# United States Patent [19]

**Onoda et al.**

[11] **3,871,200**

[45] **Mar. 18, 1975**

[54] **METHOD AND APPARATUS FOR PRODUCING SINTERED METAL PRODUCT**


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[73] Assignee: **Sumitomo Electric Industries, Ltd.**, Osaka, Japan



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[30] **Foreign Application Priority Data**

Feb. 6, 1973 Japan ................................ 48-14964

[52] **U.S. Cl.** ........... **72/41,** 29/DIG. 31, 29/DIG. 47, 29/420.5

[51] **Int. Cl.** ........................... **B21c 23/32,** B22f 3/24

[58] **Field of Search** ............. 29/DIG. 18, DIG. 31, DIG. 25, 29/DIG. 47, 420, 420.5; 72/42, 41



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[57] **ABSTRACT**

A method for producing a sintered metal product, which comprises forming a lubricating coating such as zinc stearate on the surface of a billet composed of a sintered metal of low to medium density, maintaining it at a working temperature ranging from room temperature to 750°C., applying a back pressure to the billet and extruding it. A single action press can be used which is equipped with a punch for applying the back pressure. The sintered metal product obtained has uniform high density and is free from surface and inner cracks with its inner pores not enlarged.

**3 Claims, 20 Drawing Figures**

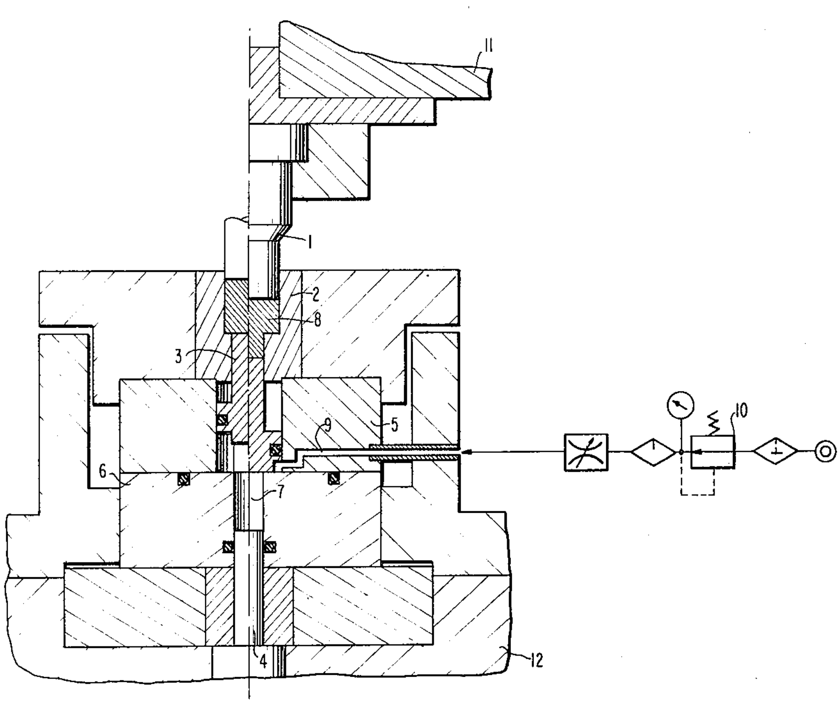
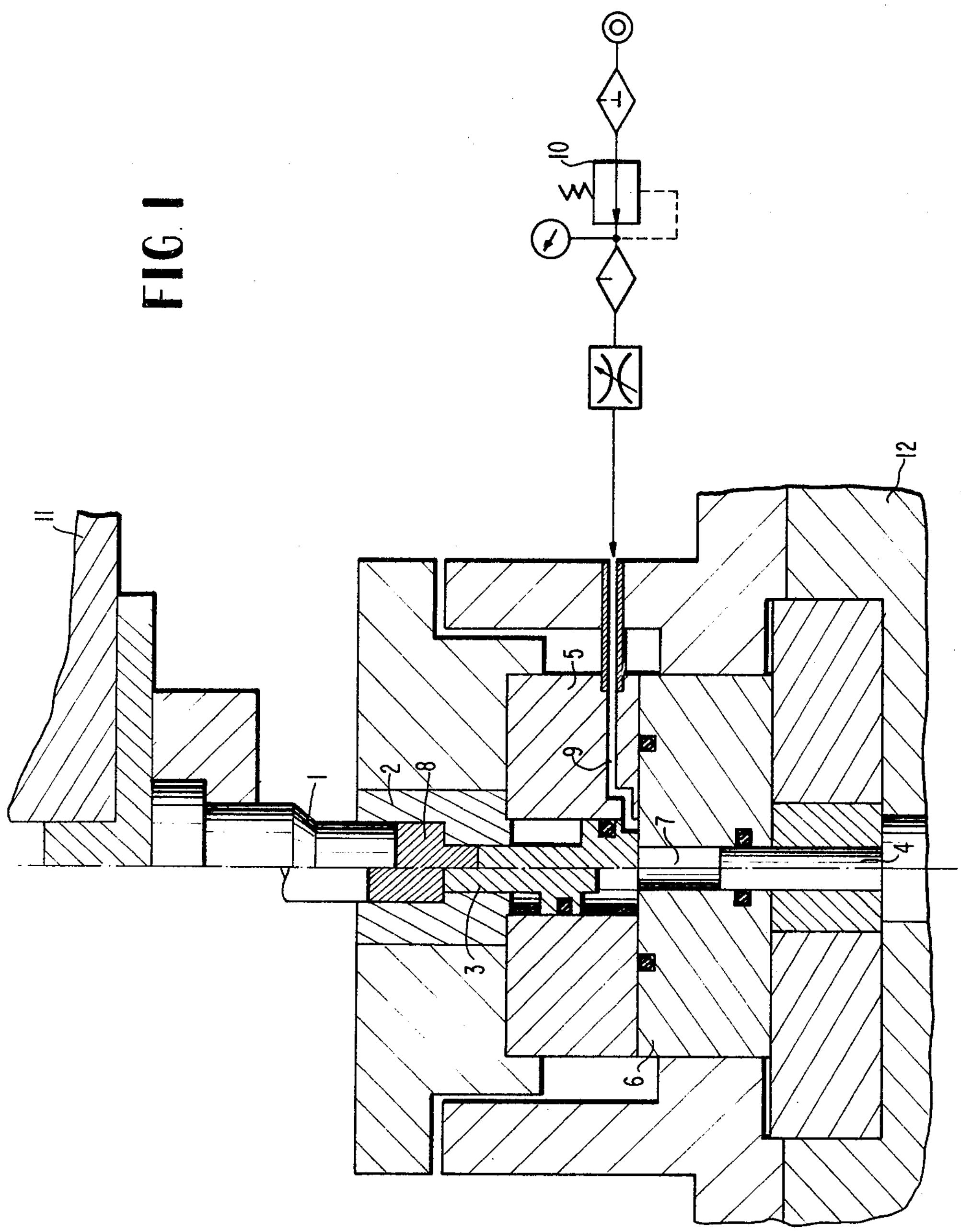



FIG 1



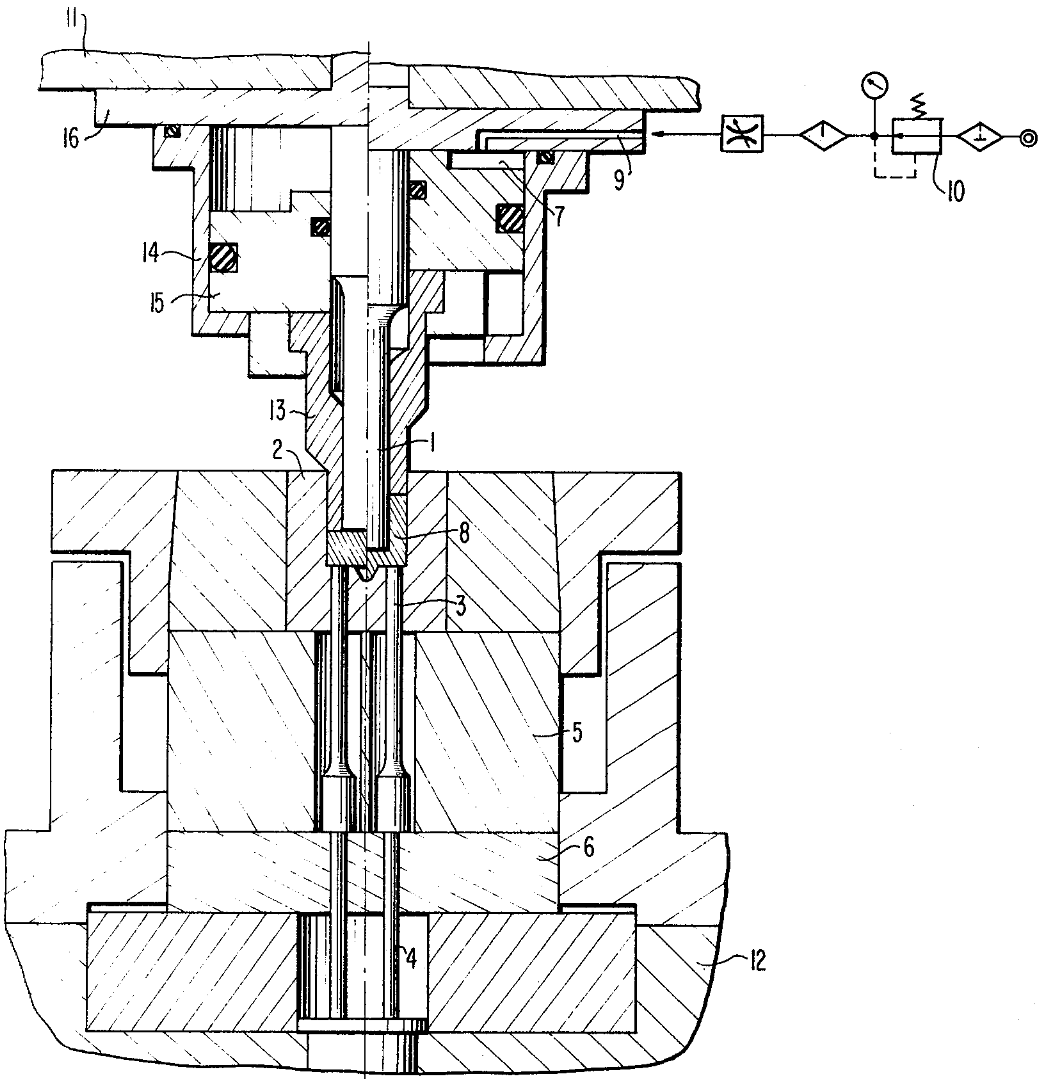



FIG. 2

FIG. 3


FIG. 4

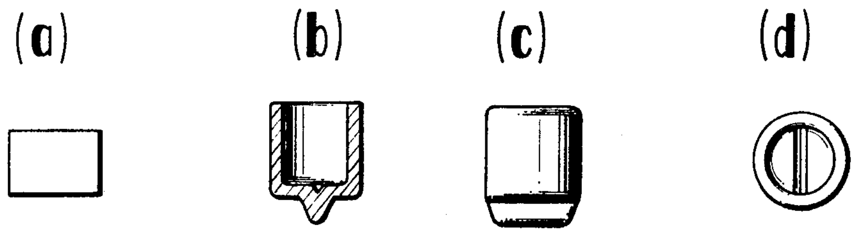



FIG. 5

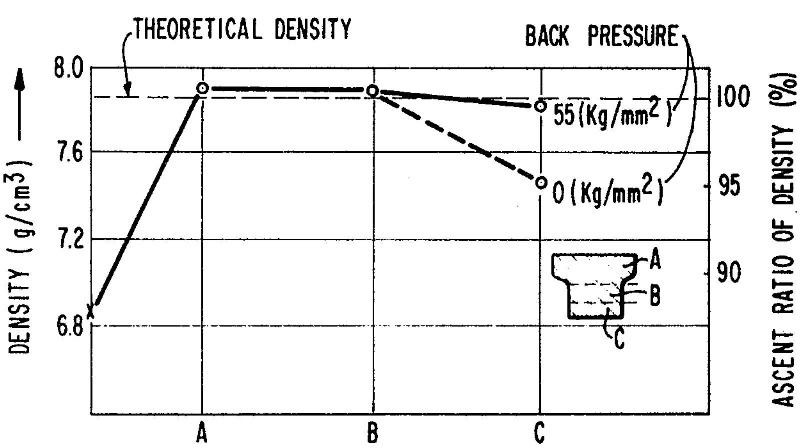
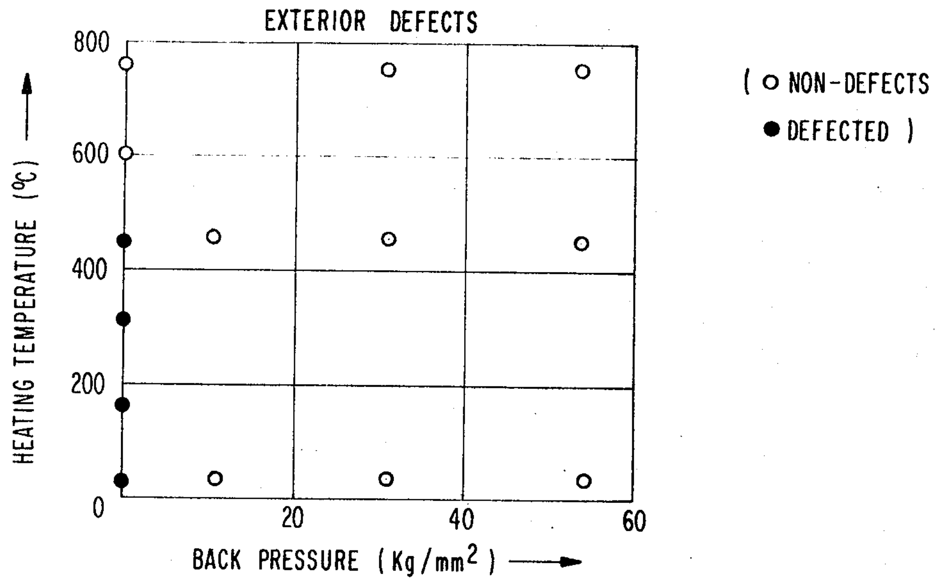


FIG 6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BACK PRESSURE (Kg/mm²)
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40
60
200
400
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( ○ NON-DEFECTS
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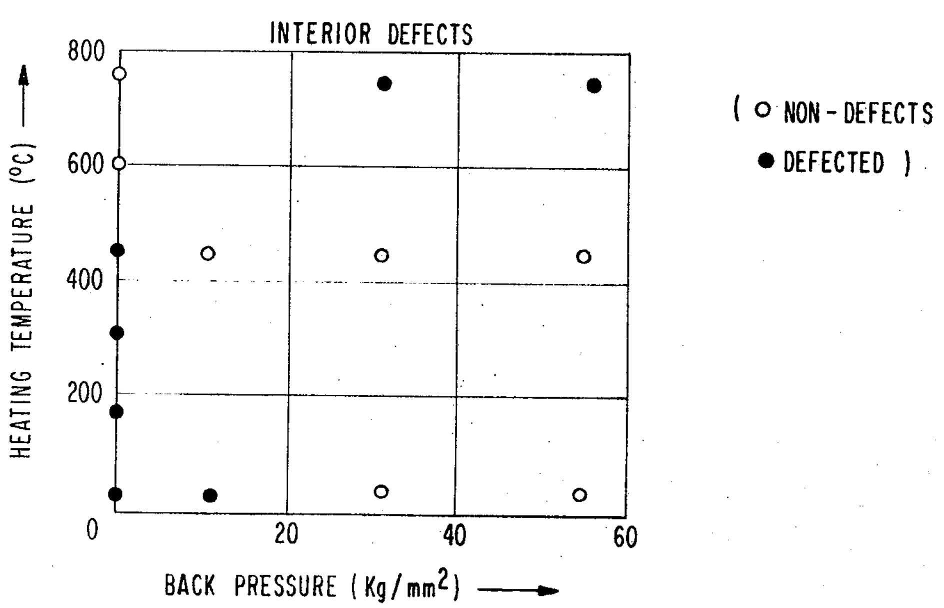
(a)


INTERIOR DEFECTS
HEATING TEMPERATURE (°C)
BACK PRESSURE (Kg/mm²)
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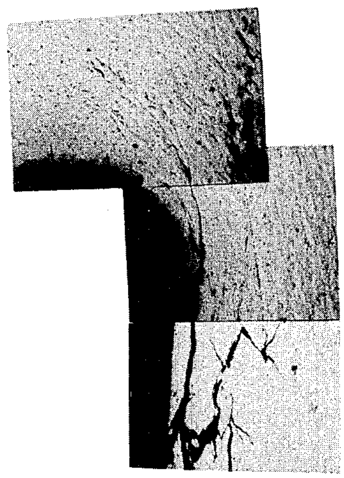
(b)

FIG.7

(1)



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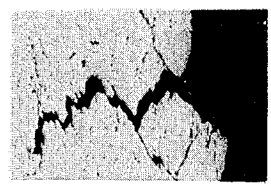

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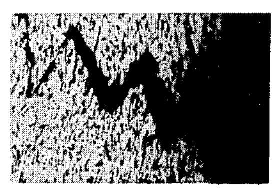

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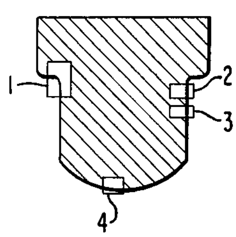


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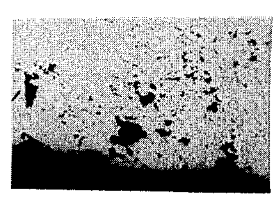
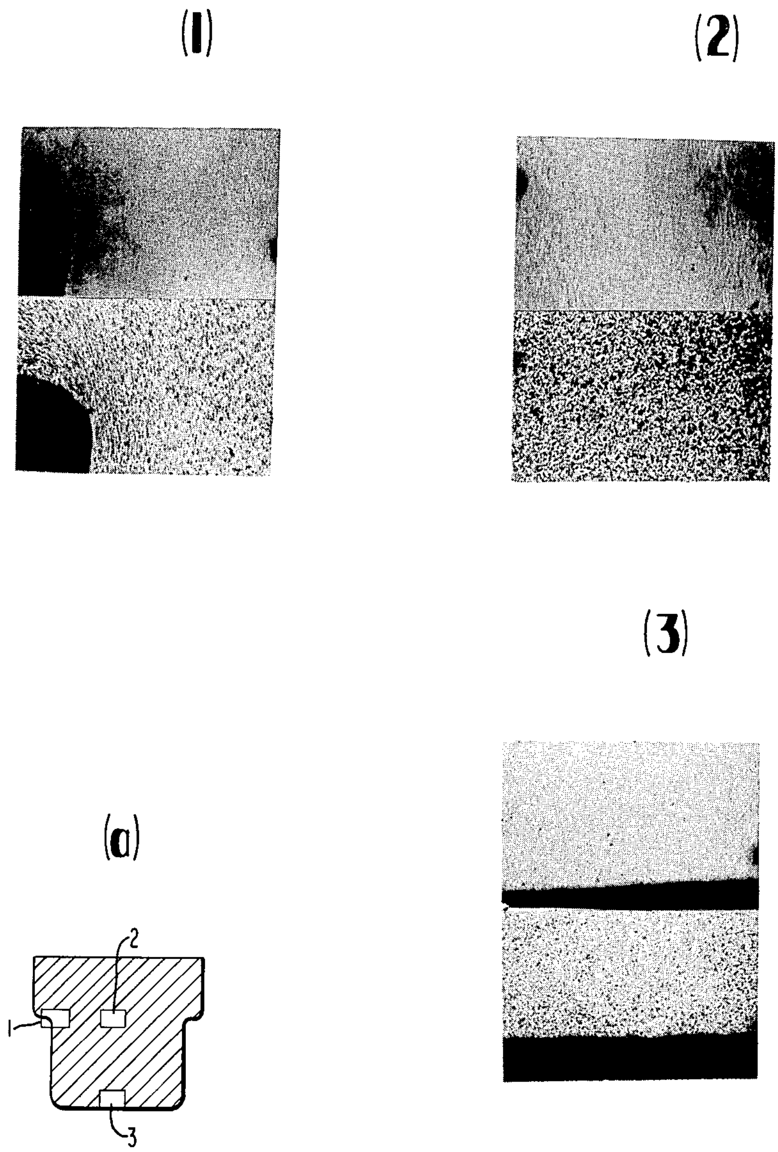


FIG.8



# METHOD AND APPARATUS FOR PRODUCING SINTERED METAL PRODUCT

## BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a method and an apparatus for producing a sintered metal product made of sintered iron, sintered steel or a sintered metal such as a sintered non-ferrous metal, especially a sintered metal product of high density for use as component parts of machines.

2. Description of the Prior Art

Since sintered metals considerably poorer mechanical properties that cast and wrought material, their use as machine parts is often limited to parts of complicated shapes which do not so much require strength. In recent years, parts or components made of sintered metals having high density and strength have been obtained easily, for example by mechanically collapsing the voids or pores present in sintered alloys, or by using an improved sintering technique to reduce the voids.

Generally, machine parts made of sintered metals have a complicated shape, they are in some cases required to be machined into final shapes. Furthermore, there is a limit action because a part having a thin portion becomes non-uniform in density. In order to remove this limit action, it would be effective to apply to sintered metals the extrusion process which is usually employed to work cast and wrought material. However, sintered metals contain an innumerable number of pores therein, and the application of an ordinary extruding technique to such metals results in the formation of cracks in and outside the extruded product, which in turn renders the product almost valueless. Typical methods for working a brittle material which are now in use include a hydrostatic working method for aluminum alloys, magnesium, etc., or a method wherein a back pressure is generated by a dummy block at a temperature as high as 1,100°C. or more.

In an ordinary hydrostatic working method, oils are generally used as a pressure medium and lubricant. However, since the oils penetrate into an innumerable number of pores present in the sintered pre-form billet under high pressures, the extruded product tends to develop cracks easily both in its interior and on its surface, and does not get uniform high density.

## SUMMARY OF THE INVENTION

A feature of this invention is to provide a method which comprises forming a lubricant coating on the surface of a sintered metal of low to medium density as an extruding material (to be referred to as billet), feeding the billet into a die hole called, a container exerting a back pressure thereon, and extruding it using a punch.

Another feature of this invention is to provide a very effective method for providing the lubricant coating.

Still another object of this invention is to provide an apparatus for exerting a back pressure on the billet and working it by extrusion using a punch.

According to the present invention, there is provided a method for producing a sintered metal product, which comprises forming a lubricant coating on the surface of a sintered metal billet of low to medium density, maintaining it at a working temperature ranging from room temperature to 750°C., applying a back pressure to the billet, and extruding it.

According to the present invention, there is also provided an apparatus for producing a sintered metal product, said apparatus comprising a die hole for feeding thereinto a sintered metal billet of low to medium density with its surface coated with a lubricant coating, a first punch for applying an extruding pressure to the billet in the die hole, and a second punch for applying to the portion of the billet which has been deformed by the extruding pressure, a back pressure lower than the extruding pressure in a direction opposite to the direction of said deformation.

The invention will be further described by reference to the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an explanatory view of a back pressure-applying device for use in the first example in accordance with the method of this invention;

FIG. **2** is an explanatory view of a back pressure-applying device for use in the second example in accordance with the method of this invention;

FIG. **3**(a) shows the configuration of a billet in the first example of the invention;

FIG. **3**(b) is a vertical sectional view of a worked product made from the billet of FIG. **3**(a);

FIG. **4**(a) shows the configuration of a billet in the second example of the invention;

FIG. **4**(b) is a vertical sectional view of a worked product made from the billet of FIG. **4**(a);

FIG. **4**(c) is a side elevation of the product of FIG. **4**(b);

FIG. **4**(d) is a top plan of the product of FIG. **4**(b);

FIG. **5** is a graphic representation of the density distribution of a worked product obtained by the method of this invention using a sintered ferrous alloy;

FIG. **6** is a graphic representation showing the state of detects of the sintered material by influences of the back pressure and the working temperature, (a) showing exterior defects and (b) showing interior defects;

FIG. **7**(**1**), (**2**), (**3**) and (**4**) are microscope photographs of a worked product without back pressure (a) at positions **1**, **2**, **3**, and **4**, the product being formed into the configuration showing FIG. **3**(b); and,

FIG. **8**(**1**), (**2**) and (**3**) are microscopic photographs of a worked product (a) obtained in the first example by this invention at position **1**, **2** and **3**.

## DETAIL DESCRIPTION OF THE INVENTION

The critical feature of the present invention is that sintered pre-form is subjected to a back pressure which is minimum 20% of the extruding pressure, using a special back pressure applying device, and extruded at room temperature to 750°C. to form parts or components of complicated configurations which cannot be easily obtained by ordinary sintered techniques. Prior to extrusion, the sintered pre-form must be subjected to a lubricating treatment. If a liquid lubricant is directly coated on the pre-form, the liquid penetrates into the interior of the preform to prevent the collapsing of the pores, and it becomes difficult to increase the density of the resulting product. Moreover, if the lubricating liquid contaminates the walls of the pores, the strength of the product cannot be increased even if its density increases. These defects have been removed by the following lubricating treatment in accordance with the present invention.

The porous sintered metal billet and a powdery solid lubricating material such as, a metallic soap (such as zinc stearate), $MoS_2$ or graphite are placed in a rotary barrel together with elastic beads such as rubber or plastics that do not scar the sintered material, and tumbled together. This tumbling operation result in uniform and intimate adhesion of the solid lubricating material only on the surface of the sintered material without scarring.

The amount of the powdery solid lubricant is sufficiently such that it uniformly covers the surfaces of the sintered material and the elastomer beads. There is no significance in adding it in an amount of more than 40% by volume of the sintered material and the elastomer beads, and moreover, the adhesion becomes nonuniform. On the other hand, amounts below 2% are in sufficient. It is recommended to heat the sintered preform to about 100°C., because this not only results in improvement of the adhesion of the metallic soap, but also makes it possible to adhere an inorganic lubricant such as graphite conjointly.

The amount of the elastic beads is at least equal in volume to the sintered material. Within this range of the amount, there is hardly any scar, and a uniform adhesion can be obtained. If the amount of the elastomer beads is smaller, the material undergoes scars as a result of hitting, and these scars do not disappear even after coining.

Suitably, the tumbling is performed using an ordinary rotary barrel for use in deburring. A period of 3 minutes is sufficient for the tumbling, and there is no significance in continuing the tumbling for too long periods of time.

Another effective procedure for providing the lubricous coating on the surface of the sintered metal comprises spraying a solution in an organic solvent, or a suspension in water, of a solid lubricant such as a metallic soap such as zinc stearate, $MoS_2$, graphite or glass onto the sintered material heated to a temperature above the boiling point of the organic solvent or water, and instantaneously evaporating off only the solvent or water on the surface of the sintered material, thereby to adhere the solid lubricant only to the surface of the sintered material without penetration of the liquid into the interior of the pores.

When the spraying is performed continuously for long periods of time, the temperature of the material falls down by the vaporization of the solvent and the surface of the material becomes wet. In such a situation, the liquid undesirably penetrates into the interior of the pores, and therefore, the spraying should be stopped, and the material reheated. By repetition of this procedure, a coating of the desired thickness can be obtained.

The temperature at which the material is heated may be above the evaporating point of the solvent. However, too high temperatures are undesirable since the solvent is volatilized before the solution spray reaches the sintered material. If the solvent is water, the suitable heating temperature is 150° to 250°C., and if the solvent is methylene chloride, it is 40° to 60°C.

When the above billet is subjected to an ordinary extrusion working, a tension stress acts on its free surface not in contact with tools, resulting in the enlargement of the pores and ready formation of surface cracks. On the surface which is in contact with tools, an innumerable number of cracks occur inside the worked product.



Accordingly, a back pressure is required to be applied to the billet through its extrusion free surface in a direction opposite to the extrusion direction at the same time as the initiation of extrusion. This application of back pressure makes it possible to prevent the enlargement of the pores, and the formation of cracks both on the surface and in the interior of the sintered billet.

The back pressure-applying device for use in the present invention is designed to remove these defects, and a solid pressure medium is used for applying back pressure to the sintered preform billet. This device can easily be mounted on a single-action mechanical press. Examples of this device are illustrated in FIGS. **1** and **2.**

FIG. **1** shows an assembly of an apparatus for working the material by forward extrusion. The left half of the figure shows the state of the apparatus before working, and the right half, the state of the apparatus after working. Referring to FIG. **1,** the apparatus includes a punch **1,** a die **2,** an ejector (lower punch) **3,** a knockout pin **4,** a fitting plate **5,** a knockout pin guide plate **6,** an oil hole **9,** a relief valve **10,** an upper ram **11** of a press, and a table **12** of the press. The reference numeral **8** designates the workpiece. A space **7** surrounded by the fitting plate **5,** knockout pin guide plate **6,** ejector **3** and knockout pin **4** is maintained air-tight by O-rings. The pressed (25 $kg/mm^2$) oil fed from the oil hole **9** provided in the fitting plate **5** causes the ejector to move upwards and the knockout pin to move downwards. When the working operation begins, the workpiece is rapidly extruded to push down the ejector, and an oil pressure is generated in the space **7.** The pressure can be controlled by the relief valve **10.** The total working pressure at this time is 130 $kg/mm^2$.

FIG. **2** shows an assembly of an apparatus for working the material by backward extrusion. Referring to FIG. **2,** a punch for applying a back pressure is shown at **13,** a punch holder at **14,** a fitting plate for applying a back pressure at **15,** and an upper punch fitting plate at **16.** The punch **13** is adapted to slide vertically along an upper punch **1.** A space **7** surrounded by the punch holder **14,** the fitting plate **15,** fitting plate **16** and upper punch **1** is maintained air-tight by O-rings. The pressure of air or oil (5 $kg/cm^2$), fed from an oil or air hole **9** provided in the upper punch fitting plate **16** causes the punch **13** to move downwards. The outside diameter of the fitting plate **15** is so determined as to generate a pressure of 20 $kg/mm^2$ at the end surface of the punch. When the ram comes down and the working operation begins, the extruded workpiece pushes up the punch **13** in the same way as in the first example to generate pressure in the space **7.** The pressure generated can be controlled by a relief valve **10.** The total working pressure at this time is 100 $kg/mm^2$.

Among the various advantages brought about by the method of this invention are:

1. Machine parts or components of uniformly high density can be obtained;
2. It is possible to prevent the formation of defective cracks in the interior and on the surface of the extruded product;
3. Flattening of the extruding free surface can be performed by adding back pressure to said surface; It is, therefore, expected to increase remarkably the dimensional precision;
4. Elimination of machining enable to lessen considerable amount of scrap less;

5. The method is economical since there is no need for using expensive double action presses;
6. Billet of more complicated configurations can be made by powder metallurgy process;
7. By extruding, the mechanical properties of the sintered metal product are improved.

## EXAMPLE 1

Each of four starting powders of Fe, Fe-0.2C, Fe-0.4C and Fe-3Ni-0.3Mo-0.5C was mixed with 0.8% of zinc stearate in a mixer. The mixture was molded into a billet with a size of 25 × 17.5 mm and a density of 6.8 g/cm$^3$, dewaxed for 1 hour at 550°C., and then sintered for 30 minutes in an atmosphere of $H_2$ in a continuous sintering furnace at 1250°C.

A lubricant coating was formed on the resulting billet by tumbling with zinc stearate (when the billet was to be worked at room temperature), or by spraying a suspension of graphite on the heated billet (when the billet was to be worked at elevated temperatures). The billet was then heated for about 20 minutes in a furnace containing a hydrogen gas atmosphere and held at room temperature to 750°C., and transported therefrom to a die hole called a container. It was fabricated into a forged product of the desired shape by a forging press equipped with a back pressure applying device.

When the billet was heated to room temperature to 750°C. and forged into the shape (b) in FIG. 3 by the conventional method without applying a back pressure, shear rupture of the fir-like shape was formed on the extrusion side of the product as shown by the microscopic photographs in FIG. 7.

On the other hand, when a back pressure was applied in accordance with the method of this invention in a direction opposite to the extruding direction, the enlargement and destruction of the pores could be prevented as shown in the microscopic photographs in FIG. 8, and the product had uniform high density as shown by the density distribution in FIG. 5. Furthermore, FIG. 6 shows that the properties of the sintered material in its interior and on its surface were very good as a result of applying back pressure at a heating temperature of 450°C., and this substantiates the superiority of the method of this invention.

## EXAMPLE 2

Copper powders obtained by electrolysis were compacted to a density of 7.9 g/cm$^3$, and sintered in an atmosphere of $H_2$ at 790°C. for 1 hour to form billet (20 $\phi$ × 15). A coating of zinc stearate was formed on the surface of the billet by the tumbling method described above, and the billet was subjected to extrusion working at room temperature using an apparatus of the type shown in FIG. 2.

When the billet was extruded by the conventional method, tensile stress acted on the surface and in the interior of the extruded product and on the free surface not in contact with the tools, and because an innumerable number of pores were present inside the sintered alloy, the enlargement of the pores and the formation of surface cracks, and defective cracks occurred at the surface of the product contacting with the tool when the velocity of extrusion was not uniform under the state of deformative stress.

On the other hand, when the extrusion was performed by applying a back pressure (20% of the extruding pressure) in accordance with the method of this invention, the formation of surface cracks, the enlargement of the pores, and the occurrence of internal cracks can be prevented, and a product of good quality could be obtained. This substantiates the superiority of the method of this invention.

What is claimed is:

1. In a method for producing a sintered metal product, including the steps of:
   - lubricant cooling the surface of a sintered metal preform billet of low to medium density, and
   - extruding said billet under pressure through a die in one direction while maintaining it at a temperature ranging from room temperature to 750°C.,
   
   the improvement comprising:
   - the step of simultaneously applying a back pressure to said billet during extrusion in a direction opposite to that of extrusion with said back pressure being at least twenty per cent of extrusion pressure;
   - whereby, the sintered metal product thus obtained has a higher, more uniform density and is free from surface and inner crack with its inner pores not enlarged.

2. The method of claim 1 wherein said lubricant coating is formed by tumbling the billet in a mixture of a powdery solid lubricant and elastic beads which do not scar the sintered metal.

3. The method of claim 2 wherein said lubricant coating is formed by spraying a mixture of a liquid solvent and a solid lubricant which remains after evaporation of the solvent to the billet heated to a temperature above the evaporation temperature of the solvent.

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