

[54] APPARATUS FOR INJECTING A FLUID INTO POWDERED MATERIALS BEING COMPACTED

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Related U.S. Application Data

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- [52] U.S. Cl.425/78, 425/130, 425/344, 425/256
- [51] Int. Cl.B29f 1/03
- [58] Field of Search18/5 H, 5 P, 16 R, 16 E, 16.5, 18/16.7, 30 NA, 30 NY, 30 PG, 30 GA, DIG. 26, DIG. 35

[56] References Cited

UNITED STATES PATENTS

- 2,524,057 10/1950 Jungersen et al.18/16.5 UX
- 2,543,439 2/1951 Coomes et al.18/16.5 UX
- 3,122,787 3/1964 Adams18/16 R X

FOREIGN PATENTS OR APPLICATIONS

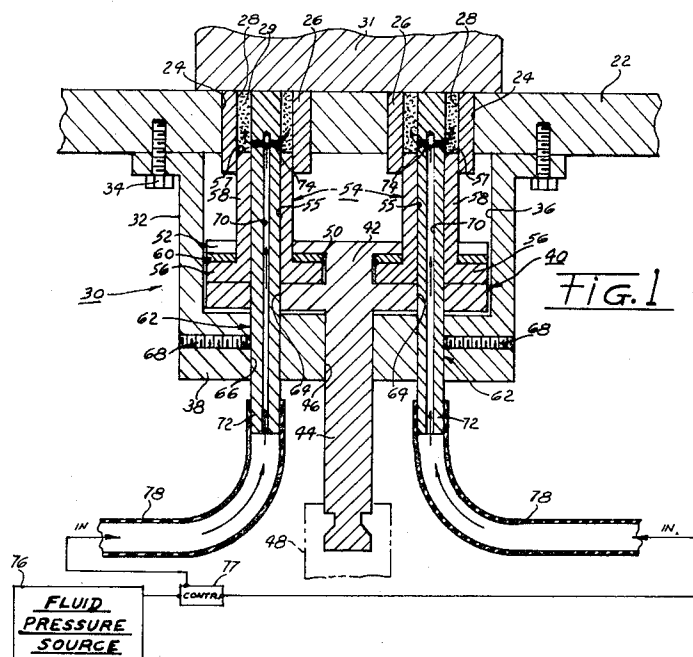
- 707,612 0/1941 Germany18/DIG. 35

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[57] ABSTRACT

A method and apparatus for adding an additive material, such as a fluid (gas or liquid) to a granular base material which is to be compacted, providing for maximum saturation of the granular base material with the fluid by injecting the fluid into the granular base material in metered proportions prior to or during the compacting operation. The method may be advantageously carried out in an apparatus such as a compacting press having a die provided with at least one die cavity into which a lower compacting member extends for movement upwardly through the die cavity. The die cavity is filled with a granular base material from a filling head positioned above the die cavity. The filling head is part of a positioner assembly pivotally supported over the die cavity and which comprises, in addition to the filling head, an anvil or upper compacting member adapted to be placed over the filled die cavity for compression of the granular material between the anvil or upper compacting member and the lower compacting member. The fluid, under controlled pressure and in a predetermined amount, is injected into the granular base material immediately prior to or during advancement of the lower compacting member within the die cavity for compression of the granular material into a fluid-saturated compacted article, and thereafter the fluid-saturated compacted article is ejected from the die cavity for disposal into a suitable receptacle.

13 Claims, 10 Drawing Figures



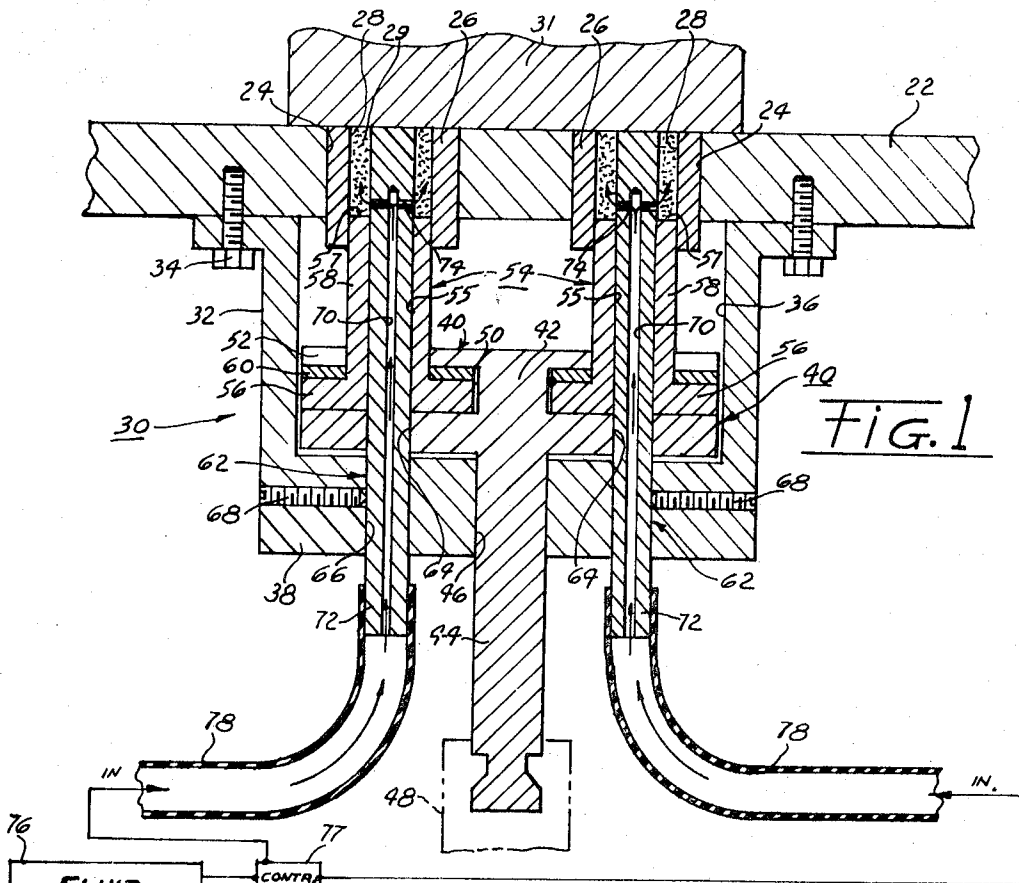


FIG. 1

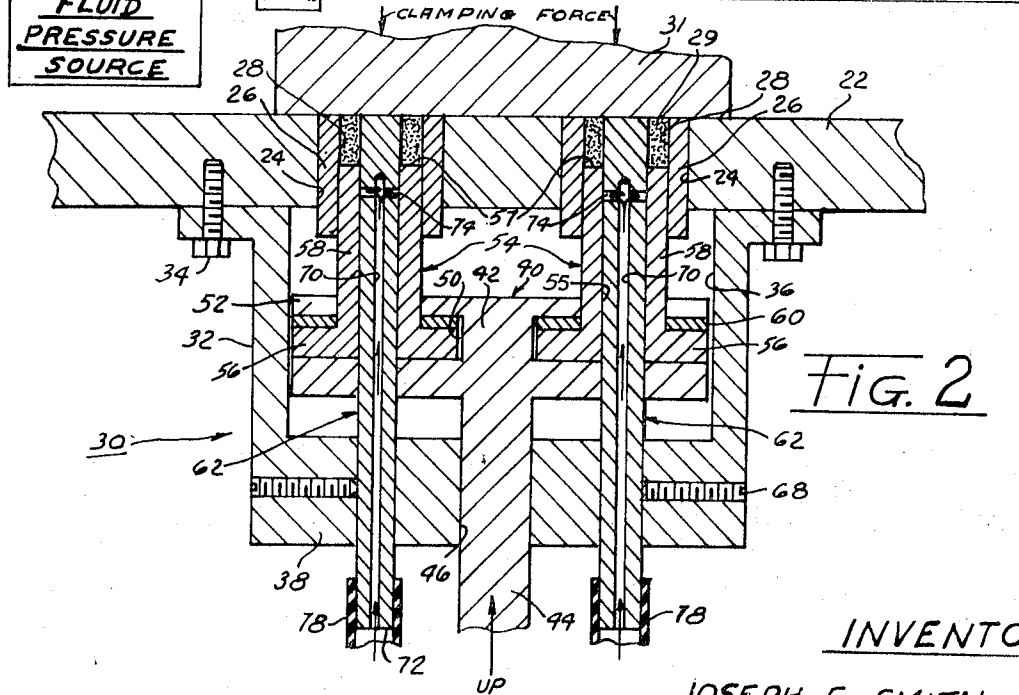


FIG. 2

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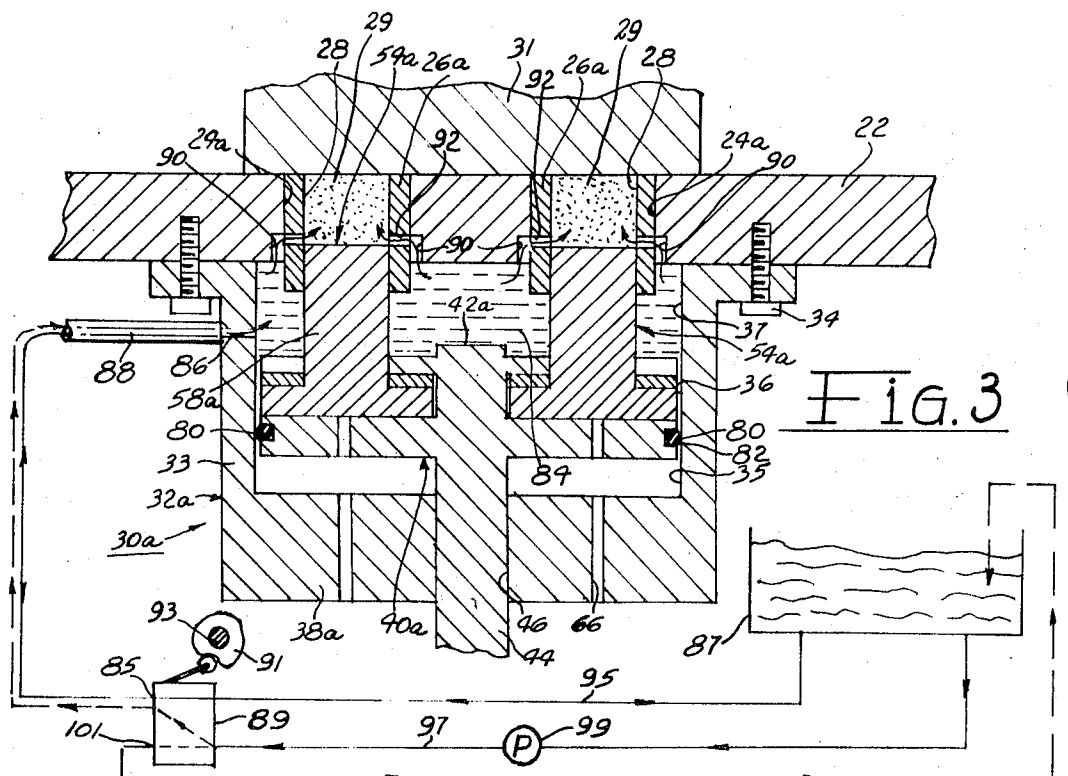


Fig. 3

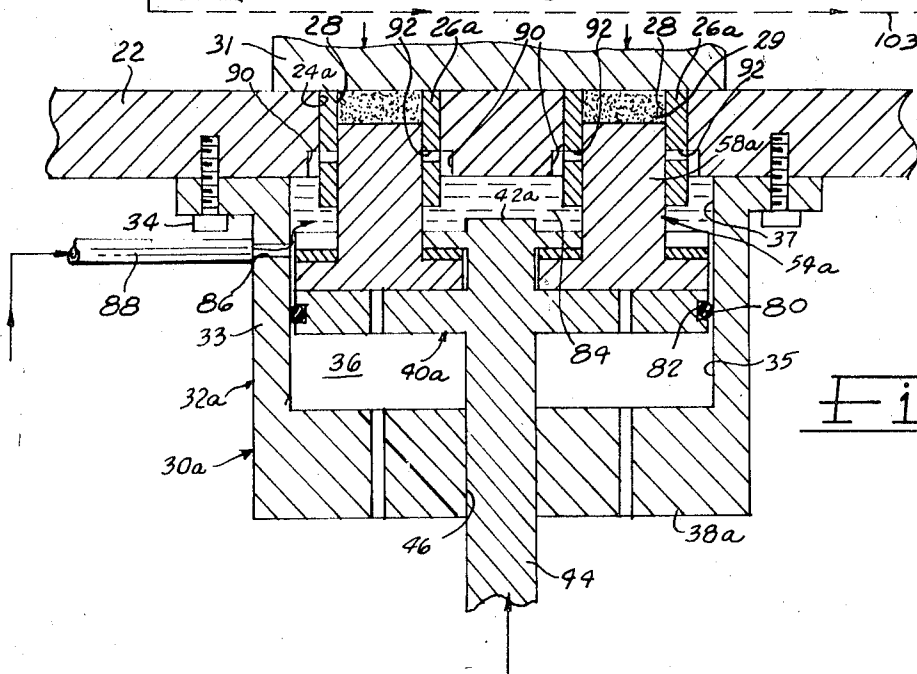


Fig. 4

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Fig. 5

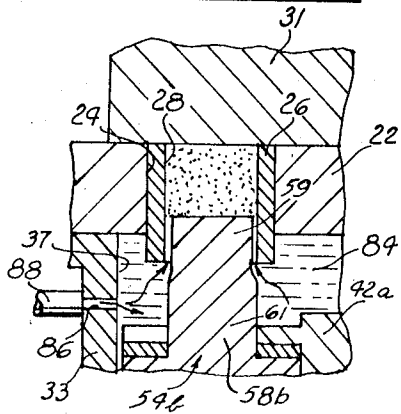


FIG. 9

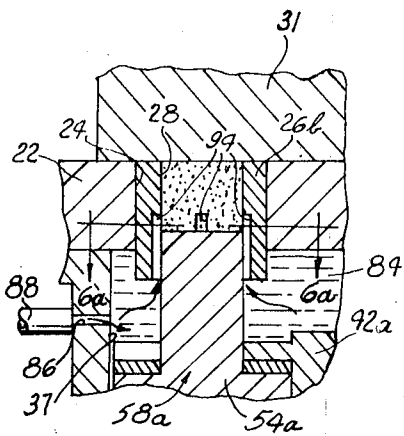
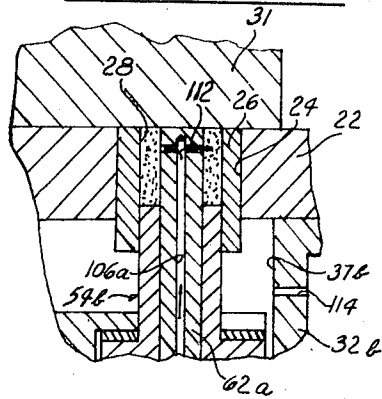


Fig. 6

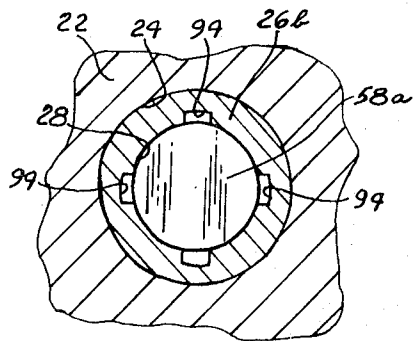


FIG. 6a

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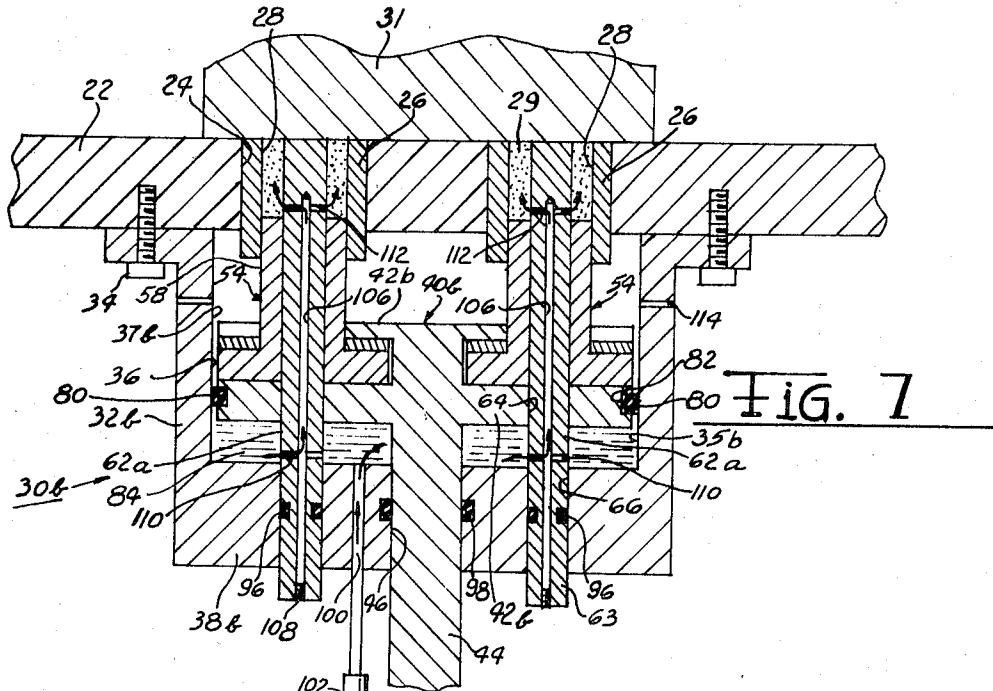


FIG. 7

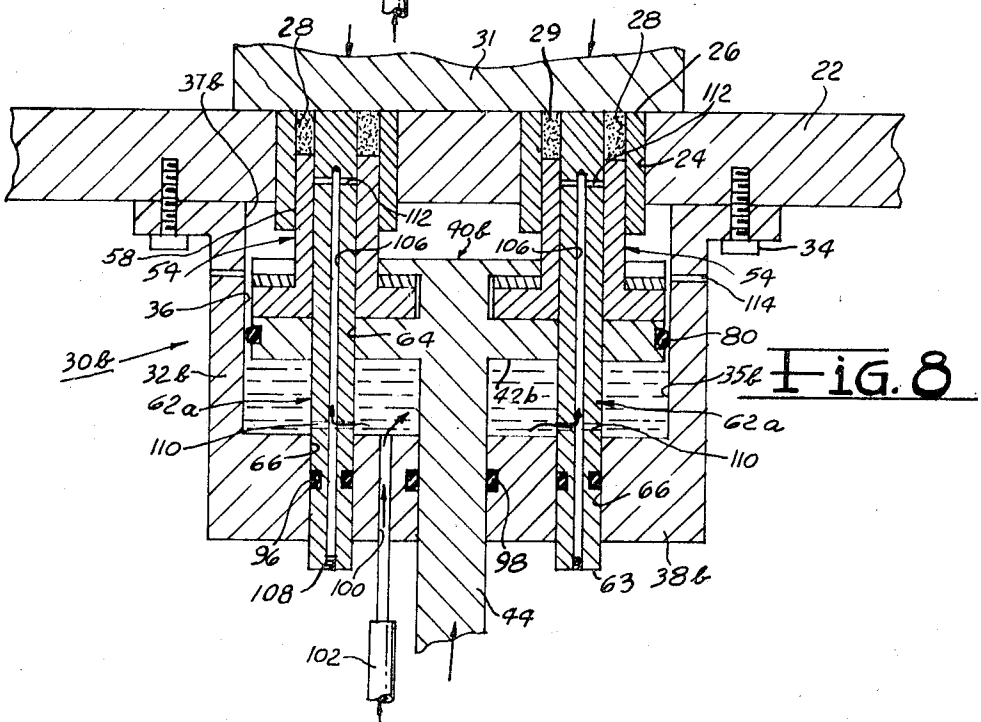


FIG. 8

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APPARATUS FOR INJECTING A FLUID INTO POWDERED MATERIALS BEING COMPACTED

REFERENCE TO RELATED APPLICATIONS

The present invention is related to and is a continuation-in-part of copending application Ser. No. 850,204, filed Aug. 14, 1969, for "Method and Apparatus for Adding a Fluid or a Solid to a Powdered Material Being Compacted" in the name of Joseph E. Smith, and which is assigned to applicant's assignee.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates in general to a powder-compacting method and apparatus, and more particularly to a method and apparatus for making a fluid-saturated compacted article by injecting a fluid into a granulated base material immediately prior to or during the compacting operation.

2. Description of the Prior Art

It is known in the art to introduce fluid, such as a gas or liquid, into a compacted powder mass, as for instance in the introduction of a binder or plasticizer into a compacted powder material or to introduce an inert gas into a compressed foodstuff or the like, after compaction of the material.

However, none of these known methods and apparatus provide for introduction of precisely metered amounts of a fluid into a granular base material prior to or during the compacting operation to obtain saturated, compacted, relatively small articles, such as memory cores, tablets, pellets of the like.

SUMMARY OF THE INVENTION

The present invention provides an improved apparatus and method for producing compacted articles, such as tablets or pellets of ceramic, metallic, pharmaceutical or other types of powders or granules having a fluid injected into the granular base material. The injection of the additive fluid is preferably done just prior to the compacting stroke.

The improved apparatus and method provide the injection of precisely metered amounts of a fluid into powder material already dispensed in a die cavity. The addition of fluids to bulk powder material prior to dispensing the bulk powder material into the die cavity causes the material to become unyielding and difficult to handle to be effectively dispensed into the die cavity.

It may be desirable to add fluids to the base powder material for chemical reaction therewith, or for the purpose of incorporating additives such as binders, lubricants, etc. As a result of injecting fluids into the base powder material already dispensed in the die cavity, the improved method and apparatus of the present invention provide infinite latitude in the selection of fluids, such as for example binders or lubricants.

The improved method and apparatus of the invention is of particular advantage, for instance when it is desired to add expensive and costly additives to compacted articles, such as narcotics or other pharmaceuticals which are injected in liquid form into the base granular material in the die cavity and which could not be easily or economically added to the bulk powder.

Additionally, the improved apparatus and method of the invention is useful for injection of a gas or vapor into the base powder material for the purpose of changing the chemical composition of the powder material in the die cavity prior to or during compacting of the powder material.

In a particular example, the compacted article may be a flavored pellet containing a flavoring oil, such as is used in flavored foods or drinks. Conventionally, the flavoring oil is already dispersed in the bulk of the granulated base material. Dispersion of the flavoring oil in the bulk of the granulated material before compacting is found to have many disadvantages since the flavor begins to deteriorate in storage under the influence of light, heat, exposure to air, and with the passage of time. The oil-saturated bulk powder material is dif-

5 difficult to handle in processing and an oil content of from 10 percent to 20 percent in the bulk powder material renders the feeding and dispensing of the saturated bulk powder material by conventional methods impractical. Saturated bulk powder or granules having any amount of oil dispersed therein becomes increasingly lumpy and nonuniform in time. Likewise, the percentage content of oil to solid when mixed in the bulk powder is extremely difficult to control. On the other hand, reducing the flavor oil to solids, that is to a powder, a granulate or to a crystal form, has the disadvantage of causing a high percentage of the flavor to be lost during processing, which in addition is also costly. Obviously, a form of containing the oil within a solid compressed article and thereby locking in the flavor will be of advantage. However, tableting of the conventionally used oil-saturated powder base materials is extremely difficult for the above stated reasons.

15 The primary objective to be obtained in tableting or pelletizing articles of this kind is to obtain a maximum amount of usable flavor in the smallest practical form, which must be capable of being produced economically in large quantities. The physical form of these articles must be such that they can be economically stored, transported, weighed, metered, and handled in processing with conventional methods and equipment, and at the lowest cost possible.

20 These objectives are achieved by the improved method of the present invention, which contemplates feeding the base powder material at high speed into the die cavity or cavities and injecting the oil or other liquid under pressure into the base powder material, prior to compacting, by injection means through the compacting members and thereby obtaining an increased production rate and a maximum oil content saturation.

25 The improved fluid injection method of the invention can be carried out with a substantially conventional powder compacting press, although the present invention is described hereinafter in application with a press provided with a die plate having at least one die cavity and a lower punch member extending from below the die plate into the die cavity, and a work station positioner arm disposed above the die plate for swinging movement across the die plate. The work station positioner arm includes a powder dispensing station connected to a primary powder feeding means, an anvil or upper compacting member for closing off die cavity on the compacting stroke of the lower punch member, and an ejecting station to eject the finished compacted article from the die cavity. Such presses are for instance disclosed in U.S. Pat. Nos. 3,328,840, 3,328,842, 3,344,213, 3,414,940, 3,415,142, 3,561,054, 3,461,056 and 3,574,892 as well as in copending applications Ser. No. 782,918, filed Dec. 11, 1968, Ser. No. 785,584, filed Dec. 20, 1968.

30 In the embodiment of the invention disclosed in the related copending application of which the present application is a continuation-in-part, the injection of the liquid or gas is accomplished through the anvil or upper compacting member, or a separate injection head is provided on the work station positioner arm disposed between two adjacent anvils or other compacting members. The invention in the present application, which is adaptable without modification to conventional powder-compacting presses having upper and lower punches, provides for injection of an additive fluid through a lower compacting member or punch, or through the punch supporting housing.

35 In one embodiment of the present invention, the additive fluid is injected into the powder-filled die cavity at a predetermined constant pressure or timed pulse injection through core rods which are stationarily retained within the punch housing and extend axially through the reciprocating punches. In another embodiment of the invention, the additive fluid is injected through the punch retaining housing and from there through appropriate channels, slots, passages or the like provided in the die plate and communicating apertures provided in the die bushings into the die cavity or cavities, the pressure means for injection of the fluid into the die cavities being pro-

vided by the reciprocating action of the punch holder. In still another embodiment of the invention, the additive fluid is injected through the punch retaining housing and is conveyed from there through appropriate transverse and axial bores, or passes through core rods axially movably retained within the reciprocating punches.

In all the embodiments of the invention the advance of the punches through the die cavities functions to close off the fluid supply into the die cavity or cavities at a predetermined stage of the compacting stroke to achieve in addition to the timed injection a controlled saturation of the powdered material with the fluid.

Obviously, the fluid injection system may incorporate appropriate check valves and other suitable fluid pressure and fluid flow control mechanisms which may be operable in timed sequences by means of the press mechanism.

The improved method and apparatus of the present invention can be used for other purposes, such as the purging or introduction of release agents, lubricants, etc., to enter the die cavity after the injection and prior to refilling, or for treating or conditioning of the tools such as treating the inner surface of the die cavity or cavities and the outer surface of the punches and core rods. The present invention can also be used for sterilization of the compacting tools when making pharmaceutical articles. Furthermore, heated gas or vapors can be introduced in the die cavities to preheat the die cavities and punches.

Other obvious advantages and novel features will become apparent or be particularly pointed out in the following detailed description with particular reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings illustrate several preferred embodiments of the present invention wherein like numerals refer to like or equivalent parts throughout, and in which:

FIG. 1 is a cross section through the tool portion of a compacting apparatus illustrating an example of embodiment of the invention shown in a position prior to the compacting of the powder material;

FIG. 2 shows the embodiment of FIG. 1 in the position causing maximum compacting of the powder material;

FIG. 3 is a cross section of another example of embodiment of the invention shown in a position prior to the compacting of the powder material;

FIG. 4 shows the embodiment of FIG. 3 in the position causing maximum compacting of the powder material;

FIG. 5 is a fragmentary cross section illustrating a modification of the fluid injection means of the embodiment shown in FIG. 3;

FIG. 6 is a fragmentary cross section of a further modification of the fluid injection means of the embodiment shown in FIG. 3;

FIG. 6a is a transverse section along line 6a—6a of the embodiment shown in FIG. 6;

FIG. 7 is a cross section of still another example of embodiment of the invention shown prior to the compacting of the powder material;

FIG. 8 shows the embodiment of FIG. 7 in the powder material compacting position; and

FIG. 9 is a fragmentary section of a position of the embodiment shown in FIG. 7 illustrating a modification of the fluid injection means of FIG. 7.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present novel method and structure shown in the drawings is illustrated and will be hereinafter described in combination with a powder-compacting apparatus similar to that illustrated and described in the aforementioned copending application of which the present application is a continuation-in-part.

In the copending application, a die assembly is disclosed comprising a die plate having at least one die cavity formed by a die bushing in which a reciprocable punch extends from underneath the die plate. A station positioner, disposed over the die cavity, is provided with a powder material dispenser for filling the die cavity with a powder or granular base material, which is of appropriate composition to be able to act as a base or carrier for a fluid intended to be dispersed within the powder or granular material. The cavity is filled with the powder material as the punch recedes downwardly from its eject position to thereby draw the powder material into the die cavity.

After filling of the die cavity with a proper amount of powder base material, the station positioner is displaced to place a combination injector and anvil over the die cavity. The combination injector and anvil is provided with fluid injection means actuated by the anvil clamping member to inject fluid into the powder mass in the die cavity during the compacting stroke.

The example of improved fluid injector mechanism of the present invention, illustrated in FIGS. 1 and 2, comprises a die plate 22 having a plurality of die cavities 28 defined by the axial bores of appropriate die bushings 26, each retained within an aperture 24. The die cavities 28 are adapted to be filled with a powder or granulated material 29 for compaction therein.

A tool capsule 30 comprising a housing 32 is attached to the underside of the die plate 22 by means of bolts 34. The housing 32 is provided with an inner bore 36 which is open at its end disposed towards the die plate 22, and which is closed at its other end by a bottom wall 38. The bore 36 of the housing 32 is adapted to reciprocally retain a punch holder 40 comprised of a head portion 42 and a push rod portion 44 which is integral therewith and which extends through a central aperture 46 in the bottom wall 38 outwardly of the housing 32 for attachment to a ram member indicated at 48 for reciprocation of the punch holder assembly 40 and which is part of the actuating mechanism of the compacting press (not shown) in which the die plate 22 and tool capsule 30 are incorporated.

The head portion 42 of the punch holder 40 is formed to provide a circumferential groove 50, which is intersected at the top of the head portion 42 by a plurality of radially inwardly extending slots 52 to thereby provide a restraining means for a plurality of identical punch members 54 formed each with an enlarged head portion 56 adapted for insertion into the groove 50, and an integral shank portion 58 extending upwardly from the head portion 56 through the radial slots 52. The punch members 54 are retained in the head portion 42 of the punch holder 40 by means of an outer retaining ring 60 placed around the shank portions 58 of the punches within the circumferential groove 50. The upper ends of each of the shank portions 58 of each of the punch members 54 are aligned with and each extends in one of the die cavities 28 for reciprocating movement therein.

Each of the punch members 54 is provided with a central axial bore 55 in which is slidably disposed a core rod 62, whose upper end extends outwardly of the shank portion 58 of each of the punch members and centrally through the die cavities flush with the upper surfaces of the die plate 22 and die bushings 26. The lower end of each core rod 62 projects beyond the head portion 56 of the punch member 54 through correspondingly aligned apertures 64 in the head portion 42 of the punch holder 40 and are secured in correspondingly aligned apertures 66 in the bottom wall 38 of the tool housing 32, in which they are fastened in aligned position by means of setscrews 68 or the like. The head portion 42 of the punch holder 40 is reciprocally slidable along the stationarily retained core rods 62 which thus provide an axial and radial alignment means for the punch holder and punch members relative to the die cavities 28.

In the structure of FIG. 1, the core rods 62, in addition to making apertured compacted articles, are adapted to provide a means for introducing a fluid into the powder-filled die cavi-

ties 28, for which purpose each of the core rods is provided with an axial passage 70 extending from the lower end 72 of the core rod proximate the upper end thereof which projects within the die cavity 28. The upper end of the axial passage 70 in each of the core rods 62 is normally open to the die cavity 28 by means of transverse passages 74 which are disposed such as to provide communication between the axial passage 70 and the die cavity when the punch members 54 are in their lowermost position or at the bottom of their downward stroke, as shown in FIG. 1. It will be noted that the transverse passages 74 are located just slightly above the upper ends 57 of the punch members within the die cavities, such that upon advance of the punch members upwardly into the die cavities upon initiation of the compacting stroke by the press the transverse passages 74 will be gradually closed by the advancement of the punches during the compacting stroke until they are completely closed off to thereby interrupt communication between the axial core rod passages 70 and the die cavities 28, as shown in FIG. 2, which represents the relative position of the diverse elements at the end of the punch compacting stroke.

The axial passages 70 of the core rods 63 are each connected to and in communication with a source of fluid under constant pressure 76, as for instance by means of lines 78 which are appropriately secured to the lower end 72 of each of the core rods 62 which extends outwardly of the tool housing 32. The pressure of the fluid in the injection system is moderate and in accordance with conventional practice fluid flow control means 77, such as check valves or the like, may be incorporated between the source of fluid pressure 76 and the axial passages 70 within the core rods.

In operation, the fluid injection system of the embodiment in FIGS. 1 and 2 when using only the constant pressure of the fluid pressure source as fluid injection means functions as follows: After the die cavities 28 have been filled with the powdered or granulated material 29 in the manner described hereinbefore, the compacting stroke is initiated by the sequenced cam-operated drive mechanism of the press (not shown) placing an anvil or upper compacting member 31 over the die cavities and exerting a predetermined holddown force thereon, as indicated by the arrows in FIG. 2, to counterbalance the stroking force exerted on the push rod 44 by the ram member 48. Just prior to this stage of the compacting operation, the receding punch members 54 have uncovered the injection passages 74 at the top of the core rods 62 to establish fluid communication with the source 76 by means of the axial fluid passages 70 in the stationary core rods 62 to thereby inject a fluid of any particular kind into the powder material 29 in the die cavities 28 through the injection passages 74, as indicated by the direction of the arrows in FIG. 1. At the same time as the upper compacting member 31 is clamped down, the ram member 48, by means of the push rod 44, moves the punch holder assembly 40 upwardly within the bore 36 of the tool housing 32 to thereby advance the shank portions 58 of the punch members 54 upwardly within the die cavities 28 towards the upper compacting member 31 to effect compaction of the fluid-saturated powder material 29 between the upper end surfaces 57 of the punch members and the surface of the upper compacting member at a predetermined pressure to obtain the desired compaction density as determined by the particular powder material being used.

The amount of fluid being injected into the powder material 29 within the die cavities 28 in the constant fluid pressure arrangement is predetermined by the desired saturation-to-powder ratio and can be precisely metered by several means and inherent factors designed into the operation of the compacting press, such as the magnitude of injection pressure provided by the fluid pressure source 76 or the respective diameters of the fluid passages 70 and 74. However, interruption of fluid flow into the die cavities is primarily determined by the relative location of the transverse fluid passages 74 in relation to the upper surfaces 57 of the shank portions 58 of the punch members 54. As noted in FIG. 1, in the lowermost position of

the punch members 54, the transverse fluid injection passages 74 are exposed to be open to the die cavities 28 just a short distance above the upper surfaces 57 of the punch members. As the punch members 54 are advanced upwardly in the die cavities by the actuation of the ram member 48 and longitudinally slide along the stationary core rods 62, the fluid injection passages 74 will be gradually closed. Obviously, the speed with which the punch members 54 advance upwardly in the die cavities 28, together with the relative location of the fluid injection passages 74, provides a timed value means to precisely meter a predetermined amount of fluid to be injected into the powder material in the die cavities. As shown in FIG. 2, upon further advance of the punch members 54 in the die cavities 28, the fluid injection passages 74 will be completely closed by the inner walls of the axial bores 55 of the shank portions 58 of the punch members, thereby preventing further fluid injection into the powder material 29. Thereafter, as described earlier, the fluid-saturated compacted finished articles will be ejected from the die cavities in the manner described in the aforementioned related U.S. patents and copending patent applications, or by any other suitable means.

As will be evident from the foregoing description and from the illustration of the embodiment in FIGS. 1 and 2, any additional mechanical or hydraulic fluid injection controls between the fluid source 76 and the fluid injection passages 70, 74 can be omitted completely by maintaining a constant fluid pressure of moderate magnitude within the fluid lines 78 and passages 70, 74. The movement of the punch members 54 provide the controlling action of metering the fluid injection and shutting off the fluid injection at a predetermined point in the compacting operation. Thus, upon downward movement of the punch members from the position shown in FIG. 2 to the position shown in FIG. 1 after the prior compacted finished fluid-saturated articles have been ejected from the die cavities, the receding shank portions 58 of the punch members will gradually reopen the fluid injection passages 74. Thus, while the die cavities are refilled with powder material at a predetermined timed stage in the operation of the press, the fluid is automatically injected into the powder material by means of constant fluid pressure provided by the source 76 just prior to complete positioning of the upper compacting member 31 over the die cavities.

Although, theoretically, the pressurized fluid moving into the die cavity 28 would tend to float the loose powder out of the cavity when the upper compacting member has not completely moved into place over the die cavities, the time constant it takes for the flow to become effective is much greater than the few milliseconds it takes for the upper compacting member to move into place, thus no powder will be washed out of the die cavities upon initial opening of the injection passages 74.

Conversely, instead of using the constant fluid pressure of the fluid source 76 for injection of the fluid into the die cavities, a timed pulse injection can be utilized in which case the control 77 would be a cam-operated pilot valve, such as shown and described in copending application Ser. No. (PEN-111-A) to thereby forcibly inject fluid into the die cavities at timed intervals as dictated by the cam drive mechanism of the press and substantially coinciding with the movement of the upper compacting member over the die cavities.

With reference now to FIGS. 3-6 and 6a, the modified embodiments of fluid injection systems shown therein are preferably used in conjunction with punch members without core rods, however, they do not preclude the use of conventional core rods, if so desired.

In the embodiment of FIGS. 3 and 4, a die plate is indicated at 22 provided with a plurality of apertures 24a adapted to each receive a die bushing 26a, whose internal bore provides a die cavity 28. A tool capsule 30a is attached by means of bolts 34 to the underside of the die plate 22 and comprises a housing 32a which is open at the top towards the die plate 22 to provide a chamber 36 closed by a bottom wall 38a. The hous-

ing chamber 36 is adapted to reciprocally retain the head portion 42a of a punch holder assembly 40a which is further provided with push rod 44 extending outwardly of the tool housing 32a through a central aperture 46 in the bottom wall 38a of the housing for connection to the usual ram member 48 of the press, as shown in FIG. 1. The head portion 42a of the punch holder assembly supports and retains a plurality of punch members 54a corresponding in number to the number of die cavities 28 and each having its shank portion 58a axially aligned with one of the die cavities for reciprocable extension therein. The punch members 54a are retained on the head portion 42a in the same fashion as shown in the embodiment in FIGS. 1 and 2, and as previously described in connection therewith.

As will be noted, the punch members 54a are of solid construction, that is, no core rods are provided for extension through the punch members as in the embodiment in FIGS. 1 and 2, however, if desired, punch members having provisions to receive conventional core rods may also be used.

The head portion 42a of the punch holder divides the housing chamber 36 into a lower chamber section 35 and an upper chamber section 37 which are sealed off from each other by an annular seal 80, such as an O-ring or the like, retained around the head portion 42a of the punch holder 40a in the circumferential groove 82.

The upper chamber section 37 is adapted to be filled with a fluid 84 under pressure by means of an inlet opening 86 in the sidewall 33 of the tool housing 32a at the upper end thereof so as to be normally disposed above the head portion 42a when the punch holder assembly 40a is in its lower position, shown in FIG. 3. The inlet opening 86 is connected by means of a fluid line 88 to a source of pressurized fluid 87 for communication therewith so that the upper chamber section 37 can be filled with fluid.

In order to inject a metered amount of fluid 84 from chamber section 37 into the die cavities 28, each of the die bushing apertures 24a of the die plate 22 at the lower end facing the chamber section 37 is counterbored or notched as at 90 and each of the die bushings 26a is provided with a plurality of circumferentially spaced fluid injection passages 92, which are in open communication with the notches 90 to thereby permit fluid to enter through the notches 90 and passages 92 into each of the die cavities 28 during a predetermined portion of the compacting stroke of the punch holder 40a. The necessary pressure to forcibly inject a portion of the fluid 84 into the die cavities 28 is provided conjointly by the pumping action of the reciprocating punch holder 40a within the tool housing 32a and a timed cam-actuated pilot valve arrangement, as will be described hereafter with reference to the schematic fluid system illustrated in FIG. 3.

The inlet fluid line 88 is connected to a first outlet 85 of a pilot valve 89, which is operable by a timing cam 91 secured for rotation to the main drive shaft 93 of the press operating mechanism. The pilot valve 89 has a first fluid inlet line 95 which is in direct communication with the source of fluid 87 and a second fluid inlet line 97 which is likewise in communication with the source of fluid 87 by means of a pump 99 disposed in line 97. Thus, the pilot valve 89 is operable between the positions as determined by the angular position of the cam 91 to connect either fluid line 95 or 97 with the inlet line 88 and in which the positively pressurized fluid line 97, if connected to the inlet line 88, is adapted to provide timed pressurized injection of the fluid into the die cavities during a predetermined stage in the compacting operation preferably substantially coinciding with the positioning and clamping of the upper compacting member over the die cavities. During the remainder of the press operation, the fluid pressure supplied by line 97 into the pilot valve 89 is fed back to the source of fluid 87 through a second outlet 101 and return fluid conduit 103. During the greater part of the press operation, the cam 91 retains the pilot valve 89 in the first position connecting the inlet line 88 with the first fluid line 95 for direct communication with the tool housing chamber 37. The fluid line

95, as indicated by the direction of the arrows, provides a surge effect to accommodate changes in volume in the tool housing chamber 37 as the punch holder 40a rises to the press and eject position and provides for refilling the tool housing chamber with fluid when the punch holder moves down to the fill position. At one stage during the compacting cycle, that is, during a complete cycle of up and down movement of the tool holder 40a within the tool housing 32a, the pilot valve 89 will be positioned by means of the relative angular position of the rotating cam 91, which makes a complete rotation during each compacting cycle, to disconnect the surge line 95 from the inlet line 88 and connect the positive pressure line 97 to the inlet of the tool housing chamber 37 to forcibly inject a predetermined amount of fluid at a certain pressure determined by the capacity of the pump 99 into the die cavities 28. The valve operating cam 91 is designed such as to preferably initiate the forced fluid injection cycle substantially simultaneously with the positioning and clamping of the upper compacting member over the die cavities and is shut off approximately at the same time when the upper compacting member is being removed from over the die cavities, thus a timed pulsed fluid injection is being obtained during any one compacting cycle of the press operation within about 30° of cam rotation, whereas during the remaining 330° of cam rotation the positive pressure line 97 will be shut off from the inlet 88 which during that time is connected to the surge line 95. For positive ingress and egress of fluid into and from the tool housing chamber 37, the pressure and vacuum sides of the pump 99 could be used to assist in the movement of fluid in and out of the tool housing chamber 37 upon reciprocation of the tool holder 40a therein.

To summarize, during operation of the fluid injection system illustrated at FIGS. 3 and 4, upon the downward stroke of the punch holder assembly 40a the die cavities 28 are filled with a powder material, as previously described, and after predetermined maximum retraction of the punch members 54a downwardly in the die cavities 28, as determined by the timed cam-actuated mechanism of the press, the fluid injection passages 92 will be opened by the receding punch members to permit fluid to enter the die cavities 28 at a nominal pressure provided by the pressure source 87. During the positioning of the upper compacting member 31 over the die cavities by the station positioner and a clamping or holddown force, indicated by the direction of the arrows in FIG. 4, has been applied thereto, the compacting stroke of the press will be initiated causing the punch holder assembly 40a to be moved upwardly in the chamber 36 of the tool housing 32a to advance the shank portions 58a of the punch members 54a upwardly within the die cavities and towards the upper compacting member 31 for a predetermined maximum compression of the powder material 29 in the die cavities. As described in the foregoing, during the initial upward stroke movement of the punch holder assembly 40a, the valve cam 91 will be in a position to actuate the pilot valve 89 to inject a predetermined amount of the fluid 84 into the powder material 29 in the die cavities 28, as indicated by the fluid flow arrows. The head portion 54a of the punch holder assembly 40a by reciprocating within the tool housing chamber 36 creates a surge pressure on the fluid 84 within the upper chamber portion 37 when connected to the surge line 95 sufficient to maintain the chamber supplied with fluid. The injected fluid amount can be further determined or metered by means such as the size of the notches 90 and passages 92, the volume of the chamber 37, the location of the opening of the injection passages 92 relative to the upper surfaces of the punch members 54a, the speed of the compacting stroke and other inherent factors which can be easily designed into the programmed operation of the press to obtain the desired fluid saturation content of the powder material 29.

With reference to FIG. 4, upon further upward movement of the punch members 54a within the die cavities 28, the fluid injection passages 92 will be gradually closed by the advancing shank portions 58a of the punch members until they are completely closed substantially simultaneously with the timing

out of the pilot valve 89, as illustrated in FIG. 4, to thereby prevent further fluid from entering the die cavities 28. Since, as stated before, the fluid 84 inherently is only subject to a moderate pressure from the fluid source 87 further compression of the fluid within the upper chamber section 37 by the head portion 42a after closing of the injection passages 92 causes the fluid flow to be reverted back to the fluid source after connection of the surge line 95 with the inlet line 88 since the compacting force of the punch holder assembly 40a exceeds the moderate fluid pressure provided by the fluid source.

The complete advance of the shank portions 58a of the punch members 54a upwardly through the die cavities 28 towards the upper compacting member 31 compresses the fluid-saturated powder material 29 to produce solid compacted pellets, tablets or the like having a predetermined fluid saturation content and which are thereafter ejected from the die cavities by means described herebefore to initiate a new compacting cycle. As the shank portions 58a recede downwardly in the die cavities 28, the injection passages 92 will be gradually reopened again to permit fluid to enter the die cavities. Passages 66 in the bottom wall 38a of the housing 30a provide air and fluid venting means for the lower chamber 35 upon reciprocation of the punch holder 40a.

FIGS. 5, 6 and 6a illustrate two modifications of a fluid injection means adaptable to the tooling structure and system illustrated in FIGS. 3 and 4.

In FIG. 5, instead of providing the counterbores or notches 90 in the die bushing apertures 24a and injection passages 92 in the die bushings 26a, as in FIGS. 3 and 4, the upper part 59 of the shank portion 58b of the punch member 54b, which extends in any working position of the press within the die cavity 28, is of slightly reduced diameter relative to the lower part 61 of the shank portion 58b of the punch member 54b, which substantially corresponds to the internal diameter of the die cavity 28. Thus, the fluid 84 in the upper chamber section 37 in the downward or initial upward stroke position of the punch member 54b enters the die cavities 28 through the radial spacing provided between the inner wall of the die cavities and the reduced outer diameter of the upper part 59 of the punch shank portion 58b, as indicated by the direction of the arrows in FIG. 5. In this embodiment, likewise, the forced fluid injection into the die cavity 28 at a predetermined ratio is provided by the pulsed fluid injection system schematically illustrated in FIG. 3 until the lower part 61 of the shank portion of the punch member, which is of a diameter substantially equal to the diameter of the die cavity 28, enters the die cavity and thereby prevents further fluid entrance into the die cavity substantially together with the timing out of the pilot valve 89.

In the embodiment of FIGS. 6 and 6a, a fluid injection means adaptable to the tooling structure and fluid system illustrated in FIGS. 3 and 4 is provided in which the lower portion of the internal diameter of the die bushing 26b is provided with a plurality of longitudinal notches or grooves 94, radially spaced around the inner circumference of the die bushing which extend a substantial distance upwardly within the die cavity. In this instance, the fluid 84 in the upper chamber section 37 enters the die cavity 28 along the outer surface of the shank portion 58a of the punch member 54a through the longitudinal grooves 94 and is forcibly injected thereinto by the pulsed fluid injection system above described in connection with FIG. 3 until the upper end of the punch shank portion 58a reaches the upper end of the longitudinal grooves 94 to thereby interrupt any further fluid entrance into the die cavity 28 substantially together with the timing out of the pilot valve 89.

As stated hereinbefore, all three modifications of the fluid injection means adaptable to the tool structure and injection system shown in FIG. 3 are primarily used for punch members without the provision of core rods, however, conventional core rods may nevertheless be utilized for the production of apertured tablets, pellets or the like compacted articles without hindrance, disturbance or modification in the fluid injection system.

Referring now to a further modification of a fluid injection means according to the present invention, as shown in FIGS. 7 and 8, a die plate is illustrated at 22 provided with a plurality of spaced apertures 24 adapted to each receive a die bushing 26 which internal bore, as in the manner described herebefore, each forms a die cavity 28 adapted to be filled with a powder material 29 for compaction therein.

A tool capsule 30b comprising a housing 32b is attached to the underside of the die plate by means of bolts 34 and provides a chamber 36 which is open at the top towards the die plate and closed at the bottom by means of a bottom wall 38b having an internal diameter of such dimension as to circumscribe all of the die cavities 28. The chamber 36 is adapted to reciprocally retain a punch holder assembly 40b which is similar to the punch holder assembly 40 described and shown in FIGS. 1 and 2 and which supports a plurality of punch members 54.

Each of the punch members 54 is provided with a core rod 62a, the upper end of each of which normally extends outwardly of the shank portion 58 of each of the punch members and centrally through one each of the die cavities 28 to be flush with the upper surfaces of the die plate 22 and die bushings 26. The lower ends 63 of each of the core rods 62a extends out of the head portion of each of the punch members through correspondingly aligned apertures 64 in the head portion 42b of the punch holder assembly 40b to be slidably disposed therein and extend further through correspondingly aligned apertures 66 in the bottom wall 38b of the tool housing 32b from which they extend a short distance outwardly.

In this embodiment, however, the core rods 62a are not positively stationarily secured within the bottom portion 38b, as described and shown relatively to the structural embodiment of FIGS. 1 and 2. In the embodiment in FIGS. 7 and 8, the lower ends 63 of each of the core rods 62a within the apertures 66 in the bottom wall 38b are each provided with sealing means, such as O-rings 96, to provide a fluidtight seal towards the chamber 36. Similarly, the push rod aperture 46 through the bottom wall 38b is provided with a sealing means, such as an O-ring 98, to provide a fluidtight seal around the reciprocating push rod 44.

The head portion 42b of the punch holder assembly 40b divides the chamber 36 into a lower chamber section 35b and an upper chamber section 37b, which are sealed off from each other by the provision of an O-ring 80 retained within a circumferential groove 82 extending around the radial surface of the head portion 42b and which is in fluidtight, sliding sealing contact with the inner wall surface of the chamber 36.

The lower chamber section 35b provides a fluid chamber adapted to be filled with a fluid 84 of any desired kind through an inlet conduit 100 in the wall of the housing 32b which is in communication with a source of fluid under pressure by means of a fluid line 102 through a suitable flow control such as schematically illustrated in FIG. 3.

Each of the core rods 62a is provided with an axial fluid passage 106 which is closed at the lower end of the core rod by a sealed plug or the like 108 and which ends in the upper end of the core rod. Normally, the axial fluid passages 106 within the core rods 62a are in open fluid communication with the fluid chamber 35b by means of transverse passages or orifices 110 such that the fluid 84 is permitted to freely enter the axial passages 106. At the upper ends of the core rods 62a which extend into the die cavities 28 each of the axial fluid passages is normally in open communication with its respective die cavity by means of transverse injection passages or orifices 112 so as to permit fluid to enter the die cavities from the fluid chamber 35b through the transverse orifices 110, axial passage 106 and injection orifices 112. As will be noted from FIG. 7, the injection orifices 112 of the core rods are positioned such as to be slightly above the top surfaces of the punch members 54 within the die cavities when the punch members are in the lowermost or downward stroke position, which position is shown in FIG. 7.

In operation of the fluid injection means of FIGS. 7 and 8, when the punch holder assembly 40b moves downwardly

within the housing chamber 36 thereby lowering the punch members 54 in the die cavities 28, a powder material 29 is being dispensed into the die cavities in the manner previously described. As the punches 54 recede, the injection orifices 112 will be opened towards the die cavities to establish communication with the fluid chamber 35b. As the upper compacting member 31 is positioned over the die cavities 28, the fluid injection system of the type as illustrated in FIG. 3 becomes effective to cause a pressure being applied to the fluid 84 within the fluid chamber 35b, which is normally under moderate pressure necessary to cause fluid flow from the fluid pressure source (not shown) into the fluid chamber 35b through the fluid line 102. As described previously, a metered amount of the fluid 84 will be forced under pressure through each of the lower core rod orifices 110 into the axial core rod fluid passages 106 to be forcibly injected into the die cavities 28 through the opened injection orifices 112 to saturate the powder material in the die cavities. As described before, this is preferably done during positioning and clamping of the anvil 31 over the die cavities as shown in FIG. 8. Upon the upward compression stroke, the shank portions of the punch members 54 are forced upwardly in the die cavities under relatively high pressure to compact the fluid-saturated powder material therein against the upper compacting member 31. Upward movement of the punch members 54 in the die cavities 28 causes a gradual closing of the fluid injection orifices 112 until they are completely closed substantially simultaneously with the timing out of the fluid injection pilot valve (FIG. 3) by the maximum compacting position of the punch holder assembly 40b, as shown in FIG. 8, to thereby interrupt further fluid communication between the fluid chamber 35b and the die cavities. By predetermining the size and location of the injection orifices 112 relative to the top surface of the punch members 54, the amount of fluid being injected into the powder material in the die cavities can be additionally metered. The upward compacting stroke of the punch holder assembly 40b, as likewise described previously in connection with the schematic system illustrated in FIG. 3, causes an ancillary function to take place in that the reciprocating head portion 42b performs a pumping action causing a suction force to be created within the chamber 36 by which additional fluid will be pumped into the fluid chamber 35b to replenish the amount of spent fluid. In accordance with common practice, the upper chamber section 37b is provided with appropriate air vents 114 to release the air in the upper chamber section to the atmosphere upon reciprocation of the punch holder 40b.

FIG. 9 shows a modification of the fluid injection means illustrated in FIGS. 7 and 8. As will be noted in this embodiment, the axial fluid passage 106a through the core rod 62a has been extended upwardly to relocate the injection orifice 112 further above the upper surface of the punch member 54. In this embodiment, the core rod 62a is only initially used during the powder filling stage of the operation, and thereafter recedes from the die cavity simultaneously with the upward advance of the punch member in the die cavity during the precompacting stroke, such that, at the final stage in the compacting stroke the punch member 54 and core rod 62a form a unit a compact the fluid-saturated powder material into a solid tablet or pellet form in a manner as more in detail described in the copending application Ser. No. 850,204 of which the present application is a continuation-in-part. In this embodiment, likewise, the amount of fluid to be injected into the die cavity is by means of a timed pulse system as described in connection with the schematic shown in FIG. 3.

In regard to the modified embodiment shown in FIG. 9 providing a receding core rod during the compacting stroke by means of precompacting the base powder in the die cavity and by the provision of an initial core aperture in the precompact powder mass, a better control of a more effective saturation of the base powder with the fluid can be obtained. In this embodiment, likewise, the fluid may be a liquid or a gas which is injected into the precompact powder mass through the injection orifices 112.

In all of the foregoing embodiments of the invention, the density of the finished compacted and impregnated articles can be closely controlled in the same manner as with a dry powder material compacted in accordance with the operation of a powder-compacting press as described in the aforementioned U.S. Pat. No. 3,328,842, or similar apparatus, and the finished compacted articles will be of consistent accuracy in relation to the fluid to powder content throughout any one production run. Although the base powder will be thoroughly saturated with the liquid or treated with a gas, the finished compacted articles will not be brittle but will be sufficiently solid so as not to fall apart or be easily crushed in handling.

As stated herebefore, the various embodiments of fluid injection means herein described and shown can also be conveniently and advantageously used to treat the die cavity surfaces and the surfaces of the punches and core rods for cleaning or for lubrication purposes and also for sterilization when producing pharmaceutical tablets, or hot vapor may be injected for preheating of the die cavities and punches.

From the foregoing description of several examples of the improved fluid injection method and apparatus in accordance with the present invention, those skilled in the art will observe that the invention herein achieves and realizes all of the objects and advantages stated in the introduction, as well as having manifold additional advantages which are readily apparent from the detailed description.

The present invention may be embodied in certain other forms without departing from the spirit or essential characteristics thereof, therefore, the present embodiments are to be considered in all respects as illustrative only and not restrictive.

I claim:

1. In an apparatus for making a fluid-saturated compacted powder article:

a die plate having at least one die cavity, said die cavity adapted to be filled with a powder material;

a lower and an upper compacting member adapted to be aligned with said die cavity and disposed for relative movement towards each other to compact said powder material within said die cavity;

passage means having an opening into said die cavity between said lower and upper compacting member;

means for injecting a fluid through said passage means opening into said powder material in said die cavity prior to compacting said powder material; and

one of said compacting members traversing said passage means opening to precisely meter the amount of said fluid ejected through said opening into said die cavity at a predetermined stage during movement of said compacting members toward each other.

2. In the apparatus as defined in claim 1, the provision of at least one core rod disposed in said lower compacting member for the provision of at least one core hole in said compacted article.

3. In the apparatus as defined in claim 2, said fluid being injected into said core hole provided by said core rod.

4. In the apparatus as defined in claim 3, said fluid being a liquid.

5. In the apparatus as defined in claim 3, said fluid being a gas.

6. In combination with an apparatus for making a fluid-saturated compacted powder article:

a die plate having at least one die cavity;

a housing secured to one side of said die plate in alignment with said die cavity and extending below therefrom;

a punch member reciprocally retained in said housing, having a shank portion for extension into said die cavity;

an upper compacting member positionable over said die cavity, said die cavity adapted to be filled with a powdered material for compaction between said reciprocable punch member and said upper compacting member;

passage means having an opening into said die cavity between said punch member and said upper compacting member;

means for injecting a fluid through said passage means opening into said die cavity between said punch member and said upper compacting member;

means associated with said housing to inject a fluid under pressure through said passage means opening into said powder in said die cavity and said punch traversing said passage means opening to precisely meter the amount of said fluid ejected into said die cavity as said punch member is reciprocated toward said upper compacting member.

7. In the combination as defined in claim 6, said means associated with said housing to inject a fluid comprising a source of fluid under pressure, said housing having an inlet opening and a fluid line communicating with said inlet opening in said housing, and said passage means being between said inlet opening and said die cavity providing an injection orifice within said die cavity between said punch member and said upper compacting member selectively opened and closed by reciprocation of said punch member to thereby control the amount of fluid injected into said die cavity.

8. In the combination as defined in claim 7, said fluid passage means comprising a fluid injection orifice being positioned relative to said punch member and said die plate such that upon reciprocating movement of said punch member within said die cavity the amount of fluid injected into said die cavity can be precisely proportioned.

9. A fluid injection system for a powder-compacting press adapted to inject a fluid into a powder material to be compacted comprising:

- a die plate having at least one die cavity adapted to be filled with a powder material;
- an upper compacting member adapted to be positioned over said die cavity;
- a reciprocating lower compacting member disposed in said die cavity;
- passage means having an opening into said die cavity

between said compacting members;
a source of fluid under pressure having an outlet communicating with said die cavity through said passage means; and

5 means associated with said lower compacting member adapted to control the injection of fluid through said passage means opening into said powder in said die cavity upon reciprocation of said lower compacting member, said lower compacting member traversing said opening to precisely meter the amount of said fluid ejected into said die cavity as said lower compacting member is reciprocated toward said upper compacting member.

10. The apparatus defined in claim 2 wherein said passage means are provided in said core rod.

11. The apparatus defined in claim 1 wherein said passage means extends through said die plate and has an opening into said die cavity between said compacting members.

12. The apparatus defined in claim 7 further comprising at least one core rod disposed in said punch member and movable relative to said punch member, said passage means being provided in said core rod, said injection orifice being formed in said core rod and opening into said die cavity, said punch member traversing said injection orifice of said core rod to selectively open and close the same as said punch is reciprocated in said die cavity.

13. The apparatus defined in claim 7 wherein said passage means extends through said die plate and said injection orifice is formed on the surface of said die cavity between said upper compacting member and said punch member, said punch member traversing said orifice to selectively open and close the same upon reciprocation of said punch member.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,647,333 Dated March 7, 1972

Inventor(s) Joseph E. Smith

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

In the Abstract

Line 1, cancel "A method and", insert thereinstead --An-- ;
Lines 6 & 7, after "The" (second instance) cancel "method
may be advantageously carried out in an" ;
Line 7, cancel "such as", insert thereinstead --comprises-- .

In the Specification

Col. 1, line 17, cancel "method and" ,
after "to" cancel "a" ;
line 18, before "apparatus" cancel "method
and" and insert --an-- ;
lines 34 & 35, cancel "and method" ;
line 41, after "apparatus" cancel "and method" ;
change "provide" to --provides-- ;
line 52, cancel "method and" ;
line 53, change "provide" to --provides-- ;
line 55, cancel "method and" ;
line 62, cancel "and method" .

Col. 3, line 17, cancel "method and" ;
line 70, cancel "method and" .

Col. 4, line 21, after "of" (first instance) cancel
"improved" and insert --an-- ,
before "fluid" cancel "an" and
insert --improved-- ,
line 52, after "punches" insert -54-- ,
line 54, after "extends" change "in" to --into-- .

- Col. 5, line 16, after "punches" insert --54-- ;
line 22, change "63" to --62-- ;
line 38, change "stoke" to --stroke-- ;
line 72, after "cavities" insert --28-- .
- Col. 6, line 45, after "cavities" insert --28-- ;
line 48, after "member" insert --31-- ;
lines 59-60, change "(PEN-111-A)" to --850,204-- .
- Col. 7, line 19, after "2" change the comma "," to a
period --.-- ,
change "however" to --However-- ;
line 68, after "member" insert --31-- .
- Col. 10, line 9, after "plate" insert --22-- ;
line 51, after "wall" insert --38b-- ;
line 53, before "flow" insert --fluid--.
- Col. 11, line 29, after "valve" insert --89-- ;
line 56, after "cavity" insert --28-- .
- Col. 12, line 21, cancel "method and" •
Col. 11, line 57, after "member" insert --54-- ;
Col. 11, line 60, before "compact" change "a" to --to-- .

In the Claims

- Col. 12, line 35, change "on" to --one-- .

Signed and sealed this 29th day of August 1972.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents