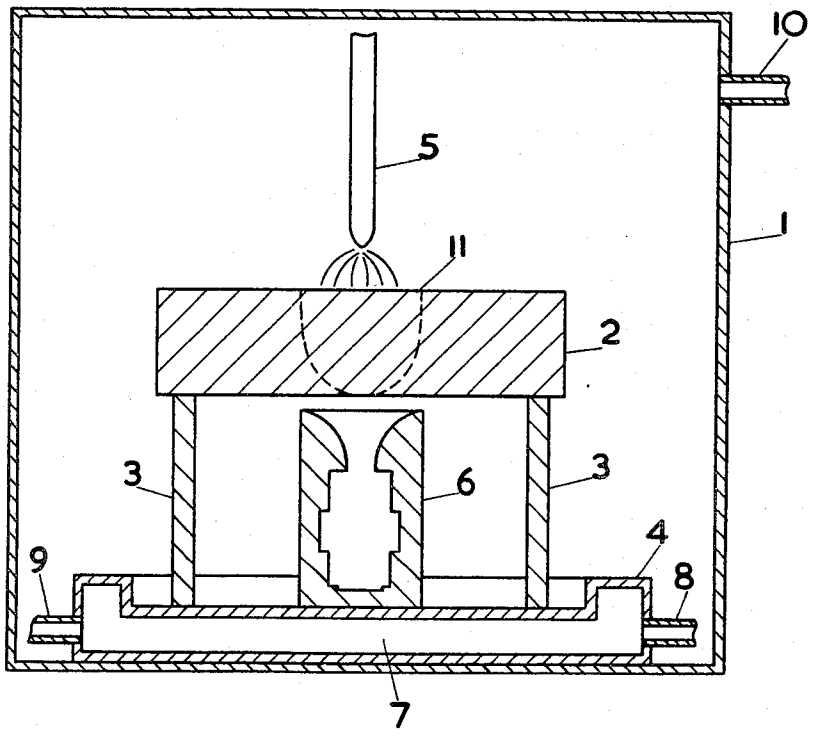
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CASTING METALS

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CASTING METALS

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This invention relates to a method of casting metals.

Certain high melting point metals and alloys, e.g. titanium, zirconium, which have a great affinity for oxygen and nitrogen may, when in a molten condition, react with most known refractories and thereby become contaminated. It has become common practice in an endeavour to overcome the contamination problem to melt these metals or their alloys in a metal crucible, which is cooled by liquid, by the use of an electric arc discharge between an electrode and the metal to be melted. The melting operation is carried out either in an inert atmosphere or in vacuo. At the end of the operation the metal is allowed to solidify in the crucible to form an ingot.

This method is applicable for casting the metal into simple shapes only, such as ingots or slabs for rolling or forging. More complex shapes require a suitable mould, usually machined from graphite, and a melting furnace from which the metal is cast into the mould.

Furnaces for this purpose have hitherto taken the form of a container or crucible having an opening which in operation is closed by means of a plug of graphite or a plate of the metal being melted. Such furnaces have been made from graphite or from metal such as copper and supplied with water cooling. The high melting point metal is melted in the furnace and at the appropriate time the plug is removed or the plate melted through and the metal allowed to fall into a mould placed underneath the opening. Heating may be by arc or by induction.

Casting methods utilising such furnaces suffer from serious disadvantages. When the container or crucible is water-cooled, heating is inefficient due to the large heat losses to the cooling system. Graphite containers contaminate the molten metal by pick-up of carbon. Another difficulty experienced with such furnaces is blocking of the casting orifice in the bottom of the container by drops or skulls of solidified metal after pouring, thus making it impracticable to re-plug the orifice efficiently without carrying operations to remove the solidified metal. If the plug closing the orifice becomes wetted by the molten metal it may become impossible to remove the plug to allow the casting to be made.

According to the present invention we provide a method of casting metal in a mould which comprises supporting, above the mould, a block of the metal to be cast, striking an arc between an electrode located above the block and the end surface of the block remote from the mould, melting, by means of the arc, part of the block in such a manner that the molten part is contained by a solid wall of the metal, until the molten pool extends from the end surface of the block remote from the mould to the end surface adjacent the mould, whereupon the molten metal runs into the mould and the arc is then extinguished. The method may be carried out in vacuo or in inert atmosphere.

The term "block" is intended to include a mass of metal produced by compacting and/or sintering but preferably by melting and/or working, or a stack of sheets or plates

secured in close contact with one another, compressed scrap, and like forms of consolidated metal. For example, the block may be a piece cut from an ingot or a bar.

The part of the block to be melted is so chosen as to provide an adequate amount of solid metal surrounding the pool.

Preferably the mould is supported upon a water-cooled base to ensure efficient and unidirectional cooling of the casting.

The electrode may be either non-consumable, e.g. tungsten or graphite, or consumable.

After the molten metal has been cast, a cavity with an aperture at the bottom is left in the block and this aperture is normally closed when molten metal adhering to the sides of the cavity drains to the bottom and solidifies. If the aperture is, however, unduly enlarged it may not be possible for the aperture to be completely closed. The feature of closing the aperture is important in that it enables the block to be used again.

According to a modification of the method according to the invention the block initially has in it a blind hole which is at least partially filled with the metal to be cast in particulate form, and the arc is struck between the electrode and the upper surface of the particulate metal so as to melt the particulate metal and then that part of the block on which the molten metal rests until the molten metal runs into the mould.

The term "particulate or divided form" includes powder, sponge and other pieces of metal small enough to go into the blind hole or cavity. Thus, the block, after the pool of molten metal has been cast, may be re-used by filling the cavity with pieces or particles of the metal to be melted and applying the arc to material in the cavity to form a pool of molten metal which may be cast into the mould by melting through the bottom of the pool. When the aperture at the bottom of the cavity is open it may be closed by means of a suitable piece of the metal to be melted. The cavity in the block can thus be used for producing castings from titanium sponge or powder or from pieces of titanium scrap. While the cavity in the block would normally have been produced by melting by means of an arc, it is, of course, possible to use a block in which the cavity had been made by another process, such as machining or forging.

The electrode is connected to the negative pole and the block to the positive pole of a suitable direct current supply. The electrical connection to the block may be made through the supports for the block and in such a case there should be good electrical contact between the block and its supports.

A high rate of input of heat energy is required in order that the metal beneath the arc reaches the required casting temperature before the outer portion of the block becomes hot enough, by thermal conduction, to melt. The molten pool should be narrow and deep, rather than wide and shallow. It is necessary that the metal should be heated to a temperature in excess of the melting point, i.e. superheated, in order that the metal may have the required degree of fluidity to produce a sound casting.

After casting the molten metal into the mould, since feeding is not possible in the normal way, "hot-topping" of the casting may be carried out by allowing the arc to melt more metal from the sides of the cavity in the block, the molten metal then falling on to the top of the casting.

The method is useful for producing small castings of a few cubic inches in volume and by providing several blocks and moulds on a turntable within a sealed chamber, a number of castings may be made by moving each block and mould in succession in line with the electrode and melting in the manner already described. An ad-

vantage of the method is that neither a crucible nor a pouring spout or nozzle is required.

One embodiment of the invention is illustrated by way of example in the accompanying drawing, which represents a cross-section of an arrangement, in accordance with the invention, for producing a titanium casting.

Referring to the drawing, in a vacuum-tight container **1** a block **2** of titanium, rests upon, and is in electrical contact with, supports **3**, of electrically conducting material preferably of the same material as the block, which stand upon a water-cooled metal plate **4**. Cooling water is circulated through the water-jacket **7** by means of the pipes **8** and **9**. Located above the approximate centre of the block **2** is a non-consumable electrode **5**, the movement and operation of which is controlled from outside the container **1** through a flexible vacuum seal (not shown) in a known manner.

A graphite mould **6** is positioned beneath the block **2** substantially vertically below the electrode **5**. The base of the mould **6** is in contact with the water-cooled metal plate **4**.

A direct current supply provides power for an arc between the electrode **5** and the block **2** and for this purpose the electrode **5** is connected to the negative pole and the block **2** is connected to the positive pole by way of the support **3** and the water-cooled plate **4**.

In the present example, the volume of the casting to be produced is about 2 to 3 cubic inches excluding feeder and in order to provide an adequate amount of solid metal in which to contain the required amount of molten metal during the melting operation a block of titanium about **4** inches in diameter by **2** inches thick is used.

To produce a casting by means of the arrangement just described, the container **1** is evacuated through a connection **10** and if desired an inert atmosphere can then be supplied. An arc is struck between the electrode **5** and the approximate centre of the block **2**, using, for the size of block already mentioned a starting voltage of about 50 volts. With a current of about 1500 amperes at about 20 volts, a deep pool of metal is melted, adjustment of arc length and power being carried out during the operation. The deep pool shown by broken line **11** is maintained until a suitable degree of superheating of the molten metal is obtained, the arc length is shortened or the power is increased to effect melting of the solid metal retaining the bottom of the molten pool and the molten metal falls by gravity into the graphite mould beneath.

Solidification of the metal takes place in the mould starting at the bottom and proceeding upwardly and this desirable feature is brought about by the use of a water-cooled plate **4**. Such a casting is sound and any segregation is limited to the feeder which is subsequently removed. If it is desired to "hot-top" the casting, that is, to add a further quantity of molten metal to make up for shrinkage, the arc is directed into the cavity left in the block and allowed to strike against one side so that drops of molten metal are formed which fall into the mould.

In order to use the block **2** again it may be necessary, particularly if "hot-topping" has been carried out, to close the bottom of the cavity and a small piece of metal of similar composition to the block is used for this purpose. The cavity is then filled with small pieces of similar metal, such as titanium sponge or powder but preferably cut-up scrap, and an arc is struck between the contents of the cavity and the electrode **5** in the manner just described, and a pool of molten metal formed. Additional pieces of titanium may be necessary to fill the cavity completely with molten metal. The metal is cast in the mould **6** as already described. In order to prevent any change in composition, the metal being melted should have substantially the same composition as that of the block.

While the invention has been described with reference to high melting point metals and alloys, the method can be applied to other metals and alloys.

I claim:

1. A method of casting metal in a mould which comprises supporting, above the mould, a block of the metal to be cast so that no portion of the block lies within the mould, striking an arc between an electrode located above the block and the end surface of the block remote from the mould, melting, by means of the arc, part of the block in such manner that the molten part is contained by a solid wall of the metal, until the molten pool extends from the end surface of the block remote from the mould to the end surface adjacent the mould, whereupon the molten metal runs into the mould and the arc is then extinguished.

2. The method claimed in claim 1, in which the block of metal to be cast initially has a blind hole which is at least partially filled with the metal to be cast in particulate form, and the arc is struck between the electrode and the upper surface of the particulate metal so as to melt the particulate metal and then that part of the block on which the molten metal rests until the molten metal runs into the mould.

3. A method of casting metal into a mould as claimed in claim 1 in which, in order to carry out a "hot-topping" operation after casting the molten metal into the mould, an arc is struck between the electrode and the block and additional metal is cast into the mould.

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