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METHOD OF PRODUCING SHAPED BODIES FROM POWDERED METALS

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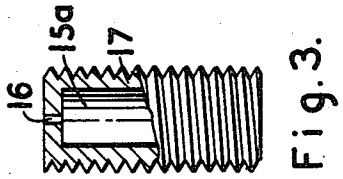


Fig.3.

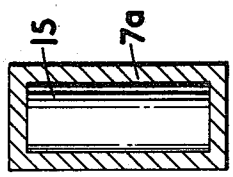


Fig.2.

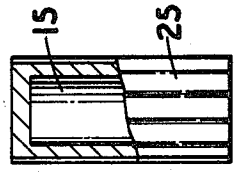


Fig.5



Fig.4.

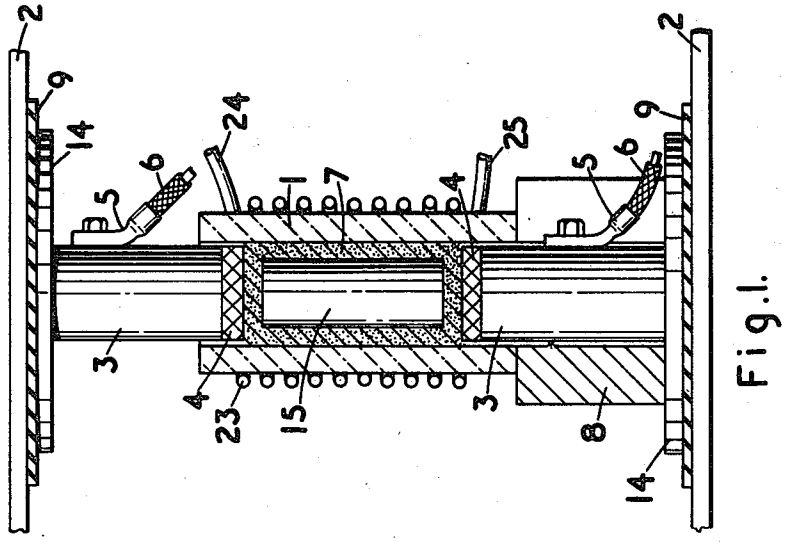


Fig.1.

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METHOD OF PRODUCING SHAPED BODIES FROM POWDERED METALS

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This invention relates to the production of shaped bodies by compacting pulverulent materials in a mould or die.

In the forming of shaped bodies by compaction of powders in a die, frictional effects, particularly between the powder and die walls, cause a falling off in compacting pressure as the distance from the movable compression members of the die increases. Hence, to ensure that such shaped bodies are satisfactorily compacted throughout, it has been necessary to limit the ratio of the dimension of the compact in the direction of the compression (herein referred to as the "depth" of the body) to the transverse dimension, and accordingly bodies having sections of small thickness and substantial depth have not been practical. The above mentioned frictional effects have also made it difficult, if not impracticable, to obtain in shaped bodies of compacted powders satisfactory reproduction of relatively deep patterns or impressions carried by the wall of the die.

The object of the present invention is to provide a method of forming shaped bodies of compacted powder whereby satisfactory compaction of the material is obtained in relatively thin sections of substantial depth, and whereby the compression may serve to apply a pattern, impression or the like to the transverse surface of the body.

In accordance with the invention in the production of shaped bodies by compacting powder masses, substantially uniform compaction of powder in sections of substantial depth and relatively small thickness is obtained by compacting the powder mass with such sections in contact with a mass of substance which under the conditions of compaction has the quality of deforming or flowing and so transmitting isotropic pressure.

Also in accordance with the invention, shaped bodies having sections of relatively small thickness and substantial depth are produced from powders by subjecting the powder forming the said sections to pressure through the medium of a mass of substance which is subjected to compression with the powder and has the quality of deforming or flowing under the conditions of compaction and so transmitting isotropic pressure.

Also according to the invention a shaped body is formed by compacting a mass of powder material in a die within a surround or about a core or cores of a substance, which under the conditions of compacting has the quality of so flowing or deforming as thereby to transmit isotropic pressure. The powders may be fine or coarse for use in the invention and the resulting compacted powder, while preferably impermeable, may be made porous, if desired.

The substance forming the core employed according to the invention may be one which will flow at ordinary temperatures when subjected to the compacting pressure, for example metallic sodium, lead or other soft metal or soft metal alloy, or it may be a substance which will flow under such pressure at an elevated temperature at which the compression will be effected, for example a

metal or alloy which softens at a temperature which conveniently may be in the neighbourhood of the sintering or softening temperature of the powdered material. The core may alternatively be of a plastic or resilient substance, for example rubber or a rubber-like polymerisation product (for example, silicone, rubber, polyvinyl chloride or the like) or a thermoplastic substance.

By means of the invention a core or cores of metal or alloy may be encased in a sheath of compacted powdered metal or heavy metal carbide, oxide, or alloy by compressing the powdered metal or metal carbide or oxide or alloy about the core or cores in an appropriate die at a temperature at which the core or cores soften and the surrounding powder will sinter or cohere.

In carrying the invention into effect according to a preferred method, as applied to forming a protective sheath of beryllium metal on a bar of uranium metal, a demountable die, preferably of a metal of small creep at 800° C., for example Mond nickel-chromium alloy "Nimonic" or nickel-titanium carbide, is used, the die having a cavity which will receive the bar leaving a space between sides and ends of the bar and die walls equal to about twice the desired thickness of the sheath. A quantity of powdered beryllium, which has preferably been ground in the presence of a hydrocarbon oil, is spread uniformly over the face of the lower compression member of the die to a thickness corresponding to the clearance between the uranium bar and the die walls. The uranium bar is centrally placed on the layer of beryllium and further beryllium powder added to fill the spaces between the bar and the die wall and for a layer over the bar of substantially the same depth as the initial layer. The beryllium powder mass is then thoroughly impregnated with a hydrocarbon oil to displace air. The upper compression member of the die is brought into position and the charge subjected to a pressure of substantially 10 tons per square inch while the die and contents are heated to a temperature above the β-γ transition point of uranium, preferably at about 800° C., by electric heating elements associated with the die or by passage of current through the charge and core by way of the die compression members.

At the temperature specified uranium is very soft and under the action of the pressure applied will spread laterally in the die exerting pressure perpendicularly on the powdered beryllium forming the side walls of the sheath, which powdered beryllium will be compacted into an impervious mass about the uranium. The die compression members may be provided with grooves or slots on their faces so as to form ribs, ridges, fins or the like on the sheath. When the compacting action is complete, the die is cooled and taken apart for the removal of the sheathed uranium bar.

A uranium bar sheathed with zirconium may be made in a similar way using zirconium powder in place of beryllium powder.

The atmosphere provided by vaporisation of the hydrocarbon prevents atmospheric attack of the metals.

According to a further form of the invention, powdered metal, for example beryllium, zirconium, molybdenum, tungsten titanium, tantalum, niobium, iron, copper, brass, bronze and light metal alloys is compressed at ordinary temperatures to form shaped bodies having protuberances, threads, corrugations or the like surface effects on the lateral wall (i.e. the wall which extends in the direction of the applied pressure) by employing a split or demountable die having the appropriate surface effects and making use of a plastic or resilient core or cores. Thus a cylindrical body carrying an external thread may be produced by filling powdered metal around a cylindrical core in a split cylindrical die carrying the thread counterpart, the filling being effected as described above.

Compacting pressure is then applied to give a preform, which after removal from the die may be subjected to sintering treatment in the usual way. The core may be formed of resilient or elastic material, such as rubber, or of sodium, lead or other soft metal or soft metal alloy which is melted out prior to sintering.

By employing a plurality of separate core members of a substance capable of transmitting isotropic pressure under the conditions of the compacting operation, compacts having narrow internal channels may be produced by the method of the invention. In that way such shaped bodies as gas turbine blades having internal cooling channels may be produced.

If the substance capable of transmitting isotropic pressure is in the form of a surround it may be employed to compact metal or other powder about a shaped mandrel. The surround in this case may be an annular mass having an internal pattern, shape or form suitable for producing a compact having, for example, high fins or other protuberances.

The accompanying drawings illustrate ways of carrying the invention into effect.

Fig. 1 is a diagrammatic view of apparatus for preparing bodies of the invention.

Fig. 2 is a cylindrical sheathed rod, partly in section.

Fig. 3 is a body having an external screw thread.

Fig. 4 is a cross section of a body having a sheath carrying corrugations.

Fig. 5 is an elevation partly in section of the body shown in Fig. 4.

Referring to Fig. 1, the platens **2** of a press or other member to which pressure or impact may be applied are separated by insulating members **9** from the metal plates **14** carrying the compression members **3** of a demountable die **1**, supported on block **8**. The die **1** may be of "Nimonic" or nickel-titanium carbide. Within the die body is contained beryllium or titanium or other metal powder **7** and a cylindrical core **15**, which may be of soft metal, or where beryllium or titanium are used, may be uranium as described above. The die may be heated by means of the electrical heating element represented by **23**, the ends **24** and **25** of which are connected to a suitable source of current supply.

Where the die walls are of sufficiently low conductivity, heating of the die contents may be effected by passage of current through the die contents, current being passed to and from the compression members **3** by cables **6**. In this case the compression members **3** may be of metal of good electrical conductivity, e.g. copper, and may be tipped with discs of material of lower conductivity, e.g. copper-tungsten alloy, so that the end faces of the compacted powder are not unduly cooled by contact with the compression members.

The die is filled with powder and a suitable core as described above and heat and pressure are applied to compact the powder **7** to form an impervious sheath about the core **15**. Fig. 1 illustrates the apparatus at the conclusion of the compacting treatment, and Fig. 2 shows the sheathed bar after removal from the demountable die. The bar **15** carries a sheath **7***a* of compacted metal powder.

By providing the inner surface of the die members with a thread, a body as shown in Fig. 3 may be produced. The inner space **15***a* was occupied by a sodium, lead, lead-tin or other low melting point alloy core around which was compacted metal powder in an internally threaded demountable die. The core was then removed through an opening bored in the end face and the resulting hollow **17** body sintered in the ordinary way.

To produce the body shown in Figs. 3 and 4 a demountable die having internal corrugations is employed, the core **15** of uranium, for example being provided with a sheath **25** of corrugated surface in the manner described above.

I claim:

1. A method of producing a shaped body constituted by a core of uranium metal completely enveloped in a sheath of compacted beryllium powder, which method comprises the steps of placing the uranium core on a layer of uncompacted powder beryllium, surrounding the core with the powder and covering it with a further layer of uncompacted powder beryllium, applying compacting pressure of approximately 10 tons per square inch to the said layers to compact the whole while heating the whole to a temperature above the β–γ transition point of uranium, whereby the uranium but below the melting point thereof will flow and transmit isotropic pressure to compact the powder beryllium surrounding the core.

2. A method of producing a shaped body constituted by a core of uranium metal completely enveloped in a sheath of compacted zirconium powder, which method comprises the steps of placing the uranium core on a layer of uncompacted zirconium powder, surrounding the core with zirconium powder and covering the core with a further layer of uncompacted zirconium powder, applying compacting pressure of approximately 10 tons per square inch to the said layers to compact the whole while heating the whole to a temperature above the β–γ transition point of uranium but below the melting point thereof, whereby the uranium will flow and transmit isotropic pressure to compact the zirconium powder surrounding the core.

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