Sept. 30, 1969 P. VINSON 3,469,283

POWDER HOPPER FOR POWDER COMPACTING PRESS

Filed Feb. 24, 1966 2 Sheets-Sheet 1

FIG. 1

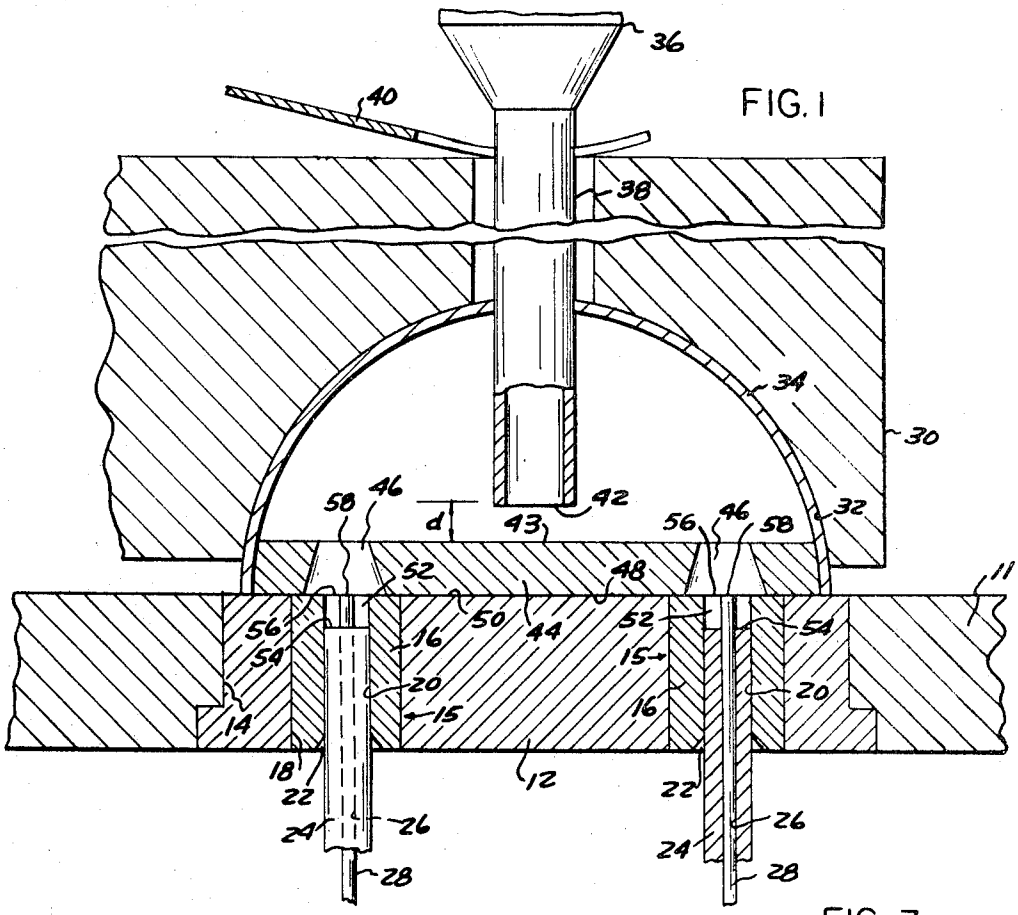


FIG. 2

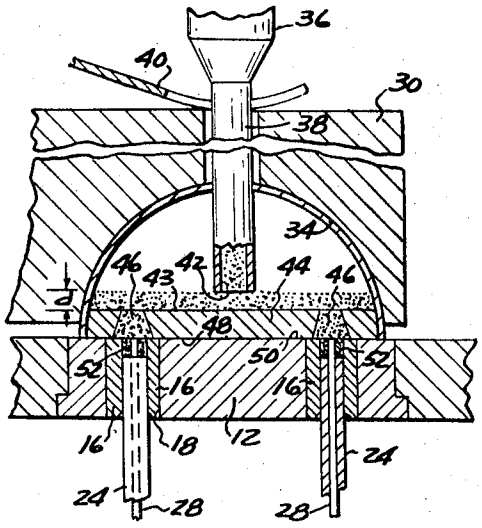
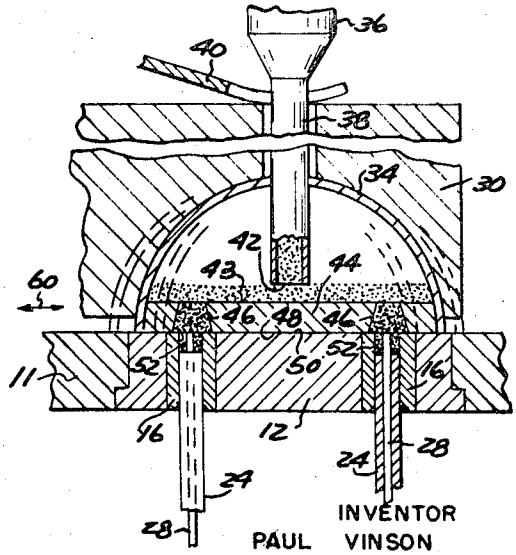


FIG. 3



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POWDER HOPPER FOR POWDER COMPACTING PRESS

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FIG. 4

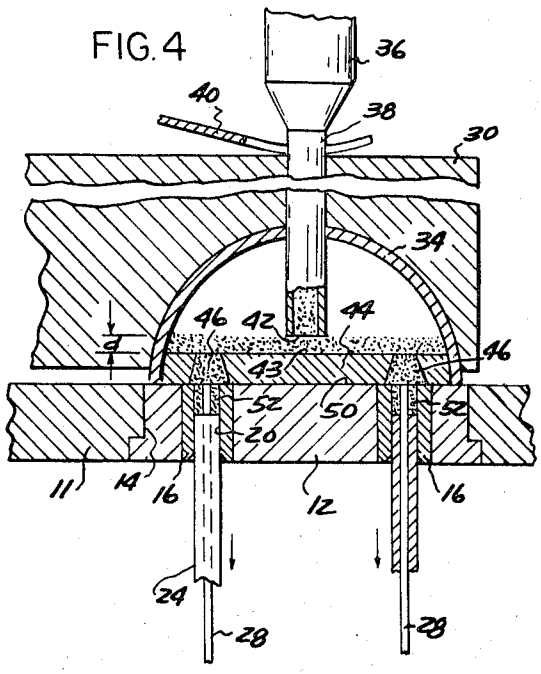


FIG. 5

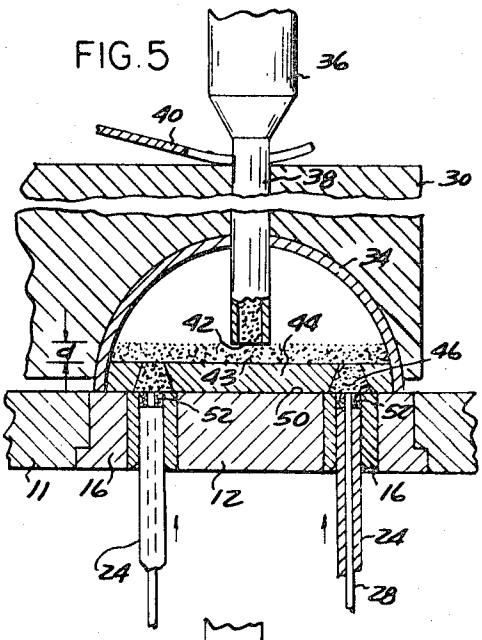


FIG. 6

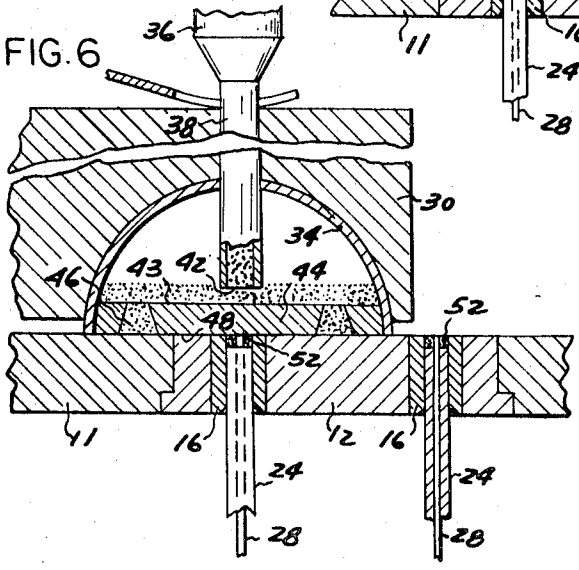
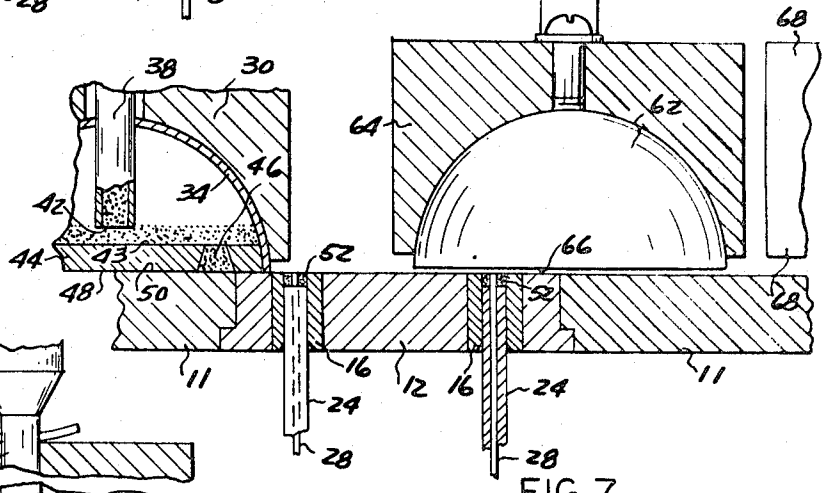


FIG. 7



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POWDER HOPPER FOR POWDER COMPACTING PRESS

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Int. Cl. B29c 3/00
U.S. Cl. 18—16 4 Claims

ABSTRACT OF THE DISCLOSURE

A powder hopper for powder compacting press consisting of a primary hopper connected by way of a flexible conduit to a gravity fed secondary hopper displaceable over a die plate having die cavities to be filled with powder. The secondary hopper has an inlet disposed at a predetermined distance above the die plate and has a closure plate provided with apertures disposed to correspond to the die cavities when the secondary hopper is displaced thereover. The powder flowing by gravity from the primary hopper into the secondary hopper is held at a substantially constant level in the secondary hopper and, preferably, the secondary hopper is vibrated during filling of the die cavities to improve the powder flow into such cavities.

The present invention relates to powder hoppers for powder compacting presses and the like, and more particularly it relates to an improved powder hopper providing accurate fill of the die cavities of a powder compacting press with an exact amount of powder for compacting into a finished article having well defined characteristics.

The present invention is an improvement upon the secondary powder hopper disclosed as part of the powder compacting press being the subject matter of copending application Ser. No. 450, 427, filed Apr. 23, 1965, and now abandoned, and of copending applications Ser. Nos. 529,733, 529,734 and 529,842, all filed Feb. 24, 1966, and now U.S. Patent Nos. 3,328,840, 3,344,214, and 3,328,842, respectively, and Ser. No. 618,230, filed Feb. 23, 1967, now U.S. Patent No. 3,415,142. The powder compacting press described and claimed in the copending patent applications consists of a machine for the purpose of manufacturing cores, beads, pellets, balls, etc., made of powder, ferrite, glass, or any other powder metal or comparable substance. The primary purpose of the machine is the manufacture of memory cores which are normally toroidal, pills such as pharmaceutical pills, balls for ball point pens, porous bearings and bushings, and the like. Memory cores and porous bearings and bushings are normally toroidal, although, pharmaceutical pills may be in the forms of tablets such as aspirin tablets, and balls for ball point pens are spherical.

Ferrite cores have dimensions from approximately .005 to .015 inch in thickness, and from approximately .005 to .025 inch in diameter, and the accuracy of the dimensions must be held to within 1/10 of a thousandth of an inch. The density of the cores must also be held accurate, thereby making it necessary that the fill or amount of powder placed in each die cavity of the press must be substantially the same and must be repetitively maintained within very close limits. The resulting density of all the cores must be the same, that is, it must be uniform and accordingly, the compressing of the powdered material must be exact and repeatedly constant. If these dimensional and density specifications are not held within close tolerances the playback level from the cores in a memory stack will not be substantially constant from core to core. In order to realize these dimensional accuracies, it is necessary that the press be capable of accurate adjustment

of movements of several parts within at least fifty millionths of an inch, and that precautions be taken to insure correct fill of each die cavity. The powder in each die cavity is compressed by means of a punch which not only controls the dimensional thickness to which the cores are compressed, but which also controls the amount of fill of the die cavity with powder, and consequently controls the quality and density of the finished articles.

In the preferred exemplary form of a powder compacting press as disclosed in the hereinbefore referred to copending applications, the articles are compacted and formed in a multicavity die. The finished articles are automatically ejected from the die, are picked up by a vacuum suction head and are delivered into vials or bottle. A flipper assembly, which is part of the press, is mounted movable transversely over the die and carries a secondary powder hopper, an anvil, and a vacuum pick up head. The secondary powder hopper, which is supplied in powder from a primary hopper connected thereto by means of a flexible tubing, is first positioned over the die cavities, the die cavities are filled with powder to overflow, the punches are displaced so as to expel from the die cavities a predetermined amount of excess powder, the hopper is removed while wiping the die surface clean from excess powder, and the secondary hopper is replaced by the anvil which is in turn positioned over the die cavities.

The powder in each die cavity is then compacted against the anvil by way of the punches, the anvil is removed and replaced by the vacuum pickup head. The punches are caused to be displaced so as to bring the ends thereof substantially flush with the opening of each die cavity, so as to eject the finished compacted articles from the die cavities and enable them to be picked up by the vacuum pickup head. The vacuum pickup head is then moved from over the die cavities and displaced over a series of ducts disposed in an arrangement similar to the arrangement of the die cavities in the die, preferably in a circle, and the articles are dropped into separate vials or bottles.

The present invention refers to an improvement of the secondary powder hopper which insures accurate fill of the die cavities with an appropriate amount of powder material, and which permits the punches to be displaced in the die cavities so as to expel therefrom the excessive powder without impressing upon the powder in each die cavity a pressure partly compacting the powder, or, alternately, which insures that whatever amount of compacting is exerted during the expulsion of the excess powder from the die cavities is uniformly the same from die cavity to die cavity and repetitively the same each time the secondary hopper is placed over the die cavities for filling thereof. Additionally, the present invention insures that the die surface is wiped clean of excess powder when the secondary hopper is moved away from over the die.

Consequently, the principal object of the invention is to provide a secondary powder hopper for a powder compacting machine which provides uniform and repetitive fill of the die cavities so as to obtain finished articles of the same density.

An additional object of the present invention is to provide a powder hopper for a powder compacting machine which provides minimum compacting of the powder during the die cavity fill operation preceding the compacting operation.

A further object of the invention is to provide a practical and foolproof powder hopper for powder compacting machines which is not subject to wear and which requires a minimum of maintenance.

Further objects and advantages of the present invention will become apparent when the following description is considered in conjunction with the accompanying draw-

ings wherein like reference numerals represent like parts and in which:

FIGURE 1 represents a schematic cross-sectional view of a secondary hopper according to the present invention disposed over the die cavities of a powder compacting press;

FIGURE 2 is a figure similar to FIGURE 1, but illustrating a die fill operation;

FIGURE 3 is a figure similar to FIGURE 2, but illustrating the secondary hopper being oscillated or vibrated for the purpose of completely and evenly filling the die cavities with powder;

FIGURE 4 is a figure similar to FIGURE 3, but illustrating how the punches in the die cavities are pulled down in order to help or assist in drawing or injecting a predetermined amount of powder into each die cavity;

FIGURE 5 illustrates how the punches are displaced upwardly in order to expel from the die cavities a predetermined amount of excess powder;

FIGURE 6 illustrates how the secondary hopper wipes clean the surface of the die; and

FIGURE 7 illustrates the die cavity filled with powder to an even level flush with the surface of the die, with the secondary hopper moving away and the anvil portion of the press in the process of moving into position over the die cavities.

Referring now to the drawings, and more particularly to FIGURE 1 thereof a powder compacting press, not shown, comprises a table portion **11** supporting a tooling capsule comprising a die **12** disposed in a countersunk bore **14** in the table portion. The die is held in position by means, not shown, such as clamps or screws. The die is provided with a plurality of cavities which in the examples shown, are arranged to cooperate with appropriate punches in order to form finished articles in the form of toroids, such as magnetic cores. It should, however, be appreciated that the die cavities may have any shape whatsoever, without departing from the spirit and scope of the invention, and that it is contemplated to utilize the principles as disclosed herein for filling die cavities in the manufacture of pellets, pills, balls, etc., made of compacted powder material or substance.

The die cavities designated generally by numeral **15** are defined by die inserts such as shown at **16**, substantially in the shape of bushings made of hard material preferably such as a carbide, and press-fitted or otherwise fastened into appropriate bores **18** in the die. The die inserts **16** have a longitudinal bore **20** having a chamfered portion **22** disposed at the lower end thereof, as seen in the drawings. The tooling capsule also comprises slidably disposed in each bore **20** a punch **24** having an outer diameter accurately fitting the inner diameter of the insert bore **20**. In the example of punch assemblies shown in the drawings, each punch **24** has a longitudinal bore **26** extending therethrough from end to end in which is slidably disposed a core rod member **28** having close fit within the inner bore **26**. The punches and the core rod members are separately reciprocable by means, not shown, which are explained in detail in the copending application.

Alternatively, the core rods **28** may be held stationary while the punches **24** are capable of reciprocation within the insert bores **20**. There is a plurality of punches **24** with core rod members **28** disposed therein corresponding to the plurality of die cavities, the latter being generally disposed in a circle, and all the punches are reciprocable in unison and the core rod members are also reciprocable in unison or, alternately, held stationary in a predetermined position. The chamfered portion **22** disposed at the lower end of the bore **20** of the die inserts **16** is to facilitate assembly of the punches **24** within the die inserts, the punches being generally self-centering in the bores **20** and the core rod members **28** being also self-centering in the longitudinal bores **26** within the punches.

As referred to in greater details in the above mentioned copending applications, the compacting press is provided with a flipper member, not shown in the accompanying drawings, carrying, among others, a support member **30** having a substantially hemispherical cavity **32** formed in one end thereof. In the hemispherical cavity **32** is disposed a hemispherical hollow secondary hopper **34** connected to a primary powder hopper **36** by means of a flexible tube **38**. The secondary hopper support member **20** is hingedly mounted upon the body of the flipper member and is normally biased toward the die **12** by means such as flat spring **40**.

The end of the tubing **38** projecting through the interior of the hollow secondary hopper **34** is open, as shown at **42**, a predetermined distance away from the upper face **43** of a plate **44** obturating the open end of the hemispherical secondary hopper **32**. The plate **44**, which is fixedly mounted upon the open end of the secondary hopper by means such as welding, soldering, brazing, or by any other conventional means, is preferably made of a hard material such as a carbide and is provided with a series of apertures **46** disposed so as to normally correspond to the openings of the die cavities **15**. In the example of secondary hopper shown in the drawings, the apertures **46** in plate **44** are preferably made in the shape of frustoconical bores with their larger diameter end disposed toward the die cavities.

The lower face **48**, as seen in the drawings, of the plate **44** is ground and polished to a very high finish, and the upper face **50** of the die **12** is also ground and polished to a very high finish to insure perfect contact and fit between the two surfaces, substantially similar to the polish and resulting fit existing between high precision master gage blocks, well known in the gaging art.

In operation, the secondary hopper **34** is placed over the die **12** by action of the flipper member, so that the apertures **46** of plate **44** correspond with the open end of each bore **20** of the die inserts **15**. Powder is allowed to flow from the primary hopper **36** through tubing **28** and be introduced by way of tubing end **42** into the interior of the secondary hopper **34** to a self-seeking level above the upper face **43** of plate **44** substantially at a constant distance *d* from said upper face. Powder flows by gravity through each aperture **46** into a space **52**, in the die cavities, defined between the end face **54** of each punch **24** and the open end **56** of each die cavity. In arrangements where the punches are provided with core rod members, the end **58** of each core member **28**, previous to the filling operations, has been brought or adjusted flush with the plane defined by the open end **56** of each die cavity. The herein enumerated succession of steps explaining the operation of the improved secondary hopper of the invention is described in relation to a tooling capsule for compacting toroidal articles including core rod members disposed within the punch members. It is evident, however, that the principles of operation of the invention are the same, irrespective of the type of tooling used and irrespective of the shape of the compacted finished articles.

FIGURE 2 shows the die cavity spaces **52**, above the punch ends **54**, being filled with the powder situated in the interior of the secondary hopper **34** to the level substantially at a constant distance *d* from the upper face **43** of plate **44**. FIGURE 3 illustrates an optional, although preferred, step in the die cavity filling operation, whereby the secondary hopper **34** is oscillated or vibrated sideways by means of appropriate control of the flipper member of the machine, or by means of appropriate motions impressed upon the hopper support arm **30**. The lateral reciprocable oscillatory motions of the secondary hopper **34**, as arbitrarily represented by arrow **60**, and oscillating the secondary hopper from the position shown in full lines to the position shown in phantom, for example, causes the grains of powder to roll over one another and shakes the powder back and forth over the die cavities so as to completely fill the spaces **52**, preventing the formation of

air pockets or uncontrolled buildup of grains adhering to each other and thus forming voids in the midst of the powder mass in the cavity spaces **52**.

As shown in FIGURE 4, simultaneously with the oscillation of the secondary hopper **34** over the die **12** in operations where such optional preferred step has been adapted, the punches **24** are withdrawn downwardly of a predetermined distance to help and assist in drawing powder evenly into the spaces **52**.

It is evident that during all the filling operation, steps hereinbefore explained, any powder falling into the die cavity spaces **52** is immediately volumetrically replaced by powder flowing out of end **42** of tube **38** so as to maintain the upper level of powder substantially constant. Consequently, the pressure exerted by the head of powder disposed above the powder grains at the bottom of the spaces **52** is proportional to the sum of the distance *d* of the powder level above the upper face **43** of plate **44**, the thickness of the plate **44** and the depth of the spaces **52**. As the sum of these dimensions are of the order of a few thousandths of an inch, the pressure head exerted on the lower grains in the cavity spaces is substantially small and, because of the even level of the powder within the hopper chamber, the pressure due to this head is substantially the same for all the die cavities and is repetitively the same from one fill operation to another. Consequently, the density of the powder introduced into the die cavities during the fill operation is the same for all the cavities and is repetitively the same from one fill operation to the next, with the result that the amount of compacting of each finished article is the same, thus providing finished articles which are not only similar dimensionally but are also similar as to density and quantity of material included in each article.

FIGURE 5 illustrates how the punches **24** are actuated upwardly in order to expel from the cavity spaces **52** any excess quantity of powder so as to insure that each cavity space is first filled with an excess of powder which is subsequently removed so as to obtain a remaining finite quantity of powder filling a finite space **52** in each cavity preparatory to compacting of the powder in each space **52** into a finished article.

In FIGURE 6 is shown the wiping action of the lower face **42** of plate **44** when the secondary hopper **35** is moved from over the die to a position away from the die. It can be seen that during the displacement of the secondary hopper away from the die, the lower edge of each aperture **46** in plate **44** operates as a wiper evening the level of the powder contained in each space **52** and carrying away any surplus powder. The lower face **48** of the plate **44** and the upper face **50** of die **12** being ground and polished to a superfinish, there is no possibility for any grain of powder being trapped between the surfaces and damaging them.

In FIGURE 7, the secondary powder hopper **34** is shown in the course of being moved away from the die by the motion of the flipper member, not shown, and the anvil **62** supported by anvil holder **64** in the course of being transferred over the die cavities having spaces **52** completely and evenly filled with powder. As explained in details in the copending applications, the anvil **62** is indexed over the die **12** and the face **66** of the anvil is forced to engage the upper face **50** of the die. The punches **24** are displaced upwardly, as seen in the drawings, so as to compress the powder in the spaces **52** into compacted finished articles which, in the example shown here, are in the form of toroids. Numeral **68** represents the vacuum pickup head which, subsequently to the forming of the finished articles, is used to pickup the articles ejected from the die cavities by further upward travel of the punches after removal of the anvil from over the die.

It can thus be seen that the present invention provides a secondary powder hopper for a powder compacting press which fulfills and achieves all the objects and advantages herein presently indicated. More particularly, the secondary powder hopper of the invention provides means for filling die cavities with a predetermined quantity of powder material under a predetermined static pressure head as a result of a predetermined thickness of loose and free flowing powder being disposed above the cavities, so as to limit to a finite and almost negligible amount the degree of self-compacting of the powder in the cavities before the actual controlled compacting operation, so that all the finished articles are substantially similar in dimensions and material density.

It is evident that a powder hopper according to the invention has many applications, particularly in all types of powder compacting presses or machines and the specific example of powder hopper given in the present specification is not intended to be exhaustive or to be limiting of the invention. The herein illustrations and description have been given in order to permit others skilled in the art to be enabled to modify the invention and to adopt and apply it in numerous forms each as may be best suited to the requirement of the particular use.

What is claimed as new is:

1. In an apparatus for making articles compacted from powder, by means of a die having a plurality of cavities and a punch disposed at the bottom of each of said cavities and movable therein for compacting said powder, a hopper arrangement for gravity fill of said cavities with said powder comprising:

a primary powder hopper having an outlet at the bottom thereof;

a secondary powder hopper comprising an enclosure with an open end having a rim in contact with the surface of said die and displaceable relatively thereto to a position over said die cavities;

a flexible conduit having an end connected to the outlet of said primary hopper and another rigid end leading within the enclosure of said secondary hopper;

a closure plate obturating the open end of the enclosure of the secondary hopper;

a polished lower surface in said closure plate continuously engaged with the upper face of said die;

apertures in said closure plate each corresponding to one of the die cavities; and

an outlet for said rigid end of the conduit in said secondary hopper situated a predetermined substantially short distance above the upper surface of said closure plate for limiting the level of the powder flowing by gravity in said enclosure from said primary hopper to a predetermined constant level.

2. The hopper arrangement of claim **1** wherein each aperture in the closure plate is frustoconical and has its larger diameter substantially larger than the diameter of the corresponding cavity in the die and disposed toward said cavity.

3. The hopper arrangement of claim **2** wherein said closure plate is made of a carbide.

4. The hopper arrangement of claim **1** further comprising means for oscillating said enclosure when said enclosure is positioned over said cavities.

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U.S. Cl. X.R.

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