

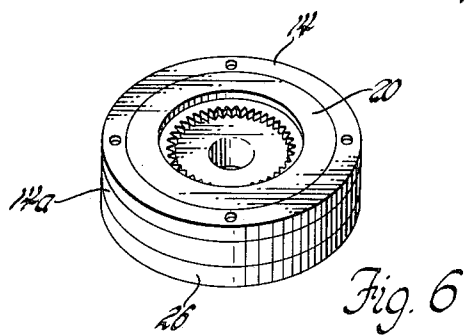
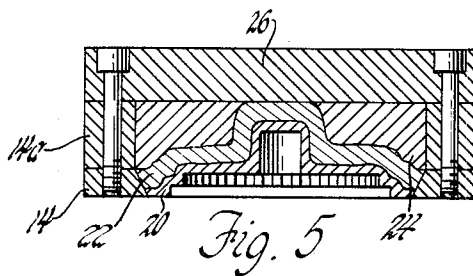
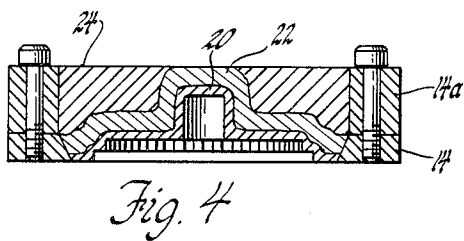
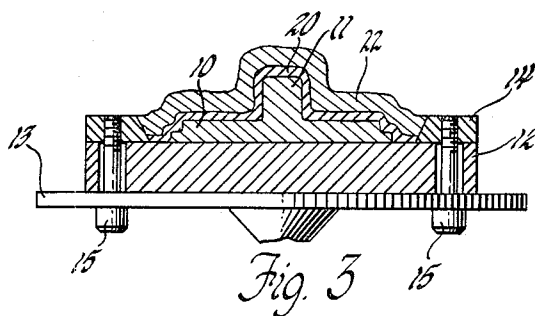
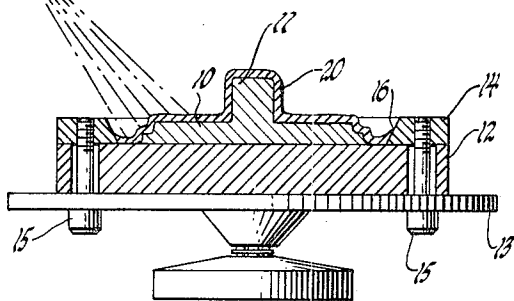
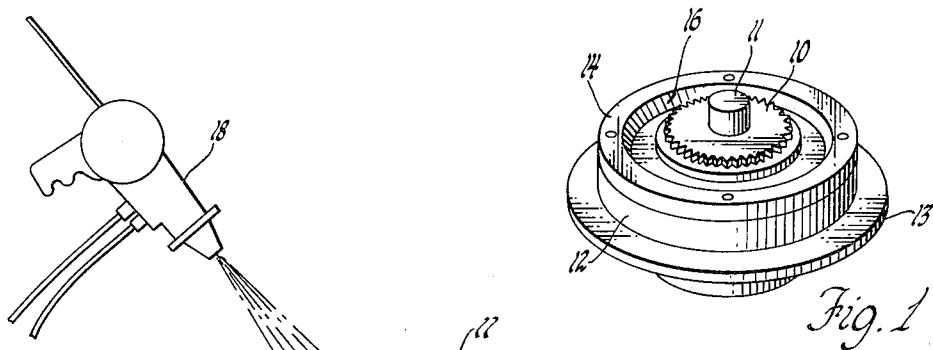
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3,228,650

DIE AND METHOD FOR ITS MANUFACTURE

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DIE AND METHOD FOR ITS MANUFACTURE
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This invention relates to dies, molds and the like and more particularly to an improved method for the manufacture of such articles.

Because of the high cost involved in the established methods of die construction such as those in which a die body is cast and the die cavity contours are then formed by mechanical operations including machining, kelling, coining, etc., considerable effort has been made by the industry to develop more economical and speedier methods of making dies. Among those which have shown promise is one in which a suitable die cavity facing metal is first sprayed onto a pattern and then a backup of suitably rigid substance is applied over the sprayed layer. This technique, however, has enjoyed limited success because of the tendency of the sprayed metal to warp and move away from the pattern during spraying with consequent inaccurate dimensions in the die cavity and because of the difficulty in properly associating the sprayed surface with the backup member.

It is accordingly an object of this invention to provide an improved die, mold or the like by a method which employs the technique of spraying metal onto a pattern to form the die face and avoids the aforementioned difficulties. It is a more specific object of this invention to provide a method for making dies and the like in which a steel frame or border is fixed about the pattern at the parting line which is tapered outwardly in the direction away from the pattern face at its inner vertical surfaces. This frame, which forms a part of the die structure, allows for the accurate formation of outside dimensions of the die and locks the sprayed structure to a backup member and further reduces the tendency of the sprayed metal to warp from the pattern during the spraying procedure.

These and other objects are accomplished by first forming a pattern having the shape or contour of the die or mold cavity to be formed. A steel frame or border tapered outwardly on the inner vertical side thereof is then positioned about the pattern and fixed with respect thereto at the parting line of the die to be formed. The pattern is coated with a release agent and the frame is masked so that sprayed metal will not adhere to them. A layer of mold facing metal is sprayed over the pattern surface. Next, a second or backup layer of metal is sprayed over the facing layer which preferably possesses thermal expansion and deformation properties similar to that of the facing metal. The backup material is sprayed so as to fill the space within the frame walls. Finally, a backing plate is bolted to the frame member whereby the tapered frame sides mechanically firmly hold the sprayed layers to the backing plate. Other objects and advantages of the invention will be apparent from the following detailed description of the invention, reference being had to the drawings, in which:

FIGURE 1 is a perspective view of the pattern mounted on a base plate and having a frame fastened thereabout;

FIGURE 2 is a cross-sectional elevation view of the pattern structure of FIGURE 1 having a facing layer of sprayed metal applied thereto;

FIGURE 3 is a cross-sectional elevation view showing a backup layer applied to the facing layer;

FIGURE 4 is a cross-sectional elevation view of one embodiment of the finished die;

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FIGURE 5 is an elevation cross-sectional view of another embodiment of the finished die; and

FIGURE 6 is a perspective view of the completed die.

The manufacture of a die in accordance with the method of this invention involves the advantageous step of accurately forming the facing contour of the die by the simple expedient of spraying a layer of metal over a pattern surface whereby expensive operations such as machining, kelling, coining and the like are avoided. Dies constructed in accordance with this invention may advantageously be used for applications such as die casting of zinc alloys, aluminum alloys, for injection and compression molding of thermoplastic and thermosetting materials and the construction of permanent molds.

The first step in the method of this invention involves the provision of a suitable pattern over which molten metal may be sprayed. If a master die exists, a pattern may be formed by pressure casting a suitable metal such as a zinc-tin alloy into the die using a suitable ring or frame around the die to contain the cast metal. In the absence of a master die, an inexpensive pattern may be made by making a model of the part in question, then sectioning it across the desired parting line and affixing the section to a supporting plate or block, the pattern supporting surface of the supporting plate being located at the parting line of the die to be formed. The pattern may be made of plaster, a suitably treated wood, various plastics, plastic material with a metallized surface or any other convenient material that is dimensionally stable approximately to temperatures of about 180° F. or more. If desired, graphite rods may be fixed to the pattern for the purpose of forming holes for ejector pins in the die to be formed.

In FIGURES 1 and 2 of the drawings, the pattern 10, in this instance, in the form of a toothed wheel, is affixed to a base plate or block 12 which in turn is preferably mounted on a rotatable table 13. The pattern supporting block 12 may, of course, be formed integrally with the pattern 10 and its upper mounting surface forms the parting line of the die to be made. A steel frame 14 is mounted on the pattern supporting block 12 about the pattern portion 10 and bolted to the table 13 by means of the studs 15. It will be noted that the frame 14 has the inclined vertical inner side 16 which inclines in a direction outwardly of the pattern. The frame 14 with its inner side 16 as will be hereinafter described constitutes an important aspect of the invention.

After the border plate 14 and the pattern 10 including the pattern support 12 have been bolted to the table 13, the structure is preferably subjected to a thorough vapor blasting cleaning treatment in the case of the preferred zinc-tin alloy pattern to promote the adherence of the sprayed metal. In the event that the pattern is formed of non-metallic materials, vapor blasting is not suitable. In the latter event, a coating of polyvinyl alcohol with or without silica flour may be used as an agent to cause the sprayed metal to adhere to the pattern surface and to effect an exact duplication of detail and the dimensions thereof. It is preferred to employ the zinc-tin alloy as a pattern material since subsequently the sprayed die facing may be easily removed from the pattern by inverting it and heating the pattern to cause sufficient melting thereof to cause it to fall away. Moreover, the destructible metal pattern avoids the need for a bonding and release coating over the pattern and hence promotes exact duplication of the pattern contour.

After the frame 16 has been mounted, the pattern is preheated to a temperature of about 180° F. and a layer 20 of the facing metal is sprayed onto the pattern surface. The pattern is preheated to prevent condensation of water vapor from the products of combustion. Preferably the

preferred metal is sprayed from an oxyacetylene or oxyhydrogen powder metallizing gun. The metal may also be sprayed in the form of a wire made from plastic bonded powder. The preferred metal composition for use for the facing surface is as follows:

Nickel -----	70% to 82%
Chromium -----	7% to 17%
Boron -----	2% to 3.5%
Iron -----	1.5% to 4%
Carbon -----	0.15% to 4%
Silicon -----	2.5% to 4.5%

In the above composition small amounts of cobalt may be used to replace equal amounts of nickel. Where a somewhat higher hardness is desired in the die structure, a composition such as the following may be used.

Nickel+cobalt -----	67% to 68%
Chromium -----	16% to 19%
Boron -----	3% to 4%
Molybdenum -----	2% to 6%
Copper, maximum -----	3%
Iron -----	1% to 3%
Carbon -----	0.5%
Silicon -----	4%

Where it is desired that the sprayed metal coating have a retained hardness at elevated temperatures, additional cobalt may be added with tungsten to provide compositions as follows.

Nickel+cobalt -----	60% to 70%
Chromium -----	13% to 28%
Boron -----	1.9% to 4%
Tungsten -----	4.5% to 16%
Iron, maximum -----	4%
Carbon, maximum -----	1%
Silicon -----	3.5%

The alloys listed above can all be fused between about 1800° F. and 2000° F. In general, the facing metal will be observed as a mixture of powders consisting of about 7% to 28% chromium, about 1% to 4% iron, about 2% to 4% boron, about 0.1% to 4% carbon, about 2.5% to 4.5% silicon, up to 6% molybdenum, up to 3% copper, up to 16% tungsten and the balance nickel and cobalt. The boron and silicon are present as fluxing agents and the boron also serves as a hardener. The molybdenum, tungsten or copper are present as hardeners. It has also been found that substantially pure molybdenum may be satisfactorily used as the facing material.

In the event that the detail of the pattern presents any deep narrow cavities, it has been found advantageous to spray the metal facing 20 with the pattern inverted and clamped to an inverted turntable. Preferably, the spray is projected at an angle greater than 45 degrees above the horizontal. This procedure along with an impinging air blast assists in the dropping or blowing out of unbonded particles which may cause porosity and loss of detail.

A backup mass is then sprayed over the facing layer 20 in the form of the layer 22 as shown in FIGURE 3. Ideally the backup material possesses thermal expansion and deformation properties similar to that of the face material. Preferably the backup material is subjected to hardening by heat treatment to provide a hardened material after the fusion treatment to be herein-after described. A suitable backup metal for this purpose is type 420 stainless steel because it is hardenable by heat treatment and has a low shrink factor when sprayed even though the coefficient of thermal expansion does not coincide ideally with the above-mentioned facing metals. The type 420 wire is sprayed with an oxyacetylene wire gun until a thickness of 3/8 inch has been built up over the highest point in the pattern as shown in FIGURE 4. Areas over the the low spots in the pat-

tern are then sprayed to at least this level as shown in FIG. 4.

The height of the pattern detail will determine whether the frame 14 is in one piece or more. As shown in FIGURES 2 through 4, in view of the high central point of the pattern, a second frame 14A is superimposed over the frame 14. The frame 14A is of sufficient height so that it rises above the highest point 11 of the pattern by an amount sufficient to permit a thickness of backup metal of about 3/8 inch to be built up over the highest point 11 of the pattern. As shown in FIGURE 4, only the base frame 14 need be provided with the tapered inner edge. It is obvious that a number of additional sections such as 14A may be superimposed with the frame 14 to provide the desired height. In building up a backup of sufficient height as shown in FIGURE 4, sequential layers of about 3/8 inch in thickness are applied. In all spraying operations, care, of course, must be taken to avoid melting of the pattern surface.

While the pattern is still in place on the back of the sprayed die, the sprayed surface 24 of the backup is then dressed flat for attaching a backup plate 26 of cold rolled steel as shown in FIGURE 5. The plate 26 is bolted in place utilizing the same bolt holes which had been used to bolt the frames 14 and 14A to the table 12. With the plate 26 bolted in place through the beveled frame 14, the sprayed portions 20 and 22 are firmly locked in place and at this point the pattern is removed. It will be apparent from the above description that the frame 14 serves the important functions of providing for accurate die outside dimensions, a means for locking the sprayed metal layers to the backing plate 26 and most importantly of reducing the tendency of the sprayed metal facing from warping and moving away from the pattern during the spraying operations.

Finally the assembly shown in FIGURE 5 is subjected to a fusion heat treatment at approximately 1850° F. This temperature is just below the fusion temperature of the facing metals mentioned above and is also the hardening temperature of the type 420 backup metal. The heat treatment applied involves heating the die assembly to a temperature of about 1925° F. in an endothermic atmosphere, allowing five minutes for maximum fusing of the face, then dropping the temperature to 1850° F. and then allowing one-half hour for the temperature to stabilize in the material of the backup layer 22. During this fusion treatment the metal of the facing layer 20 diffuses to some extent with the frame member 14 to form a metallurgical bond therewith and to thereby provide additional means for locking the facing layer to the die body. The die is then quenched in oil to effect a hardening of the backup layer which had been annealed in the fusion step. In the event that other backup materials are used, it may be preferable to fuse the face layer 20 before spraying or to cast the backup layer 22. In the event that molybdenum is used as the facing material, the fusion and hardening steps may be omitted since the molybdenum has an adequate compressive strength as sprayed. In this event refractory sand is tamped and held behind the face 20 to prevent distortion during fusion.

Although the invention has been described in the form of a preferred embodiment, it is to be understood that other embodiments may be adopted within the spirit of the invention and the invention is not to be limited except by the following claims.

We claim:

1. The method of forming a die member having a die cavity therein comprising the steps of positioning a pattern on a support, positioning a metal frame on said support and about said pattern and securing it to said support, said frame having inner sides which taper outwardly of the pattern, spraying a layer of a fusible facing metal over said pattern and over at least a portion of said tapered sides, then spraying sufficient backing metal over said fac-

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ing layer to a level which exceeds the highest point of said facing layer, removing the pattern, fusing said facing metal and diffusion bonding it to said frame, and applying a backing plate over said backing layer and fastening said backing plate to said frame whereby the said facing layer and the said backing layer are firmly clamped between said frame and said backing plate.

2. The method of forming a die member having a die cavity therein comprising the steps of positioning a pattern on a support, positioning a metal frame on said support and about said pattern and securing it to said support, said frame having inner sides which taper outwardly of the pattern, preheating said pattern to about 180° F., spraying a layer of a fusible facing metal over said pattern and over at least a portion of said tapered sides, then spraying sufficient backing metal over said facing layer to a level which exceeds the highest point of said facing layer, said backing metal being sprayed in sequential layers to avoid pattern distortion due to excessive generation of heat, removing the pattern, fusing said facing layer and diffusion bonding it to said frame, and applying a backing plate over said backing layer and fastening said backing plate to said frame whereby the said facing layer and the said backing layer are firmly clamped between said frame and said backing plate.

3. The method of forming a die member having a die cavity therein comprising the steps of positioning a pattern on a support, positioning a metal frame on said support and about said pattern and securing it to said support, said frame having inner sides which taper outwardly of the pattern, preheating said pattern to a temperature of at least about 180° F., spraying a layer of a powdered mixture over said pattern and over at least a portion of said tapered sides consisting essentially of about 7% to 28% chromium, about 2% to 4% iron, about 0.1% to 4% carbon, about 2.5% to 4.5% silicon, up to about 6% molybdenum, up to about 3% copper, up to about 16% tungsten and the balance substantially nickel, then spraying sufficient backing metal over said facing layer to a level which exceeds the highest point of said facing layer, removing the pattern, subjecting the facing layer to heat at a temperature between 1800° F. and 2000° F. whereby the sprayed layer fuses and diffuses into said tapered surfaces to form a metallurgical bond therewith, and attaching a backing plate over said backing layer and securing said backing plate to said frame whereby said facing layer and said backing layer are firmly clamped between said frame and said backing plate.

4. The method of forming a die member having a die cavity therein comprising the steps of positioning a pattern on a support, positioning a steel frame on said support and about said pattern and bolting it to said support by means of bolts extending through said support and screwed into threaded openings in said frame, said frame having inner sides which taper outwardly of the pattern, preheating the pattern to about 180° F., spraying a layer of a facing metal over said pattern and over at least a portion of said tapered sides consisting essentially of about 7% to 28% chromium, about 2% to 4% iron, about 0.1% to 4% carbon, about 2.5% to 4.5% silicon, up to about 6% molybdenum, up to about 3% copper, up to about 16% tungsten and the balance substantially nickel, then spraying sufficient backing metal over said facing layer to a level which exceeds the highest point of said facing layer, removing the pattern, heating said facing layer to a temperature in the range of 1800° F. to 2000° F. whereby said facing layer is fused and metallurgically bonded to said steel frame, and bolting a backing plate over said backing layer by means of bolts extending through said backing plate and screwed into the threaded openings of said frame whereby the facing layer and backing layer are firmly clamped between said frame and said backing plate.

5. The method of forming a die member having a die cavity therein comprising the steps of positioning a pattern on a support, positioning a steel frame on said support and

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about said pattern and bolting it to said support by means of bolts extending through said support and screwed into threaded openings in said frame, said frame having inner sides which taper outwardly of the pattern, preheating the pattern to about 180° F., spraying a layer of a facing metal over said pattern and over at least a portion of said tapered sides consisting essentially of about 7% to 28% chromium, about 2% to 4% iron, about 0.1% to 4% carbon, about 2.5% to 4.5% silicon, up to about 6% molybdenum, up to about 3% copper, up to about 16% tungsten and the balance substantially nickel, then spraying sufficient heat hardenable stainless steel backing metal over said facing layer to a level which exceeds the highest point of said facing layer, said backing metal being sprayed in sequential layers to avoid pattern distortion due to excessive generation of heat during spraying, removing the pattern, heating said facing layer to a temperature in the range of 1800° F. to 2000° F. whereby said facing layer is fused and metallurgically bonded to said steel frame, quenching the assembly to harden said stainless steel and bolting a backing plate over said backing layer by means of bolts extending through said backing plate and screwed into the threaded openings of said frame whereby the facing layer and backing layer are firmly clamped between said frame and said backing plate.

6. A die having a cavity therein consisting of a metal frame located at the parting line of the die having inner surfaces which taper outwardly in a direction inwardly of the die face, a die cavity facing layer supported on said tapered sides of said frame and diffusion bonded thereto, a backing layer superimposed over said facing layer and being supported by said tapered surfaces and a backing plate clamping said backing layer and said facing layer against said frame.

7. A die having a cavity therein consisting of a steel frame located at the parting line of the die having inner surfaces which taper outwardly in a direction inwardly of the die face, a die cavity facing layer supported on said tapered sides of said frame and being metallurgically bonded thereto, said facing layer being a fused mixture consisting essentially of about 7% to 28% chromium, about 2% to 4% iron, about 0.1% to 4% carbon, about 2.5% to 4.5% silicon, up to about 6% molybdenum, up to about 3% copper, up to about 16% tungsten and the balance substantially nickel, a backing layer superimposed over said facing layer and being supported by said tapered surfaces and a rigid metal backing plate clamping said backing layer and said facing layer against said frame.

8. A die having a cavity therein consisting of a flat steel frame located at the parting line of the die having inner surfaces which taper outwardly in a direction inwardly of the die face, a die cavity facing layer supported on the said tapered sides of the frame and being metallurgically bonded thereto, said facing layer being a fused metal consisting essentially of about 7% to 28% chromium, about 2% to 4% iron, about 0.1% to 4% carbon, about 2.5% to 4.5% silicon, up to about 6% molybdenum, up to about 3% copper, up to about 16% tungsten and the balance substantially nickel, a heat hardened stainless steel backing layer superimposed over said facing layer and abutting said frame and a rigid metal backing plate bolted to said frame and wedging said facing layer and said backing layer between said frame and said backing plate.

9. The method of forming a die member having a die cavity therein comprising the steps of positioning a pattern on a support, positioning a metal frame on said support and about said pattern and securing it to said support, said frame having inner sides which taper outwardly of the pattern, preheating said pattern to about 180° F., spraying a layer of molybdenum over said pattern and over at least a portion of said tapered sides, then spraying sufficient backing metal over said facing layer to a level which exceeds the highest point of said facing layer, said backing metal being sprayed in sequential layers to

avoid pattern distortion due to excessive generation of heat, removing the pattern, fusing said facing layer and metallurgically bonding it to said frame and attaching a backing plate over said backing layer which is firmly fastened to said frame whereby the said facing layer and the said backing layer are firmly clamped between said frame and said backing plate.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,228,650

January 11, 1966

Harry J. Gilliland et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 5, line 28, for "metal" read -- steel --; line 29, for "port" read -- support --.

Signed and sealed this 6th day of December 1966.

(SEAL)

Attest:

ERNEST W. SWIDER

Attesting Officer

EDWARD J. BRENNER

Commissioner of Patents