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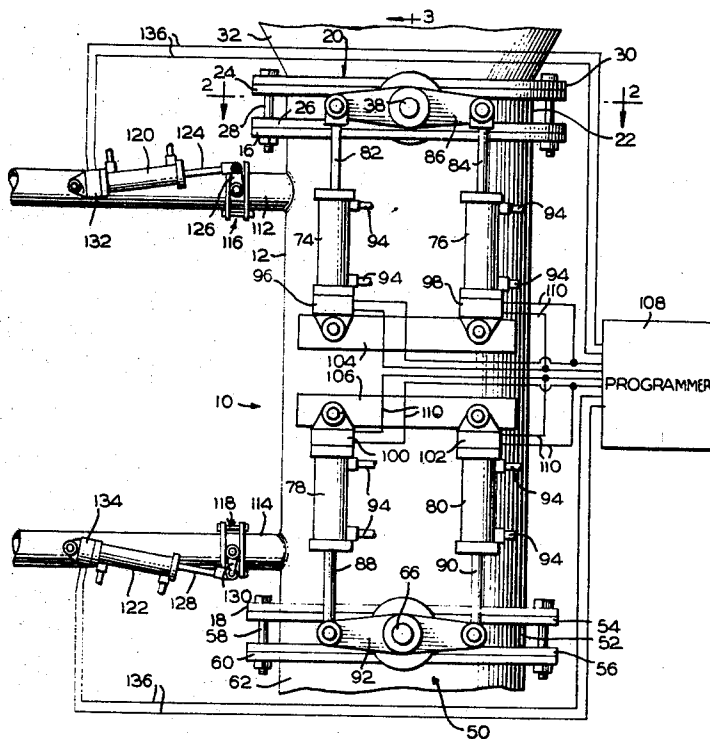
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[54] APPARATUS FOR INTRODUCING MATERIALS INTO OR REMOVING MATERIALS FROM A HERMETICALLY SEALED VESSEL

16 Claims, 7 Drawing Figs.

[52] U.S. Cl. 99/237,
214/17
[51] Int. Cl. B65g 3/08,
A23b 9/00
[50] Field of Search 214/17.4,
17.68; 251/305, 306, 307; 99/237

ABSTRACT: An apparatus for introducing materials into and removing materials from a hermetically sealed vessel without destroying the hermetic integrity of the vessel comprising; a container defining a chamber therein which chamber communicates between the vessel and an environment having a dissimilar pressure, four valve means each operatively connected to the container and communicating between the interior and exterior thereof, and means for cyclically actuating said valve means so that the pressure within the chamber is equalized to the pressure within the vessel before the materials are transferred between the container and the vessel, and the pressure within the chamber is equalized to said dissimilar tainer and said dissimilar pressure environment.



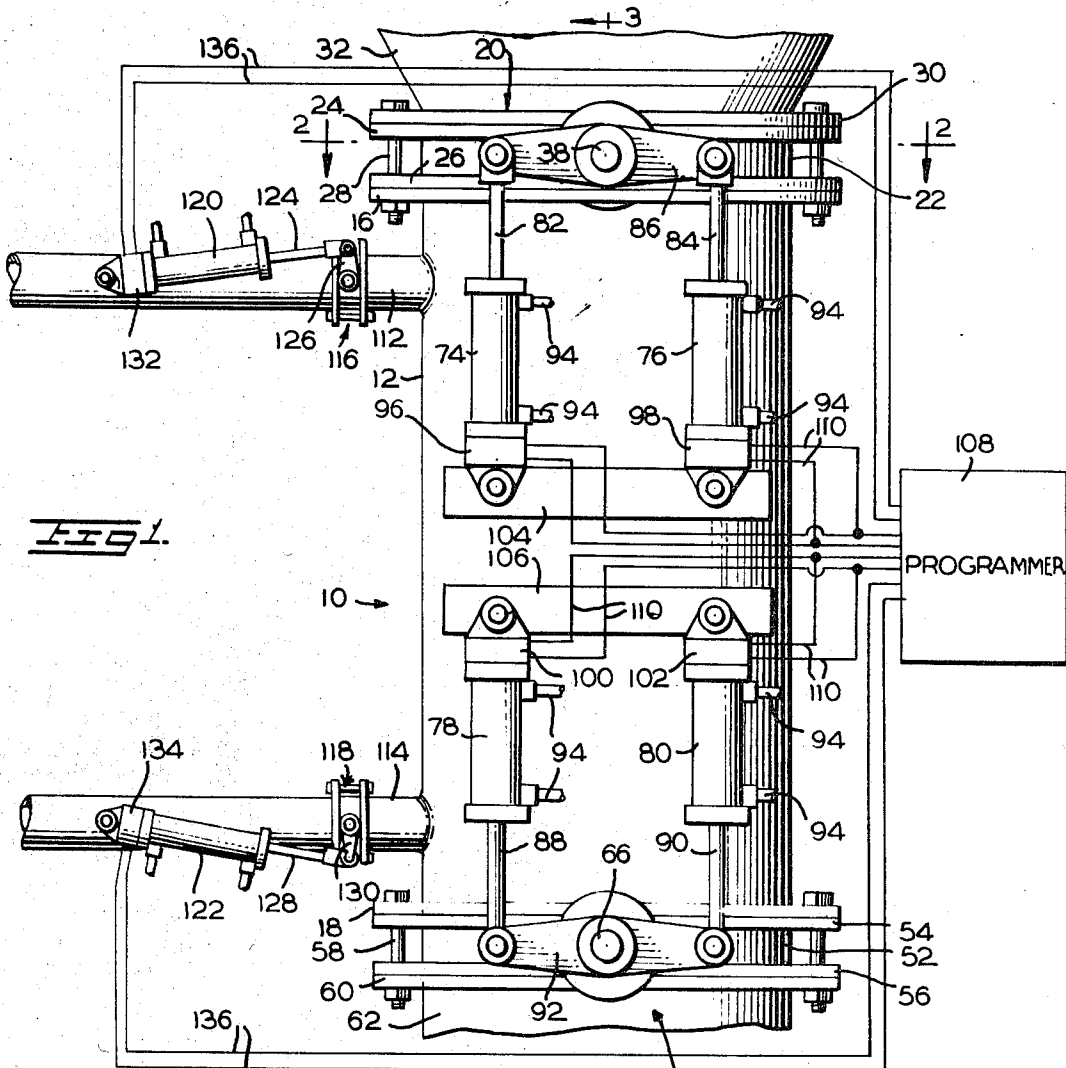


FIG. 1.

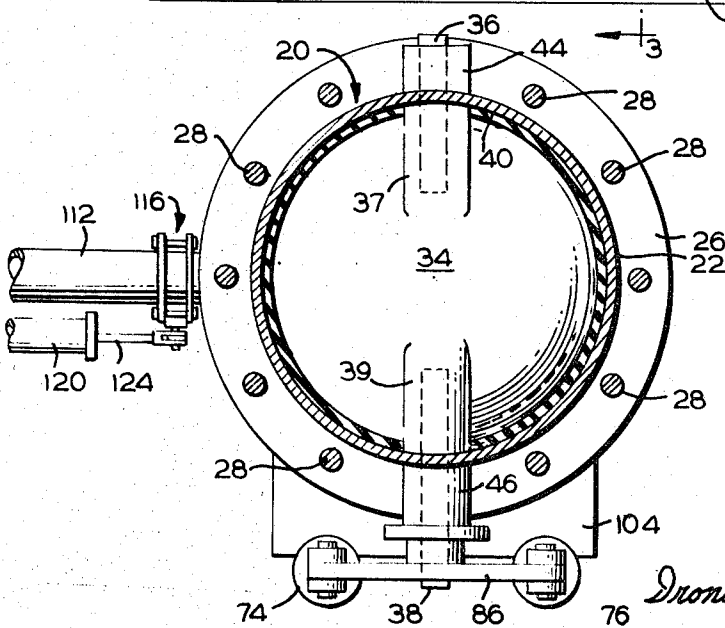
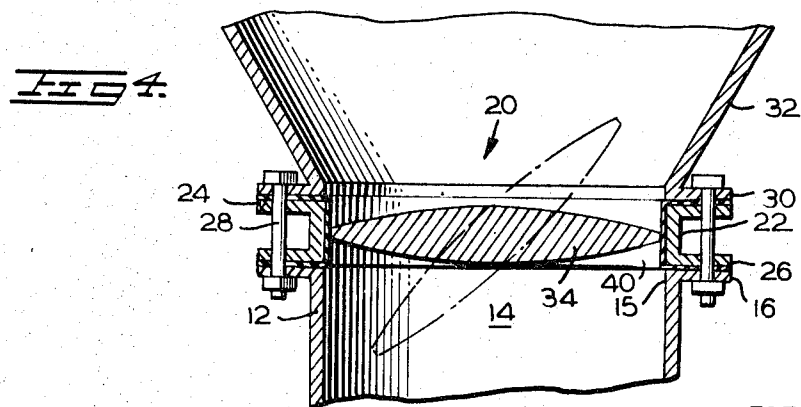
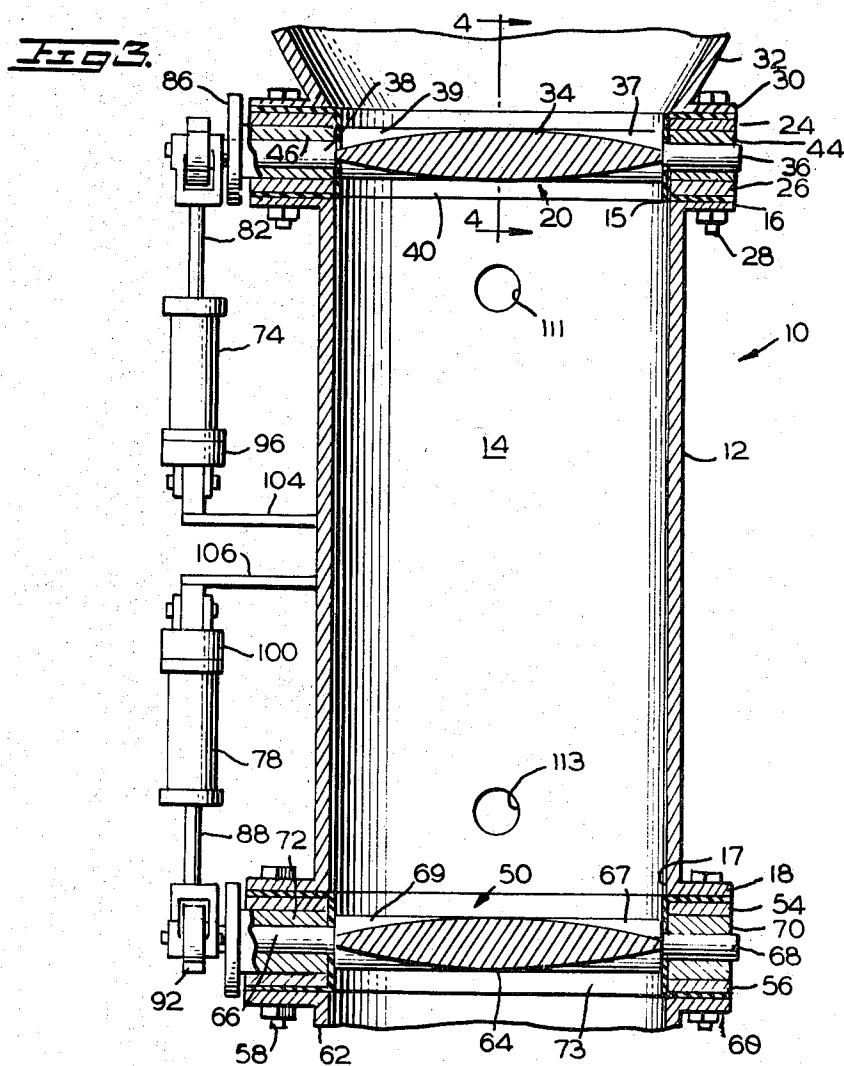


FIG. 2.

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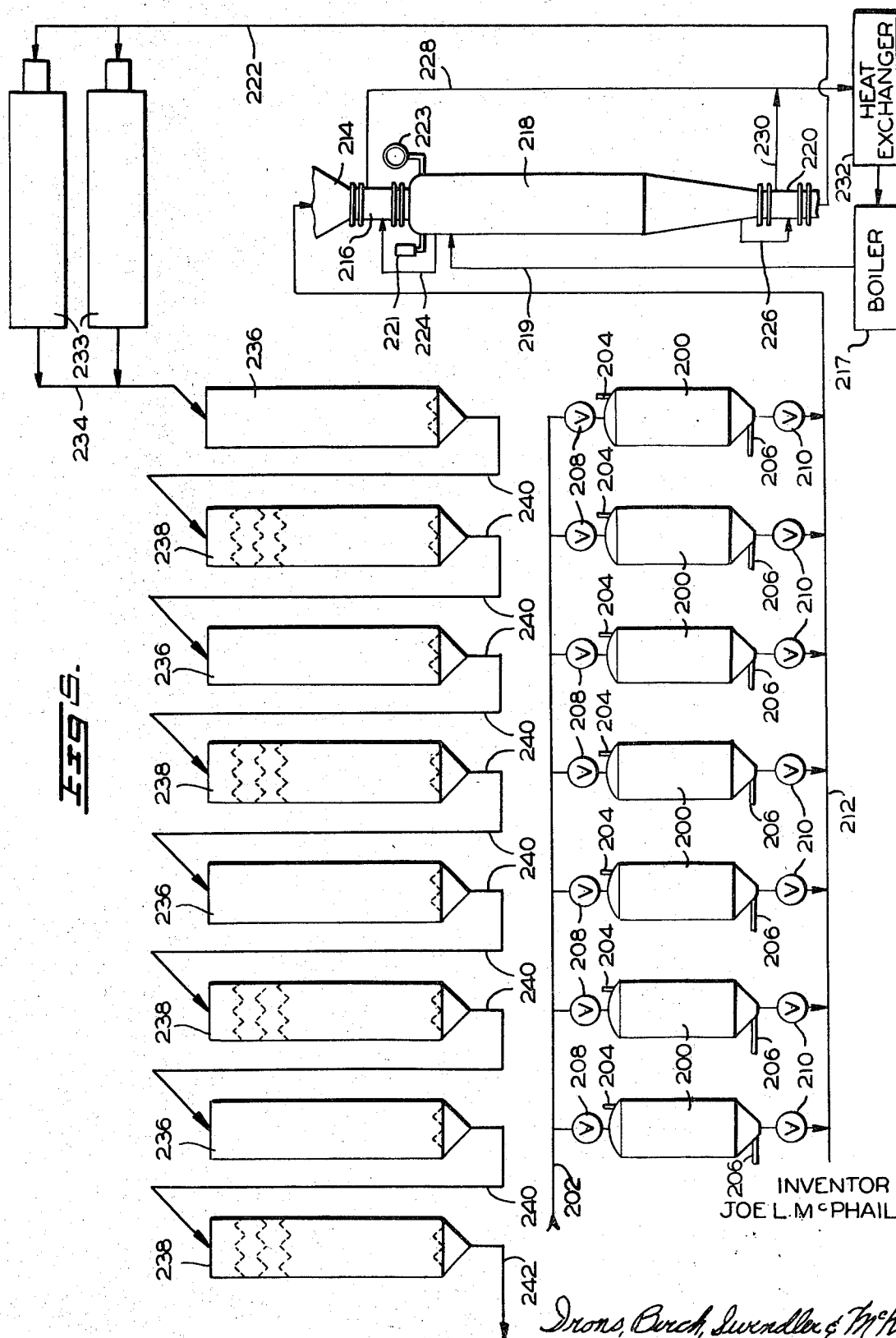
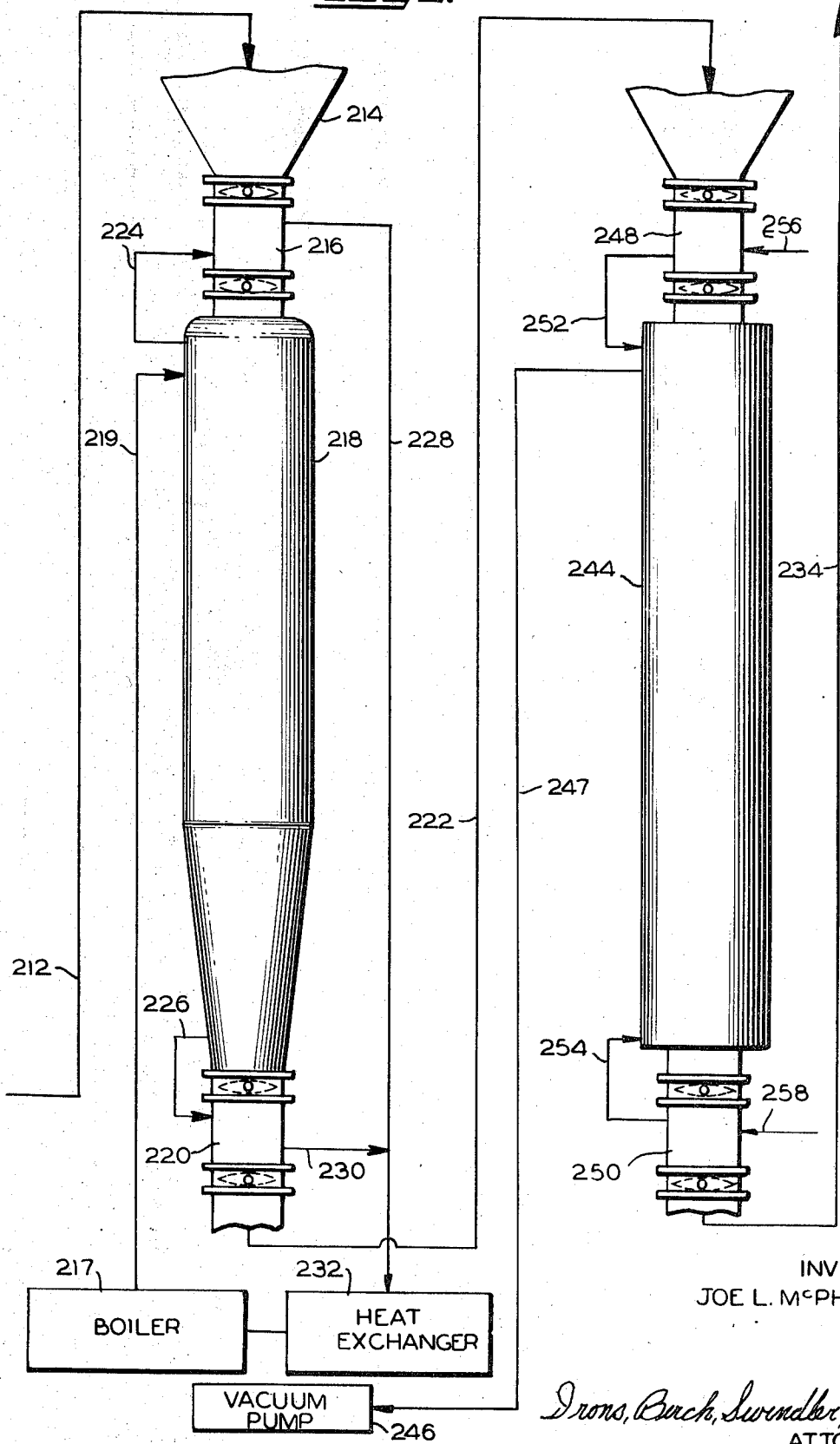
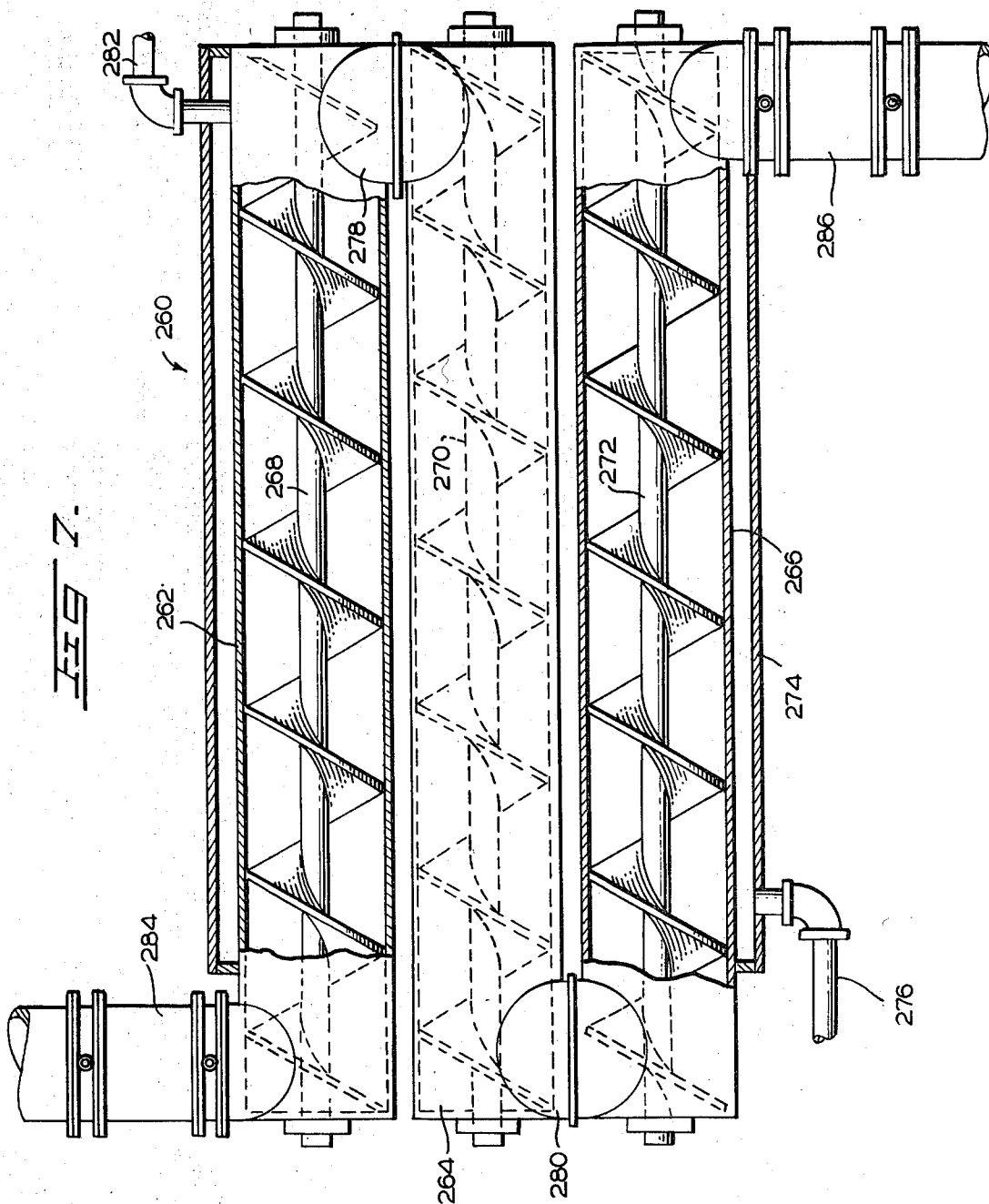


FIG. 6.



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APPARATUS FOR INTRODUCING MATERIALS INTO OR REMOVING MATERIALS FROM A HERMETICALLY SEALED VESSEL

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an apparatus which provides access to the interior of a hermetically sealed vessel for introducing materials into or removing materials from the vessel without destroying its hermetic integrity. Specifically, the invention concerns an apparatus for communicating between a hermetically sealed vessel and an environment having a dissimilar pressure, wherein the pressure within the apparatus is sequentially equalized to the pressure within the vessel and the pressure of the environment so that materials may be transferred to or from the vessel from or to the environment through said apparatus without destroying the hermetic integrity of the vessel.

2. Description of the Prior Art

Many industrial processes of a continuous nature include one or more steps in which a material is treated in an atmosphere having a pressure that is either greater or lesser than ambient pressure. Generally, such steps are carried out within hermetically sealed vessels.

A particularly troublesome problem associated with the use of such a vessel in a continuous process is the necessity for introducing and removing the materials to be treated from the vessel without destroying its hermetic integrity. One well-known means used for accomplishing this function is a rotary valve. Such valves basically comprise a valve body and a rotatably mounted closure member which is positioned within the cavity defined by the body. Generally, the closure member has a plurality of radially extending paddles which divide the cavity into a plurality of individual compartments. As the closure member rotates, the compartments rotate about the central axis of the member. Each compartment sequentially moves past the valve inlet where the materials to be treated are introduced therein, and then past the valve outlet where the materials are discharged therefrom into a hermetically sealed vessel.

Ideally, each of the compartments is hermetically sealed from the other compartments so that the hermetic integrity of the vessel will be maintained. In order to approach this ideal condition, however, the clearance between the valve body and closure member must be extremely small, yet sufficient clearance must be provided for the closure member to rotate within the body. Any slight expansion or contraction of the valve body and closure member relative to each other results either in the closure member scraping against the body or in gases escaping around the closure member.

Frequently, the materials being handled and/or one or both of the environments between which the valve communicates are maintained at an elevated temperature, causing the metallic structural elements of the valve to expand. In such instance, the aforementioned operating difficulties are magnified.

Moreover, rotary valves are extremely expensive to manufacture. The cavity within the valve body and the paddles of the closure member must be carefully machined to insure that a minimum clearance is provided therebetween when the elements are assembled. Frequently, the maximum acceptable clearance is .005 inch or less. In addition, due to the aforementioned operating difficulties, such valves require frequent maintenance, resulting in expensive process stoppages as well as necessitating costly repair work.

Thus, a long felt need has existed for a means for introducing and removing materials from hermetically sealed vessels without destroying the hermetic integrity thereof, which means is economical to operate and manufacture, and which requires a minimum of maintenance.

SUMMARY OF THE INVENTION

The present invention offers an optimum solution to the problems associated with the known means for introducing and removing materials from hermetically sealed vessels without destroying the hermetic integrity thereof.

Basically, the apparatus of the invention comprises; a container defining a chamber therein, which chamber communicates between a hermetically sealed vessel and an environment having a pressure dissimilar from the pressure within the vessel, a first valve means connected to the container and communicating between said chamber and the exterior of the container for admitting materials into the chamber, a second valve means connected to the container and communicating between said chamber and the exterior of the container for discharging materials from the chamber, a third valve means operatively connected to the container and adapted to communicate between said chamber and said vessel so that the pressure within the chamber may be equalized to the pressure within the vessel, a fourth valve means operatively connected to the container and adapted to communicate between said chamber and said dissimilar pressure environment so that the pressure within the chamber may be equalized to said dissimilar pressure, and means for cyclically actuating the valve means so that the pressure within the chamber will be equalized to the pressure within the vessel before the materials are transferred between the container and the vessel, and the pressure within the chamber will be equalized to said dissimilar pressure before the materials are transferred between the container and said dissimilar pressure environment.

The method of the invention essentially comprises the steps of: equalizing the pressure within a hermetically sealed chamber to the pressure of a first environment from which materials are to be delivered to the chamber, transferring the materials into the chamber, equalizing the pressure within the chamber to the pressure of a second environment to which the materials are to be discharged from the chamber, transferring the materials into the second environment, and cyclically repeating the aforementioned steps for a protracted period of time.

The container of the apparatus of the invention may be of any desired configuration, and conveniently comprises a short length of cylindrical pipe having sufficient internal volume for holding the quantity of material desired to be introduced into or discharged from a hermetically sealed vessel at one time. Conveniently, the first and second valve means are positioned at opposite sides of the container such as at each end of a cylindrical pipe section, and preferably comprise quick-acting valves, such as butterfly or slide valves.

The third and fourth valve means are individually operatively connected to the container at any convenient locations, such as at different locations on the wall of a cylindrical pipe section, and also preferably comprise quick-acting valves, such as butterfly or ball valves.

The actuating means for the valve means preferably includes power means for opening and closing the valve means, and a programmer for energizing the power means in the proper sequence. The power means may comprise any suitable hydraulic, pneumatic or electrical actuators, and the programmer may comprise any suitable electromechanical, electronic or electrofluidic programming device.

With the foregoing in mind, it is an object of the present invention to provide an apparatus for introducing materials into and removing materials from a hermetically sealed vessel without destroying the hermetic integrity of the vessel.

It is another object of the invention to provide a method for introducing materials into and removing materials from a hermetically sealed vessel without destroying the hermetic integrity of the vessel.

It is a further object of the invention to provide an apparatus having an internal chamber which communicates between two environments having dissimilar pressures and through which materials may be transferred from one environment to the

other while maintaining the hermetic integrity of both environments.

It is yet another object of the invention to provide an apparatus which is particularly adapted for transferring materials between two environments having dissimilar pressures without destroying the hermetic integrity of either environment, wherein the materials and/or one or both of the environments is maintained at an elevated temperature.

It is still another object of the invention to provide an apparatus which includes a container, four valve means independently communicating therewith and means for sequentially operating the valve means so that materials may be transferred through the container and between two environments having dissimilar pressures without destroying the hermetic integrity of either environment.

It is yet a further object of the invention to provide an apparatus for introducing materials into and removing materials from a hermetically sealed vessel without destroying the hermetic integrity of the vessel, which apparatus is economical to manufacture, operate and maintain.

These and other objects of the invention will become apparent upon a consideration of the detailed description of a preferred embodiment thereof given in connection with the following drawings.

BRIEF DESCRIPTION OF THE DRAWINGS:

FIG. 1 is an elevational view of a preferred embodiment of the apparatus of the invention;

FIG. 2 is a sectional view taken on line 2-2 of FIG. 1;

FIG. 3 is a sectional view taken on line 3-3 of FIG. 1;

FIG. 4 is a sectional view taken on line 4-4 of FIG. 3;

FIG. 5 is a diagrammatic flow sheet of a typical process in which the apparatus and method of the invention may be advantageously employed;

FIG. 6 is a diagrammatic flow sheet of a portion of the process shown in FIG. 5, further showing a modification of the process; and

FIG. 7 is a sectional view of a particular type of hermetically sealed vessel with which the apparatus and method of the invention may be advantageously employed.

DESCRIPTION OF THE PREFERRED EMBODIMENT:

A preferred embodiment of the apparatus of the invention is shown in FIGS. 1-4, as designated by reference numeral 10. Apparatus 10 includes a container 12 defining a chamber 14 therein (FIGS. 3 and 4). Container 12 may be of any desired configuration and conveniently comprises a short section of cylindrical pipe. The size of container 12 is selected so that the volume of chamber 14 is sufficient to hold all of the material desired to be introduced into or removed from a hermetically sealed vessel at one time.

As shown in FIGS. 1-4, apparatus 10 is installed between the lower end of a feed hopper 32 and the upper end of a hermetic vessel 62 for transferring materials, either liquids or particulate solids, from the feed hopper to the vessel. Typically, feed hopper 32 is exposed to the environment of the ambient atmosphere and the interior of vessel 62 is maintained at a pressure that is either greater or lesser than ambient pressure.

Container 12 has an upper opening 15 surrounding by a flange 16 and a lower opening 17 surrounded by a flange 18. As shown in FIG. 3, upper opening 15 is vertically aligned with an opening in the lower end of feed hopper 32, and lower opening 17 is vertically aligned with an opening in the upper end of vessel 62 so that material will freely pass from the feed hopper into chamber 14 and from the chamber into the vessel under the influence of gravity.

A first valve means, such as quick-acting butterfly valve 20, is connected to container 12 at upper opening 15 thereof and communicates between chamber 14 and the exterior of the container, specifically the interior of hopper 32. Valve 20 includes a cylindrical valve body 22 having a pair of flanges 24 and 26 attached at opposite ends thereof. Flange 26 of valve

body 22 abuts flange 16 of container 12 to align valve 20 centrally of opening 15.

Flange 24, disposed at the other end of valve body 22, abuts a flange 30 which is affixed to the lower end of feed hopper 32 and surrounds the opening therein. Flanges 24 and 30, and 26 and 16 are secured in abutting relationship by appropriate fasteners, such as by bolts 28.

Valve 20 also includes a disc-shaped closure member 34 which is rotatably mounted within valve body 22 by a pair of opposed stubshafts 36 and 38. The stubshafts are secured to a pair of diametrically opposed, radially extending shaft supports 37 and 39 formed integrally with closure member 34, and are journaled in suitable bushings 44 and 46 secured between flanges 24 and 26 of the valve body. In the closed position, closure member 34 seats against a resilient annular liner 40 which is affixed to valve body 22 contiguous to the inside wall thereof. When closure member 34 is moved to the closed position, as shown in solid lines in FIG. 4, liner 40 insures that chamber 14 will be hermetically isolated from feed hopper 32.

A second valve means, such as quick-acting butterfly valve 50, is connected to container 12 at lower opening 17 thereof and communicates between chamber 14 and the exterior of the container, specifically the interior of vessel 62. Valve 50 is structurally identical to valve 20 and includes a cylindrical valve body 52 having a pair of flanges 54 and 56 attached at opposite ends thereof. Flange 54 of valve body 52 abuts flange 18 of container 12 to align valve 50 centrally of opening 17.

Flange 56, disposed at the other end of valve body 52, abuts a flange 60 which is affixed to the upper end of vessel 62 and surrounds the opening therein. Flanges 56 and 60, and 54 and 18 are secured in abutting relationship by appropriate fasteners, such as by bolts 58.

Valve 50 also includes a disc-shaped closure member 64 which is rotatably mounted within valve body 52 by a pair of stubshafts 66 and 68. The stubshafts are secured to a pair of diametrically opposed, radially extending shaft supports 67 and 69 formed integrally with closure member 64, and are journaled in suitable bushings 70 and 72 secured between flanges 54 and 56 of the valve body. In the closed position, closure member 64 seats against a resilient annular liner 73 which is affixed to valve body 52 contiguous to the inside wall thereof. When closure member 64 is moved to the closed position, liner 73 insures that chamber 14 will be hermetically isolated from vessel 62.

Apparatus 10 also includes actuating means for operating valves 20 and 50. Such means conveniently includes power means for opening and closing the valves, such as a pair of pneumatic expansible-chamber actuators 74 and 76 for actuating valve 20, and a similar pair of actuators 78 and 80 for actuating valve 50. Actuators 74 and 76 are operatively connected to closure member 34 of valve 20 by connecting rods 82 and 84, respectively, and a rocker arm 86 which is affixed to the end of stubshaft 38. As shown in FIG. 1, the ends of connecting rods 82 and 84 are pivotally connected to the opposite ends of arm 86 so that as the connecting rods move in and out of actuators 74 and 76, rocker arm 86 is caused to rotate about the axis of shaft 38 to thus open and close closure member 34.

Similarly, actuators 78 and 80 are connected to closure member 64 of valve 50 by a pair of connecting rods 88 and 90, respectively, and a rocker arm 92 which is affixed to the end of stubshaft 66. As shown in FIG. 1, the ends of connecting rods 88 and 90 are pivotally connected to the opposite ends of rocker arm 92 so that as the connecting rods move in and out of actuators 78 and 80, rocker arm 92 is caused to rotate about the axis of shaft 66 to thereby open and close closure member 64.

Actuators 74, 76, 78 and 80 communicate with a suitable source of compressed gas by means of conduits 94.

The operation of actuators 74, 76, 78 and 80 is controlled by suitable electromechanical control units 96, 98, 100 and 102, respectively, which conveniently comprise conventional

solenoid-operated valve units. As best shown in FIGS. 1 and 3, each actuator and the associated control unit form a structurally integral actuating unit, with the control unit being pivotally connected to one of two L-shaped mounting brackets 104 and 106 attached to the exterior wall of container 12. Control units 96, 98, 100 and 102 are electrically connected to a programmer 108 by cables 110 and are sequentially energized by the programmer as described hereinbelow.

Container 12 has third and fourth openings 111 and 113 therein (FIG. 3) which are spaced apart along the wall of the container. Connected to the container at openings 111 and 113 are conduits 112 and 114, respectively, which are attached to the wall of the container by any suitable means, such as by welding.

Interposed in conduits 112 and 114 are a third and fourth valve means which conveniently comprise quick-acting butterfly valves 116 and 118, respectively. Valves 116 and 118 are structurally similar to valves 20 and 50 but are of a much smaller size than the latter valves.

Actuating means, including suitable power means are provided for operating valves 116 and 118, such as expandable-chamber pneumatic actuators 120 and 122, respectively. Actuator 120 includes a connecting rod 124 which is pivotally connected to a rocker arm 126. The rocker arm in turn is secured to the end of one of the stubshafts which rotatably support the closure member of valve 116.

Similarly, actuator 122 includes a connecting rod 128 which is pivotally connected to a rocker arm 130. The rocker arm in turn is secured to the end of one of the stubshafts which rotatably support the closure member of valve 118.

Electromechanical control units 132 and 134 are provided for controlling the operation of actuators 120 and 122, respectively, and conveniently comprise conventional solenoid-operated valve units. As shown in FIG. 1, each of actuators 120 and 122 and the associated control unit form a structurally integral actuating unit, with control units 132 and 134 being pivotally connected to conduits 112 and 114, respectively. Control units 132 and 134 are electrically connected to programmer 108 by cables 136 and are sequentially energized by the programmer as described hereinbelow.

Programmer 108 may be any suitable electromechanical, electronic, or electrofluidic programming unit and conveniently comprises an electromechanical unit having a plurality of rotary cams and a corresponding number of microswitches which are opened and closed by the cams in the proper sequence for energizing control units 96, 98, 100, 102, 132 and 134 in the desired sequence.

The operation of apparatus 10 will now be described with respect to the use of the apparatus for introducing materials into hermetically sealed vessel 62 from feed hopper 32. In such instance, conduit 114 communicates between the chamber 14 and vessel 62, and conduit 112 communicates between chamber 14 and the ambient atmospheric environment in which hopper 32 is exposed or an environment having a similar ambient pressure. Initially, valves 20 and 50 and 118 are closed and valve 116 is opened to equalize the pressure within chamber 14 to ambient pressure. Valve 20 is then opened to admit materials, either liquids or particulate solids, into chamber 14 from feed hopper 32 by gravity feed. Both valves 116 and 20 are then closed to hermetically isolate chamber 14 from the ambient atmospheric environment. Valve 118 is then opened to equalize the pressure within chamber 14 to the pressure within vessel 62 which may be greater or lesser than ambient pressure. Valve 50 is then opened to discharge the materials from chamber 14 into vessel 62 by gravity feed. After the materials have passed into vessel 62, valves 50 and 118 are closed to hermetically isolate chamber 14 from the vessel. Valve 116 is then reopened and the foregoing sequence is repeated sequentially to provide a sequential flow of materials from feed hopper 32 into vessel 62 through chamber 14. Programmer 108 energize control unit 96, 98, 100, 102, 132 and 134 in the proper sequential operation of the valves.

When apparatus 10 is employed for removing materials from a hermetically sealed vessel, the operating sequence of the valves remains the same. In such instance, upper opening 15 of container 12 communicates with the discharge opening of the vessel and lower opening 17 of the container communicates with an environment having a pressure that is dissimilar from the pressure within the vessel, for example, the environment of the ambient atmosphere. Also, conveniently conduit 112 communicates between chamber 14 and the vessel, and conduit 114 communicates between chamber 14 and the ambient atmospheric environment in which the materials are to be discharged from the container or an environment having a similar ambient pressure.

When it is desired to remove materials from the vessel, valves 20, 50 and 118 are initially closed and valve 116 is opened to equalize the pressure within chamber 14 to the pressure within the vessel. Valve 20 is then opened to discharge the materials from the vessel to chamber 14 by gravity feed. Valve 116 and 20 are then closed to hermetically isolate chamber 14 from the vessel. Valve 118 is then opened to equalize the pressure within chamber 14 to ambient pressure and valve 50 is opened to discharge the materials from chamber 14 to the ambient atmospheric environment by gravity feed. Valves 118 and 50 are then closed to hermetically isolate chamber 14 from the ambient atmospheric environment and valve 116 is reopened to again equalize the pressure within chamber 14 to the pressure within the vessel. The foregoing sequence is thereafter repeated for sequentially removing the materials from the vessel.

From the foregoing description it will be appreciated that apparatus 10 is particularly suited for transferring both liquid and particulate solid materials to or from a hermetically sealed vessel from or to an environment having a dissimilar pressure, without destroying the hermetic integrity of the vessel. The apparatus is not subject to the operating and maintenance difficulties associated with the rotary valves which have been commonly used for this purpose. Moreover, the valve means of apparatus 10 are not subject to the thermal expansion problems associated with rotary valves, and thus the apparatus is ideally suited for use in processes wherein the materials being treated and/or one or both of the environments between which the materials are transferred is maintained at an elevated temperature.

An example of a typical process in which apparatus 10 may be advantageously employed is shown in FIG. 5. The process shown in FIG. 5 is a continuous process for treating grains, and in particular is a continuous process for parboiling rough rice. In this process the rice is subjected to three basic steps: (1) soaking; (2) cooking; and (3) drying. After the rice has been dried, it is ready to be milled or stored as desired.

The parboiling process will now be described in detail with reference to the diagrammatic flow sheet shown in FIG. 5. Rough rice having a known moisture content is initially conveyed from storage bins to a plurality of soaking or steeping tanks 200 by a suitable conveying means 202. Tanks 200 are pressurized vessels, each communicating with a source of compressed air by means of a conduit 204 and a source of hot water by means of a conduit 206. The air pressure within tanks 200 is maintained well above atmospheric pressure, and the water temperature within the tanks is maintained well below the vaporization temperature of water.

An individual batch of rough rice is subjected to a complete soaking cycle in each tank 200 before additional rice is admitted to the tank. The desired batch quantity of rice is introduced into each tank through a suitable valve 208 and removed from the tank through a similar valve 210. Valves 208 and 210 conveniently comprise quick-acting butterfly valves, such as valves 20 and 50 described above. Since the flow of rice into and out of tanks 200 is on a batch, as opposed to a continuous, basis there is no need to provide a means for continuously transferring rice into and out of the tanks.

The soaking cycles performed within tanks 200 are staggered timewise with respect to one another so that a substantially continuous and even flow of rice will be discharged from

the tanks. While seven soaking tanks are employed in the process shown in FIG. 5, it will be appreciated that a greater or lesser number of tanks may be employed to provide the desired rate of product flow.

The rice is discharged from tanks 200 onto a suitable conveying means 212 which delivers the soaked rice to a feed hopper 214. Hopper 214 is similar to hopper 32 described above and is exposed to the environment of the ambient atmosphere. The discharge outlet of hopper 214 is connected to the upper end of an apparatus 216 which is similar to apparatus 10 described above. The lower end of apparatus 216 is connected to a receiving inlet at the upper end of a cooker 218 in which the rough rice is cooked on a continuous basis. A discharge outlet at the lower end of cooker 218 is connected to the upper end of an apparatus 220 which is also similar to apparatus 10. The lower end of apparatus 220 communicates with a suitable conveying means 222 onto which the rice is discharged from apparatus 220. As shown in FIG. 5, feed hopper 214, apparatus 216, cooker 218 and apparatus 220 are vertically aligned with one another so that the rice will pass from the feed hopper, through apparatus 216, through the cooker and through apparatus 220 under the influence of gravity.

A boiler 217 is provided which generates steam to be used for cooking the rice. The steam is delivered to cooker 218 by means of a conduit 219. A safety valve 221 and pressure gauge 223 are connected to cooker 218 for controlling and monitoring the pressure of the steam therein.

A pair of conduits 224 and 226 communicate between cooker 218 and apparatuses 216 and 220, respectively, for delivering steam from the cooker to the apparatuses to thereby equalize the pressure within the apparatuses to the pressure within the cooker. A second pair of conduits 228 and 230 communicate between a heat exchanger 232 and apparatuses 216 and 220, respectively, for delivering water vapor from the apparatuses to the heat exchanger to thereby equalize the pressure within the apparatuses to the pressure within the heat exchanger. The interior of heat exchanger 232 is maintained at ambient pressure, thus, when conduits 228 and 230 are opened the pressure within apparatuses 216 and 220 is equalized to ambient pressure. Water vapor from apparatuses 216 and 220 is recondensed in heat exchanger 232 to provide makeup water for boiler 217.

The quality of parboiled rice is known to be directly related to the pressure at which the rice is cooked. Generally, higher cooking pressures produce a better quality finished product.

Heretofore cooking pressures have been limited by the lack of a suitable means for introducing and removing the rice from the cooker while maintaining the hermetic integrity thereof. The rotary valves which have been used for this purpose are subject to the operating and maintenance difficulties discussed above. These difficulties are magnified if cooking pressures even slightly greater than ambient pressure are employed.

Such difficulties are obviated by the use of apparatuses 216 and 220, which, as described above with respect to apparatus 10, are ideally suited for transferring rice into and out of steam pressurized cooker 218. In operation apparatuses 216 and 220 sequentially introduce and remove rice from the cooker on a continuous basis to provide the desired rate of product flow.

After the rice is discharged from apparatus 220 onto conveying means 222, it is delivered by the conveying means to a pair of tandem-operated rotary dryers 233. Dryers 233 conveniently comprise conventional forced flow hot air dryers in which the moisture content of the cooked rice is reduced.

From dryers 233, the rice is transferred by a suitable conveying means 234 to a series of tempering bins 236 and bin dryers 238. The tempering bins and bin dryers are alternated so that the rice passes serially from a tempering bin into a dryer and from a dryer into a tempering bin. The process shown in FIG. 5 employs four tempering bins 236 and four bin dryers 238, but it will be appreciated that a greater or lesser number of either may be employed if desired. The rice is

transferred between the tempering bins and bin dryers by suitable conveying means 240, and after passing through the final drying state is transferred to a milling process or storage bin by a suitable conveying means 242.

The rice parboiling process shown in FIG. 5 is merely one of many processes in which the apparatus and method of the invention may be advantageously employed. Many continuous processes require that a liquid or particulate solid material be transferred into and out of a hermetically sealed vessel in which a pressure other than ambient pressure is maintained. The apparatus of the invention is ideally suited for this purpose and particularly where elevated temperatures are encountered.

A modification of the process shown in FIG. 5 is shown in FIG. 6. The process shown in FIG. 6 is identical to the process shown in FIG. 5 except that a hermetically sealed vacuum dryer 244 is substituted for rotary dryers 233. A vacuum pump 246 communicates with dryer 244 by means of a conduit 247 for producing a vacuum environment within the dryer.

Apparatuses 248 and 250, which are similar to apparatuses 10, 216 and 220 described above, are connected to the inlet and outlet, respectively, of dryer 244 for transferring the rice into and out of the dryer.

A pair of conduits 252 and 254 communicate between dryer 244 and apparatuses 248 and 250, respectively, for equalizing the pressure within the apparatuses 248 and 250, respectively, for equalizing the pressure within the apparatuses to the pressure within the dryer. A second pair of conduits 256 and 258 communicate between the environment of the ambient atmosphere and apparatuses 248 and 250, respectively, for equalizing the pressure within the apparatuses to ambient pressure. The operation of apparatuses 248 and 250 is identical to the operation of apparatus 10 described above.

If desired, apparatus 220 may communicate directly between cooker 218 and dryer 244. In such instance the cooker preferably would be positioned directly above the dryer so that rice will be transferred from apparatus 220 into the dryer by gravity feed. Also, conduit 230 would communicate between dryer 244 and apparatus 220 for equalizing the pressure within apparatus 220 to the pressure within the dryer.

After the rice is discharged from apparatus 250, it is received by conveying means 234 and delivered thereby to tempering bins 236 and bin dryers 238 as described above.

The modified parboiling process shown in FIG. 6 illustrates the use of the apparatus of the invention with both a pressurized vessel, steam cooker 218, and a vacuum vessel, vacuum dryer 244.

The use of the apparatus of the invention with a different type of vacuum vessel is shown in FIG. 7. The vessel shown in FIG. 7 is a horizontal flow vacuum dryer 260 which comprises three drying chambers 262, 264 and 266, three screw conveyors 268, 270 and 272 disposed within chambers 262, 264 and 266, respectively, for conveying materials through the chambers, and a steam jacket 274 which surrounds the drying chambers. Suitable conventional means (not shown) are provided for driving conveyors 268, 270 and 272. A conduit 276 is connected to steam jacket 274 for delivering steam to the interior of the steam jacket to provide the heat required for drying materials as they pass through chambers 262, 264 and 266.

Chamber 262 communicates with chamber 264 through a connector 278, and chamber 264 communicates with chamber 266 through a similar connector 280, so that a common environment exists within the chambers.

A conduit 282 is connected to chamber 262 and communicates between the interior of chambers 262, 264 and 266, and a vacuum pump (not shown) which produces a vacuum environment within the chambers.

An apparatus 284, similar to apparatus 10 described above, is connected to the receiving inlet of chamber 262 for delivering materials into the dryer, and a similar apparatus 286 is connected to the discharge outlet of chamber 266 for removing the materials from the dryer. Apparatuses 284 and 286

sequentially introduce materials into and remove materials from the dryer to provide a continuous flow of materials therethrough.

Dryer 260 is particularly adapted for use in a solvent extraction process, such as the extraction of solvents from soy bean or cotton seed meal. In such processes a solvent, such as hexane, conventionally is added to the product to dissolve and absorb the natural oils therein. The wetted meal or mucella is then separated from the solvent-oil solution as by filtering. The mucella is thereafter dried in a dryer similar to vacuum dryer 260 in which the impregnated solvent is extracted therefrom and recondensed for use in the process again. With respect to dryer 260, evaporated solvent is removed from chambers 262, 264 and 266 through conduit 282 by the vacuum pump for delivery to a suitable recondenser.

The specific uses of the apparatus and method of the invention described above in connection with FIGS. 5-7 merely illustrate a few of the many processes in which the invention may be advantageously employed. For example, the invention may be used in continuous fumigation or bleaching processes, such as the fumigation or bleaching of flours.

Further, while the processes specifically described concern the treatment of agricultural products and by-products such as grains, cereal grains, legumes and seeds, it will be apparent that the invention is adaptable for use in a wide variety of processes in which particulate solid or liquid materials are to be treated on a continuous basis in a hermetically sealed vessel.

Moreover, the apparatus of the invention is not susceptible to the operating and maintenance difficulties associated with the known means for accomplishing this function, such as rotary valves, and is particularly adaptable for use in processes where the materials being handled and/or one or both of the environments between which the materials are transferred is maintained at an elevated temperature.

While the foregoing constitutes a detailed description of a preferred embodiment of the invention, it is appreciated that various modifications thereof will occur to those skilled in the art. Therefore, the scope of the invention is to be limited solely by the scope of the appended claims.

I claim:

1. An apparatus for introducing relatively fragile particulate materials into or removing said materials from a hermetically sealed vessel without damaging said materials or destroying the hermetic integrity of the vessel, said apparatus comprising:

a container defining a chamber therein, which chamber communicates between said vessel and an environment having a pressure dissimilar from the pressure within the vessel;

a first valve means connected to said container and communicating between said chamber and the exterior of the container for admitting said materials into the chamber, said first valve means comprising, a first valve body, a first closure member rotatably mounted within said first body, the periphery of said first member being spaced inwardly from said first body in all rotated positions of said first member, and a first resilient seal mounted within said first body and interposed between said first body and first member, said first member being frictionally engageable with said first seal and engageable solely with said first seal for closing said first valve means so that said materials will not be crushed by said first member upon closing of said first valve means;

a second valve means connected to said container and communicating between said chamber and the exterior of the container for discharging materials from the container, said second valve means comprising, a second valve body, a second closure member rotatably mounted within said second body, the periphery of said second member being spaced inwardly from said second body in all rotated positions of said second member, and a second resilient seal mounted within said second body and interposed between said second body and second member, said second

member being frictionally engageable with said second seal and engageable solely with said second seal for closing said second valve means so that said materials will not be crushed by said second member upon closing of said second valve means;

a third valve means operatively connected to said container and adapted to communicate between said chamber and said vessel so that the pressure within the chamber may be equalized to the pressure within the vessel;

a fourth valve means operatively connected to said container and adapted to communicate between said chamber and said dissimilar pressure environment so that the pressure within the chamber may be equalized to said dissimilar pressure; and

means for cyclically actuating said valve means so that the pressure within the chamber will be equalized to the pressure within the vessel before said materials are transferred between the container and vessel, and the pressure within the chamber will be equalized to said dissimilar pressure before said materials are transferred between the container and said dissimilar pressure environment, said actuating means including power means positioned externally of said container and operatively connected to said first and second closure members and to said third and fourth valve means for opening and closing said valve means without contaminating said materials.

2. An apparatus as recited in claim 1, wherein said power means comprise at least one expansible-chamber pneumatic actuator operatively connected to each of said first and second closure members and to each of said third and fourth valve means.

3. An apparatus as recited in claim 2, further comprising an electromechanical control unit operatively connected to each said actuator for controlling the operation thereof.

4. An apparatus as recited in claim 2, wherein a pair of said actuators are operatively connected to said first and second closure members.

5. An apparatus as recited in claim 1, wherein said actuating means further includes programming means for cyclically energizing said power means so that the fourth valve means is opened while the other valve means are closed to equalize the pressure within the chamber to said dissimilar pressure, then the first valve means is opened to admit the materials from the dissimilar pressure environment into the chamber, then the fourth and first valve means are closed and the third valve means thereafter opened to equalize the pressure within the chamber to the pressure within the vessel, then the second valve means is opened to discharge the materials from the chamber into the vessel, and then the third and second valve means are closed and the operating cycle of the valve means is repeated for sequentially transferring the materials from the dissimilar pressure environment through the container into the vessel.

6. An apparatus as recited in claim 1, wherein said actuating means includes programming means for cyclically energizing said power means so that the third valve means is opened while the other valve means are closed to equalize the pressure within the chamber to the pressure within the vessel, then the first valve means is opened to admit the materials from the vessel into the chamber, then the third and first valve means are closed and the fourth valve means thereafter opened to equalize the pressure within the chamber to said dissimilar pressure, then the second valve means is opened to discharge the materials from the chamber to the dissimilar pressure environment, then the fourth and second valve means are closed and the operating cycle of the valve means is repeated for sequentially transferring the materials from the vessel through the container to the dissimilar pressure environment.

7. An apparatus as recited in claim 1, wherein each of said valve means comprises a butterfly valve.

8. An apparatus as recited in claim 1, wherein said container comprises a cylindrical pipe section.

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9. The combination of a hermetically sealed vessel and the apparatus as recited in claim 1, wherein said vessel has an opening therein for receiving said materials therethrough and said apparatus is connected to the vessel at said opening with said second valve means interposed between said chamber and the interior of the vessel.

10. The combination as recited in claim 9, further comprising a conduit communicating between said apparatus and said vessel, and wherein said third valve means is connected to said conduit and interposed between the apparatus and vessel.

11. The combination as recited in claim 9, further comprising a means for generating a pressurized fluid and a conduit communicating between said generating means and said vessel for delivering pressurized fluid from the generating means to the vessel.

12. The combination as recited in claim 11, wherein said generating means comprises a steam boiler.

13. The combination as recited in claim 12, further comprising a heat exchanger for condensing water vapor makeup to provide makeup water for the boiler and a second conduit communicating between said chamber and said heat exchanger for delivering water vapor from the chamber to the

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heat exchanger, and wherein said fourth valve means is connected to said second conduit and interposed between the chamber and heat exchanger.

14. The combination as recited in claim 9, further comprising a means for producing a vacuum and a conduit communicating between said vacuum producing means and said vessel so that a vacuum environment will be produced within the vessel.

15. The combination as recited in claim 9, wherein said vessel has a second opening therein for discharging said materials therethrough, and further comprising a second said apparatus connected to said vessel at said second opening with the first valve means of said second apparatus interposed between the chamber of said second apparatus and the interior of the vessel.

16. The combination as recited in claim 15, further comprising a conduit communicating between said second apparatus and said vessel, and wherein the third valve means of said second apparatus is connected to said conduit and interposed between the second apparatus and vessel.

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