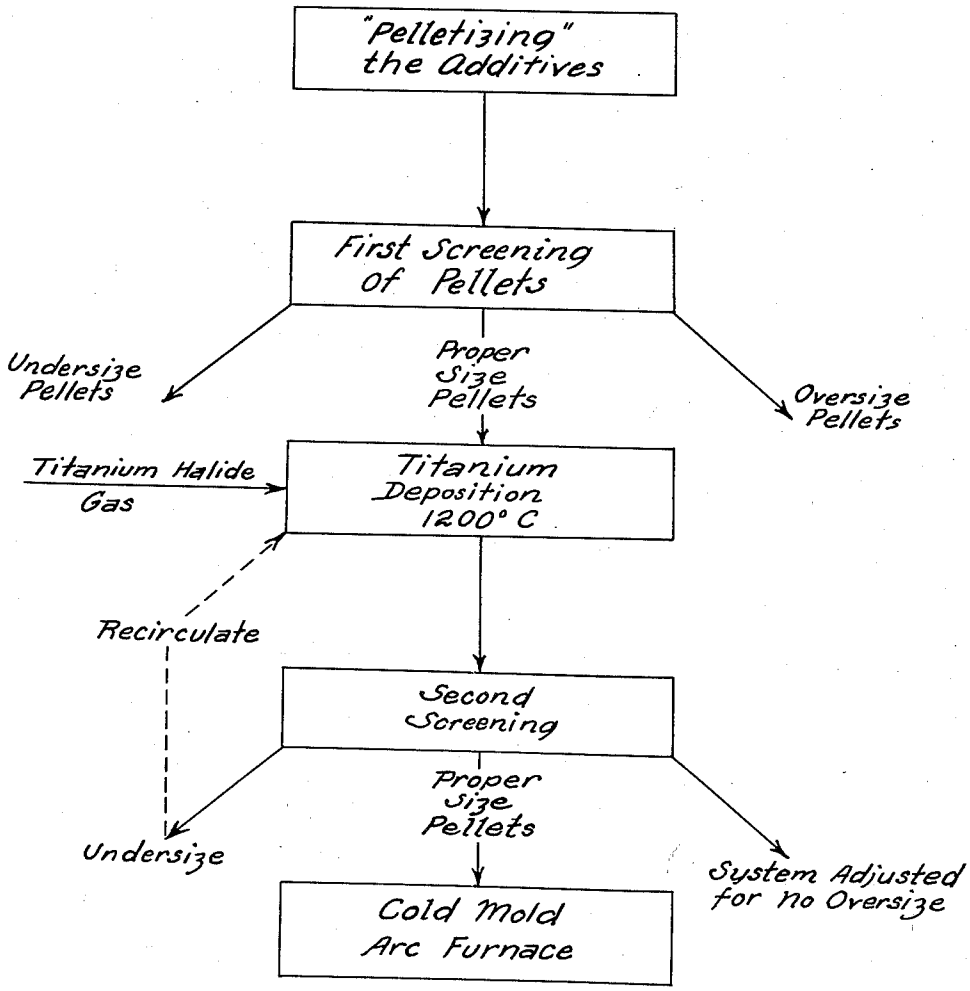
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METHOD OF ALLOYING TITANIUM

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METHOD OF ALLOYING TITANIUM

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The invention described herein may be manufactured and/or used by or for the Government for governmental purposes without the payment to me of any royalty thereon.

This invention relates to the production of titanium alloys and is particularly directed to an improved method for obtaining such alloys. In the art of titanium alloy melting it has generally been found necessary to "double melt" in order to obtain the desired structural uniformity and compositional homogeneity. In this "double melt" process, titanium sponge and the desired alloy additions are physically mixed and fed into a "cold mold arc furnace" where they are melted and solidified into an ingot. The ingot obtained from this first melting is of such poor uniformity, as the result of inherently poor premixing and the shallow molten metal pool in this type of melting, that it is entirely unsuitable for fabrication into finished products. Instead, the ingot becomes the consumable electrode in a larger cold mold arc furnace where it is remelted into a more homogeneous ingot which is suitable for fabrication.

Since this rather cumbersome and expensive process is due in large measure to the poor uniformity obtained in premixing, it would appear that great advantage might be derived from improving the character of the mixture first subjected to the arc. In U.S. Patent No. 2,855,331, issued October 7, 1958, there is disclosed a method for obtaining titanium metal of high purity. Briefly stated, the method involves deposition of titanium halide on metallic particles maintained at a temperature above the decomposition temperature of the titanium halide. In the process for obtaining titanium alloys which is the subject of the present invention, the halide decomposition method for obtaining titanium metal will be employed. This halide decomposition method yields a solid, dense deposit of titanium metal, rather than a porous deposit as in the sponge (Kroll) process. While the significance of the fact will be more fully explored in the subsequent discussion, it should be noted at this point that since the titanium deposit is relatively dense and uniform in this process, there is close correlation between the volume of the titanium deposit and its weight.

It is an object of this invention to simplify the production of titanium alloys.

It is another object of this invention to utilize the thermal decomposition of titanium halides in a method for producing titanium alloys.

It is a further object of this invention to utilize an improved physical mixture of titanium and additives to reduce the number of melting steps required to produce titanium alloy ingots.

It is still another object of this invention to closely control the composition of a titanium alloy melt by controlling the composition of the mechanical mixture charged into the furnace.

Still another object of this invention is the provision of a method for melting and casting titanium alloys which is easily adapted to continuous operation.

Other objects and advantages of the invention will become apparent in the course of the description which follows.

In the drawing, which forms a part of this description, the FIGURE is a flow sheet illustrating the method of this invention.

The process as shown in the figure includes the following principal steps in the order listed:

(1) *"Pelletizing."*—This is the production of "seed" particles or pellets for use in a later deposition step. The pellets are composed of the alloying materials or additives desired in the final titanium base alloy. The manner in which the additive pellets are produced depends to a large degree upon the physical properties of the additive. Those metals which are ductile can be "pelletized" in a shot tower. Brittle metals can be reduced to pellets by a crushing process.

(2) *First screening.*—This step is calculated to obtain pellets of a predetermined weight by size screening. At least two screens are used, and pellets which pass through a first screen element but are retained on a second screen element are of the proper uniform size (weight). Both undersize and oversize pellets are removed from the process at this point, but, with proper adjustment of the processing equipment they may be run through the balance of the process at a later time.

(3) *Titanium deposition.*—In this step the alloy pellets receive a titanium coating of predetermined weight. The additive pellets of proper size are introduced into a dissociating furnace in which there is maintained an atmosphere of a titanium halide, preferably titanium tetraiodide. In the dissociating furnace the pellets are heated to a temperature of approximately 1200° C., at which temperature the halide dissociates, depositing titanium on the alloy pellets. The amount of titanium deposited on the pellets, so long as the temperature is maintained at 1200° C. and a flow of titanium halide through the furnace is established, depends only upon the time the pellets remain in the furnace. It is contemplated that the time of operation of the dissociating furnace will be so adjusted that oversize pellets will not be produced. When the pellets have grown to some predetermined size they are removed from the furnace for further processing.

(4) *Second screening.*—The tri-metallic pellets having the proper titanium-to-alloy weight ratio are in this step segregated from the undersize pellets. The undersize pellets can later be recirculated through the deposition equipment. As previously pointed out, the titanium deposit obtained is dense and uniform and therefore, titanium deposits having similar volumes will have very nearly the same weight. Since the "seed" or additive pellets are of nearly the same weight, it may be said that the tri-metallic pellets have the same titanium-to-alloy weight ratio. Just what that ratio is, of course, depends upon the screens used.

(5) *Melting.*—The tri-metallic pellets having the proper titanium-to-alloy ratio are melted and cast into titanium alloy ingots. This step is ordinarily carried out in the conventional cold mold arc furnace.

It should be understood that the undersize and oversize pellets obtained in step 2 of this process could be run through steps 3–5 in separate batches. The time in the dissociating furnace would be shorter for the undersize pellets and longer for the oversize pellets. Screens of appropriate size would be used in step 4 to secure pellets having the proper titanium-to-alloy weight ratio.

A dissociating furnace suitable for the practice of this invention is disclosed in U.S. Patent No. 2,855,331. In that furnace the pellets are kept in continuous motion by rotating the furnace while the moving pellets are inductively heated to the proper temperature by a coil surrounding the furnace. Automatic removal and screening of the bi-metallic pellets can be effected by employing the inclined rotary dissociating furnace also shown in U.S. Patent No. 2,855,331.

The tri-metallic pellets of titanium and alloy metal have very large surface areas at which the two constituents of the pellet are in intimate contact with each other.

This is a condition most favorable for rapid and uniform intermixture upon melting, with minimum loss of additives. This intimate and uniform mixture obtained in this manner cannot be approached by conventional mechanical mixing techniques.

As an example of the product of this process, if an alloy of titanium and chromium is desired, relatively uniform pellets of chromium are obtained by "pelletizing" the chromium and then screening the pellets. The pellets would then be fed into the dissociating furnace, and titanium deposited thereon until 95% of the weight of the pellet (as determined by the second screening) was titanium. Since each chromium pellet is surrounded by the proper amount of titanium and the metals have relatively large surface areas in contact with each other the mixture may be characterized as both "uniform" and "intimate." Upon melting a charge of these bi-metallic pellets in the usual cold mold arc furnace, a 95% Ti-5% Cr alloy having a high degree of uniformity results.

By using a bi-metallic pellet as "seed" a ternary alloy of titanium can be made. The two alloying metals are premelted in the correct proportions and cast as small shot. These pellets are then fed into the dissociation furnace upon which the much larger quantity of titanium (the base metal of the finished alloys) is deposited.

For ternary alloys such as iron-chromium-titanium, iron-manganese-titanium, copper-silicon-titanium, and iron-silicon-titanium, the binaries ferrochrom, ferromanganese, cuprosilicon, and ferrosilicon form the original pellets. Since these binaries are brittle, the binary pellet is produced by a crushing process.

Quaternaries, quintaries, etc. can be produced by the same general method.

From the foregoing, it is apparent that I have devised a novel method incorporating the advantages stated in the above description. It is to be understood that the invention is susceptible of various modifications without departing from the spirit or scope of the invention.

What is claimed is:

A method for producing alloys of titanium comprising the steps of pelletizing the additives, screening the additive pellets to obtain pellets of a uniform size and composition, heating said pellets to a halide decomposing temperature in a titanium halide atmosphere to deposit titanium metal thereon, screening the composite pellets to obtain pellets of a selected size and composition, and melting said composite pellets of said selected size and composition, in a cold mold arc furnace to obtain the desired titanium alloy.

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