Aug. 16, 1949. D. L. JOCELYN 2,479,364

METHOD OF MAKING MOLDS

Filed Oct. 25, 1945 2 Sheets-Sheet 1

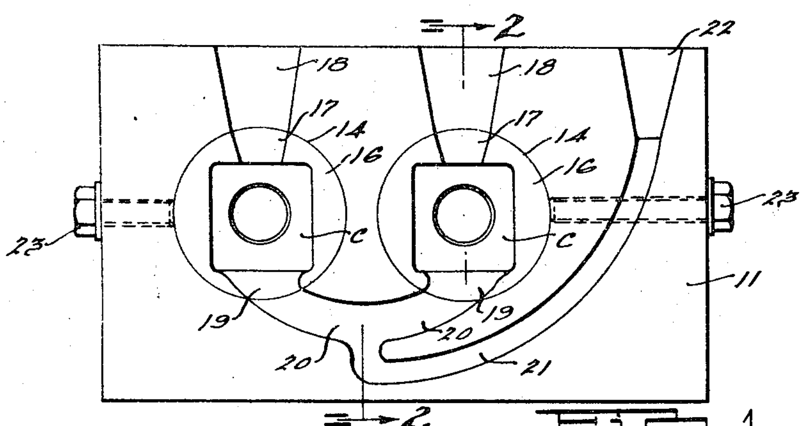

FIG. 1.

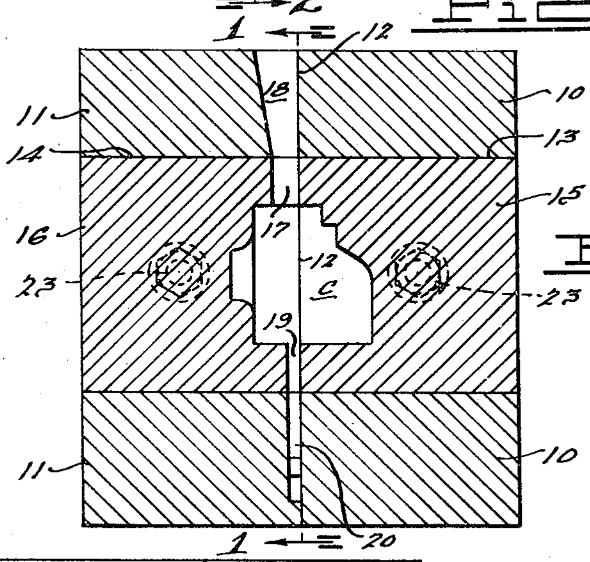

FIG. 2.

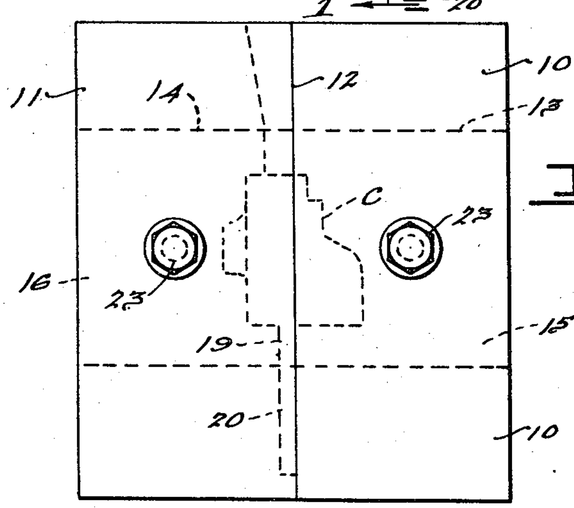

FIG. 3.

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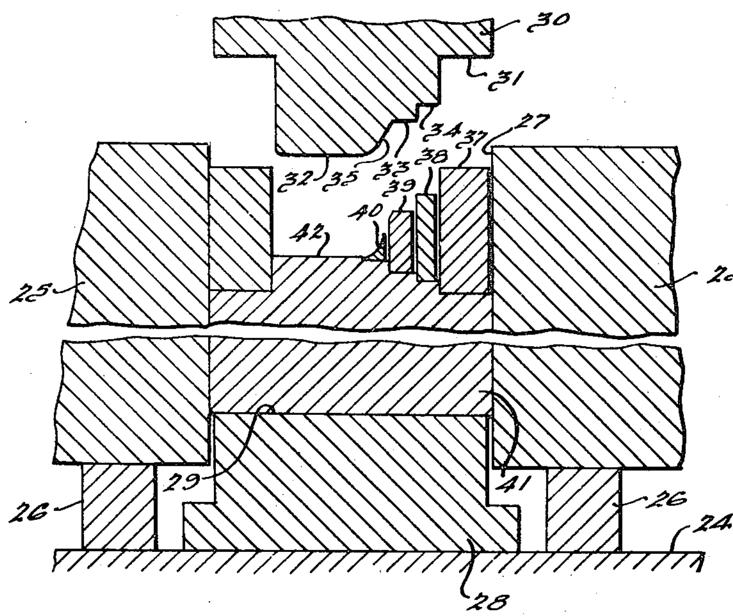

FIG. 4.

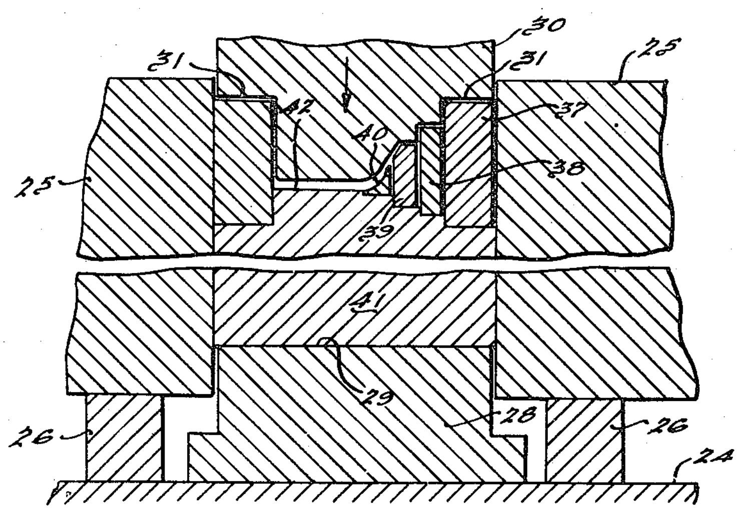

FIG. 5.

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METHOD OF MAKING MOLDS

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2 Claims. (Cl. 29—160.5)

1

This invention relates to molds for use in the production of cast or molded articles and particularly to so-called permanent type molds which may be used repeatedly for the production of relatively large numbers of castings in the same mold. An important object of the invention is to provide a metallic mold which is permeable in character thereby permitting the rapid escape of gases from the mold cavity during the casting operation and as a consequence enabling superior castings or molded articles to be made.

A further object of the invention is to provide a sintered metal mold formed of powdered metal which, before sintering, is pressed through the medium of dies under great pressure to produce the casting cavity, the mold having substantially all of the advantages of a conventional permanent mold yet capable of being produced at a fraction of the cost theerof, thus enabling many articles to be cast by permanent mold methods which otherwise would not be possible owing to the great cost of conventional type permanent molds.

Still another object of the invention is to provide a sintered powdered metal mold which is self-venting due to the permeability thereof and which is thus capable of producing a casting having a smoother surface than ordinary molds.

A further object of the invention is to provide a permanent metal mold of relatively inexpensive character in which the portions of the mold having the casting cavity or cavities are formed of sintered powdered metal preferably in the form of one or more replaceable inserts in a mold block having the usual pouring sprue, gating and risers communicating with the casting cavity, the improved construction providing a permeable self-venting metal mold portion, or any desired number thereof, which may be replaced at relatively low cost after wearing out and without requiring scrapping and replacement of the remaining parts of the mold.

Another object of the invention is to provide a method of producing a sintered powdered metal mold formed by dies under great pressures and having a high degree of uniformity in the density of the walls of the mold.

Still another object of the invention is to produce a powdered metal foundry mold of substantially uniform density for casting an article of irregular contour, such as an article having protruding bosses or stepped portions forming different levels, as a result of which uniform density and freedom from distortion during heat treatment of the mold briquette are not possible by

2

the use of conventional methods of forming the briquette from powdered metal. In accordance with the present invention, however, I introduce into the die cavity containing the loose or uncompacted powdered metal one or more preformed briquettes of powdered metal which has been partially compressed to predetermined density, the pre-formed briquettes of required size and shape being positioned in the die cavity at localities where different levels are present in the punch. Upon compression of the material between upper and lower punches the pre-formed briquettes are consolidated with the powdered mass and augment the density of the final briquette at the localities where variations in density would otherwise occur due to the different levels on the punch. Thus, by the use of these preformed briquettes it is possible to compensate for variations in density which otherwise would occur in the formation of a powdered metal mold.

A further object of the invention is to produce a powdered metal mold having sufficient permeability to cause the mold to be self-venting during the casting operation, and in addition to provide a metallic surfacing of chromium, or other high heat resistant metal, on the mold permitting molten metals to be poured at higher temperatures in the mold while reducing the tendency of the pores of the mold to become closed or blocked as the result of fusing of the surface of the mold in contact with the molten metal. Such metallic surfacing of the mold renders the mold highly wear resistant and more durable while at the same time providing a smoother, harder surface capable of producing smoother surfaces on the castings.

This application is a continuation in part of my application Serial No. 572,117, filed January 10, 1945, now abandoned.

Other objects of this invention will appear in the following description and appended claims, reference being had to the accompanying drawings forming a part of this specification wherein like reference chaarcters designate corresponding parts in the several views.

Fig. 1 is a side elevation of a mold unit or section constructed in accordance with the present invention, this view being taken substantially through lines 1—1 of Fig. 2 looking in the direction of the arrows.

Fig. 2 is an enlarged section of the assembled mold units or sections taken substantially through lines 2—2 of Fig. 1 looking in the direction of the arrows.

Fig. 3 is a side elevation of the assembled mold shown in Fig. 2.

Fig. 4 is a fragmentary sectional view of a punch and die apparatus for forming the powdered metal mold unit.

Fig. 5 is a view similar to Fig. 4 illustrating the position of the upper punch at the commencement of a pressing operation.

Before explaining in detail the present invention it is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced or carried out in various ways. Also it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

It will be understood that the invention is capable of use in casting or molding a wide variety of articles from different materials, principally metal and its alloys, thermoplastics and thermosetting resins. Any suitable number of articles may be cast simultaneously in the same mold and in the present embodiment I have shown a mold constructed to cast two articles, each of which is cast in a mold cavity formed partly in one mold section, such as the cope, and partly in the other mold section, such as the drag.

In the drawings, wherein one embodiment is illustrated by way of example, the mold comprises two sections 10 and 11, preferably in the form of cast iron blocks, assembled along a parting line 12. The block 10 is provided with a pair of similar bores 13 and in like manner the block 11 is provided with a pair of bores 14. These bores preferably extend entirely through the supporting blocks 10 and 11, the bores 13 being adapted to receive cylindrical powdered metal mold inserts 15 and the bores 14 being adapted to receive cylindrical powdered metal mold inserts 16. The corresponding pairs of mold inserts 15 and 16, when positioned within their respective bores, meet at the common parting line 12. In the present instance, each mating pair of powdered metal mold inserts 15 and 16 are formed to provide a common casting cavity C, as shown in Fig. 2. As hereinafter described, the mold inserts are formed of sintered powdered metal such as ferrous metal or an alloy thereof, and the cavities C are shaped so as to produce the desired articles when the molten metal congeals within the cavities after the pouring operation. In the present instance, each insert 16 is formed with a portion 17 of a riser extending upwards from the cavity and communicating therewith. Each riser portion 17 communicates with a riser portion 18 formed in the supporting block 11 for the inserts 16. Also each mold insert 16 is formed with a portion 19 of a runner gate leading into the cavity C from below.

The supporting block 11 is cast or otherwise fabricated to provide diverging runner gate portions 20, as clearly shown in Fig. 1, register with which leads upwards to the sprue passage 22 into which the molten metal is poured. The gate portions 20, as clearly shown in Fig. 1, registers with the gates 19 through which the metal enters the cavities C.

The powdered metal mold inserts 15 and 16 have a smooth sliding fit within their respective bores 13 and 14 in the supporting blocks 10 and 11. Thus, when assembling the mold, the mold inserts will slide into the bores until flush with the inner upright faces of the blocks 10 and 11 at the parting line 12. They are then rigidly clamped in place by means of retainer bolts 23 extending through tapped holes in the blocks 10 and 11 and engaging the inserts. The blocks 10 and 11, with their assembled mold sections, are then assembled as illustrated in Fig. 2, being clamped together in tight abutting relation at the parting line 12 in any conventional manner, after which the castings are poured. Suitable knock-out pins (not shown) of any conventional kind may be mounted in the inserts 15 and 16 for ejecting the castings after the mold sections have been separated. Thereafter the riser and gate portions of the castings are removed to provide the finished article.

The mold inserts 15 and 16 are prepared from powdered metal, preferably ferrous metal or an alloy thereof, and are shaped under high pressure and then sintered. In Figs. 4 and 5 there is illustrated a press designed for the purpose of forming the mold inserts 15, it being understood that the mold inserts 16 will be formed in substantially the same manner as the inserts 15. As illustrated in Figs. 4 and 5, the press herein utilized to prepare the powdered metal mold inserts comprises a bed or bolster 24 and a side die 25 supported upon the bed by means of removable blocks 26. The die 25 has a central vertical bore 27 corresponding in diameter to the bore 13 or 14 in the mold supporting block 10 or 11. Suitably anchored to the bed 24 of the press is a lower punch 28 having a vertically extending cylindrical portion fitting into the bore 27 in the die 25 and in the present instance terminating in a flat top surface 29. The press also comprises an upper vertically reciprocable punch 30 of a diameter to have a sliding fit within the bore 27 of the side die 25. The working end of this punch is shaped to produce, in cooperation with the bottom punch and side die, the powdered metal mold insert 15 with its portion of the casting cavity C. Accordingly, the punch has an annular surface 31 which produces that portion of the mold insert 15 lying along the parting line 12. The nose of the punch, which protrudes downwardly below the surface 31, is formed with sections 32, 33 and 34 which lie at different levels, the portions 32 and 33 being joined by an upwardly curving or inclined surface 35.

In order to obtain as high a degree of accuracy as possible in respect to shape and dimensions of the casting cavity C, it is important that the greatest possible uniformity and density of the compressed metal powder be obtained throughout all wall sections of the inserts 15 and 16. The more uniform the density the less distortion occurs due to uneven shrinkage of the powdered metal during the sintering operation. Where the article to be cast has different levels, such as the different levels or heights clearly shown by the casting cavity C, the punch 30 which forms this cavity in the insert will also have these corresponding levels, as indicated by the levels 32, 33 and 34 in Figs. 4 and 5. If it is attempted to prepare the mold insert by compressing a mass of powdered metal introduced between the punches 28 and 30, the powder at the different levels of the punch 30 will be pressed under different pressures and the densities of the compressed powder will correspondingly vary. In other words, utilizing the punch 30 shown in Figs. 4 and 5, the powdered metal after compression would normally be compacted to the greatest extent so as to produce the greatest density opposite the highest level 32 of the punch. The density of the powdered metal would decrease opposite the curved surface **35** and would be increasingly less opposite the successive lower levels **33**, **34** and **31** in proportion to the distances of these levels from the level **32**. Thus, in the absence of mold compensating means in accordance with the present invention for increasing the density of the powdered metal opposite the different levels **31**, **33**, **34** and **35**, the finally compressed powdered mold would have widely varying densities and would not produce a satisfactory mold after the sintering operation. This variation in compactness and density arises from the fact that the metal powder will not flow under pressure as in the case of flowable or plastic materials, and hence, the compression of the powder opposite different levels of the punch will vary.

According to the present invention, therefore, I obtain a high degree of uniformity in density of the pressed metal powders by compensating for the lower levels in the punch through the medium of pre-formed powdered metal briquettes. These briquettes are pre-compressed to the desired extent and are so dimensioned that they may be positioned within the die before the pressing operation commences and arranged opposite and coextensive with the lower levels of the punch so as to increase the density of the final mold to the desired extent. Thus, as illustrated in Figs. 4 and 5, an annular or ring-shaped pre-compressed powdered metal briquette **37** is positioned opposite the annular flat surface forming the lowest level **31** in the punch **30**. A pre-compressed powdered metal briquette **38** is positioned opposite the surface forming the next lower level **34**, the adjacent surfaces of briquette **38** and level **34** being coextensive. A pre-compressed powdered metal briquette **39** is positioned opposite the next lower level **33**, and a pre-compressed briquette **40** is positioned opposite the curved level **35**, the adjacent surfaces of these briquettes and the associated portions of the punch being coextensive.

With the lower punch **28** and die **25** positioned in the press as illustrated in Fig. 4, and the upper punch **30** retracted, a mass of powdered metal **41** is introduced into the bore **27** over the lower punch, the level of fill of the powder being indicated by the line **42**. Thereafter the pre-formed and pre-compressed powdered metal briquettes **37—40** are embedded in the powder **41** and arranged opposite the various levels of the punch **30**, as clearly illustrated in Fig. 4. After the pre-formed briquettes have been properly positioned and firmly embedded in the powder, an additional small amount of metal powder may be sprinkled over the briquettes in order to fill any crevices, cracks or voids therebetween and provide a slight covering therefor. Thereupon the upper punch **30** is caused to descend so as to position the same in the shaped cavity formed between the pre-formed briquettes **37—40** and the intervening level of powder **42**, as in the manner shown in Fig. 5. With the lower punch in stationary position on the bed **24** and the die **25** in like manner supported on the removable blocks **26**, the descent of the upper punch is continued so as to apply pressure and compress the powders, resulting in consolidating the pre-formed briquettes intimately and homogeneously with the mass of loose powder **41**. Thereupon the pressure of the upper punch is released to permit removal of the blocks **26**, after which the upper punch is caused to descend again. Inasmuch as the die **25** at this time is unsupported it will move in unison with the upper punch relative to the lower punch **28** thereby resulting in upward pressure being exerted by the stationary lower punch against the bottom of the compressed briquette equalizing the density of the powder. The briquette thus compressed under predetermined pressure will be of substantially uniform density throughout and may thereafter be heat treated or sintered to produce the final mold unit **15** without danger of any appreciable buckling, warping or distortion. It will be understood that the mold unit **16** or any other selected mold unit or section may be produced in accordance with the foregoing described method utilizing pre-compressed briquettes at regions where variations in levels exist so as to increase the amount of powder at these regions and compensate for variations in density of the compressed powdered metal which otherwise would occur by the use of conventional methods.

It will be manifest that the dimensions as to width, height and shape of the pre-compressed or pre-formed briquettes **37—39** will be governed by the dimensions of the low level areas of the upper punch, or the complementary areas of the article being formed, as well as the differences in height of the several levels. The densities of the pre-compressed briquettes may of course vary but should be selected in advance in order to determine the correct heights or thicknesses in a vertical direction of the briquettes. The amount of pre-compression of the powder to form the briquettes **37—39** should preferably be such as to give as low a density as possible while permitting safe handling thereof without disintegration or crumbling of the briquette. Assuming that the selected density of the finally compressed mold is on the order of 95 grams per cubic centimeter, and the compression ratio is approximately three to one, the pre-formed briquette may be satisfactorily formed with a density on the order of approximately 70 grams per cubic centimeter. The height or vertical thickness of the briquette may be readily calculated by the following formula:

$$\frac{D^1}{D^2}\times H=T$$

where D^1 is the desired density of the final briquette, D^2 is the selected density of the pre-formed briquette **37**, **38**, **39** or **40**; H is the distance between the highest level and the level opposite which the briquette is to be placed; and T is the vertical thickness of the pre-formed briquette. Assuming that the distance between levels **31** and **32** is three inches, and using the density values mentioned above by way of example, then the vertical thickness of briquette **37** would be calculated as follows:

$$\frac{95}{70}\times 3=4.07 \text{ inches}$$

It will be understood that the densities of the pre-formed briquettes may be varied to suit conditions and that small amounts of suitable binders, such as sugar water, syrup or any other material which on heat treatment will char or reduce to a harmless carbon residue, may be added to the metal powder in order to facilitate handling of the pre-formed briquettes. Irregular or odd shapes of pre-formed briquettes may be formed in suitably shaped dies or may be cut from pre-formed plates, slabs, cylinders, rings, etc.

From the foregoing it will be seen that substantially uniform density distribution, equalization of strength throughout all sections of the final briquette, freedom from distortion during heat treatment or sintering, and greater accuracy in detail of contour and shape are achieved by virtue of the present invention. As a consequence the molds 15 and 16 produced from sintered briquettes in accordance with the present method will not only be highly permeable but will be stronger, more durable and lasting and more accurate in all respects.

Although castings produced in ferrous metal molds embodying the present invention will have relatively smooth surfaces free from excessive pitting, even superior results may be achieved by providing a metallic surfacing or coating over the inner surfaces of the molds 15 and 16. A thin film of chromium, or other high heat resistant metal, is deposited over the mold surfaces by ordinary electrolytic procedure. However, the deposition of the chromium is conducted so as to eliminate the absorption of hydrogen by the metal which, in carrying out the process, is in effect de-hydrogenated. The chromium film will not obstruct or close the minute pores which permeate the mold but instead form thin protective walls or layers around the pore openings at the surface of the mold, and due to its high heat resistance properties will prevent over prolonged periods of use any tendency of the metal of the mold to fuse at the surface thereof and close off the pore openings. The pores in the surface of the chromium film provide a multitude of tiny expansion areas enabling the chromium film to expand and contract sufficiently to resist cracking, flaking or peeling during the casting operation. A chromium surface powdered ferrous metal mold in accordance with the present invention may be used advantageously for casting various metals, such as aluminum and brass. In fact, highly successful results have been obtained in making repeated runs of steel castings in a powdered ferrous metal mold surfaced with chromium. Even though the molten steel was poured at a temperature on the order of 2800° F. no destructive effects on the surface of the mold were discerned.

I claim:

1. The method of making a powdered metal mold utilizing a forming punch contoured with different levels, including the steps of supporting a loose mass of powdered metal in a confined space opposite said punch, positioning a pre-compressed powdered metal briquette in said mass opposite a lower level of the punch, and consolidating said mass and briquette together by pressure exerted thereon by said punch.

2. The method of making a powdered metal mold utilizing a forming punch contoured with different levels, including the steps of supporting a loose mass of powdered metal in a confined space opposite said punch, positioning a plurality of pre-compressed powdered metal briquettes of different thicknesses in said mass opposite the different lower levels of the punch, and consolidating said mass and briquettes by pressure of the punch.

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