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Overhoff et al.

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[54] **MANUFACTURE OF COMPRESSED-POWDER BODIES**

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Sept. 9, 1971 Germany 2145006

[52] **U.S. Cl.** **264/109;** 264/313; 264/314

[51] **Int. Cl.** **B29j 5/00**

[58] **Field of Search** ..... 264/109, 111, 313, 314; 425/78, 405 H, DIG. 44

[56] **References Cited**

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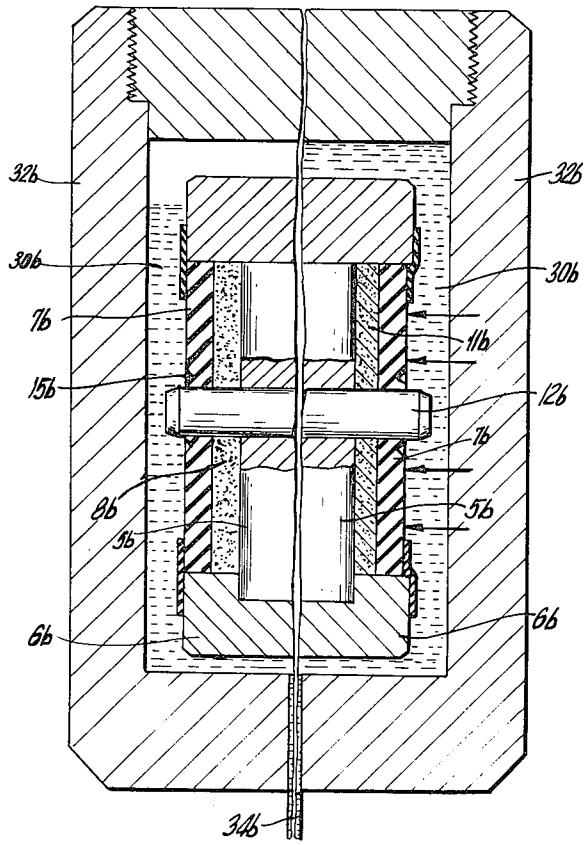
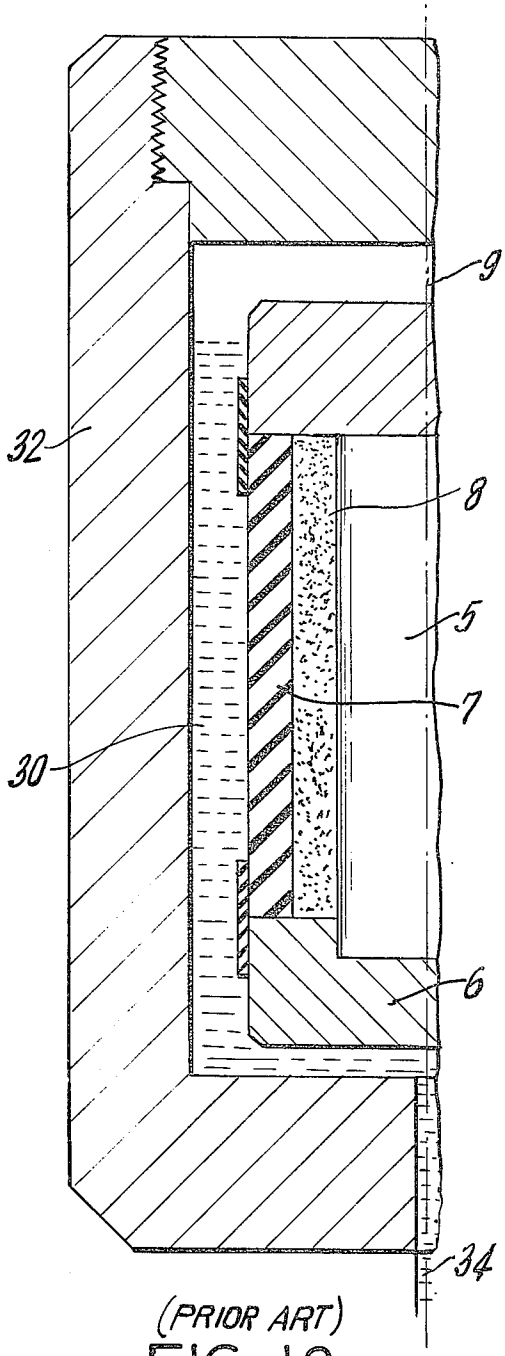
Assistant Examiner—J. R. Hall
Attorney, Agent, or Firm—Toren, McGeady and Stanger

[57] **ABSTRACT**

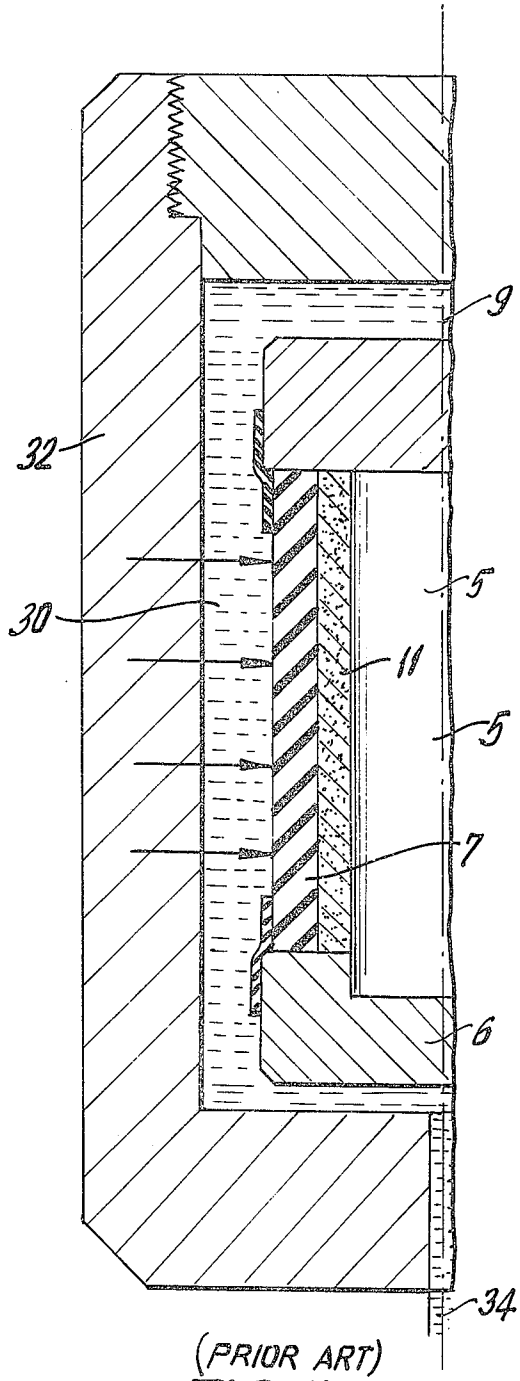
In the manufacture of bodies by isostatic compression of a powder, a press tool includes an elastically flexible jacket which is subjected to pressure in order to compress the powder. A main core, either within or surrounding the jacket, may be used to determine the shape of the body if the body is to be hollow. For the formation of a slot or other opening in the body, an auxiliary core is provided, and this core may move with the jacket during compression of the powder, or may extend through an aperture in the jacket which then slides relative to the auxiliary core during the compression operation. A piston may operate in a bore in the main core to generate pressure for urging the auxiliary core into contact with the surface of the jacket, and the piston may also be used to produce a partial vacuum for retracting the auxiliary core after formation of the body.

6 Claims, 9 Drawing Figures





(PRIOR ART)
FIG. 1a



(PRIOR ART)
FIG. 1b

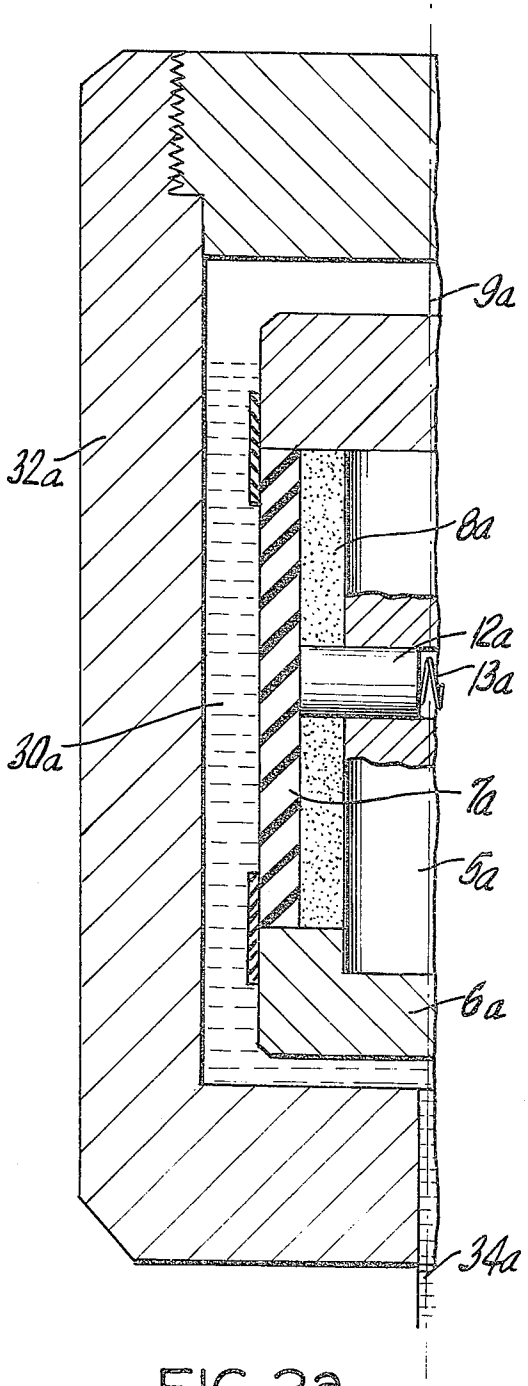


FIG. 2a

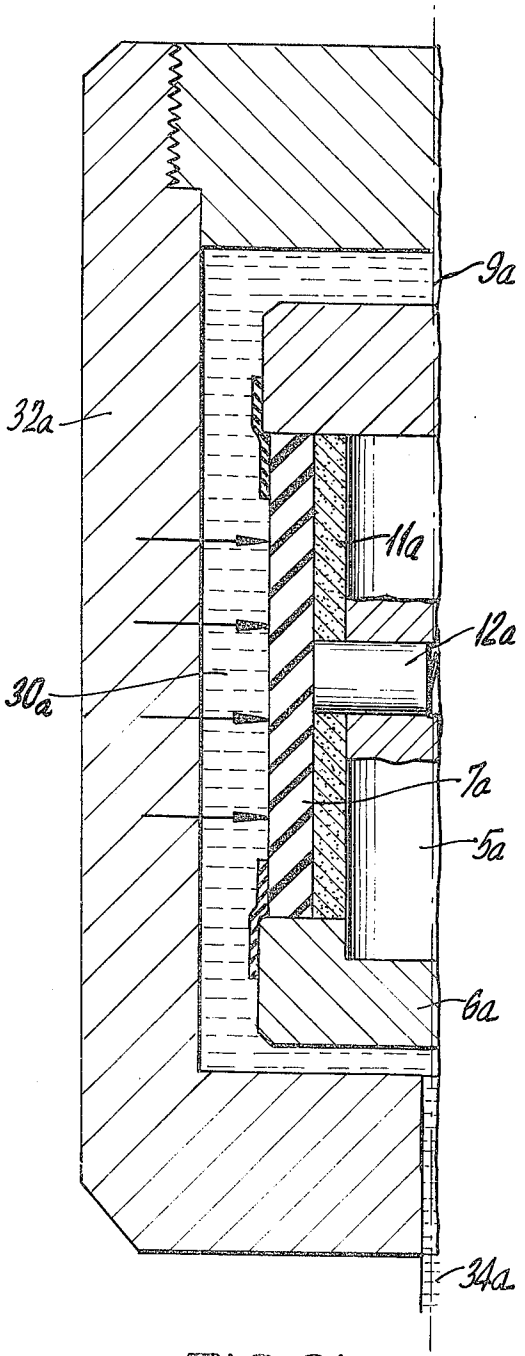


FIG. 2b

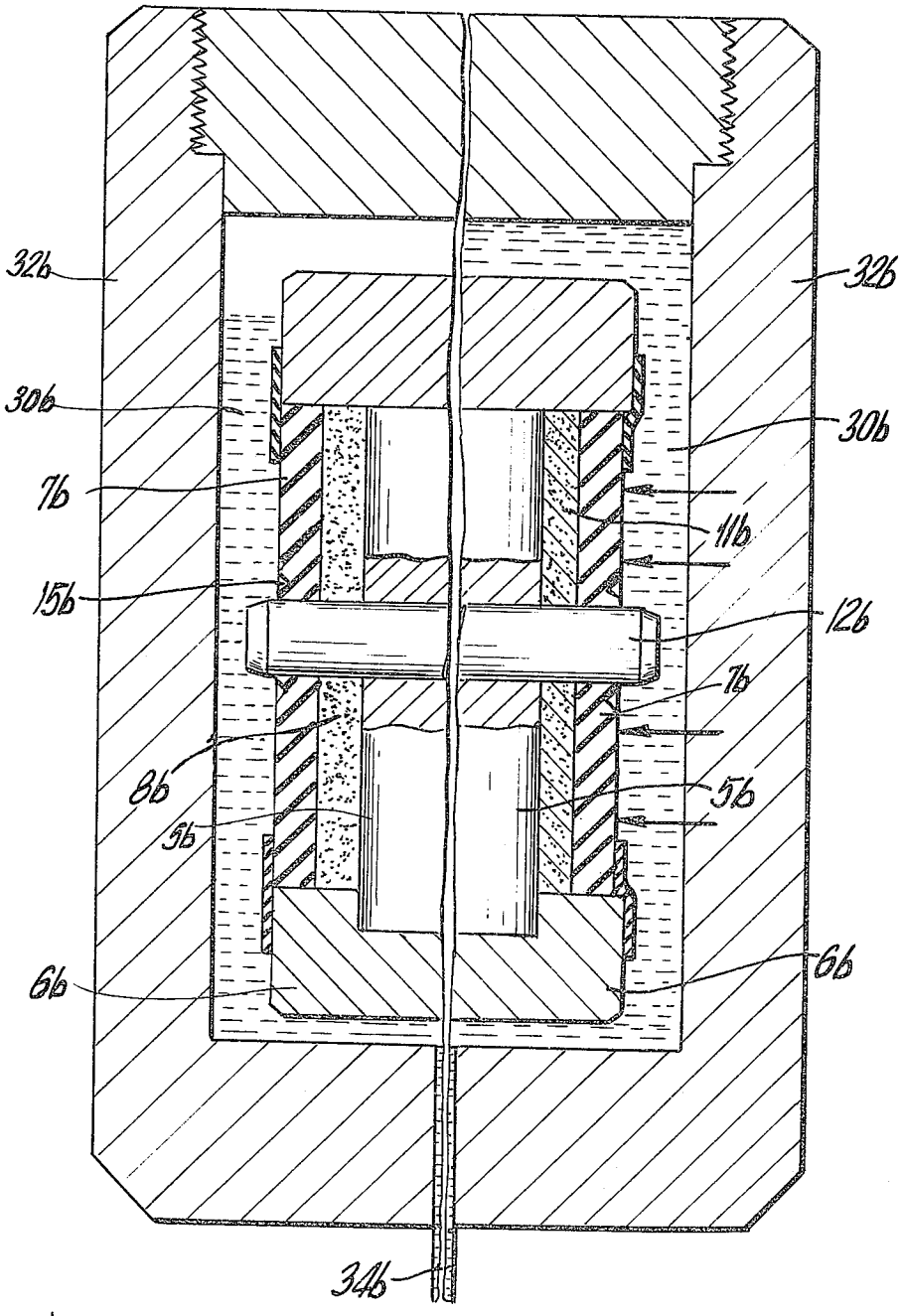
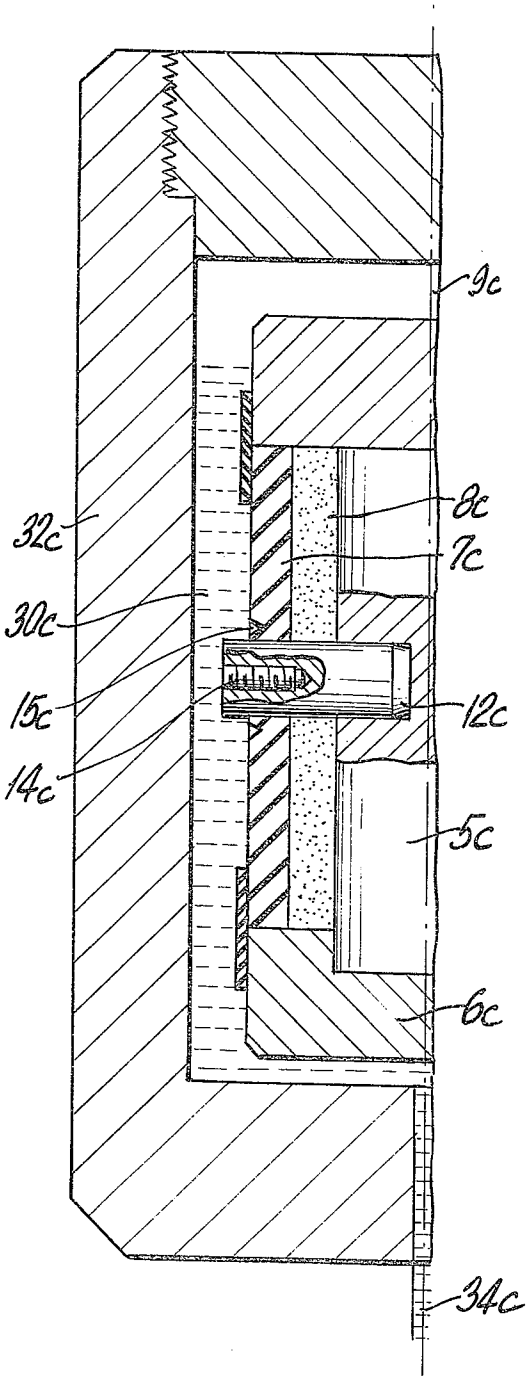


FIG. 3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6c
34c

FIG. 4a

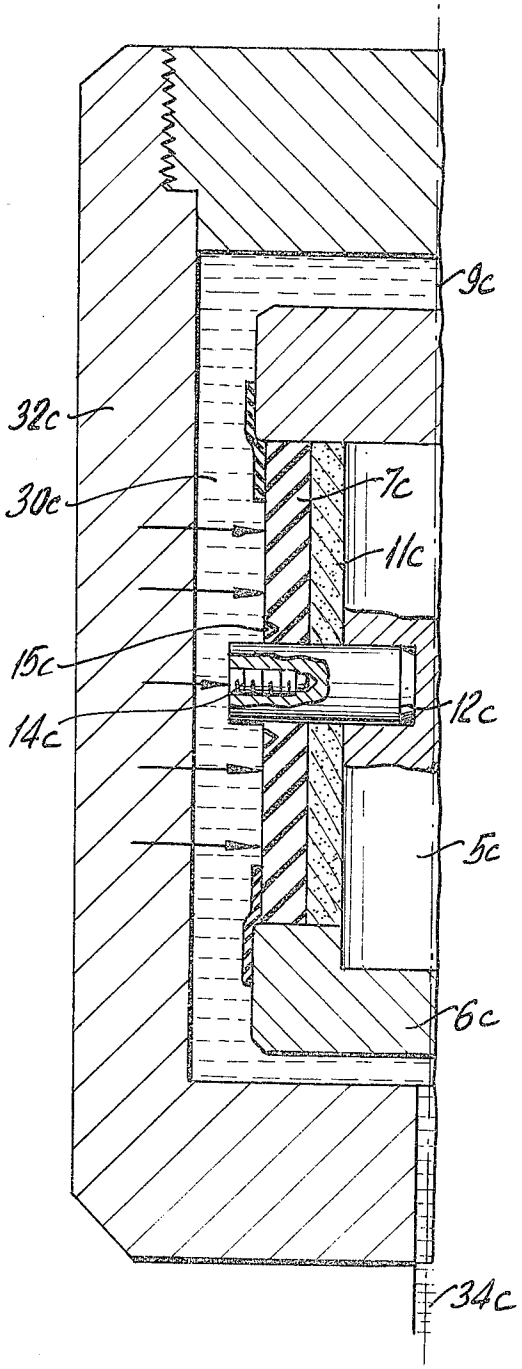
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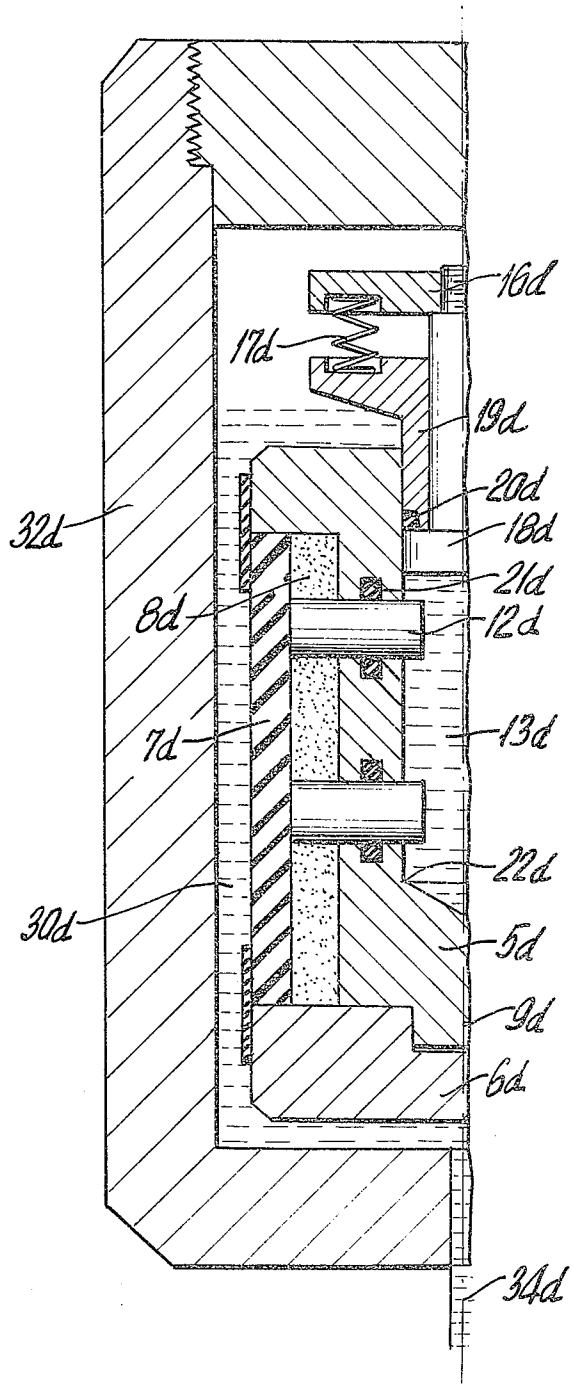
FIG. 4b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5d
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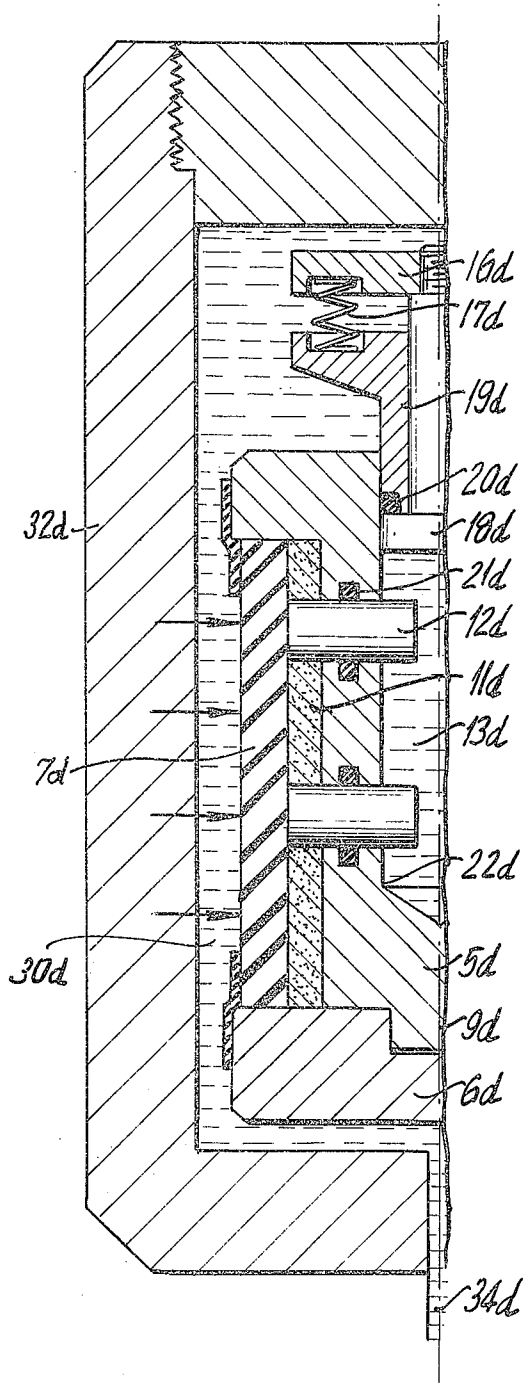
6d
34d

FIG. 5a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22d
30d
5d
9d
6d
34d

FIG. 5b

MANUFACTURE OF COMPRESSED-POWDER BODIES

This invention relates to the manufacture of bodies by isostatic compression of powders.

A known method of manufacturing bodies by the isostatic pressing of powder using a press tool, consists in mounting an elastically flexible jacket around a core so that a chamber for containing the powder is formed by a gap between the jacket and the core. After pouring the loose powder into the chamber to fill it up, the entire press tool is introduced into a fluid, which is put under pressure. The jacket is deformed elastically, thereby compressing the powder. A compressed blank is produced in the form of a hollow cylindrical body. In principle, the method could alternatively be used without a core, in which case a compressed blank in the form of a solid cylinder would be produced. It should be observed that the method can be used not only for manufacturing cylindrical bodies but also, if desired, for forming bodies of other configurations.

In the application of this known method, considerable difficulties are encountered when attempting to form bodies containing blind holes, or containing slots or other openings which pass right through the wall of the body.

An object of the present invention is to provide a process to simplify the manufacture of bodies of this kind.

According to the invention, there is provided a process for manufacturing a body by isostatic compression of a powder, in which an elastically flexible jacket compresses the powder under the action of pressure applied to the jacket; in which a transverse opening is formed in the body by an auxiliary core on which said pressure acts either directly or via the jacket; and in which the jacket and the auxiliary core move together or one relatively to the other, substantially in the direction of the applied pressure, during compression of the powder.

The auxiliary core can be arranged so that during the pressing operation the core is pushed along sideways by the jacket in the direction of the applied working pressure, the core moving from an initial position which it occupies when the powder is being inserted into the chamber, to a final position which it occupies when the powder is fully compressed. On the other hand, if a core which is acted on directly by the working fluid is used, the jacket can move relatively to the core during the compressing of the powder.

The method allows slots or other openings to be introduced at negligible cost into the walls of bodies made by the isostatic pressing of powders.

In forming a hollow body, a main core is provided to cooperate with the jacket to determine the inner and outer dimensions of the body. The auxiliary core can extend, for example, perpendicular to the longitudinal axis of the main core. In this case the auxiliary core is retained in place, relative to the main core, while the powder is being inserted into the chamber. When the pressing operation has been completed, and after removing the jacket, the auxiliary core can be moved out of the way by pushing it inwards into the main core or by pulling it inwards, for example by means of a partial vacuum.

A device for operating the process according to the invention has a jacket for compressing the charge of powder, and an auxiliary core for forming the slots or other wall openings, the auxiliary core being arranged

so that it can move in the direction of the working pressure applied to the jacket, moving either in common with the jacket or relative to it.

When forming hollow bodies, the auxiliary core is preferably mounted to slide sideways, in the direction of the applied working pressure, in a main core which extends substantially perpendicular to the auxiliary core. The press tool comprising the cores and the jacket is preferably arranged in such a way that, when the tool is full of powder, the auxiliary core projects outwards beyond the outer periphery of the main core ad thrusts against the surface of the jacket so that it is not in contact with the pressure fluid. The auxiliary core can rest in contact with the inner surface of the jacket, the working pressure acting on the outer surface of the jacket.

Alternatively, if desired, the jacket can be positioned in the interior of the tool, in which case the auxiliary core rests in contact with the outer surface of the jacket. The working pressure in this case acts on the inner surface of the jacket, the jacket moving outwards during the pressing operation, towards the inner surface of, for example, an outer hollow cylindrical main core, pushing the auxiliary core outwards with it.

In each case, a plurality of auxiliary cores may be provided.

The auxiliary core may project outwards from the outer periphery of the main core, across the chamber and through the wall of the jacket, a fluid-tight seal being formed with this wall. It is not necessary to provide a separate seal because the elastically flexible jacket forms its own seal against the auxiliary core.

During the filling operation, the press tool is preferably held in position by a retainer which can conveniently be situated inside the main core and can be used for pulling the auxiliary core into the main core after the completion of the pressing operation. The retainer can be actuated hydraulically or mechanically.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which each figure shows, in its left-hand half, a press tool device filled with powder before pressing, whilst the right-hand half represents the device after compression of powder. In the drawings:

FIGS. 1 (*a*) and (*b*) are sectional views of a conventional press tool assembly wherein a hollow blank may be formed without slots or other wall openings, FIG. 1 (*a*) showing the assembly prior to the application of pressure and FIG. 1 (*b*) showing the assembly after pressure has been applied;

FIGS. 2 (*a*) and (*b*) are sectional views of a device in accordance with the present invention, with FIG. 2 (*a*) showing the device prior to the application of pressure and FIG. 2 (*b*) showing the device during or after the application of pressure;

FIG. 3 is a sectional view showing another embodiment of the invention;

FIGS. 4 (*a*) and (*b*) are sectional views showing still another embodiment of the invention, with FIG. 4 (*a*) showing the embodiment prior to the application of pressure while FIG. 4 (*b*) depicts the device after pressure has been applied; and

FIGS. 5 (*a*) and (*b*) show still a further embodiment of the invention, with FIG. 5 (*a*) depicting the device prior to the application of pressure and FIG. 5 (b) showing the device after pressure has been applied.

Referring to FIGS. 1 (*a*) and (*b*) of the drawings, in conventional practice, a press tool for isostatic pressing consists of a central core **5** the lower end of which is inserted into a connecting piece **6.** An elastically flexible jacket **7** rests with one end on the surface of the connecting piece **6.** Between the core **5** and the jacket **7** there is a gap which forms a chamber **8** into which a powder can be poured. When the chamber **8** has been filled with the powder, the press tool containing the powder is immersed in a pressure medium, such a **30** which is put under pressure through a pressure medium supply port **34.** The entire assembly is enclosed by an outer jacket **32** which permits the fluid **30** to be placed under pressure, thereby causing pressure to be applied to the jacket **7.** The pressure acts on the outer surface of the elastically flexible jacket **7** in the direction indicated by the arrows in FIG. **1** (*b*), that is to say essentially in a direction perpendicular to a longitudinal axis **9** of the core **5.** The applied pressure compresses powder within the chamber **8** by squeezing it between the jacket **7** and the core **5,** the jacket moving inwards towards the core. The product is a compressed blank **11,** in this case a hollow cylinder.

However, the present invention is concerned with the manufacture of bodies which have slots or other openings in their walls. As shown, for example, in FIGS. **2** (*a*), and (*b*) such an opening is formed in the blank **11***a* with the help of an auxiliary core **12***a* which extends in the direction of the applied pressure. The auxiliary core **12***a* passes through the main core **5***a* with enough clearance to allow the auxiliary core **12***a* to slide in the main core **5***a* under the influence of the applied pressure. As shown in FIG. **2** (*a*), the auxiliary core **12***a* extends right across the chamber **8** *a*, the outer end of the auxiliary core resting in contact with the inner surface of the jacket *a*.

Before introducing the powder into the chamber **8***a* and also during the introduction of the powder, the auxiliary core **12***a* is retained in this position, with its outer end in contact with the inner surface of the jacket **7***a*, by means of a retainer system **13***a* which is not represented in detail in the figure but which can, for example, be a hydraulic, pneumatic or mechanical system.

With the parts in the positions shown in FIG. **2** (*a*), the press tool is immersed in a fluid **30***a* under pressure contained within the outer jacket **32***a*. The pressure which is applied through an inlet port **34***a* compresses the powder by acting on the outer surface of the elastically flexible jacket **7***a*. During the pressing process, the jacket **7***a* moves inwards towards the main core **5***a*, the auxiliary core **12***a* moving inwards with the jacket.

When the pressing has been completed, the jacket **7***a* is removed. The auxiliary core **12***a* can then be moved out of the way in various ways. It can be pushed inwards from outside entirely into the main core **5***a* or it can be extracted by pulling it outwards, after which the compressed blank is pulled off the main core. On the other hand, the retainer system **13***a* which has been used for retaining the auxiliary core **12***a* in position during the filling operation can be used for pulling the auxiliary core inwards entirely into the main core **5***a*. Once the auxiliary core **12***a* has been shifted out of the way, the compressed blank **11***a* can easily be removed from the main core **5***a* either by pulling it off or by pushing it off.

An alternative arrangement (not shown) can, if desired, be used. In this case, the elastically flexible jacket is situated inwards of the body of powder, the pressure being aplied to the inner surface of the jacket. The powder is inserted into a chamber which in this case is situated between the outer surface of the jacket and a surrounding hollow steel cylinder. Before and during the filling operation, the auxiliary core is retained in the wall of the outer hollow cylinder by a retainer system in such a way that the inner end of the auxiliary core rests against the outer surface of the elastically flexible jacket.

To compress the powder, pressure is applied to the inner surface of the jacket. During the pressing operation, the jacket moves outwards, pushing the auxiliary core outwards with it, the auxiliary core sliding in the wall of the outer hollow cylinder. When the pressing has been completed, the jacket is removed and the auxiliary core can be extracted from the wall of the hollow cylinder. With the auxiliary core out of the way the compressed blank is easily removed from the press tool.

FIG. **3** shows a modified version of the invention. A central main core **5***b* is inserted at its lower end into a connecting piece **6***b*. An elastically-resilient jacket **7***b* is mounted on the upper surface of the connecting piece **6***b*, a gap between the jacket and the central core forming a chamber **8***b* for receiving the powder. In this version of the invention, the auxiliary core **12***b* extends not only through the main core **5***b* and through the body of powder which will form the compressed blank **11***b*, but also extends at each end through the wall of the jacket **7***b*. When this press tool is immersed in a fluid **30***b* contained under pressure within the outer jacket **32***b*, the pressure applied through a supply port **34***b* therefore acts directly on both ends of the auxiliary core **12***b*.

During the pressing operation, the jacket **7***b* moves inwards towards the main core **5***b*, and also moves inwards relative to the auxiliary core **12***b*. The material of the jacket **7***b* should form a fluid-tight seal with the auxiliary core **12***b*. To improve the seal, the material of the jacket is cut away to form annular grooves **15***b* around the apertures where the auxiliary core **12***b* passes through the jacket wall. The material between each groove **15***b* and the core **12***b* forms a lip which is pressed against the core **12***b* by the fluid pressure.

After the pressing has been completed, the auxiliary core **12***b* is pushed out of the press tool, in one direction or the other, either manually or by means of a mechanical, hydraulic or pneumatic device. Once the auxiliary core has been removed, the pressed blank **11***b* is easily withdrawn from the main core **5***b*.

FIGS. **4** (*a*) and (*b*) show a variation of the arrangement represented. in FIG. **3.** FIG. **4** (*a*) shows the press tool containing powder which has just been inserted. FIG. **4** (*b*) the powder has been compressed to form a pressed blank **11***c*. In this example of the invention, the auxiliary core **12***c* does not pass all the way through the main core **5***c* but works in a blind bore in the main core. Removal of the auxiliary core **12***c*, after the pressing operation has been completed, is facilitated by screwing a suitable extracting tool into an internally threaded bore **14***c* in the auxiliary core.

In FIGS. **5** (*a*) and (*b*) a hydraulic retainer system **13***d* is shown which serves both for retaining a number of auxiliary cores **12***d* in place and for moving them out of the way after the pressing operation. The hydraulic retainer system **13***d* comprises a supporting plate **16**

and a sliding sleeve **19***d* which slides axially in a pressure-compensating bore **22***d* in the main core **5***d*. Between the supporting plate **16***d* and the sleeve **19***d* there is a compression spring **17***d*. The sleeve **19***d* supports a piston **18***d* which can slide longitudinally in an aperture through the sleeve. Between the head of the piston **18***d* and the sleeve **19***d* there is a sealing ring **20***d*. Further sealing rings **21***d* are interposed between the auxiliary cores **12***d* and the main core **5***d*. The rod of the piston **18***d* is screwed into the supporting plate **16***d*. The working area of the piston **18***d*, that is to say the thrust area which acts on the fluid in the pressure-compensating bore **22***d*, is slightly less than the sum of the thrust areas of all the auxiliary cores **12***d*.

Before introducing the powder, enough pressure is caused to build up in the pressure-compensating bore **22***d* to thrust the auxiliary cores **12***d* outwards until the outer end of each auxiliary core is in contact with the inner surface of the jacket **7***d*. The chamber **8***d* is then filled with the powder.

After immersing the press tool in the fluid **30***d* within the jacket **32***d*, the pressure in the fluid is gradually built up, and the pressure acting on the external surface of the jacket **7***d* compresses the powder. During the pressing operation, the jacket **7***d* moves inwards towards the main core **5***d*, pushing the auxiliary cores **12***d* inwards into the pressure-compensating bore **22***d*. This inwards movement of the auxiliary cores is made possible by the fact, already mentioned above, that the thrust area of the piston **18***d* in the bore **22***d* is slightly less than the sum of the thrust areas of the auxiliary cores.

The hydraulic retainer system **13***d* which is used for retaining the auxiliary cores **12***d* in position during the filling operation, and which makes it possible for the auxiliary cores to be pushed slowly inwards into the pressure-compensating bore **22***d* during the pressing operation, is also used for moving the auxiliary cores **12***d* out of the way after the pressing has been completed. To move the auxiliary cores, the piston **18***d* is retracted upwardly within the bore **22***d*, the resulting suction in the pressure-compensating bore **22***d* urging the auxiliary cores inwards into the pressure-compensating bore **22***d*, so that the pressed blank **11***d* can easily be removed from the main core **5***d*.

If there is too much friction between the auxiliary cores **12***d* and the pressed blank **11***d* to allow the auxiliary cores to be urged inwards by the suction in the pressure-compensating bore **22***d*, the auxiliary cores can be moved out of the way, after removing the jacket **7***d*, by applying a thrust to the supporting plate **16***d* and so to the piston **18***d*, so that the auxiliary cores are ejected outwards.

In order to remove air entrapped in the pressure-compensating bore **22***d* by the introduction of the piston **18***d*, a venting system is provided consisting of the supporting plate **16***d*, the compression springs **17***d*, the piston **18***d*, the sleeve **19***d* and the seal **20***d*. The system functions as follows. When the piston **18***d* is initially advanced in the bore **22***d* by pressure on the plate **16***d*, the head of the piston moves away from the end of the sleeve **19***d* thereby allowing the air entrapped in the pressure-compensating bore **22***a* to escape through the clearances between the piston **18***d* and the main core, and between the piston rod and the sleeve **19***d*, the seal **20***d* being ineffective. When the advancing piston **18***d* is brought to a stop by the hydraulic fluid in the pressure-compensating bore **22***d*, the sleeve **19***d*, urged by the compression springs **17***d*, advances towards the head of the piston **18***d*, a conical surface of the sleeve **19***d* squashing the seal **20***d* into close contact with the neighbouring surfaces of the piston head and the pressure-compensating bore **22.** This arrangement ensures that the pressure-compensating bore **22***d* is completely sealed.

We claim:

1. A method for manufacturing molded articles from pressed powder material by compression within molding apparatus including a centrally located, generally cylindrical main core member consisting essentailly of solid inelastic material, an outer pressing jacket formed from elastic material surrounding said main core with a spacing therebetween forming a generally cylindrical annular molding cavity, and means including said outer pressing jacket enclosing said molding cavity, comprising:

a. positioning auxiliary core means consisting essentially of solid inelastic material to extend completely through said molding cavity transversely thereof between said pressing jacket and said main core member;

b. filling said molding cavity with moldable powder material;

c. applying fluid pressure externally of said pressing jacket to compress said powder material and bond the particles thereof into said molded article, said pressure being applied in a manner to act againt said auxiliary core means;

d. disassembling said apparatus to permit removal of both said auxiliary core means and said molded article from within said molding cavity; and

e. removing said molded article from said cavity, said article being thereby formed with a transverse aperture extending therethrough.

2. The method according to claim **1** wherein said auxiliary core means is positioned within said molding cavity in abutment with the internal surface of said pressing jacket and wherein said main core is formed with recess means into which said auxiliary core means may extend, with application of said external pressure operating to move said auxiliary core means together with said pressing jacket in a direction centrally of said main core member.

3. The method according to claim **1** wherein said auxiliary core means are positioned to extend through said pressing jacket to the exterior thereof, and wherein application of said external pressure causes relative movement between said auxiliary core means and said pressing jacket.

4. The method according to claim **1** wherein said main core member comprises a generally central axis extending longitudinally thereof and wherein the said auxiliary core means comprise a generally longitudinal body member, said auxiliary core means being positioned with its longitudinal direction extending generally perpendicularly to the longitudinal axis of said main core member.

5. The method according to claim **4** wherein said auxiliary core means is retained in a fixed position relative to said main core member during application of said external molding pressure.

6. The method according to claim **4** wherein said main core member includes an internal recess into which said auxiliary core means extends and wherein said auxiliary core means is removed from said molding cavity by being retracted into said main core member to enable removal of said molded article.

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