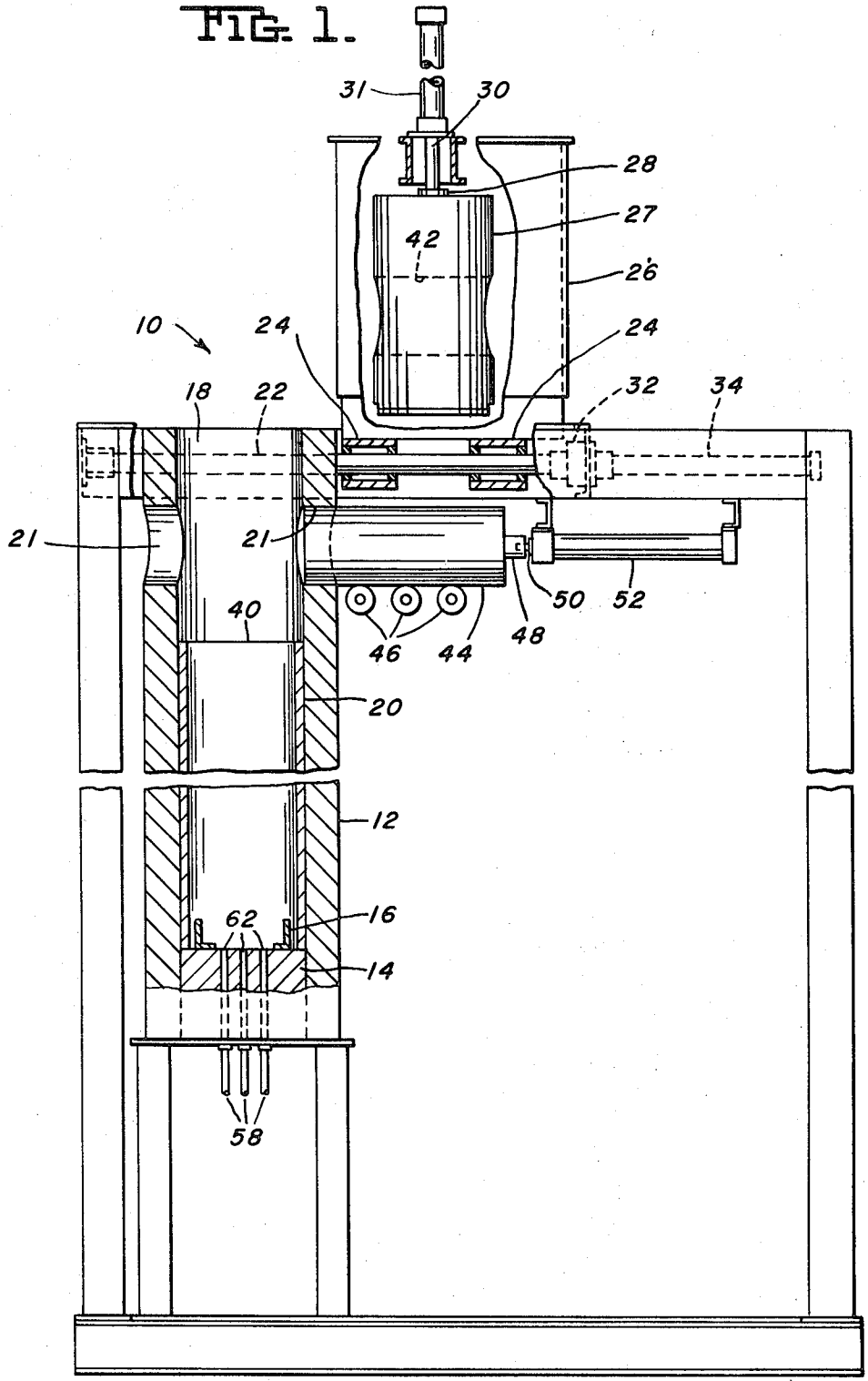
Dec. 1, 1970 C. B. BOYER 3,543,345

APPARATUS FOR RAPID FLUID COMPACTING

Filed Dec. 12, 1968 2 Sheets-Sheet 1

FIG. 1.



INVENTOR.
CHARLES B. BOYER
By Clair X. Mullen Jr.
Attorney

Dec. 1, 1970 C. B. BOYER 3,543,345

APPARATUS FOR RAPID FLUID COMPACTING

Filed Dec. 12, 1968 2 Sheets-Sheet 2

FIG. 2.

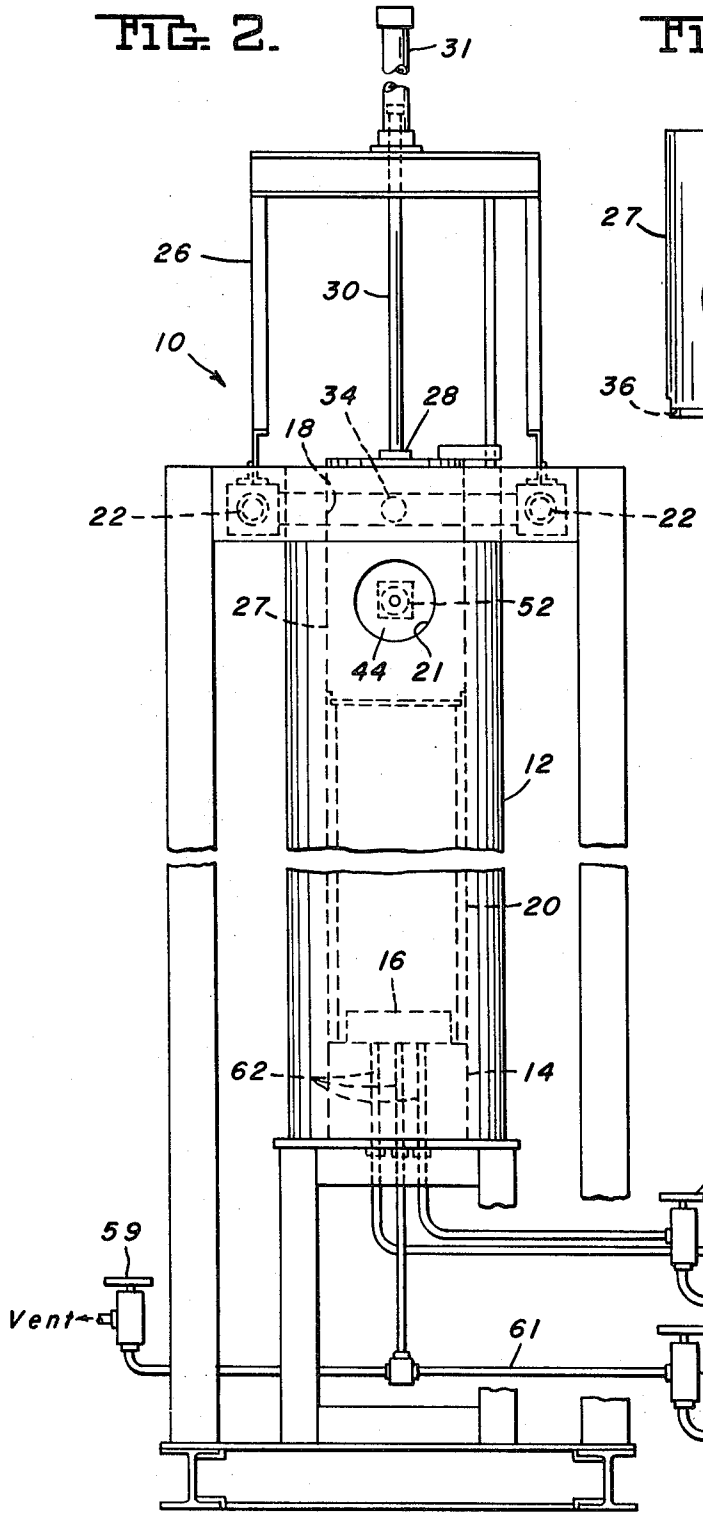


FIG. 3.

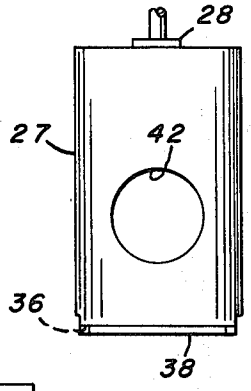
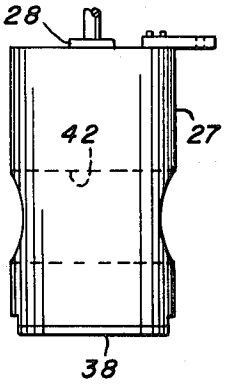
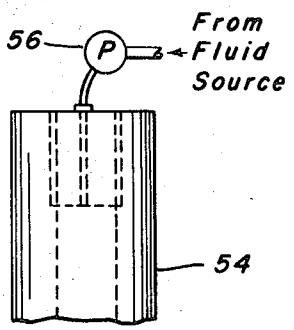


FIG. 4.





INVENTOR.
CHARLES B. BOYER
By Claire L. Mullen Jr.
Attorney

United States Patent Office 3,543,345 Patented Dec. 1, 1970

3,543,345

APPARATUS FOR RAPID FLUID COMPACTING

Charles Benjamin Boyer, Columbus, Ohio, assignor to Crucible Inc., Pittsburgh, Pa., a corporation of Delaware

Filed Dec. 12, 1968, Ser. No. 783,237
Int. Cl. B29g 1/00
U.S. Cl. 18—16 7 Claims

ABSTRACT OF THE DISCLOSURE

This disclosure relates to apparatus for use in producing compacted articles from powdered-metal charges in a pressure vessel. The apparatus is particularly adapted for quick compacting, whereby cooling of a previously heated charge for compacting is minimized. This is achieved by providing means for quickly opening and resealing or closing the pressure vessel after loading thereof with a charge to be compacted. Also, means are provided for quickly pressurizing the vessel upon loading.

In the art of powder metallurgy, wherein metal in powdered form is heated to an elevated temperature and while at said temperature subjected to pressure to form a dense metal compact, it is well known to perform this operation in a fluid-pressure vessel, commonly termed an autoclave. By the use of an autoclave, as opposed to mechanical compacting, more uniform pressure application is achieved. With many powder-metallurgy products, such as tool-steel articles, the quality of the product is greatly improved by this uniform pressure application.

Prior to the present invention, however, the use of an autoclave for the compaction of metal articles, and particularly tool-steel articles, has not been commecrcially feasible. This resulted from the fact that many metal articles, and particularly tool steels, must be compacted at extremely high temperatures. For tool steels, the compacting temperature may be typically within the range of 1800 to 2200° F. To achieve these compacting temperatures, the powdered metal charge, prior to compacting, must be heated for times on the order of five hours or longer. Obviously, if the charge is heated within the autoclave to compacting temperature, which may take about five hours, only a very few compacts could be produced by a single autoclave. Consequently, an operation such as this is not suitable for commercial production from the economic standpoint. Alternately, the powdered-metal charge may be heated to compacting temperature within a furnace, and when compacting temperature has been achieved the charge may be then transferred to the autoclave for compacting. By the use of a plurality of furnaces to service a single autoclave, the production rate for each autoclave may be substantially increased over the practice of heating the charge to compacting temperature within the autoclave. This practice, however, also has not been feasible from the commercial standpoint. This resulted from the fact that by the time the powdered metal charge is transferred from the furnace and placed in the autoclave, the autoclave is sealed, and then pressurized to the required compacting pressure, the powdered metal charge has cooled to a temperature less than that required for satisfactory compacting. This sequence, which prior to the present invention has been necessary for autoclave compacting, may take an hour or more for completion. In view of this, it may be readily seen that the high compacting temperatures on the order of 1800 to 2200° F., which are required in the compacting of tool-steel compositions, cannot be maintained throughout the loading, sealing and pressurizing sequence.

It is, accordingly, the primary object of the present invention to provide an apparatus for rapidly compacting powedered metals.

Another, more specific, object of the invention is to provide an apparatus for rapidly compacting powdered-metal charges by providing for quick (typically one minute or less) pressurization of the autoclave for compacting.

Another more specific object of the invention is to provide for rapid compacting in an autoclave by providing fast-acting apparatus for closing and sealing the autoclave upon loading of the powdered-metal charge therein.

Yet another object of the invention is to provide an apparatus permitting rapid fluid-pressure compacting of powdered-metal charges in an autoclave by the combination of an arrangement for quickly closing and sealing the autoclave with an arrangement for quickly pressurizing the autoclave after a powdered-metal charge has been loaded and the autoclave has been sealed.

These and other objects of the invention, as well as a complete understanding thereof, may be obtained from the following description and drawings, in which:

FIG. 1 is an assembly view of one embodiment of apparatus in accordance with the present invention in elevation and partial section;

FIG. 2 is a side view in elevation of the apparatus of FIG. 1 with the plug closure in sealing position;

FIG. 3 is a detailed view of the plug closure used with the apparatus of FIGS. 1 and 2; and

FIG. 4 is a side view of the plug closure of FIG. 3.

In its broaded aspects, the apparatus of the invention embodies a pressure vessel, or autoclave, that is adapted to receive a powdered-metal charge that has been heated to an elevated temperature, on the order of for example 1800 to 2200° F., and is contained within a metal container for compacting. A plug is provided as a top closure for the pressure vessel. The plug is housed at a position above and offset from the open top of the autoclave. Means are provided for quickly moving the plug from this offset position to a position in axial alignment with the autoclave after a charge of powdered metal has been placed therein for compacting. When the plug is in axial alignment with the autoclave top, means are provided for quickly moving it axially into closed, sealing engagement with the autoclave. By this arrangement, the autoclave may be quickly sealed against the atmosphere immediately upon loading of a powdered-metal charge for compacting. Upon sealing in the manner above described, the autoclave is quickly pressurized (typically one minute or less) by the introduction of high-pressure fluid thereto, which immediately compacts the powdered-metal charge therein to a density typically of 95 percent or more. In accordance with the present invention, quick pressurization is achieved by having an auxiliary or storage pressure vessel. Prior to loading the autoclave, the storage vessel is pumped to a high fluid pressure. High-volume valving means are provided between the storage vessel and the autoclave. Immediately upon sealing of the autoclave, with the powdered-metal charge to be compacted therein, the valving means are operated to quickly transfer the high-pressure fluid from the storage vessel to the autoclave. By this arrangement, the conventional pumping of the autoclave to achieve the required high fluid pressure and the long times required for this pumping operation are eliminated. Therefore, the autoclave-pressurizing operation, which typically may take an hour or more if pumping is used, may now be achieved within one minute or less.

With reference to the drawings, and for the present to FIGS. 1 and 2 thereof, there is shown an autoclave

assembly, designated generally with the numeral **10**. The autoclave assembly **10** has an elongated cylindrical pressure vessel **12** with a fixed lower closure **14** supporting a base pedestal **16** upon which a container (not shown) filled with powdered metal to be compacted is supported. The top of the pressure vessel **12** has an opening **18**. The interior of the pressure vessel is provided with a liner member **20**, which is preferably constructed from a temperature-resistant steel. The liner **20** is preferably readily removable. In this manner, the inside diameter of the pressure vessel may be varied in accordance with the size of the charge being compacted. This serves to minimize heat loss from the charge. Near the top of the pressure vessel **12** there are two axially aligned horizontal drillings **21**, which extend through the pressure vessel walls. Above the drillings and adjacent the top surface of the pressure vessel are two parallel rods **22**. Connected to the rods **22** are sliders **24** that slidably or movably support a housing **26** on the rods **22**. Within the housing **26** there is suspended, as best shown in FIGS. 3 and 4, a plug **27**. The plug is connected at its top surface at **28** to a ram **30** that is connected for actuation to a conventional hydraulic piston-cylinder arrangement **31**. The housing **26**, with the plug **27** suspended therein, is moved to a position atop the pressure vessel **12** by the action of ram **32** as part of a hydraulic piston-cylinder arrangement **34**. When it is desired to close the autoclave, which is after a charge has been placed therein for compacting, the piston-cylinder arrangement **34** is actuated to extend ram **32** and thus move the housing horizontally, or to the left, as viewed in FIG. 1, to a position where the plug **27** is axially aligned with the top opening **18** in the pressure vessel, At this time, ram **30** is actuated by its associated hydraulic piston-cylinder arrangement to push the plug **27** axially into sealing engagement within the pressure vessel. The lower portion of the plug **27** is provided with an annular notch **36** to which is attached a sealing ring **38**. When the plug **27** is inserted into the pressure vessel for closure thereof, the sealing ring **38** seats and seals against the top surface **40** of the pressure vessel liner **20**. With the plug so positioned, the openings **20** in the pressure vessel walls are aligned with a similar diameter horizontal drilling **42** through the plug **27**. A pin **44** is supported on rollers **46** in axial alignment with openings **21** in the pressure vessel and **42** in the plug. The diameter of the pin **44** is substantially the same as that of openings **21** and **42**. The end of the pin **44** opposite that of the pressure vessel is connected as at **48** to a ram **50** of piston-cylinder arrangement **52**. With the plug in the closed position within the pressure vessel, the piston-cylinder arrangement **52** is actuated to extend the ram **50**, and in this manner move the pin **44** through the openings **21** in the autoclave wall and the drilling **42** through the plug. In this manner, the plug **27** is locked in sealing engagement in the closed position in the pressure vessel.

With the plug **27** in the closed position in the pressure vessel, as described above, the pressure vessel is then pressurized to compact the powdered-metal charge therein. The apparatus for this purpose includes an auxiliary or storage vessel **54** connected to a fluid pump **56**, which is adapted to fill said vessel **54** with high-pressure fluid, such as helium gas. The vessel **54** is connected to the pressure vessel via high-pressure lines **58** having high-pressure valves **60**, and to a vent valve **59** via high-pressure line **61**. The lines **58** extend into the pressure vessel via drillings **62** in the pressure vessel lower fixed closure **14**. The vent valve **59** and the valves **60** are closed during pressuring of the storage vessel **54**. This operation is completed prior to the loading of the pressure vessel **20** with the powdered-metal charge to be compacted. Upon loading and sealing of the pressure vessel, the valves **60** are opened and high-pressure fluid from the storage vessel **54** is immediately transferred to the pressure vessel, which causes the powdered-metal charge

therein to be compacted. The valves **60** are then closed. After compacting, vent valve **59** is opened to exhaust the autoclave, the pin **44** is withdrawn, the plug **27** is lifted upwardly and out of the pressure vessel and into the housing **26**. The housing **26** is then moved along the rods **22** to its position offset from the pressure vessel top, which is the position shown in FIG. 1. The compact may now be removed from the pressure vessel and the vessel is ready to receive another charge for compacting. A typical overhead crane may be used to load and unload workpieces with respect to the pressure vessel.

It is to be understood that in typical commercial operation a multiplicity of furnaces will be located adjacent the pressure vessel. The furnaces will be used to simultaneously heat a number of powdered-metal charges to compacting temperature, and in this manner as one charge is removed from the pressure vessel a second charge, which has been previously heated to compacting temperature, may be immediately removed from a furnace and placed in the pressure vessel for compacting. By using the proper number of furnaces, the pressure vessel may if desired be operated on a substantially continuous basis. For this purpose, a plurality of auxiliary or storage pressure tanks may be employed so that repressurizing of the autoclave for compacting need not await the pumping-up of a single storage vessel.

A particularly significant feature of the apparatus of the present invention is the utilization of means for quickly pressurizing the vessel or autoclave upon loading. Prior, known fluid-pressure compacting devices require times of from one-half hour to several hours to acquire the needed pressures to compact powdered metals, such as tool steel powders. These excessive times render fluid-pressure compacting inapplicable to modern production techniques due to the inefficiency of time consumption per autoclave load. By utilizing a valve between storage vessel **54** and pressure vessel **12** (or a multiplicity of such valves in conduits communicating with a multiplicity of such storage vessels **54** and a pressure vessel **12**), it is possible to raise the pressure within autoclave **12** by evening out the pressure between one or more such storage vessels and the pressure vessel or autoclave in 10 minutes or less. This rapid time period renders the apparatus and process practical from a production standpoint.

For the purposes of the present specification and the claims, the term "quickly pressurized" as it applies to the release of pressure from one or more storage vessels (such as vessel **54**) to a pressure vessel (such as autoclave **12**) shall mean a time period of 10 minutes or less or it shall mean apparatus capable of effecting such a release of pressure within such a time period.

A valve known as P/N 4010–3119 (50,000 p.s.i. yoke valve air to close assembly, replaceable seat) manufactured by Autoclave Engineers, Inc. of Erie, Pa. may be used as the valve **60**. However, other commercially available valves capable of effecting the required rapid pressure release (10 minutes or less) may also be utilized in the apparatus of the present invention.

Although specific embodiments of the invention have been shown and described herein, it is obvious that other adaptations and modifications may be made by those skilled in the art without departing from the scope and spirit of the appended claims.

I claim:

1. Apparatus for producing compacted articles from fully preheated powdered metal charges comprising a first pressure vessel, a fluid-tight closure for said vessel, said closure being selectively positionable between an open and closed fluid-tight position, a second pressure vessel, a fluid pump connected to pressurize said second pressure vessel by introduction thereto of fluid under pressure, and valving means interposed between said first vessel and said second vessel for permitting fluid flow from said second vessel, upon pressurization thereof, to

said first vessel, whereby said first vessel may be quickly pressurized.

2. The apparatus of claim 1 wherein said fluid-tight closure is selectively positionable between an open and closed fluid-tight position by means for moving said closure along a substantially horizontal plane to a position above and in axial alignment with a top opening in said first pressure vessel, means for moving said closure axially to a closed position within said first vessel opening, and means for securing said closure in the closed fluid-tight position, whereby pressurization of said vessel is permitted.

3. The apparatus of claim 2 wherein said fluid-tight closure comprises a plug providing pressure-tight engagement with an interior surface of said first pressure vessel when in said closed position.

4. The apparatus of claim 2 wherein said means for moving said closure includes a housing, means for supporting said closure within said housing in a vertical position, a horizontal way extending over said top opening in said first pressure vessel, means slidably connecting

said housing to said way, and means for sliding said housing along said way to a position wherein said closure is in axial alignment with said top opening.

5. The apparatus of claim 2 wherein said means for securing said closure in the closed fluid-tight position is a pin that extends substantially horizontally through mating passages in said closure and vessel.

6. The apparatus of claim 5 wherein said pin rests on a plurality of rollers movably supporting said pin during movement through said mating vessel and closure passages.

7. The apparatus of claim 1 having a vent valve for exhausting said first pressure vessel upon the completion of compacting.

References Cited

UNITED STATES PATENTS

3,172,153	3/1965	Loomis et al.	18—16 X
3,478,920	11/1969	Pecheck	18—16 X

WILLIAM S. LAWSON, Primary Examiner