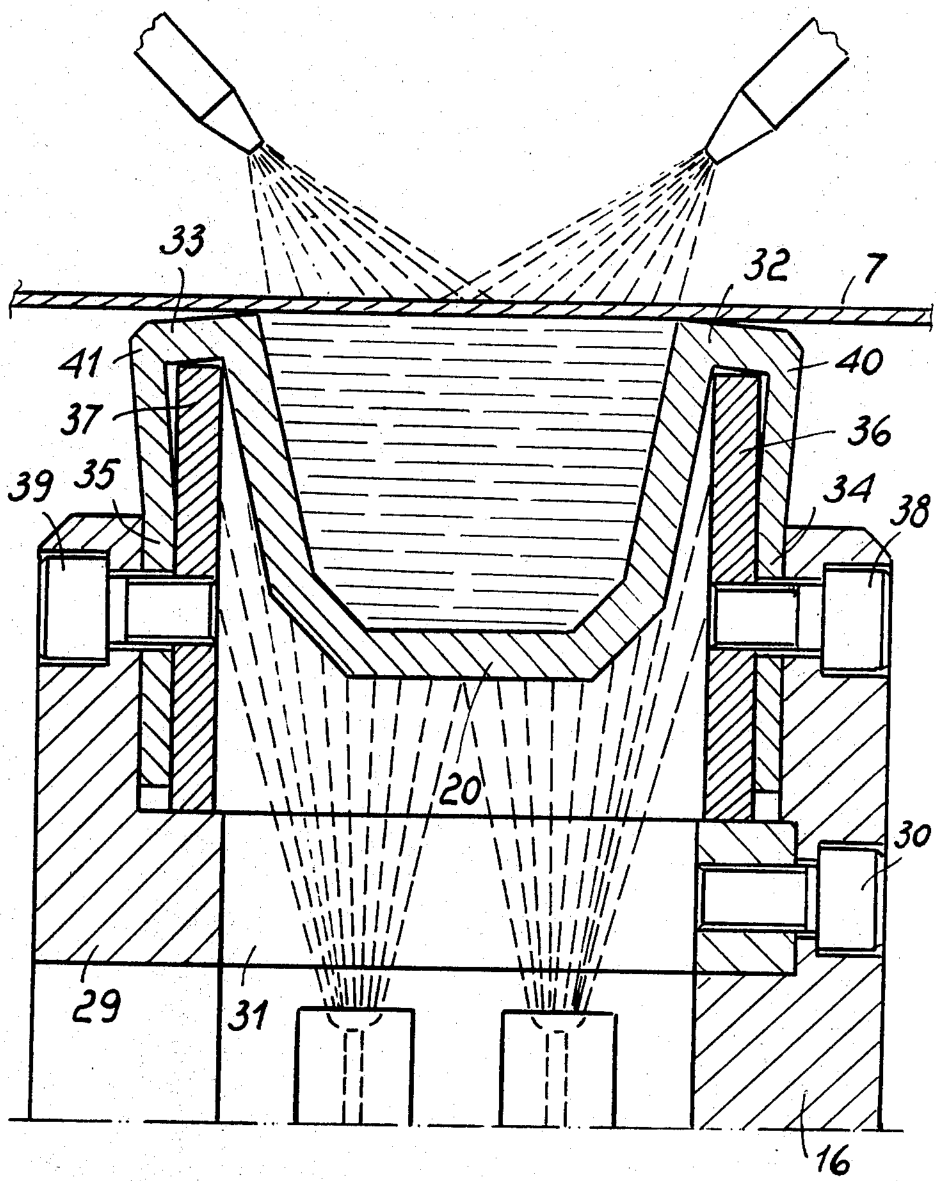

Fig. 3

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Sept. 22, 1970 I. PROPERZI 3,529,658

CONTINUOUS CASTING WHEEL WITH IMPROVED COOLING ARRANGEMENT

Filed Jan. 8, 1968 4 Sheets-Sheet 4

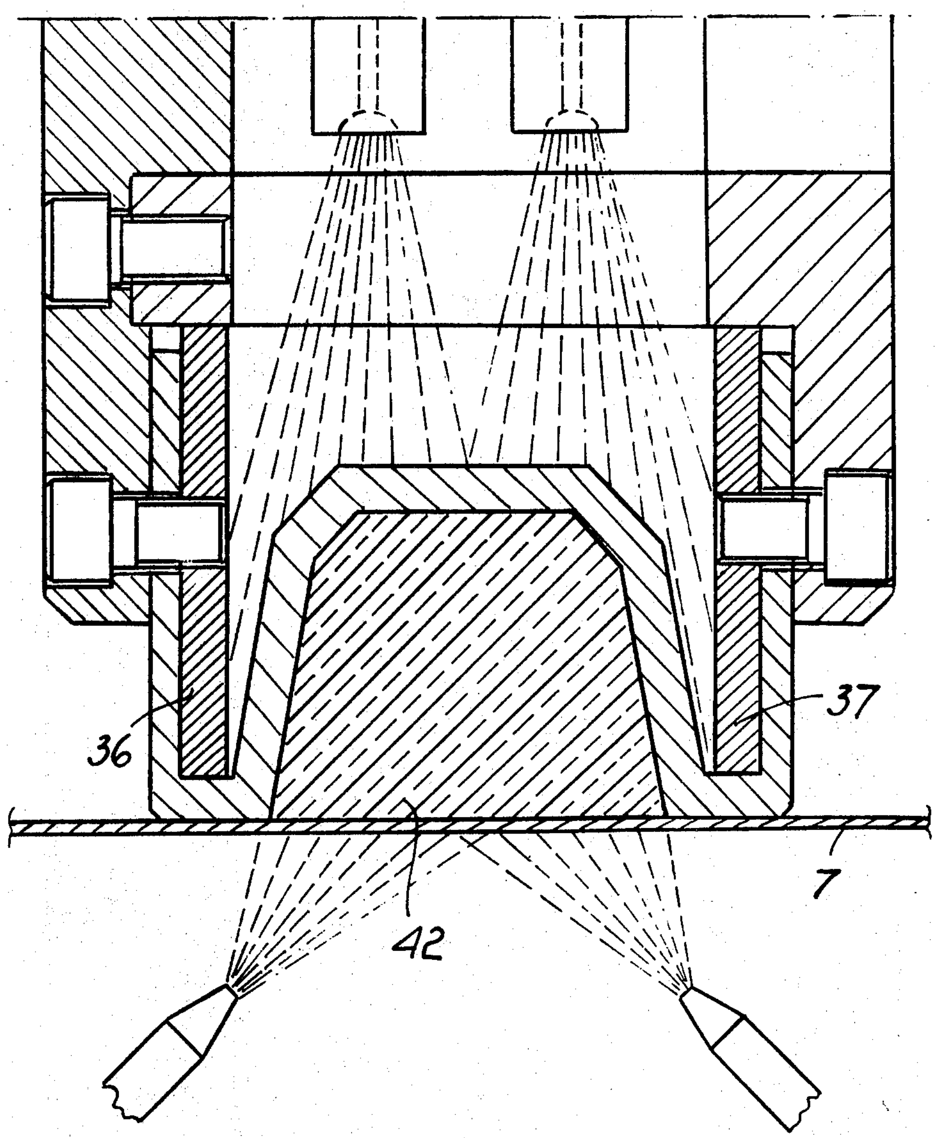

Fig. 4

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CONTINUOUS CASTING WHEEL WITH IMPROVED COOLING ARRANGEMENT

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Int. Cl. B22d 11/06
U.S. Cl. 164—278 2 Claims

ABSTRACT OF THE DISCLOSURE

This disclosure relates to a continuous casting wheel for producing metal ingots. The casting wheel is a turning wheel provided with a flexibly mounted grooved periphery or mould, with a metal tape arrange to cover an arc portion of said groove and cooperating with a water jet cooling system designed to cool the walls of said groove and said tape. Molten metal is loaded into said groove at the beginning of the portion covered by said tape and leaves the latter in solid ingot or bar form.

The present invention relates to an improved grooved ring or casting mould peripherally carried by casting wheel in a continuous casting machine.

As it is known, the continuous casting machine for producing continuous metal bars essentially comprises a turning wheel peripherally provided with a groove or casting mould of section equal to the section of the ingot to be cast. Said groove is covered along a certain portion of arc by a metal tape which closes the corresponding portion of groove to retain therein the metal which, entering the groove in liquid or molten state at the beginning of said closed portion, leaves the covered portion of said groove in the form of a solid continuous bar or ingot.

In order that the bar be solid and well formed at the end of the covered portion, it is necessary that an adequate controlled cooling occur while the wheel describes an angular rotation corresponding to the arc covered by said tape.

Due to production requirements it is necessary, when dealing with bars or ingots of narrow section, that the wheel complete such rotation in a relatively brief time, for example of the order of 10 seconds, whence the cooling must take place with extreme rapidity and uniformity. This rapid cooling is hindered by solidification shrinkage (or contraction) of metals when undergoing a change from liquid to solid state and the thermal contraction of metal between the solidification temperature and the extraction temperature.

For instance, this linear contraction due to solidification and cooling in the case of aluminium has a value of 1.7%. It is thus evident that the total contraction is considerable, whence, during formation, the ingot separates from the cooling walls of the surrounding mould, disturbing the rapid and uniform cooling thereof.

It is well known that the cooling of the molten metal in a continuous casting machine is an especially intricate and difficult operation.

Unbalanced cooling of the molten metal will result in a defective ingot structure, the ingot being subject to crystallization malformations, segregations, cracks, surface roughness and brittleness etc. and these defects become more noticeable according to increase of the ingot section.

The prior art discloses many attempts to overcome this most important problem. A continuous casting apparatus includes a disc-shaped inner flange concentrically sup-

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ported at the end of a rotatable shaft, an annular casting wheel clamped to the front face of the inner flange by a spring loaded outer flange which is designed to allow the casting wheel to expand and contract with thermal changes. The casting wheel is provided with a partially covered peripheral groove or mould adapted to receive the molten metal and a water jet arrangement is provided to cool the inner, the side and the covered portions of the mould.

However this casting arrangement, as in the case of other known casting wheels in which the peripheral groove is not spring loaded but completely rigid, provides a cooling which is inefficient and defective in principle.

This is because, whilst these known casting arrangements provide for cooling of the molten metal by conduction through the enclosing walls of the peripheral groove, they do not provide any adequate means for maintaining contact between such walls and the molten metal as the latter contracts.

It is consequently evident that such casting arrangements, whilst representing substantial improvements on the older methods, do not satisfy the paramount requirement of providing a balanced, rapid and uniform cooling of the molten metal.

It is an object of the invention to abandon the generally rigid structure grooved rings of the prior art in order that a more satisfactory, uniform and controlled cooling of the cast ingots or bars may be obtained.

An important object of the invention is that of providing a grooved mould which is mounted and formed in manner such as to be free to expand and contract according to the insertion of molten metal to be cast and its contraction due to the cooling, walls of the groove thus being arranged to remain in constant contact with the ingot to be cast during all stages of its formation.

A further object of the invention is that of providing a grooved ring or mould which expands automatically and elastically in an extremely short time by means of elastic connections of the edges of the groove with the rigid parts of the wheel.

A further object is that of producing ingots by wheel casting of the described type which are perfectly smooth, shiny and perfectly formed.

According to the present invention there is provided a continuous ingot casting apparatus with a rotable casting wheel, a continuous grooved mould peripherally provided on said wheel for receiving molten metal, a metal tape arranged to cover an arc portion of said grooved mould, one end of said arc portion corresponding to the molten metal inlet point and the other end thereof corresponding to the outlet point of solid ingot, cooling means arranged for the cooling of said tape and the walls of said grooved mould, wherein according to the improvement said grooved mould has an M-like cross-section defining a central trough-like portion receiving the cast metal and two arms on both sides of the trough-like portion, said arms having one end connected with an upper portion of said trough-like portion of the mould and a free end portion spaced from said trough-like portion thereby defining between said trough-like portion and the respective arm an interspace on each side of said trough-like portion, clamp means rigid with said wheel being provided to clamp said free end portions of the mould in a point substantially distant from said one end of said arms connected with said tough-like portion at least the portion of said arms between said clamp means and said one end thereof being of resilient material thereby to allow a flexible connection between said mould and said wheel and an expansion of the mould.

BRIEF DESCRIPTION OF THE DRAWINGS

The characteristics of the invention will appear more clearly from the following detailed description of an embodiment of a continuous casting machine illustrated by way of non-limiting example in the accompanying drawings in which:

FIG. 1 is a front elevational view of a continuous casting machine, and shows the feeding system for the tape covered peripheral groove of the turning or casting wheel,

FIG. 2 shows a sectional view of the turning wheel of the casting machine of FIG. 1,

FIG. 3 shows a sectional view of the grooved ring or mould (full of molten metal) in phase of expansion at a point near to the filling level,

FIG. 4 shows a section of the grooved ring of FIG. 3 with an ingot already in solid state in a low point of the turning wheel.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 shows an elevational view of a continuous casting machine with a turning wheel **1** in which a peripheral groove **2** is fed with molten metal through the nozzle **3** extending from a feeding crucible **4** which is fed by the normal known means (not shown).

The groove **2** and the tape **7** are cooled internally and externally, respectively, by a series of water jets **5** and **6** for the mould and for the tape respectively.

The tape **7** encloses an arcuate portion of the groove **2** from the point in which it is controlled by the roller **8** to the point in which the solid ingot **10** leaves the wheel.

The tape **7** is maintained in constant tension by devices which act on the pulley **11**. The device **12** allows the lower point of the nozzle **3** to be adjusted below the filling level **13**.

FIG. 2 shows a section of the casting wheel comprising a rotation shaft **14** which terminates with a sturdy flange **15**. A disc **16** is secured to said flange **15** and forms the revolving part of the wheel, which is set in motion by a gear **17** actuated by a pinion **18** which is set in motion by a shaft **19** of a motor (not shown).

On the periphery of the disc **16** is secured a grooved ring **20**. The cooling liquid comes from a tube **21** which, through a manifold **22** and tubes **23** and **24**, feeds a manifold **25** intended to feed a series of jets **26**.

FIG. 3 shows a section of the grooved ring full of liquid or molten metal in a point near the filling level.

Reference numeral **20** indicates the section of the ring secured to the disc **16** by means of a counter-ring **29**.

Said counter-ring **29** (secured to the disc **16** by means of bolts **30**) is provided with slits or apertures **31** through which jets of water may be sprayed onto the inner surface of the grooved ring **20**. Said grooved ring **20** is formed by said cavity that is that part of the walls which is in direct contact with the molten metal by the edges **32** and **33** on which the closure tape **7** is supported and by the edges **34** and **35** which are folded towards the centre of rotation so as to form the closure surface of the mould between the disc **16**, the counter disc **29** and the ring members **36** and **37**.

Reference numerals **38** and **39** indicate some locking bolts of the mould.

As best seen from FIG. 3 elastic members **40** and **41** are thus formed which allow the expansion of the groove.

The desired expansion depends upon the thickness of the walls of the mould, the metal to be cast and is in ratio to the ingot section and the respective specific heats. Such expansion of the mould must therefore be obtained as a result of the heat given out as the metal passes from its liquid state temperature to its solid state temperature, that is to say its latent heat of fusion.

The latent heat of fusion of a metal is generally defined as the heat absorbed by 1 kg. of the metal during its passage from a solid at its fusion temperature to a liquid at the same temperature. This quantity of thermic energy is given out by the metal as it solidifies.

Taking once again the example of aluminium, the latent heat of fusion is about 93 calories per kilogram.

A considerable amount of heat may thus be provided for the rapid expansion of the mould and this establishes a ratio between the ingot section and the thickness of the mould walls according to the desired expansion and the expansion rapidity.

Excluding from the following calculation the steel tape which encloses the groove because of its minimal thickness 2 mm. or even less, let us consider the said mould proper normally formed of a copper ring which constitutes the periphery of the turning wheel.

The copper ensures a rapid heat transmission and it is assumed that the copper has an average specific heat of 0.1 calorie kilogram degree centigrade.

Let us now consider the production of an aluminium ingot of rectangular section of 6 x 5 cm. sides, i.e. 30 $cm.^2$.

A segment of such an ingot of aluminium of 1 cm. thickness has a weight of about 80 gm. This segment will give out from the moulding temperature of about 700° C. to the solidification temperature of 658° C. a total of about 7 calories. But considering that it is desirable to obtain an expansion of the mould when a good deal of the metal still remains in liquid state it may be assumed that only 3 calories are available.

These 3 calories must be sufficient to expand a corresponding segment of the mould due to its increase of temperature and thus the thickness of the walls of the mould according to the metal of which the mould is formed will be calculated bearing this requirement in mind.

It is consequently necessary that the time required for the expansion of the mould be considered, in which time the grooved ring should not be cooled by water sprays.

The hourly production of the machine depends upon the thermic energy which may be transferred to the cooling liquid through the walls of the mould. If these walls are thin, the required expansion is rapidly obtained.

With a copper mould it is possible to obtain walls having a thickness of a few millimeters. In this case the expansion of the mould which is in contact with the molten metal is very rapid.

Owing to this expansion the groove is thus such as to receive a greater quanity of metal and thus permits contact with the ingot throughout the cooling phase since when the ingot cools and shrinks a corresponding contraction of the cavity occurs.

The construction of the mould must also be such as to allow the rhythmic expansion and contraction in elastic manner and this occurs by means which will hereinafter be described to avoid permanent deformation of the mould.

The widening of the groove occurs due to the elongation of the copper ring, where it is superheated, thereby the radius of curvature thereof is increased with respect to the wheel centre.

The lateral edges, however, remain in a clamped condition and cool, and the central cavity upon increase of the said radius, is then caused to spread outwards, thus increasing the volume capacity.

The cyclic increase at each revolution of the wheel of the groove cross-section is then a consequent of the resilient connection between the grooved portion when elongation and thus of radius increase, and the lateral arms securely clamped to the wheel structure.

Thereafter the cooling of the mould is effected by means of sprays which act upon the internal walls of the cavity.

This method of moulding produces an ingot which is perfectly formed and which has perfectly smooth surfaces. This is due to the intense heat exchange ensured by the uninterrupted contact between the ingot and the mould and the minimal thickness of the walls of the mould. This method also allows high productions to be obtained with rings of relatively small diameter which is extremely economically advantageous since the rings are the most expensive members of the process.

The resultant increase of volume of the groove is automatic and controlled because when the contraction of the mould occurs during the successive cooling phase such volume must return to its initial position.

In FIG. 4 a solid ingot **42** may be seen in the mould which has returned to its initial position due to the ring members **36** and **37** which are fast with the rigid parts of the wheel.

Whilst an embodiment of the invention has been described by way of illustration it will be clear to those skilled in the art that many variations may be made without departing from the scope of the invention as defined by the appended claims.

What is claimed is:

1. A continuous ingot casting apparatus with a rotatable casting wheel, a continuous grooved mould peripherally provided on said wheel for receiving molten metal, a metal tape arranged to cover an arc portion of said grooved mould, one end of said arc portion corresponding to the molten metal inlet point and the other end thereof corresponding to the outlet point of solid ingot, cooling means arranged for the cooling of said tape and the walls of said grooved mould, wherein, according to the improvement, said grooved mould has an M-like cross-section defining a central trough-like portion, receiving the cast metal and two arms on both sides of the trough-like portion, said arms having one end connected with an upper portion of said trough-like portion of the mould and a free end portion spaced from said trough-like portion thereby defining between said trough-like portion and the respective arm an interspace on each side of said trough-like portion, clamp means rigid with said wheel being provided to clamp said free end portions of the mould in a point substantially distant from said one end of said arms connected with said trough-like portion, at least the portion of said arms between said clamp means and said one end thereof being of resilient material thereby to allow a flexible connection between said mould and said wheel and an expansion of the mould and wherein said clamp means comprise a flange-like side wall rigid with said wheel, a flat ring section member parallel with said side wall and spaced therefrom, said flat ring section member extending with its outside peripheral portion into said interspace between said arms and said trough-like portion thereby to clamp the free end portions of said arms between said flat ring section member and said side walls and screw means for clampingly pressing said free end portions of said arms between said flat ring member and said side walls.

2. An apparatus according to claim **1**, wherein the width of said interspace is greater than the thickness of said flat ring section member to provide a play therebetween.

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