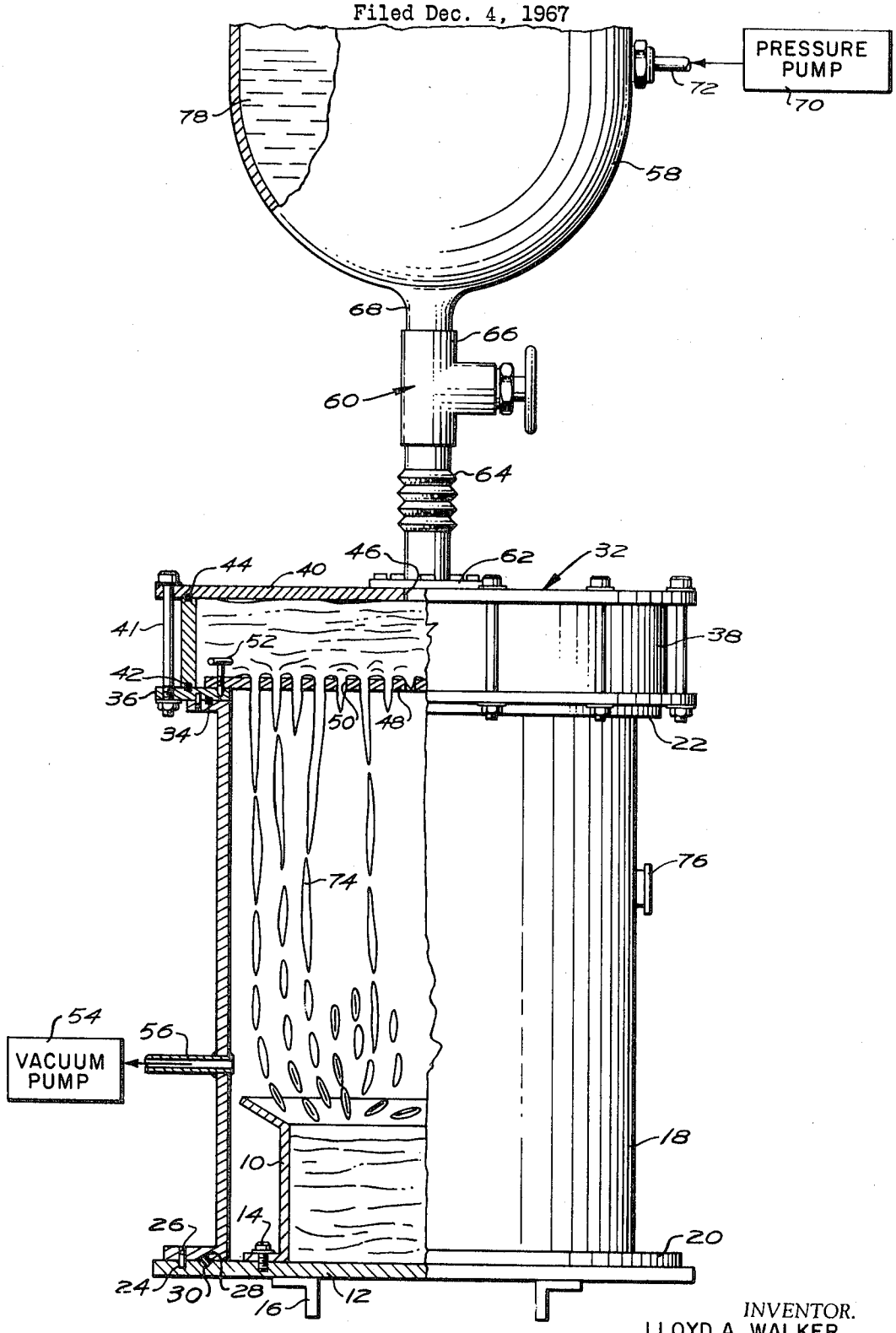
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PRESSURE CASTING PROCESS

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PRESSURE CASTING PROCESS

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ABSTRACT OF THE DISCLOSURE

A pressure casting apparatus for casting highly viscous material having a casting mold within a vacuum bell, whereby the vacuum prevents voids in the cast material and reduces the pressurization otherwise required on a transfer pot containing the material to be cast. The transfer pot is operably connected to a pressure casting head having pattern holes in the bottom thereof, which casting head forms the top of the vacum bell above the casting mold. The casting process is performed by drawing a vacuum in the bell, pressurizing the transfer pot, forcing the material from the transfer pot through the casting head, and dropping the extruded material into the casting mold for curing.

BACKGROUND OF THE INVENTION

The invention herein described was made in the course of or under a contract or subcontract thereunder with the Department of the Army.

This invention relates to a new and useful pressure casting apparatus for form casting highly viscous material into desired and useable configurations and the process for performing the casting operation by using this apparatus. This invention is particularly useful in the form casting of solid rocket propellants whereby a highly viscous propellant mixture is cast into a desired form and cured, after which it is further processed for utilization in a solid rocket motor.

Prior to this invention highly viscous material could be molded or form cast into desired configurations. One method of molding the material was to pour the highly viscous material into a mold using care to prevent voids within the mold. However, by this method, components within the mixture, such as metal staples, are randomly disposed throughout the mold. Another method used prior to this invention was the use of a vacuum bell with a screen therein. A charge of highly viscous material would be placed upon the screen and enclosed in the upper portion of the bell. A vacuum was drawn in the lower portion of the vacum bell and a slight vacuum in the upper portion of the bell. The differential in pressure across the screen would cause the viscous material to be drawn through the screen as extruded fascicles. The vacuum bell would then be vibrated to control the length of the fascicles. The upper portion of the bell above the screen had to be recharged prior to each molding operation. This required disassembly of the vacuum bell and filling the upper portion thereof with sufficient viscous material so that openings would not develop through the material to destroy the differential in vacuum pressures. Each charge for the casting operation had to be substantially more material than would be required to fill the mold.

SUMMARY OF THE INVENTION

In the instant invention, a casting head defines a cavity through which highly viscous material is forced. The casting head rests on a vacuum bell within which there is a casting mold, and the casting head is of sufficient height above the mold so that the viscous material stretches and breaks prior to being deposited into the mold. The casting head is operably connected to a transfer pot containing the viscous material to be cast. Within the connection between the transfer pot and the casting head there is arranged a flexible coupling which allows the casting head to be lifted from the vacuum bell so that a filled mold may be removed and a fresh mold inserted. Several casting heads may be manifolded to a single transfer pot so that several casting operations may be simultaneously in process. A predetermined amount of highly viscous material is charged into the transfer pot. A vacuum is drawn on the vacuum bell and the transfer pot is pressurized with a gas compatible with the viscous material. The rate of flow through the casting head and the length of fascicles extruded through the casting head are a function of the difference in pressure between the transfer pot and the vacuum bell. The fascicles as they are extruded through the casting head fall into the mold, and as they are elongated fascicles, they fall into a horizontal plane so that any components, such as metal staples, contained in the fascicle become oriented in the horizontal plane, although they may be randomly dispersed within that plane. When the mold is full, the vacuum on the vacuum bell is released and the pressure on the transfer pot is reduced to prevent flow of viscous material through the casting head. The casting head may then be removed from the vacuum bell so that a new mold may be inserted.

It is therefore an object of this invention to provide an improved method for casting viscous material in a mold.

Another object of this invention is to provide an improved apparatus whereby a single charge of feed-stock highly viscous material may be used to cast one or more molds in succession.

Still another object of this invention is to provide an improved apparatus whereby a single charge of feed-stock highly viscous material may be used to cast more than one mold simultaneously.

A further object of this invention is to provide an improved casting apparatus whereby filled molds may be readily replaced by empty molds.

Still a further object of this invention is to provide an improved apparatus whereby feed-stock of highly viscous material containing components such as metal staples may be forced through a casting plate having patterned holes so that the components contained in the viscous material will be in planar alignment within the filled mold.

These and other objects of this invention will be apparent from the detailed description which follows, when taken together with the appended drawing.

BRIEF DESCRIPTION OF THE DRAWING

The appended drawing is a cutaway view of the pressure casting apparatus of the present invention during the casting process.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The instant invention concerns an improved casting apparatus. The feed-stock for this apparatus is a highly viscous material capable of flowing. The viscous material may, for example, be a polymer which is to be cast and cured. The polymer is mixed in the normal manner and may have additives therein, for instance, metal staples. Normally, the additive components contained in the viscous material will then have random dispersion and orientation throughout the mixture. However, by extruding the viscous material through a casting plate a planar orientation of the additive components will be attained.

Reference is made to the drawing showing the instant invention during the casting process. A casting mold **10** is removably mounted to a base plate **12** by a fastening means **14**, which may be a bolt and nut arrangement, or may be a bolt screwed into the base plate **12**. Legs **16** are rigidly affixed to the base plate **12**. The legs **16** may serve several functions; for example, they provide clearance be-

tween a floor and the base plate **12**. Also, the legs **16** may be positioned to slide along rails or to engage in a conveyor system to facilitate handling.

A cylindrical vacuum bell **18** has outwardly extending flanges **20** and **22** at each end thereof. One end of the vacuum bell **18** rests on the base plate **12** and surrounds the casting mold **10**. In order to properly assure alignment of the vacuum bell **18** on the base plate **12**, index pins **24** may be rigidly mounted on the base plate **12** and positioned to fit into index slots **26** located in flange **20**. An air tight sealing means between the vacuum bell **18** and the base plate **12** may be attained by an O-ring **28** located between the base plate **12** and the flange **20**. The O-ring **28** may be partially imbedded in a peripheral slot **30** in order to assure proper location of the O-ring **28**.

Resting on the upper end of the vacuum bell **18** is a pressure casting head **32**. There is an O-ring **34** located between the flange **22** and the pressure casting head **32** for the purpose of insuring an air tight seal between the two components.

The pressure casting head **32** is fabricated with a ring plate **36** as a base. A cylindrical pressure casting spacer member **38** separates the ring plate **36** from a head plate **40**. O-rings **42** and **44** may be located around the edges of the spacer member **38** in order to insure an air tight seal. The head plate **40** has an inlet opening **46** in substantially the center thereof. The headplate **40** is spacially separated from but rigidly connected to the ring plate **36** by a connecting means, as for example, by head bolts **41** or machine screws. In order that the casting head **32** may be properly positioned on the vacuum bell **18**, there may be index pins between the flange **22** and the ring plate **36**.

The ring plate **36** has an opening therein, which opening has a diameter of substantially the same diameter as that of the interior of the vacuum bell **18**. Overlapping and resting on top of the ring plate **36** is a casting plate **48** which covers the opening in the ring plate **36**. Casting plate **48** has pattern holes **50** through it so that viscous material may be forced through the patterned holes **50** from the casting head **32** and be deposited in the mold **10**. As a matter of convenience, the casting plate **48** may have two or more casting plate handles **52** rigidly attached thereto. The casting plate **48** may also have index pins attached to it to fit into index holes located in the ring plate **36** for the purpose of aiding the positioning of the casting plate **48** onto the ring plate **36**. The holes **50** may be of uniform diameter or they may vary in size. Whether or not the holes **50** vary in size will be a function of the ability of the viscous material to be forced therethrough at substantially equal rates so that the build-up in mold **10** will be substantially uniform. In the event the holes **50** do vary in diameter, the smaller holes would be located adjacent the center of the casting plate **48** and the holes **50** would increase in size as they are located further from the center.

It is readily apparent that the casting head **32** may be rigidly connected to the vacuum bell **18** and the vacuum bell **18** may be in turn rigidly connected to the base **12**. It was found in practice that the mentioned rigid connections were not required. The O-rings **28** and **34** provided a sufficient sealing means between the components such that when the vacuum was drawn on the vacuum bell **18** the separate components were drawn together, provided sufficient connection so that the component parts would not separate from each other, and were air-tight.

A means for drawing a vacuum within the vacuum bell **18** is connected thereto. One means of drawing a vacuum on the vacuum bell **18** is to connect a vacuum pump **54** to the vacuum bell **18** by use of a vacuum connection nipple **56** being operably connected to the vacuum bell **18**.

In order that the viscous material may be fed into the casting head **32**, a transfer pot **58** is operably connected thereto. One connecting means between the transfer pot **58** and the casting head **32** may be made up of a pipeline arrangement **60**. The pipeline arrangement **60** has a piping flange **62** rigidly attached to the head plate **40** and covering the inlet opening **46** in such a manner that viscous material may pass through the piping flange **62** through the inlet opening **46** into the casting head **32**. A bellows pipe **64** provides a flexure means and connects the piping flange **62** to a control valve **66**. The control valve **66** as a flow control means is connected to the discharge of the transfer pot **58** by a pipe **68**.

The transfer pot **58** receives a charge of viscous material to be cast. The transfer pot **58** is then sealed and pressurized. One means of pressurizing the transfer pot **58** is to connect a pressure pump **70** to the transfer pot **58** through a pressurizing nipple **72**. As any viscous material may be cast by use of this invention, the pressurizing gas must be compatible with the viscous material used as feedstock. It is readily apparent that air may be used as the pressurizing gas. However, in some instances where polymers are being cast, it may be desirable to use gaseous nitrogen as the pressurizing media.

Though disclosed herein as pressure casting one or more molds in succession, it is readily apparent that this invention may be used to pressure cast one or more molds simultaneously. A single transfer pot **58** may be connected to one or more control valves **66** by proper manifold arrangement well known to those with ordinary skills in the art.

During the casting operation, fascicles **74** are being extruded through the pattern holes **50**. The casting head **32** is of sufficient height above the mold **10** that the extruded fascicles **74** stretch and break due to their own weight prior to being deposited into the mold **10**. The fascicles **74** are elongated when they fall into the mold **10** so that they come to rest in a horizontal plane. Any components contained in the fascicles **74**, for example, metal staples, will be oriented in the horizontal plane; however, they may be randomly dispersed within that horizontal plane. The fascicles **74** being a viscous material and in a vacuum environment so that voids will not be present between the fascicles **74**, they tend to flow together into a homogeneous mass. Alternatively, the length of the fascicles may be controlled by vibrating the pressure casting apparatus by means well known to those having ordinary skill in the art.

The rate at which the mold **10** is filled may be controlled and timed so that it can be determined when one casting operation is complete. Rather than relying on time, it is preferable that the casting operation be capable of observation. A transparent viewing port **76** provides a viewing means through the vacuum bell **18** so that the mold **10** may be observed during the casting operation.

In operation, the transfer pot **58** is loaded with a feedstock charge **78** of highly viscous material. The transfer pot **58** is closed so it can be pressurized. A vacuum of approximately 27 inches of mercury is drawn on the vacuum bell **18** by the vacuum pump **54**. The transfer pot is pressurized by the pressure pump **70** to a predetermined pressure. The control valve **66** is opened to allow the flow of the highly viscous material feedstock charge **78**. The pressure causes the material to flow from the transfer pot **58**, through the pipeline arrangement **60** into the pressure casting head **32**. The differential pressure between the vacuum bell **18** and the transfer pot **58** causes the highly viscous material to be extruded through the patterned outlet holes **50**. As the casting plate **48** is of sufficient height above the mold **10**, the fascicles **74** stretch and break of their own weight before being dropped into the mold **10**. The stretched or elongated fascicles drop into the mold **10** through a vacuum environment and fall into a horizontal plane or arrangement. The environment within the bell **18** being a vacuum, no voids are allowed to form between the fascicles. The highly viscous material will flow together and become a homogeneous mass within the mold **10**.

When the mold **10** is filled, the casting operation is terminated. The vacuum within the bell **18** is released so that the bell **18** returns to ambient pressure. The pressure on the transfer pot **58** is reduced to ambient pressure and the control valve **66** is closed. Alternatively, the valve **66** may be closed and it is not essential to reduce the pressure on the transfer pot **58**. The pressure casting head **32** is kept full of the highly viscous material for the next casting operation. The flexure means or bellowed pipe **64** allows the casting head **32** to be lifted from the vacuum bell **18** so that together the base plate **12** and vacuum bell **18** may be removed from under the casting head **32** and new ones placed in position. The casting operation can then be repeated while the filled mold **10** is further processed for curing the cast material.

The casting process follows a programmed procedure in order to obtain the best cast. The transfer pot **58** is charged with a viscous material for casting. A vacuum of approximately 27 inches of mercury is drawn upon the vacuum bell **18** before the transfer pot **58** is pressurized. The transfer pot **58** is then pressurized to fill the casting head **32** and force the viscous material through the casting plate **48**. The pressure applied to the transfer pot **58** will determine the rate of cast and the sizing of the fascicles **74**, as the casting plate **48** is high enough above the mold **10** so that the extruded material stretches and breaks into fascicles **74** due to gravitational forces. Therefore, the pressure on the transfer pot **58** is adjusted to provide the rate of cast and size of fascicles **74** desired. When the mold **10** becomes filled to the desired depth, the casting process is terminated by releasing the vacuum on the vacuum bell **18**. The control valve **66** is closed so that the casting head **42** will be maintained full and thereby prevent the development of voids. The casting head **32** may then be raised from the vacuum bell **18** so that the vacuum bell **18** and base plate **12** may be removed and a fresh one inserted.

What is claimed is:

1. The method of pressure casting highly viscous material into a mold, the mold being contained within a vacuum bell having a pressure casting head mounted thereon, the method comprising the steps of:

creating a pressure differential between the pressure being exerted on the material in the casting head and the pressure within the vacuum bell by at least drawing a vacuum on said bell;

pressure feeding, by reason of said pressure differential, a highly viscous material through a casting plate mounted in said casting head, said plate having patterned holes therein which said plate is at a distance above the mold so that the extruded viscous material stretch and break into elongated fascicles due to gravitational forces; and

gravity depositing said fascicles into said mold whereby said fascicles fill the mold by a substantially uniform build-up and the fascicles come to rest horizontally in the mold so that solid particles, such as metal staples, contained in said material are oriented in a horizontal plane.

2. The method of pressure casting highly viscous material into a mold as described in claim **1**, wherein said mold is maintained in a vacuum environment during the casting operation whereby the material deposited in the mold will become a homogeneous mass.

3. The method of pressure casting highly viscous material into a mold, the mold being contained within a vacuum bell having a pressure casting head mounted thereon, the method comprising the steps of:

creating a vacuum within a vacuum bell containing the mold;

pressurizing a transfer pot containing the viscous material to be cast;

forcing the viscous material from said transfer pot into a pressure casting head, said transfer pot being operably connected to said casting head;

extruded the viscous material into fascicles from said pressure casting head through a casting plate having holes therein, said plate being mounted in said casting head; and

depositing the extruded material into said mold whereby said fascicles fill the mold by a substantially uniform buildup and the fascicles come to rest horizontally in the mold so that solid particles, such as metal staples, contained in said material are oriented in a horizontal plane and the material deposited in the mold will become a homogeneous mass.

4. The method of pressure casting highly viscous material into a mold as described in claim **3**, and in addition, the steps of:

reducing said vacuum to ambient pressure;

releasing said pressure on said transfer pot;

removing said material and said mold; and

curing said material.

5. The method of pressure casting highly viscous material into a mold as described in claim **3**, and after extruding the viscous material, the additional step of:

dropping, by reason of gravitational forces, the viscous material through a vacuum environment.

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