

Jan. 24, 1956

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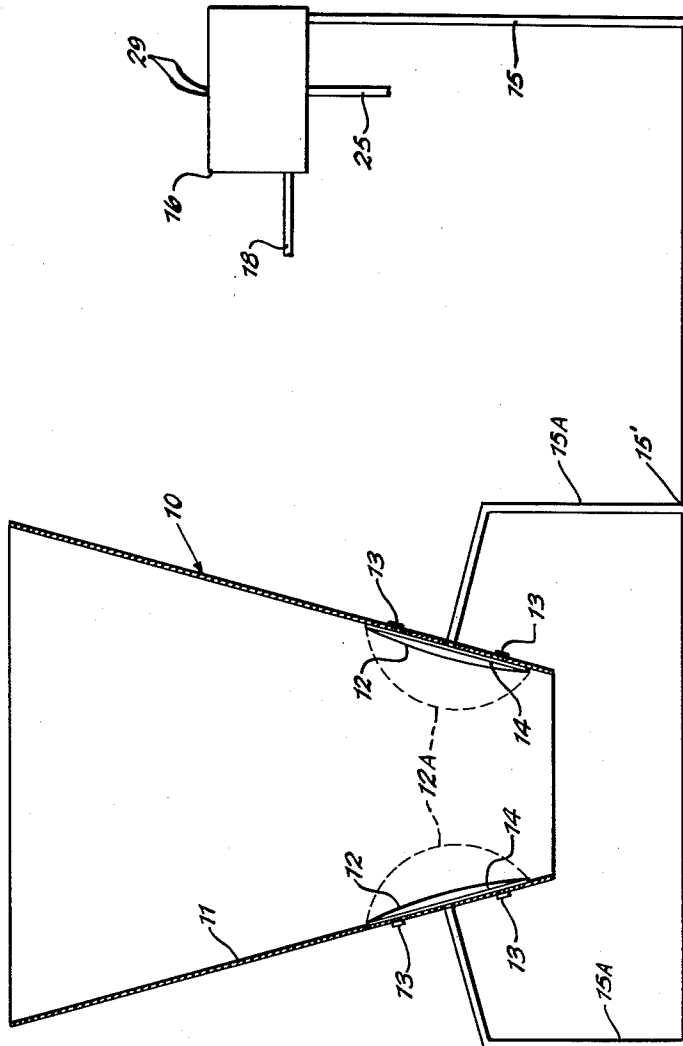
2,732,099

HOPPER CONTROL APPARATUS AND METHOD

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2 Sheets-Sheet 1

FIG. 1.



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FIG. 2.

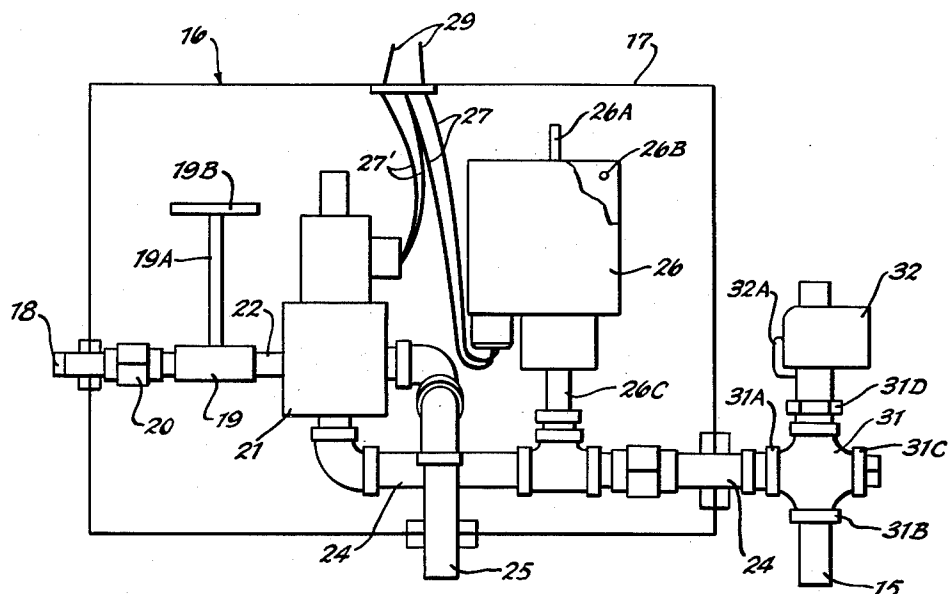


FIG. 3.

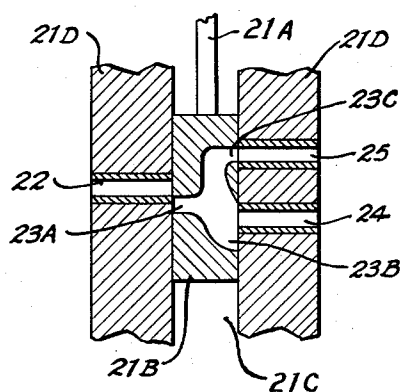
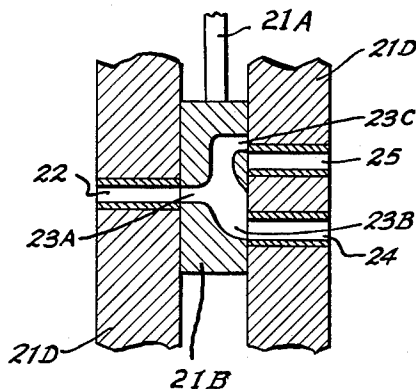


FIG. 4.



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HOPPER CONTROL APPARATUS AND METHOD

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9 Claims. (Cl. 222—1)

My invention relates generally to storage bins and hoppers and the like, and particularly concerns both a method and apparatus for insuring the unobstructed discharge from such bins of materials contained therein.

An object of my invention is to provide a method for insuring the free and unobstructed flow of materials through or from bins and hoppers adapted for the storage, loading and classification of an infinite variety of generally granular materials, which method is at once simple, rapid, certain and predictable in results, involving a minimum investment in plant space, equipment and materials, demanding minimum labor requirements of but moderate skill, and adjustable sensitively and accurately to widely variant loading conditions maintaining within the bin or hopper.

Another object is to provide apparatus for facilitating unobstructed passage of the granular contents through bins, hoppers and the like in rapid and sensitive response to the momentary load conditions prevailing therein and which is certain, reliable and predictable in operation, and which employs a minimum number of component parts which in themselves are small, simple, rugged and readily available.

All these and many other highly practical objects and advantages attendant upon the practice of my invention, which in part will be obvious and in part more fully pointed out hereinafter during the course of the following description.

Accordingly, my invention resides in the arrangement parts, features of construction, combination of elements, as well as in the several operational steps and the relation of each of the same with one or more of the others as described herein, the application of all of which is more fully set forth in the claims at the end of this specification.

In the several views of the drawings, wherein I have disclosed, illustratively, that embodiment of my invention which I prefer at present,

Figure 1 is a schematic elevation, with parts shown in section, wherein I disclose the general assembly of apparatus according to the practice of my invention;

Figure 2 is a schematic view, on enlarged scale, wherein I disclose the control mechanism employed in the apparatus of Figure 1; while

Figures 3 and 4 are sectional views showing the two control positions of a typical three-way valve employed in the apparatus of Figures 1 and 2.

Throughout the several views of the drawings like reference characters denote like constructional parts.

As conducive to a more ready understanding of certain features of my invention, it may be noted at this point that in industrial or manufacturing operations it frequently becomes necessary to store granular or powdered material, thereafter channelling it to one or more points of use, and this either in continuous or intermittent manner. Moreover, it frequently is required to classify or grade such materials as they pass from the storage containers. A hopper or storage bin proves entirely satis-

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factory for this purpose. Usually such hoppers have walls sloping with respect to the horizontal. And mechanical take-off means are employed at the bottom of the hopper such as a continuous belt, a worm or a rotatable disc, any of which serves effectively to remove the processed substance from the discharge end of the bin.

It is well recognized, however, that difficulty frequently is encountered when the materials undergoing processing are finely divided substances or those which are slightly damp. It is found that these materials occasionally are inclined to compaction, forming an arch at or above the throat of the hopper as a result of the vertical pressures on the material contained in the hopper, or forming a hollow cone against the walls of the hopper as a result of the horizontal pressures encountered. These effects are especially pronounced in sticky material such as foundry core mixes. Upon obstruction at the throat or along the walls of the hopper, the materials jam and build up in back and on top of the obstructing material. With initial clogging, of course, the effect builds up quickly, further intensifying the obstruction to the extent that operation of the hopper becomes uncertain and unpredictable. To ensure that the hopper contents flow readily and certainly ordinarily requires the constant attendance of an operator.

For one reason or another, therefore, the art has long sought to provide for shaking, vibrating or pulsating the material as it passes through the hopper, not so much as to break up the jammed material after jamming has taken place as to prevent the material from jamming the hopper before such jamming occurs.

Illustratively, mechanical vibrators have been employed. These, however, are not readily employed in the conventional hopper fashioned of wood or of concrete. Moreover, these vibrators do not always shake down the material in the desired certain and satisfactory manner.

Effort also has been directed towards providing elastic membranes or diaphragms sealed at their margins to the interior surfaces of a hopper into which the granular materials are charged. The seal between membrane and hopper wall is made air-tight and the membranes are pulsed by admittance of air under pressure to the space between membrane and wall, the air being subsequently exhausted. This has the effect, in cyclic operation, of initially distending or dilating the membrane, and then collapsing the same. Exhaust of the space between membrane or hopper wall is accomplished by the elasticity of the membrane itself, particularly as aided by the load of the bin. Typical of this mode of operation is that disclosed in the United States Letters Patent to Tainton, No. 1,570,795, wherein a three-way air-control valve is motor-driven to control the pulsation of one or more diaphragms provided in the hopper, these being mounted as panels on the sloping surfaces of the bin. They are inflated and deflated by admitting and exhausting air from the space defined by the diaphragm and the portion of the wall of the bin upon which the diaphragm is mounted.

In general the pulsating-wall type of operation proved substantially better than the techniques theretofore available in the art. I find, however, that there is one important difficulty inherent in such construction: there is a definite lack of flexibility in adapting the apparatus to the various load conditions maintaining within the bin, as presented by passage of various types and consistencies of granular materials. Moreover, the compressed air line pressures available in the average industrial plant tend to rupture the rubber diaphragms even when the latter are reinforced. To preclude rupture various air pressure regulators have been employed. But when these regulators are of a size sufficient to pass requisite unit

volumes of air with required regulation, then of necessity they are so unwieldy in size and costly of production as to make their use well-nigh prohibitive.

As the art thus developed, satisfaction of need for variation both of frequency and amplitude of the cycles of incoming air could be achieved only through resort to specially constructed assemblies of mechanical parts. And such assemblies, constituted illustratively of an electric motor with variable ratio drive, speed reducer and cam, and these in addition to the valve and pressure regulators, proved extremely costly.

To avoid the necessity of a high capacity air-pressure regulating valve it was proposed to supply a special valve connected to and controlled by the under-surface of the pulsating membranes of the panels. This was with the thought that movement of the membrane itself would determine the moment at which air was either admitted into or exhausted from the space defined by membrane and panel and the extent to which this was to take place, all this by way of a valve mechanism physically remote from the membrane and disposed exteriorally of the bin. Here again, however, a fundamental difficulty was encountered in that specially constructed equipment was required. Moreover, sticking of the valves was noted, due probably to the deposition of moisture and foreign particles in the closely fitting parts of the valve from the air and dust about the bin or hopper with which the panel was associated. A final difficulty remained, notably, that unless air pressure regulation—just what it was sought to avoid—was again resorted to, then the proposed control was too insensitive for practical operation. For it was found that where an upper portion of the panel became exposed in the course of emptying the bin or hopper, then this exposed portion of the membrane inflates to the point of rupture before correction is provided by sufficient movement of that portion of the membrane bearing the connection to the control valve.

Thus, for one reason or another, the bin control expedients heretofore available in the art, unfortunately, have proved to be satisfactory. Either they have been impractical or else they have been too costly, both of initial installation and subsequent maintenance and operation. Requirements of simplicity and low first cost were not satisfied, nor were the three-fold requirement of certainty, rapidity, and sensitivity of operation. Long, useful life could not be achieved.

A further object of my invention, therefore, is to avoid in substantial respect the many disadvantages and defects resident in the prior art, and at the same time to provide both a method and an apparatus which will properly, sensitively and accurately pulsate the membranes of the bin panels in close response to the load conditions therein without danger of rupture of the membranes and with long useful life, without clogging the bin or hopper, requiring only component parts which in themselves are simple, inexpensive, reliable and certain, which are readily available on the market and which require minimum supervision and attendance.

Turning now to a consideration of my invention, and having reference to the several views of the drawings, I provide a hopper or bin indicated generally at 10 (Figure 1) for the storage and delivery, as the case may be, of the generally granular or flaky material. While it may be constructed of any suitable material I conveniently employ sheet metal of substantial gauge, displaying good wear qualities. The hopper may have any desired and suitable shape with a charging opening at the top and a discharge opening at the bottom to assure gravity discharge. In a typical embodiment disclosed, I provide a conical bin symmetrical about a vertical axis and displaying a circular cross-section with suitable openings at top and bottom.

As stated, bins and hoppers of the general type noted may be used for a variety of purposes, illustratively, storage, delivery in metered supply either continuously

or intermittently with volume either varying or continuous in amount as desired, for classification of material from one sorting container to another, as well as for a variety of other and generally similar usages. Take-off from the bottom outlet of the bin may be accomplished in a variety of conventional manner, as heretofore indicated. Illustratively, a rotating screen, a continuously rotatable worm, or the like is provided at the bottom of the hopper. Since these elements are conventional, however, and comprise no part of the present invention specific disclosure thereof is dispensed with in the interest of simplicity and clarity.

Now, if the material undergoing handling be dry and displays rounded, smooth surfaces, it is unlikely that any real difficulty will be experienced during its passage through the hopper. But, when the material being handled is flaky and displays a rough surface, whereby adjacent particles can interengage with each other, or where the material is damp, and particularly when the granular substance is light in weight, jamming frequently is inclined to occur, along the narrowed throat portion of the hopper in the region discharge.

Accordingly on the interior surfaces 11 of the inclined walls of the hopper in the region where jamming is likely to occur of the granular contents of the bin, I provide one or more membranes 12. These membranes are formed of elastic material, of which rubber, either natural or synthetic, is typical, conventional and suitable. Each membrane 12 is made fast to a metal plate 14, illustratively steel, and these plates are secured in desired convenient manner to the walls of the hopper 10 as for example by bolts 13. The combination of membrane and plate conveniently is referred to as a panel.

The membranes 12, shown in collapsed position by solid lines in Figure 1, are intended for distension in pulsating manner by air admitted to the panel, that is, between membrane and back plate. The pulsation of the membranes imparts a pulsating movement to the contents of the hopper thereby eliminating static compression stress zones or arches, either horizontal or vertical, supporting overlying material. This, of course, has the effect of preventing the jamming of the contents of the bin. Both the frequency of pulsation and the amplitude of the same may be adjusted to respond most satisfactorily to the load conditions maintaining within the bin. Thus, when the tendency toward jamming is slight, the frequency of cyclic inflation and deflation of the panels may be decreased, and along with it the amplitude of inflation. And where it is substantial the frequency and amplitude may be increased. A typical inflated position of the panels with distension of the membranes is indicated in dotted lines in Figure 1 at 12A.

I find that it is not enough simply to inflate and deflate the panels 12, 12 with fixed frequency; it is required, for really satisfactory operation, that the control be pressure-responsive, and that means be provided for adjusting the pressure limits to which the control responds. The apparatus now to be disclosed is directed to that objective.

An air line, consisting of metal piping indicated generally at 15, leads from a control unit, indicated generally at 16 (Figure 1), to the panels 12, 12. At 15' the pipe line 15, illustratively of half inch diameter, separates into branch circuits 15A, 15A, provided one for each panel within the hopper. In the illustrative embodiment, two such panels are provided, so that there are two branch lines 15A, 15A. In suitable manner these branch lines let through the walls 11 of the hopper 10 and through the steel plates 14, opening directly into the spaces defined by the plates and corresponding membranes 12, 12. The pipe line 15 serves to admit air to the panels and to exhaust the latter to the atmosphere, likewise through the control 16. The details of this control 16 are best shown in Figure 2.

Having reference now more particularly to Figure 2 it will be seen that although part of the control 16 is

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disposed exteriorly of the casing 17 thereof, this control is provided and installed as a single unit. Control 16 is connected to a suitable source of air supply by way of conduit 18. This air supply is usually maintained in industrial practice at a pressure of some 80 to 150 pounds per square inch.

In order to control the frequency of pulsation, I provide, within the control 16, a valve indicated generally at 19 and directly in line with the air line 18 by union 20 or generally similar connection. Valve 19 is provided with conventional stem 19A and handle or other control means 19B. When control 16 is in use the valve 19 is cracked open only to an extent which will cause inflation of the panels just sufficient to keep the material moving satisfactorily through the hopper 10. Further opening of valve 19 has the effect of permitting air to more quickly inflate the panels, thereby increasing the rate of pulsation of the panel membranes 12, 12.

It will be recalled that in order to properly effect operation of the pulsating membranes, they must first be provided, according to a determinable cycle, with air to inflate the panels with which they are associated and then be subjected to collapse by suitable exhaustion of air within the panels. During a portion of any cycle of operations the air from conduit 18 and valve 19 is provided to the panels. Membranes 12, 12 are thus distended. The amount of distension, or the amplitude of the pulsators, is controlled by a suitable valve dependent upon the pressures reached within the panel as appears more fully hereinafter. When the predetermined distension, or rather, the predetermined distension pressure is reached in the cycle the flow of air to the panels is terminated and these latter are connected to the exterior through conduits 15A, 15' and 15 and control 16. At this point in the operating cycle the load within the hopper 10, as well as the elasticity of the membranes, collapses the same and exhausts the panels to the exterior.

To bring about the intermittent action I provide within control 16 a three-way solenoid valve indicated generally at 21, and having its inlet port connected directly in line with the valve 19. This solenoid valve 21, which in itself is conventional has a valve stem 21A (Figures 3 and 4) which passes through the solenoid winding not shown and is connected to a ported valve piston 21B. The piston passes generally through a cylindrical opening 21C defined by valve walls 21D. Throttled-air line 22 (Figures 2, 3 and 4) lets through the left-hand cylinder wall 23 (Figure 3) into the cylinder 21C.

In the de-energized position of the solenoid as shown in Figure 4, and upon cracking the valve 19 to start the apparatus into operation, the air through pipe 22 passes through the ports 23A and 23B of the solenoid cylinder 21B to the line 24, which latter, it will be called, conveys air to the panels with membranes 12, 12. In the energized position, as illustrated in Figure 3, the solenoid rod 21A brings piston 21B into position which breaks the channel connection between conduit 22 and channel 23A. The piston then establishes a connection between panel line 24, channel 23B, channel 23C and exhaust pipe line 25. This latter passes exteriorly of housing 17 and opens directly to the atmosphere.

For the control of solenoid valve 21 I provide a pressure switch indicated generally at 26 connected to air-line 24. This pressure switch is itself of conventional type such as is now readily available on the open market and its details of construction in large measure are omitted in the interest of clarity. The switch is provided with a low limit pressure adjustment indicated generally at 26A (Figure 2). Usually, and by way of illustration, this is set for actuation of the switch at a pressure of approximately one pound per square inch in air-line 24—15. A high pressure adjustment, indicated generally at 26B, is provided to assure reverse actuation of the switch when a predetermined maximum

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pressure is reached in the line. I find that in my apparatus an upper limiting pressure of thirteen pounds per square inch usually is sufficient. The setting of the adjustment 26B determines the particular pressure in line 24—15 at which the admission of air to the line, and hence to the panels and membranes 12, 12 is cut-off during the course of each operational cycle. The pressure switch 26 is a control for making and breaking electrical contacts, and determines the moment of making and breaking the electrical operating connections for the solenoid valve 21.

As air passes through the valve 21 when the valve 19 is cracked open, it passes through three-way valve 21 in the rest position of the latter, as shown in Figure 4. Air then passes through lines 24 and 15 to the panels having flexible membranes 12. These latter are thereby distended against the load within the bin or hopper 10. At the same time, part of the air passing through line 24 is branched to line 26C leading directly to the pressure switch 26.

Air-pressure builds up within the switch 26 to the same extent as in the panels until a critical value is reached, responding to the particular setting of the high pressure limit adjustment 26B provided. When this pressure is reached the switch is actuated to operate solenoid valve 21, this by way of an electric circuit from the electrical supply line 29 through leads 27, 27 and leads 27', 27' passing directly to solenoid valve.

When valve 21 is operated in the manner indicated, the latter assumes the Figure 3 position, discontinuing air supply from valve 19 and pipe 22, and connecting the panel air line 15 by way of lines 24 to the exhaust conduit 25. As the air passes through line 24 towards the exhaust pipe 25 the pressure falls off in the switch 26 until there is reached the no-load limit pressure setting of adjustment 26A.

When switch 26 acquires its no-load position, it again is actuated, this time however, to bring the solenoid valve 21 into the Figure 4 position, re-establishing the air circuit connections between valve 19 and the panels. The cycle of operation then begins anew.

The control had with the pressure switch 26 is rapid and sensitive and is entirely unaffected by conditions maintaining within the hopper. The pressure-actuated diaphragm or element within switch 26 is affected solely by the air-pressures within the line 24 and associated line 15. Thus, the supply of air to the panels and the flexible membranes 12, 12 is entirely a function of pressure maintaining in the panels and the lines supplying them.

In my apparatus, I preferably employ a safety valve 32 suitably connected between the line 24 from the pressure limiting switch and the line 15 to the inflatable panels. Thus air line 24, as regulated by switch 26, passes through the wall of container 17 to a four-way fitting 31, being connected thereto at 31A. The panel air line 15 is connected to fitting 31 at 31B. An air-pressure gauge, not shown, may be connected to 31 at 31C, here shown as plugged. The safety valve 32, of conventional design, is connected to fitting 31 at 31D. I provide this latter with a mechanical trip member 32A. It should be operated occasionally, to insure freedom of pop-off action. Usually this safety valve is adjusted to release at a pressure of 15 pounds per square inch.

It will be apparent from the foregoing that my new control need be operated only when the hopper is actually in operation. Complete shut-down is achieved by disconnecting the source of electrical supply to the incoming lines 29 and closing valve 19. When control 16 is in service, the valve 19 and pressure switch 26 are adjusted to produce a rate of pulsation and of amplitude best suited for the particular load conditions. These adjustments, as more particularly noted above, may be changed readily and rapidly as load conditions vary. Unlike the earlier expedients first introduced, wide variation in ad-

justment of both speed and amplitude is effectively and readily achieved.

Moreover, since the control is provided at a point which is removed from the panels undergoing control, a more sensitive assembly is effectively achieved. It is free of the dust and vibration of the hopper or bin. No danger of membrane rupture is encountered even through it may be momentarily exposed by the load passing through the associated hopper. This attends upon effective control of the maximum panel pressure by the upper limit position of the pressure switch 26. Since the assembly utilizes a true control, on which are placed no power demands, the parts thereof may be kept quite small. A variety of substantial economies are thereby achieved. The entire assembly is of low first cost and is certain and predictable in operation. Minimum maintenance or attendance is required, and the system displays long useful life.

Moreover, as a further advantage, the control itself readily may be connected to and disconnected from the hopper or bin with which it is associated. Accordingly, therefore, one control readily may serve a number of bins or hoppers provided with expansible panels. And it serves a variety of hoppers whether fashioned of steel, wood or concrete.

It is apparent from the foregoing that once the broad aspects of my invention are disclosed, many embodiments thereof will readily suggest themselves to those skilled in the art. Additionally, many modifications of the present embodiment will likewise be suggested. Accordingly, I desire the foregoing disclosure to be considered simply as illustrative, and not by way of limitation.

I claim as my invention:

1. In combination, a hopper for the passage therethrough of granular and generally similar substances; an elastic membrane provided on the interior wall of said hopper and adapted to be distended and collapsed in pulsating manner, through the admittance and expulsion of air behind said membrane; a source of high pressure air; an air line connecting said source with said hopper wall and membrane for admitting air between the same; and a control means in said air line and physically removed from said hopper, said control means including means for throttling the high pressure air, valve means for intermittently and alternately connecting the membrane air line, first with the throttled air and then with an exhaust line to the atmosphere, and a pressure switch operable as an incident to the pressure of air in said line and membrane, to control, upon reaching its low pressure and high pressure limit positions, the operation of said valve means.

2. In combination, a hopper for the passage therethrough of granular and generally similar substances; a panel with elastic membrane provided on the interior wall of said hopper and adapted to be inflated and collapsed in pulsating manner; an air line connected with said panel for admitting air therein; and a control means physically removed from said hopper, said control means being provided in line with a source of high pressure air and said panel and including means for throttling the high pressure air, electrical solenoid valve means for intermittently and alternately connecting said panel air line, first with the throttled air line and then with an exhaust line to the atmosphere, and an electric switch operated by air pressure of said panel to control, upon reaching its low pressure and high pressure limit positions, the operation of said solenoid valve, and means for adjusting the said limit positions of said pressure switch.

3. Control apparatus, comprising in combination, inlet means connectible with a source of air under positive pressure; throttle means in line with said inlet means for controlling the flow therethrough; outlet means connectible with a load to be supplied by said air; exhaust means connectible with the atmosphere; a three-way valve

physically interconnecting said outlet means with a selected one of said inlet means and exhaust means; and a pressure responsive pressure switch physically connected with said outlet means and electrically connected with said three-way valve, and controlling said valve, in response to air pressure within said outlet means, for changing the position of said valve when the said pressure switch reaches its limit position of maximum pressure and minimum pressure.

4. Control apparatus, comprising in combination, inlet means connectible with a source of air under positive pressure; throttle means in line with said inlet means for controlling the rate of flow of air therethrough; outlet means connectible with a load to be supplied by said air; exhaust means connectible with the atmosphere; a three-way valve physically interconnecting said inlet means, said outlet means and said exhaust means in such manner as to operably connect said outlet means with a selected one of said inlet means and exhaust means while disconnecting the same with the other of the two last-mentioned means; a pressure responsive switch physically connected with said outlet means and electrically connected with said three-way valve, and controlling said valve, in response to air pressure within said outlet means, for changing the position of said valve when the said pressure switch reaches its high pressure and low pressure limit positions and having adjustments for changing the limiting operating pressures; and safety means in line with said outlet means for venting the same upon excess air pressures being reached therein.

5. As part of a pulsating control for facilitating operation of storage bins and hoppers wherein panels with elastic walls are provided within the bin or hopper adapted to be inflated and collapsed in pulsating manner through the admission and avoidance of air led thereto through an air line, a control for regulating the passage of air through said panels provided in the air line to said panels but physically removed from the latter and in circuit with said air line, said control comprising: inlet means adapted to be connected with a positive pressure air supply; outlet means for leading the air to the panels; exhaust means for conducting exhaust air to the atmosphere; a three-way valve for connecting the outlet means with a selected one of said inlet means and said exhaust means; and an air pressure switch controlled by the pressure in said panel line and connected to said valve so as to operate the same upon attainment of high pressure and low pressure limit positions of the said switch.

6. As part of a pulsating control, inlet means adapted to be connected with a positive pressure air supply; a throttle valve connected with said inlet means; outlet means for the throttled air; exhaust means for conducting exhaust air to the atmosphere; a three-way solenoid valve for connecting the outlet means with a selected one of said inlet means and said exhaust means, the connection of said outlet means to either one of the two last-mentioned means being terminated upon establishment of its connection with the other of the two last-mentioned means; and an air pressure switch connected to the outlet line and electrically connected through a source of electric supply to said solenoid valve so as to operate the solenoid valve upon attainment of high pressure and low pressure limit positions of the said switch, said pressure switch including means for adjusting the limit positions thereof.

7. In combination, an elastic air-tight walled membrane; means for supplying air under pressure back of said membrane; means physically removed from said membrane and responsive to the pressure of the air; and valve means under the control of the pressure responsive means for periodically interrupting said air flow and interconnecting said membrane to the atmosphere for discharge upon a predetermined maximum limiting pressure being reached in said pressure-responsive means and re-establishing said flow of air upon reaching a predetermined minimum pressure.

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8. The method of assuring a free flow of material from a storage bin having therein a flexible membrane secured to a back plate, across which flexible membrane said material passes, comprising distending said membrane with air from an external source to build up the pressure against said membrane to a predetermined maximum; momentarily discontinuing, from a removed control point, the supply of air to said membrane; releasing the air against said membrane and exhausting the same into the atmosphere to permit the membrane to collapse; and upon a predetermined minimum pressure against said membrane being reached continuing from said removed control point the supply of air against the membrane, whereby intermittent discharge of said membrane is had at a rate depending upon the maximum and minimum pressures against the same.

9. In combination, a bin or hopper having sloping walls for the storage or discharge of material therefrom; an elastic, air-tight walled membrane provided on the inner surface of said bin in the path of said material; means for supplying air under pressure back of said membrane; and means, physically removed from said mem-

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brane and in circuit with said air-supply means, for controlling the flow of air to said membrane in response to predetermined maximum and predetermined minimum pressure values of the air circuit including valve means under the control of said pressure responsive means for periodically interrupting said air flow and interconnecting the said membrane to the atmosphere for discharge upon the maximum pressure being reached and reestablishing said air flow upon reaching said minimum pressure.

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