April 29, 1969 B. R. REUTER ET AL 3,440,733

MATERIAL DRYING AND CONVEYING APPARATUS

Filed Dec. 7, 1967 Sheet 1 of 2

FIG. 1

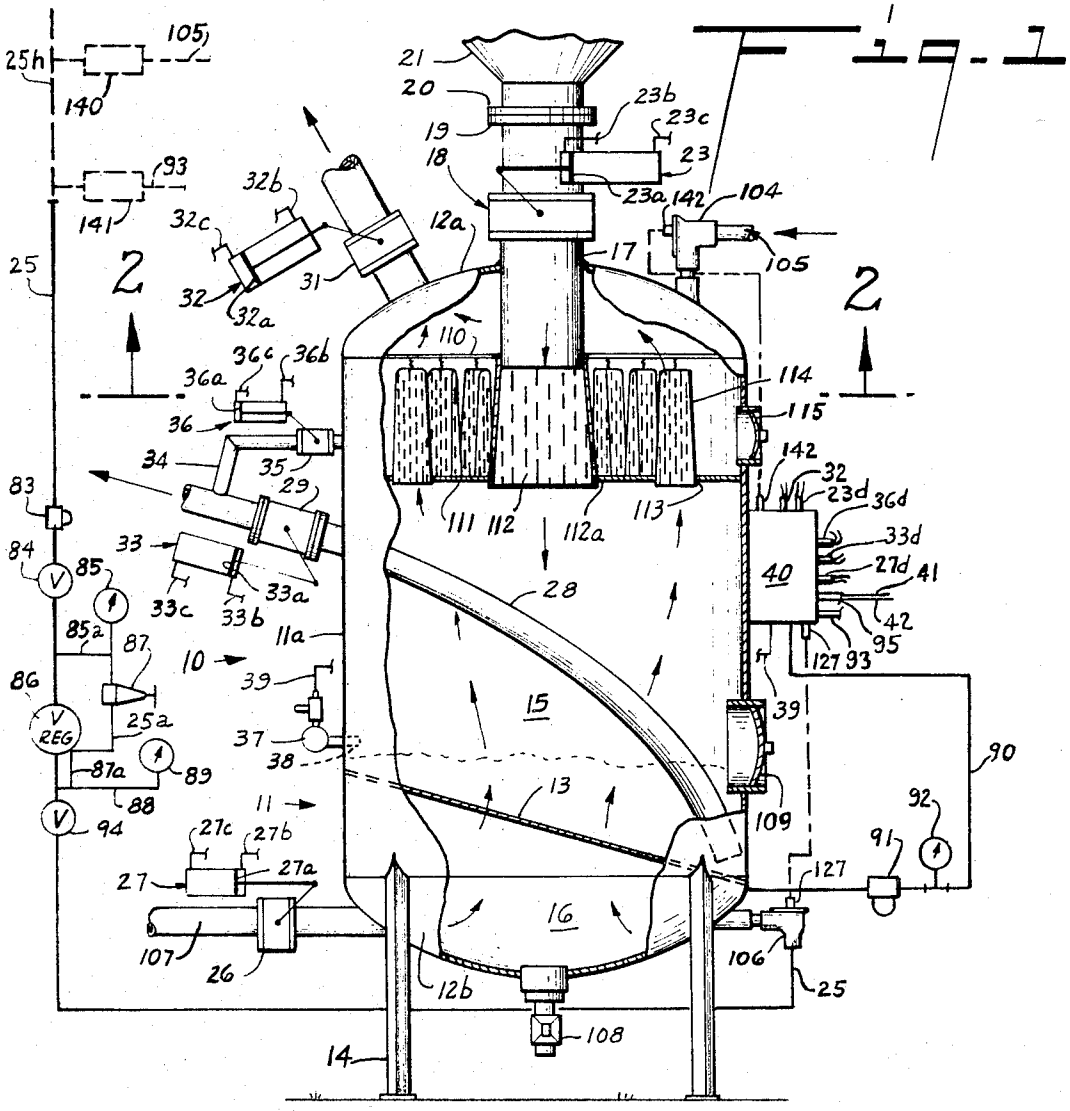
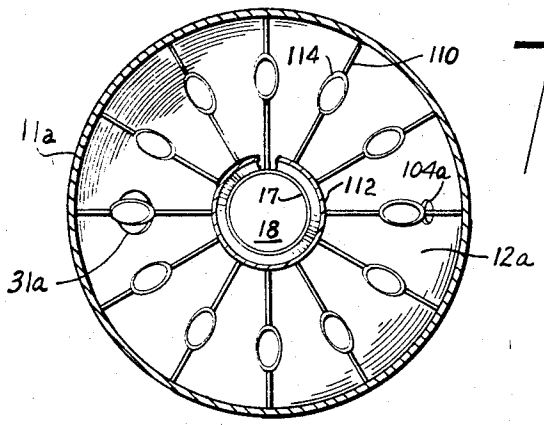


FIG. 2



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MATERIAL DRYING AND CONVEYING APPARATUS

Filed Dec. 7, 1967 Sheet 2 of 2

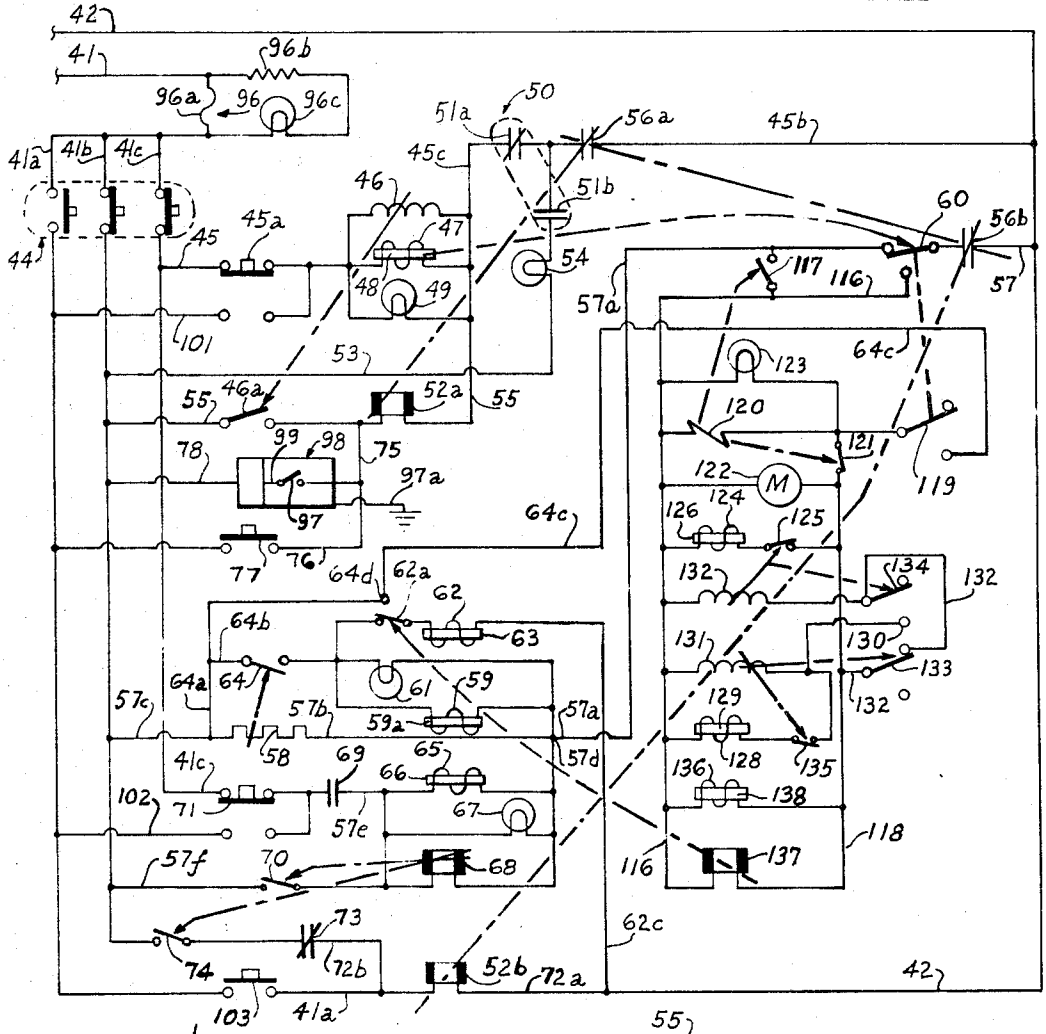

FIG. 3

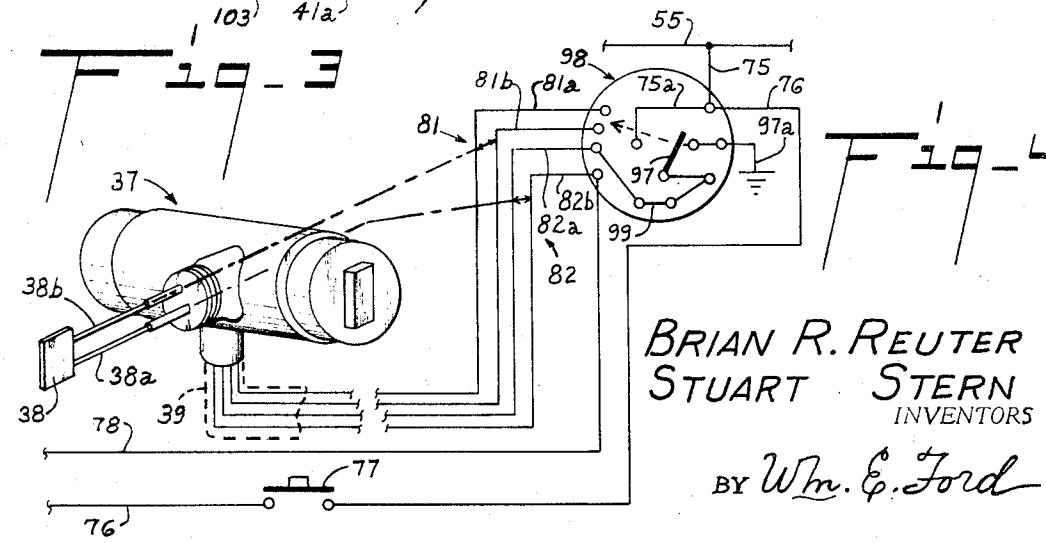

FIG. 4

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MATERIAL DRYING AND CONVEYING APPARATUS

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U.S. Cl. 34—10 12 Claims

ABSTRACT OF THE DISCLOSURE

This invention relates to material drying and conveying apparatus of the type which automatically controls the entry of a quantity of moisture containing material into a vessel or pump housing. The material is dried as by a heated gas, with time or weight automatically turning on the activation of the dried material; the material being rendered freely flowable, as by pressurized compressed air; and its activation being followed by the delivery of the dried material from its container or vessel; thereafter the vessel or pump being purged by the residual pressure remaining after discharge.

As a primary object the invention sets out to provide a means for automatically controlling the cyclic measured entry, drying while back-filtering, activating, full discharging and purge discharging of a material which enters the processing pump, vessel, or container, the entering material having a moisture content which is removed by drying as the material is rendered flowable by a pressurized activating and discharging gas.

It is also an object of this invention to provide apparatus of this class which is selectively set to automatically control fill, drying, activation, full discharge and purge discharge, or alternately, when the handled material does not have to be dried, to automatically control, fill, activate, full discharge and purge discharge.

It is still a further object of this invention to provide apparatus of this class which additionally provides a safeguard to close the fill valve in case the regularly provided fill valve closing means should not function, or fail to function timely.

It is also another object of this invention to provide apparatus of this class which may dry the handled material by interspersing predetermined filter blast periods between predetermined drying intervals between blasts.

Other and further objects will be apparent when the specification herein is considered in connection with the drawings, in which:

FIG. 1 is an elevational view, part in section, of a container, pump or pressure vessel, partially diagrammatical, which discloses an embodiment of the invention;

FIG. 2 is a sectional bottom view, looking upward along line 2—2 of FIG. 1;

FIG. 3 is an electrical diagram of the apparatus and circuitry therefor, as employed in actuation of the apparatus disclosed generally in FIG. 1; and

FIG. 4 is an isometric view of safeguarding apparatus indicated in FIG. 1, with a circuit diagram of the circuitry entering into its operation.

Referring now to the drawings in which like reference numerals are applied to like elements in the various views, a material container, housing, pump or activator **10** is shown in FIG. 1 comprised of a shell **11** including a cylindrical main body **11***a* with upper end closed by a top comprised of a spherical segment or dome **12***a* and a bottom comprised of a spherical segment or lower closure **12***b*, the container being constructed after the general

manner of conventional pressure vessels, and designed with safety factors, to withstand the highest pressures that may be developed therein.

The pressure vessel or container **10** is supported on legs **14** which upstand from a conventional base or grout, not shown. A gas permeable membrane or diaphragm **13**, sloped at substantially 13 degrees, as indicated, separates the container into an upper, or material plenum **15**, and a lower, or gas plenum **16**.

The dome **12***a* has an inlet flange or neck **17** connected centrally into the top thereof with an inlet gate valve or fill valve **18** being mounted thereon. The top flange **19** of the fill valve **18** is shown connecting the fill valve **18** with a discharge flange **20** from a hopper **21**.

A valve operator **23** is shown diagrammatically, as disposed to open and close the gate valve **18**, a piston **23***a* being shown provided in the valve operator **23**, with instrument air admissable under the piston **23***a* through a conduit **23***b* to open the fill valve, and with instrument air being admissable through a conduit **23***c* above the piston **23***a* to close the fill valve. Obviously, the conduits **23***b* and **23***c* must be in a closed compressed circuit with a pressurized reservoir, or otherwise selectively supplied with compressed air, to carry out their respective functions.

A hot drying gas conduit **107** is shown connected into the lower end closure **12***b* of the shell or pressure vessel **11** below the high side of the membrane **13**, and such hot drying gas inlet line **107** has a drying gas valve **26** therein, which is shown connected to be opened and closed by a valve operator **27**, constructed and equipped in correspondence with the valve operator **23**. Also, a discharge outlet pipe **28** extends downwardly through the dome **12***a* to terminate in a pick-up end **28***a* disposed slightly above the low side of the gas permeable or air permeable membrane **13**. A valve **29** is shown connecting this discharge outlet pipe **28** with a discharge conduit **30**. The discharge valve **29** is shown operated by a valve operator **33**, which is indicated as being constructed, and as having connections thereto, in correspondence with the fill valve operator **23**.

A purge line **34** extends between the discharge conduit **30**, downstream of the discharge valve **29**, to the material plenum or chamber **15** and has a purge valve **35** therein to control its opening and closing, a valve operator **36** being shown connected to the purge valve **35** for this purpose, such valve operator **36** being constructed, and having connections in correspondence with the fill valve operator **23**. However, it may be pointed out, in this regard, that the purge valve **35** should be a normally open valve, whereas the fill valve **18**, gas inlet valve **26**, and discharge valve **29** are normally closed valves.

Additionally, the support body **37** for a safeguarding vibratory paddle **38**, operative on the tuning fork principle, is shown connected into the cylindrical body **11***a* of the shell **11**, the material sensitive paddle **38** being indicated in dotted lines in FIG. 1 as extending within the housing **10** near the top thereof, such paddle being operative to actuate the valve operator **23** to close the fill valve **18**, as will be hereinbelow described.

An insulative cord **39**, having therein the electrical conduits to the paddle **38**, extends from the paddle support body **37** to a control box **40**, to be hereinbelow described, and shown mounted on the exterior of the activator shell body **11***a*.

A vent valve **31** is shown connected into the dome **12***a* in FIG. 1 and operated by a valve operator **32** which is constructed, and has connections thereto, in correspondence with the fill vale operator **23**. Also a solenoid operated blast air valve **104** is shown connected into the dome **12***a* oppositely of the vent air valve connection, with

blast air, to be hereinbelow described, being supplied to the valve **104** through a blast air conduit **105**. Additionally, a solenoid operated, transfer or moving air valve **106** is connected into the shell bottom **12***b* or gas plenum chamber **16**, a conduit **25** being connected to supply moving air to the valve **106**. Also, the shell segment **12***b* is shown having a drain valve **108** connected into the bottom thereof. Also, a conventional manhole **109** is shown provided in the side of the shell cylinder **11***a*.

The neck or nipple **17** which supports the fill valve **18**, and by means of which the valve **18** is connected to communicate through the top of the dome **12***a*, extends downwardly into the shell or vessel **11** as indicated in FIG. 1. A series of equally angularly spaced apart, radially extending support rods or bars **110** have their inner ends connected to the nipple **17** and are connected at their outer ends to the inner surface of the shell **11***a*, as best seen in FIG. 2. At a spaced distance below the suspension bars **110** a baffle plate **111** extends across the shell **11***a* and has a central enlarged opening **12***a* therein into which is connected the lower end of a central perforated sleeve **112** of frusto-conical shape, the upper end of the sleeve **112** being affixed to the outer periphery of the lower end of the nipple **17**.

A ring of round or eliptical holes or openings **113** is provided in the baffle plate **111**, the hole being equally angularly spaced apart, and such holes receive therein the lower ends of perforate filter sleeves **114** to be affixed to the baffle plate **111**. The filter sleeves **114** are of reduced cross-sectional area upwardly and the top of each sleeve **114** is connected upwardly to a respective suspension bar **110** as best indicated in FIG. 1. The filter sleeves **114** may be of woven metal cloth, perforate glass or perforate plastic of such porosity to admit the processing gas or air to pass therethrough while entraining or stopping the passage of the process material. A suitable handhole **115** is shown provided in FIG. 1 for access to the filter sleeves **114** and central sleeve **112**. It should also be noted in the bottom view of FIG. 2 that the relative positions of the blast air inlet **104***a* and the vent air outlet **31***a* are discernible.

As shown in FIG. 3, a positive line **41** and a negative line **42** extend from a source of electrical power, the positive line **41** having three parallel lines **41***a*, **41***b* and **41***c* branching therefrom with the line **41***a* serving when manual control is to be used as will be hereinbelow described with the line **41***b* serving as a neutral third positive conductor and with the line **41***c* serving as the positive conductor when automatic control is to be employed. A three-way switch, indicated generally by reference numeral **44**, is provided to control the selection of automatic or manual control, as desired, and as shown, the switch **44** indicates that automatic control has been selected, the conductors **41***b*, **41***c* thus being closed and the conductor **41***a* being open.

A conductor **45** extends from the conductor **41***c*, and a push-button switch **45***a* is shown in FIG. 3 as closing circuit in this conductor, the conductor **41***c* continuing to a junction with three parallel circuits including the circuit of a variable time delay relay **46**, the circuit **47** for a solenoid **48** which operates the fill valve operator **23** shown in FIG. 1, and the circuit of an indicator light **49** which may be designated as a green light for illustrative purposes.

The conductor **45** continues as the conductor **45***c* and has contacts **51***a* therein of a double acting pressure actuated switch **50**, such contacts **51***a* being normally closed at atmospheric pressure and opening upon increase of pressure in the gas plenum **16**. The conductor **45***c* continues from the contacts **51***a* to a junction with a conductor **45**b having therein the normally closed relay contacts **56***a* of a latching relay **52**, the conductor **45***b* terminating at its connection to the negative power line **42**.

A parallel circuit **53** extends from the neutral or central positive conductor **41***b*, to the junction of the conductors **45***c*, **45***b*, such parallel circuit also including therein the contacts **51***b* of the aforesaid pressure actuated switch **50**, such contacts **51***b* being normally open at atmospheric pressure and closing upon increase of pressure in the aforesaid gas plenum **16**. The circuit **53** also has therein an indicating light **54**, designated as a yellow light for indicating purposes, as will be hereinbelow described.

Another parallel circuit **55** from the positive conductor **41***b* has the switch **46***a* therein which is closed by the variable delay relay **46** at the end of its preselected cycle, the circuit **55** also having therein the coil **52***a* of the latching relay **52**, and the circuit **55** being continued by the circuit **45***c*, as aforesaid. The circuit **55**, as thus closed, energizes the latching relay coil **52***a* to open the normally closed relay contacts **56***a* to break the aforesaid parallel circuits **46**, **47**, **49** and **55**, and upon the solenoid circuit **47** being de-energized, the solenoid **48** retracts and moves the valve operator **23** to close the fill valve **18**, both valve operator and fill valve being shown in FIG. 1.

The latching relay **52** is of the well known type, which, when its coil **52***a* is energized, it actuates conventional switching means which opens the normally closed contacts **56***a*, and pulls closed the normally open contacts **56***b* in a parallel circuit **57** extending from the negative conductor **42**, in manner that the latching relay mechanism latches against any movement except that which may be imparted to the switching means to pull open the normally open contacts **56***b*, which can only be effectuated by the energization of the latching relay coil **52***b*, to be hereinbelow described as to operation.

The apparatus for handling a material not requiring drying will be first described, for purposes of clarity, and with its operation understood, the apparatus for interjecting the drying processes will then be described, and the relationship to the activating, full discharging and purge discharging apparatus and steps set forth therewith.

The circuit **57**, hereinabove referred to, has the aforesaid latching relay, normally open contacts **56***b* therein, and adjacent thereto, in direction of the positive conductor **41***b*, a manual throw switch **69** is connected into the circuit **57**, so that when the switch **60** is manually or selectively disposed to connect the circuit **57** with a continuation circuit **57***a*, the apparatus is set to handle a material which does not require a drying process before delivery for subsequent handling. Thus the four circuits: **57***b*, and then **59**, **61** and **62**, to be hereinbelow described, are joined to the circuit **57***a*, the circuit **57***b* being continued by the circuit **57***c* to the positive conductor **41***b*.

From the junction of the circuits **57***b*, and **57***c*, a circuit **64** *a* having a switch **64** therein, continues as the circuit **64***b* to the negative side junction of the aforesaid circuits **59**, **61** and **62**. A fixed time delay relay **58** of the thermal delay type, in the circuit **57***b*, operates for its time interval, when the circuit **57***a* is closed, and closes the switch **64** whereby the solenoid **59***a* in control box **40** releases air from the tube **127** to open the moving air inlet valve **106** whereby the circuit including the light **61**, blue to indicate activation, is closed, and whereby the circuit **62** actuates the solenoid **63** to close the purge valve **35**; see FIGS. 1, 2 and 3.

Also, a circuit **57***d* continues from the junction of the circuits **57***b*, **59**, **61** and **62** with the circuit **57***a*, and branches into: a circuit **65** including the coil which operates a solenoid **66** which actuates the valve operator **33**, shown in FIG. 1, to open and close the discharge valve **29**; a circuit including a light **67** therein, which is designated as a red light, for purposes of illustration; and a circuit having a relay **68** therein; from the positive side junction of the circuits **65**, **67** and **68**, there extends a circuit **57***e* (having a normally open pressure actuated switch **69** therein, to be hereinbelow described), with its positive side connection being completed with the conductor **41***c*; and there also extends from such junction a circuit **57***f* having a pair of contacts **70** therein operated

by the relay **68**, and terminating by connection with the neutral or positive conductor **41***b*. A push-button switch **71** is shown in FIG. 3 closing the circuit **41***c* adjacent its connection to the circuit **57***e*.

Additionally, a circuit **72***b*, **72***a* connects the positive or neutral conductor **41***c* with the negative power line or conductor **42**; the circuit **72***b* having in series therein a pair of contacts **74**, (operated by the relay **68** substantially simultaneously with its operation of the contacts **70** in the circuit **57***f*), and a pressure sensitive switch **73** which functions as will be hereinbelow described. Then, the circuit **72***a*, with which the circuit **72***b* connects, has therein the latching relay coil **52***b* which operates to break circuit closed by the hereinabove described relay contacts **56***b*.

The gas, as compressed air, which activates and transports the material which enters the container, shell, or pressure vessel **11**, arrives from its source, as a compressor or pressure header **25***h*, as shown in FIG. 1, and enters conduit **25** to pass through a strainer **83** and a globe valve **84** on its way to being regulated as to the pressure at which it is to be supplied. Thus the gas is first measured by a high pressure gauge **85** in the top of a gauge pipe **85***a* which upstands from the main gas line **25** through which the strained gas passes on downstream, and to the transfer gas valve **106**.

A smaller sized by-pass line **25***a* extends between the gauge pipe **85***a* and the aforesaid pressure regulating valve **86** in the main conduit **25**, and has a pilot regulating valve or regulator **87** therein, thus to permit a finer and more responsive control of the pressurized gas on its way to the pressure vessel **11**. A by-pass line **87***a* conveys the reduced pressure gas from the pilot regulator **87**, and connects with an upstanding gauge pipe **88** above the main conduit **25**, a low pressure gauge **89** being mounted on top of the gauge pipe **88** to indicate the lowered pressure of the gas.

A conduit **90** extends from the lower closure **12***b* to conduct pressurized gas from the gas plenum **16** to the control box **40**, there to bear upon and cause actuation of the pressure sensitive switch **50**, operative as hereinabove described, and to bear upon and cause actuation of pressure sensitive switches **69** and **73**, to be further described as to operation hereinbelow.

The switch actuating gas, which must be taken from within the pressure vessel **11**, enters the conduit **90** and passes through a strainer **91** therein, and on to the panel box **40**, a gauge **92** being provided to indicate the pressure of the actuating gas as it passes downstream of the strainer **91** on its way to the panel box pressure sensitive switches, as aforesaid. The instrument air required by the pressure sensitive switches, as contradistinguished from the actuating air or gas, and any other air or gas required to actuate any of the apparatus, as that required to operate the valve operators shown in FIG. 1, may be brought to the panel box **40** through a conduit **93** for selective distribution.

Also, the power conductors **41**, **42**, from a source of electrical power, as a 60 cycle, 115 A.C. voltage source, may be brought to the panel box **40** through an insulated conductor cord **95**. A conventional fuse **96** is provided in the positive power line **41**, indicated as comprising the conventional fuse strip **96***a*, and in a parallel circuit therewith, the conventional resistance **96***b* and indicating light **96***c*.

The operation of the apparatus shown in FIGS. 1, 2 and 3 may be set forth in a sequence, and partially by way of reiteration, with the composite switch contacts **51***a* and the latching relay contacts **56***a* closed, the switch **45***a* may be manually closed whereby the solenoid **48** actuates its associated valve operator to open the fill valve, as the variable time delay relay **46** starts its cycle and "times out" as it closes the switch **46***a* at which time the relay **52***a* of the latching relay is energized to break the latching relay contacts **56***a* and close the latching relay is energized to break the latching relay contacts **56***a* and close the latching relay contacts **56***b*, the fill valve **18** thus being closed. The switch arm **60** closes circuit with the circuit **57***a*, and the fixed time delay relay **58** is energized so that the switch **64** is closed and the solenoid **59***a* actuates its associated valve operator to open the activating air or gas valve **106** to let gas, such as compressed air, into the gas plenum **16** to pass through the membrane **13** and into the material plenum **15** to start pressurizing the vessel or activating the material to be transferred. Also, as this occurs, the circuit **62**, having therein the switches **62***a*, **62***b* on either side of the solenoid windings **62**, in circuit closed position, the energized solenoid windings **62** actuate the solenoid **63** to actuate the valve operator **36** to close the purge valve **35**. This pressurizes the vessel **10** and activates the material until that pressure is attained which will close the normally open pressure actuated switch **69** whereby the solenoid **65** is actuated to move its associated valve operator **33** to open the discharge valve **29**. Also the relay **68** is energized to close the normally open switch **70** and the normally open switch **74**.

Discharge then continues until the pressure drops to open the pressure sensitive switch **69**, then to close the pressure sensitive switch **73**, thus completing circuit to the latching relay coil **52***b* which is energized to open the latching relay contacts **56***a*, thereby to close the latching relay contacts **56***b* whereby the windings of the discharge control solenoid **66**, of the activating air control solenoid **59***a*, and of the purge control solenoid **63** are de-energized, so that discharge valve **29** and air supply valve **26** are closed and the purge valve **35** is opened. The vessel then purges itself until the pressure falls substantially to atmospheric to close switch contacts **51***a* and open switch contacts **51***b*, thus returning the apparatus to initial status.

Also, a "fail-safe" or safeguarding, material sensitive, frequency change actuated, control assembly **37** is provided to insure the closing of the fill valve **18** in case the variable time delay relay **46** may not function to close the time-out switch **46***a* at the end of the time cycle period selected, as indicated diagrammatically in FIG. 3, and as shown partially diagrammatically and in greater detail in FIG. 4.

The "fail-safe" circuit **75** is shown extending from a point on the conductor **55** between the time-out switch **46***a* and the latching relay coil **52***a*, and is continued to a solids state relay housing **98**, there to be connected to the junction between a conduit **75***a* to the normally open side of a relay switch **97**, and a circuit **76** which extends to the positive conductor power line **41***a*, the circuit **76** having the push-button switch **77** therein, to be hereinbelow described. Normally, the relay switch **97** closes contact between a grounded conductor **97***a* (and thus the negative power line side **42**) and a conductor means **99** between the relay switch **97** and the negative terminal of a coil **82** in the control housing **37**.

The coil **82**, within the housing **37**, is indicated externally thereof by its connections **82***a*, **82***b* which terminate within the plug **98**. Within the housing **37** the coil **81** energizes a plunger or armature, not shown, in manner that it normally vibrates 120 cycles per second to impart vibration at this frequency to the lower tuning fork tine **38***a* which is shown connected in FIG. 4 to the paddle or vibrator **38**. Thus normally the tine **38***b* also vibrates with the paddle **38** at 120 cycles per second. The vibrations of the tine **38***b* are imparted to an armature, not shown, which normally actuate a second coil **81**, at an imparted voltage, 60 cycles per second frequency. Such coil **81**, also not shown within the housing **37**, is indicated externally thereof in FIG. 4 by its connections **81***a*, **81***b*, which terminate within the plug **98**.

An induction coil, not shown, is imposed across the terminals of the coil **81** within the plug so disposed with relation to the switch **97** that this switch may be shifted

when the differential between the line voltage and the imparted voltage achieves a certain value, as is the case when material entering the container or activator **10** extends at such an angle of repose to interfere with, reduce, or stop the vibrations of the paddle **38**.

When the aforesaid induction coil across the terminals of the coil **81** thus shifts the switch **97** to close circuit from the neutral or positive side conductor **41***b*, by way of the conductor **78**, the coil **82**, and the conductor **99**, through the switch **97**, as thus shifted, and by way of the conductors **75***a*, **75**, **55** (including the latching relay coil **52***a*), and on through the conductor **45***c*, the closed switch contacts **51***a*, and the circuit **45***b* (including the latching relay closed contacts **56***a*), to the negative power line **42**. The energization of the latching relay coil **52***a* in the circuit **55** results in the latching relay breaking the circuit **45***b* by shifting open the contacts **56***a*, whereby the solenoid winding **47** is de-energized to actuate the solenoid **48** to operate the valve operator **23** to close the fill valve **18**.

Obviously the quicker the "fail-safe" switch **97** is operated after a failure of the variable time delay relay **46** to close the time-out switch **46***a*, the less the material from the hopper **21** can over fill the container **10**, and the closer the delivered batches of material may be controlled to deliver a desired lesser volume per batch.

Also, it is obvious that the variable time delay relay **46** may be omitted entirely, together with its time-out switch **46***a*, and in this case the frequency control device **37** alone can be relied upon to actuate the valve operator **23** to close the fill valve **18**.

On occasion it may be desirable to operate the filling and evacuation of the container **10** by manual control of the sequence of steps, rather than automatically, as hereinabove described. For such occasion, it may be considered that the variable time delay relay **46** and its timing out switch **46***a* are immobilized. Then a circuit **101** is provided, parallel with the circuit **45**, to extend from the positive conductor **41***a* and to connect with the circuit **45** between the pushbutton **45***a* and the circuit junction **46**, **47**, **49**. Also in this case, there also serves the aforesaid circuit **76** from the circuit **41***a* to the junction of circuits **75**, **75***a*, and having the pushbutton **77** therein; also, the circuit **102**, parallel with the circuit **57***e* and connected thereinto between the pushbutton **71** and the normally open pressure sensitive switch **69**; also, the positive power circuit **41***a* is extended to connect with the junction of the circuits **72***a*, **72***b*, and to have the pushbutton **103** therein.

Thus, with the three-way switch controlling the parallel conductor lines **41***a*, **41***b* and **41***c* turned from the position shown in FIG. 3, in manner that the conductors **41***a*, **41***b* are closed, the conductor **41***c* thus being left open. Beginning with the container **10** empty and at atmospheric pressure, the pushbutton **45***a* may be pushed downwardly and held to close the circuit **101**. The circuit **47** is thus energized so that the solenoid **48** actuates the valve operator **23** to open the fill valve **18**. Then, the pushbutton **45***a* may be released from closing the circuit **101**, thus breaking circuit through the solenoid coil **47** so that the solenoid **48** actuates the valve operator **23** to close the fill valve **18**.

With a batch of material delivered into the container **10** in amount determined by the length of time the pushbutton **45***a* has closed the circuit **101**, activation of the material may be started, after the pushbutton **45***a* has been released, by manipulating the pushbutton **77** to close the circuit **76**. Circuit is thus closed through the circuit **75**, the circuit **55** including the latching relay coil **52***a*, and to the negative power line side **42**, by way of circuit **45***c*, closed contacts **51***a* of the pressure sensitive switch **50**, and the circuit **45***b*, including the latching relay closed contacts **56***a* therein. This energizes the latching relay coil **52***a* to operate the latching relay **52** to break the contacts **56***a* and close the contacts **56***b*.

Circuit is thus closed to the fixed time delay relay **58**, which actuates the "time out" switch **64** to close the solenoid coil circuit **59**, thus to actuate the valve operator **27** to open the compressed air valve **26**; also the solenoid coil circuit **62** is closed whereby the solenoid **66** actuates the valve operator **36** to close the purge valve **35**.

Then, the operator of the apparatus may observe the gauge **92**, and when the pressure indicates that the vessel is ready to discharge, or when the operator appreciates that a proper time interval after the opening of the gas inlet or compressed air valve **26** has taken place, the pushbutton **71** may be pushed to close the circuit **102**, the normally open pressure sensitive switch **69** being closed by the pressure that has built up in the vessel.

Thus, as aforesaid, the armature **65** may move to set in operation the opening of the discharge valve **29**, while circuit is closed to operate the second relay **68** so that it closes the circuit **57***f*, and closes the contacts **74** to partially close the circuit **72***b*. Discharge may thus continue as long as the pushbutton **71** is held closing circuit **102**, or even if the operator may now release the pushbutton **71**, since in this case the circuit continues completed through the contacts **70** in the circuit **57***f*, even after the pressure has fallen enough to cause the pressure sensitive switch **69** to open.

Thus to purge the vessel **10** after the pushbutton **71** has been released, or thereafter, or at any time, with the three-way switch **44** turned to manual operation, (**41***a*, **41***b* closed), it is only necessary to push pushbutton **103** to close circuit with the circuit **72***a* to energize the latching relay coil **52***b*, which, when energized, operates, as aforesaid, to close the circuit **45***b* and to break the circuit **57**, whereby the purge valve **35** is opened and the compressed air valve **106** and discharge valve **29** are closed. Then, as the purge pressure diminishes the normally closed pressure sensitive switch **73** opens, and as the pressure falls further to substantially atmospheric pressure, the contacts **51***a* of the pressure sensitive switch **50** close, and the pushbutton **45***a* may again be pushed to close the circuit **101** to admit material into the container **10**.

Respective conduits **23***b*, **33***b*, **36***b*, **27***b* and **32***b* connect into the respective fill, materials delivery, purge, hot drying gas and vent valve operator cylinders **23**, **33**, **36**, **27** and **32**, under respective piston heads **23***a*, **33***a*, **36***a*, **27***a* and **32***a*, and respective conduits **23***c*, **33***c*, **36***c*, **27***c* and **32***c* connect into such cylinders above the respective piston heads therein. Thus, as shown in FIG. 1, conductor cords or sleeves **23***d*, **33***d*, **36***d*, **27***d* and **32***d* for the respective conduits for the respective valve operator cylinders aforesaid, are provided to extend from the control or panel box **40**, where conventional instrument air, as from the instrument air conduit **93**, may pass through respective conventional solenoid actuated valves, not shown, as operated by the aforesaid solenoids **48**, **66** and **63**, and solenoids **126** and **138**, shown in FIG. 3, and to be hereinbelow described, these five solenoids admitting operative air, gas or fluid, respectively into the conduits **23***b* or **23***c*; into the conduits **27***b* or **27***c*; and into the con- **36***c*; into the conduits **27***b* or **27***c*; and into the conduits **32***b* or **32***c*; selectively to open or close the aforesaid fill valve **18**, materials delivery valve **29**, purge valve **35**, hot drying gas valve **26** and vent valve **32**.

As shown in FIG. 3, a light **49** is in circuit parallel with the solenoid circuit **47** and the variable time delay relay circuit **46**, and thus the light **49** is on when the fill valve **18** is open; also a light **61** is in a circuit parallel with the solenoid circuit **59** which actuates the valve **106** which admits the material activating gas, and with the solenoid circuit **62** which closes the purge valve; and also a light **67** is in a circuit parallel with the solenoid circuit **65** which actuates the opening of the materials delivery valve **29**. Additionally, a light **54** is shown in a circuit **53** which is completed when the latching relay **52** is actuated to close the contacts **56***a* while the pressure within the container is still high enough to maintain closed the contacts **51***b* of the pressure senstive switch **50**.

Thus, this occurs after the purge valve **35** has been reopened by opening of the latching relay contacts **56***b*, to permit the purging of the container by the residual pressure therein until such pressure drops to substantially atmospheric so that the pressure sensitive switch **50** is actuated to open the contacts **51***b* and close the contacts **51***a*, thereby breaking the circuit **53** which contains the light **54** therein.

The lights **49**, **61**, **67** and **54** may have selectively differently colored bulbs, as, respectively, green, blue, red and amber, thus to indicate, respectively, that filling, activating, discharging and purging are taking place.

The respective valve operators **23**, **27**, **33**, **32** and **36** may be used to operate the respective fill valve **18**, hot drying gas delivery valve **26**, material delivery valve **29**, vent valve **32** and purge valve **35**, as shown, but it is often not necessary, in the case of light duty installations, and/or in the case of the valves **26**, **29**, **31**, **35**, that special valve operators be required for their operation. In such cases the solenoids **60**, **66** and **63**, and the vent valve solenoid, to be hereinbelow described, may thus be connected directly to the respective valves **26**, **29**, **35** and **31** to effectuate their operation.

Also, as to the "fail-safe" feature of the vibrating paddle **38**, the sensitivity of this feature is such that it can be regulated to operate almost instantaneously as a container first starts to overfill, so that the relay **52***a* is energized to operate the latching relay **52** immediately the variable time delay relay **46** fails to function.

Additionally, as set forth hereinabove, the vibratory paddle **38** may be used instead of the variable time delay relay **46**, as the primary functional element to actuate the closure of the fill valve **18**. In such case the sensitivity of the paddle **38** to adjustment, can determine the promptness of sensitivity to material to close the relay switch **97**.

In order to carry out a preliminary drying of material preparatory to activating it and pressurizing it for discharge, as this invention entails, additional apparatus and circuitry is provided for use with the apparatus and circuitry hereinabove described. Such additional inventive circuitry and apparatus supports and controls the admission and cut off of drying air through the drying air valve **26**, the venting of the container **10** during selective cycles through the vent valve **31**, and the admission of cut off of filter cleaning blast air through the air blast valve **104**, the valves **26**, **31** and **104** being shown in relation to the container **10** in FIG. 1.

Thus the double pole, single throw switch **60**, shown in FIG. 3, may be manually switched from closing circuit between the conductors **57** and **57***a*, as shown in FIG. 3, to the dotted line position to close circuit between the aforesaid conductor **57**, and a conductor **116** from which a series or succession of parallel circuits extend to a conductor **118**. The conduit or conductor **118** in turn connects with a conductor **64***c* which connects with the junction of the conductors **64***a*, **64***b*, hereinabove described, the conductor **64***c* in turn being connected to the neutral or positive side conductor **41***b*, as aforesaid. The circuit or conductor **64***c* has a double pole, single throw switch **119** therein which is mechanically closed by the closing of the fill valve **18**, this operation being indicated diagrammatically in FIG. 3 by a heavy dotted line connecting the switch **119** and the solenoid **48** which operates the fill valve operator **23** shown in FIG. 1.

A timer **120** of the well known "Eagle" type is provided in a circuit between the conductors **116**, **118**, which is adjusted to run for a predetermined time, at the end of which time it closes a normally open switch **117** across the conductors **57***a*, **116**, and opens a normally closed switch **121** in the conductor **118**.

A motor **122**, which actuates the timer **120**, is in circuit parallel therewith, as shown in FIG. 3. Thus the motor **122** can be connected to run the timer **120** for the predetermined duration of the whole drying period. A light **123**, which may be designated as a white light, is in circuit parallel with the timer circuit **120** and its motor circuit **122** to indicate that the drying process is in progress.

A solenoid winding circuit **124**, in parallel with the circuits **120**, **122**, **123** has a normally closed switch **125** therein; the solenoid winding **124** actuating the aforesaid solenoid **126** which actuates the valve operator **27** to open the hot drying gas valve **26**. Also a solenoid winding circuit **128**, extends from the conductor **116** and includes a normally closed switch **135** therein, the circuit **128** terminating at a contact **130**, to be hereinbelow described. The solenoid winding **128** when energized, actuates a solenoid **129**, to release air in a tube **142** to permit the filter blast air valve **104** to open.

Also, a timer circuit **131** extends from the conductor **116** parallel to the circuit **128** and terminates at the contact **130**, the timer **131** serving the purpose of timing the brief opening of theair blast valve **104** between intervals of drying, as will be hereinbelow described.

Additionally a timer circuit **132** from the conductor **116** includes the timer **132** therein and a normally closed switch **133** therein adjacent its connection to the conductor **118**. Between the timer **132** and the normally closed switch **133**, the pivot of a normally open switch **134** is connected into the circuit **132**, which in closed position completes circuit to the contact or junction **130** of the circuits **128** and **131**. The timer **132** serves the purpose of timing the drying interval between successive opening of the blast air valve **104**, the drying air entering continuously through the valve **106** between those brief instances when the blast air valve **104** opens.

Also, the additional circuitry and apparatus comprised by the invention includes a solenoid winding circuit **136** between the conductors **116**, **118**, and also a relay circuit **137**, parallel thereto. The circuit **136** actuates a solenoid **138** which in turn actuates the valve operator **32** which controls the opening and closing of the vent valve **31**, shown in FIG. 1.

The Eagle timer **120** is set, as aforesaid, to run for the duration of the preselected and preset drying cycle and then "times out" to close the normally open switch **117** and to open the normally closed switch **121**. The Eagle timer cycle is divided into a number of sub-cycles, during each of which the drying air is delivered for an interval and then for an instant the drying air is shut off and blast air enters the top **12***a* of the shell to blow reversely through the filters **114** and through the central filter **112** to blow any material grains or particles impinged on the inner surfaces thereof back into the material plenum **15**. Thus, in each sub-cycle the drying air timer **132** "times out" to open the normally open switch **125** to break the solenoid circuit **124**, whereby the solenoid **126** closes the drying air valve **26**, the timer **132** at the same time closing the normally open switch **134** to start the blast air timer **131** and to close the blast air solenoid circuit **128**, whereby the solenoid **129** opens the blast air valve **104**.

The timer **131** then runs to "time out" to open the normally closed switch **135** to the solenoid winding **128** whereby the solenoid **129** opens the blast air valve **104** and opens the double pole, single throw or relay switch **133**, thus breaking the circuit to both timers. Both the timer **131** and the timer **132** may now reset, the timer **131** taking power off the normally closed switch **135** to permit the solenoid circuit **128** to be restored and taking power off the relay switch **133**, allowing it to open. Also, the timer **132** takes power off the normally open switch **134**, permitting it to open, and takes power off the normally closed switch **125** in the solenoid winding circuit **124**, allowing this normally closed switch **125** to close, whereby the solenoid **126** may open the drying air valve **26**. With the timers **131** and **132** both reset, the drying air valve **26** is opened for its sub-cycle of drying air delivery, followed by discontinuation for filter air back blast, as aforesaid.

When the drying air-blast air sub-cycles have been repeated for a total amount of time equal to the time for which the Eagle or control timer **120** has been set, this timer times out, opneing the switch **121** and closing the switch **117**, as aforesaid. During the drying process the relay **137** has been energized to move the respective switches **62***a*, **62***b* in contact with the repsective contacts **64***d*, **64***e*, thus keeping the winding **62** of the solenoid **63** energized whereby the solenoid **63** has held the valve operator **36** in purge valve closing position. At the end of the drying process the relay **137** is de-energized to switch the switches **62***a*, **62***b* into the position shown in FIG. 3, thus to complete the purge solenoid winding circuit **62** to the switch **64**, which is closed to begin the activation and transfer of material steps, as hereinabove described, the purge valve **35** thereby remaining closed after the switch **64** is closed, until it opens to start the purge step.

The closing of the switch **117** throws the apparatus directly into the activation and transfer step, while the opening of the switch **121** breaks circuit to the apparatus functioning in the drying cycles, and this apparatus and circuitry remains inactive until the next closing of the fill valve **18** mechanically closes the shift switch **119**. Then, with the switch **117** closed, the apparatus immediately embarks into the steps of activating the material, discharging it, purges the vessel, and returning to initial conditions, as hereinabove described.

By a skillful combination of circuitry and apparatus the processing may be carried out with both uniformity and alacrity, and within the fineness of detail permitted by the many features through which adjustment may be made. The materials processed, for instance, may cover a wide range of pharmaceutical components, plastics, foods, and the like, which enter with various proportions of moisture therein. The physical form of the material handled may be granular, crystalline, or powdered, as examples, in micron size particles up to from 10 to 20 mesh. The diaphragm separating the gas and material plenums should best be of 200 mesh woven, stainless steel, or of porous ceramic. Fineness of the membrane may be controlled by employing successive layers thereof. As to the angle at which the membrane may be installed, this may be varied by virtue of the type of material used, and by the moisture content, and the slope may range from 5 degrees to say 15 degrees. Also, the filter requirements may vary, it having been found that filters which provide a total filtering area in 15 to 1 ratio to the bed area of material is a satisfactory ratio, but this ratio may vary, as say from 20 to 1 to 10 to 1.

The apparatus and methods disclosed hereinabove, and hereinbelow claimed, are not all inclusive, as set forth, including as portrayed in the drawings, and other combinations of structure, circuitry and methods of employing the invention may be considered as falling within the four corners of the herein invention, as long as such also fall within the broad spirit of the invention, and within the broad scope of interpretation claimed for and merited by the appended claims.

What is claimed is:

1. Material drying and transporting apparatus comprising a pressure vessel, a gas permeable membrane across said vessel separating a lowermost gas plenum from a central, material plenum thereabove, a fill valve to admit material batches into said material plenum to be dried and transported, a valve controlled drying gas delivery conduit into said gas plenum, a vent valve from said material plenum, a valve controlled, pressurized gas conduit into said gas plenum, a pressure sensitive valve controlled discharge conduit from said material plenum, and automatically operable circuitry sequently functional to open said full valve, to close said fill valve and to open said drying gas valve and said vent valve, to close said drying gas valve and said vent valve and to open said pressurized gas valve to activate the dried material into a flowable state and to build up a pressure in said vessel to open said discharge valve whereby said materials are discharged through said discharge conduit, said discharge valve opening responsive to pressure drop, and upon further pressure drop said apparatus being restored to initial status automatically to repeat the handling of a succeeding batch of material.

2. Material drying and transporting apparatus as claimed in claim **1** which additionally includes a pressure sensitive valve controlled, purge by-pass conduit from said material plenum to said discharge conduit downstream of said discharge valve, said purge valve being opened by said circuitry responsive to the pressure drop which closes said discharge valve whereby said material is purge discharged by residual pressure in said vessel until said apparatus is restored to initial status, as aforesaid.

3. Material drying and transporting apparatus as claimed in claim **1** which additionally includes a filter means around the fill valve inlet and between the fill valve inlet and the interior of said vessel and above the material, whereby to filter the drying gas on its way to said vent.

4. Material drying and transporting apparatus as claimed in claim **1** which additionally includes a baffle across the vessel below the vent and above the material, in which said fill valve includes an inlet spout with lower end comprising a filter opening centrally through said baffle, in which a plurality of filters opening downwardly through said baffle are provided around said central filter, said apparatus additionally including a valve controlled filter blast gas conduit into said vessel above said filters, and in which said circuitry is operable intermittently to interrupt drying gas delivery to admit filter blast gas to back clean said filters.

5. Material drying and transporting apparatus comprising a pressure vessel, a gas permeable diaphragm across said vessel separating a lowermost gas plenum from a central material plenum thereabove, a baffle across said vessel separating said material plenum from a filter blast and drying gas uppermost plenum, a fill valve to admit material into the top of said vessel including a delivery spout with lower part comprising a central filter and opening downwardly through said baffle, a plurality of filters spaced about said central filter and opening downwardly through said baffle, a valve controlled drying gas delivery conduit into said gas plenum, a valve controlled filter blast gas conduit into said uppermost plenum, a vent valve from said uppermost plenum, a valve controlled pressurized gas conduit into said gas plenum, a pressure sensitive valve controlled discharge conduit from said material plenum, a pressure sensitive valve controlled purge by-pass conduit from said material plenum to said discharge conduit downstream of said discharge valve, and automatically operable circuitry sequentially functional to open said fill valve, to close said fill valve and said purge valve and to open said vent valve, and in sub-cycles, successively to open and close said drying gas valve to dry said material, and said filter blast valve to back-clean said filters, and then to close said vent valve, said drying gas valve, said filter blast gas valve and said purge and to open said pressurized gas valve to activate said dried material to a pressure to open said discharge valve to discharge said dried materials until the vessel pressure drops to close said discharge valve and open said purge valve whereby said material is purged by diminishing residual pressure until the vessel pressure drops to substantially atmospheric to start a succeeding cycle, as aforesaid.

6. Material drying and transporting apparatus as claimed in claim **1**, which additionally includes compressor means to supply drying gas, filter blast gas, and pressurized activating gas as compressed air.

7. The method of automatically drying and transporting material comprising the steps of admitting the

material as a predetermined batch into a defined space providing a gas plenum below a material plenum, passing drying gas into the gas plenum to pass through a perforate diaphragm supporting the material and through the material to be vented from the material plenum, discontinuing the drying gas admission and closing the vent and admitting pressurized gas into the gas plenum to pass through the membrane to activate the dried material and to achieve a predetermined pressure in the vessel thereby to open the material plenum to discharge, and full discharging the material responsive to the pressure built up in the space until the pressure falls to a predetermined value to actuate the discontinuation of pressurizing gas admission, and restoring initial conditions for the receipt of a succeeding batch of material into the defined space.

8. The method as claimed in claim **7** which includes the additional step of using the residual pressure in the defined space immediately after discontinuation of full discharge to purge the material plenum as the pressure falls to substantially atmospheric prior to restoration of initial conditions as aforesaid.

9. The method as claimed in claim **7** which includes the additional step of filtering the drying gas between the material and the vent.

10. The method as claimed in claim **7** which includes the additional steps of filtering the drying gas of material particles on its way to the vent while repeatedly interrupting the drying gas supply by injecting gas blasts above the filter means to back-clean the filter means.

11. The method as claimed in claim **7** which includes the additional step of filtering the drying gas of material particles on its way to the vent while repeatedly interrupting the drying gas supply by injecting gas blasts above the filter means to back-clean the filter means, the blast gas supply being discontinued when the drying gas supply is discontinued, the further additional step being included of using residual pressure in the defined space immediately after discontinuation of full discharge to purge the material plenum as the pressure falls to substantially atmospheric prior to restoration of initial conditions, as aforesaid, the drying gas and the blast gas being pre-heated, and the drying gas, blast gas, and pressurized gas for activation each comprising compressed air.

12. Material drying and transporting apparatus comprising a pressure vessel including a gas permeable membrane bridging the lower part of said vessel above the bottom thereof and dividing it into a material plenum thereabove and a gas plenum therebelow, a fill valve to admit flowable material through the top of said vessel into said material plenum to upstand from said membrane, a compressed gas inlet valve into said gas plenum, a discharge valve controlled discharge conduit with discharge valve disposed in the upper part of said material plenum, a purge valve controlled by-pass conduit with purge valve disposed in the upper part of said material plenum adjacent said discharge valve, a pressure sensitive control means, and circuitry including said control means and automatically operable sequentially to open said fill valve, to close said fill valve, then to close said purge valve while opening said gas inlet valve to admit pressurized gas substantially uniformly through said membrane and to activate said material to a high state as the pressure rises in excess of a pressure sensitive means high control pressure fully to open said discharge valve for said material to pass upwardly and onward through said discharge valve and outwardly through said discharge conduit, as the pressure falls below a pressure sensitive means lower control pressure fully to close said discharge valve and said gas inlet valve and to open said purge valve, the residual compressed gas purging upwardly through said purge valve and said by-pass conduit and on outwardly through said discharge conduit, the pressure falling to approximately atmospheric whereby to open said fill valve, as aforesaid, said pressure vessel also including a valve controlled drying gas delivery conduit into said gas plenum and a vent valve from said material plenum, said circuitry also including means operable, along with the closing of said fill valve and of said purge valve, to open said drying gas valve and said vent valve, then to close said drying gas valve and said vent valve prior to the closing of said purge valve and the opening of said gas inlet valve, as aforesaid.

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