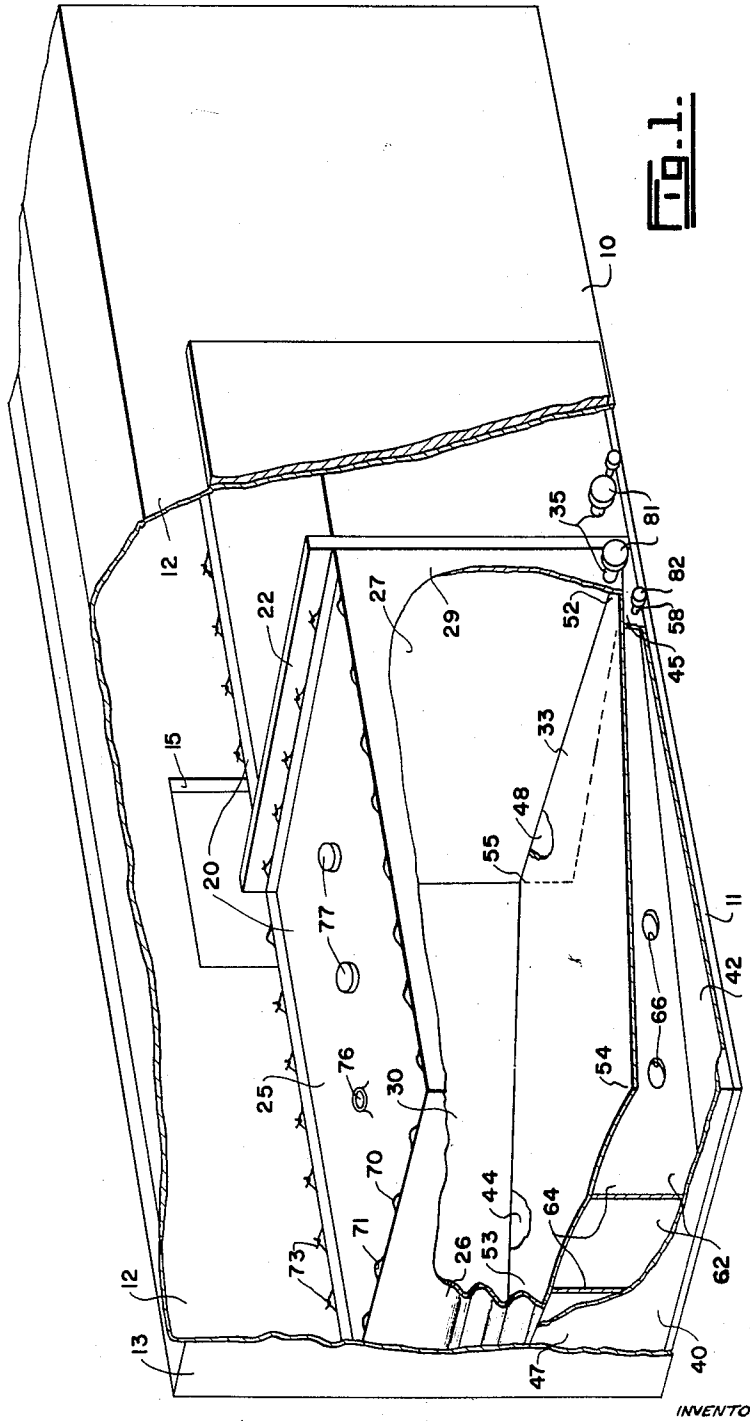
March 29, 1960 H. N. K. PATON 2,930,512

APPARATUS FOR HOLDING AND DISCHARGING FREE-FLOWING SOLID MATERIALS

Filed July 1, 1955 5 Sheets-Sheet 1

Fig. 1.



INVENTOR
HAMILTON NEIL KING PATON
BY
Fetherstonhaugh & Co.
ATTORNEYS

March 29, 1960 H. N. K. PATON 2,930,512

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5 Sheets-Sheet 2

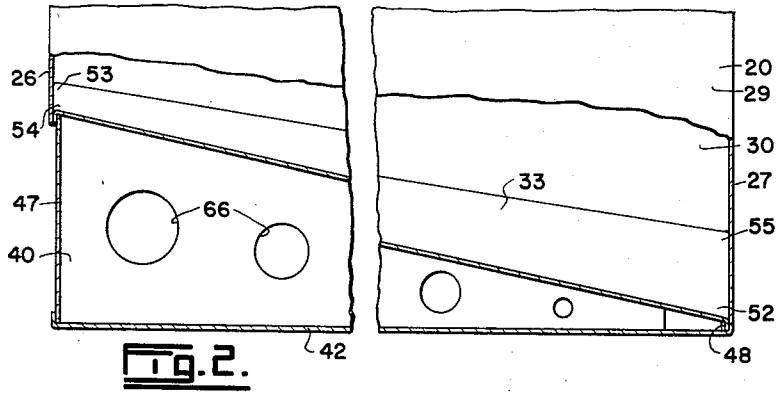


Fig. 2.

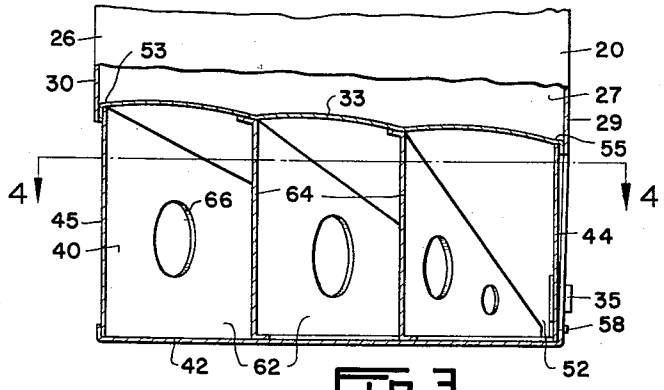


Fig. 3.

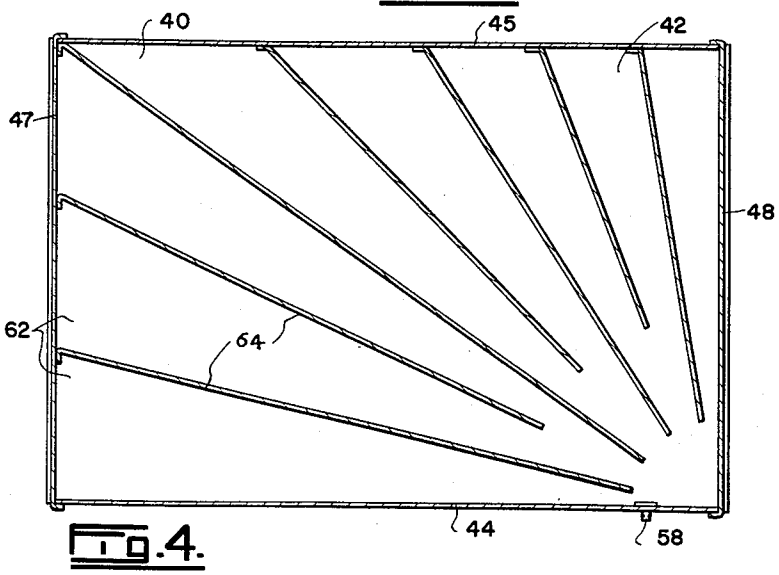


Fig. 4.

INVENTOR
HAMILTON NEIL KING PATON
BY
Fetherstonhaugh & Co.
ATTORNEYS

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5 Sheets-Sheet 3

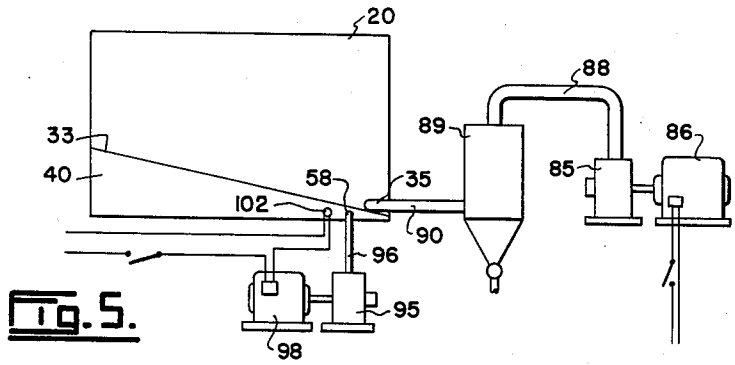


Fig. 5.

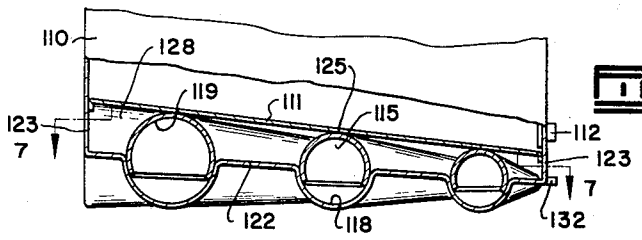


Fig. 6.

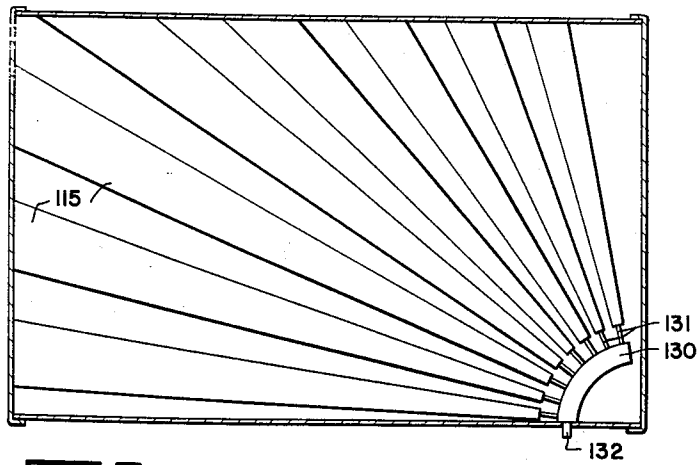


Fig. 7.

INVENTOR
HAMILTON NEIL KING PATON
BY
Fetherstonhaugh & Co.
ATTORNEYS

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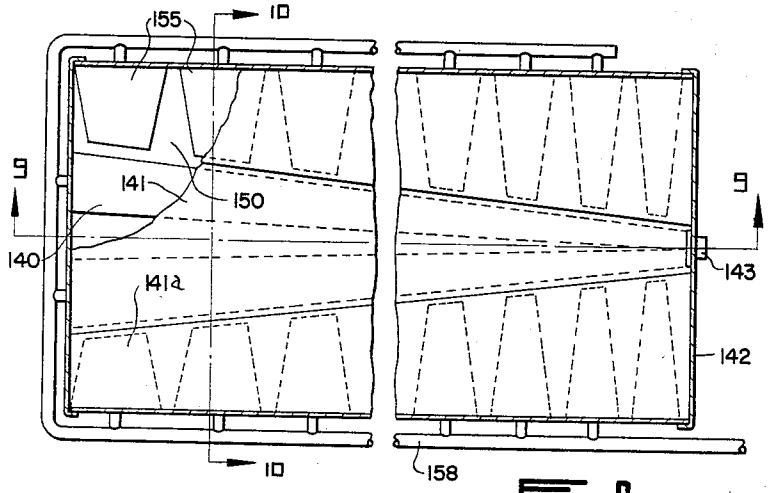


Fig. 8.

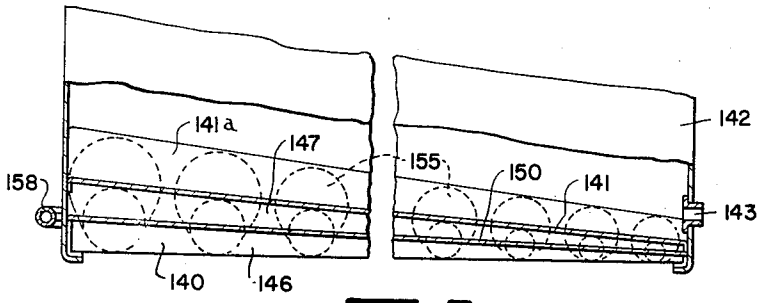


Fig. 9.

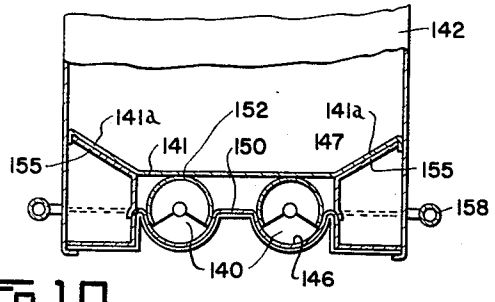


Fig. 10.

INVENTOR
HAMILTON NEIL KING PATON
BY
Fetherstonhaugh & Co.
ATTORNEYS

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APPARATUS FOR HOLDING AND DISCHARGING FREE-FLOWING SOLID MATERIALS

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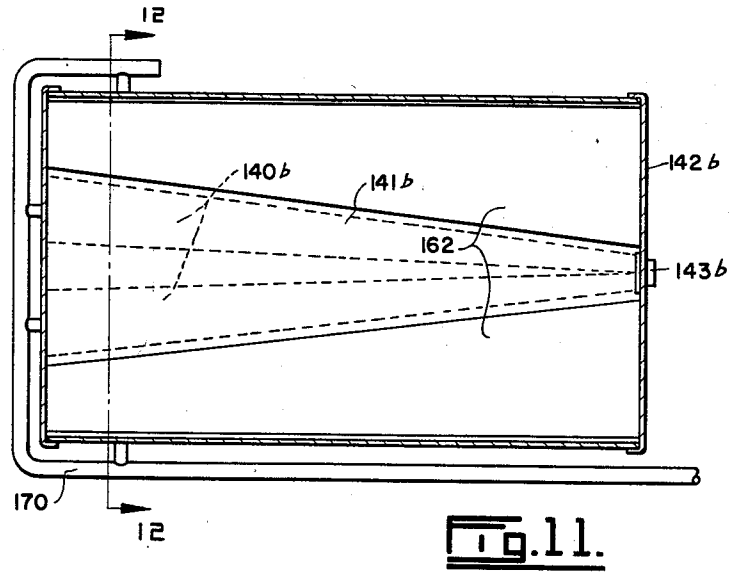


Fig. 11.

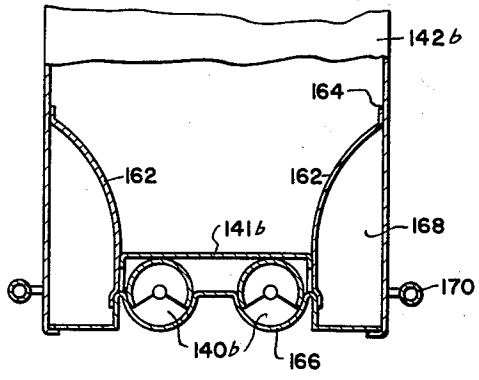


Fig. 12.

INVENTOR
HAMILTON NEIL KING PATON
BY
Fetherstonhaugh & Co.
ATTORNEYS

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Patented Mar. 29, 1960

2,930,512

APPARATUS FOR HOLDING AND DISCHARGING FREE-FLOWING SOLID MATERIALS

Hamilton Neil King Paton, Vancouver, British Columbia, Canada, assignor to Paton Holdings Ltd., Vancouver, British Columbia, Canada

Application July 1, 1955, Serial No. 519,607

20 Claims. (Cl. 222—195)

This invention relates to apparatus for holding and discharging free-flowing solid materials in particle form, such as powdered and granular materials, wheat, and the like.

The main object of this invention is the provision of a container for holding and discharging free-flowing solid materials while utilizing to the full the space available for this purpose. The container may be in the form of a bin or hopper, or it may be transportable, in which case, it may be set up in a railroad car or a freight truck. There are many forms of apparatus for holding and discharging materials of this nature. The difficulty has been in discharging the materials. In order to get them to flow out within a reasonable time, containers used in the past have had permanently sloping bottoms. This means that there is a great deal of space under these bottoms which is never utilized. In order to minimize the bottom slopes, air has been used to fluidize the material, but it has not been possible to eliminate the wastage of space.

Another very important object of this invention is the provision of apparatus for holding and discharging free-flowing solid materials which may be completely collapsed for return shipping or storage.

The present apparatus comprises a container having a gas-permeable bottom which normally lies in a substantially horizontal plane when the container is loaded. A discharge outlet for the container is provided at the bottom thereof, and the container bottom is raisable to slope generally towards said outlet. A collapsible pressure chamber is located beneath the bottom to raise the latter to its sloping position during inflation of said chamber with gas, said gas being admitted to the chamber through a suitable inlet. With this arrangement, when gas, usually air, is directed into the pressure chamber, it raises the container bottom to its sloping position, and it passes through said permeable bottom to fluidize or aerate free-flowing material thereon to assist movement of said material along the slope to the outlet.

The material may move from the outlet under the action of gravity, or it may be drawn therefrom by suitable suction equipment. In another variation of the invention, means is provided for pulsating the gas directed into the pressure chamber. Although any suitable materials may be used for the container, and the bottom thereof, it is preferable to form the container of a flexible material that is impervious to air and moisture. It is also advantageous to form the container bottom of a flexible material, such as canvas.

Examples of this invention are illustrated in the accompanying drawings, in which,

Figure 1 is a perspective view of a railroad car with one form of apparatus container therein, part of the car and the container being broken away, and the bottom of the container being shown in the discharge position,

Figure 2 is a side elevation of this container with the near wall broken away and the bottom in the unloading position,

Figure 3 is an end elevation of the container with the near wall broken away and the bottom in the raised or unloading position,

Figure 4 is a horizontal section taken substantially on the line 4—4 of Figure 3,

Figure 5 is a diagram of one form of apparatus associated with the container during the unloading operation,

Figure 6 is a view similar to Figure 3 of an alternative form of container,

Figure 7 is a horizontal section taken on the line 7—7 of Figure 6,

Figure 8 is a horizontal section through another alternative form of container, said section being taken above the container bottom,

Figure 9 is a longitudinal section taken on the line 9—9 of Figure 8,

Figure 10 is a cross section taken on the line 10—10 of Figure 8,

Figure 11 is a view similar to Figure 4 of still another form of container, and,

Figure 12 is a horizontal section taken on the line 12—12 of Figure 11.

Referring to Figures 1 to 4 of the drawings, 10 diagrammatically illustrates an ordinary railroad freight car having a bottom 11, sides 12, and ends 13. These freight cars have doorways 15 in the side walls thereof substantially midway between their ends. It is usual to provide two containers in these cars, and two containers 20 have been shown in Figure 1. As the containers are identical, one only will be described in detail. The adjacent ends of these containers may abut, but it is preferable to insert a bulkhead 22 therebetween.

In this form of the invention, container 20 is formed of material which is impervious to air and moisture. As it is desirable to use a thin, light and flexible material, nylon treated with rubber or suitable plastic has been found very desirable for this purpose. This container is formed with a top 25, end walls 26 and 27, and side walls 29 and 30. The container also has a bottom 33 secured at its edges to the side and end walls. This bottom is preferably formed of a gas-permeable material such as canvas. A discharge outlet 35 is provided for the container at the bottom thereof. This outlet may be in the container bottom, or in a side or end wall thereof. In this example, it is in side wall 29 near or at a corner of the container.

The bottom 33 is such that it is raisable to slope generally towards the outlet 35. Figures 1 to 4 show the bottom sloping from all directions towards the outlet.

A collapsible pressure chamber 40 is positioned beneath the bottom 33. In this example, the chamber covers substantially the entire bottom. The pressure chamber has a bottom 42, side walls 44 and 45, and end walls 47 and 48. The bottom of the container actually forms the top of the pressure chamber. The side and end walls of the chamber are secured to the bottom thereof and the bottom of the container.

The pressure chamber 40 is shaped to raise the container bottom 33 to its sloping position during inflation of said chamber with gas. For this purpose, side walls 44 and 45 are substantially wedge-shaped, as are the end walls 47 and 48. Actually, the container bottom is substantially in a plane which is tipped at corner 52 down to the outlet 35. The diagonally opposite corner 53 of the bottom is the highest point, while corner 54 is a little lower, and corner 55 is lower still.

An inlet or entrance pipe 58 is provided for the pressure chamber 40. While this inlet may be at any desired point in the chamber, it is preferable to locate it near the container's outlet 35, as shown.

The container bottom 33 may be formed of stiff or relatively stiff gas-permeable material, but in the preferred

form of the invention, it is made of flexible material. In this case, there is a tendency for the bottom to bow or billow upwardly when the pressure chamber is inflated. Suitable means has been provided for reducing or preventing this tendency. One way of doing this is to divide the chamber into a plurality of compartments **62** which are shaped and positioned to slope towards the outlet **35**. In this example, the compartments are formed by one or more flexible webs **64** connected to the chamber bottom **42** and to the under surface of the container bottom **33**. Each web assumes a substantially vertical position during inflation of the chamber, and it tapers downwardly and extends generally towards the outlet as shown in Figures 1 and 4. Furthermore, the latter figure shows how these webs extend from the end and side walls of the container towards the outlet or, in other words, they fan outwardly from said outlet. Each web is formed with a plurality of openings **66** therein so that the compartments of the chamber are in communication with each other. This means that air directed into the chamber through entrance **58** is distributed throughout all of the compartments. However, web holes **66** may be omitted in which case the compartments are not in communication with each other. With the latter arrangement, it would be necessary to provide a gas entrance for each compartment.

As the side and end walls of container **20** are formed of flexible material, it is necessary to provide means for maintaining the container in its proper rectangular shape in the freight car **10**. This may be done by providing a cable **70** around the top of the container, said cable emerging from the container material at spaced points to form loops **71**. Hooks **73** are provided on the car walls over which loops **71** are placed. Thus, the sides, ends, and top of the container are suspended within the car. The bottom **42** of the pressure chamber rests on the car bottom **11**. Therefore, the side and end walls, and bottom of the car support the side and end walls of the container and the bottom of the pressure chamber. The bulkhead **22** or the adjacent end wall of the other container in the car support the inner end wall of this container. One or more filling openings **76** are provided in the container top **25**. Three such openings have been illustrated in Figure 1, and each one has a removable cover **77**.

The container **20** is installed in car **10** by placing loops **71** over hooks **73**. The pressure chamber bottom **42** rests on the bottom **11** of the car, and at this time, the container bottom **33** rests on the chamber bottom. Caps **81** and **82** are provided for the outlet **35** and gas inlet **58**, and these are in place at this time. The free-flowing solid material, for example, flour, is directed into the container through one or more of the filling openings **76**. When the covers **77** close these openings, the material in the container is protected against moisture and contamination.

When it is desired to discharge the container, caps **81** and **82** are removed. A line is connected to entrance **58** in order that a gas, usually air, may be pumped into the pressure chamber **40**. The pressure of the air need not be very high, and is usually of the order of one or two pounds per square inch. As the chamber is inflated, the container bottom **33** is raised to its sloping position so that the material thereon is directed towards the outlet **35**. In addition to this, the air passes through the permeable material at the bottom, and fluidizes or aerates said material to assist the movement thereof along the slope to the outlet. It has been found that the slope angle of the bottom should be at least 5° to the horizontal. The combined action of the sloping bottom and the fluidizing of the material causes the latter to be discharged from the entire container in a comparatively short time.

It has been found that the time of discharge may be greately reduced by attaching suitable suction means to the outlet **35**. In addition to this, means may be provided for pulsating the supply of air to the pressure chamber. Figure 5 diagrammatically illustrates the apparatus including both suction and pulsating means.

An air suction pump **85** driven by a suitable source of power, such as an electric motor **86**, is connected by a pipe **88** to the air outlet of a standard cyclone **89**. The inlet of this cyclone is connected by a pipe **90** to the outlet **35** of container **20**.

A blower **95** is connected by pipe **96** to the chamber inlet **58**. This blower is driven by a suitable source of power, such as an electric motor **98**.

When it is desired to empty the container **20**, the suction pump **85** is set into operation, and this draws the flour out of the bag through pipe **90** into cyclone **89**, where the air and material are separated in the usual manner. This will remove some of the material from the container, but for proper operation, the blower **95** must be working. The air directed into chamber **40** raises the container bottom to its sloping position and at the same time fluidizes the material in the container to assist in the movement thereof towards the discharge outlet. If necessary, one of the filling openings **76** may be uncovered to permit some air to enter the container. Should this prove necessary, it would be advisable to provide suitable filter means at the uncovered opening to keep the powdered material in the container and to prevent dust or other dirt from entering the latter.

It is advantageous to pulsate the air in chamber **40**. This may be done by providing a pressure-operated switch **102** in the chamber. This switch is positioned in chamber **40** and is such that when the pressure in the chamber increases to a predetermined point and drops to another predetermined point the switch opens and closes, respectively. Switches of this type are well known, and as their construction does not form part of this invention, it is not described herein. This switch is located in the circuit of motor **98**. When the pressure in chamber **40** reaches a predetermined point, the motor is turned off, and when it drops below that point, the motor is turned on again. Obviously, switch **102** may operate a relay in the motor circuit to accomplish the same results. This stopping and starting of the motor causes a raising and lowering of the container bottom. If the latter is formed of flexible material, as is preferred, this pulsating of the pressure in the chamber tends to create an undulating effect in the container bottom. This helps to prevent the flour from adhering to the bottom, and it assists in the movement thereof towards the outlet.

Figures 6 and 7 of the drawings illustrate an alternative form of container for this purpose. A container **110** which may be constructed of the same materials as container **20**, has a gas-permeable bottom **111**, said bottom being raisable to slope generally towards the outlet **112**. A plurality of substantially cone-shaped compartments **115** are provided beneath the container bottom, each of said compartments extending generally towards outlet **112**. In other words, the cone-shaped compartments radiate from the outlet towards the walls of the container.

Each compartment is closed at its outer or large end, and the lower part **118** of the compartment is formed of an air-impervious material, while the upper part **119** of the compartment is formed of a gas-permeable material. Connecting pieces **122** of air-impervious material extend between the sides of these compartments, as clearly shown in Figure 6, and between the sides of some compartments to portions **123** of the side walls of the container which extend downwardly below the bottom **111**. The portion **119** of each compartment is connected at **125** to the container bottom throughout the length of its compartment.

Referring to Figure 6, it will be seen that the connecting pieces **122**, the impervious portions **118** of the compartments, and the portions **123** of the container side walls form the bottom and sides of a pressure chamber **128**, the top of which is the bottom **111** of the container. The permeable portions **119** of the compartments form

webs for preventing the container bottom from billowing upwardly when the chamber is inflated.

Gas or air is supplied to compartments **115** in any desired manner. In this example, a distributor **130** is provided beneath container bottom **111** near the outlet **112**. This container has tubes **131** extending into the small ends of the compartments. A gas entrance pipe **132** extends outwardly from the distributor.

The apparatus of Figures 6 and 7 operates in the same manner as that of Figures 1 to 4. Air is directed through the inlet **132** into the compartments **115** whence it passes through the permeable portions **119** of the compartments into the pressure chamber **128**. This air also passes through the bottom **111** to fluidize the material in the container. Inflation of the compartments and pressure chamber raise the container bottom to its sloping position so that it directs the material towards the outlet **112**. The suction and/or pulsating equipment of Figure 5 may be used with this form of the invention.

Figures 8 to 10 illustrate a form of the invention which is somewhat similar to that of Figure 6. One or more conical compartments **140**, two being shown in Figure 10, are located beneath a gas-pervious bottom **141** for a container **142**, the small ends of these compartments extends towards an outlet **143** above the container bottom at one end thereof. The bottom portions **146** of the compartments are gas-impervious, while the upper portions **147** thereof are gas-pervious. Pieces of gas-impervious material **150** extend between the sides of the compartments and between compartment sides and the bottom **141**. The upper portions of the compartments are connected to the container bottom at **152**.

A plurality of conical compartments **155** extend from the sides of the container inwardly towards the compartments **140**, see Figure 8. The compartments **155** are formed in the same manner as compartments **140**, and are connected to the container bottom in the same manner as the latter. Suitable pipe means **158** is connected to each of the compartments for directing gas thereto.

When the compartments **140** and **155** are inflated, the central part of the container bottom **141** slopes towards the outlet **143**, and at the same time, side portions **141***a* of said bottom slope towards said central part. Air from the compartments passes through the pervious container bottom to fluidize the flour or other material in the container. The suction and/or pulsating equipment of Figure 5 may also be used by this form of the invention.

Figures 11 and 12 illustrate a form of the invention similar to that of Figure 8. It includes conical compartments **140***b* extending to the outlet **143***b*. A narrow gas-pervious bottom **141***b* is secured to the upper portions of these compartments and extends to the outlet. Instead of compartments **155** and the portions **141***a* of the container bottom, this form of the invention includes flexible gas-impervious interior side walls **162** connected to the side edges of the container bottom **141***b* and extending upwardly to the side walls of container **142***b* near the tops thereof, where they are connected to said container walls at **164**. An air-impervious bottom **166** is connected to the side walls of the container and extends beneath the compartments **140***b* to form first pressure chambers **168** on the opposite sides of said compartments and beneath the impervious walls **162**. Suitable pipe means **170** is connected to the compartments **140***b* and to the pressure chambers **168** to direct gas thereinto.

When container **142***b* is being discharged, gas entering compartments **140***b* raises and slopes bottom **141***b* towards outlet **143***b*. At the same time, air entering pressure chambers **168** causes walls **162** to billow inwardly, thereby directing flour or other material towards the bottom **141***b*. Gas passing through the latter fluidizes material to assist the movement thereof towards the outlet. Actually some of the gas from the compartments enters a second pressure chamber around said compartments and

beneath bottom **141***b* before passing through said bottom.

What I clam as my invention is:

1. Apparatus for holding and discharging free-flowing solid materials comprising a container, a gas-permeable fluidizing bottom for the container normally lying in a substantially horizontal plane when the container is loaded, a discharge outlet for the container at the bottom thereof, said container bottom being raisable to slope generally towards the outlet for directing any free-flowing materials thereon to said outlet, a collapsible pressure chamber beneath the bottom shaped to raise the latter to its sloping position during inflation of said chamber with gas, and means for supplying gas to the chamber simultaneously to raise the gas-permeable fluidizing bottom to its sloping position and to fluidize free-flowing material thereon to assist movement of said material along the slope to the outlet.

2. Apparatus as claimed in claim 1 in which the gas admitting means is located near the outlet.

3. Apparatus as claimed in claim 1 including suction means connected to the container outlet.

4. Apparatus as claimed in claim 1 including means connected to the container bottom for maintaining it in substantially its proper sloping position when the pressure chamber is inflated.

5. Apparatus for holding and discharging free-flowing solid materials comprising a flexible container formed of material impervious to air and moisture, a flexible gas-permeable fluidizing bottom for the container normally lying in a substantially horizontal plane when the container is loaded, a discharge outlet for the container at the bottom thereof, said container bottom being raisable to slope generally towards the outlet for directing any free-flowing materials thereon to said outlet, a collapsible pressure chamber beneath the bottom shaped to raise the latter to its sloping position during inflation of said chamber with gas, and means for supplying gas to the chamber simultaneously to raise the gas-permeable fluidizing bottom to its sloping position and to fluidize free-flowing material thereon to assist movement of said material along the slope to the outlet.

6. Apparatus as claimed in claim 5 in which the outlet is at one corner of the container just above the bottom thereof, and the entire bottom slopes towards said corner.

7. Apparatus as claimed in claim 1 in which the pressure chamber is divided into a plurality of compartments each shaped and positioned to slope towards the outlet when inflated.

8. Apparatus as claimed in claim 1 in which the pressure chamber is divided into a plurality of compartments, said compartments connecting with each other.

9. Apparatus as claimed in claim 1 in which the pressure chamber is divided into a plurality of compartments each shaped and positioned to slope towards the outlet when inflated, and gas is directed to each compartment.

10. Apparatus for holding and discharging free-flowing solid materials comprising a container, a gas-permeable fluidizing bottom for the container normally lying in a substantially horizontal plane when the container is loaded, a discharge outlet for the container at the bottom thereof, said container bottom being raisable to slope generally towards the outlet for directing any free-flowing materials thereon to said outlet, a collapsible pressure chamber beneath the bottom shaped to raise the latter to its sloping position during inflation of said chamber with gas, at least one flexible web connected to the bottom of the chamber and the under surface of the container bottom, each web assuming a substantially vertical position during inflation of the chamber and tapering downwardly and extending generally towards the outlet, and means for supplying gas to the chamber simultaneously to raise the gas-permeable fluidizing bottom to its sloping position and to fluidize free-flowing material thereon to assist movement of said material along the slope to the outlet.

11. Apparatus for holding and discharging free-flowing solid materials comprising a container, a gas-permeable fluidizing bottom for the container normally lying in a substantially horizontal plane when the container is loaded, a discharge outlet for the container at the bottom thereof, said container bottom being raisable to slope generally towards the outlet for directing any free-flowing materials thereon to said outlet, a collapsible pressure chamber beneath the bottom shaped to raise the latter to its sloping position during inflation of said chamber with gas, a plurality of spaced flexible webs connected to the bottom of the chamber and the under surface of the container bottom, each web assuming a substantially vertical position during inflation of the chamber and tapering downwardly and extending generally from near a wall of the container towards the outlet, and means for supplying gas to the chamber simultaneously to raise the gas-permeable fluidizing bottom to its sloping position and to fluidize free-flowing material thereon to assist movement of said material along the slope to the outlet.

12. Apparatus for holding and discharging free-flowing solid materials comprising a container, a gas-permeable fluidizing bottom for the container normally lying in a substantially horizontal plane when the container is loaded, a discharge outlet for the container at the bottom thereof, said container bottom being raisable to slope generally towards the outlet, a plurality of collapsible cone-shaped compartments beneath the bottom with the small ends thereof extending generally towards the outlet, the lower portion of each compartment being formed of gas-impervious material and the upper portion thereof being formed of gas-permeable material, gas-impervious material connecting the sides of the lower portions of the compartments to each other and to the sides of the container to form a closed collapsible pressure chamber beneath the container bottom, the upper portions of the compartments being connected to the container bottom, and means for admitting gas to each compartment, said gas passing through the permeable upper portions of the compartments and the container bottom to fluidize free-flowing material on said bottom to assist movement thereof along the slope to the outlet.

13. Apparatus as claimed in claim 12 in which there is at least one conical compartment extending directly towards the outlet, and a plurality of conical compartments on opposite sides of said one compartment and extending towards the latter.

14. Apparatus for holding and discharging free-flowing solid materials comprising a container, a gas-permeable fluidizing bottom for the container normally lying in a substantially horizontal plane when the container is loaded, a discharge outlet for the container at the bottom thereof, said container bottom being raisable to slope generally towards the outlet, at least one collapsible conical compartment with its small end extending towards the outlet, a gas-permeable bottom for the container over said compartment, gas-impervious flexible side walls connected to the side edges of said bottom and extending upwardly to the container walls near the top thereof, a bottom connected to the container walls beneath the compartment to form pressure chambers within the impervious walls on opposite sides of the permeable container bottom, the lower portion of the compartment being gas-impervious and the upper portion thereof being gas-permeable, means connecting the upper portion of the compartment to the permeable container bottom, means connected to the compartment for preventing gas passing out of the top portion thereof from getting into the pressure chambers, and means for admitting gas to the pressure chambers and to the compartment, the gas in the compartment passing through the permeable container bottom to fluidize free-flowing material thereon to assist movement of said material along the slope to the outlet, and the gas in the pressure chambers billowing the impervious side walls inwardly to direct material towards the permeable container bottom.

15. Apparatus as claimed in claim 1 including means for pulsating the gas in the pressure chamber.

16. Apparatus for holding and discharging free-flowing solid materials comprising a container, a gas-permeable fluidizing bottom for the container normally lying in a substantially horizontal plane when the container is loaded, said container bottom being raisable, a discharge outlet for the container at the bottom thereof, a collapsible pressure chamber beneath the bottom, and means for admitting gas to the chamber simultaneously to inflate the chamber and raise the gas-permeable fluidizing bottom and to fluidize free-flowing material thereon.

17. Apparatus for holding and discharging free-flowing solid materials comprising a container, a gas-permeable fluidizing bottom for the container normally lying in a substantially horizontal plane when the container is loaded, a discharge outlet for the container at the bottom thereof, said container bottom having a central section narrowing towards the outlet and raisable to slope thereto for directing any free-flowing materials thereon to said outlet, said bottom having side portions raisable to slope towards and discharge on to the central section thereof, a collapsible pressure chamber beneath the bottom shaped to raise the central section and side portions of the latter to their sloping positions during inflation of said chamber with gas, flexible webs connected to the bottom of the chamber and the central section and side portions of the container bottom, and means for supplying gas to the chamber simultaneously to raise the gas-permeable fluidizing bottom to its sloping positions and to fluidize free-flowing material thereon to assist movement of said material along the bottom slopes to the outlet.

18. Apparatus for holding and discharging free-flowing solid materials comprising a container having a confining wall, a gas-impervious interior side wall secured to the confining wall and extending downwardly inside the container to form a first collapsible pressure chamber, a gas-impervious bottom for said chamber, a gas-permeable fluidizing bottom for the container outside the pressure chamber normally lying in a substantially horizontal plane when the container is loaded, a discharge outlet for the container at the bottom thereof, said container bottom being raisable to slope generally towards the outlet for directing any free-flowing materials thereon to said outlet, a second collapsible pressure chamber beneath the container bottom shaped to raise the latter to its sloping position during inflation of said chamber with gas, and means for admitting gas to both pressure chambers, the gas from the second chamber simultaneously passing through the permeable bottom to raise the latter to its sloping position and to fluidize free-flowing material thereon to assist movement of said material along the slope to the outlet, and the gas in the first chamber causing the interior wall of the latter chamber to billow inwardly to direct material towards the permeable bottom.

19. Apparatus for holding and discharging free-flowing solid materials comprising a rectangular container having side and end walls, a gas-impervious interior side wall secured to each of two opposite walls and extending downwardly in the container to form first collapsible pressure chambers, a gas-impervious bottom for each of said chambers, a gas-permeable fluidizing bottom for the container extending between the interior walls and normally lying in a substantially horizontal plane when the container is loaded, a discharge outlet for the container at the bottom thereof, said container bottom being raisable to slope generally towards the outlet for directing any free-flowing materials thereon to said outlet, a second collapsible pressure chamber beneath the container bottom shaped to raise the latter to its sloping position during inflation of said chamber with gas, and means for admitting gas to all the pressure chambers, the gas from the second chamber simultaneously passing through the permeable bottom

to raise the latter to its sloping position and to fluidize free-flowing material thereon to assist movement of said material along the slope to the outlet, and the gas in the first chamber causing the interior walls of the latter chambers to billow inwardly to direct material towards the permeable bottom.

20. Apparatus as claimed in claim 19 including means connected to the permeable bottom to prevent it from billowing upwardly when gas is admitted to the second pressure chamber.

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