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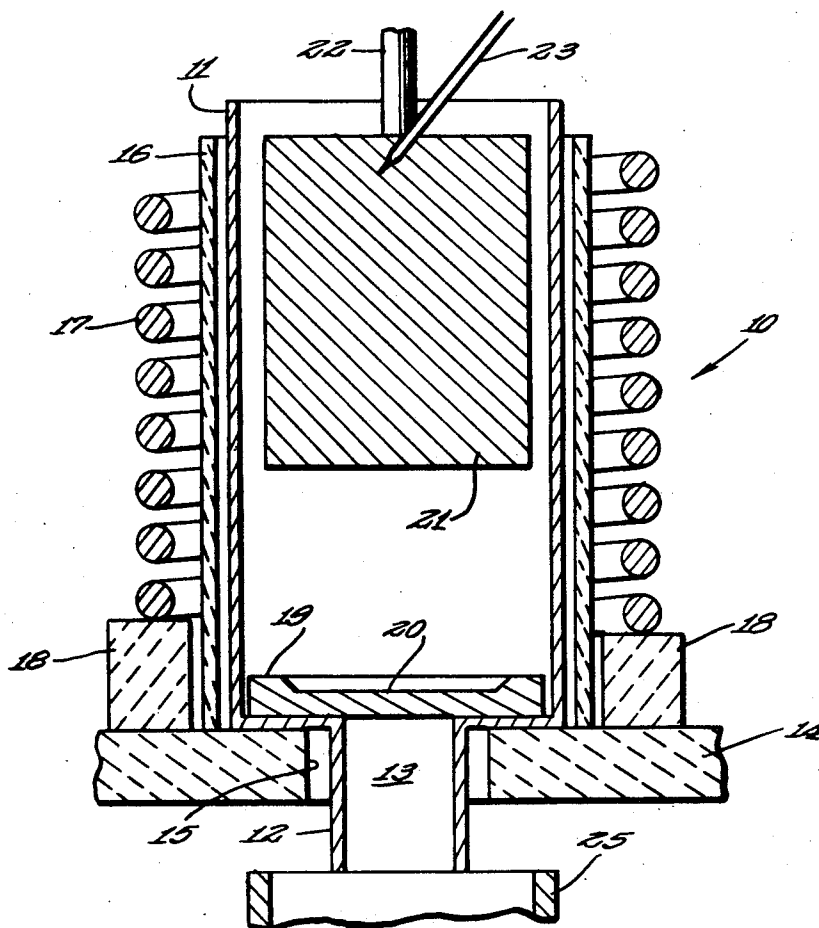
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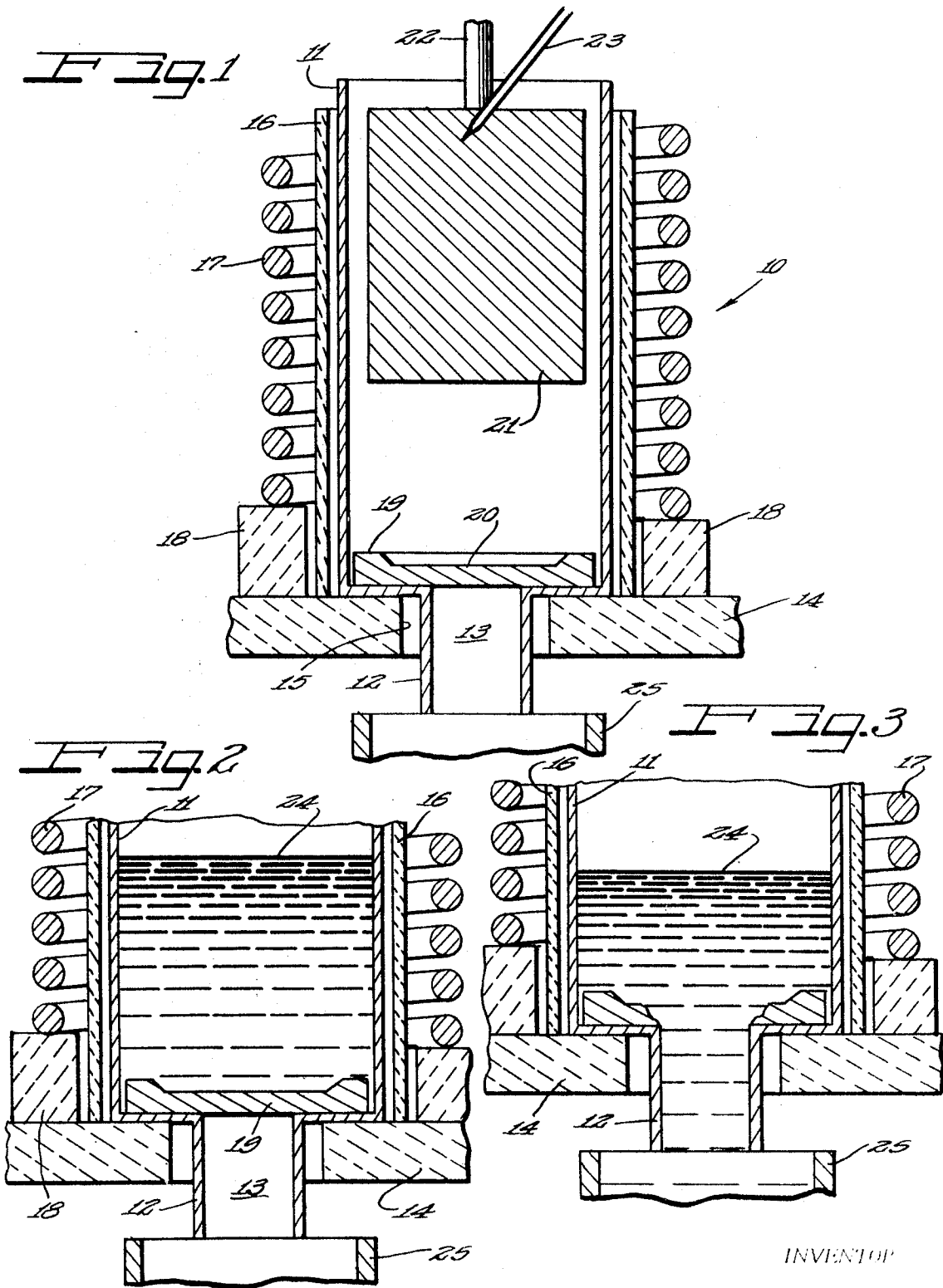
[54] **TITANIUM CASTING PROCESS**
4 Claims, 3 Drawing Figs.

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75/10, 75/135, 75/175.5
[51] Int. Cl..... B22d 27/02
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51, 50, 48; 75/10, 135, 175.5

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ABSTRACT: Method and apparatus for casting a titanium alloy which involves suspending a slug of the alloy in spaced relation to the walls of a refractory crucible, inductively heating the slug while so suspended to eventually melt the same, collecting the molten alloy on a disc of titanium alloy positioned in the crucible, and then continuing the application of heat to the molten metal while supported on the disc until the molten metal melts the disc and can then be directed to a mold.





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TITANIUM CASTING PROCESS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This application described improvements to the subject matter which is described and claimed in U.S. Pat. No. 3,484,840 issued Dec. 16, 1969 to Spoth and Chandley and entitled "Method and Apparatus for Melting and Pouring Titanium."

This invention is in the field of melting titanium alloy (70 percent titanium and above), and including commercially pure titanium (99.8 percent Ti). The invention includes the step of bringing a slug of the titanium alloy near its melting temperature while suspended out of contact with the walls of the crucible, and then applying additional heat to the slug to melt the same. The molten metal is then superheated while it is disposed on a disc of a titanium alloy which is preferably of the same chemical composition as the material of the slug. continued application of heat causes the molten metal to melt through the titanium alloy disc and the molten titanium can then be introduced into a mold.

2. Description of the Prior Art

Titanium alloys used in forming shaped castings are usually skull melted in water-cooled, crucible arc melting units. The temperature control in this type of melting is difficult because the molten titanium is cooled rapidly by the water-cooled crucible when power from the arc is terminated. A resulting variation in pouring temperature may cause many casting defects. If the temperature is too high, dimensional and metallurgical problems result. If the pouring temperature is too low, the castings misrun and also contain metallurgical defects.

One of the most serious problems in melting and pouring titanium is the avoidance of contamination. Titanium has a strong affinity for hydrogen, nitrogen, oxygen and carbon. Excess absorbed hydrogen is removed from titanium alloys by expensive processing such as vacuum annealing. According to current specifications, the hydrogen content of titanium should be limited to about 125 and 200 parts per million. Above these limits, hydrogen embrittles most titanium alloys, and reduces their impact strength and notch tensile strength, causing brittle failure under sustained loads at low stresses.

Other contaminants cause titanium alloys to become embrittled. This embrittlement is usually manifested by the formation of a brittle surface layer which must be removed by pickling, grinding or machining.

The drawbacks to commercial skull melting procedures as presently practiced in the casting of titanium are further described in the article entitled "A Look at WorldWide Titanium Technology" appearing in the Sept. 1968 issue of "Metal Progress," pages 60 to 71.

SUMMARY OF THE INVENTION

The present invention relates to a method and apparatus for melting and pouring titanium alloys in which a slug of the titanium alloy to be melted is first suspended in a refractory crucible so that it is out of contact with the walls thereof. The crucible is preferably made of dense graphite, and has an aperture in the base thereof. The aperture is covered by means of a disc of titanium alloy having the same chemical analysis as the slug to be melted, and in any event, being devoid of any contaminating elements which would affect the physical properties of the titanium melt. The slug of titanium alloy is inductively heated while so suspended to a temperature just below the melting point of the slug. When the entire slug is substantially at this temperature, an additional amount of heat is provided by the induction heating apparatus to raise the temperature of the slug above the melting temperature, whereupon a molten pool of titanium alloy is formed on the titanium alloy disc. The molten alloy is superheated and, in a short period of time, it melts through the titanium alloy disc and runs out of the crucible through the aperture. The time of contact of the

molten titanium alloy with the refractory crucible is thus held to a minimum.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a somewhat schematic view of a melting and pouring assembly which can be used in accordance with the present invention, illustrating the manner in which the titanium alloy slug is suspended in the crucible before melting;

FIG. 2 is a fragmentary view similar to FIG. 1 but illustrating the interior of the crucible after the slug has been melted; and

FIG. 3 is a view similar to FIG. 2 but illustrating the condition of the assembly after the molten titanium alloy has melted the titanium alloy disc.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is applicable to the melting and pouring of titanium alloys generally, where contamination is a problem. It is applicable to the melting of commercially pure titanium (99.2 percent Ti) as well as to alpha titanium alloys (Ti-5Al-2.5Sn) to alpha-beta titanium alloys (Ti-2Fe-2Cr-2Mo) (Ti-8Mn) (Ti-4Al-Mn)(Ti-4Al-3Mo-1V) (Ti-5Al-1.5Fe-1.4Cr-1.2Mo) (Ti-6Al-4V) (Ti-7Al-4Mo) and to beta titanium alloys (Ti-3Al-13V-11Cr).

Turning now to the drawings, in FIG. 1 reference numeral 10 indicates generally a melting and pouring apparatus which can be used for the purposes of the present invention. The apparatus 10 includes a graphite crucible 11 having a neck 12 providing a discharge opening 13. The graphite crucible 11 is positioned on a ceramic support plate 14 having an aperture 15 therein accommodating the neck 12 of the crucible. A cylindrical ceramic heat shield 16 is positioned about the graphite crucible 11 in coaxial relation. Surrounding the heat shield 16 is a high frequency induction coil 17 connected to a suitable source of power (not shown). The coil 17 rests on one or more positioning blocks 18 standing on the ceramic support plate 14.

Overlying the discharge opening 13 is a disc 19 of titanium alloy, the disc 19 having a reduced thickness central portion 20. A slug 21 of the titanium alloy to be melted is supported in spaced relation to the walls of the crucible 11 as well as the disc 19 by a support rod 22 which is suitably fastened to the slug 21 as by means of a threaded engagement. A thermocouple 23 is positioned centrally of the slug 21 to give an indication of the temperature at that portion of the slug.

When the slug is supported as illustrated in FIG. 1 of the drawings, sufficient power is applied to the coil 17 to preheat the entire suspended slug to a temperature just below its melting point. The melting points of commercial titanium alloys range from about 2800° to 3135° F. for the commercially pure titanium. With induction heating, the heat buildup occurs on the outer surface adjacent to the induction coil 17 and progresses inwardly, mainly by conduction. The progress of the heating is monitored by the thermocouple 23. When the slug is uniformly heated to a temperature within say 100° F. of its melting point, full power is applied to the coil 17, and melting is completed in a very short time. The molten metal 24, as illustrated in FIG. 2 of the drawings, is collected momentarily by the titanium alloy disc 19. This permits the melt to reach the desired superheat of 100° to 400° F. or so. The superheat can be controlled by the thickness of the reduced portion 20 of the disc and its location with respect to the coil 17. The molten bath 24 rapidly melts the disc 19 as illustrated in FIG. 3, and proceeds through the discharge opening 13 into the gate 25 of a mold assembly for producing castings.

It such be understood that the melting and pouring is done under noncontaminating conditions such as under vacuum conditions or in the presence of an inert gas such as argon. Since such melting and pouring conditions are customary for titanium alloys, the furnace enclosures have not been illustrated in the drawings.

It has been found through the use of the method and apparatus of the present invention wherein the slug is preheated

without crucible contact, that a much shorter molten cycle results, and considerably less carbon contamination is encountered.

It should be evident that various modifications can be made to the described embodiments without departing from the scope of the present invention.

I claim as my invention:

1. The method of casting a titanium alloy which comprises suspending a slug of said alloy in spaced relation to the walls of a refractory, electrically conductive crucible, inductively heating said slug while so suspended until the entire slug reaches a substantially uniform temperature slightly below the melting point, thereafter increasing the amount of heat applied to raise the temperature of said slug above its melting point, collecting the molten alloy on a disc of titanium alloy, continuing the application of heat to the molten metal while

supported on said disc until the molten metal melts through said disc and directing the molten metal to a mold.

2. The method of claim 1 in which said crucible is composed of graphite.

3. The method of claim 1 in which said disc is composed of the same alloy as said slug.

4. In a method of casting a titanium alloy, the steps comprising suspending a slug of said alloy in spaced relation to the walls of a refractory electrically conductive crucible, inductively heating said slug until the slug reaches a substantially uniform temperature throughout, which temperature is within about 100° F. of the slug melting point, and increasing the quantity of inductive heating to rapidly melt the slug and thereby create a molten pool of the alloy in said crucible.

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