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[54] **METHOD OF AND APPARATUS FOR CASTING ON MOVING SURFACES**

[75] Inventors: **Gerard Bernard Leconte; John Walter Wright,** both of Kingston, Ontario, Canada

[73] Assignee: **Alcan Research and Development Limited,** Montreal, Quebec, Canada

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[52] **U.S. Cl.** **164/73,** 164/87, 164/158, 164/268, 164/278

[51] **Int. Cl.** **B22d 11/06**

[58] **Field of Search** .. 164/72, 73, 87, 158, 268, 278

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Primary Examiner—J. Spencer Overholser
Assistant Examiner—John E. Roethel
Attorney, Agent, or Firm—Cooper, Dunham, Clark, Griffin & Moran

[57] **ABSTRACT**

In the casting of metals on or between movable endless surfaces, a two-layer dressing is applied to each casting surface. The dressing includes a heat-insulating coating fixedly adhered to the casting surface, and a removable parting layer deposited on the coating for preventing metal from sticking to the coating. As the casting surface moves successively out of and into engagement with metal being cast during each cycle of operation, it is cleaned to remove the previously applied parting layer, and a fresh parting layer is newly applied.

8 Claims, 3 Drawing Figures

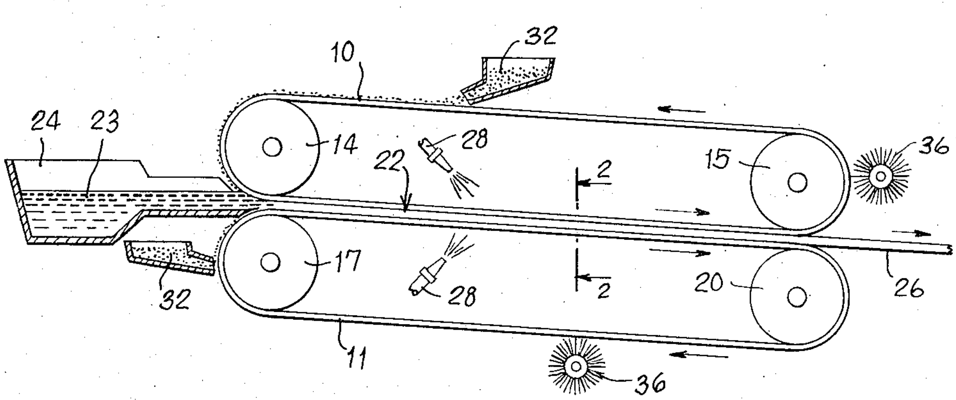
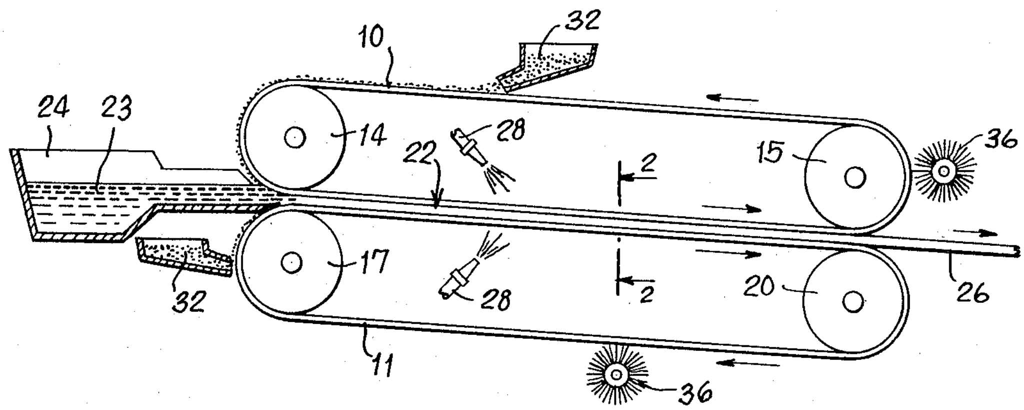


Fig. 1.



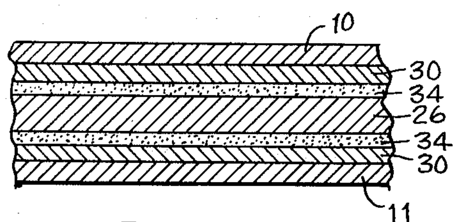


Fig. 2.

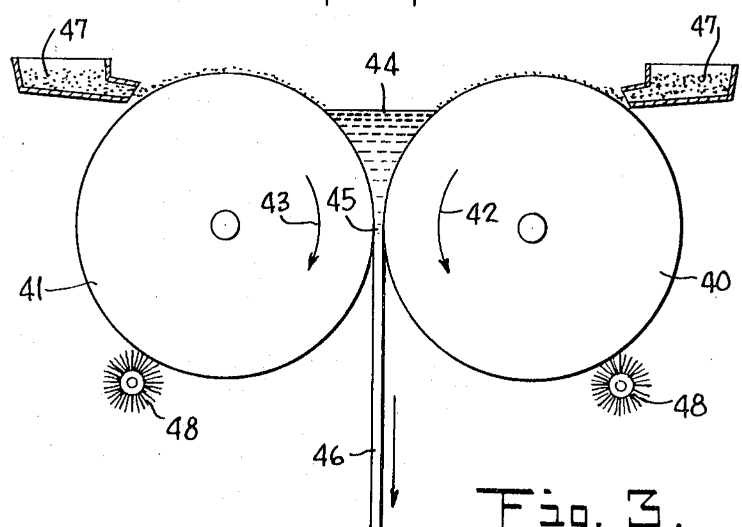


Fig. 3.

METHOD OF AND APPARATUS FOR CASTING ON MOVING SURFACES

BACKGROUND OF THE INVENTION

This invention relates to the continuous casting of aluminum and other metals on or between movable endless casting surfaces. Specifically, it relates to improvements in coatings or dressings for such surfaces, and to casting procedures employing these dressings.

Various metal casting operations involve deposit of molten metal to be cast upon a moving endless surface such as the surface of a drum, the metal being solidified as it is transported on the surface (which may, for example, be cooled as with water) and the cast ingot being separated from the moving casting surface at a point spaced from the locality of molten metal delivery to the surface. Thus in particular, continuous casting processes are known wherein molten aluminum or other metal to be cast is fed continuously between two synchronously rotating water-cooled metal drums which provide the casting surfaces. As the metal travels between the drums, it solidifies and emerges from the drums as a continuous thin ingot, ready to be rolled or otherwise worked. For purposes of illustration, the present invention will be described with specific reference to its use in a continuous aluminum ingot casting operation such as that just mentioned, but it is to be understood that the invention in its broader aspects may be utilized in other continuous casting processes that employ movable endless casting surfaces.

The production of an ingot of acceptable quality in movable-surface casting apparatus requires uniform heat extraction from the metal supplied between the casting surfaces. For achievement of this condition, the casting surfaces must be maintained in flat condition, i.e. they must not become thermally distorted or warped as a result of contact with the molten metal. In addition, the solidifying metal must not adhere to the casting surfaces.

For these reasons, i.e. including protection of the casting surfaces against excessive temperatures that might cause thermal distortion of their shape, and also to facilitate separation of the cast ingot from them, the casting surfaces in apparatus of the aforementioned type must be coated with a suitable dressing having heat-insulating and other properties. Similar problems are encountered in other types of endless-surface casting devices.

A variety of more or less permanent casting surface dressings have heretofore been proposed for use in movable-surface casting apparatus. The dressing compositions employed have included, for instance, mixtures of a resin with particulate refractory material and/or finely divided carbon. While reasonably effective, these dressings are subject to gradual deterioration over extended periods of use. In particular, material of the dressing tends to be removed with or by the cast ingot. Thus, it is periodically necessary to remove and replace the worn dressing. Such interruption of the casting operation is economically undesirable as well as inconvenient.

SUMMARY OF THE INVENTION

An object of the present invention is to provide new and improved dressings for movable endless casting surfaces. Another object is to provide procedures for casting metals on or between movable endless surfaces,

wherein desired uniformity of heat transfer from the metal being cast, and prevention of adherence of the solidifying metal to the casting surfaces, are achieved with minimization or substantial elimination of the necessity for interrupting the casting operation to replace a dressing or coating on the casting surfaces.

A further object is to provide apparatus for casting metals on or between endless movable surfaces, wherein a surface dressing providing desired uniformity of heat extraction and separation of cast metal from the surfaces is maintained with little or no interruption of continuous casting.

To these and other ends, the present invention broadly contemplates the provision of a two-layer insulating dressing on an endless casting surface comprising a moving mold. The inner layer of this dressing, i.e. the layer applied directly to the casting surface, is durable, wear resistant, and selected primarily for its heat-insulating and mechanical properties. The outer layer, which constitutes a sacrificial or parting layer, is a layer of removable material such as talc that may be applied freshly during each cycle of the moving casting surface. The purpose of the outer layer is to prevent adherence of the solidifying metal to the underlying coating, and to protect the coating from deterioration through direct contact with the metal.

In other words, in the present invention, separate dressing layers are provided to serve the separate (heat-insulating and parting) functions of a casting surface dressing. Stated with reference to operations in which an endless casting surface is advanced cyclically into and out of contact with metal being cast, the inner layer or heat-insulating coating of the dressing of the invention is first applied to the casting surface so as to be essentially permanently adhered thereto. During each cycle of the casting operation, the outer or parting layer material (e.g. talc) is deposited on the coating prior to contact with the molten metal to be cast, and residual parting layer material is removed from the casting surface at a point (in the path of travel of the surface) beyond the locality at which the cast metal article separates from the surface, so that the coated surface is appropriately clean and smooth for deposit of a fresh uniform parting layer before the surface is again brought into contact with molten metal.

Since, as stated, the parting layer protects the insulating layer against direct contact with the metal being cast, the insulating layer or coating exhibits greatly enhanced durability as compared with previously known single-layer casting surface dressings used for similar purposes. That is to say, the effectiveness and uniformity of heat insulation provided by the insulating coating of the present dressing remain essentially unimpaired over very extended periods of use. The parting layer, which is relatively inexpensive, is continuously removed and replenished, providing a maintained effectiveness of its parting and protective functions without interruption of the casting operation.

Further features and advantages of the invention will be apparent from the detailed description hereinbelow set forth, together with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic side elevational view of an illustrative type of continuous casting apparatus arranged for the practice of the present invention in one embodiment thereof;

FIG. 2 is an enlarged fragmentary sectional view taken along the line 2—2 of FIG. 1; and

FIG. 3 is a schematic elevational view of a further example of casting apparatus arranged for the practice of the present invention.

DETAILED DESCRIPTION

For purposes of illustration, the invention will be described as embodied in continuous casting apparatus and procedure of generally conventional types, for effecting the continuous casting of aluminum ingots, it being understood that the term "aluminum" as employed herein designates pure aluminum metal and aluminum-base alloys.

Referring to FIG. 1, there is shown in schematic side elevational view a casting machine comprising a pair of flat endless belts **10** and **11**, e.g. fabricated of steel, mounted for continuous movement around guide and drive rollers **14, 15,** and **17, 20,** respectively. The belts **10** and **11** and their respective rollers **14, 15** and **17, 20** are mutually disposed and arranged so that in portions of their respective paths, the two belts move in parallel, closely spaced relation to each other, in the same direction and at a common velocity, so as to define between them an extended casting region **22.** The facing surfaces of the two belts advancing through this casting region constitute the casting surfaces of the apparatus.

Molten metal **23** supplied from a trough **24** is fed continuously to the inlet end of the casting region **22,** i.e. between the parallel facing surfaces of the two moving belts **10** and **11,** so as to be carried through the casting region by and between the synchronously moving belts. As the metal thus traverses the casting region, it cools and solidifies into a continuous thin flat ingot which emerges from the downstream end of the casting region as indicated at **26.** To promote solidification of the metal in the casting region, means represented as nozzles **28** may be provided for spraying a suitable coolant fluid such as water on the outwardly facing surfaces of the portions of the two belts **10** and **11** traversing the casting region.

In accordance with the invention, the casting surface of each of the belts **10** and **11** (i.e. the surface which faces the other of the belts as it traverses the casting region **22**) is continuously coated with a fixedly adherent layer or coating of heat-insulating material having appropriate thermal and mechanical properties for use as a dressing in the casting operation. This layer or coating (represented at **30** in FIG. 2) may be applied to the casting surface of the steel belt as a paint or paintlike substance and may be subsequently cured as with heat. The insulating layer may, for example, incorporate a silicone resin as the insulating material. It must be sufficiently flexible to travel with the belt around the rollers without cracking or spalling. However, its chemical properties (as regards reactivity with molten aluminum or other metal being cast) are not critical as is the case in a conventional belt dressing.

Further in accordance with the invention, there is applied to the casting surface of each belt (as by means schematically shown as hoppers **32** in FIG. 1) a second, parting layer which may (e.g. in the case of aluminum casting operations) conveniently be a powdered material such as talc. The layer of talc (represented at **34** in FIG. 2) coats the insulating layer **30** and protects it from direct contact with the metal being cast. It will be noted that this outer layer of the dressing is applied to the casting surfaces of the belts prior to contact of those surfaces with molten metal being cast, i.e. during each cycle of the belts.

The material of parting layer **34** should be chemically inert with respect to the metal being cast; more particularly, it should be able to withstand the temperature of the molten metal, should not be wettable by the molten metal, should be nonabrasive (since it will or may come into contact with mechanical parts of the casting apparatus) and nontoxic, and it should in addition be of such character as to adhere effectively to the insulating layer **30** as it is carried into contact with molten metal in the casting region **22.** As explained, this material has as its primary function the protection of the inner, insulating layer **30.**

As and after the casting surface of each belt traverses the casting region **22,** the parting layer **34** will be at least partially removed. At the outlet end of the machine, the casting surfaces of the belts (after separation from contact with the cast strip **26**) are cleaned to remove the remnant of the parting layer from the belt so that upon reapplication of the parting layer material to the belt, a smooth and even surface will result. For example, the parting layer residue may be removed from the belts during each cycle by means of rotating stainless steel brushes **36** which brush the remaining talc off the belt surfaces, and with which may be associated suitable vacuum systems (not shown) for completely carrying away the brushed talc. In such arrangements, the insulating layer should accordingly be capable of withstanding the brushing operation. In addition to this mechanical property and to the properties of thermal insulation, flexibility and freedom from spalling, the insulating layer must also be thermally stable through the range of temperatures to which it is exposed.

As will be appreciated from the foregoing description, the removable parting layer serves to protect the underlying insulating layer against damage such as might otherwise result from contact with the ingot being cast. Thus the insulating layer has a very markedly enhanced useful lifetime as compared with the lifetime of conventional single layer belt dressings.

It will be understood that in the practice of the method of the present invention, with the apparatus shown in FIG. 1, there is first established an essentially permanent insulating layer **30** on the casting surface of each of the steel belts **10** and **11.** Then, as the belts are continuously advanced by suitable drive means (not shown), at such direction and velocity as to move in synchronous parallel relation through the casting region **22,** a uniform coating of talc is applied to the coated belt casting surfaces from the hoppers **32** ahead of the casting region, and molten metal is continuously delivered for casting to the inlet end of the casting region. The belt casting surfaces, after traversing the casting region **22** (and transporting the solidifying metal through that region while removing heat from the metal), are brushed to remove residual talc so that their casting surfaces are clean and smooth at the end of each cycle, i.e. for reapplication of a fresh parting layer from hoppers **32** prior to return of the casting surfaces to the casting region.

By way of further and more specific illustration of the invention, reference may be had to the following specific example of belt dressing composition and application:

To provide the required amount of thermal insulation to cast a flat thin aluminum ingot in apparatus of the type described above, i.e. with insured uniform heat transfer and with prevention of belt distortion, the necessary thermal resistance is found to be 1.27 cm. 0°. seconds/cal. The insulating coating is formed by spraying on the casting surface of a steel belt a paint having the following composition:

Component	Wet Gallons	Solid Gallons	Pounds
Dow 806A (50% NV)	8.7	3.6	
Dow 805 (50% NV)	3.7	1.5	
AA Mica	3.1	3.1	100
RA.67 (Rutile TiO_2)	0.2	0.2	10
Cab.O.Sil (SiO_2)	—	—	1
Cyclosol 63	3.0		
Xylene	3.0		

Volume solid = 58% of wet film (theoretical)

Pigment volume in dry film = 39% (theoretical)

Catalyst added just before coating — 2 ounces of A.1100 Silane per wet gallon (i.e. 1:80 wet volume of finished paint, on 1 part Silane to 23 parts wet resin, or 1 part Silane to 12 parts resin solid).

to provide a layer 6 mils thick. The painted belt is baked at 400°C for 1 hour. The resultant insulating coating is of a permanent nature, effectively resistant to the mechanical and thermal conditions to which it is exposed in the casting apparatus for thirty hours of operation. In particular, the layer thus provided affords the requisite thermal resistance and resists the wear imposed by continuous brushing of the surface with rotating stainless steel brushes to remove residual talc. In the above specific example of insulating layer composition, talcum or Celite may be used in place of the mica, in the specified amount.

As a parting layer, for casting of aluminum (and in use, for instance, with the above example of insulating layer), one suitable material is the talc commercially available under the designation "Desert Talc Micro 706," deposited evenly on the casting belts using a hopper distribution system. The specified material has a particle distribution of 100% < 12 microns, 90% < 7.5 microns, 80% < 5.5 microns, 70% < 4.2 microns, 60% < 3.4 microns, 50% < 2.75 microns, 40% < 2.2 microns, 30% < 1.5 microns, 20% < 1 micron, 10% < 0.65 microns, 100% > 0.35 microns, and a composition of: SiO_2 57.72%, MgO 29.00%, Al_2O_3 1.61%, Fe_2O_3 0.09%, CaO 5.7%, Na_2O 0.62%, K_2O 0.06%. Other grades of talcum can be used as can finely powdered carbon.

FIG. 3 shows another type of continuous casting apparatus in which the present invention may be used. The structure of FIG. 3 includes a pair of drums **40, 41,** e.g. fabricated of steel or the like, and having cylindrical surfaces which constitute the casting surfaces of the apparatus. The two drums are mounted in axially parallel, closely adjacent relation, as illustrated, and are driven by suitable means (not shown) in the directions respectively indicated by arrows **42** and **43,** such that molten metal **44** supplied above and between the drums (e.g. by suitable conventional means, not shown) is advanced by the rotation of the drums through the nip or narrow space **45** defined between them, emerging as a thin flat continuous ingot **46.** All the foregoing features of the FIG. 3 apparatus are generally conventional, and, further in accordance with conventional practice, the drums may be cooled internally as by circulation of water.

In accordance with the present invention, the cylindrical casting surfaces of the two drums in FIG. **3** are coated with an insulating layer having the properties of the insulating layer **30** of the apparatus of FIG. **1.** Hoppers **47** supply parting layer material such as talc to the coated drum surfaces prior to contact of the surfaces with the molten metal **44** during each cycle of revolution of the drums. Beyond the casting zone **45,** rotary brushes **48** (corresponding to the brushes **36** in FIG. **1**) remove the residue of parting layer material from the drum surfaces prior to supply to fresh parting layer material for the next cycle. The functions of the respective layers of the dressing in the apparatus of FIG. **3** are essentially the same as the functions of the corresponding layers in the apparatus of FIG. **1.**

It is to be understood that the invention is not limited to the features and embodiments hereinabove specifically set forth but may be carried out in other ways without departure from its spirit.

We claim:

1. A method of continuously casting a metal ingot in contact with a moving surface, including the steps of

a. continuously advancing an endless metal casting surface along a closed path while

b. continuously bringing molten metal into contact with said surface at a first locality in said path and while

c. continuously separating freshly cast ingot from said surface at a second locality in said path, wherein the improvement comprises

d. said casting surface bearing a continuous and fixedly adherent heat-insulating coating; and

e. continuously applying to the coating, during advance of said casting surface as aforesaid, a discrete layer of a parting material for preventing adherence of solidifying ingot to the coating.

2. A method according to claim **1,** wherein said coating comprises a silicone resin.

3. A method according to claim **1,** wherein said parting material is readily removable from said coating, and wherein the layer-applying step includes the steps of

i. cleaning the coated casting surface to remove parting material therefrom as said surface advances beyond said second locality and thereafter

ii. applying a fresh layer of parting material to the surface prior to return of the surface to the first locality.

4. A method according to claim **3,** wherein said parting material is a dry particulate material and wherein said cleaning step comprises brushing the coated casting surface to effect substantially complete removal of residual particles of parting material therefrom.

5. A method according to claim **4,** wherein said parting material is talc.

6. Apparatus for casting metal, including

a. a movable endless casting surface and

b. means for delivering molten metal thereto, wherein the improvement comprises

c. a thermally insulating coating deposited on and fixedly adhered to said casting surface and

d. means for continuously applying to said casting surface, during movement thereof, a discrete layer of parting material for preventing metal from sticking to said coating, deposited on said coating so as to be interposed between said coating and the metal delivered to said casting surface.

7. Apparatus as defined in claim **6,** wherein said parting material is a dry particulate material; and further including

e. means for continuously advancing said casting surface along a closed path past first and second localities at which metal is respectively brought into contact with said surface for casting and removed from contact with said surface after casting,

f. said applying means being disposed ahead of said first locality for depositing a layer of said particulate material on the coated casting surface; and

g. means beyond said second locality for removing residual particulate material from the casting surface.

8. A method according to claim **1,** wherein said coating comprises a silicone resin, wherein said parting material is readily removable from said coating, and wherein the layer-applying step includes the steps of

i. cleaning the coated casting surface to remove parting material therefrom as said surface advances beyond said second locality and thereafter

ii. applying a fresh layer of parting material to the surface prior to return of the surface to the first locality.

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