United States Patent

Haller

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[54] **METHOD OF PRODUCING ELONGATED HIGHLY DENSIFIED POWDERED METAL ARTICLES**

[72] Inventor: **John Haller,** Northville, Mich.

[73] Assignee: **Federal-Mogul Corporation,** Southfield, Mich.

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[52] **U.S. Cl.** **29/420,** 29/423, 75/214

[51] **Int. Cl.** **B22f**

[58] **Field of Search** 29/420, 420.5, 423; 75/214

[56] **References Cited**

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Primary Examiner—John F. Campbell
Assistant Examiner—D. C. Reiley
Attorney—Barthel & Bugbee

[57] **ABSTRACT**

An elongated air-tight can with rounded top, bottom and ends and a filling stem is prepared from heat-resistant material, filled with the powdered metal to be compacted, exhausted to a high vacuum, and the stem sealed while maintaining the vacuum. The powder-filled evacuated can is then heated to a high temperature of approximately 2,100° F. for about 1 hour, then compressed in the die cavity of a press having a recess in one of its plungers for the stem, and with at least one of its plungers having an end of reduced diameter to provide a clearance space into which the peripheral portion of the can flows as compression proceeds. When the density reaches 100 percent, the peripheral portion of the can and the surplus metal powder therein continue to move axially into the clearance space around the plunger or plungers, producing an axially projecting lip extending around the periphery of the can and containing metal powder at a somewhat lower density than in the remainder of the can. The walls of the can are then removed by machining or pickling, together with the less dense peripheral portion of the now substantially solidified elongated metal billet thus produced.

10 Claims, 5 Drawing Figures

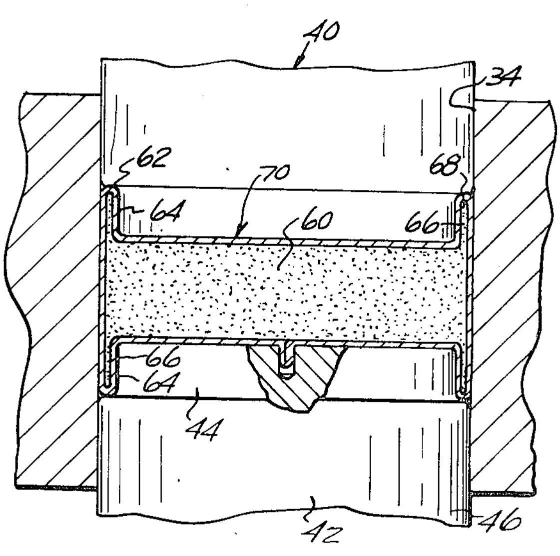


FIG. 1

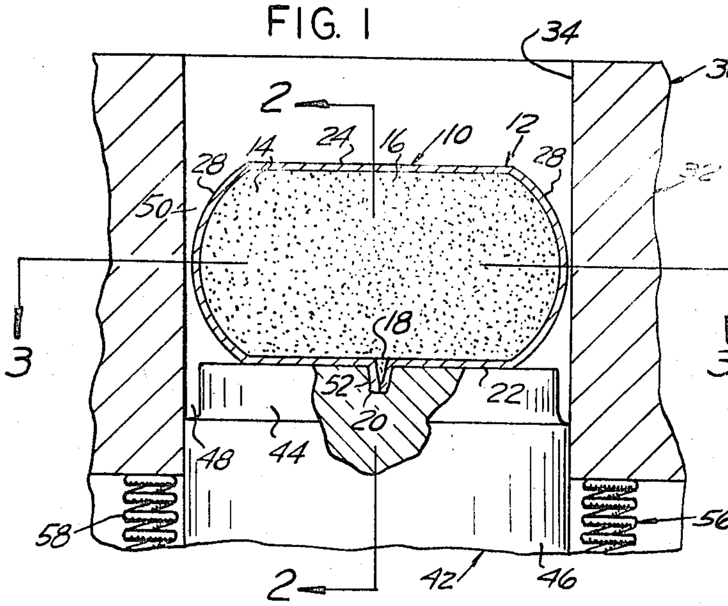


FIG. 5

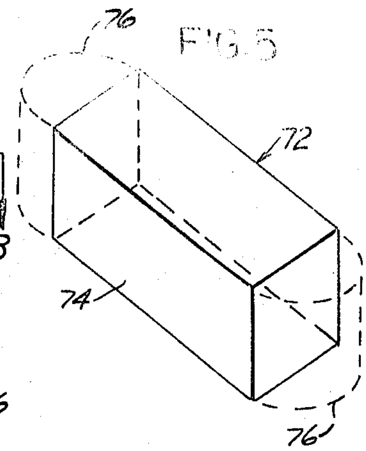


FIG. 2

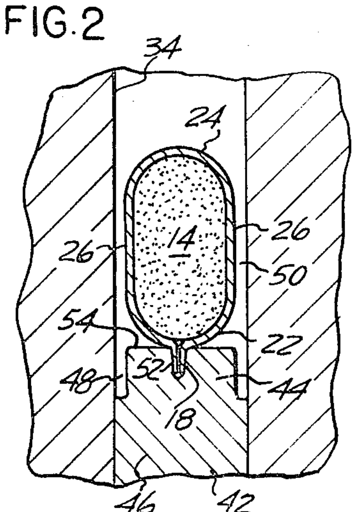
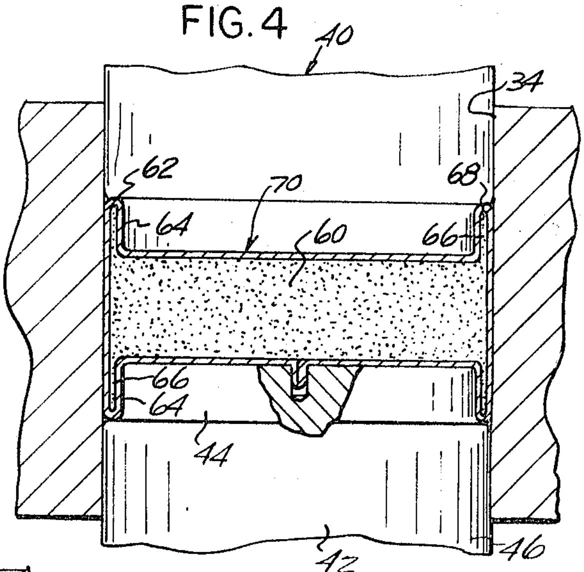


FIG. 4



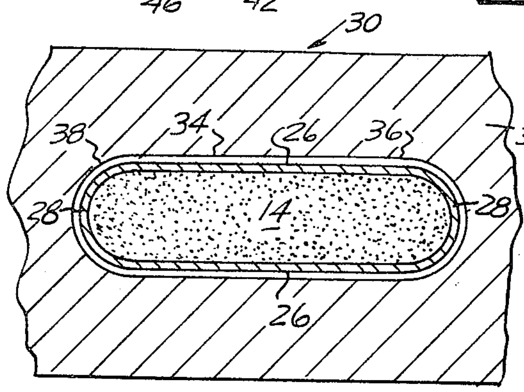


FIG. 3

INVENTOR
JOHN HALLER

BY Barthel & Bugbee
ATTORNEYS

METHOD OF PRODUCING ELONGATED HIGHLY DENSIFIED POWDERED METAL ARTICLES

BACKGROUND OF THE INVENTION

In my co-pending application, Ser. No. 779,151 filed Nov. 26, 1968 there is disclosed a "method of highly densifying powdered metal" wherein the metal powder is inserted into a cylindrical can which is then evacuated and compressed to densify the contents to approximately 100 percent density. In order to prevent the can from buckling or crinkling, as had hitherto occurred during compression, the peripheral portion of the container and its contents are permitted to flow or deform axially during compression into a clearance space around one or both of the press plungers, This, as well as in the present method, is especially valuable for producing blanks from so-called super-alloy powders composed primarily of cobalt or nickel for corrosion-resistant and minimum deformation with retained tensile strengths at higher temperatures than are possessed by ordinary alloys. Such super-alloys, prior to the method set forth in my above-identified co-pending application, have been available solely in cast form lacking uniformity of metallurgical characteristics and containing impurities in amounts excessive for aerospace use. My previous method mentioned above produces disc-shaped or pancake-shaped billets or bodies which, while possessing better and more uniform metallurgical characteristics substantially free from impurities, are of inconvenient shapes for producing elongated workpieces without a considerable waste of such metal. The method of the present invention enables the production of elongated billets which facilitate the production of elongated workpieces without serious waste of such metal.

In the drawings,

FIG. 1 is a vertical section through an elongated powder-filled, evacuated and sealed container in the die cavity of a press, ready for compression;

FIG. 2 is a vertical cross-section taken along the line 2—2 in FIG. 1;

FIG. 3 is a horizontal cross-section taken along the line 3—3 in FIG. 1;

FIG. 4 is a vertical section similar to FIG. 1, but after the powder-filled evacuated can has been compressed; and

FIG. 5 is a perspective view of the densified metal billet produced by this method.

Referring to the drawing in detail, FIG. 1 shows a powder-filled evacuated sealed container assembly, generally designated **10**, as consisting of an elongated metal container **12** which has been filled with a charge **14** of metal powder which is to be compacted to an extremely high density approaching or equallying solidity or 100 percent density. The powder charge **14** has previously been inserted in the interior chamber **16** through a tubular filling and evacuating stem **18**, the tip **20** of which has then been pinched and sealed as by welding, in order to maintain the high vacuum in the chamber **16**. The container **12** is of heat-resisting material, preferably of ordinary steel or stainless steel and has approximately cylindrical upper and lower walls **22** and **24** respectively, shown inverted in the drawing from the upright position occupied during filling and evacuating thereof. The container **12** has flat parallel opposite side walls **26** (FIGS. **2** and **3**) and toroidal opposite end walls **28** (FIGS. **1** and **3**).

The die set, generally designated **30**, within which the container assembly **10** is to be compressed, consists of a die **32** containing a die cavity **34** of elongated cross-section (FIG. **3**) having flat parallel opposite side surfaces **36** joined to one another by substantially cylindrical end surfaces **38**. Entering into the upper and lower ends of the die cavity or die bore **34** are an upper punch **40** and a lower punch **42** having corresponding cross-sections. The punches **40** and **42** are of similar configuration and each has a nose portion **44** of reduced size but of similar cross-section to the shank **46** of each plunger **40** and **42** so as to leave a clearance space **48** extending around the nose portion **44** between it and the die bore **34**. From FIG. **1** it will be seen that the die bore **34** is slightly larger in cross-section than the cross-sectional size of the can **12** so as to also leave a clearance space **50** therebetween. The lower punch **42** has a socket **52** extending downward from the top surface **54** of the nose portion **44** thereof (FIGS. **1** and **2**) for receiving the sealed filling stem **18**.

The die **32** is preferably yieldingly supported on the bed or bolster (not shown) of a conventional hydraulic or mechanical press (also not shown) as by a conventional die cushion **56** consisting either of compression springs **58** or of a conventional hydraulic die cushion (not shown). Such die cushions are well known in the press art and their details are beyond the scope of the present invention. The lower punch **42** is preferably connected to a lower press plunger (not shown) which is stationary during pressing but which is movable in order to eject the finished workpiece, as is well known in the press art. The upper punch **40** is preferably connected to the vertically movable platen (not shown) of the conventional press mentioned above.

In carrying out the method, the container **12** is first prepared in the shape shown in FIGS. **1**, **2** and **3** as described above, and is then completely filled with the charge **14** of powdered metal, which may be of the super-alloy type containing cobalt or nickel for retaining high tensile strength at a high temperature as well as for resisting deformation and corrosion. Filling is accomplished with the container **12** in an upright position with the filling and evacuating stem **18** uppermost. After the chamber **16** has been completely filled with powdered metal through the stem **18**, the latter is connected to a high vacuum pump (not shown), and the chamber **16** evacuated as completely as is commercially possible in order to prevent subsequent oxidation of the particles of metal powder in the charge **14** thereof at the high temperature to which the latter is subjected. While the chamber **16** is still being maintained in a highly evacuated state, the stem **18** is sealed off, as by pinching and welding, so as to produce the sealed pinched air-tight tip **20**.

The evacuated sealed container filled with the metal powder charge **14** is then placed in a suitable furnace and heated at a temperature of approximately 2,100° F. for approximately 1 hour and then inverted and immediately transferred to the die cavity **34** with the stem **18** projecting downward into the recess **52**. The parts are now in the positions shown in FIGS. **1** to **3** inclusive.

The upper punch **40** is now caused to descend into the die cavity **34**, while the lower punch **42** is held stationary, thereby compressing the powder-filled evacuated sealed container assembly **10** (FIG. **4**). As this hot pressing operation proceeds, the container **12** is deformed into the shape shown in FIG. **4**, and densification of the powdered metal charge **14** progressively increases as the powdered metal particles are forced into closer and closer engagement until fusion thereof occurs as a result of the combined action of the initial high temperature and the added heat resulting from the energy produced by the compressive force being exerted.

As the density of the powdered metal charge **14** increases until it exceeds 90 percent, the charge **14** becomes denser at its central portion than at its periphery where the clearances **48** occur in the lower and upper punches **42** and **40**. As a result, when the density of the charge **14** approaches 100 percent to form a completely solid central portion **60** (FIG. **4**) it can be compressed no further. Consequently, the peripheral portion **62** of the container **12** deforms as it moves into the clearance spaces **48** around the reduced size nose portion **44** of the upper and lower punches **40** so as to form a pair of oppositely extending lips or hollow flanges **64** while the excess powdered metal **66** is extruded into the channel **68** in each lip and is of lower density than the remaining portion **60** of the now substantially solidified charge of powdered metal resulting from the compression of the original charge **14**.

The operation of the press (not shown is now reversed to raise its platen (not shown) and the upper punch **40** out of the die cavity **34**, whereupon the lower punch **42** is caused to move upward to the top of the die cavity **34**, thereby ejecting the now compressed solidified metal-filled container assembly, generally designated **70**, from the die cavity **34**. The container **12** is now separated and removed from the solidified metal charge **60** by machining, pickling of other suitable means, also removing the less dense opposite end portions and peripheral portions **66** within the lips **64**. The result is an elongated billet **72** having a rectangular mid-portion **74** from which the rounded opposite ends **76** have been cut off (FIG. **5**) but otherwise corresponding in cross-section to the cross-section **5** of the die cavity **34** (FIG. **3**).

If the container **10** has been made of ordinary steel, the sheet metal forming its walls can be peeled off the solidified or compacted metal billet **72** after the compacting procedure has been carried out, thereby effecting removal thereof more rapidly in a simpler and less expensive manner than by machining it off or removing it by pickling. The temperature of 2,100° F. and the time of 1 hour will vary with the size of the billet to be produced. The range of temperatures from 2,000° to 2,200° F. has been found satisfactory for the range of sizes ordinarily produced whereas the stated period of one hour is necessarily increased as the size and weight of the billet **72** to be produced are also increased.

I claim:

1. A method of making a substantially solid elongated body from powdered metal, comprising

encasing the powdered metal in an elongated metal container having rounded opposite ends,

evacuating said container with the powdered metal therein,

heating the evacuated powder-filled container to a temperature sufficient to facilitate subsequent deformation of said container and effect coalescence of the powdered metal particles,

applying compressive force to the thus-heated powder-filled container transverse to the longitudinal axis thereof sufficient to deform the same transversely and to compact the powdered metal therein into an elongated substantially solid body,

restraining the powder-filled container from expanding longitudinally during the application of the transverse compressive force while permitting a peripheral portion of the powder-filled container to deform transversely thereto,

terminating the application of said compressive force,

and removing the thus-deformed container and the peripherally deformed portion of the now solidified powdered metal from said body.

2. A method, according to claim **1**, wherein the longitudinal deformation is produced transversely to the direction of application of the compressive force.

3. A method, according to claim **1**, wherein the peripheral portions of the container and its contents are permitted to deform transversely thereto in opposite directions on opposite sides thereof.

4. A method, according to claim **1**, wherein the container has an elongated longitudinal wall which has a rounded portion therealong on at least one side thereof.

5. A method, according to claim **1**, wherein the container has an elongated longitudinal wall which has rounded portions therealong on opposite sides thereof.

6. A method, according to claim **5**, wherein the container has substantially flat longitudinal wall portions disposed on opposite sides thereof and interconnecting the rounded portions thereof.

7. A method, according to claim **5** wherein the rounded portions are of approximately cylindrical configuration.

8. A method, according to claim **1**, wherein the container is confined in a cavity having restraining side walls and having end walls closing said cavity and having clearance spaces between said side walls and end walls adapted to receive the deformed portions of said container during deformation thereof, at least one of said end walls being movable for applying said compressive force.

9. A method, according to claim **1**, wherein said rounded opposite ends are of substantially toroidal configuration.

10. A method, according to claim **1**, wherein the container is permitted to undergo a predetermined limited deformation longitudinally before being restrained from further longitudinal deformation.

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