United States Patent

Umehara et al.

[15] **3,706,550**

[45] **Dec. 19, 1972**

[54] **METHOD FOR PRODUCING A METAL DIE OR MOLD**

[72] Inventors: **Hanji Umehara; Takashi Kimura; Hiroshi Hamamoto,** all of Nagoya, Japan

[73] Assignee: **Kabushiki Kaisha Toyoto Chuo Ken-kyusha,** Nagoya-shi, Aichi-ken, Japan

[22] Filed: **Sept. 15, 1970**

[21] Appl. No.: **72,380**

[30] **Foreign Application Priority Data**

Sept. 22, 1969 Japan 44/75691

[52] **U.S. Cl.** **75/200,** 29/182.1

[51] **Int. Cl.** **B22f 3/26**

[58] **Field of Search** .249/135, 134; 164/138; 75/200, 75/208; 29/182.1

[56] **References Cited**

UNITED STATES PATENTS

1,853,385	4/1932	Spade	264/220
2,275,420	3/1942	Clark et al.	75/200
2,363,337	11/1944	Kelly	29/182.1
2,753,261	7/1956	Goetzel et al.	29/182.1

FOREIGN PATENTS OR APPLICATIONS

984,881	7/1951	France

Primary Examiner—Carl D. Quarforth
Assistant Examiner—B. Hunt
Attorney—Berman, Davidson & Berman

[57] **ABSTRACT**

A method for producing a metal die or mold including the steps of placing a layer of sintering powder, such as iron, copper, tungsten carbide or titanium carbide, in a frame or box, placing in contact with the sintering powder a pattern made of an infiltrant metal, such as copper, lead, cobalt, nickel, iron or alloys thereof, having a lower melting point than that of the sintering powder, the pattern corresponding in configuration to that of the cavity surface of the desired die, heating the powder together with the pattern in the frame to sintering temperature, whereby to sinter the powder and infiltrate the infiltrant metal forming the pattern into the powder, and cooling so as to obtain a hardened sintered mold having a surface whose configuration complements that of the pattern surface.

23 Claims, 10 Drawing Figures

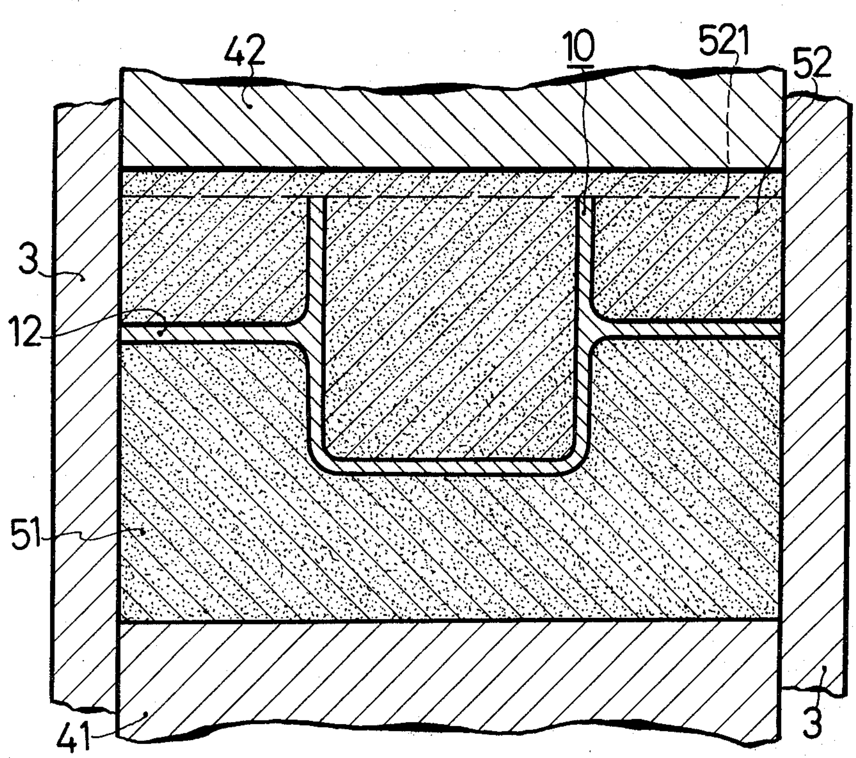


FIG.1.

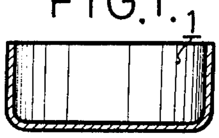


FIG.2.

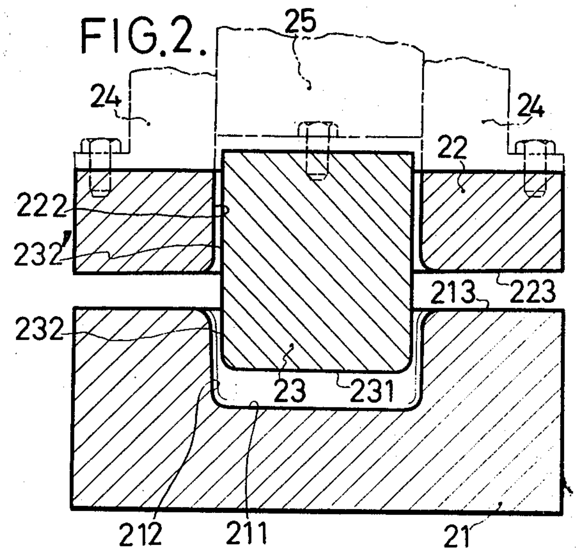


FIG.3.

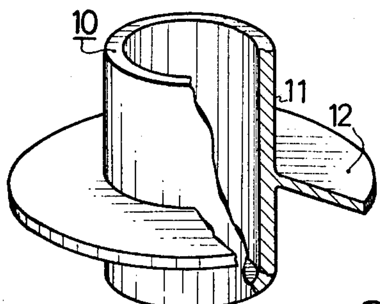


FIG.4.

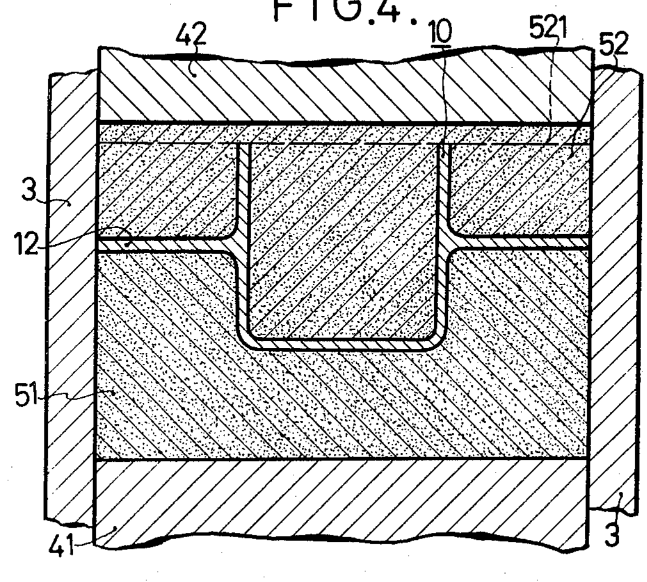
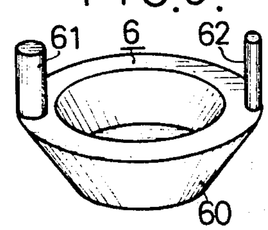


FIG.6.



INVENTORS
HANJI UMEHARA,
TAKASHI KIMURA,
HIROSHI HAMAMOTO,

BY
Berman, Davidson & Berman,
ATTORNEYS

FIG.5.

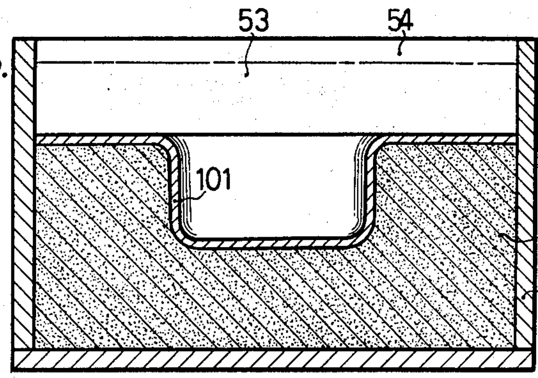


FIG.7.

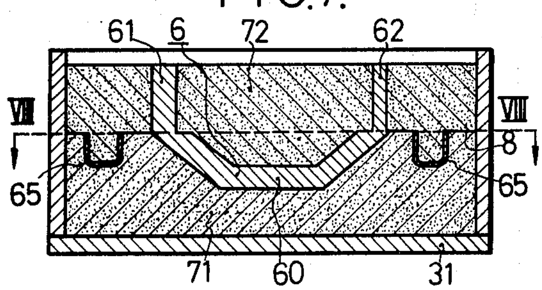


FIG.8.

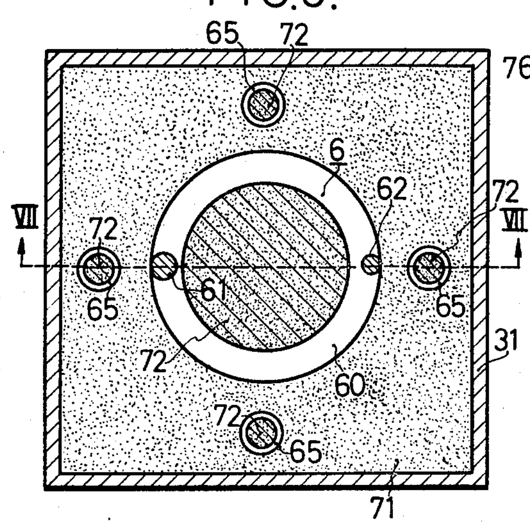


FIG.9.

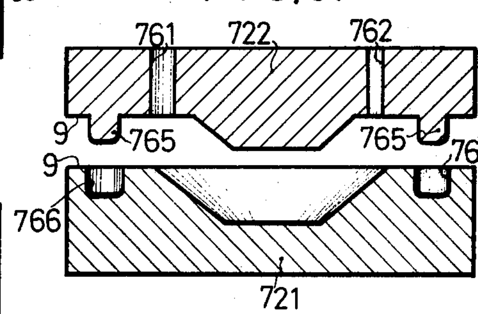
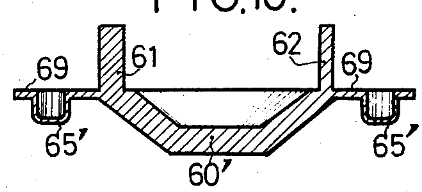


FIG.10.



INVENTORS.

HANJI UMEHARA,
TAKASHI KIMURA,
HIROSHI HAMAMOTO,

BY

Berman, Davidson & Berman,

ATTORNEYS.

METHOD FOR PRODUCING A METAL DIE OR MOLD

BACKGROUND OF THE INVENTION

This invention relates to a process for the manufacture of a metal die or mold of metal powder sintered and cooled to form a die in its broadest sense, such as a casting mold, a pressing die, or a die-cast mold.

DESCRIPTION OF THE PRIOR ART

Hitherto, the manufacture of metal dies and molds has been carried out by engraving, in which steel is machined into a desired mold shape and size by a machine tool; by precision casting, using a lost wax method mold, shell mold, or the like; or by special processing in which the mold material is treated by chemical etching or electrical spark discharge to attain a desired shape.

These known processes require, however, complex manufacturing steps, highly skilled workmen and a great deal of time, and, accordingly, are very expensive.

SUMMARY OF THE INVENTION

The present invention provides for the manufacture of a metal die or mold by a sintering process which obviates the disadvantages of the conventional methods briefly outlined above, and which can be performed at low cost, the process being simpler, requiring no finishing machining, and very little skill or training on the part of the workmen.

The improved method comprises the steps of placing in an outer frame a sintering powder such as iron, copper, tungsten carbide, titanium carbide or mixtures thereof, placing in contact with the sintering powder, a pattern made of an infiltrant metal such as copper, lead, cobalt, nickle, iron, or alloys thereof, having a lower melting point than that of the sintering powder, the pattern corresponding in configuration to that of the cavity surface of a desired die, placing the frame together with the pattern and the sintering powder in a sintering furnace, and heating the same to sintering temperature. During the sintering operation the infiltrant metal pattern melts and infiltrates entirely into the sintered metal powder. Upon cooling, the resultant produce is a hardened sintered mold or die having a cavity having a shape and size corresponding to the surface of the pattern at the portion where the pattern was disposed. In the finished product, the infiltrated metal also serves to strengthen and reinforce the bonding of the sintered material so as to provide a die or mold having a greater strength than if the product was formed of the sintered material alone. If desired, the sintering material may be compressed, either before or during the sintering, so as to increase the density of the sintered die product, Furthermore, a heat-resistant parting agent may be coated on the surface of the charged sintering powder except at the portions covered by the pattern, and additional sintering powder may be placed thereover, so that the resulting product after sintering is a split metal mold consisting of an upper portion and a lower portion having a molding surface therebetween corresponding to the surface of the pattern.

It will be apparent from the above, that a primary object of the present invention is to provide a method for producing a metal die or mold such as a casting mold or a pressing die, by sintering a metal powder material.

Another object of the invention is to provide a method for producing a metal die or mold without machining.

Still another object of the invention is to provide a method for producing a metal die or mold having precise dimensions.

A further object of the invention is to provide a method for producing a die or mold having high strength.

A still further object of the invention is to provide a method for producing a metal die or mold which is easy to follow, inexpensive, provides consistent results, and is commercially practicable.

BRIEF DESCRIPTION OF THE DRAWINGS

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims.

The invention itself, however, both as to its organization and its operation, together with additional objects and advantages thereof, will best be understood from the following descriptions of specific embodiments when read in connection with the accompanying drawings, wherein like reference characters indicate like parts throughout the several figures, and in which:

FIGS. **1** to **4** illustrate a first embodiment of the invention;

FIG. **1** is a cross-sectional view of a container formed by a pressing die;

FIG. **2** is a cross-sectional view of a pressing metal die for forming the container of FIG. **1**;

FIG. **3** is a fragmentary perspective view of a pattern used in producing the pressing die of FIG. **2**;

FIG. **4** is a cross-sectional view of the embodiment consisting of a compressed metal powder with the pattern of FIG. **3** arranged therein;

FIG. **5** is a cross-sectional view of the second embodiment of the invention consisting of the compressed metal powder with a pattern arranged thereon;

FIGS. **6** to **9** illustrate a third embodiment of the invention;

FIG. **6** is a perspective view of a pattern used in making a casting mold;

FIG. **7** is a cross-sectional view of an embodiment for making a casting mold comprising compressed metal powder with the pattern of FIG. **6** arranged therein;

FIG. **8** is a transverse section taken along the line VIII–VIII of FIG. **7**;

FIG. **9** is a cross-sectional view of the casting mold resulting from the process of this embodiment; and

FIG. **10** is a cross-sectional view of another pattern which may be used in the process illustrated in the third embodiment.

DESCRIPTION OF PREFERRED EMBODIMENTS

The first embodiment of the invention is illustrated in FIGS. **1** to **4**. This embodiment concerns the manufacture of a pressing die of sintered iron powder having a lower die **21**, a blank holder **22**, and a punch **23**, as shown in FIG. **2**. This type of die can be used for making a container such as the U-shaped container **1** as shown in FIG. **1**. In manufacturing this type of die, a pattern **10** made of copper, as shown in FIG. **3**, is employed. The pattern 10 comprises a cylinder 11 with a closed bottom and a flanged portion 12 provided in the middle of the cylinder. The flanged portion 12 has a configuration larger than a sheet material used for press-forming the container 1, and the cylinder 11 has the same diameter and thickness as those of the container 1.

The method of manufacturing the pressing die of FIG. 2 is illustrated in FIG. 4. A lower filler layer 51 of iron powder is first placed on a compression punch 41 in the cylindrical molding frame 3. The pattern 10 is then placed on top of the lower filler layer 51 in intimate contact therewith. An upper filler layer 52 of iron powder is then placed on top of the pattern 10 so as to fill the space interior of the cylinder 11 and also the space exterior of the cylinder 11 above the flanged portion 12. The iron powder is then compressed and molded under a pressure of 2-tons per square centimeter between the compression punches 41 and 42. The upper filler layer 52 preferably extends for a short distance above the top of the cylinder 11 so as to prevent curvature or deformation of the cylindrical part which would be caused by the compression of the punch 42 directly applied to the cylindrical part. The compressed iron powder compact containing the pattern 10 is then sintered in an atmosphere of nitrogen for 60 minutes at 1120° C in a sintering furnace.

Since the melting point of copper is 1083° C and thus below the temperature used for sintering, the copper pattern melts during the sintering operation. The molten copper infiltrates into the spaces in the sintered iron powder by a capillary action, thereby strengthening the bonding of the iron powder so that the finished product has a greater strength than a sintered product from iron powder alone. The infiltration of the molten copper into the sintered iron powder also leaves a cavity in the sintered material corresponding in dimensions and shape to the pattern 10 at the portion where the pattern 10 has been located. Following the sintering operation, the sintered product is then cooled.

The thus obtained sintered product is in the form of the pressing die as shown in FIG. 2, having a lower die 21 corresponding to the lower filler layer 51 of iron powder, and a blank holder 22 and punch 23 corresponding to the upper filler layer 52 of iron powder. The lower die 21 has surfaces 211 and 212 formed from the outer contour of the lower part of the cylinder 11 below the flange portion 12, and also an upper surface 213 formed from the lower surface of the flange portion 12. The blank holder 22, which is in the form of a thick-walled cylinder, has an inner peripheral surface 222 formed from the outer contour of the upper portion of the cylinder 11 above the flange portion 12, and a lower surface 223 formed from the upper surface of the flanged portion 12. The punch 23 has lower surfaces 231 and 232 formed from the inner contour of the lower part of cylinder 11 below the flange portion 12 and a lateral peripheral surface 232′ formed from the inner contour of the upper part of the cylinder 11 above the flanged portion 12.

In making the finished pressing die as shown in FIG. 2, the portion of the upper filler layer 52 above the space formed by the pattern 10 is preferably cut away long the dotted line as shown in FIG. 4, and the upper ends of the blank holder 22 and punch 23 are respectively connected to pressing means 24 and 25. The thus obtained pressing die is useful for making an article such as the U-shaped container 1 as shown in FIG. 1.

As illustrated in FIG. 4, the peripheral edge of the flange portion 12 of the pattern is closely fitted to the cylindrical molding frame 3. It is also possible, however, to form the inner part of the molding frame 3 wider in section than the area of the flanged portion 12. In this case the lower filler layer 51 is filled up to the surface of the flange portion 12 of the pattern with the iron powder, and the lower filler layer 51 outside the flange portion 12 is coated on the surface with an alumina powder parting agent. Thereafter, the upper filler layer 52 can be filled with the iron powder. After sintering, the portions outside the flanged portion 12 of the pattern are removed or mechanically machined in a shape so as to avoid disturbance against the pressed work.

The second embodiment of the invention, as shown in FIG. 5, concerns the manufacture solely of the lower die 21 of the first embodiment.

A heat-resistant ceramic molding box 31 which has been coated with alumina powder parting agent on the inside, serving for a molding frame, is filled with iron powder at the bottom thereof to form the lower filler layer 51. A copper pattern 101 is then mounted on the above-described molding box over the lower filler layer 51 and in intimate contact therewith. The pattern 101 is similar to the lower half of the pattern 10 of the first embodiment, and is made by taking off the upper cylinder from the flanged portion 12 of the pattern 10. On top of the pattern 101 is then placed magnesia powder which forms the upper filler layer 53. Pressure of two tons per square centimeter is then applied from the upper filler layer 53 through a plate 54. After compression molding, the plate 54 and the magnesia powder (upper filler layer 53) are removed. The lower filler layer 51 and the pattern 101 are then placed in a sintering furnace together with the molding box 31 and sintered in an atmosphere of nitrogen for 60 minutes at 1120° C. The sintered product, after being cooled and taken out of the molding box 31, is in the form of the lower mold 21.

During the sintering operation as previously described, the copper used for the pattern infiltrates into the sintered material. Therefore, a molding surface is formed on the upper surface of the sintered material having the same dimensions and shape as the lower surface of the pattern.

The described magnesia powder acts as a compression medium for preventing the deformation of the pattern 101 in the compression of the lower filler layer 51. Alternatively, the compression molding can be carried out without the magnesia powder by means of a punch of the same shape as the upper surface of the pattern.

In the second embodiment as described, since only a lower mold is formed, the pattern may be thinner than in the first embodiment, unless it is desired to increase the strength of the pressing die. By making the pattern thinner, it is possible to economize the infiltrant metal and facilitate the manufacture of the pattern.

The third embodiment of the invention is illustrated in FIGS. 6 to 9 and concerns the manufacture of a casting mold as shown in FIG. 9 for casting a product corresponding in shape to the pattern 6. The pattern 6, as shown in FIG. 6, is made of copper and has a gate stick **61** and a flow-off stick **62** on the upper edge of the cup **60** having a dish-shape and having a flat bottom. As shown in FIGS. 7 and 8, a molding frame **31** having a bottom plate is first coated on the inner peripheral surface thereof with alumina powder. The bottom of the molding frame **31** is filled with a sintering powder mixture comprising 97 percent iron and 3 percent graphite, by weight. The pattern **6** is then mounted on the sintering powder and additional powder is then added to the upper edge of the pattern **6** so as to form the lower filler layer **71**. Four copper patterns **65** are then imbedded in the sintering powder at four locations around the pattern **6** for molding guide portions. The patterns **65** have a cup-shaped construction, with their upper ends respectively in the same horizontal plane as the upper surface of the lower filler layer **71**. The upper surface of the lower filler layer **71** is then coated with alumina powder parting agent **8**, upon which additional sintering powder is added to form the upper filler layer **72**.

The sintering powder is then compressed under a load of one ton per square centimeter from the upper filler layer **72**. The thus compressed sintering powder containing each pattern is then placed in a sintering furnace together with the molding frame **31**, presintered for two hours at 900° C, and then further heated for 60 minutes at 1120° C to infiltrate the copper of the patterns into the sintered product. After cooling, the sintered product is taken out of the molding frame **31** to form the casting mold shown in FIG. **9**, having a lower mold **721** and an upper mold **722**.

The resulting casting mold is a split mold consisting of upper and lower mold halves. The lower mold **721** has a casting mold surface with the same shape and dimensions as the lower surface of the pattern **6** and also has guide holes **766** for receiving the guides **765** of the upper mold **722**. The upper mold **722** has a casting mold surface with the same shape and dimensions as the upper surface of the pattern **6** and also has a gate **761**, a tapping **762** and guides **765**. Therefore, the guides **765** of the upper mold **722** may be inserted into the guide holes **766** of the lower mold **721** on which is laid the upper mold **722**, whereby the inner surface forming the cavity in the split mold will constitute the casting mold surface and have the same shape and dimensions as the pattern **6**.

In the above example, the alumina powder parting agent was coated only on the lower filler layer **71**. For convenience, however, the patterns **6** and **65** may be coated on the surface with parting agent, if desired. The pre-sintering operation can be employed for strengthening the bonding of the sintering powder before regular sintering, thereby resulting in increased strength of the casting mold after sintering.

In this embodiment, since the upper and lower molds are manufactured simultaneously as a composed split mold, even if the molds have some roughness on the contact surfaces **9** of the upper and lower mold halves, these contact surfaces **9** perfectly fit with each other. Consequently leakage of molten metal from the mold is not likely to occur. Therefore it is not required to smoothly machine the contact surface, such as in the case where the upper an lower mold halves are separately and individually manufactured.

FIG. **10** shows a cross-section of a modified embodiment of the pattern used in the third embodiment as described above. This pattern differs from the one previously described in consisting of a portion **60′** forming the casting cavity and portions **65′** forming the guides, which portions are connected with a thin sheet **69** to form the split in the upper and lower mold halves. The upper and lower mold halves can be molded at the same time without use of the alumina powder parting agent. In this case the pattern **60′** forming the casting cavity will be formed thicker than the cup **60** of the pattern as shown in FIG. **6** by the thickness of the thin sheet **69** forming the split surfaces of the upper and lower mold halves.

The casting molds and pressing dies made in accordance with this invention may be used repeatedly without any modification appearing in the shape and size of both molds and dies and the products produced by use of the molds and dies.

In carrying out the method of the present invention, the metal powder used as the sintering material may be iron, copper, tungsten carbide, titanium carbide or the like. The infiltrant metal used to form the pattern must have a melting point lower than the sintering temperature of the sintering material. The sintering conditions will, of course, vary with the particular materials used for the sintering material and for the pattern. For example, if a ferrous metal powder whose main ingredient is iron or iron-carbon is used as the sintering powder, then the infiltrant metal used for forming the pattern should be either copper, a or copper alloy such as 95 percent copper – 5 percent manganese alloy, a 97 percent copper – 3 percent cobalt alloy, or the like. Typical sintering conditions for these materials would be 60 minutes at 1120° C in an atmosphere of nitrogen under a compression pressure of 2 tons per square centimeter. If copper powder whose main ingredient is copper, or a copper alloy, is used as the sintering powder, then the infiltrant metal used for forming the pattern should be lead, or lead alloy such as a 50 percent lead – 50 percent tin alloy, an 82 percent lead – 18 percent cadmium alloy or the like, with typical sintering conditions being 60 minutes at 500° C in an atmosphere of hydrogen and under a compression pressure of 0.5 ton per square centimeter. If a metal powder whose main ingredient is tungsten carbide is used as the sintering material, then the infiltrant metal used for forming the pattern should be iron cobalt, nickel, or the alloy thereof, with typical sintering conditions being 60 minutes at 1550° C in an atmosphere of hydrogen and under a compression pressure of 1 ton per square centimeter. If a metal powder whose main ingredient is titanium carbide is employed as the sintering material, then the infiltrant metal used for forming the pattern should be iron, cobalt nickel, a or the alloy thereof such as 95 percent nickel – 5 percent molybdenum alloy, with typical sintering conditions being 60 minutes at 1550° C in an atmosphere of hydrogen and under a compression pressure of one ton per square centimeter.

The pattern used in the present invention will have the same dimensions and shape as the molding surface of the metal die or mold desired. The whole pattern may be made of the infiltrant metal as shown in the above examples. If the pattern is of large volume, it may have a cavity in the interior thereof or the pattern may be formed of ceramic or the like heat-resistant material serving for the base and lined with infiltrant metal to prevent said pattern from deforming by the pressure through press molding. In the latter case, the ceramic base may be taken off after sintering. A sheet of infiltrant metal may be employed between the upper and lower mold halves or guides and guide holes which are not directly connected to the molding surface of the metal die or mold, as the pattern **65** in the third embodiment. As shown in the third embodiment, it is possible to form a boundary by coating thereon a heat-resistant parting agent such as alumina or magnesia. Such parting agent can be coated on the above-described thin sheet so as to prevent the sintering on the boundary.

In the method of the present invention, compression molding of the sintering material prior to sintering increases the density and strength of the final die or mold. In the event that the sintered product is not required to have high density and strength, sintering can be done without the compression molding of the metal powder or with compression molding under low pressure. If the sintering material is not compressed or is compressed to only a slight degree, then it is preferred to carry out the sintering operation in a molding box which is resistant to the sintering temperature, as shown in the second and third embodiments, so as to prevent collapse of the metal powder prior to sintering.

The method of the present invention can be applied not only to the manufacture of press die and casting molds, but also to diecasting molds, molds for plastic, glass or rubber molding, as well as other general metal molds. It is likewise apparent that by proper use of parting compounds or infiltrant metal sheets arranged on the surfaces as desired, it is possible by means of the present invention to make various types of multi-split molds such as a triple or quadruple split mold.

As will be apparent from the above description and embodiments, the method of manufacturing metal dies or molds in accordance with the present invention provides a vast improvement over prior methods in that it does not require complicated machining procedures nor particular skill, but is simpler, less time consuming, and more economical. Furthermore, due to the strengthening and reinforcing effect of the infiltrant metal being infiltrated into the sintered metal, the resulting metal die or mold has improved strength and quality.

Although certain specific embodiments of the invention have been shown and described, it is obvious that many modifications thereof are possible. The invention, therefore, is not intended to be restricted to the exact showing of the drawings, and description thereof, but is considered to include reasonable and obvious equivalents.

What we claim is:

1. A method for producing a metal die or mold composed of a sintered body with a hardened mold surface, comprising making a layer of sintering powder selected from the group consisting of iron, iron alloy, copper, copper alloy, tungsten carbide and titanium carbide in a frame for forming said sintered body, placing a pattern having a surface of selected configuration made of infiltrant metal with a lower melting point than that of said sintering powder on said layer to contact said pattern surface with said layer for shaping said layer with a surface complementing said pattern surface, heating said layer and pattern within said frame to a sintering temperature to sinter said powder and to infiltrate said infiltrant metal forming said pattern into said powder, and cooling so as to obtain a sintered mold having a hardened surface whose configuration complements that of said pattern surface.

2. A method of producing a metal die or mold according to claim **1**, wherein further comprising removing said hardened and sintered die or mold from said frame after cooling.

3. A method according to claim **1**, wherein said sintering powder is ferrous metal powder selected from the group consisting of iron powder and iron-carbon powder, and said pattern is made of one metal selected from the group consisting of copper, copper-manganese alloy, and copper-cobalt alloy.

4. A method according to claim **1**, wherein said sintering powder is copper powder or copper alloy powder, and said pattern is made of one metal selected from the group consisting of lead, lead-tin alloy, and lead-cadmium alloy.

5. A method according to claim **1**, wherein said sintering powder is tungsten carbide powder and said pattern is made of one metal selected from the group consisting of iron, cobalt, nickel and the alloy thereof.

6. A method according to claim **1**, wherein said sintering powder is titanium carbide powder and said pattern is made of one metal selected from the group consisting of iron, nickel, cobalt or the alloy thereof.

7. A method according to claim **1**, wherein said sintering powder layer is presintered at a lower temperature than the melting temperature of the infiltrant metal forming said pattern before heating to sinter said sintering powder layer completely.

8. A method according to claim **1**, wherein said powder layer is compressed before heating to sinter said powder layer.

9. A method according to claim **8**, wherein a pressure medium layer of heat-resistant powder such as magnesia powder layer is placed on said sintering powder layer such that the upper surface is made plane, and said sintering powder is compressed through said pressure medium layer, then said pressure medium layer is removed before heating to sinter said sintering powder layer.

10. A method according to claim **1**, wherein said pattern has a thin plate member surrounding said selected configuration part to be overspread on the upper surface of said sintering powder layer except the area covered by said selected configuration part.

11. A method according to claim **1**, wherein said pattern has a core made of a heat-resistant material such as ceramic and covered by said infiltrant metal and said core is removed from the mold after sintering.

12. A method according to claim **1**, wherein a heat-resistant parting agent is placed as a thin layer between said frame and said layer of sintering powder.

13. A method according to claim **12**, wherein said heat-resistant parting agent is selected from the group consisting of alumina and magnesia.

14. A method according to claim **1**, wherein said layer of sintering powder substantially completely surrounds said pattern whereby the completed mold has a configuration complementing that of the pattern.

15. A method according to claim 14, wherein a plurality of said patterns is provided in said frame, said powder is disposed in said frame about each of said patterns in a plurality of layers separated from one another by thin layers of infiltrant metal with a lower melting point than that of said sintering powder, whereby upon completion of sintering and cooling a plurality of metal molds is obtained constituting a set and which together have the configuration of the pattern immersed in said layers of sintering powder.

16. A method for producing a set of metal dies or molds composed of a sintered body with a hardened mold surface, comprising making a first layer of sintering powder selected from the group consisting of iron, iron alloy, copper, copper alloy, tungsten carbide and titanium carbide in a frame for forming said sintered body, placing a heat-resistant parting agent as a thin layer on the upper surface of said first layer, placing a pattern having a surface of selected configuration made of infiltrant metal with a lower melting point than that of said sintering powder on said layer to contact said pattern surface with said first layer for shaping said first layer with a surface complementing said pattern surface, making a second layer of said sintering powder on said pattern and layer of parting agent to contact the remaining surface of said pattern with said second layer of sintering powder before heating for sintering, heating said first and second layers and pattern within said frame to a sintering temperature to sinter said powder and to infiltrate said infiltrant metal forming said pattern into said powder, and removing said hardened, sintered dies or molds from said frame after cooling so as to obtain a set of metal dies or molds.

17. A method according to claim 16 wherein said pattern has a thin plate member surrounding said selected configuration part, said thin plate member is disposed between the first and second layers of sintering powder and said thin layer of parting agent is placed between said first and second layers of sintering powder.

18. A method according to claim 16 wherein a plurality of patterns for guide portions having U-shaped section and being made of infiltrant metal with a lower melting point than that of said sintering powder are embedded between said first and second layer of sintering powder, whereby guide pins and holes are formed on the counter surfaces of the dies upon completion of sintering.

19. A method according to claim 17, wherein said sintering powder is ferrous metal powder selected from the group consisting of iron powder and iron-carbon powder, and said pattern and thin plate are made of one metal selected from the group consisting of copper, copper-manganese alloy, and copper-cobalt alloy.

20. A method according to claim 16, wherein said sintering powder is ferrous metal powder selected from the group consisting of iron powder and iron-carbon powder, and said pattern is made of one metal selected from the group consisting of copper, copper-manganese alloy, and copper-cobalt alloy.

21. A method according to claim 16, wherein said sintering powder is tungsten carbide powder, and said pattern is made of one metal selected from the group consisting of iron, cobalt, nickel, and the alloy thereof.

22. A method according to claim 16, wherein said sintering powder is titanium carbide powder and said pattern is made of one metal selected from the group consisting of iron, nickel, cobalt and the alloy thereof.

23. A method according to claim 16, wherein said sintering powder is copper powder or copper alloy powder, and said pattern is made of one metal selected from the group consisting of lead, lead-tin alloy, and lead-cadmium alloy.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,706,550 Dated December 19, 1972

Inventor(s) HANJI UMEHARA, TAKASHI KIMURA & HIROSHI HAMAMOTO

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

The name of the Assignee is changed to read -

KABUSHIKI KAISHA TOYOTA CHUO KENKYUSHO.

Signed and sealed this 29th day of May 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,706,550 Dated December 19, 1972

Inventor(s) HANJI UMEHARA, TAKASHI KIMURA & HIROSHI HAMAMOTO

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

The name of the Assignee is changed to read -

KABUSHIKI KAISHA TOYOTA CHUO KENKYUSHO.

Signed and sealed this 29th day of May 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,706,550 Dated December 19, 1972

Inventor(s) HANJI UMEHARA, TAKASHI KIMURA & HIROSHI HAMAMOTO

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

The name of the Assignee is changed to read -

KABUSHIKI KAISHA TOYOTA CHUO KENKYUSHO.

Signed and sealed this 29th day of May 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents