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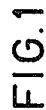
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VACUUM MELTING AND CASTING APPARATUS

Filed Dec. 30, 1963

3 Sheets-Sheet 1



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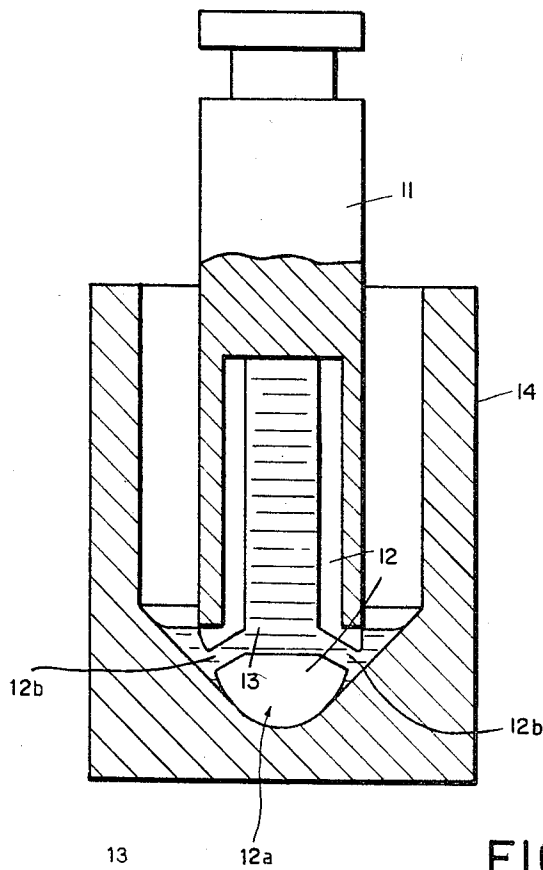


FIG. 2

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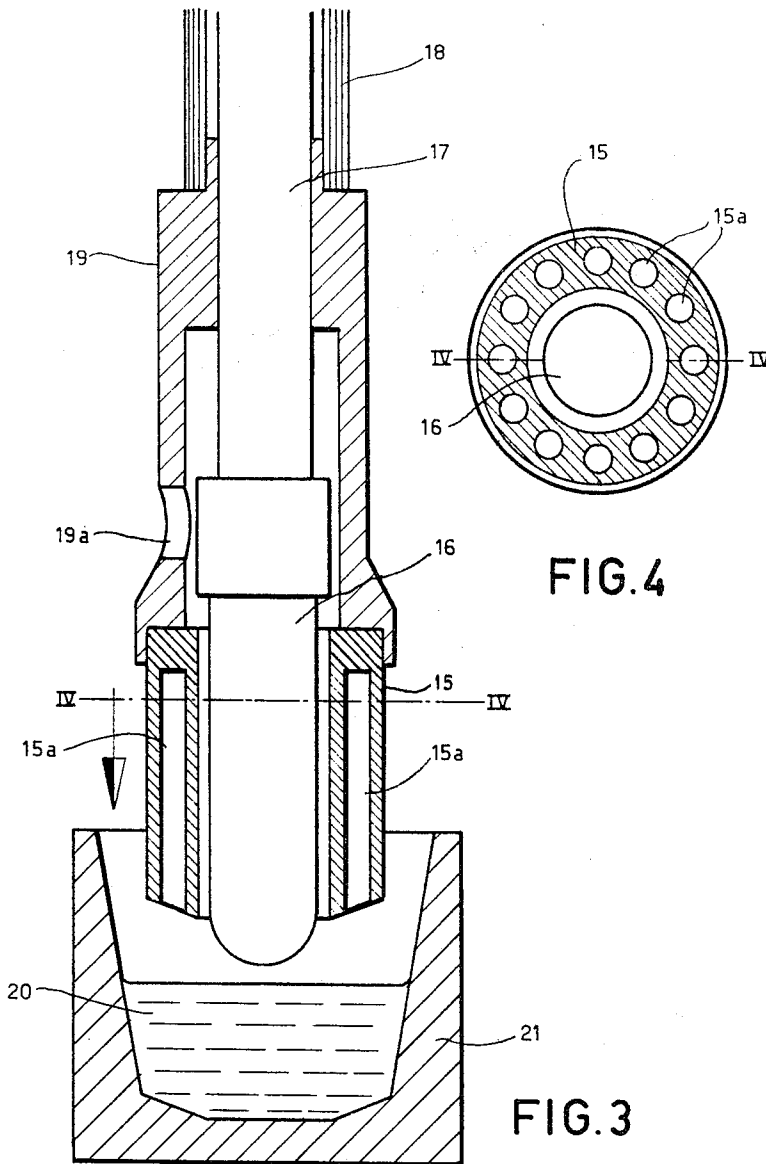
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VACUUM MELTING AND CASTING APPARATUS
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5 Claims. (Cl. 22—57)

This invention relates to a process and apparatus for melting and casting very high melting point and/or strongly reactive materials in a melting furnace.

In the metallurgy of high temperature materials, such as in the production of very high melting point nuclear fuels like uranium carbide, the so-called skull-melting has attained particular importance. This is a melting process in an arc furnace, in which a solid shell of the material to be melted forms the melting crucible. In contrast with the widely industrially applied vacuum arc melting, the casting process is carried out therein separately by tipping or rotating (centrifugal casting) the water-cooled copper crucible which carries the so-called skull. Depending on the melting conditions there is obtained by this process a homogenization and possibly refining and degassing of the material, independently of the melting speed which can otherwise only be set within narrow limits.

When combining the melting and casting processes it is required that both processes take place under the best possible conditions, both from the viewpoint of the apparatus and of the operation. The best apparatus conditions are taken herein to mean essentially that the construction of the furnace is not determined by the casting process, but is instead entirely set up for the requirements of the melting process. The best operational conditions means that the manner of carrying out both processes is superior to other methods even under extreme conditions of materials and temperatures.

In the above mentioned skull-melting, the melting process can be handled satisfactorily, but the casting procedure cannot be considered to have been solved as an optimum in the sense of the above definition, when it is a question of casting thin rods, tubes and other thin elements. Special complex furnace constructions are required; the yield is small and the variability of the casting parameters such as casting and solidifying speed as well as direction of filling is limited.

The object of the present invention is to provide a process and apparatus for the production of thin elements of very high melting and/or strongly reactive materials, which enables the melting and casting to be carried out separately under optimum apparatus and operational conditions, and in which furthermore no difficulties are met in passing from the melting to the casting procedure. In accordance with the invention the process is characterized in that the materials are melted in known manner in a water-cooled melting crucible with or without a skull in vacuum or under a gaseous atmosphere, but at the end of the melting step the molten material, also in a manner known per se, is cast by suction in a chill-mould which is then dipped with its opening in the bath, the chill-mould being preferably carried by the electrode.

The advantages achieved in this manner over the conventional skull-melting process and the suction casting in an induction furnace are as follows:

Use of the industrially tried vacuum arc furnace with fixed water-cooled melting crucible of copper for the melting and casting steps. Consequently avoidance of the polluting reaction between the melt bath and the crucible material and attainment of highest melting temperatures.

Utilization of the casting method by pressure difference (suction casting) without, however, the melting limita-

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tions due to the type of heating. Consequently a simple casting apparatus (no movement of the crucible), large yield capacity, easy variation of the casting speed (variability of the casting procedure within wide limits) and advantageous temperature conditions during casting.

Small combined investment for the melting and casting elements, electrode and chill-mould. This means: mere connection of the suction casting apparatus to the furnace space of the vacuum arc furnace, and the arc electrode, in case of a permanent electrode, also serving as support for the chill-mould (consequently effective preheating of the chill-mould by electric heating and radiation).

The complete apparatus for carrying out the process consists accordingly of a vacuum arc furnace with fixed water-cooled melting crucible, a longitudinally displaceable arc electrode carrying axially the chill-mould, a pressure gas container connected to the furnace vessel and, for melting under vacuum or under superatmospheric pressure, a pump.

The accompanying drawings illustrate schematically by way of example embodiments with three forms of chill-moulds. In the drawings:

FIG. 1 is a longitudinal section of a melting-casting apparatus according to the invention,

FIG. 2 is a longitudinal section of an arc electrode with exchangeable chill-mould insert,

FIG. 3 is a longitudinal section of an arc electrode with a jacket-type chill-mould, and

FIG. 4 is a cross-section of the chill-mould along line IV—IV of FIG. 3.

In FIG. 1, numeral 1 designates the housing of the vacuum arc furnace, 2 an optional crucible liner of graphite, 3 the melting crucible of copper, 4 the melt bath, 5 the water-cooling jacket with in- and outlets 5a and 5b. The arc electrode—a permanent electrode—is indicated at 6 and includes a casting space 7 of about 200 mm. height and 12 mm. diameter constituting the chill-mould. The arc electrode is secured to an electrode rod 8 which is provided with in- and outlets 8a and 8b for cooling water.

Externally connected to the furnace is the pressure container 9 (for example inert gas) with a conduit 9a and an inlet valve 9b; furthermore, a suction tube 10 with a safety valve and a separator. To the separator is connected a vacuum pump set-up (not shown).

In accordance with the invention the melting and casting process proceeds as follows: the casting material, for example uranium carbide, is melted by arc in the water-cooled melting crucible, but at the end of the melting process the melt is not, as usual, poured off or centrifuged, but is instead pressed into the chill-mould by suction casting, namely by providing a positive pressure difference between the melt space and the chill-mould space. For this purpose the chill-mould—in the present case the electrode—dips with its opening into the bath.

In the embodiment of FIG. 1 the chill-mould is worked out of the electrode. The same consists of electrode material, for example graphite, and forms with the chill-mould a single structural element. This means that the electrode 6, with its arc constantly burning shorter, is sunk to short-circuit into the melt bath 4. At the same instant the pressure in the housing is raised by opening the valve 9b. By reason of the pressure drop between the melt space and the chill-mould space the molten material rises in the chill-mould and fills it up.

Depending on the level of the pressure difference, which can be set as desired, and of the equally controllable pressure equalization speed, the casting speed, and even the solidification speed can be varied within wide limits. Thus it is possible to cast thin-wall tubes in a core-less chill-mould.

Successful experiments have shown that in rods and tubes of uranium carbide there is thus obtained a fine-

grain and dense casting structure with excellent carbon distribution ($\pm 0.05\%$ of C).

FIG. 2 shows an embodiment in which the chill-mould is formed as a separate exchangeable insert of graphite in a permanent electrode. Numeral 11 designates the arc electrode, 12 the chill-mould, 13 the melt and 14 the melting crucible. The chill-mould is closed at its bottom portion 12a but is provided with inlet openings 12b for the molten material. Due to the part 12a, the chill-mould can be sunk to the floor of the crucible during the casting operation.

While the chill-moulds disclosed hitherto only permit single casting, the chill-mould according to FIG. 3 makes possible multiple casting as well as, with suitable alterations, the casting of hollow elements.

The chill-mould 15 is formed as a thick-wall graphite cylinder with casting spaces 15a in the wall thereof. It is concentric with and movable with respect to the electrode, that is the electrode and also the chill-mould can be longitudinally displaced independently of each other. The displacement member of the electrode is indicated at 17 and that of the chill-mould at 18. The chill-mould is secured at the lower end of a bushing 19 made of insulating material. The bushing has a pressure equalizing bore 19a which prevents molten material from entering the annular space between the electrode and the chill-mould during casting. The melt bath is indicated at 20 and the melting crucible at 21.

The relative displaceability between the electrode and the chill-mould makes it possible to keep the chill-mould sufficiently far away from the bath surface, especially when operating with self-consuming electrodes, so that no spatter can reach the casting space of the chill-mould. Furthermore the arc can be allowed to subsist until the chill-mould dips into the melt, so as to prevent premature cooling.

Hollow elements can be cast with the jacket-type chill-mould according to FIG. 3, if the casting bores, as shown in FIG. 4 are unified into a single (suitably narrowed)

annular space. A chill-mould is then produced with which pipes can be cast.

We claim:

1. Apparatus for melting and casting very high melting point and/or strongly reactive materials in the same furnace, comprising a vacuum arc furnace with a housing and a fixed water-cooled melting crucible, a longitudinally displaceable arc electrode, a chill-mould carried by said arc-electrode, and a pressure container connected to said furnace housing.
2. Apparatus according to claim 1, wherein a pump is connected to said furnace housing.
3. Apparatus according to claim 1, wherein said chill-mould is made of electrode material and consists of a recess in the end of said electrode.
4. Apparatus according to claim 1, wherein said chill-mould consists of an exchangeable insert mounted in the end of said electrode.
5. Apparatus according to claim 1, wherein said electrode consists of a thick-wall cylinder concentric with and longitudinally displaceable with respect to said electrode and having casting spaces in the wall thereof.

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