Aug. 18, 1970 S. J. DAVISON 3,524,220

DIE SET FOR COMPACTING POWDER

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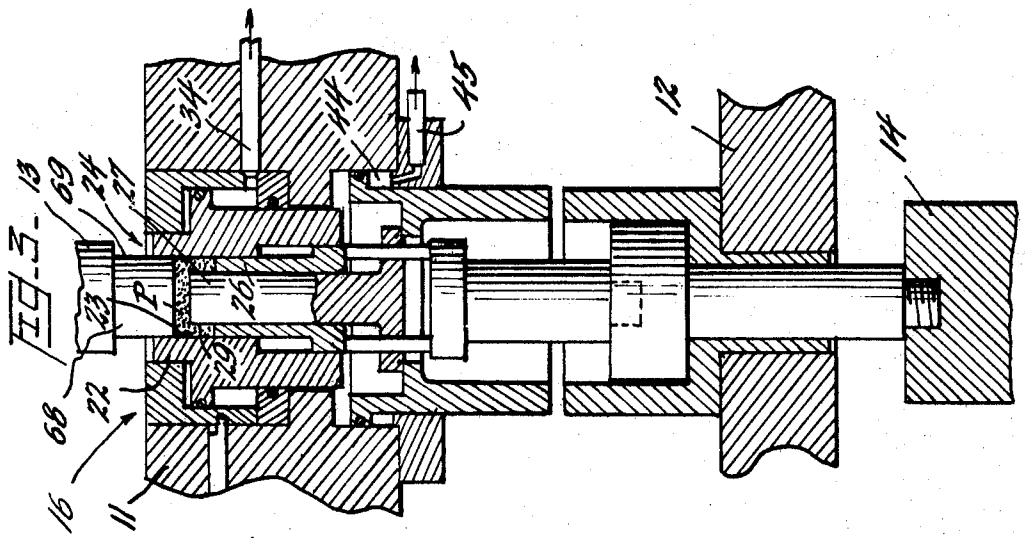


FIG. 3

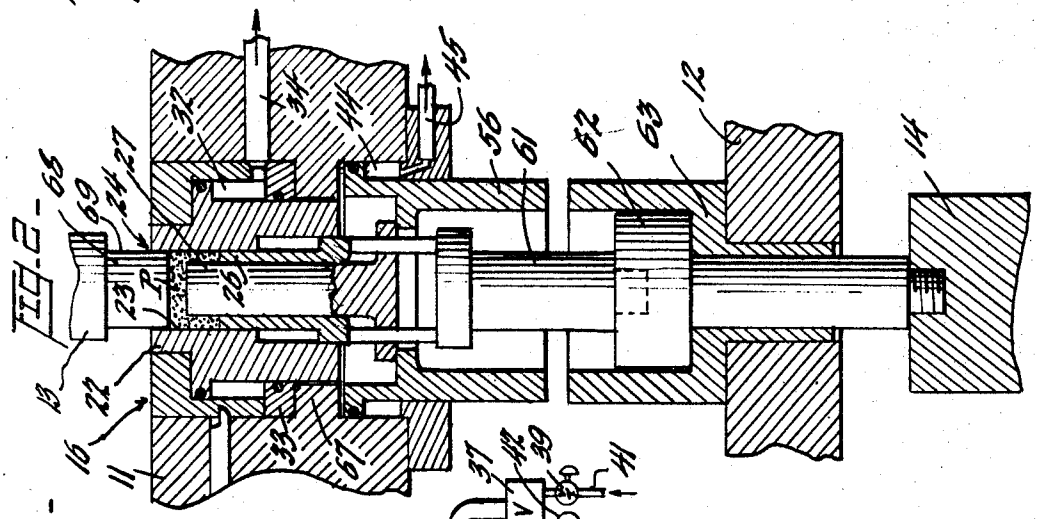


FIG. 2

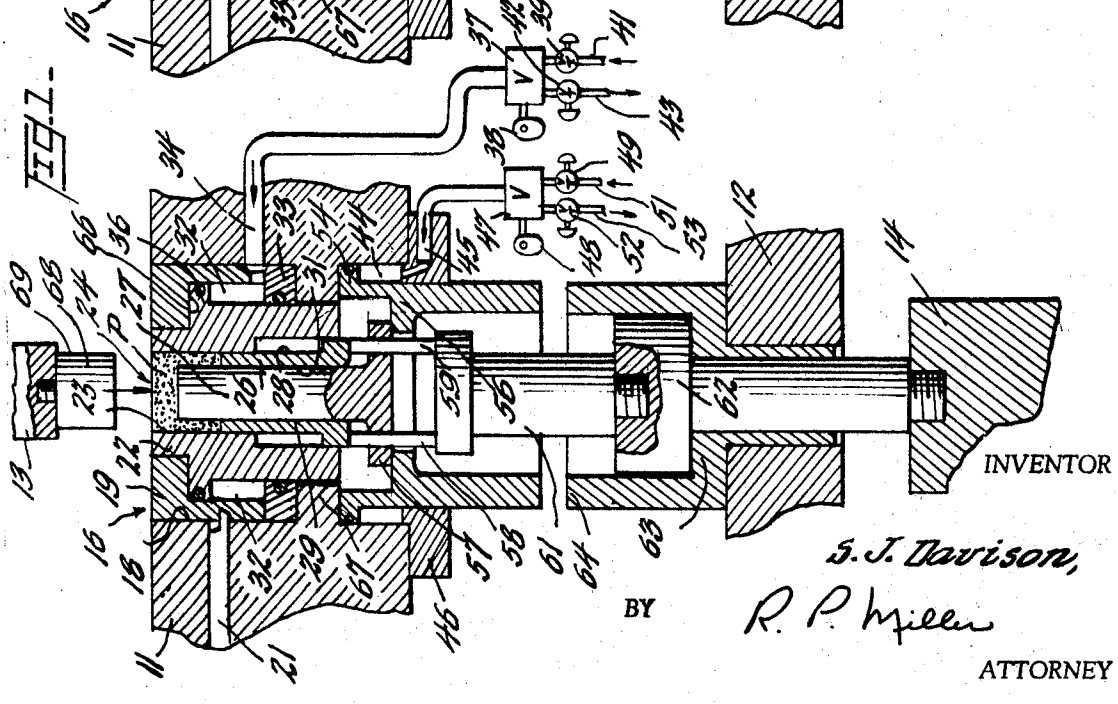


FIG. 1

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FIG. 6

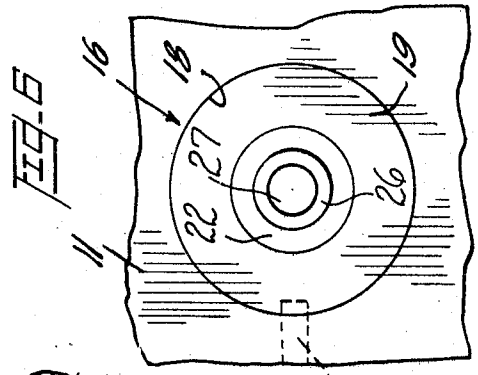


FIG. 5

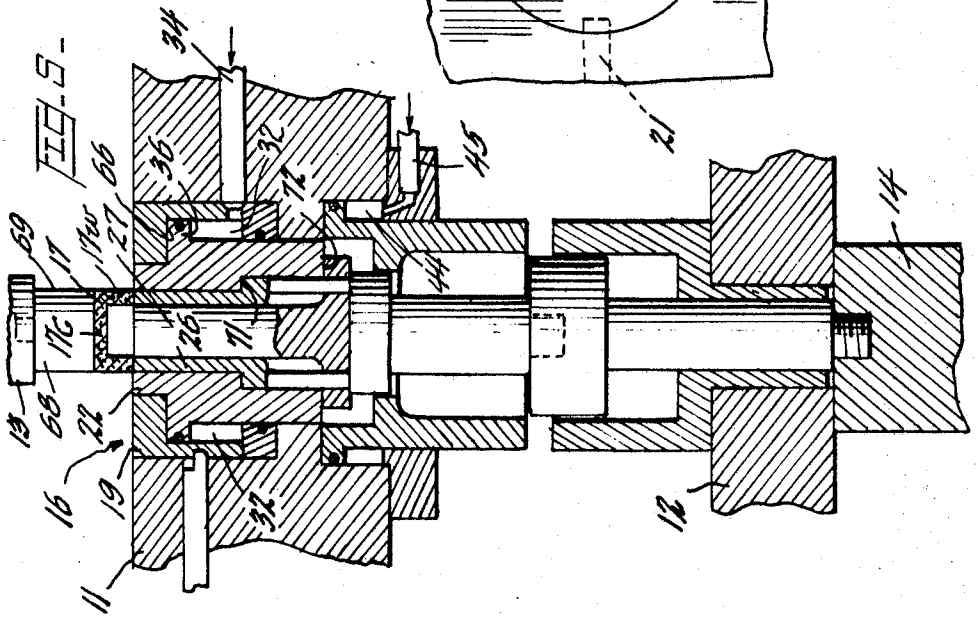
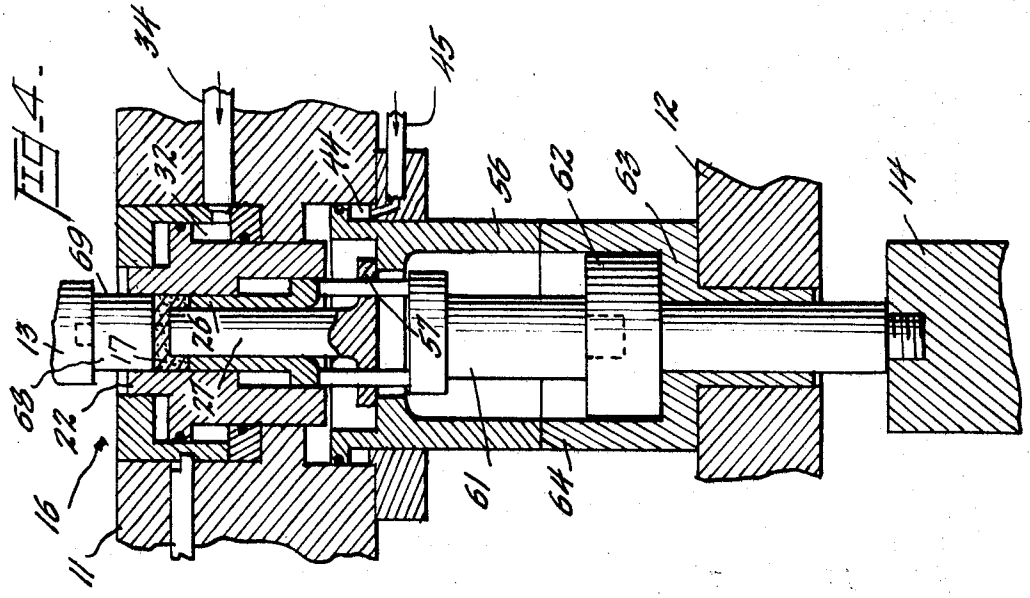


FIG. 4



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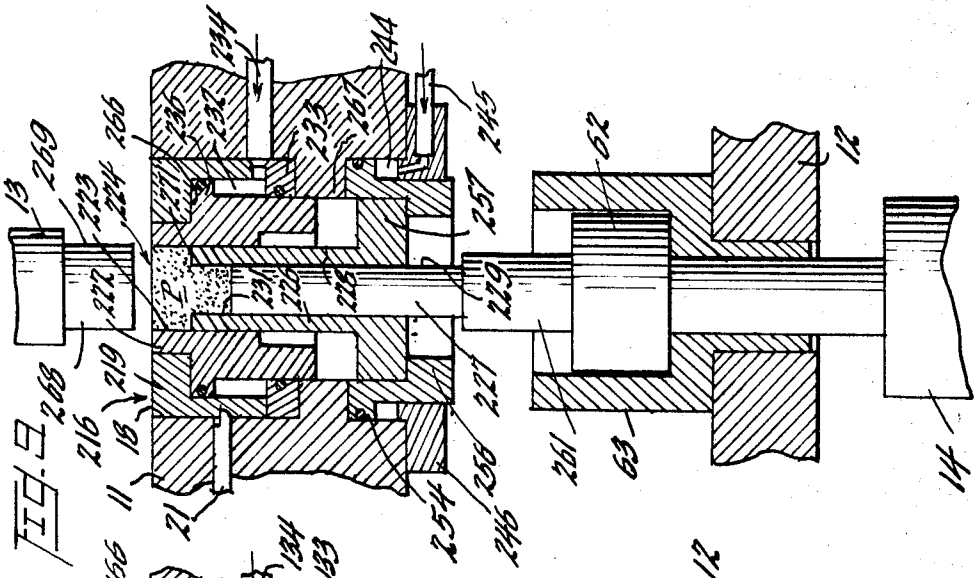


FIG. 5

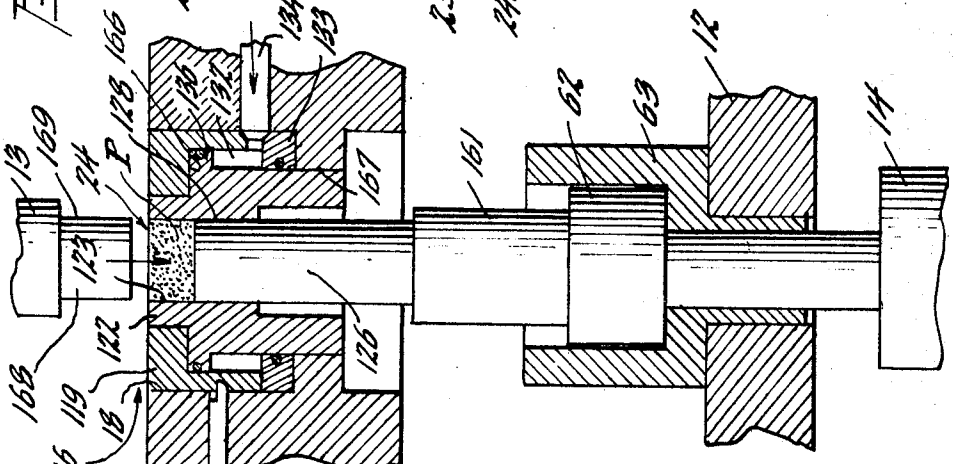


FIG. 6

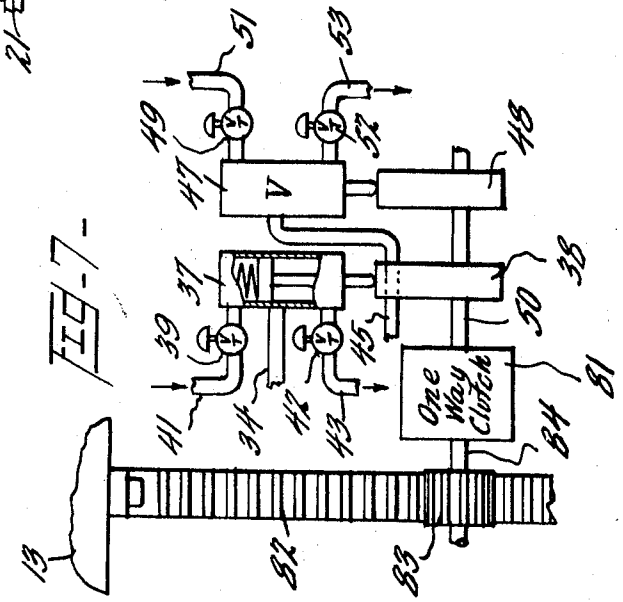


FIG. 7

United States Patent Office 3,524,220 Patented Aug. 18, 1970

3,524,220

DIE SET FOR COMPACTING POWDER

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Filed Nov. 15, 1967, Ser. No. 685,732
Int. Cl. B29c 3/00
U.S. Cl. 18—16.7 3 Claims

ABSTRACT OF THE DISCLOSURE

A secondary action type die set is usable for compacting powder in a single action type press. An outer wall defining a die cavity and a reaction die member are each supported independently by pressurized fluid in separate chambers within the die. Compacting forces exerted upon powder in the die cavity cause yielding movements of both the reaction die member and the outer wall away from an advancing primary die member as the powder is compacted and fluid is exhausted from the chambers. Exhaust back pressures are controlled by separate throttle valves for each chamber.

BACKGROUND OF THE INVENTION

In the manufacture of articles by compacting powder into unitary, coherent masses, secondary action and multiple action type presses are known. Secondary action type presses include at least one reaction punch which is supported resiliently by pressurized fluid. Multiple action presses are those which include two or more independently fluid-supported reaction punches. In presses of these types, the reaction punches of the press act as yieldable supports for reaction die members, against which the powder is compacted by movement of primary die members carried by one or more primary punches of the press. A compacting force is applied to the powder by the primary dies through operation of the press to move the primary punches of the press in the direction of the reaction punches of the press. This results in a yielding movement or secondary action of the reaction punches and the reaction dies supported thereon away from the primary punches and the primary dies carried thereby.

It is desirable that the powder compacting operation take place with as great a degree of uniform powder pressurization as possible. A minimization of shear stresses in the powder being compacted is also desirable. The uniform pressurization and minimization of shear stresses decreases the possibility of the occurrence of a powder spill-over, that is, a shifting of powder during compacting from a zone of relatively high pressure to a zone of relatively low pressure. Such occurrence results in a product containing undesirable dislocation regions and areas of nonuniform density.

Secondary and multiple action operations are effective to apply compacting pressure to the powder with substantial uniformity. Relative movement between reaction die members is permitted by the mounting of such members on reaction punches of the press which are separately fluid-mounted. This allows the forming of articles of relatively complex shape while maintaining the desired pressure distribution throughout the powder being compacted.

Known secondary and multiple action type presses, however, may involve two or more primary punches and two or more fluid-supported reaction punches. Such presses are, therefore, relatively complex and costly machines, suited only to a specific powder compacting operation. It is, therefore, desirable to provide mechanisms whereby a standard, universal type press which is not of the secondary or multiple action type may be employed to compact powder uniformly, thereby to form articles either of simple or of complex shape, for example, ferrite cores.

Additionally, a major source of shear stresses and pressure variations in known powder compacting dies occurs from surface friction caused by interaction between the powder being compressed in a die cavity and stationary outer walls bounding the die cavity. Fluid support of the outer walls, allowing movement thereof as powder is compacted and delayed application of maximum force until after partial compacting has occurred, may serve to greatly lessen the presence and effect of destructive shear stresses in the vicinity of the outer walls.

SUMMARY OF THE INVENTION

An object of the invention resides in new and improved apparatus for forming articles by compacting powder in substantially uniform manner through utilizing a die set having secondary or multiple action capability, rather than a secondary or multiple action type press.

The invention contemplates the provision of die sets having secondary or multiple action capability, for use with a single action type press, i.e., a press not including a fluid-supported reaction punch. Each such die set, used for producing a specific article of a desired shape and size, includes one or more reaction die members. Preferably, one or several of these reaction dies are supported as pistons by fluid in chambers located within the die set itself. The die sets are interchangeable in the single action press to produce different articles, each being of uniform consistency and essentially free of flaws. The desired secondary or multiple action for forming such articles, thus, is obtained through the operation of the die set, rather than from the press.

Preferably, the outer wall members, i.e., those members which bound the die cavity formed by the die members in each die set, are also fluid-supported, acting as hollow pistons within the die set. This allows movement of the outer wall with the powder being compacted, once the powder is compressed sufficiently to transfer tangential forces to the outer wall. Excessive friction-caused shearing stresses at the surface of the outer wall, involving relative scraping movements between the powder being compacted and the outer wall, are thereby avoided. The result is a minimization of these shear stresses and a more uniform pressure distribution within the powder during the compacting operation. Thus, articles, such as ferrite cores, may be manufactured with a minimal chance of a spill-over occurring.

Further, each of the reaction die members and the wall members is preferably supported on a separate column of fluid in a separate die chamber. Each such member, thus, may function completely independently of the other members, in reaction to compacting forces exerted by primary die members. Uniform articles of complex shapes may, therefore, be formed with the single action type press, multiple action being provided by the separately fluid-mounted reaction dies.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a side elevational view, partly in section showing a portion of a press, mounting removably therein a first embodiment of a secondary action type powder compacting die set constructed in accordance with the principles of the invention;

FIGS. 2–5 are side elevational views, partly in section, showing successive stages in the operation of the embodiment of FIG. 1;

FIG. 6 is a top view of the embodiment of FIG. 1 shown with the apparatus in a fill position prior to the introduction of powder into a die cavity of the die set;

FIG. 7 is an end elevational view of part of the apparatus showing a system for controlling both the application of pressurized fluid to portions of the die set and the exhausting of pressurized fluid therefrom;

FIG. 8 is a side elevational view, partly in section, illustrating the press with a secondary action type powder compacting die set constituting a second embodiment constructed in accordance with the principles of the invention; and

FIG. 9 is a side elevational view, partly in section showing the press with a die set constituting a third embodiment constructed according to the invention.

DETAILED DESCRIPTION

A first embodiment

Referring first to FIGS. 1–5, a portion of a single action type press is shown. The press may be any of various known hydraulically or mechanically operated types. Included as part of the press are a stationary die set body **11**, a stationary bolster plate **12**, a vertically movable top punch or ram **13**, and a vertically movable bottom punch or ram **14** axially aligned with the top punch **13**. The press removably mounts a secondary action type die set **16**, consituting a first embodiment constructed in accordance with the principles of the invention. The die set **16** is used to produce coherent, cup-shaped articles **17** composed of a solidly compacted powder, for example, ferrite core structures. FIG. 5 illustrates a finished article **17**, shown in cross section, which is ejected from the die set **16** after the completion of a compacting cycle.

Turning now to FIGS. 1 and 6, the press and the powder compacting die set **16** are shown in the operative conditions thereof at the start of a new compacting cycle. The rigidly mounted die set body **11** has an opening, which may be bounded by a circularly or otherwise shaped wall **18**, extending vertically therethrough within which the die set **16** is mounted. The die set includes a fixed die member or shouldered ring **19**. A die lock **21** is slidable horizontally in the die set body **11** to selectively lock the fixed die member **19** in place. Lateral movement of the die lock permits removal of the fixed die member and substitution into the die set body **11** of different die sets for compacting articles of different configurations and dimensions.

An annular die wall member or piston **22**, constituting a hollow cylinder or sleeve, has a vertical inner wall **23** thereof defining an outer, circular boundary of a die cavity or chamber **24** for receiving and compacting loose powder. A pair of concentric reaction die members or plungers **26** and **27** define the bottom of the powder-receiving cavity **24**.

The outer reaction die or plunger **26**, which is also an annular member constituting a hollow cylinder or sleeve, is vertically movable relative to the die wall member **22** with an outer wall **28** of the die **26** in contact with and enveloped by the inner wall **23** of the die wall member. The inner reaction die or central core rod **27**, which is in the form of a cylinder, is vertically movable within the hollow outer reaction die **26** with an outer wall **29** of the inner reaction die **27** in contact with and enveloped by an inner wall **31** of the outer reaction die **26**. The three die member **22**, **26**, and **27** which define the sides and bottom of the cavity **24** are all vertically movable relative to the fixed die set body **11** and the fixed die member **19** which is held against vertical movement by the die lock **21**.

An annular, sealed fluid chamber **32** is defined between boundaries of the fixed die member **19** and the die wall member **22**, with a sealing ring or annulus **33** forming the bottom of the chamber. A fluid, such as compressed air or other pressurized fluid, is controllably introduced into and exhausted from the chamber **32** through a fluid line **34**. Fluid line **34** communicates with the chamber **32** by passing through a bore in the fixed die member **19**. The line **34** may also, for the sake of convenience, travel through the die set body **11**, a suitable channel being built therein. The pressurized fluid in the chamber **32** acts as a horizontal support for an outwardly extending flange **36** on the die wall member **22**.

Supply or exhaust of fluid through the line **34** is controlled by a reversing valve **37**, operated in conventional manner, for example by rotation of a control cam **38** (FIGS. 1, 7). The exhausting of fluid from the chamber **32** permits vertical movement of the die wall member **22** in the manner of a fluid-suspended piston moving in a cylinder. A throttle valve **39** is located in a supply line **41** for regulating the flow of fluid into the reversing valve **37**. Another throttle valve **42** provides a regulatable back pressure in an exhaust line **43** leading from the reversing valve **37**.

Another annular, sealed fluid chamber **44** permits the application of a variable supporting pressure to the inner reaction die **27** by similarly controlled introduction and exhaust of fluid through another fluid line **45** extending to a passageway in an annulus **46** also constituting a part of the die set **16**. Similarly to fluid line **34**, fluid line **45** includes a reversing valve **47** operated by a cam **48** or other cyclical actuating mechanism. The cams **38** and **48** are mounted to a common cam shaft **50** (FIG. 7). Associated with the fluid line **45** are throttle valves **49** and **52**, and lines **51** and **53**, corresponding to the throttle valves **39** and **42**, and the lines **41** and **43**, respectively, which are associated with the fluid line **34**.

Separate and independent fluid systems are, thus, provided for the chambers **32** and **44**. The throttle valves **39**, **42**, **49**, and **52** may each be separately regulated, for example, manually, to proportion fluid supply and fluid exhaust flow rates between the lines **34** and **45**.

Referring to FIG. 7, the cam shaft **50** carrying the cams **38** and **48** is rotatable in a single direction through a conventional unidirectional or one-way clutch **81**. A rack **82** is mounted for movement with the top punch **13** of the press and is engaged with a pinion **83** on an input shaft **84** of the one-way clutch **81**. Downward movement of the top punch will cause rotation of the cam shaft **50** through the clutch **81** as the rack **82** rotates the pinion **83** and the shaft **84** in a forward direction. Upon movement of the top punch, raising the rack **82**, will cause rotation of the pinion **83** and the shaft **84** in a reverse direction, but the one-way clutch **81** will not transmit this rotation to the cam shaft **50**. As a result of this arrangement, the cams **38** and **48** will both be rotated through 360 degrees with a downward stroke of the top punch **13** of the press, yet will remain stationary upon an upward stroke of the top punch **13**.

The upper boundary of the chamber **44** is defined by an outwardly extending flange **54** on an inner reaction die supporting member **56**, upon which supporting member there rests a bottom surface of a flange **57** on the inner reaction die. The application of pressurized fluid to the chamber **44** provides a support for the inner reaction die **27**, while the exhausting of fluid, with back pressure controlled by throttle valve **52**, permits vertical movement thereof.

The outer, concentric reaction die **26** is rigidly mounted on two or more pins **58**, **59** extending upwardly through openings in the flange **57** from a supporting column **61**. The supporting column is mounted to a flange **62** on the vertically movable bottom punch **14** which constitutes an ejection ram of the press. The flange portion **62** normally rests upon a seat **63** fixed to the stationary bolster plate **12** of the press, thereby setting a lowermost limit for vertical movements of the outer reaction die. An upwardly extending portion **64** of the seat **63** provides a bottom stop for the inner reaction die supporting member **56** to provide a minimum column position for the variable column fluid chamber **44** (see FIG. 4) and a lowermost limit for vertical movements of the inner reaction die **27**.

An exemplary operating cycle (FIGS. 1–5) for the press and the die set **16** of this first embodiment will next

be described. As may be seen in FIG. 1, the die wall member 22 is initially held fluid-suspended in its topmost position, i.e., with the top of the flange 36 contacting a bottom surface of a shoulder 66 of the fixed die member 19, due to the presence of pressurized fluid in the chamber 32. Likewise, the inner reaction die supporting member 56 is fluid-suspended in its topmost position with the top of the flange 54 contacting the bottom of a flanged portion 67 of the die set body 11 extending inwardly from the boundary wall 18. The top surfaces of the die set body 11 and the die members 19 and 22 form a flat plane beneath which the powder-receiving cavity 24 extends downwardly.

With the press and die set in the initial condition shown in FIGS. 1 and 6, a filling operation first takes place. Powder P is introduced into the open die cavity 24 defined by the outer and inner reaction dies 26 and 27 and the die wall member 22. This powder may be introduced from a hopper positioned generally above the cavity and excess powder may be removed by a scraper member (not shown).

Note, by comparing FIGS. 1 and 5, that the top surface of the inner reaction die 27 is initially spaced vertically from the top surface of the die wall member 22 by a first gap greater than the thickness of a central portion 17*c* (FIG. 5) of a finished article 17. Note also that the top surface of the outer reaction die 26 is initially spaced vertically from the top surface of the die wall member 22 by a second gap greater than the height of an outer wall 17*w* of a finished article. The first gap is greater than the thickness of the central portion 17*c* by a first spacing difference, smaller than a second spacing difference by which the second gap is greater than the outer wall 17*w*. The first and second spacing differences are, of course, necessary due to the fact that the powder P must be compacted into a much lesser volume in order to produce a finished, coherent article 17. The first and second spacing distances are proportional to the respective vertical dimensions of the finished article. In order to pressurize the powder uniformly during compacting, thereby avoiding spill-over, substantially the same vertical dimensional ratios must be maintained throughout the compacting cycle. This is accomplished by controlling the yielding action of the fluid suspension system supporting the inner reaction die 27 through an appropriate setting of the throttle valve 52.

Turning now to FIG. 2, the top punch 13 which constitutes a ram of the press, mounts a primary or top punch die or plunger 68 associated with the die set 16. The top punch die 68 is moved downwardly into the open die cavity 24 to begin compacting the powder P therein. Conventional hydraulic or mechanical press apparatus forming part of the press may be used to move the top punch 13 in a vertical direction to lower the top punch die. The primary or top punch die 68 has an outer wall 69 of substantially the same dimension as the inner wall 23 of the die wall member 22 to completely enclose the powder within the die cavity.

The rack 82 (FIG. 7) moves downwardly with the top punch 13. Rotation of the pinion 83 is transmitted through the clutch 81 to rotate the cams 38 and 48. Thus, the valves 37 and 47 are operated to permit the controlled release of fluid from the chambers 32 and 44 as the top punch die 68 moves downwardly. The settings of the throttle valves 42 and 52 (FIG. 1) set the back pressures and proportion the exhaust rates between the lines 34 and 45 in a predetermined ratio so as to minimize wall shear stresses and to maintain the aforesaid dimensional ratios substantially uniform during compacting.

The initial compacting of the powder transmits a force in the vertical direction to the inner reaction die 27 to start its downward movement as the supporting member 56 is displaced downwardly and the volume of chamber 44 decreases. However, the powder is not initially sufficiently compact to transmit large enough tangential surface forces to the inner wall 23 of the die wall member 22 to move the die wall member downwardly against the back pressure of fluid still within the chamber 32. The outer reaction die 26, meanwhile, is held against downward movement by the flange 62, which mounts the supporting column 61, resting on the seat 63, and by the support pins 58, 59.

Referring next to FIG. 3, as the primary or top punch die 68 continues its downward movement and fluid continues its discharge from the chamber 44, the inner reaction die 27 continues to move downwardly and the outer reaction die 26 remains stationary. The powder P is further compacted and the downward movement is transmitted by the compacted powder to the inner wall 23, causing the fluid-suspended die wall member 22 also to move downwardly, against the back pressure in the line 34. Three cavity-defining members 68, 22, and 27 are now moving downwardly, with only the outer reaction die 26 stationary. The top punch die 68 advances toward the stationary cavity bottom provided by the outer reaction die 26, while the inner reaction die 27 yields downwardly at a lesser rate than that at which the top punch or primary die advances. The throttle valves 42 and 52 (FIG. 1) control the relative rates of fluid exhaust through the lines 34 and 45, respectively, to set the relative rates of downward movement of the members 68, 22, and 27 which define the cavity 24. Thus, the vertical dimensional ratios are maintained substantially constant, while forces are substantially compressive in nature. Shearing forces at the surfaces of the vertical walls 23 and 29 are minimized by the downward, yielding movements of the members 22 and 27 as the powder is compacted with the secondary action provided by the die set 16.

The yielding movements of the die wall member 22 and the inner reaction die 27 delay the application of maximum forces until a final compression stage shown in FIG. 4. This occurs only after a substantial portion of the compacting operation has occurred and shearing forces can be more readily withstood by the well compacted powder without spill-over. As shown in FIG. 4, bottoming contact between the inner reaction die supporting member 56 and the upwardly extending portion 64 of the seat 63 terminates the downward movement of the inner reaction die 27. The final compacting stage now takes place forming the desired article 17. The rack 82 (FIG. 7) has meanwhile rotated the cams 38 and 48 through 360 degrees and application of pressurized fluid to the lines 34 and 45 begins again.

Referring now to FIG. 5, the ejection operation next occurs as the top punch die 68 is removed and the bottom punch or ejection ram 14 is moved upwardly by the conventional hydraulic or mechanical press mechanisms forming part of the press. The supplying of pressurized fluid to the chambers 32 and 44, meanwhile, continues, the cams 38 and 48 remaining stationary due to the fact that reverse rotary movement of the pinion 83 (FIG. 7) is not transmitted by the one-way clutch 81.

The upward movement of the bottom punch 14 raises the outer reaction die 26 toward the topmost position thereof. The article 17 is raised by the upward movement of the outer reaction die. Internal forces in the compressed article 17, tending to expand the article both radially outwardly and radially inwardly, lift the inner reaction die 27 and the die wall member 22 to the topmost position of each with the rising article 17. All top surfaces attain a position flush with the top surface plane of the die set body 11 as the finished article 17 is ejected and may be removed from the die set 16. In this position, the top of flange 36 contacts the bottom surface 66 of the fixed die member 19 to prevent further upward movement of the die wall member 22. The outer and inner reaction dies 26 and 27, meanwhile, contact lower surface portions 71 and 72, respectively, of the

stopped die wall member 22, providing positive stops to limit the upward movement of these die members.

Next, downward movement of the bottom punch or ejection ram 14 returns the outer reaction die 26 to the initial fill position of FIG. 1. The article 17 having been removed, the inner reaction die 27 is now free to return to its initial position, resting on the supporting member 56. Pressurized fluid in the chambers 32 and 44 maintains the die wall member 22 and the inner reaction die 27, respectively, in the correct FIG. 1 fill positions thereof. A new cycle may now begin and operation may continue in the manner explained above.

A second embodiment

FIG. 8 illustrates a second embodiment constructed in accordance with the principles of the invention. This embodiment constitutes a second die set 116, mounted in the die set body 11 of the press by means of the die lock 21. The die set 116 is operable to form articles of cylindrical shape.

The die set 116 is essentially similar to the die set 16 (FIG. 1–6). Corresponding elements of the die set 116 of FIG. 8, therefore, are identified by like reference numerals to those used for the die set 16, being varied therefrom by the use of a prefix value of 100. Certain elements, e.g., those with reference numerals 119 and 133, may be identical to, so as to be interchangeable with, corresponding elements of the die set 16.

The second embodiment differs from the first in that no element corresponding to the fluid-supported inner reaction die member 27 is present, such member being unnecessary in forming cylindrical articles. Instead, a single reaction die member 126, having a circular outer wall 128 enveloped closely by an inner wall 123 of an annular fluid-supported die wall member or piston 122, has its supporting column 161 mounted to the bottom punch flange 62. Thus, the reaction die 126 is not fluid-supported, instead being directly mounted to the bottom punch of the press. As such, it is operated in similar manner to the outer reaction die 26 of the die set 16.

The operation of the die set 116 is obvious from FIG. 8. Downward movement of a flat, circular top punch die 168 into die cavity 124 compacts powder P therein against the flat, circular reaction die 126, which is held fixed in position by the flange 62 bottoming on the seat 63. As the powder is compacted, the shearing stresses are lessened in the vicinity of the wall 123 bounding the cavity 124, due to downward movement of the wall member 122. Such downward movement occurs as a pressurized fluid, such as compressed air, is exhausted from chamber 132 against a preset back pressure in fluid line 134. The top punch die 168 is then removed and an upward ejection stroke of the bottom punch moves the reaction die 126 to eject a finished cylindrical product from the die cavity 124, while returning the die wall member 122 to its topmost position. The bottom punch, thereafter, returns the flange 62 to again contact the seat 63. The die set 116 is now back in the initial FIG. 7 position, whereupon the die cavity 124 may be refilled with powder for compaction in a succeeding cycle.

A third embodiment

FIG. 9 shows the press having mounted in the die set body 11 a die set 216 providing a third embodiment constructed in accordance with the principles of the invention. Die set 216 is operable to produce articles in the shape of flanged cylinders.

The die set 216 is essentially similar to the die set 16. Reference numerals identifying elements of the die set 216 of FIG. 9 are, thus, prefixed by a value of 200 above those identifying similar elements of the die set 16. Again, certain elemeents, e.g., those numbered 219, 233 and 246, may be interchangeable with corresponding elements of the die set 16.

The embodiment of FIG. 9 differs from that of FIGS. 1–6 in that an annular outer reaction die member 226 is fluid-supported, while an inner reaction die member 227 is joined directly to the bottom punch 14 of the press through column 261 and flange 62.

Note that all die members which define die cavity 224 are fluid-supported except for the reaction die 227 which defines the bottommost surface of the die cavity. The same principle is true with respect to all three exemplary embodiments of the invention. For example, in the die set 16 of FIGS. 1–6, all cavity-defining members except for the bottommost reaction die member 26 are fluid-supported.

Once again, in order to prevent spill-over caused by pressure nonuniformities during compacting, it is necessary to preserve the dimensional ratios in the die cavity 224 as the volume thereof is decreased. Thus, a top surface 271 of the outer reaction die 226 must retreat from an advancing primary or top punch die 268 at a predetermined rate, less than the rate of advance of the top punch into the die cavity. The rate of downward movement of an outer reaction die supporting member 256, which carries a flange 257 of the outer reaction die, is regulated by controlling back pressure in fluid line 245 by means of the throttle valve 52 (FIGS. 1, 7).

In order to minimize the shear stresses adjacent the wall 223 bounding die cavity 224, an annular die wall or piston member 222 is yieldably supported by pressurized fluid in chamber 232 in similar manner to the die wall members 22 and 122 of the above-described embodiments. Throttle valve 42 (FIG. 1) may be adjustably set to control the exhaust of fluid from the chamber 232.

The die set 216 is operable in similar manner to the die set 16, being insertable into the die set body 11 of the single action press in order to compact powder into flanged cylinders of uniform, essentially flaw-free consistency.

In like manner, various other die sets having secondary and multiple action capability in accordance with the principles of the invention, may be inserted into the single action press for forming articles of various sizes in various simple or complex shapes. Additional, independent chambers may be located within any such die set for resiliently supporting additional reaction die members upon pressurized fluid therein. Additional bottommost die members, not fluid-supported, may be joined to the supporting column 61(FIGS. 1–5), as may core members for forming articles with openings therethrough.

It is to be understood that the above-described apparatus is simply illustrative of three embodiments of the invention. Other embodiments might include die sets employing spring mounting systems in place of one or more of the fluid-suspension chambers. Many other modifications may be made without departing from the invention.

What is claimed is:

1. In an apparatus for compacting powder into a cup-shaped article:

a fixed die block having a first vertical bore therethrough;

a sleeve;

means for supporting the sleeve within the first bore;

a core rod slidably mounted within the sleeve;

a first piston having a first annular flange slidably engaging the wall of the first bore for supporting the core rod;

an annulus surrounding the first piston and spaced from said first flange to define a first annular chamber between the first piston and the wall of the first bore;

means including a first throttle valve for maintaining fluid within the first annular chamber to support said first piston and said core rod with an end of the core rod projecting upwardly beyond the sleeve;

a second piston movably mounted within the first bore in said fixed die block, said second piston having a second vertical bore therethrough for receiving powder and for housing the sleeve and core rod;

said second piston having a second annular flange positioned within said first bore in said fixed die block;

means supported by said fixed die block and cooperating with said second flange to define a second annular chamber;

means including a second throttle valve for maintaining fluid within the second annular chamber to support said second piston with end of the second bore extending upwardly beyond the end of the core rod; and

ram means movable downwardly into the second bore to compact the powder into a cup-shaped article while moving downwardly said first piston and then said second piston in the first bore to exhaust the fluids through the respective throttle valves.

2. In an apparatus as defined in claim **1**, wherein said core rod includes a third flange with a hole extending axially therethrough, and wherein said sleeve supporting means extends through said hole and comprises a ram for moving the sleeve relative to said core rod to eject the compacted powder article.

3. In an apparatus as defined in claim **1**, wherein the means defining the second annular chamber comprises a ring member having a radially inwardly extending shoulder for housing said second flange therebeneath in said first bore of the fixed die block, wherein said fixed die block includes a locking member movable to lock said ring member in the fixed die block, and wherein said ring member including means adjacent the fixed die block for receiving said locking member.

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2,509,783	5/1950	Richardson	18—16.7
2,562,876	8/1951	Baeza	18—16.5
2,821,748	2/1958	Willi	18—16.7
2,831,212	4/1958	Belden	18—16.7
3,132,379	5/1964	Crane	18—16.5

J. HOWARD FLINT, JR., Primary Examiner