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[54] **SEALED STORAGE STRUCTURE INCORPORATING A CATALYTIC BURNER ATMOSPHERE GENERATOR**
7 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **99/235,** 99/154
[51] **Int. Cl.** **A01f 25/16**
[50] **Field of Search** 99/234, 235, 271, 270, 269, 273, 204, 153

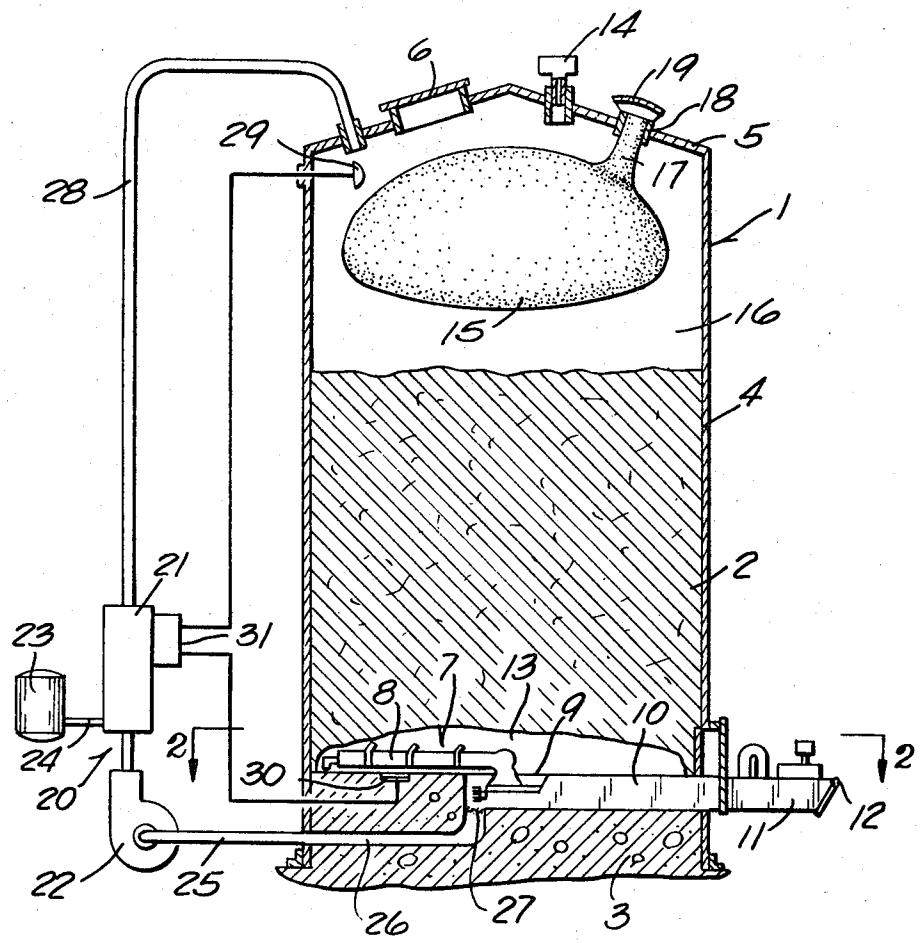
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ABSTRACT: The invention relates to a sealed storage structure for storing a perishable material such as silage. An atmosphere control apparatus is provided for rapidly reducing the oxygen content in the structure. The control apparatus includes a catalytic reactor located on the outside of the structure, and when the oxygen content in the structure increases beyond a predetermined value, a circulating system draws gas from the structure to the reactor and returns the gas to the structure in a condition of reduced oxygen concentration.



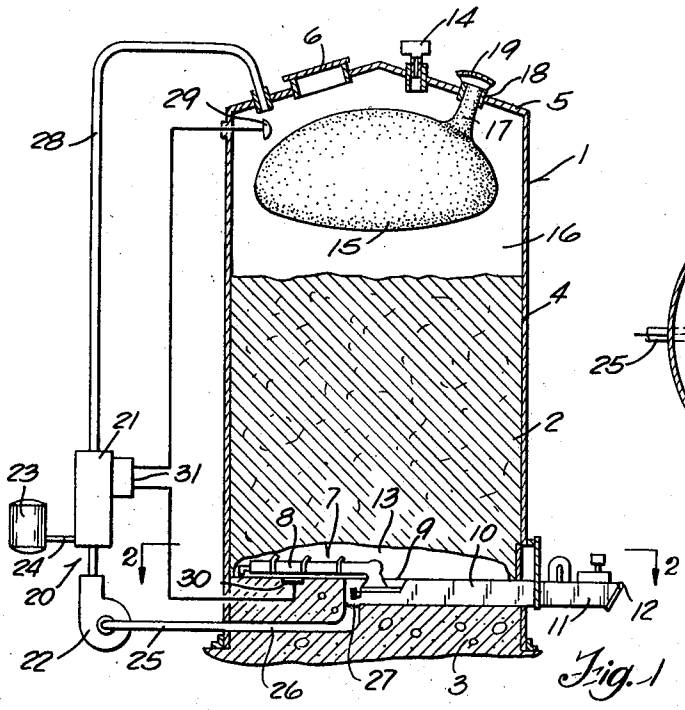


Fig. 1

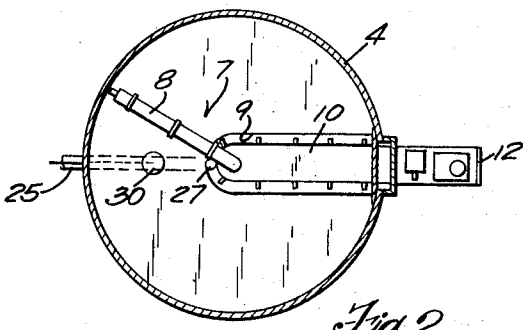


Fig. 2

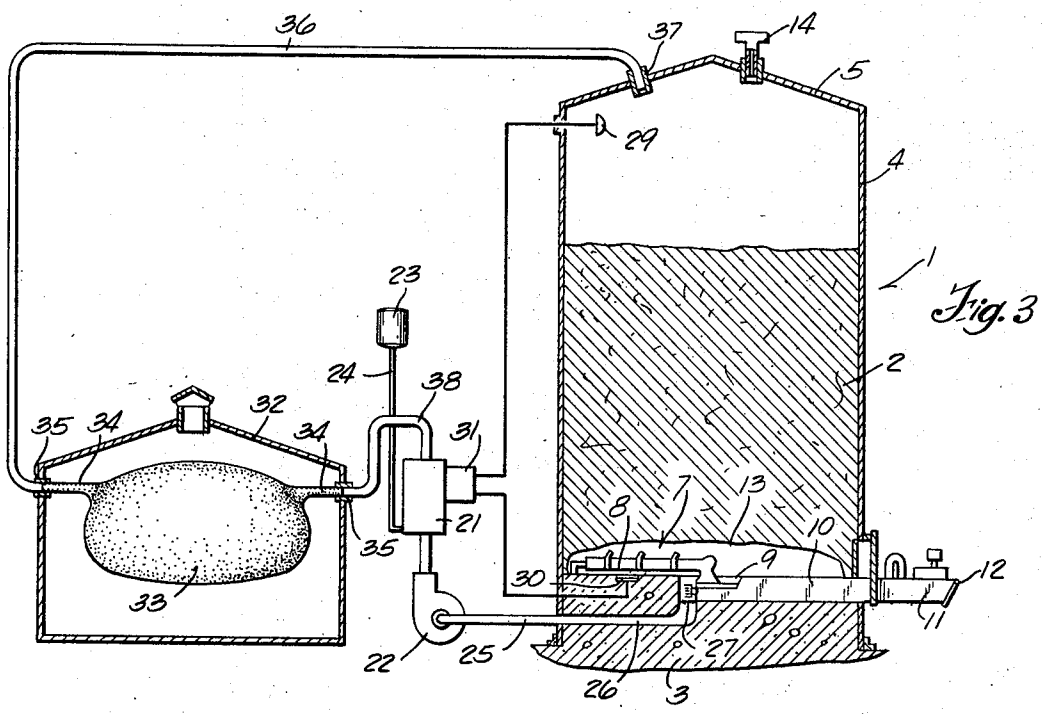


Fig. 3

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SEALED STORAGE STRUCTURE INCORPORATING A CATALYTIC BURNER ATMOSPHERE GENERATOR

This invention relates to an atmosphere control system for a sealed storage structure such as a silo. Silos of this type are often used to store materials which are subject to spoilage due mainly to contact with oxygen in the air.

Since the silo is sealed, pressure differentials will occur between the interior and the exterior of the silo. Gas being generated by the stored material, such as the carbon dioxide arising from oxidation of carbohydrates often contained in stored materials, variations due to ambient temperature, and normal atmospheric pressure changes all contribute to the pressure differentials. As too large a pressure differential between the exterior and interior of the silo can cause destructive stresses in its walls, a relief valve is usually provided on the roof of the structure. The relief valve allows gas to pass in or out of the silo whenever a predetermined pressure differential is reached. In addition, the sealed silo is normally provided with a flexible pressure responsive member, such as a breather bag, which serves to equalize the exterior and interior pressures at levels of pressure not reaching the extremes required to actuate the relief valve. The pressure responsive member is normally located in the head space of the silo, and has its interior surface exposed to atmospheric pressure by means of a neck which is secured within an opening in the roof of the silo so that the atmospheric air enters the silo only by entering the confines of the breather bag. With the exterior surface of the bag being subject to the pressure of the gas inside the sealed silo, the expansion and contraction of the flexible bag in response to the pressure differential serves to balance the atmospheric and interior pressures, but nevertheless, prevents outside air from contacting the stored material.

Although sealed silos are generally air tight, air will enter at times. First, in some areas, large daily variations in temperature occur, causing large pressure differentials to arise between the exterior and interior of the silos. This large differential at times causes the relief valve to allow air into the silo. Also, when the stored material is unloaded through the use of a mechanical unloading unit, the interior of the silo is exposed to the atmosphere. If the breather bag is in an expanded condition when the unloader door is opened, it deflates in response to the pull of gravity and allows an inrush of air into the space previously occupied by the expanded bag.

Attempts have been made in the past to decrease the available oxygen in the interior by purging the contents with an inert gas or carbon dioxide. The purging method is not satisfactory with a conventional breather bag, since purging requires that a positive pressure be maintained in the silo relative to the exterior of the structure so that gas flow will be outward rather than inward. A positive pressure would interfere with the operation of a conventional breather bag if it were used. Similarly, breathing systems other than conventional breather bags, such as a system which employs a labyrinth of lengthy tubular air passageways for purposes of reducing internal and external pressure differentials, cannot satisfactorily be combined with a positive pressure purge method.

In view of the problems of the prior art, an object of the invention is to provide an efficient and economical system of controlling the atmosphere of the interior of a sealed storage structure employing a breather system.

Another object is to provide a convenient and efficient means of reducing the oxygen concentration of the gas within a storage structure.

A further object is to provide an atmosphere control apparatus which will automatically operate whenever the oxygen concentration in the silo reaches a predetermined maximum level and will discontinue its operation at predetermined minimum level.

A still further object is to provide an atmosphere control apparatus for a storage structure which employs a conventional breather bag or other pressure balancing apparatus.

Other objects and advantages will appear in the course of the following description.

The drawings illustrate the best mode presently contemplated of carrying out the invention.

In the drawings:

FIG. 1 is a diagrammatic side elevational showing one embodiment of the invention, with parts broken away in section;

FIG. 2 is a sectional view taken along line 2—2 of FIG. 1; and

FIG. 3 is a diagrammatical side elevational view showing another embodiment of the invention.

FIGS. 1 and 2 illustrate a sealed storage structure or silo 1 which is adapted to contain a perishable material 2, which could be silage, haylage, shelled corn, grain or the like. The silo 1 is supported on a foundation 3 and includes a generally cylindrical wall 4 having an open top which is enclosed by roof 5. The stored material 2 is loaded into the silo through an opening 6 in the roof 5, and an unloader unit 7 is located in the bottom of the silo. The unloader unit is of a type commonly used, as the one disclosed in the Tiedemann U.S. Pat. No. 2,035,770. The unloader unit consists of a cutter arm 8 which is journaled for rotation about the center of the silo and disposed over its foundation 3, and which serves to cut or dislodge the silage as the cutter arm rotates and then moves the silage to the center of the silo where it falls into a radially extending trough 9 formed in the foundation 3. A conveyor unit 10 is mounted within the trough 9 and extends outwardly through the housing 11 to the normally closed discharge door 12. The conveyor unit 10 operates to discharge silage to the exterior of the silo through the door 12, which is open during operation. If a fibrous material such as silage is stored in silo 1, the silage will arch-over and form a cavity 13 in the lower end of the silage mass.

To allow partial balancing of extreme pressure differentials which occur between the interior and the exterior of the silo, a relief valve 14 is provided in the roof 5. When the pressure in the silo exceeds the atmospheric pressure by a predetermined maximum, the relief valve 14 opens to permit gas to vent from the silo. Conversely, when the atmospheric pressure exceeds the pressure of the interior by a predetermined amount, the valve 14 opens to allow air flow into the silo. For example, the relief valve 14 is a typical air-tight silo which may be set to allow air into the silo when a negative pressure differential of −1.5 inches of water is exceeded, and similarly to allow gas to flow out of the silo when a positive pressure differential of +3.5 inches of water is exceeded.

To balance pressure differentials of lesser magnitude, a conventional breather bag 15 is mounted in the head space 16 of the silo. The bag 15 is a flexible, expandable member, having a neck 17 which is secured to a fitting 18 in the roof 5 of the silo so that the interior surface of the bag 15 is exposed to atmospheric pressure while the exterior of the bag is exposed to the pressure of the gas in the silo. When atmospheric pressure is greater than the interior pressure of the silo, the bag 15 expands in the head space 16 and thus tends to equalize the pressures. Conversely, when the interior pressure is greater than that of the atmosphere, the bag 15 contracts, again equalizing the pressure difference. Since the bag 15 is enclosed, no air from the atmosphere comes in contact with the perishable material 2 stored in the silo.

Fitting 18 is enclosed by a suitable vent cap 19 which prevents moisture or other foreign materials from entering bag 15.

According to the invention, an air recirculating and reactor unit 20 is provided to control the oxygen and carbon dioxide content of the air within the silo and consists of a catalytic reactor 21 and a blower 22. The catalytic reactor is mounted on the exterior of the silo and can be similar to the type disclosed in the patents to W. T. Harvey, Jr., U.S. Pat. No. 3,313,630 or W. P. Jensen, U.S. Pat. No. 3,313,631. The catalytic reactor 21 is provided with a fuel tank 23 and a fuel line 24 connects the tank 23 to the reactor 21. The fuel is preferably a hydrocarbon gas, such as propane, natural gas or

the like. The blower 22 draws gas from the interior of silo 1 and discharges the gas to the reactor 21. The catalytic reactor 21 operates to chemically combine oxygen in the gas with the oxidizable portion of the fuel to thereby produce a resultant gas having a low concentration of oxygen and a high concentration of carbon dioxide, water vapor and nitrogen.

Gas from the interior of silo 1 is supplied to the reactor 21 through a conduit 25 which connects the reactor 21 and the outer end of a passage 26 formed in foundation 3. The inner end of passage 26 communicates with trough 9. Blower 22 is connected in conduit 25. The inner end of passage 26 is covered by a screen 27. The screen 27 permits gas to enter the passage 26 and prevents plugging of the system by the silage or other perishable material 2 which falls into the trough 9.

The gas being discharged from the catalytic reactor 21 and having a reduced concentration of oxygen, is directed to the head space 16 of the silo by a conduit 28 which is connected to an opening in the roof 5 of the silo.

For purposes of automatically actuating the recirculating and reactor unit 21 whenever a predetermined oxygen concentration is reached in the silo, a control system is provided. The control system consists of an oxygen sampling probe unit 29 disposed in the head space 16 of the silo and a similar probe unit 30 disposed in the cavity 13 at the lower end of the silo. These probe units can be of any commercially available type which sense the concentration of oxygen in the air and emit a signal at a predetermined oxygen value. Such a probe is disclosed in Beckham U.S. Pat. No. 2,913,386. The probes 29 and 30 are mechanically or electrically connected to a starter unit 31 for the recirculating and reactor unit 20.

The control system is used to control the oxygen concentration of the gas within the silo. To summarize its operation, air at times enters through the door 12, through the relief valve 14, and through any leaks in the silo wall. The oxygen sampling probes 29 and 30 are set to develop a signal at a maximum level of oxygen concentration in the head space 16 and the cavity 13 respectively. The signal actuates the starter unit 31 for the recirculating and reactor unit 20, causing the blower to draw gas from the cavity 13 through the conduit 25 and discharge the gas into reactor 21. A substantial portion of the oxygen in the gas reacts with the fuel which is supplied from tank 23 to convert the oxygen to gaseous carbon dioxide. The gas, primarily in the form of carbon dioxide, water vapor and nitrogen and having a lowered oxygen content, is discharged from the reactor 21 through the conduit 28 to the head space of the silo. When the oxygen concentration in the silo reaches a predetermined minimum level, the probe units 29 and 30 develop another signal which acts to shut off the recirculating and reactor unit 20.

In this manner, minimum contact of oxygen with the perishable material in the silo is maintained and spoilage is reduced. Additionally, the resulting higher concentration of carbon dioxide lessens the degree of spoilage, since carbon dioxide is a product of the major chemical reactions which cause decomposition and since an abundance of the carbon dioxide will force the equilibrium of these reactions in favor of less spoilage.

Except for the slight contraction and expansion due to pressure variations during the operation as above, of the recirculating and reactor unit 21, the breather bag 15 functions independently of the atmosphere control operation. The unloading unit operates in the conventional manner.

As shown in FIG. 3, the recirculating and reactor unit 20 can be adapted for use with a storage silo which has a breather bag unit on the exterior of the silo. In this embodiment of the invention the silo 1, the unloader unit 7, the blower 22, the catalytic reactor 21 and control unit 31 are identical in disposition, construction and function to that described above.

Referring particularly to FIG. 3, a shelter 32 of any common construction is disposed on the exterior of the silo and contains a breather bag 33 which is similar to the flexible bag 15 shown in FIG. 1. The bag 33 has a pair of necks 34, each of which is secured to a fitting 35 in the wall of the shelter. A conduit 36 connects one of the fittings 35 and a fitting 37 in the roof 5 of silo 1, while a second conduit 38 connects the other fitting 35 to the outlet of reactor 21. Thus, the interior of the bag 33 is exposed to the pressure in the head space 16, while the exterior of the bag is exposed to atmospheric pressure in the shelter 35. The bag thus operates to balance the pressures on the interior and the exterior of the silo by contracting and expanding similarly to the bag 15 in FIG. 1.

The operation of this embodiment of the invention is identical to that described in relation to FIG. 1, except that the discharged gas is directed by conduit 38 through the breather bag 33 before it enters the head space 16 of the silo.

It is contemplated that further atmosphere control devices may be inserted between the reactor unit 21 and the exhaust conduit. For example, a condenser or absorber unit may be connected at the outlet side of the reactor for purposes of decreasing the carbon dioxide or water vapor content of the gas exhausted from the oxidizer. Also, a cooling unit may be similarly inserted to control the temperature of the gas being directed to the head space of the silo.

The above description relates mainly to a silo but the invention can be applied to any hermetically sealed storage vessel. Further, the above description is made only by way of example and numerous changes may be made therein without departing from the scope of the invention as claimed below.

Various modes of carrying out the invention are contemplated as being within the scope of the following claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention.

I claim:

1. In a storage unit, a generally sealed storage structure to contain a perishable material, unloading means located in the lower end of the structure for dislodging and removing the material from the structure, pressure balancing means for balancing pressure differentials between the interior and the exterior of said storage structure, conduit means located on the exterior of the structure and connecting the upper end of the structure to the lower end of the structure, gas circulating means for circulating gas through said conduit means from one end of the structure to the other end of the structure, and reactor means disposed in said conduit means for reducing the oxygen content of the gas circulating through said conduit means whereby the gas being returned to said structure has a reduced oxygen content.

2. The unit of claim 1, and including control means operably connected to said reactor means and to said circulation means, and means responsive to a predetermined maximum oxygen content of the gas within said storage structure for actuating said control means to thereby operate said reactor means and said circulation means.

3. The unit of claim 2, wherein said means responsive to a predetermined oxygen content includes a pair of oxygen sensing elements, one of said elements being located in the upper end of the structure above the level of said material and the other of said elements being located in the lower end of said structure.

4. The unit of claim 1, wherein said pressure balancing means includes a generally flexible pressure responsive member having one surface exposed to pressure within said storage structure and the opposite surface exposed to the pressure external of said storage structure whereby said member flexes in response to differences in said internal and external pressures.

5. The unit of claim 1, wherein said structure includes a foundation having a radially extending trough formed therein, said trough extending from the center of the structure to the exterior, said unloading means including a material dislodging member mounted for movement on said foundation and disposed to dislodge the stored material and discharge the material in said trough, said unloading means also including a conveyor mounted for movement in said trough for conveying the material to the exterior of the structure, said conduit

means extending within the foundation and being connected to said trough.

6. The unit of claim 5, wherein the circulation means acts to draw gas through said conduit means from the trough in the foundation and returns gas to the upper end of the structure.

7. In a storage unit, a generally sealed storage structure to contain a mass of stored material, said structure having a first gas cavity within said storage structure and located above the material stored therein, a material unloading unit operating in a second gas cavity at the bottom of the mass of material, said unloading unit disposed to discharge said stored material to the exterior through an opening in said storage structure, a flexible pressure responsive member having one surface exposed to the pressure external of said storage structure and an opposite surface exposed to the pressure within said storage structure, a reactor unit disposed on the exterior of said storage structure and operating to reduce the oxygen content of a gas passed therethrough, a first conduit member connecting the outlet to said reactor unit to said first gas cavity whereby gas is discharged from said reactor unit to said first gas cavity, a second conduit member connecting the inlet of said catalytic reactor unit to said second gas cavity, whereby said reactor unit receives gas from said second cavity, said first and second conduits, said reactor unit and the interior of said storage structure comprising a closed gas flow system, blower means for circulating gas through said closed flow system, oxygen measuring means disposed within one of said cavities for measuring the oxygen content within said gas cavity and operable to generate a signal when a predetermined maximum oxygen content is reached, and means operably connected to said reactor unit and to said blower means and responsive to said signal to operate said reactor unit and said blower means.