

Feb. 3, 1959

E. SWAINSON

2,871,533

METHOD AND APPARATUS FOR MELTING AND CASTING
OF HIGH MELTING POINT METALS OR ALLOYS

Filed May 18, 1953

2 Sheets-Sheet 1

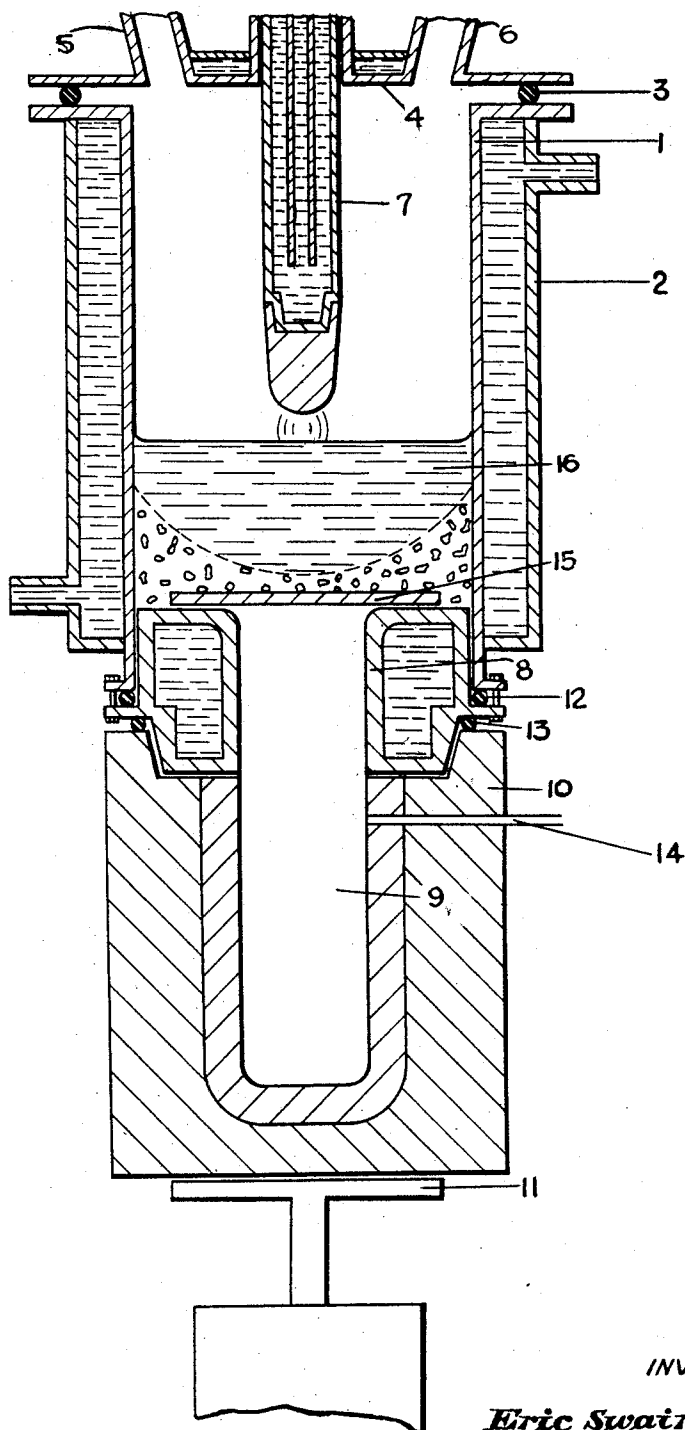


FIG. 1.

INVENTOR:

Eric Swainson,

BY *Cushman, Darby & Cushman*
ATTORNEYS

Feb. 3, 1959

E. SWAINSON

2,871,533

METHOD AND APPARATUS FOR MELTING AND CASTING
OF HIGH MELTING POINT METALS OR ALLOYS

Filed May 18, 1953

2 Sheets-Sheet 2

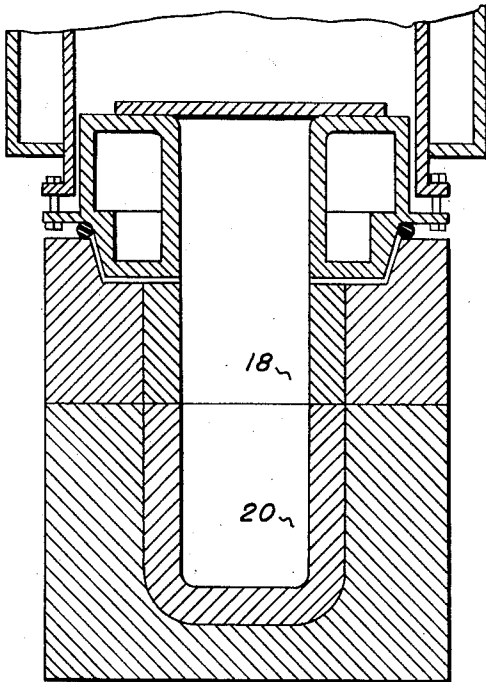


FIG. 2.

FIG. 4.

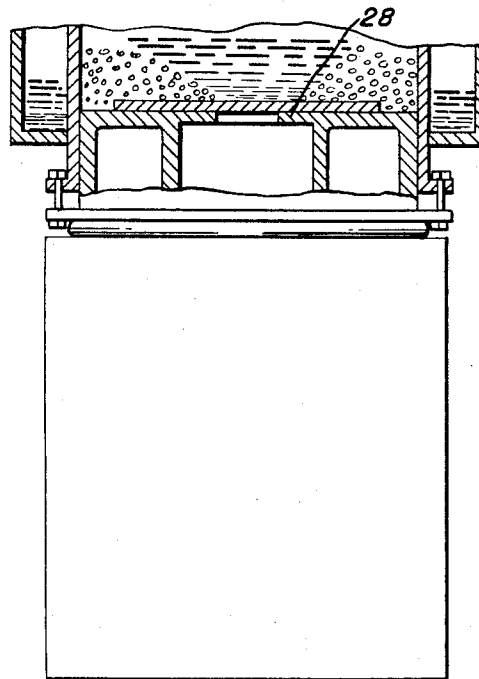
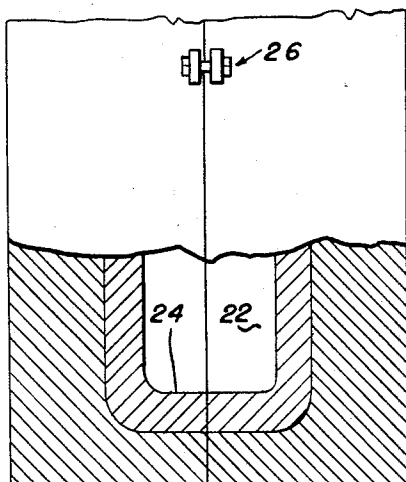


FIG. 3.



INVENTOR

ERIC SWAINSON

BY *Cushman, Darby & Cushman*

ATTORNEYS

1

2,871,533

METHOD AND APPARATUS FOR MELTING AND CASTING OF HIGH MELTING POINT METALS OR ALLOYS

Eric Swainson, Sutton Coldfield, England, assignor to Imperial Chemical Industries Limited, a corporation of Great Britain

Application May 18, 1953, Serial No. 355,559

Claims priority, application Great Britain May 30, 1952

7 Claims. (Cl. 22—200)

This invention relates to an improved process and apparatus for use in the arc melting and casting of high melting point reactive metals and alloys, such for example as titanium, zirconium, molybdenum, thorium, hafnium, tantalum, chromium and their alloys.

Owing to the reactivity of these metals in the molten state they can be melted with least contamination in a water-cooled crucible under an inert atmosphere, the heat required for melting being supplied by means of an arc struck between the surface of the metal to be melted and a second electrode. The second electrode may be cooled and tipped with a material such as graphite or tungsten which is not rapidly consumed during working, or uncooled and made of the same metal or alloy as is to be melted, the electrode being then continuously melted into the crucible. With either type of electrode, a molten pool is first formed at the bottom of the crucible and then further material is continuously added and melted. However, as new material is melted, the original metal solidifies, so that only a relatively small molten pool is formed and the whole ingot is not all molten at one time. This has the disadvantage that segregation occurs in the final ingot unless the composition of each successive molten pool is the same, so that, in making alloy ingots, the correct proportion of constituents must be accurately maintained in each individual addition to the furnace and not merely throughout the ingot as a whole. A further disadvantage is that the thermal history of each layer of the final ingot may be different, which tends to lead to difficulties in subsequent working and manipulation, sometimes resulting in splitting of the metal. A third disadvantage is that only ingots of cylindrical or somewhat similar shape can readily be produced, which are not very suitable for rolling into plate, sheet or strip. A fourth disadvantage is that there is a danger of developing local unmelted regions in the ingot, particularly adjacent to the crucible walls.

The object of the present invention is to provide a modified arc melting furnace in which these disadvantages are overcome and a homogeneous fully melted ingot or casting of any desired shape obtained.

According to the present invention we provide a process for arc melting and casting metals and alloys of the kind described which comprises arc melting a charge or charges of the said metal or alloy under an inert atmosphere in a cooled crucible communicating through a centrally disposed orifice in its base with a separable mould, the said orifice being closed by means of an initially positioned plate of the same composition as the metal to be melted, under conditions such that a molten pool of metal, at least sufficiently large to form the casting, is formed and maintained below the electrode, and thereafter melting the plate at least in part, to permit the molten charge to flow into the mould where it solidifies.

In a preferred embodiment of the invention, after the metal plate has been placed over the orifice, a lining or skull of metal is first built up in the bottom of the crucible

2

by melting at low arc current and allowing to solidify on to the plate one or more small charges of the raw material positioned above the plate. The main charge is then introduced and the arc current increased to effect melting of this charge and penetration of the molten pool to the plate to form an aperture through which the molten metal flows into the mould. For the next casting operation, the aperture through which the molten metal has flowed is closed by means of a suitably shaped piece of the metal, a small charge or charges are melted at low current and built up as described above, and the main charge then introduced, melted and cast as before.

When a consumable electrode is used the charge or charges referred to above will not of course be discrete charges of raw material introduced in the solid state into the crucible but will be obtained by melting the electrode to the required extent in each case.

The process according to the invention may be employed for the production of simple ingots such as cylinders or slabs, or of shaped castings. The mould may be permanent or non-permanent, and mould materials include graphite, cooled metal, or refractory moulding sand or compound.

The formation of a large molten pool of metal below the electrode may be ensured by suitable dimensioning of the crucible. Thus by increasing the diameter and decreasing the length of the crucible as compared with the relative order of dimensions which has hitherto been regarded as customary in the art of arc melting metals in water-cooled copper crucibles, heat losses to the cooled walls are reduced and a large molten pool of approximately hemispherical shape is formed beneath the electrode.

The invention is illustrated but not limited by the accompanying drawing. Figure 1 shows in vertical section a crucible and mould assembly for melting and casting titanium. Figure 2 is a partial vertical section showing a mould in which only the base thereof is separable. Figure 3 is a partial vertical section in which the mould is adapted to be opened longitudinally for extraction of the casting. Figure 4 is a partial vertical section showing a crucible base provided with an annular projection forming a pouring lip. In the drawings 1 is the copper crucible with water-jacket 2. The crucible 1 is sealed and insulated by an O-ring 3 from the water-cooled lid 4 carrying a feed tube 5, sight tube 6 and argon, helium or vacuum connections (not shown). Through the centre of the lid 4 passes a water-cooled tungsten-tipped electrode 7. The water-cooled bottom plate 8 of the crucible has a central aperture 9 and registers with a graphite-lined mould 10 supported on a jack 11. Vacuum seals are maintained between crucible and bottom plate at 12 and between bottom plate and mould at 13. An argon, helium or vacuum connection 14 is provided to the mould so that air can be entirely excluded from it during melting and casting.

In operation, a titanium plate 15 is positioned so that it covers the aperture 9 and a small charge of titanium sponge is placed on top of the plate. The arc is struck and charge and plate are fused together at a small arc current. The pool is allowed to cool and further material added and melted again at a small current. By repeating this three or four times a skull of titanium is built up. An additional charge is then made and melting continued at a higher current until the molten pool 16 penetrates to the plate 15 and the molten charge is cast into the mould 10 where it is allowed to solidify. The mould is then withdrawn on the jack and the ingot removed. The hole through which pouring has occurred is blocked with a suitable piece of titanium, and the crucible and mould reassembled for a further melting operation.

The skull of titanium is built up again and melting and casting continued as before.

In another form of construction the mould may be provided with a separable base whereby the central aperture is divided into two portions 18 and 20, as specifically shown in Figure 2, so that at the end of the casting operation only the base is withdrawn, carrying the solidified ingot with it. Alternatively a longitudinally split mould may be employed, whereby the central aperture is split into two portions 22 and 24, as specifically shown in Figure 3, to facilitate extraction of the casting. In use, the split mould is maintained closed with the aid of any conventional locking means 26.

The upper part of the bottom plate 8 may be so shaped that it projects some distance across the aperture 9 to provide a lip 28, as shown in Figure 4, over which pouring of the molten metal takes place directly into the mould.

In addition to the production of homogeneous fully melted ingots or castings from conventional raw material such as metal sponge or powder, the process of the present invention has the additional advantage that scrap can be readily melted by means of it, since it enables mixing of pieces of various initial composition prior to solidification of the casting and there is no physical difficulty of feeding into the furnace.

I claim:

1. A process for arc-melting and casting of high melting point reactive metals and alloys comprising introducing at least one small initial charge of solid raw material selected from the group consisting of high melting point reactive metals and alloys into a crucible having a bottom comprising in part a destructible plate of the same composition as the metal to be melted, applying an arc current sufficient to melt said initial charge but insufficient to melt said plate, decreasing said current to allow said initial charge to solidify to form a lining in said crucible, introducing a complete main charge of said solid raw material into said crucible, then applying an arc current to said complete main charge after it has been completely introduced into said crucible and arc-melting this charge and maintaining it in the molten condition so as to produce a pool of molten metal of sufficient quantity to form a complete casting of predetermined size, thereafter increasing the arc current to melt a centrally disposed part of said destructible metal plate and that portion of said lining immediately above said part of said plate to form an aperture therein to permit escape of the molten metal from said crucible and flowing said molten metal into a mold.

2. The process of claim 1 wherein said raw material is introduced into said crucible by means of a consumable arc electrode of the required composition.

3. A process for arc-melting and casting of high melting point reactive metals and alloys comprising introducing at least one small initial charge of solid raw material selected from the group consisting of high melting point reactive metals and alloys into a crucible having a bottom comprising in part a destructible plate of the same composition as the metal to be melted, applying an arc current sufficient to melt said initial charge but insufficient to melt said plate, decreasing said current to allow said initial charge to solidify to form a lining in said crucible, introducing a complete main charge of said solid raw material into said crucible, then applying an arc current to said complete main charge after it has

been completely introduced into said crucible and arc-melting this charge and maintaining it in the molten condition so as to produce a pool of molten metal of sufficient quantity to form a complete casting of predetermined size, thereafter increasing the arc current to melt a centrally disposed part of said destructible metal plate and that portion of said lining immediately above said part of said plate to form an aperture therein to permit escape of the molten metal from said crucible and flowing said molten metal into a mold, and after said molten metal has flowed through said aperture in the bottom of the crucible, said aperture is closed by means of a piece of metal of the same composition as the metal to be melted, a second small initial charge of said raw material is then introduced, arc-melted, and allowed to solidify to form a lining of said metal on said piece of metal, thereafter introducing a second complete main charge of said raw material and applying an arc current to effect melting of said second main charge and to maintain a molten pool of the metal, and thereafter increasing the arc current to melt at least a centrally disposed part of said piece of metal and that portion of the lining immediately thereabove to form an aperture therein and to permit escape of the molten metal from said crucible, and flowing said molten metal into a mold.

4. Apparatus for arc-melting and casting of high melting point reactive metals and alloys comprising, a cooled side wall, and a bottom wall constructed in part of a cooling plate in the form of an annular ring having a centrally disposed orifice passing therethrough and in part of a solid plate of the same composition as the metal to be melted, said solid plate acting as an initial closure for said orifice, said side wall and said bottom wall defining a melting chamber, an arc electrode extending into said melting chamber and a separable mold juxtaposed adjacent said bottom wall to receive molten metal from said melting chamber.

5. Apparatus in accordance with claim 4 wherein only the base of the mold is separable.

6. Apparatus in accordance with claim 4 in which said mold is longitudinally separable from said bottom wall for extraction of the casting.

7. Apparatus in accordance with claim 4 in which said bottom wall of said melting chamber is provided with an annular projection into said orifice to form a pouring lip.

References Cited in the file of this patent

UNITED STATES PATENTS

1,664,452	Daniels et al.	Apr. 3, 1928
2,305,071	Fahlman	Dec. 15, 1942
2,369,233	Hopkins	Feb. 13, 1945
2,380,238	Hopkins	July 10, 1945
2,734,244	Herres	Feb. 14, 1956

FOREIGN PATENTS

676,708	France	Nov. 29, 1929
---------	--------------	---------------

OTHER REFERENCES

Transactions of the Electrochemical Society, September 1949, pp. 160, 165 and 167 relied on.

The Iron Age, October 1952, vol. 170, issue 16, p. 113 relied on.