

Jan. 16, 1945.

H. BEDDOES

2,367,260

PRESSURE AND VACUUM RELIEF DEVICE

Filed May 2, 1942

4 Sheets-Sheet 1

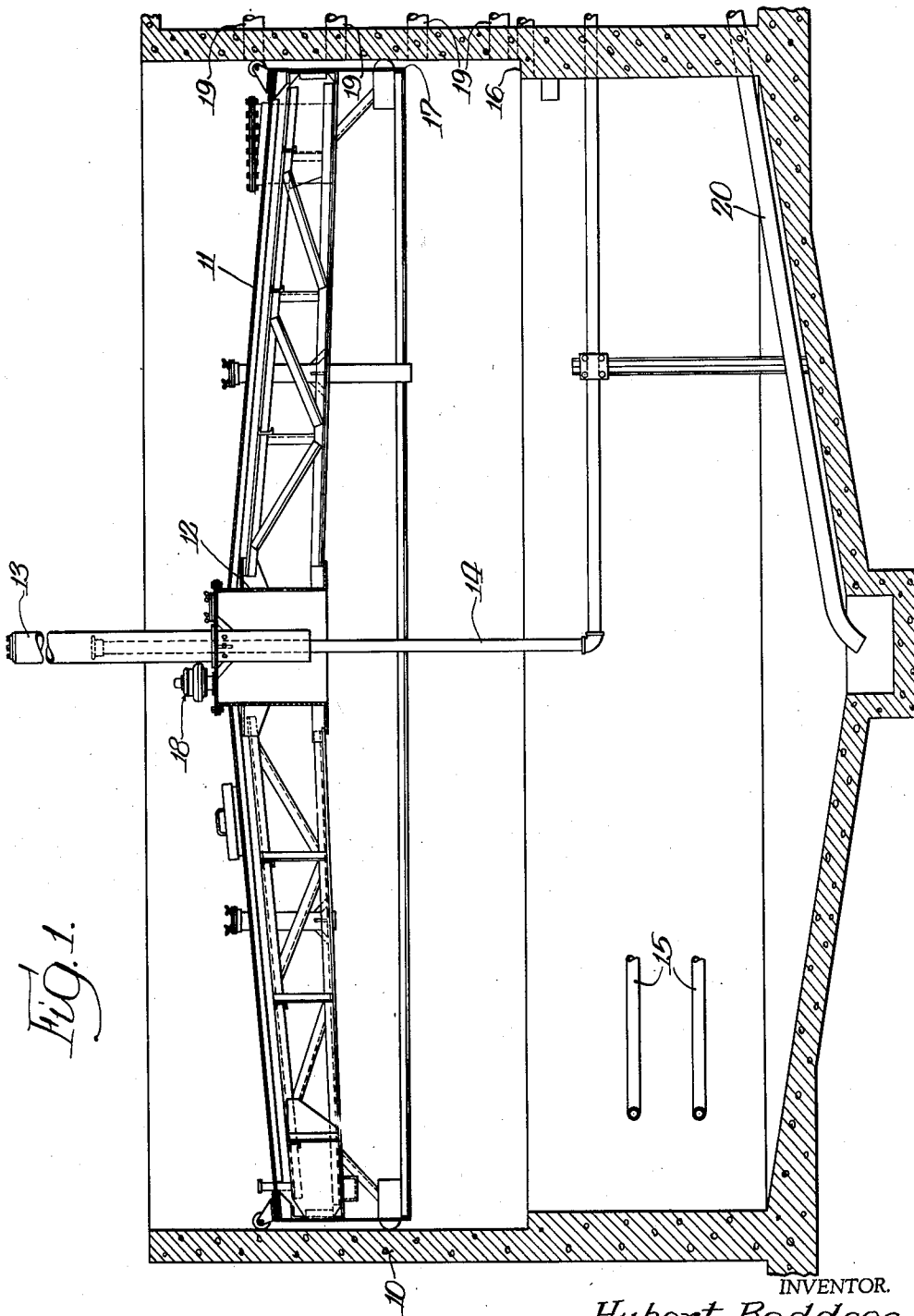


Fig. 1.

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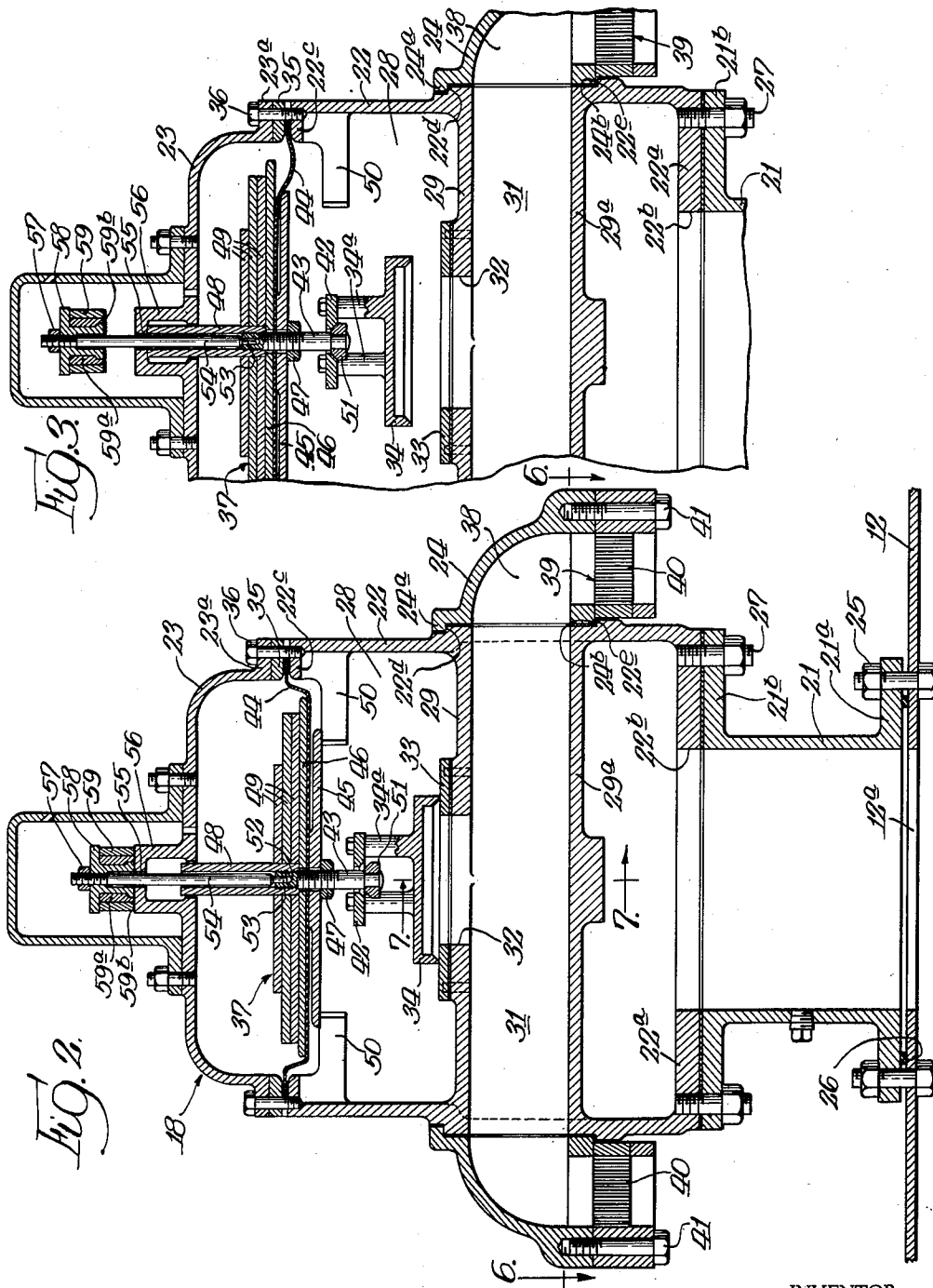
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PRESSURE AND VACUUM RELIEF DEVICE

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4 Sheets-Sheet 2



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PRESSURE AND VACUUM RELIEF DEVICE

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4 Sheets-Sheet 3

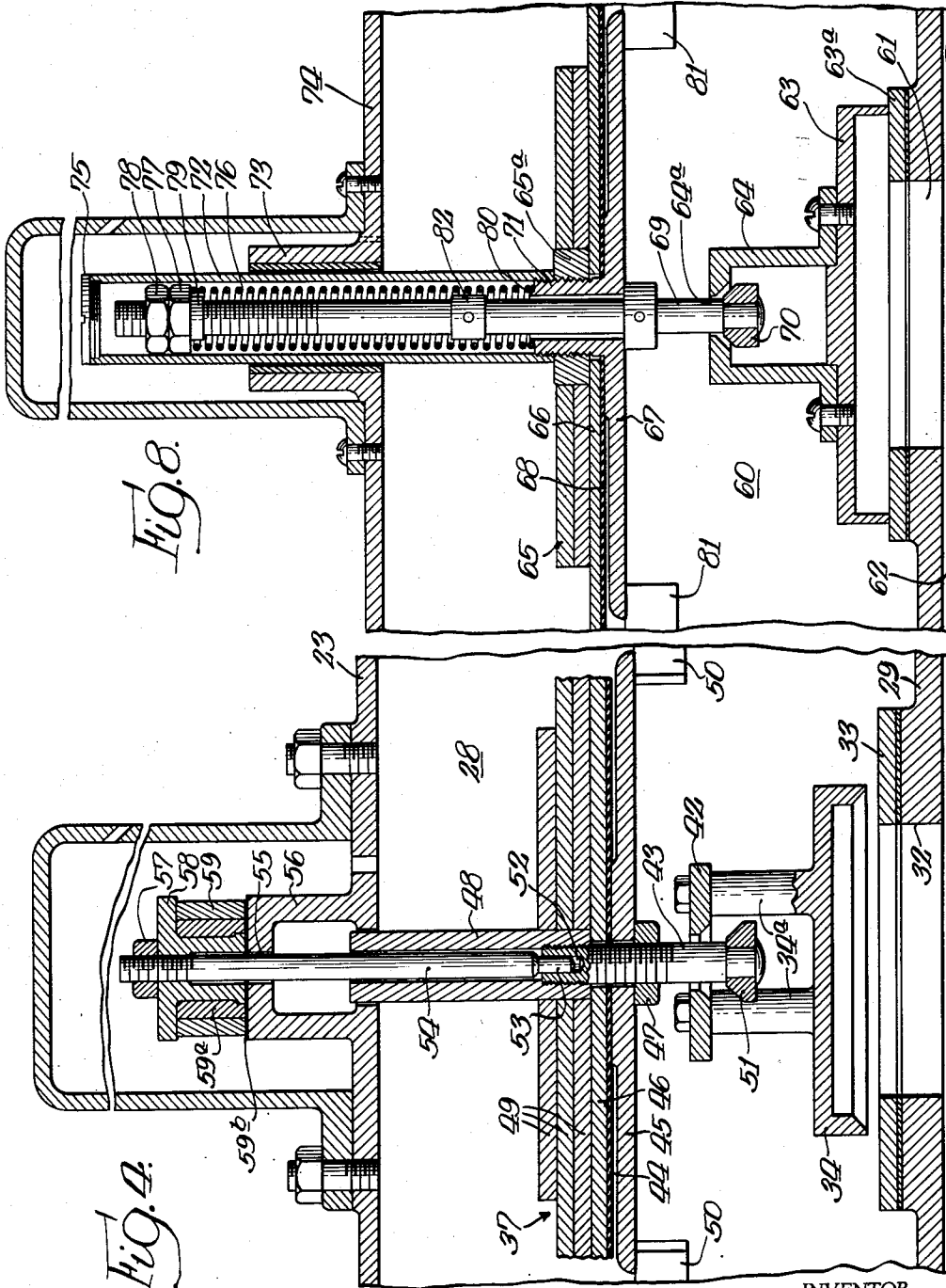


Fig. 4.

Fig. 8.

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PRESSURE AND VACUUM RELIEF DEVICE

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Fig. 5.

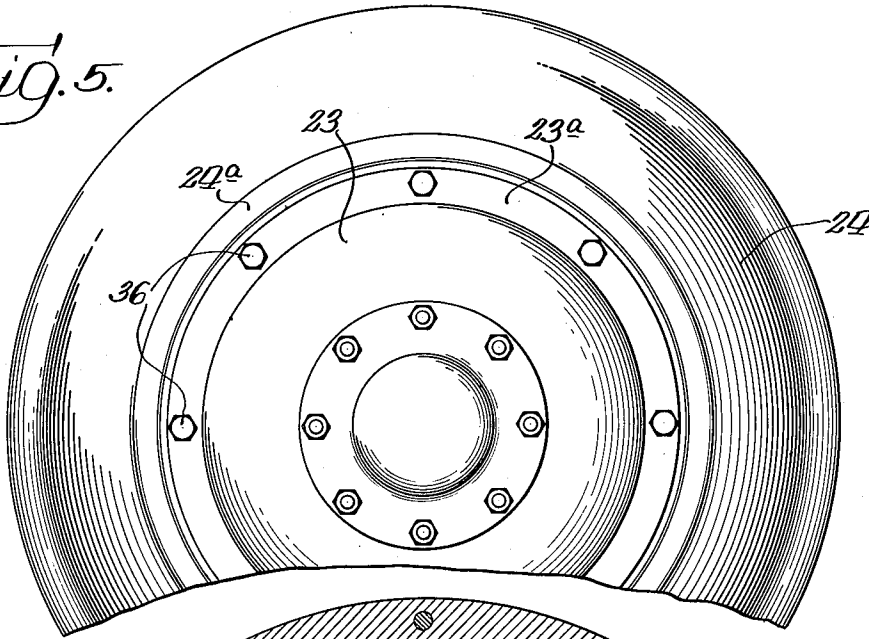


Fig. 6.

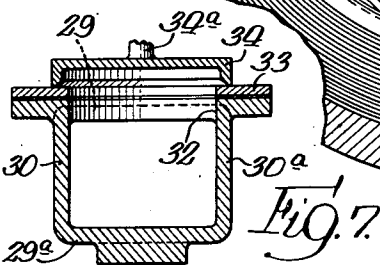
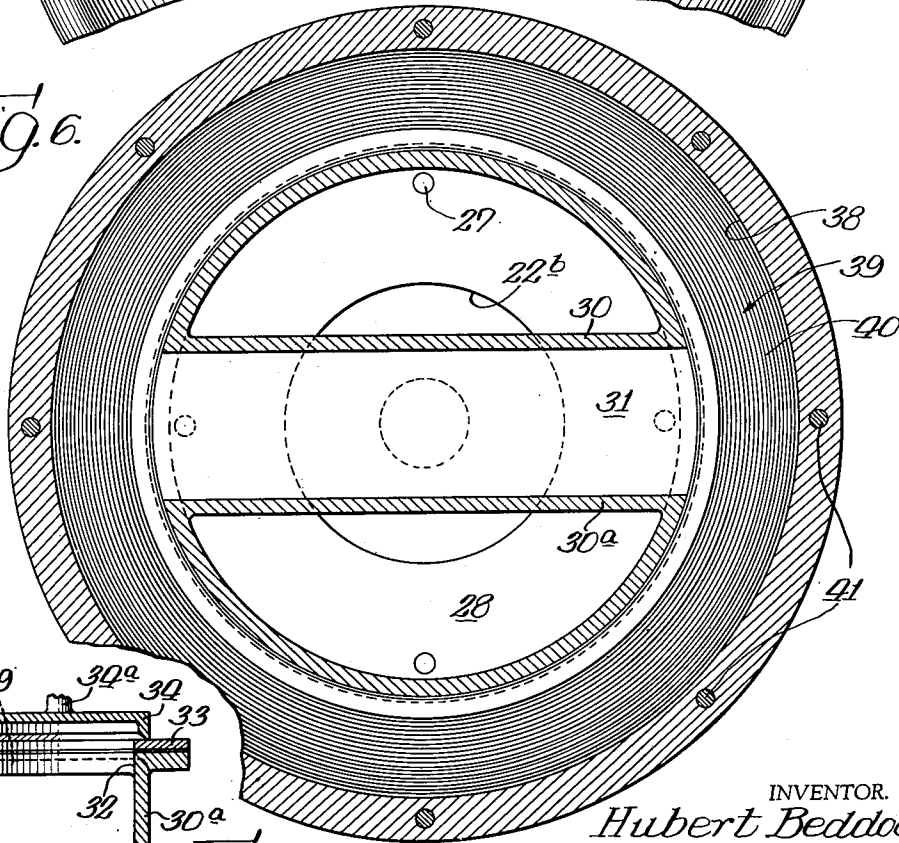


Fig. 7.

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UNITED STATES PATENT OFFICE

2,367,260

PRESSURE AND VACUUM RELIEF DEVICE

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corporation of Illinois

Application May 2, 1942, Serial No. 441,459

10 Claims. (Cl. 137—53)

My invention relates to pressure control devices and it has to do particularly with pressure and vacuum relief devices especially adapted for use with sewage digestion tanks.

In the digestion of sewage sludge a combustible gas is formed. Such gas is formed at varying rates depending upon the character of the sludge, the quantity of sludge introduced into the digestion tank from time to time, and the temperature under which the digestion action is carried on. It is desirable that this gas be discharged as rapidly as it is generated to avoid the build-up of an excessive pressure within the digestion tank.

The gas so generated, or at least part of it, is ordinarily utilized in the operation of the sewage plant and, naturally, more gas may at times be generated than is required for consumption purposes in the operation of the plant. In that case it becomes necessary to discharge the unused or waste gas to a point of waste consumption such, for example, as a waste gas burner, as more fully explained in my copending application Serial No. 425,248, which issued as Patent No. 2,348,104 on May 2, 1944, covering a Safety device for gas producing systems.

My invention is particularly well suited for use in connection with digestion tanks of the floating cover type wherein, as the pressure in the tank is increased, the cover tends to rise, compensating for the same. There is, though, a limit to which the cover may be safely raised and, if raised beyond that point, the equilibrium of the cover may be upset thereby causing possible damage to pipes and other equipment associated therewith. Such a condition may result in the escape of gas thereby creating highly objectionable conditions from the standpoints of odor and explosion. Under ordinary circumstances, the waste gas burner, together with the normal gas consuming devices of a sewage plant, such as explained in my said copending application, take care of normal gas pressure conditions within the digestion tank. However, these consumption devices are usually located quite some distance from the digestion tank, thus requiring long piping with valves or other control devices therein. Consequently, neglectful closing of valves or the collection of moisture in this piping may prevent the flow of gas through the normal relief channels, in which case an excess pressure might be built up within the digestion tank with damaging results. Or, this condition might result through the functioning of flame arrester or other safety gas cut-off means at the point of utiliza-

tion or waste consumption. Therefore, in order to provide a fool-proof safety control means in the handling of the gas generated in the digestion tank, and to prevent under all conditions excess pressure therein, it is highly desirable to provide pressure relief means directly associated with the digestion tank, the same functioning as a secondary control.

Also, in the use of the floating cover type of tank, the cover is lowered as material is withdrawn from the tank. Due to the fact that various piping and other equipment may be located within the tank, it is desirable to limit the extent to which the cover may be lowered. Consequently, if, after the cover reaches its lower limit, a further withdrawal of material is effected, a subatmospheric condition or partial vacuum may be produced within the tank with resultant collapse of the cover or tank wall. This condition might also exist in extremely cold weather in the event that the cover should become frozen in place and would not lower normally upon the withdrawal of material from the tank. Vacuum relief means is required to prevent the foregoing conditions.

It has been customary heretofore to handle the foregoing conditions by combined pressure and vacuum relief units, which units employ two separate valves, one for pressure relief whereby excess gas is discharged to atmosphere, and the other for vacuum relief whereby atmosphere is admitted to the tank. These prior devices are subject to serious objection for various reasons. For example, the valve structure which is adapted to relieve vacuum operates only on rare occasions and is therefore inclined to become corroded and frozen, so to speak, in place so that when operation is required it tends to stick with damaging results. Also, the pressure relief valve of such unit has always been so arranged that it opens gradually to relieve gas in varying quantities. This produces a very objectionable condition during cold weather operation in that the digestion action is carried on under a much higher temperature condition than exists outside the tank with the result that the relieved or escaping gas is warmer than the atmosphere and the gradual release of the same in the form of a small stream of vapor-laden gas results in the coating of the discharge with frost and ice, thereby tending to block or objectionably restrict the same. This is all the more objectionable due to the fact that for safety purposes a flame arresting means is usually associated with the discharge for the usual purpose and the frost and ice tends to col-

lect very rapidly in the small discharge passages of the flame arrester device, quickly clogging the same during cold weather to such an extent that if not carefully attended to it may result in harm because of excess pressure or may create a fire and explosion hazard.

One of the objects of my invention is to provide a pressure and vacuum relief unit for sewage digestion tanks by which all of the foregoing objectionable conditions are avoided.

Another object is to provide improved means of the foregoing character which is of simple construction, embodies a minimum number of parts all of which are readily accessible, is economical to manufacture and maintain, and is highly reliable in operation under all weather conditions.

A further object is to provide an improved pressure and vacuum relief valve wherein a single valve member serves for both pressure and vacuum relief, the arrangement being such that the same valve member will be opened when either a predetermined subatmospheric or a predetermined above-atmospheric pressure is acting on the same side thereof.

Additional objects are to provide valve structure of the foregoing character which is provided with a quick opening action; to provide valve structure which is self-cleaning in operation, thereby insuring proper opening and closing of the valve means at all times; to provide a pressure and vacuum relief arrangement including a valve which is actuated for instantaneous opening when a predetermined excess pressure is built up and which is opened gradually and variably when a predetermined subatmospheric pressure exists within the tank; to provide valve structure adapted for the discharge of excess pressure from the tank without the danger of ice or vapor forming and clogging the discharge passageway; to provide valve structure having flame arrester means associated with its discharge and being so constructed and arranged that the flame arrester discharge is kept free of ice and frozen vapor formations during cold weather operation; to provide valve structure which is adapted to open in such a way as to permit a large quantity of gas to escape very quickly; to provide valve structure of the foregoing character which is provided with magnetic control for producing a quick, full opening action; to provide valve structure of the foregoing character adapted to be actuated by diaphragm means for pressure relief opening, the valve normally being disengaged from the diaphragm means so that it remains closed under its own weight plus the pressure acting thereon; to provide valve structure of the foregoing character which is especially adapted for the inclusion of flame arrester means in its discharge; and to provide valve structure by which an opening action for pressure relief does not take place until the maximum pressure permitted is either reached or exceeded.

Other objects and advantages will become apparent as this description progresses and by reference to the drawings wherein,

Figure 1 is a vertical sectional view of one form of digestion tank having my invention applied thereto;

Fig. 2 is an enlarged vertical sectional view of one form of pressure and vacuum relief unit embodying my invention, the structure being shown in valve-closed condition;

Fig. 3 is a fragmental sectional view similar to

Fig. 2 except illustrating the structure in full, valve-opened condition for pressure relief;

Fig. 4 is an enlarged vertical sectional view of the valve and operating mechanism of Figs. 2 and 3, the valve being shown in open position as when a vacuum or subatmospheric pressure is present in the digestion tank;

Fig. 5 is a top plan view of the relief unit shown in Figs. 2 and 3;

Fig. 6 is a section taken substantially on line 6—6 of Fig. 2;

Fig. 7 is a section taken substantially on line 7—7 of Fig. 2; and

Fig. 8 is a vertical sectional view of a modified form of pressure and relief unit embodying my invention.

I have illustrated my invention as applied to a digestion tank 10 (Fig. 1) having a floating cover 11 with the usual gas dome 12. The cover 11 is adapted normally to rest upon the material in the tank 10 and is raised and lowered as the level of such material changes. Gas generated in the digester is collected in the dome 12, which gas is discharged therefrom through a gas pipe housing 13 and pipe 14 leading to points of plant utilization and waste disposal (not shown). The digestion tank is provided with the usual heating coils 15.

It is desirable that the lowering movement of the cover 11 be limited and to that end the inner wall of the tank 10, which is circular, is provided with an annular shoulder 16 adapted to be engaged by the annular skirt or side wall 17 of the cover when the latter is lowered a predetermined extent. In accordance with my invention, a combined vacuum and pressure relief unit 18 is associated with the gas dome 12 for relieving excess pressure within the tank or for admitting atmospheric pressure to the tank when such pressure is lowered a predetermined extent as by withdrawing material from the tank after the cover 11 is resting on the shoulder 16 or in the event that material is withdrawn from the tank with the cover frozen in place, as might occur during extremely cold weather. The tank is further provided with the usual supernatant liquor draw-off pipes 19 and a sludge draw-off pipe 20.

The vacuum and pressure unit 18 (Figs. 2 to 7) takes the form of a sectional annular casing having a hollow base section 21, an intermediate or body section 22, a top section 23 and a flame arrester discharge section 24 carried by the intermediate section 22. The base section 21 is provided with a bottom flange 21^a secured to the top of the dome 12 by stud bolts 25 in alignment with a gas dome opening 12^a. The joint between the flange 21^a and the dome 12 may be sealed by any suitable gasket means such as that indicated at 26 (Fig. 2). The upper end of the base section 21 is provided with an annular flange 21^b upon which is received the bottom 22^a of the intermediate or body section 22, these sections being secured together by stud bolts 27. The bottom of the intermediate section 22 is provided with an opening 22^b which communicates with the base section 21 and, in turn, the gas dome 12.

The intermediate or body casing section 22 provides an enlarged intermediate or so-called pressure chamber 23 which is directly connected to the gas dome 12 so that there exists therein at all times the same pressure as in the gas dome. The interior central portion of the body section 22 is provided with right-angularly disposed partition walls 28, 29^a, 30 and 30^a (Fig. 7)

forming within the chamber 28 a discharge or so-called atmospheric chamber 31 which is connected to the intermediate pressure chamber 28 through an opening 32 in the wall 29. The opening 32 is provided therearound with a valve seat 33 adapted to cooperate with a valve 34 which is adapted normally to close the opening 32 under its own weight and the pressure in the chamber 28.

The upper casing section 23 is provided with an annular flange 23^a which seats upon a so-called holding ring 35 which is in turn seated upon an annular flange 22^c at the upper end of the intermediate section 22, being secured thereto by stud bolt devices 36. The top casing section 23 houses a diaphragm unit 37 and mechanism operated thereby for opening the valve 34 when a predetermined pressure is built up in the chamber 28.

The flame arrester discharge section 24, which is ring-shaped, is provided with a discharge chamber 38 which is directly connected to the opposite ends of the atmospheric or discharge chamber 31. This section is supported by the section 22 and to that end the section 22 is provided with a pair of vertically spaced annular shoulders 22^d and 22^e upon which are adapted to seat annular shouldered portions 24^a and 24^b of the section 24, the section 24 being adapted to be passed downwardly over the body section 22 until these shouldered portions engage each other. When the section 24 is so mounted as shown in Fig. 2, it is held in position by its own weight plus that of a flame cell or arrester 39 mounted in the discharge end of the discharge chamber 38. This flame arrester may take any suitable form and, preferably, comprises an annular cell-like structure including a plurality of elongated restricted passageways 40 supported as a unit in the discharge end of the chamber 38 by a plurality of stud bolts 41. The flame arrester, as customary, is so constructed that in the event escaping gas is ignited exteriorly thereof, it will prevent the flame from passing backwardly therethrough into the discharge chambers 38 and 31 and into the digestion tank.

As already pointed out, my invention contemplates the use of a single valve 34 openable to discharge to atmosphere when an excess pressure is built up in the digestion tank 10 and which is also openable to admit atmosphere to the tank when a vacuum or subatmospheric pressure is produced within the tank. I am able to accomplish this by at all times exposing the upper or pressure chamber side of the valve 34 to the pressure within the tank 10 and by providing the diaphragm unit 37 which acts as a pressure control for the valve for venting excess pressure, which control is ineffective for opening the valve to admit atmosphere to the tank when a vacuum condition exists therein.

More particularly, the valve 34, which is circular in shape, is provided with central upstanding lugs 34^a which support at their upper ends a valve lifting plate 42. Valve 34 is adapted to be moved to open position by a valve lifting stem 43 operated by the diaphragm unit 37, the valve 34 and stem 43 being connected by a lost-motion connection, as will be pointed out further hereinafter.

The diaphragm unit 37 includes an annular flexible diaphragm 44 having its peripheral edge secured between the holding ring 35 and the upper flange 22^c of the body section 22. Follower plates 45 and 46 are secured to the opposite

sides of the diaphragm 44 as follows: The follower plates 45 and 46, as well as the diaphragm 44, are provided with aligned openings through which an upper threaded portion of the valve operating stem 43 passes. These members are secured together by a lower follower nut 47 engaging the threaded valve stem and an upper diaphragm guide sleeve 48 secured to the upper end of the valve guide stem and projecting upwardly through the top wall of the upper section 23. The diaphragm unit is further provided with a plurality of weight plates 49 having central openings which permit them to be passed downwardly over the guide sleeve 48 so that they rest upon the upper follower plate 46. The foregoing arrangement is such that the underside of the diaphragm unit 37 is exposed to the pressure in the chamber 28 and, in turn, the digestion tank, and by varying the number of plates 49 or the weight thereof, or both, the pressure required to lift the diaphragm unit may be varied.

The diaphragm unit 37 in its normal lower position has its bottom follower plate 45 resting upon a plurality of radial arms 50 extending inwardly from the wall of the body section 22. These arms are so positioned that when the diaphragm unit 37 comes to rest thereupon, the weight of the diaphragm is carried by such arms and is not imposed upon the valve 34, the lost motion connection between the valve 34 and stem 43 permitting this, whereby the valve 34 is free, independently of the diaphragm unit 37, to open when a predetermined subatmospheric pressure is present in the chamber 28.

To the foregoing end, the valve lifting plate 42 is provided with a central opening through which the valve lifting stem 43 passes downwardly. The lower end of the valve lifting stem below the valve lifting plate 42 is provided with an enlarged head member 51, the arrangement being such that in the lowered position of the diaphragm unit wherein it rests upon the arms 50 the valve operating stem 43 moves downwardly sufficiently to move the head 51 below the plate 42 a predetermined extent, thereby permitting the valve 34 to rest upon its seat 33 under its own weight. With this arrangement, whenever a pressure exists in chamber 28 sufficient to raise the diaphragm unit 37, the first movement of such unit upwardly lifts the same from the arms 50 until eventually the head 51 of the valve operating stem 43 engages the valve lifting plate 42 so that upon further upward movement of the diaphragm unit the valve 34 is lifted from its seat 33.

The actual opening of the valve is accomplished by a quick action feature. Such valve remains closed until a predetermined maximum pressure is built up in the chamber 28, at which time it is opened not only fully but quickly so as to instantaneously vent the chamber 28 and, in turn, the digestion tank 10 to atmosphere past the valve 34 through discharge passages 31 and 38 and a flame arrester 39. By operating the valve in this manner, any tendency for ice or frost to form in the flame arrester orifices is avoided, the velocity of escaping gas will keep the valve seating surfaces clean, and the device will be kept in condition at all times not only for pressure relief but vacuum relief.

The quick action opening just referred to, in the form shown in Figs. 2, 3 and 4, is accomplished through magnetic means. Specifically, the upper end of the valve lifting stem 43 is provided with an elongated axial bore 52 in which

is received the reduced lower end 53 of a depending stem 54 of a so-called floating magnetic unit. The stem 54 extends upwardly and slidably through the diaphragm guide sleeve 48 and therebeyond through an opening 55 in a cage-like stationary armature member 56 projecting upwardly from the top wall of the upper section 23. The casing including the cage member 56 is preferably formed of cast iron and the top surface of the cage is provided with a smooth machined surface. The upper end of the stem 54 is threaded and is secured by a nut 57 to an annular magnet core element 58 formed of a comparatively soft steel material and which carries a ring-shaped permanent magnet 59 within which is disposed a lead or other suitable non-magnetic core 59^a. The magnet 59 is supported in such a way that it is normally spaced about .010 inch from the armature member 56. To this end a spacer 59^b formed of paper or any other suitable material may be secured in any desired manner to the lower face of the magnet 59. In this way the magnet 59 rests normally in spaced relation to the armature 56 under the weight of the magnetic unit, and it is held in that position by the magnetic locking or holding effect afforded by the magnet 59 and the armature 56. This magnetic locking or holding effect may be varied, but I have found, for example, that my purpose may well be served, under conditions hereinafter pointed out, by employing a magnet which requires a force of approximately five pounds to initially move it away from its normal or at-rest position. The armature cage 56 receives the upper end of the diaphragm guide sleeve 48, as illustrated in Fig. 3, and it serves as a stop for the upper end of such sleeve, thereby limiting the extent of opening movement of the valve 34 under the influence of the diaphragm 44.

It will be noted, by reference to Fig. 2, that, when the diaphragm unit 37 is in its lowermost position resting upon the arms 50 and the magnet 59 is in its lowered at-rest position relative to the armature 56, the enlarged head 51 on the valve lifting stem 43 is spaced downwardly from the valve lifting plate 42 a distance greater than the distance that the lower end of the reduced stem 53 is spaced from the bottom of the bore in the valve lifting stem 43. Thusly, there is provided a greater lost motion connection between the valve 34 and its valve operating stem 43 than between the valve operating stem 43 and the magnet stem 54. By this arrangement when the diaphragm unit 37 is initially raised, the valve lifting stem 43 will first be moved to pick up the magnet operating stem 54 before the head 51 on the stem 43 picks up or engages the valve lifting plate 42. By way of example, assuming that the structure is set to operate to relieve an excess pressure in the digestion tank (chamber 28) of, for example, $4\frac{1}{2}$ "', the diaphragm unit will be so weighted by the weight plates 49 that when a 3" pressure is built up in the tank, the diaphragm will be raised sufficiently to engage the valve lifting stem 43 with the magnet stem 54. A further increase in pressure, for example to 4"', will overcome the initial holding effect of the magnet 59 whereby the diaphragm 44 will lift the magnet stem 54 and move the magnet 59 further from the armature 56 until the head 51 on the valve lift stem 43 engages the valve lifting plate 42. This movement of the magnet 59 is about $\frac{1}{64}$ "' and when the magnet is so moved its holding effect is reduced to approximately three pounds. At this time there are

three separate forces tending to prevent further motion; namely, the weight of the diaphragm unit 37, the magnetic assembly and the valve assembly, the pressure acting on the upper side of the valve, and the pull or holding effect of the magnet 59. At a predetermined maximum pressure, of, for example, $4\frac{1}{2}$ "', all of these forces will be overcome and the valve 34 will be raised from its seat, thereby admitting a slight pressure to its underside which tends to reduce the force necessary to cause motion upward. Furthermore, in this action, the magnet 59 is moved further away from its armature 56 causing a very rapid reduction in the force tending to prevent motion. As this movement of the magnet 59 continues, the force of the same is rapidly reduced to zero, thereby resulting in a rapid upward motion of the valve opening means to the fullest extent, as shown in Fig. 3.

While the foregoing manner of operation well serves my purpose, equally good results may be obtained by the following modified arrangement. The power of the magnet 59 may be increased to an extent (for example, ten pounds, or such other holding power as is greater than the weight of the valve 34 plus the pressure holding it to its seat) wherein the magnetic locking effect of the magnet 59 will then hold the diaphragm unit 37 against movement until the maximum pressure of $4\frac{1}{2}$ "' is built up in chamber 28. In other words, upon a 3" pressure build-up in the digestion tank (chamber 28) the diaphragm unit will move the valve lift stem 43 to pick up the magnet stem 54, but the magnet 59 will not be moved until the predetermined maximum pressure is built up in the chamber 28. When this maximum pressure is reached or exceeded, the magnetic lock afforded by the magnet 59 is broken and the magnetic unit starts to move away from its armature 56. As soon as that happens the magnetic hold of the magnet 59 is rapidly reduced to zero and the full pressure in the chamber 28 is effective to move the diaphragm unit 37 upwardly. This diaphragm movement is very rapid with a resultant quick opening action of the valve 34 to its fullest extent, as shown in Fig. 3. In this case, the valve 34 is picked up by the stem 43 and moved at about the time that the magnet 59 is removed from the armature 56 about $\frac{1}{64}$ "'.

In either of the foregoing arrangements, as soon as the excess pressure in the chamber 28 has been relieved and the normal or near normal pressure permitted in the digestion tank is reached, the diaphragm unit 37 moves downwardly, in turn lowering the magnet 59 and the valve 34 until the parts are restored to the position shown in Fig. 2 wherein the magnet again exerts its full drag effect and the valve closes the opening 32. This action is repeated again and again whenever excess pressure conditions exist in the tank.

The quick action valve opening produced in the foregoing manner discharges the gas through the flame arrester unit 39 at such a high velocity that the flame arrester cells or passages 40 are kept free of ice and frost formations even though the discharging gas may be at a much higher temperature than the outside temperature, and the valve 34 and its seat 33 are kept free of scale and dirt so that the valve will always seat properly and will not stick.

It will be seen by referring to Fig. 2 that when the valve 34 and the diaphragm unit 37 are in their normal, non-pressure conditions, the valve

34 is resting under its own weight against its valve seat 33. Also, the top of the valve 34 is exposed to the pressure in the chamber 28 and in the digestion tank while the bottom or opposite side of the valve is exposed to atmospheric pressure through the discharge passages 31 and 38. Consequently, with the valve 34 a floating unit as described, the same being free to move upwardly independently of the valve lifting stem 43, if the pressure in the chamber 28 is reduced to a sub-atmospheric pressure or a vacuum, the pressure differential then existing between the discharge chamber 31 and the chamber 28 will tend to lift the valve 34 from its seat 33. Consequently, when a predetermined subatmospheric pressure or vacuum is produced in the chamber 28, creating a pressure differential sufficient to overcome the weight of the valve 34, this valve will be moved upwardly, being guided by the valve lifting stem 43, thereby admitting air past the flame arrester unit 39 through the discharge passages 31 and 38 and past the valve 34 into the chamber 28, as illustrated in Fig. 4. As soon as the pressure conditions between the digestion tank and the atmosphere have been nearly equalized, dependent upon the weight of the valve 34, the valve 34 will move downwardly under its own weight and again become seated to close the opening 32 and cut off the digestion tank from the atmosphere. The diaphragm unit 37 and the magnet 59 do not enter into operation and no quick action opening is required. In this case, the cooler atmospheric air is passing inwardly from the outside and the frost or ice forming condition previously described will not exist. The proper opening of the valve for vacuum relief is insured through the quick action opening of the valve during pressure relief, which keeps the valve surfaces clean and in condition to open at all times without sticking.

While I prefer to utilize magnetic means for accomplishing the quick action opening feature of my invention, it may well be accomplished in other ways, for example, as illustrated in Fig. 8. This form is similar to that previously described except that I employ a spring means for accomplishing the quick action opening movement of the valve. Specifically, the pressure chamber 60 is connected to a discharge chamber 62 by an opening 61 which is closed by a valve 63 having a lift cage 64 projecting upwardly therefrom. The valve 63 is adapted to be opened for pressure relief by a diaphragm unit 65 having follower plates 66 and 67 disposed on opposite sides of a flexible diaphragm member 68 and locked together by a nut 65^a engaging a central threaded hub 71 on the lower plate 67 which passes freely through an opening in the other plate 66. The valve 63 is connected to the diaphragm unit 65 by a valve lift stem 69 which projects downwardly through an opening 64^a in the valve lift cage 64. The lower end of the stem 69 is provided with an enlarged head 70 which is adapted to cooperate with the valve cage 64 similarly to the head 51 on the valve lifting stem 43 of the first form.

The valve lifting stem 69 projects upwardly through the hub 71 and extends upwardly therefrom within a tubular guide sleeve 72 slidably mounted within a tubular extension 73 in the upper wall of the valve body 74. The upper end of the sleeve 72 is provided with a closure cap 75 which is adapted to form a gas tight closure to prevent escape of gas which tends to pass between stem 69 and hub 71. The valve lifting stem is connected to the diaphragm unit by a

spring 76 as follows: The upper end of the valve lifting stem is threaded for reception of a pair of nuts 77 and 78, the latter being a lock nut. The spring 76 is long enough to extend from the upper end of the follower plate hub 71 to the nut 77, the nut 77 and the upper end of the hub 71 being provided with reduced annular portions 79 and 80 for receiving and confining the opposite ends of such spring. With this arrangement, the valve stem is lifted and the valve 63, in turn, opened by movement of the diaphragm unit 65 through the spring 76. That is to say, as pressure is built up in the digestion tank and, in turn, the chamber 60 to a certain point, for example, 3", the diaphragm unit 65 is moved from its supporting arms 81 to a predetermined extent, in turn moving the stem 69 upwardly to engage its enlarged head 70 with the valve lifting cage 64. As the pressure in the chamber 60 is increased, the diaphragm unit 65 continues to move upwardly and when it is moved upwardly sufficiently, as when a 4½" pressure is reached, the spring 76 is compressed sufficiently to exert the force necessary to additionally lift the weight of the valve 63 and its cage 64 against the force tending to hold it to its seat, thereby moving the valve with a snap-action away from its seat 63^a to vent the chamber 60 to atmosphere by way of the discharge chamber 62, as in the first described form.

In this snap action movement the diaphragm unit 65 moves upwardly on the stem 69 compressing the spring until the hub 71 comes in contact with a collar 82 fixedly secured to the stem 69. At this time there are two forces tending to prevent upward motion, that is, the weight of all the moving parts and the pressure exerted upon the valve 63. A predetermined increase in pressure, as stated, will overcome both of these forces and cause the valve 63 to lift from its seat thereby admitting a slight pressure on its underside. As the valve 63 continues to open this further reduces the force tending to hold it to its seat and this reduction in force is at a greater rate than the force of the spring 76 tending to lift the valve and its stem through the hub 71 thereby causing it to snap open without further motion of the diaphragm unit 65. The reverse movements are carried out when the pressure in the digestion tank is reduced a predetermined extent, the valve 63 being again closed.

The floating connection between the valve lifting stem 69 and the valve lift cage 64 permits the same valve action under control of a vacuum or subatmospheric pressure in the digestion tank, as explained in connection with the first form. In that case, atmospheric pressure acting on the underside of the valve 63 and a subatmospheric pressure acting on the top of such valve causes the valve to lift whenever a predetermined differential sufficient to overcome the weight of the valve 63 is established, thereby admitting atmospheric air to the tank by way of the discharge passage 62 and chamber 60.

I believe that the operation and advantages of my invention will be clearly understood from the foregoing description. Briefly, my invention provides an arrangement wherein, during pressure relief operations, the valve is not opened until the maximum pressure permitted is fully reached or exceeded. When the valve opens it opens fully and quickly so as to instantaneously vent the excess pressure to atmosphere at a very high rate. This fully eliminates the objectionable conditions existing in prior systems wherein

a gradual opening of the valve with the consequent escape of gas is carried out. The valve is thus made self-cleaning, the discharge is kept free of frost and ice formations, and other clogging conditions are eliminated. The valve arrangement for pressure relief facilitates vacuum relief in that the same valve is employed for both and it is always maintained in a condition ready for operation. Furthermore, my invention provides a foolproof device which is positive in operation and which insures a proper control of the digestion tank pressure at all times under all weather conditions.

I claim:

1. In structure of the class described, a casing having a pressure chamber and an atmospheric chamber disposed within and connected to said pressure chamber, a valve in said pressure chamber and normally acting under its own weight and the pressure in said pressure chamber to close the connection between said chambers so that when a subatmospheric pressure sufficient to overcome the weight of said valve exists in said pressure chamber said valve is opened to admit atmospheric air to said pressure chamber from said atmospheric chamber, and means normally disconnected from said valve and movable upon a predetermined increase in said pressure chamber to engage and move said valve to open position, and releasable holding means adapted to prevent opening movement of said first means beyond the point of initial engagement with said valve until a predetermined maximum pressure is built up in said pressure chamber, at which time said holding means is released to cause said first means to move beyond said point of initial engagement with said valve under said predetermined maximum pressure to open said valve fully with a quick action.

2. In structure of the class described, a casing having a pressure chamber and an atmospheric chamber disposed wholly within and connected to said pressure chamber, means for venting said atmospheric chamber to atmosphere comprising a valve in said pressure chamber and normally acting under its own weight and the pressure in said pressure chamber to close the connection between said chambers so that when a subatmospheric pressure sufficient to overcome the weight of said valve exists in said pressure chamber, said valve is opened to admit atmospheric air to said pressure chamber from said atmospheric chamber, means operable upon a predetermined increase in pressure above atmospheric pressure in said pressure chamber for moving said valve to open position to vent said pressure chamber to said atmospheric chamber and the atmosphere, said means including a valve operating member normally disconnected from said valve and movable to engage and move said valve to open position, a diaphragm device for actuating said member and tending to move said member to valve opening position upon an increase in pressure in said pressure chamber, and means holding said diaphragm device to prevent actuation of said valve operating member beyond the point of its initial engagement with said valve until a predetermined maximum pressure is built up in said pressure chamber, at which time said holding means is released to cause said diaphragm to move said member beyond the point of initial engagement with said valve under said predetermined pressure to open said valve fully with a quick action.

3. In structure of the class described, a casing

having a pressure chamber and an atmospheric chamber connected to said pressure chamber, a valve normally acting under its own weight and the pressure in said pressure chamber to close the connection between said chambers so that when a subatmospheric pressure sufficient to overcome the weight of said valve exists in said pressure chamber said valve is opened to admit atmospheric air to said pressure chamber from said atmospheric chamber, means operable upon a predetermined increase in pressure above atmospheric pressure in said pressure chamber for moving said valve to open position to vent said pressure chamber to said atmospheric chamber and the atmosphere, said means including a valve operating member normally disconnected from said valve and movable to engage and move said valve to open position, a diaphragm device for actuating said member, and magnetic means adapted to be engaged by said diaphragm device to normally hold the latter against valve opening movement, beyond the point of its initial engagement with said valve until a predetermined maximum pressure is built up in said pressure chamber to cause said diaphragm device to actuate said member and open said valve fully with a quick action.

4. In structure of the class described, a casing having a pressure chamber, means forming a second chamber in said pressure chamber, means connecting said second chamber to the atmosphere, a valve in said pressure chamber for controlling communication between said two chambers which valve is normally held closed by its own weight and pressure in said pressure chamber whereby said valve is automatically opened when a subatmospheric pressure sufficient to overcome the weight of said valve exists in said pressure chamber, and means for opening said valve when a predetermined pressure above atmospheric pressure is built up in said pressure chamber, said means comprising a valve operating member normally disconnected from said valve, a diaphragm device operated by pressure in said pressure chamber to actuate said valve operating member to engage said valve and move said valve to open position, and means normally out of operative engagement with said diaphragm but engaged by said diaphragm device prior to engagement of said valve operating member with said valve for releasably holding said diaphragm device against valve opening movement, said holding means being released by the build-up of a predetermined pressure in said pressure chamber acting through said diaphragm device.

5. In structure of the class described, a casing having a pressure chamber and a chamber constantly connected to atmosphere, a valve for controlling communication between said two chambers which valve is normally held closed by its own weight and pressure in said pressure chamber whereby said valve is automatically opened when a subatmospheric pressure sufficient to overcome the weight of said valve exists in said pressure chamber, and valve operating means including a member normally disengaged from said valve and movable to engage and move the same to open position, a diaphragm device operated by pressure in said pressure chamber for moving said member to engage and move said valve to open position, and magnetic means adapted to hold said diaphragm device to prevent movement of the member beyond the point of its initial engagement with said valve until a predetermined

maximum pressure is built up in said pressure chamber.

6. In structure of the class described, a casing having a pair of connected members, one adapted to be connected to a source of pressure and the other connected to atmosphere, a valve acting under its own weight and the pressure in the pressure chamber for closing the connection between said chambers and adapted to be automatically opened when the pressure in said pressure chamber is reduced to a predetermined subatmospheric pressure, means normally disconnected from said valve and movable to engage and open said valve, and means normally disconnected from said first means for holding said first means against valve opening movement, said two means being so constructed and arranged that said first means is engaged with said second means upon an initial predetermined increase in pressure in said pressure chamber, and said second means then holds said first means against valve opening movement until a predetermined maximum increase in pressure in said pressure chamber is reached when said second means is released permitting said first means to move under said maximum pressure to instantly and fully open said valve.

7. In structure of the class described, a casing having a pair of connected chambers, one adapted to be connected to a source of pressure and the other connected to atmosphere, a valve acting under its own weight and the pressure in said pressure chamber for closing the connection between said chambers and adapted to be automatically opened when the pressure in said pressure chamber is reduced to a predetermined subatmospheric pressure, means movable upon a predetermined increase in pressure in said pressure chamber to engage and open said valve, and magnetic means adapted to be engaged by said first means upon an initial pressure build-up in said pressure chamber and before said moving means engages said valve, said magnetic means being movable by a predetermined build-up of pressure beyond said initial build-up to permit said first means to engage said valve, said valve being opened by a final pressure build-up sufficient to overcome the magnetic effect of said magnetic means plus the weight of said valve and said first means and the pressure in said pressure chamber.

8. In structure of the class described, a casing having a pressure chamber and a chamber connected to atmosphere, a valve connecting said chambers and adapted normally to remain closed under its own weight and the pressure in said pressure chamber but to open automatically when a predetermined subatmospheric pressure exists in said pressure chamber, and means for opening said valve upon a final predetermined increase in pressure in said pressure chamber comprising a valve opening member normally detached from said valve, a device for moving said valve opening member to engage said valve upon a predetermined intermediate increase in pressure in said pressure chamber and to move said valve to open position upon said final predetermined increase in pressure, and means adapted to become effective upon a partial movement of said device for holding said device, member and valve

against valve opening movement until said final predetermined pressure is built up, said latter means being then constructed and arranged to release said device permitting the same to move under said final predetermined pressure and open said valve fully with a quick action.

9. In structure of the class described, a casing having a pressure chamber and a chamber connected to atmosphere, a valve connecting said chambers and adapted normally to remain closed under its own weight and the pressure in said pressure chamber but to open automatically when a predetermined subatmospheric pressure exists in said pressure chamber, and means for opening said valve upon a predetermined increase in pressure in said pressure chamber comprising a valve lifting member normally disconnected from said valve but movable axially to engage and move the latter, a diaphragm secured to said member and subject to the pressure in said pressure chamber, a magnetic device for holding said diaphragm and member from valve opening movement until said predetermined pressure is reached when said magnetic device releases said diaphragm member, said diaphragm being normally disconnected from said magnetic device but engageable therewith for said holding action upon an initial diaphragm movement under a pressure less than said predetermined pressure, said diaphragm movement being less than that required to engage said member with said valve.

10. In structure of the class described, a casing having a pressure chamber and a chamber connected to atmosphere, a valve connecting said chambers and adapted normally to remain closed under its own weight and the pressure in said pressure chamber but to open automatically when a predetermined subatmospheric pressure exists in said pressure chamber, means for opening said valve upon a predetermined increase in pressure in said pressure chamber, including a valve lifting member normally disconnected from said valve but movable axially to engage and move the latter, a diaphragm secured to said member and subject to the pressure in said pressure chamber, and magnetic means for holding said diaphragm against valve opening movement until said predetermined pressure is built up including a movable permanent magnet element, a fixed armature element associated with said magnet, and a magnet moving member normally disengaged from said diaphragm, the arrangement being such that upon an initial pressure built-up in said pressure chamber and before said valve lifting member engages said valve said diaphragm engages said magnet moving member and the holding effect of said magnet element holds said diaphragm against further movement until a certain predetermined pressure is built up when said magnetic element is moved away from said armature element causing said valve lifting member to engage said valve, the magnetic holding effect of said magnet plus the weight of said valve and the parts associated therewith holding said valve lifting means against opening movement until said final predetermined pressure is reached.

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