

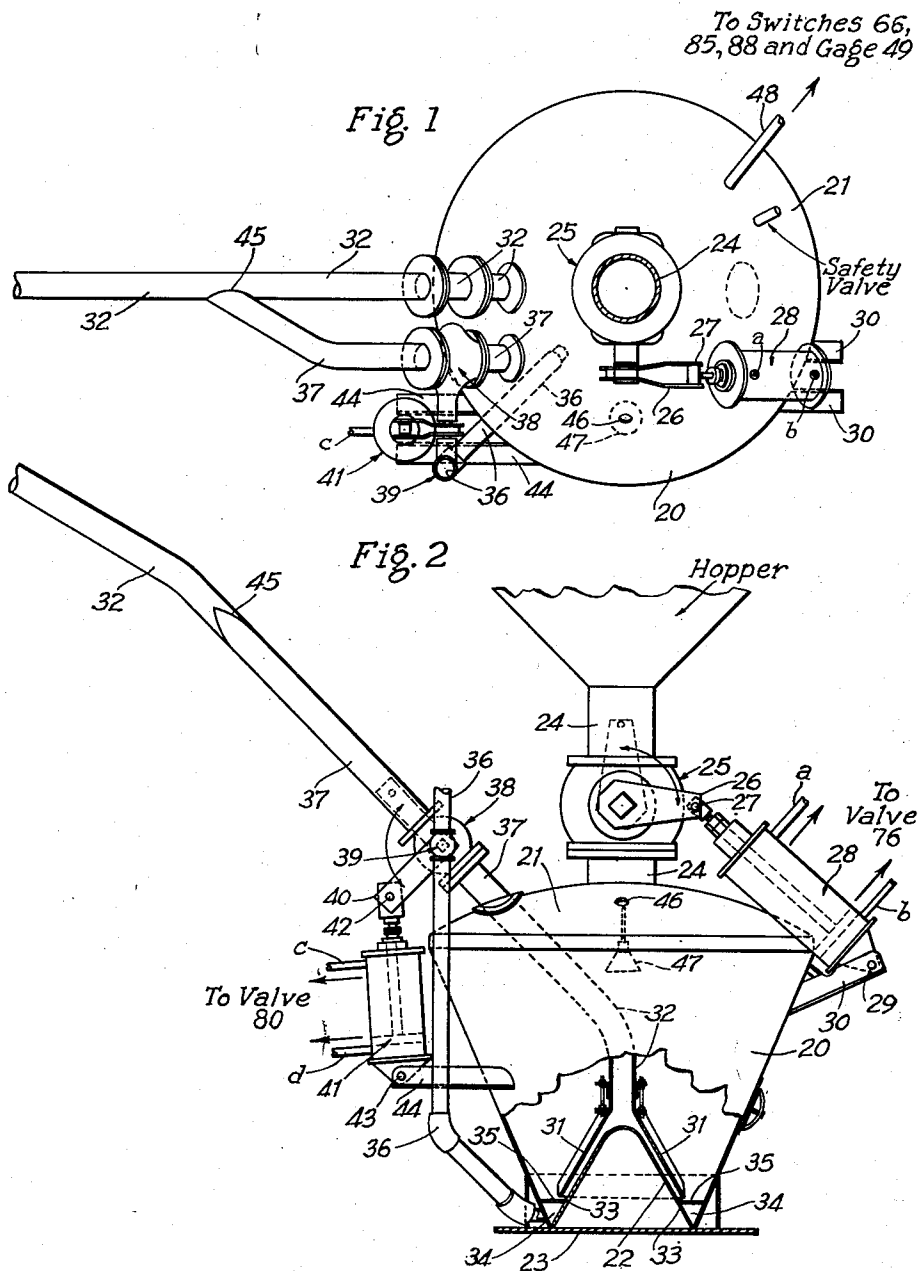
Feb. 2, 1954

C. A. BARESCH
ACTIVATOR CONTROL

2,668,085

Filed Jan. 24, 1951

2 Sheets-Sheet 1



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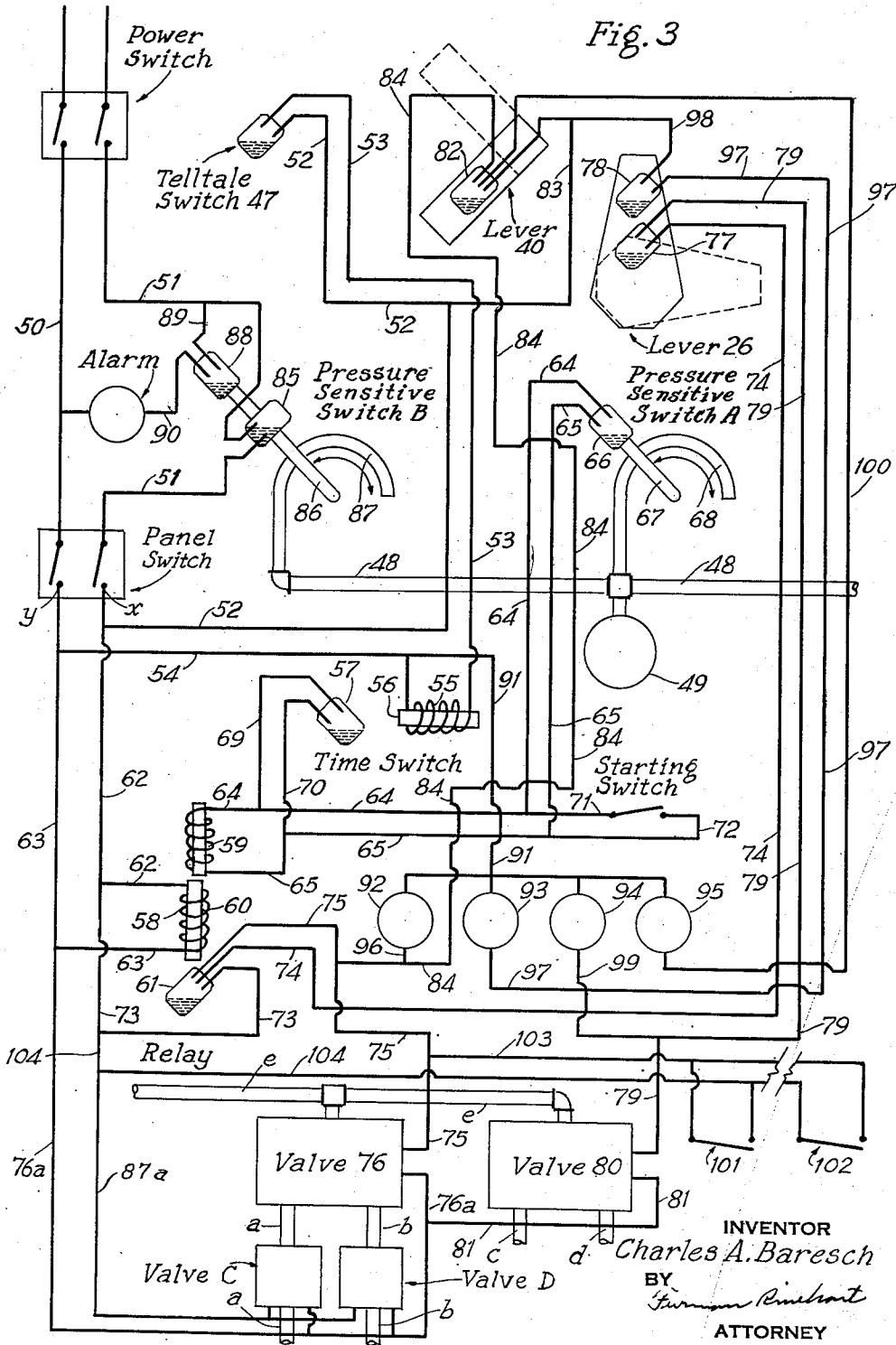
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UNITED STATES PATENT OFFICE

2,668,085

ACTIVATOR CONTROL

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11 Claims. (Cl. 302—53)

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The present invention relates to an automatic control system for governing continuous cyclic operation of apparatus for pneumatically transporting finely divided material.

Apparatus of this class, in which granular, flocculent, pulverulent, or otherwise comminuted material is air suspended and then blown to a distant station, is generally referred to as an activator. Broadly, an activator comprises a container in which a mass of comminuted material may be air suspended; a gated inlet duct at the top of the container through which a charge of material may be loaded by gravity from a storage hopper or the like; an exit nozzle and outlet duct through which air suspended material may be discharged from the container; and means for introducing compressed air into the container when the latter is charged with material and the gate of the inlet duct has been closed.

Ordinarily the capacity of an activator is but a fraction of that of the storage hopper to which it relates, the capacity of the latter often being great enough to hold a carload of material. Consequently the activator is required to be charged and discharged a considerable number of times in order to exhaust the storage hopper. Heretofore this cyclic operation of an activator has required an attendant. Thus the general object of the invention is to provide a novel and highly efficient control system whereby an activator may be governed automatically to operate in a continuity of cycles to exhaust a large store of material.

A particular object of the invention is to utilize the presence of a sufficient charge of material within the container to initiate an operational cycle, and to utilize diminution of internal pressure within the container after the material has been discharged to terminate the cycle, to vent the container, and to open the gate of the inlet duct to receive another charge.

Further objects are to provide a control system adapted to shut down the activator automatically in the event of malfunctioning resulting in a dangerous increase of internal pressure; to provide an alarm to indicate when the apparatus has been shut down due to such malfunctioning; to provide means for preventing opening of the gate of the inlet duct of the activator in the presence of internal pressure greater than atmospheric; and to provide stand-by means whereby the activator may be operated manually when necessary.

In apparatus of the class described an opera-

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tional cycle involves opening the gate of the inlet duct so that a charge of material may flow into the container; closing the gate when a suitable charge has been received; introducing compressed air into the container to suspend the material and thereupon blow it out of the container through the exit nozzle and outlet duct; and, after the material has been discharged, venting the container to make certain that its internal pressure will be atmospheric when the gate is next opened.

It will be understood that in a continuing cyclic operation, to be automatically controlled, detection of the presence of a suitable charge is necessary at the beginning of a cycle, and detection of the exhaustion of material is necessary at the end of a cycle.

In this invention the presence of a suitable charge of material within the container is detected by means of one or more position sensitive switches adapted to be actuated by the material itself when the charge attains a predetermined height. A switch of this class is referred to hereinafter as a telltale switch, and such a device is shown in U. S. Patent No. 2,442,275, issued May 25, 1948.

The detection herein of the exhaustion of material is accomplished by means of a pressure sensitive switch, the diminution of internal pressure toward the end of a cycle being relied upon to actuate the switch. In apparatus of the class described the pressure within the container is, of course, atmospheric at the moment of closing of the gate of the inlet duct. Compressed air is presently introduced into the container and internal pressure rises until the material is sufficiently suspended to flow readily out the exit nozzle and through the outlet duct. During pneumatic transportation of the material the density of the suspension, the resistance to the escape of air at the exit nozzle, and the internal pressure of the container remain nearly uniform; but when the material is about exhausted the suspension becomes rapidly less dense, air escapes at a greatly accelerated rate, and the internal pressure sharply drops. This drop in internal pressure signals the end of a cycle; upon actuation of the pressure sensitive switch above-mentioned, the supply of compressed air is shut off and, simultaneously, the container is vented so that internal pressure may almost immediately become atmospheric preparatory to the next opening of the gate of the inlet duct.

It will be apparent from the foregoing that there are two periods within a cycle during which

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the internal pressure is low: just after the beginning of a cycle, and just before it ends. Plainly, then, a means for signaling the diminution of pressure at the end of a cycle must be prevented from governing operation of the activator during the first part of a cycle. Thus it is a further object of the invention to provide, in such a control system, means whereby the operation of a cycle is initiated exclusively by the presence of a suitable charge of material and continues until internal pressure has been built up, and thereafter is governed exclusively by a diminution of internal pressure.

Another object of the invention is to provide an activator control system including a first pneumatic means for opening and closing the gate of the inlet duct, a second pneumatic means for controlling the supply of compressed air for the container and for the sealing and for the venting thereof, magnetic valves for governing operation of said pneumatic means, and a circuit embracing said valves and controlled during the first part of a cycle by one or more telltale switches and during the latter part of a cycle by a pressure sensitive switch.

These and other objects of the invention will be more fully understood from the following description and from the drawing, in which Figs. 1 and 2 are, respectively, a conventionalized top plan view and a corresponding elevational view of an activator adapted to be controlled by the present system, and in which Fig. 3 is a diagram generally illustrative of the invention.

The activator shown conventionally in Figs. 1 and 2 comprises a container 20, here shown to be in the shape of an inverted frustrum of a cone; a domelike roof 21; and a conical bottom 22. Such containers are commonly of plate steel, the roof being welded to the top edge of the side wall and the base of the conical bottom being welded to the lower edge of the side wall. The structure rests upon a base plate 23.

An inlet duct 24 enters the container through the center of the roof; and a gate, designated 25, is provided in the duct just above the container. In Fig. 2 the duct is shown to connect with a storage hopper surmounting the activator. Frequently such hoppers are of great size. They are commonly connected with the inlet gate by means of a flexible duct. Also, sometimes a hopper bottom car may be spotted for unloading through such a duct directly into the activator mounted beneath a trestle on which the car stands.

The gate 25 is provided with a lever 26 by means of which it may be opened and closed. The outer end of lever 26 is pivotally connected at 27 to a pneumatic ram 28, the piston of which is indicated in dotted lines. The ram is pivotally mounted at 29 on brackets 30 suitably secured to the side wall of the container. The position of lever 26 shown in solid lines in Figs. 1 and 2 is that obtaining when the gate 25 is closed. The position of the lever shown in dotted lines in Fig. 2 indicates that the gate is open. The operation of this ram is more particularly described below. Air lines *a* and *b* for this ram are shown only in part in Figs. 1 and 2; the other terminals of these lines are indicated diagrammatically in Fig. 3. Air line *a* is utilized for closing the gate 25; air line *b* for opening the gate.

Surrounding the conical bottom 22 within the container is a conical cowl 31 from which, at the top thereof, extends an outlet duct 32. The structure shown in Fig. 2, wherein the cowl is

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seen to be slightly removed from the bottom of the container, comprises, in terms of the activator art, an exit nozzle, here designated 33.

The outlet duct 32 is shown, in Fig. 2, to be bent just above the cowl 31, and passes eccentrically through the roof of the container and extends to a distant station, not shown, to which material is to be pneumatically transported. The outlet duct is partly obscured in Fig. 2; compare Fig. 1.

The bottom of the container being conical and the side wall of the container being part of an inverted cone, as shown, an annular valley is formed in the lower part of the activator. The lower portion of this valley is utilized, in usual manner, as a plenum chamber, here designated 34, and is covered by an annular sill plate 35, this latter being provided with numerous perforations, not shown, through which jets of compressed air may be directed against material resting within the container upon the plate. The air line to the plenum chamber is designated 36.

A vent 37 extends from the roof of the container and, for a short distance, is parallel to the outlet duct. Compare Figs. 1 and 2. Just above the container the vent is provided with a valve 38. The air line 36 extends upwardly from the plenum chamber and passes the vent near the position of valve 38. Here a valve 39 is provided in the air line 36. A common control lever 40 serves as a means for operating valves 38 and 39 simultaneously. These two valves are arranged so that when one is open the other is closed. For example, in Fig. 2, the position of lever 40 shown in solid lines indicates that valve 38 of the vent 37 is open, and that valve 39 of the air line 36 is closed; conversely, the position shown in dotted lines indicates that valve 38 is closed and valve 39 open.

A pneumatic ram 41 is provided for opening and closing valves 38 and 39. The ram is pivotally connected to the outer end of lever 40 at 42; and is pivotally mounted at 43 on brackets 44 suitably secured to the side wall of the container. The operation of this ram is more particularly described below. Air lines *c* and *d* for this ram are seen in part in Fig. 2; the other terminals of these lines are indicated diagrammatically in Fig. 3. Air line *c* is utilized for opening valve 38 for venting the container and, simultaneously, for closing valve 39 to terminate the supply of compressed air to the container. Air line *d* is utilized for simultaneously closing the vent valve 38 and for opening valve 39 to initiate the introduction of compressed air to the container.

As shown in Figs. 1 and 2, the vent 37 joins the outlet duct 32 at 45 just beyond valve 38. When a charge of material has been exhausted from the container, ram 41 is actuated in response to diminution of pressure within the container, through means to be described, to cut off the supply of compressed air and to vent the container rapidly of air of greater than atmospheric pressure, so that the gate 25 may be safely opened for the next charge.

As seen in Figs. 1 and 2, an inlet 46 (not shown sealed) is provided in the roof of the container for lead wires communicating with a telltale switch 47. Of course the inlet 46 is hermetically sealed after the lead wires for the telltale switch are inserted. The switch, indicated in dotted lines, is more particularly described below. No wiring is indicated in Figs. 1 and 2.

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An air line 48 (Figs. 1 and 3; not shown in Fig. 2) leads from the roof of the container to a pressure gage and to pressure sensitive switches, the latter being adapted to operate responsively to certain shell pressures of the container (see below; also see Fig. 3 wherein the other terminals of line 48 are indicated). A safety valve is shown in Fig. 1, mounted on the container roof.

Fig. 3 is a pneumatic and electrical diagram, and while only fragmentary parts of the activator of Figs. 1 and 2 are here shown, the control system of the present invention may be fully understood from the description and by comparing the three figures.

Fig. 3 shows a power switch (labeled) connected by lines 50 and 51 with a panel switch (labeled), assumed to be, together with certain other elements to be described, upon a suitable control panel (not indicated).

A line 52 extends from a terminal *x* of the panel switch to one terminal of the telltale switch 47 within the activator. Telltale switch 47 may be a device as shown in U. S. Patent No. 2,442,275, above cited. Essentially the telltale switch is any suitable switch which remains open when disposed in a particular position and automatically closes when caused to assume another position angularly different from said particular position. A mercury toggle switch suspended within the container from the roof thereof in such manner that the switch is open when hanging normally and closed when shoved out of its normal angular position, as by flowing material on the top of a growing pile within the container, is competent for the purposes of the present invention; and such a switch is diagrammatically indicated (and labeled) in Fig. 3.

A telltale switch, as used in the activator art for the purpose of signaling the presence of a sufficient charge of material within the container, is usually suspended from and near the roof of the container by means of a flexible member, such as a light chain or the functional equivalent; and, also, the switch is suspended to the side of the mouth of the inlet duct. Normally the switch is open, as is the switch here shown. As finely divided material is introduced into the container through the inlet duct the top of the forming pile is roughly conical in shape. When the top of the pile reaches a predetermined height additional material entering the container flows to repose on the pile, and some of the material, flowing against the switch, tends to move the switch out of its normal angular disposition into another at which the switch closes and excites a suitable signal to indicate the presence of a sufficient charge. Such signal is ordinarily observed by an operator who thereupon operates means for closing the gate of the inlet duct. However, in the present control system, the signal is utilized automatically to actuate means for closing the gate and the vent valve and for initiating the introduction of compressed air into the container.

The effectiveness of a telltale switch of the toggle type is augmented considerably by the rapidity of the charging operation. Obviously if the influx of material into the container is extremely slow the final sweep of material against the switch may be powerless to effect a suitable deflection thereof to close the same. Hence a fairly large inlet duct is usually provided. Quite frequently a large activator can be loaded by gravity from a surmounting hopper in less than two minutes, the charge running

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as high as a hundred cubic feet of material, or several tons thereof.

A line 53 leads from the other terminal of the telltale switch 47 to one terminal of a time switch (labeled Fig. 3), the other terminal of which is connected to terminal *y* of the panel switch by a line 54. In Fig. 3 the coil 55 and armature 56 of the actuating magnet, and a mercury toggle switch 57 assumed to be controlled by the armature are shown. A type of time switch which may well be used here is the well known dashpot solenoidal switch arranged to close the controlled circuit quickly upon energization of the coil of the solenoid, and to open the controlled circuit slowly upon deenergization of the coil, the return of the armature (here indicated a solenoid core) to normal position being retarded by confined liquid within the dashpot. No dashpot is here shown. The controlled circuit of the time switch is normally open, as shown.

Thus when a suitable charge has been received within the container of the activator the telltale switch 47 is closed, the time switch coil is energized, and the controlled circuit is closed.

A relay is indicated and labeled in Fig. 3. This relay may be of the transformer type, as shown, comprising a primary 58, a secondary 59, an armature 60, and a mercury toggle switch 61 adapted to be actuated by said armature. Here the armature is assumed to be the core of a solenoid of which the coil is the primary 58. The armature is shown in attracted position within the coil, and is assumed to be returnable to non-attracted position by a spring (not shown). When the armature is in the position shown in Fig. 3 the toggle switch 61 is open. The primary is connected by lines 62 and 52 to terminal *x* of the panel switch and by lines 63 and 54 to terminal *y* thereof. Thus the primary is invariably closed with respect to these terminals, and therefore the primary is normally closed. The secondary, however, is normally open; and accordingly the armature is normally attracted, i. e., in the position shown in Fig. 3, and wherein switch 61 is open. But when the secondary is closed, the field of the primary becomes ineffective to maintain the armature in the position shown in Fig. 3 and, in consequence, the toggle switch 61 closes.

The secondary 59 is connected by lines 64 and 65 with a pressure sensitive switch A (labeled, Fig. 3). The electrical element is a mercury toggle switch 66 mounted on a suitable oscillatory member 67 adapted, in usual manner, to be actuated in response to change of pressure within an arcuate tube 68, shown to be connected with air line 48. Switch 66 is normally open, but is mounted so as to close when carried into a particular range of angular positions by said member moving in response to increased shell pressure of the container. For example, pressure sensitive switch A may be arranged to remain open in the presence of shell pressures not more than four pounds per square inch, and to close when the pressure reaches this much. The example is taken from data relating to actual installations of activators. Immediately after the gate 25 of the inlet duct 24 is closed (see Fig. 2) and introduction of compressed air is begun, the pressure rises but discharge of material does not begin in force; after the discharge is completed the resistance to escape of compressed air through the exit nozzle 33 is so reduced that the pressure within the container 20 drops rapidly and soon becomes less than four pounds. This

pressure is sometimes referred to as the shell pressure. It being desired not only to avoid a waste of compressed air, but also to clear the container instantly of residual compressed air, a low shell pressure signal indicating that the material has been discharged is relied upon for actuating means for terminating the supply of compressed air and for venting the container. Thus, in certain installations, a drop below four pounds, properly detected, would be such a signal. Plainly, of course, pressure sensitive switch A is never closed except during the actual discharge portion of a cycle; also, since, as will be seen, this switch A serves during such portion of the cycle to maintain the secondary closed, other means for maintaining the secondary closed before switch A becomes operative are required. Two such means are described in the following paragraph.

The toggle switch 57 of the time switch previously described is connected in parallel with the secondary 59 by means of lines 67 and 70. Thus when the telltale switch 47 is closed, as by a charge of material within the container, the time switch operates to close the secondary 59. Thereupon the relay operates by releasing its armature 60 and so closing toggle switch 61 (more particularly described below).

Also a manually controllable starting switch (labeled, Fig. 3) is connected in parallel with the secondary 59 by means of lines 71 and 72. This switch is provided not only as a standby switch, but because a last batch from a store charged into the container may not be sufficiently great to actuate the telltale switch, and some means must be provided for initiating a cycle under such circumstances to clear the container of the last portion of material being handled.

Three means for closing the secondary 59 have been described: the time switch controlled by the telltale switch, pressure sensitive switch A which is adapted to remain closed in the presence of pressure obtaining during the discharge portion of a cycle, and the manually controllable starting switch.

All three means for closing the secondary effect operation of the relay and consequent closing of toggle switch 61 thereof. This toggle switch is provided with three terminals, being the terminals of lines 73, 74 and 75. The first-mentioned connects with line 62 and so with terminal *x* of the panel switch. The last-mentioned connects with one terminal of a solenoidal valve 76 which controls the air supply for the ram 28 for opening and closing the gate 25 of the inlet duct. The other terminal of this valve is connected by line 76a to line 63 and so with terminal *y* of the panel switch.

Solenoidal valve 76, indicated only by a box and label in Fig. 3, is of a type well known in the art. An air line *e* from a receiver or compressor (neither shown) is seen entering the box at a port at the top thereof in the figure; air lines *a* and *b*, previously described and shown in part Figs. 1 and 2, and respectively used for closing and opening gate 25 of the inlet duct, are seen issuing from the bottom of the box. Valve 76 is arranged so that when its solenoid is deenergized the receiver or compressor line is connected to one of the other lines (here, specifically, *b*, whereby the gate is opened when the solenoid is deenergized), and when its solenoid is energized the receiver or compressor line is connected to the third line (here, specifically, *a*, whereby the gate is closed). Thus, normally, the gate 25 is open.

When the telltale switch is closed the time

switch and the relay operate in rapid succession; toggle switch 61 is accordingly closed and effects operation of valve 76 to connect line *e*, the line from the receiver or compressor, with line *a*. Air pressure in line *a* carries the piston of ram 28 to the position shown in dotted lines in Fig. 2, whereupon the solid line position of lever 23 obtains. The gate is then closed and no further material can enter the container nor can subsequently introduced compressed air escape through the gate.

Suitably mounted on lever 26 (indicated only in Fig. 3) are two mercury toggle switches 77 and 78, each so mounted as to be open at angular positions of the lever 26 except that obtaining when the gate is completely closed. The positions of the arm 26 shown in solid lines in Figs. 2 and 3 indicate, respectively, that the gate is closed and open. Conversely, the dotted line positions of the lever in these two figures indicate, respectively, that the gate is open and closed.

Line 74 leads from a terminal of toggle switch 61 to a terminal of toggle switch 77; and from the other terminal of switch 77 a line 77 leads to one terminal of a solenoid valve 80 which controls the air supply for the ram 41 for opening and closing valves 38 of the vent 37 and 39 of the air line 36. The other terminal of valve 80 is connected by a line 81 with line 76a and so with terminal *y* of the panel switch.

Solenoidal valve 80, indicated only by a box and label in Fig. 3, is of the same well known type as valve 76, previously described. Line *e*, from a receiver or compressor, enters the top of the box; lines *c* and *d*, previously described, and shown in Fig. 2, are seen issuing from the bottom of the box.

Valve 80 is arranged so that when its solenoid is deenergized line *e* is connected to line *c*, whereby valve 38 is opened and valve 39 simultaneously closed, so that the compressed air supply to the plenum chamber and container is cut off simultaneously with the venting of the container; and when its solenoid is energized line *e* is connected to line *d*, whereby valve 38 is closed and valve 39 is opened, so that compressed air is admitted to the plenum chamber and container, and escape through the vent 37 simultaneously checked.

It will be understood from the foregoing that actuation of the telltale switch 47, the time switch and its toggle 57, the relay and its toggle 61, and solenoidal valve 76 takes place in extremely rapid sequence, nearly simultaneously. But a relatively considerable amount of time is required for the flow of compressed air from line *e* through line *a* to ram 28 to effect a complete closure of gate 25. So it is not until the gate is completely closed that toggle switch 77 may close and so effect energization of the solenoid of valve 80. Valve 80 does not operate to connect line *e* with line *d*, to close the vent and initiate the introduction of compressed air to the plenum chamber, until after the gate 25 has been completely closed and the chamber sealed off from its supply hopper.

It is extremely undesirable in this art that the gate of the inlet duct of the container be opened by accident or otherwise in the presence of compressed air in the container, for it will be instantly realized that a blast of compressed air against an oncoming stream of material falling from the supply hopper might cause serious damage.

For this reason the present invention includes

a safety device rendering opening of the gate of the inlet duct in the presence of compressed air in the container extremely unlikely.

Mounted on lever 40, the common control lever for valves 38 and 39, is a mercury toggle switch 82, seen only in Fig. 3. This switch is normally open. Lever 40 is indicated in two positions in both Figs. 2 and 3. In solid lines in both figures the lever is shown in the position which obtains when the vent is open and the air is cut off. In dotted lines in both figures the lever is shown in the position which obtains when the vent is closed and air is being supplied to the plenum chamber. Switch 82 is so mounted on the control lever 40 that when the supply of compressed air is cut off the switch is open, and that when the air is flowing into the plenum chamber from a receiver or compressor, the switch is closed.

Switch 82 is provided with three terminals. One is connected by a line 83 to line 52 and so to terminal *x* of the panel switch. A second is connected by a line 84 to line 75 and so to a terminal of the solenoid of valve 76 which controls the opening and closing of gate 25 of the inlet duct. It will be seen from Fig. 3 that once switch 82 is closed the solenoid of valve 76 is no longer exclusively dependent upon the relay for energization. Toggle switch 61 of the relay may open for accidental or other reasons without effecting an opening of gate 25.

Also it will be understood that actuation of lever 40 by the ram 41 requires some appreciable time. Thus when valve 30 is deenergized and so connects line *e* with line *c* to open the vent valve 38 and to close the air line valve 39, a very considerable portion—in fact, nearly all—of the residual compressed air within the container will have been exhausted before switch 82 opens and deenergizes the solenoid of valve 76.

Switch 82 not only, therefore, prevents deenergization of the solenoid of valve 76 during the build-up of air pressure within the container at the beginning of a cycle or during the discharge portion of the cycle, with consequent opening of gate 25; but also insures adequate venting of the container before the gate is opened.

The invention includes another safety device—an emergency means for shutting down the activator altogether when dangerously excessive pressure builds up within the container due to malfunctioning resulting from choking of the exit nozzle or outlet duct.

It will be seen in Fig. 3 that line 51, leading from the power switch to the terminal *x* of the panel switch includes a pressure sensitive switch B (labeled). The electrical element is a mercury toggle switch 85 mounted on a suitable oscillatory member 86 adapted, in usual manner, to be actuated in response to change of pressure within an arcuate tube 87, shown to be connected with air line 48. Switch 85 is normally closed but is so mounted as to open when carried into a particular range of angular positions by said member moving in response to increased shell pressure of the container. For example, pressure sensitive switch B may be arranged to remain closed in the presence of all normal operating shell pressures, but to open at a predetermined danger pressure. When switch 85 opens of course the panel switch is immediately deenergized and entire activator stops operating.

However, it will be realized that simultaneous deenergization of solenoidal valves 76 and 80 would ordinarily cause the stoppage of compressed air to the plenum chamber, venting of

the container, and coincident opening of the gate 25 of the inlet duct. This would be dangerous inasmuch as the excessive pressure within the container would at once seek to blast air and material through both the vent and the gate. Pressure sensitive switch B is provided for use only under extreme pressure conditions, so upon simultaneously opening the vent and the gate resultant damage might well be as great as would happen under normal discharge pressure conditions were said gate opened. Thus a further safety measure is required to prevent the gate from opening under any circumstances in the presence of pressure greater than atmospheric within the container.

This requirement is met by the introduction into air line *a* of a magnetic valve C adapted to operate merely as a gate, and as such only when deenergized; and by introduction into air line *b* of a like magnetic valve D. In Fig. 3 it will be seen that valves C and D are connected in parallel, and are connected directly to the terminals *x* and *y* of the panel switch by means of lines 76*a*, 63 and 54 on one side and by lines 37*a*, 104, 73, 62 and 52 on the other. Thus these two valves are always energized under normal working conditions, and being energized, do not operate as gates, and the air lines *a* and *b* are consequently normally open. However, when pressure sensitive switch B operates to break line 51 between the power switch and the panel switch, and so to deenergize all elements of the control system except the alarm, it is immaterial that solenoidal valve 76 immediately connects air line *c* with air line *b*—the connection obtaining when the gate is to be opened—for no air from a receiver or compressor can pass valve D, and no air in the cylinder of the ram 28 can escape past valve C. Thus when the entire system is deenergized ram 28 is locked against operation.

Another mercury toggle switch 88 may be mounted together with switch 85 on member 86, the former switch being arranged to remain normally open and to close in the presence of excessive shell pressure. Terminals of switch 88 may be connected as by line 89 to line 51 and by line 90 to line 50, line 90 including the alarm (labeled Fig. 3) mentioned above, such as a bell or light to attract attention.

Certain indicator lights may advantageously be included in the control system of the present invention. A line 91, connecting with line 54 and so with terminal *y* of the panel switch, connects, through branches, with one terminal each of four lights 92, 93, 94 and 95 (Fig. 3).

Light 92, having its other terminal connected by a line 96 to line 84 and thereby to line 75 of toggle 61 of the relay (line 75 leading from the toggle to one terminal of the solenoid of valve 76), becomes energized immediately said solenoid is energized. This instant, however, is just the beginning of the pneumatic operation controlled by the solenoid, that is the operation of ram 28 and the closing of the gate 25. Light 92, therefore, is a first visual indication that the gate is about to close.

Light 93, having its other terminal connected by a line 97 to one terminal of toggle switch 78 mounted on lever 26—the other terminal of said switch being connected by a line 98 to line 93 and thereby to line 52 and terminal *x* of the panel switch—is energized only when switch 78 closes upon completion of the closure of gate 25. Light 93, therefore, shows that the gate is completely

closed and that the container is ready for the admission of compressed air.

Light 94, having its other terminal connected by a line 99 to line 79, previously described, is energized immediately that the solenoid of valve 80 is energized. Therefore light 94 indicates that the vent is about to close and that air is about to be introduced into the plenum chamber.

Light 95, having its other terminal connected by a line 100 with the third terminal of toggle switch 32 mounted on lever 40, is energized only when the vent is closed and the air is feeding in force into the plenum chamber and the container.

Plainly the lights 92 through 95 are turned on one after another if the cycle is progressing in normal manner. All lights remain on during the discharge portion of the cycle.

Two manually controllable switches 101 and 102 are indicated in Fig. 3. Both are connected in parallel to lines 103 and 104. The first-mentioned line connects with line 75, leading from the toggle switch 61 of the relay to one terminal of the solenoid of valve 76—the valve which controls opening and closing of the gate of the inlet duct. The other line from switches 101 and 102 connects with line 73 and thereby with terminal *x* of the panel switch. Note that the other terminal of the solenoid of valve 76 connects with terminal *y* of the panel switch by means of lines 76a, 63, and 54.

It will also be noted in Fig. 3 that lines 103 and 104 between switches 101 and 102 are shown to be interrupted, the purpose being to indicate that the two switches may be widely separated. For example, all elements indicated in Fig. 3, excepting only switch 102, are assumed to be either on the activator, on a control panel, or nearby both. A pneumatic transportation set-up employing such an activator may be adapted to transport material several hundred feet or even a greater distance away from the activator itself. Switch 102, then, is suggested as a remote control switch to be placed near the station to which the material is to be transported so that an operator there may stop the activator when enough material has been received at said station. Of course switch 101 has the same function, electrically, as switch 102.

Switches 101 and 102 are normally open. When either is closed the solenoid of valve 76 is no longer exclusively dependent for energization on the relay, as it will be seen that the solenoid is then included in a closed circuit, i. e., from terminal *x* of the panel switch along lines 52, 62, 73 and 104, switch 101 or 102, and lines 103, 75, which connects with one terminal of the solenoid, 76a which connects with the other terminal thereof, 63, and 54 to terminal *y* of the panel switch. Therefore if either switch 101 or 102 is closed and maintained closed during a cycle, at the end thereof the solenoid will remain energized and the gate 25 will remain closed. No further material can enter the container; in consequence the telltale switch cannot be utilized to initiate a following cycle, and the activator remains idle until required for further transportation of material.

The operation of the automatic control system and of the activator will now be described chronologically with respect to a single cycle, the operation of each element being ordinarily numbered so that the system may be easily understood. A wholly automatic operation of the control sys-

tem and activator is described, it being assumed that the cycle involved is one of a series of automatic cyclic operations.

1. Gate 25 being open, material flows by gravity from a supply hopper through the inlet duct 24 into the container 20 and forms a pile upon the sill plate 35 between the side wall of the container and the conical cowl 31. In Fig. 2 it is shown that the outlet duct 32, centrally disposed within the container where the outlet duct joins the cowl, is presently bent to one side and passes out of the container through the roof thereof. After the pile of material has grown to a height beyond the bend in the outlet duct the material may then form itself into a mass having a roughly conical upper surface as the particles seek an angle of repose. Presently the pile reaches a height at which settling particles flowing onto the top of the pile sweep against the telltale switch 47 as they seek such angle, and, in consequence, shortly a sufficient deflection has been had in the switch to close the same, thereby energizing the coil 55 of the time switch.

2. Upon energization of coil 55 of the time switch its armature 56 is drawn into attracted position, thereby toggling switch 57 and closing the same, and also completing the circuit of secondary 59 of the relay. It will be understood that energization of coil 55 of the time switch, and completion of the circuit of the secondary 59 of the relay through switch 57 continues not only until the telltale switch opens but also until the slowly opening time switch has regained normal position.

3. Upon the closing of switch 57 of the time switch and completion of the circuit of the secondary 59, induction of current in the secondary reduces the field of the primary 58 of the relay, whereupon the armature 60 thereof is released, effecting closing of toggle switch 61.

4. Closing of switch 61 effects energization of the solenoid of valve 76, controlling ram 28 relating to the gate of the inlet duct. Energization of this solenoid is had by completion of the circuit loop involving terminal *x* of the panel switch, lines 52, 62, and 73, switch 61, line 75, the solenoid, and lines 76a, 63, and 54 to terminal *y* of the panel switch.

5. Upon energization of the solenoid of valve 76 the movement of the armature of the solenoid effects, in well known manner, connection between a receiver or compressor air line with one of two branches, here, specifically, a connection between line *e* and line *a*.

6. Flow of compressed air through line *a* forces the piston of ram 28 into the position shown (in dotted lines) in Fig. 2, thereby closing gate 25. Of course the flow of material from the supply hopper is terminated. When the gate 25 is completely closed the lever 26 will assume the position shown in solid lines in Fig. 2 and in dotted lines in Fig. 3. In this position, and not until this position has been fully attained, toggle switches 77 and 78, both mounted on lever 26, are closed.

7. The closing of switch 77 effects energization of the solenoid of valve 80, controlling ram 41 relating to vent valve 38 and main air line valve 39. Energization of this solenoid is had by completion of the circuit loop involving terminal *x* of the panel switch, lines 52, 62, and 73, switch 61, line 74, switch 77, line 79, the solenoid, and lines 81, 79a, 63, and 54 to terminal *y* of the panel switch.

8. Upon energization of the solenoid of valve

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80 the movement of the armature of the solenoid effects, in usual manner, connection between a receiver or compressor air line with one of two branches, here, specifically, a connection between line *e* and line *d*.

9. Flow of compressed air through line *d* forces the piston of ram 41 away from the position shown (in dotted lines) in Fig. 2 to the other end of the cylinder of the ram, thereby simultaneously closing the vent valve 38 and opening the main air line valve 39. When the vent valve is completely closed and the main air line valve is completely open, the common control lever 40 will assume the dotted line position shown in Fig. 2 and the solid line position indicated in Fig. 3. In this position, and not until this position has been fully attained, toggle switch 82, mounted on the lever, is closed. The closing of switch 82 is merely for purposes of safety, previously described. However, it will be understood that now the solenoid of valve 78 cannot be deenergized by a failure at switch 61 of the relay, and so cause a premature opening of gate 25 of the inlet duct.

10. The container is now sealed at the inlet duct gate and at the vent valve, and unactivated material forms a seal at the exit nozzle and upon the sill plate. Compressed air flows into the plenum chamber and jets of air impinge upon the material resting on the sill plate. As the gate 25 closed the pressure within the container was, of course, atmospheric. Shortly after the closing of gate 25 the supply of compressed air to the plenum chamber is had in full force. But an appreciable time is required for sufficient pressure to build up in the container to effect pressure sensitive switch A or to render the material sufficiently air suspended and thereby fluid enough to be discharged in normal fashion. The jets of air entering the container through the sill plate perforations presently form a suspension of particles of the material and air within the container; the pressure sensitive switch A, responsive to shell pressure of the container, presently is closed; and shortly thereafter the increasing shell pressure effects a flow of the suspension of material and air out the exit nozzle and through the outlet duct. The discharge has now begun in force. It will be understood that the time lag of the time switch is sufficient to maintain switch 57 in closed position and thereby maintain completion of the circuit of the secondary 58 of the relay until sufficient pressure has been built up within the container to close pressure sensitive switch A. After switch A closes the return to normal position of switch 57 is immaterial.

11. During a normal discharge of material no elements of the control system nor of the activator are in motion until the last portion of the discharge. During this last portion the amount of material left within the container is so slight that the suspension is of great fluidity and may accordingly flow out of the exit nozzle at an accelerated rate. This rapid escape of air from the container operates to reduce the pressure considerably, and shortly the pressure is so low that pressure sensitive switch A cannot be maintained in closed position, and so opens. This signals the end of the discharge. Also this action breaks the secondary circuit; the field of the primary at once builds up and the armature 80 is again attracted, thereby opening switch 61. It is to be remembered that switch 82 is still closed at this time and that the solenoid of valve 78 is still energized through that switch. Thus the gate 25 remains closed. But as soon as switch 61 opens the

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circuit including solenoid of valve 80 is broken, and upon deenergization of the solenoid valve 80 changes its earlier connection of line *e* with line *d* to line *e* with line *c*.

5 12. Air flows through line *c* to ram 41, and carries the piston to the position shown in dotted lines in Fig. 2, and so opens the vent valve 38 and closes the main air line valve 39. Immediately residual compressed air within the container escapes not only through the exit nozzle and outlet duct but in great volume through the vent, and so into the outlet duct just beyond valve 38. When lever 41 attains the solid line position of both Figs. 2 and 3 switch 82 opens thus deenergizing the solenoid of valve 78.

13. Deenergization of the solenoid of valve 78 effects a change of the connection of line *e* with line *a* to a connection of line *e* with line *b*, whereupon air flows into the cylinder of ram 28 and forces the piston to the upper end of the cylinder, that is, opposite to the position shown in dotted lines in Fig. 2. Thereupon the cycle is over. Of course new material begins to flow into the container preparatory for the next cycle.

The terms and expressions which have been employed herein are used as terms of description and not of limitation, and there is no intention in the use of such terms and expressions of excluding any equivalent of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of invention claimed.

What is claimed is:

1. Apparatus for transporting sequentially a plurality of batches of finely divided material from a store comprising an activator container adapted to be loaded by gravity; an inlet duct for said container extending from said store; a gate for said inlet duct; an outlet duct extending from said container to a distant station; a source of compressed air; a compressed air duct connected to said container; an openable and closable compressed air valve in said compressed air duct; a pneumatic ram for opening and closing the gate of said inlet duct; another pneumatic ram for opening and closing said compressed air valve; a position sensitive switch in said container adapted to close when displaced by a predetermined amount of material loaded into said container; a pressure sensitive switch adapted to close in response to more than a predetermined amount of pressure in said container; a first magnetic valve for introducing air to the first-mentioned ram for closing the gate of said inlet duct when said position sensitive switch closes; another switch adapted to be closed in response to operation of said first-mentioned ram; a second magnetic valve controlled by said last-named switch for introducing compressed air to the second-mentioned ram for opening said compressed air valve and introducing compressed air into said chamber through said compressed air duct; means for closing said magnetic valves upon a diminution of pressure within said container, said means being actuated in response to an opening of said pressure sensitive switch, and another normally closed pressure sensitive switch within said container adapted to open in response to more than another predetermined pressure within said container for the purpose of deenergizing said valves.

2. Apparatus for transporting sequentially a plurality of batches of finely divided material from a store comprising an activator container adapted to be loaded by gravity; an inlet duct for said container extending from said store; a gate

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for said inlet duct; an outlet duct extending from said container to a distant station; a source of compressed air; a compressed air duct connected to said container; a compressed air valve in said compressed air duct; a pneumatic ram for opening and closing the gate of said inlet duct; another pneumatic ram for opening and closing said compressed air valve; a position sensitive switch in said container adapted to close when displaced by a predetermined amount of material loaded into said container; a pressure sensitive switch adapted to close in response to more than a predetermined amount of pressure in said container; a first magnetic valve for introducing air to the first-mentioned ram for closing the gate of said inlet duct when said position sensitive switch closes; another switch adapted to be closed in response to operation of said first-mentioned ram; a second magnetic valve controlled by said last-named switch for introducing compressed air to the second-mentioned ram for operating said compressed air valve to introduce compressed air through said compressed air duct into said chamber; means for closing said magnetic valves upon a diminution of pressure within said container, said means being actuated in response to an opening of said pressure sensitive switch.

3. Apparatus for transporting sequentially a plurality of batches of finely divided material from a source of supply which comprises an activator container, an inlet duct connected to said container and adapted for connection with said source, a charging valve in said inlet duct, a first mechanism operative to open and close said charging valve, a discharge duct extending from said container to a station a distance away from said container, a vent duct connected to said container and extending to a point outside said container, a vent valve in said vent duct, a compressed air duct connected to a source of compressed air and to said container, a compressed air valve in said compressed air duct, a second mechanism operative to open and close said compressed air valve, an electrical circuit connected to a main source of current, a position sensitive switch connected in said circuit operative in response to charging material to said container up to a predetermined level to actuate said first mechanism to close said charging valve and to actuate said second mechanism to close said vent valve and open said compressed air valve, a pressure sensitive switch in said circuit operative in response to a fall of pressure within said container below a predetermined amount after a batch of material has been discharged from said container to actuate said second mechanism to close said compressed air valve and to open said vent valve.

4. Apparatus for transporting sequentially a plurality of batches of finely divided material from a source of supply which comprises an activator container, an inlet duct connected to said container and adapted for connection with said source, a charging valve in said inlet duct, a first mechanism operative to open and close said charging valve, a discharge duct extending from said container to a station a distance away from said container, a vent duct connected to said container and extending to a point outside said container, a vent valve in said vent duct, a compressed air duct connected to a source of compressed air and to said container, a compressed air valve in said compressed air duct, a second mechanism operative to open and close said compressed air valve, an electrical circuit connected to a main source of current, a position sensitive

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switch connected in said circuit operative in response to charging material to said container up to a predetermined level to actuate said first mechanism to close said charging valve and to actuate said second mechanism to close said vent valve and open said compressed air valve, a pressure sensitive switch in said circuit operative in response to a fall of pressure within said container below a predetermined amount after a batch of material has been discharged from said container to actuate said second mechanism to close said compressed air valve and to open said vent valve, and a pressure sensitive device operative in response to a pressure above a predetermined amount to cut off said main source of current to said position and pressure sensitive switches.

5. Apparatus for transporting sequentially a plurality of batches of finely divided material from a source of supply which comprises an activator container, an inlet duct connected to said container and adapted for connection with said source, a charging valve in said inlet duct, a first mechanism operative to open and close said charging valve, a discharge duct extending from said container to a station a distance away from said container, a compressed air duct connected to a source of compressed air and to said container, a compressed air valve in said compressed air duct, a second mechanism operative to open and close said compressed air valve, an electrical circuit connected to a main source of current, a position sensitive switch connected in said circuit operative in response to charging material to said container up to a predetermined level to actuate said first mechanism to close said charging valve and to actuate said second mechanism to open said compressed air valve, a pressure sensitive switch in said circuit operative in response to a fall of pressure within said container below a predetermined amount after a batch of material has been discharged from said container to actuate said second mechanism to close said compressed air valve.

6. Apparatus for transporting sequentially a plurality of batches of finely divided material from a source of supply which comprises an activator container, an inlet duct connected to said container and adapted for connection with said source, a charging valve in said inlet duct, a first mechanism operative to open and close said charging valve, a discharge duct extending from said container to a station a distance away from said container, a compressed air duct connected to a source of compressed air and to said container, a compressed air valve in said compressed air duct, a second mechanism operative to open and close said compressed air valve, an electrical circuit connected to a main source of current, a position sensitive switch connected in said circuit operative in response to charging material to said container up to a predetermined level to actuate said first mechanism to close said charging valve and to actuate said mechanism to open said compressed air valve, a pressure sensitive switch in said circuit operative in response to a fall of pressure within said container below a predetermined amount after a batch of material has been discharged from said container to actuate said second mechanism to close said compressed air valve, and a second pressure sensitive switch operative in response to a pressure above a predetermined amount to cut off said main source of current to said position and pressure sensitive switches.

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7. Apparatus for transporting sequentially a plurality of batches of finely divided material from a source of supply which comprises an activator container, an inlet duct connected to said container and adapted for connection with said source, a charging valve in said inlet duct, a first mechanism including a pneumatically operated ram operative to open and close said charging valve, a discharge duct extending from said container to a station a distance away from said container, a vent duct connected to said container and connected to said discharge duct at a point outside said container, a vent valve in said vent duct between said point and said container, a compressed air duct connected to a source of compressed air and to said container, a compressed air valve in said compressed air duct, a second mechanism including a pneumatic ram operative to open and close said compressed air valve, an electrical circuit connected to a main source of current, a position sensitive switch connected in said circuit operative in response to charging material to said container up to a predetermined level to actuate said first pneumatic ram to close said charging valve and to actuate said second pneumatic ram to close said vent valve and simultaneously open said compressed air valve, a pressure sensitive switch in said circuit operative in response to a fall of pressure within said container below a predetermined amount after a batch of material has been discharged from said container to actuate said second pneumatic ram to close said compressed air valve and to open said vent valve, and thereafter to actuate said first pneumatic ram to open said charging valve.

8. Apparatus for transporting sequentially a plurality of batches of finely divided material from a source of supply which comprises an activator container, an inlet duct connected to said container and adapted for connection with said source, a charging valve in said inlet duct, a first mechanism including a pneumatically operated ram operative to open and close said charging valve, a discharge duct extending from said container to a station a distance away from said container, a vent duct connected to said container and connected to said discharge duct at a point outside said container, a vent valve in said vent duct between said point and said container, a compressed air duct connected to a source of compressed air and to said container, a compressed air valve in said compressed air duct, a second mechanism including a pneumatic ram operative to open and close said compressed air valve, an electrical circuit connected to a main source of current, a position sensitive switch connected in said circuit operative in response to charging material to said container up to a predetermined level to actuate said first pneumatic ram to close said charging valve and to actuate said second pneumatic ram to close said vent valve and simultaneously to open said compressed air valve, a pressure sensitive switch in said circuit operative in response to a fall of pressure within said container below a predetermined amount after a batch of material has been discharged from said container to actuate said second pneumatic ram to close said compressed air valve and to open said vent valve, and thereafter to actuate said first pneumatic ram to open said charging valve, and pressure sensitive device operative in response to a pressure above a predetermined amount to cut off said main source of current to said position and pressure sensitive

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switches providing a safety device for preventing a dangerously high pressure within said container.

9. Apparatus for transporting sequentially a plurality of batches of finely divided material from a store comprising an activator container adapted to be loaded by gravity; an inlet duct for said container extending from said store; a gate for said inlet duct; an outlet duct extending from said container to a distant station; a vent conduit extending from said container to a point outside said container; a gate for said vent interposed between said container and said point; a source of compressed air; a pneumatic ram for opening and closing the gate of said inlet duct; another pneumatic ram for opening and closing the gate of said vent; a position sensitive switch in said container adapted to close when displaced by a predetermined amount of material loaded into said container; a pressure sensitive switch adapted to close in response to more than a predetermined amount of pressure in said container; a first valve for introducing air to the first-mentioned ram for closing the gate of said inlet duct when said position sensitive switch closes; another switch adapted to be closed in response to operation of said first-mentioned ram; a second valve controlled by said last-named switch for introducing compressed air to the second-mentioned ram for simultaneously closing the gate of the vent and for introducing compressed air into said chamber; means for closing said valves upon a diminution of pressure within said container, said means being actuated in response to an opening of said pressure sensitive switch, and another normally closed pressure sensitive switch within said container adapted to open in response to more than another predetermined pressure within said container for the purpose of denergizing said valves.

10. Apparatus for transporting sequentially a plurality of batches of finely divided material from a store comprising an activator container adapted to be loaded by gravity; an inlet duct for said container extending from said store; a gate for said inlet duct; an outlet duct extending from said container to a distant station; a vent extending from said container to said outlet duct at a point outside said container; a gate for said vent interposed between said container and said point; a source of compressed air; a pneumatic ram for opening and closing the gate of said inlet duct; another pneumatic ram for opening and closing the gate of said vent; a position sensitive switch in said container adapted to close when displaced by a predetermined amount of material loaded into said container; a pressure sensitive switch adapted to close in response to more than a predetermined amount of pressure in said container; a first magnetic valve for introducing air to the first-mentioned ram for closing the gate of said inlet duct when said position sensitive switch closes; another switch adapted to be closed in response to operation of said first-mentioned ram; a second magnetic valve controlled by said last-named switch for introducing compressed air to the second-mentioned ram for simultaneously closing the gate of the vent and for introducing compressed air into said chamber; and means for closing said magnetic valves upon a diminution of pressure within said container, said means being actuated in response to an opening of said pressure sensitive switch.

11. Apparatus for transporting sequentially a

plurality of batches of finely divided material from a store comprising an activator container adapted to be loaded by gravity; an inlet duct for said container extending from said store; a gate for said inlet duct; an outlet duct extending from said container to a distant station; a vent extending from said container to said outlet duct at a point outside said container; a gate for said vent interposed between said container and said point; a source of compressed air; a pneumatic ram for opening and closing the gate of said inlet duct; another pneumatic ram for opening and closing the gate of said vent; a position sensitive switch in said container adapted to close when displaced by a predetermined amount of material loaded into said container; a pressure sensitive switch adapted to close in response to more than a predetermined amount of pressure in said container; a first magnetic valve for introducing air to the first-mentioned ram for closing the gate of said inlet duct when said position sensitive switch closes; another switch adapted to be closed in response to operation of said first-mentioned ram; a second magnetic valve controlled by said last-named switch for introducing compressed air to the second-mentioned ram for simultane-

ously closing the gate of the vent and for introducing compressed air into said chamber; means for closing said magnetic valves upon a diminution of pressure within said container, said means being actuated in response to an opening of said pressure sensitive switch, and another normally closed pressure sensitive switch within said container adapted to open in response to more than another predetermined pressure within said container for the purpose of deenergizing said valves.

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