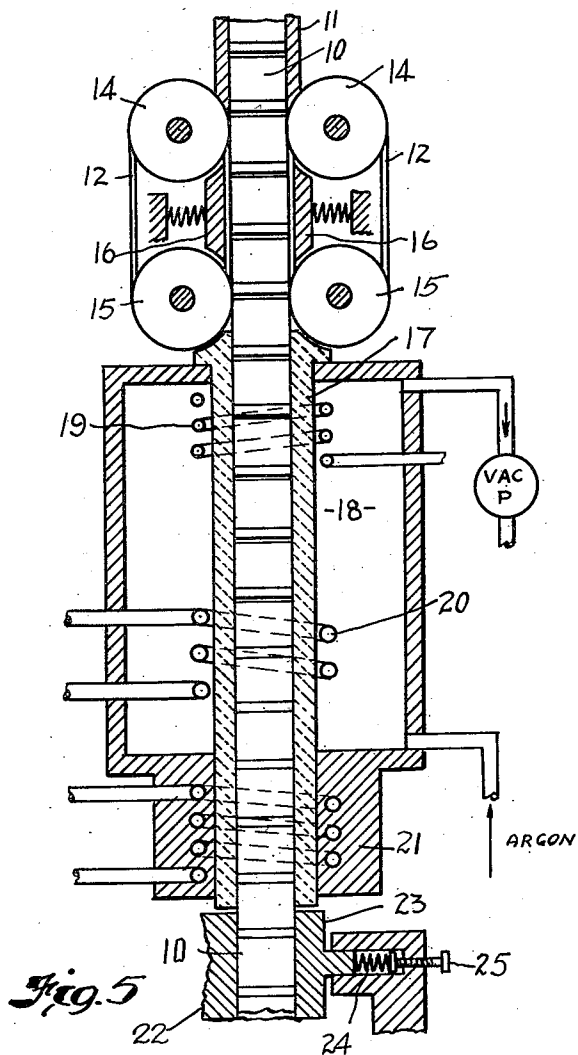
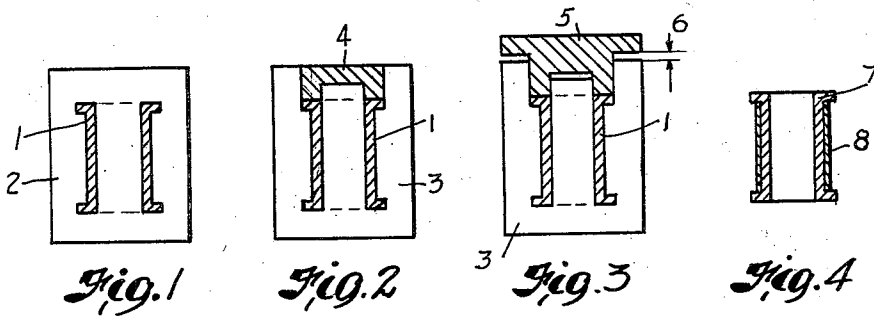


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 APPARATUS FOR MAKING ARTICLES FROM
 POWDERED METAL BRIQUETS
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APPARATUS FOR MAKING ARTICLES FROM POWDERED METAL BRIQUETS

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1 Claim. (Cl. 22—75)

The present invention relates generally as indicated to an apparatus for making articles from powdered metal briquets and more particularly to certain improvements in apparatus for carrying out the methods and processes disclosed in my co-pending applications Serial Nos. 104,369, 161,344, 202,707, all now abandoned and 252,938. This invention also relates to turbine blades.

It is one object of this invention to provide an apparatus by which accurate articles of desired denseness (porous or non-porous) may be formed from powdered metal briquets.

It is another object of this invention to provide an apparatus by which and with which a powdered metal briquet may be partially or completely fused while contained within a non-distorting heat-resistant enclosure, which enclosure may, in some instances, be wholly or partly of a material which imparts desired physical or chemical properties to the briquet therein or which bonds to the briquet.

Other objects and advantages of my invention will appear as the description proceeds.

To the accomplishment of the foregoing and related ends, said invention then comprises the features herein-after fully described and particularly pointed out in the claim, the following description and the annexed drawings setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but a few of the various ways in which the principles of the invention may be employed.

In said annexed drawings:

Fig. 1 is a cross-section view of a powdered metal briquet and surrounding enclosure;

Fig. 2 is a cross-section view similar to Fig. 1 except that a false piston is included in the enclosure in contact with the powdered metal briquet;

Fig. 3 is a cross-section view showing the false piston of Fig. 2 replaced by a piston which is adapted to exert pressure on the powdered metal briquet when the latter is melted;

Fig. 4 is a cross-section view of a special form of powdered metal briquet with a surrounding solid metal band to which the powdered metal is to be bonded or alloyed; and

Fig. 5 is a cross-section view of one form of apparatus which may be employed for the practice of the present method.

Referring now more particularly to the drawing and first to Fig. 1 thereof, the powdered metal briquet 1 is formed in well-known manner by the mechanical consolidation of the metal powder in suitable dies provided with cavities of the desired shape and size. The pressure required to form the briquet 1 will, of course, vary according to the particular metal which is used; and, except in the case of low-melting point metals, the pressed compact or briquet is mechanically weak and must be handled with care. Any of a variety of different metals and alloys may be employed for forming the

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metals and alloys from which powdered metal briquets may be formed are: RC 130 B or Ti Alloy 150A, whose powdered metal briquet 1. Examples of some of the compositions are as follows: N. N. 4%, Al 4%, O 2%, N .1% max., and Ti balance; and Fe 1.3%, Cr. 2.7%, O .25%, N .02% max., C .02% max., and Ti balance.

After the briquet 1 has been formed, it is enclosed in a body 2 of heat-resistant material, usually a ceramic material including carbon, mica, plaster of Paris, asbestos, stabilized zirconium oxide, and other heat-resistant and preferably, but not necessarily, non-metallic materials which can be heated to at least the melting point of the briquet without melting, burning, or otherwise rendered inoperative by the melting of the briquet therein. Enclosing of the briquet 1 within the body of a heat-resistant material 2 may be done as is disclosed in my aforesaid co-pending applications Serial Nos. 161,344 and 202,707.

In the case that the enclosure 2 is in the form of a mold made of two or more pieces, the same may be pre-fired or fused so that said mold will have a very close fit in the guide portion of the apparatus which will be presently described.

In Figs. 2 and 3 the briquet 1 is enclosed within a composite enclosure which comprises a body 3 of heat-resistant material and a plug 4 of any desired material such as metal, said plug being positioned adjacent one end of the briquet 1 so as to form therewith and with the body 3 a cylinder for a piston 5. It can be seen from Fig. 3 that when the briquet 1 is fused, pressure on the top of the piston 5 will cause the end of the piston to exert pressure on the top of the fused briquet. The degree of compacting of the melted briquet 1 is determined by the distance 6 which is additionally selected so that the article will be of the desired dimensions in the direction of pressure application thereon. Thus, where the briquet is of a tubular form as shown in Figs. 1 to 3, the axial dimension thereof will be somewhat greater than that of the finished article because of the reduction in bulk owing to the fusing thereof and mechanical consolidation in addition, when the piston 5 is employed as shown in Fig. 3. The diameters of the briquet can, of course, be made to correspond with the desired final diameters of the article except to take into account shrinkage owing to a thermal contraction.

In Fig. 4, the powdered metal briquet 7 is formed inside a continuous solid metal band 8 and the composite briquet 7 and band 8 will be enclosed in heat-resistant material as shown in Figs. 1 or 2 and upon fusing of the briquet 7, the same will become bonded to or alloyed with the band 8 according to the particular selection of materials for the briquet and for the band 8.

In Fig. 5, there is shown a preferred form of apparatus through which the briquets and surrounding enclosures of Figs. 1 and 3, for example, are adapted to pass. In Fig. 5, the composite enclosures and briquets therewithin are represented by the reference numeral 10 and for purposes of illustration, these composite enclosures and briquets are of the form illustrated in Fig. 3.

At the top of the apparatus, there is provided a guide tube 11 in which the units 10 are superimposed one upon the other with the pistons 5 at the top of each unit. These units 10 are fed downwardly as by means of power-driven chains or belts 12 which run over sprocket wheels or pulleys 14 and 15. The opposed parallel portions of the belts 12 may be pressed into frictional engagement with the units 10 therebetween as by means of spring loaded blocks 16. It is to be understood that positive feed means may be employed if desired and in such case, the exterior of the units 10 may be provided with gear teeth or like formations for meshing with teeth on the wheels 14 or with spaces in the opposed chains 12. One

pair of the wheels 14 or 15 will be power-driven and as evident, downward feeding of the units 10 may be accomplished at a constant speed.

Or the units 10 and pistons 5 may be successively pushed down through tube 11 by a reciprocating hydraulic ram.

The apparatus below the just-described feeding device comprises a guide tube 17 which may be formed of graphite or like material having a non-oxidizable coating on its inner surface. Such coating may be of stabilized zirconium oxide or similar refractory material.

The guide tube 17 thus interiorly coated serves to seal the units 10 from the surrounding atmosphere and also to provide a precision guide. Said guide tube 17 also alleviates gas contamination.

The upper portion of the guide tube 17 has a heating chamber 18 therearound for pre-heating the units 10 as they pass downwardly through the guide tube 17. Said heating chamber may be heated by any suitable means such as the electric heating element 19, or by hot inert gases circulated through said chamber 18, or by molten material contained in the chamber 18 and heated to predetermined temperature by any suitable means.

As the units pass downwardly through the heating chamber 18, substantially all of the gases are expelled therefrom.

Below said pre-heating chamber 18 or as shown in the lower portion of said chamber, there is a high frequency heating coil 20 which encircles the guide tube 17. Thus, as the units 10 move downwardly at constant speed, the pre-heated briquets 1 will be further heated and melted or fused from the bottom thereof upwardly; and, because the gases have been expelled by the pre-heating of said briquet 1 and the enclosure 3 therearound, the melted metal will completely fill the space in the enclosure without any trapped gas pockets. Where the pistons 5 are employed in association with the enclosures 3, the resistance to downward movement of the units 10 as will be hereinafter explained will cause the end of the piston 5 to exert pressure on the fused briquet 1 for densifying the same and further causing the melted briquet to completely fill the cavity within the enclosure 3 including sharp corners, etc.

The chamber 18 is preferably operated under a vacuum or partial vacuum with an inert gas such as argon therein when desired by means of a vacuum pump and exhaust pipe system attached thereto.

In passing downwardly through the high frequency heating coil 20, the briquets 1 within the units 10 are successively completely melted and after the melting has been completed, the units 10 now pass through a cooling unit 21 which surrounds the guide tube 17 and through which a suitable cooling medium is adapted to be circulated. Therefore, as the units 10 pass downwardly through the portion of the guide tube 17 located within the cooling unit 21, the enclosures 3 and melted briquets 1 therewithin are cooled to effect solidification of the briquet 1.

Thus, when the units 10 are discharged from the lower end of the guide tube 17, the finished accurate articles of desired density are removed from within the enclosures 3 by breaking away the enclosures 3 where the latter is of one-piece construction or by opening the enclosure for removal of the article therewithin in the case that said enclosure is formed of two or more mating pieces.

Where the enclosure 3 is formed of graphite or of a ceramic material having carbon therein a certain amount of carbon pick-up may be obtained in this type of fusion casting whereby at least the outer skin of the melted and subsequently solidified briquet 1 is made more abrasive resistant. For example, in casting titanium alloys, the outside skin is partially converted to titanium carbide.

In order that a desired resistance may be built up against the downward movement of the units 10 through the guide tube 17, there is disposed adjacent the lower end of said guide tube a friction mechanism which includes for example, a fixed shoe 22 engaging one side of superimposed units 10 and a movable spring load shoe 23 which resiliently presses against the opposite side of said units 10. The pressure which the shoe 23 exerts against the units 10 may be varied by adjusting the compression of the spring 24 by means of a suitable adjusting screw 25. Instead of the particular resistance unit shown at the bottom of Fig. 5, other well-known expedients may be employed. For example, a mechanism such as used for downward feeding may be positioned adjacent the lower end of the guide tube 17 and instead of positively driving one pair of the wheels 14 or 15, adjustable brakes may be associated therewith for building up the desired resistance against downward movement of the units 10, or a reciprocating hydraulic ram may be used to assist and/or control the resistance for compression desired.

When the briquet is of the form illustrated in Fig. 4, it is possible to bond the solid metal 8 to the powdered briquet 7 by using the apparatus illustrated in Fig. 5. It should be further noted that the briquets 1 may be made of spherical particles of metal or loose spherical particles may be loaded into a mold cavity and by fusing the spherical particles only partly, the final article will be partially permeable and will be uniformly orificed since in that case, only the contacting portions of the spherical particles will bond together.

Other modes of applying the principle of the invention may be employed, change being made as regards the details described, provided the features stated in the following claim, or the equivalent of such, be employed.

I therefore particularly point out and distinctly claim as my invention:

Apparatus for making articles from powdered metal briquets comprising open top molds containing such briquets, pistons fitted into the respective molds to bear on the top of the briquets therein, a downwardly extending guide member, means for feeding said molds and pistons downwardly through said guide member in superimposed relation with each piston engaged by the bottom of the mold thereabove, pre-heating means around said guide for heating said molds and briquets therein and thus expelling gases therefrom as said molds are moved downwardly through said guide member, heating means effective to progressively fuse the briquets in said pre-heated molds from the bottom upwardly as said molds continue to move downwardly through said guide member, artificial cooling means for solidifying the fused metal in said molds, and means below said heating means opposing downward movement of said molds whereby said pistons are actuated into the respective molds by the molds thereabove so as to bear on the fused metal.

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