Sept. 29, 1970 B. T. McCUTCHAN 3,531,064

METHOD AND APPARATUS FOR TRANSPORTING GAS

Filed April 12, 1968 2 Sheets-Sheet 1

FIG. 3

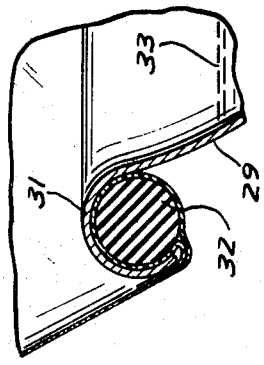


FIG. 2

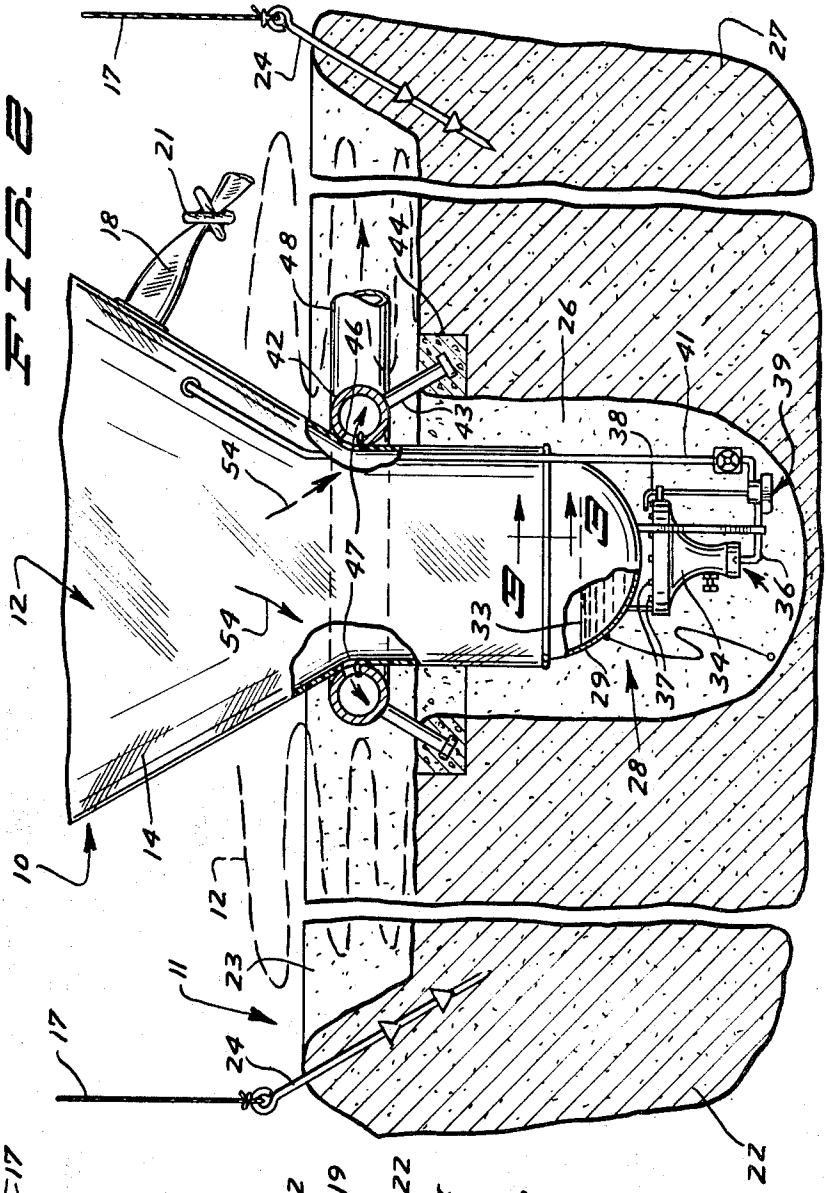
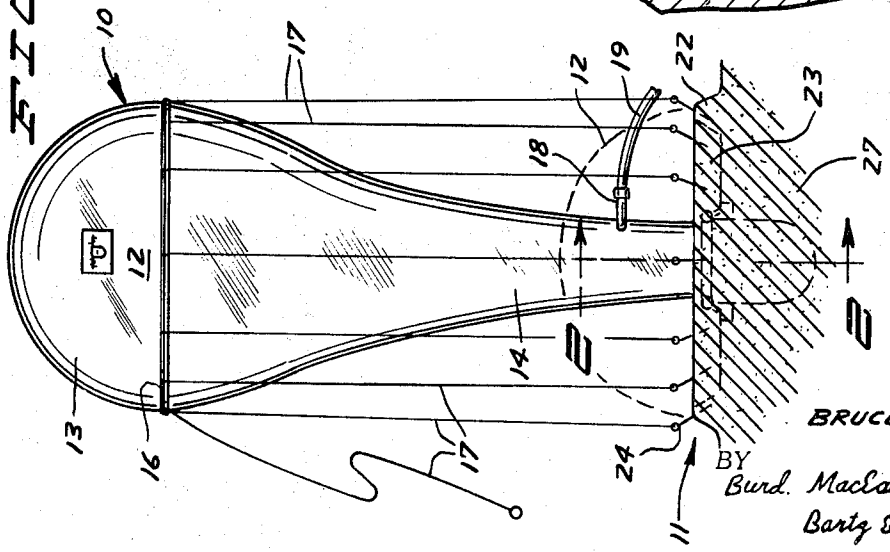


FIG. 1



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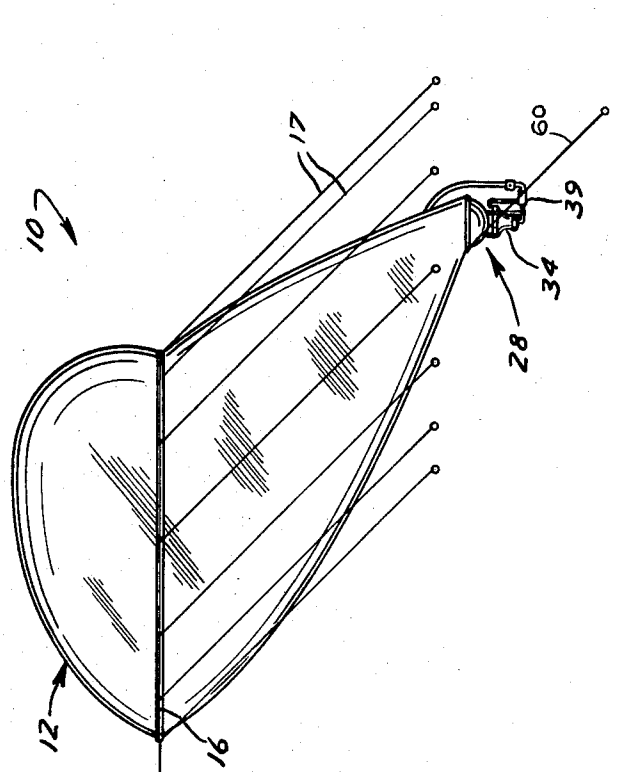


FIG. 4

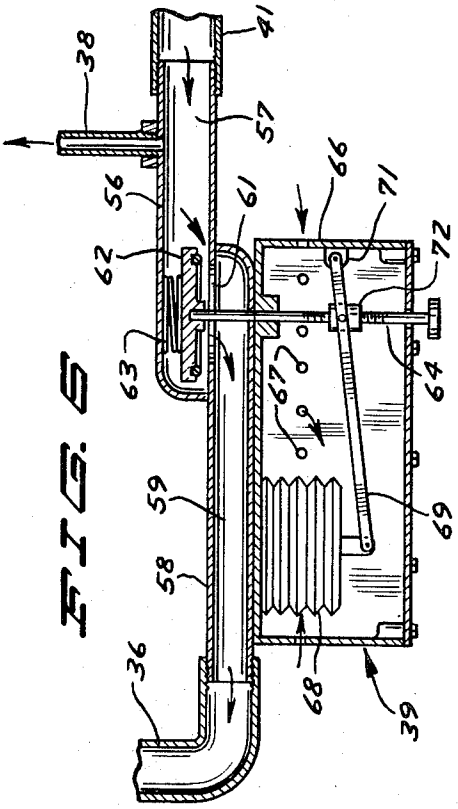


FIG. 6

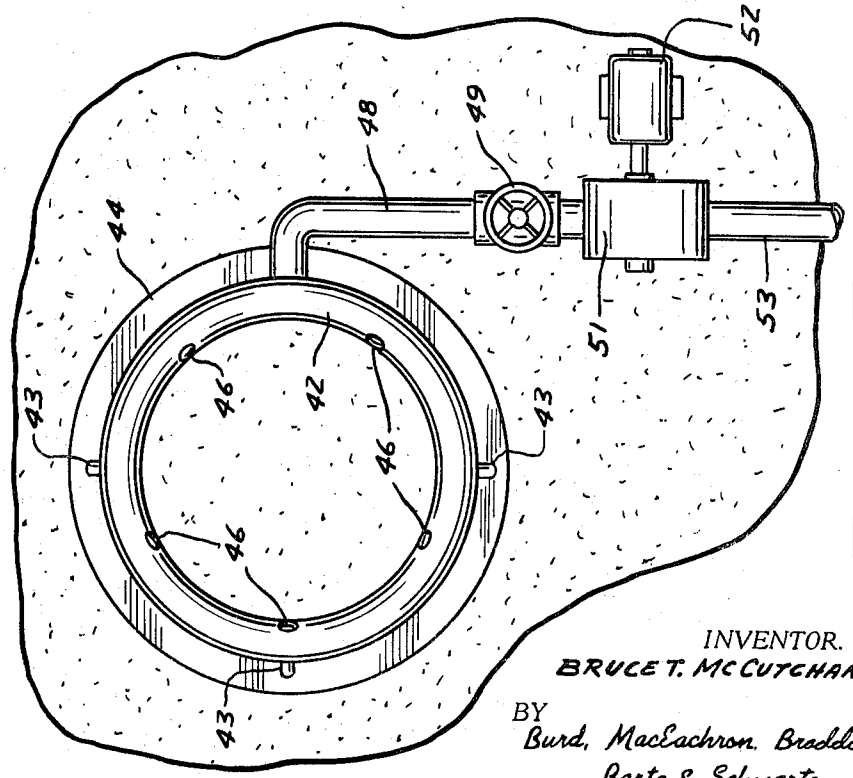


FIG. 5

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METHOD AND APPARATUS FOR TRANSPORTING GAS

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Int. Cl. B64b 1/40, 1/62
U.S. Cl. 244—31 15 Claims

ABSTRACT OF THE DISCLOSURE

A light weight flexible bag used to collect and transport natural gas to a location for use or storage. The gas pressure inside the bag is regulated by a temperature control unit having a barometric control valve used to stabilize the pressure of the gas during periods of low external energy. The temperature control unit also functions as a ballast to control the flight elevation of the bag. A pump connected to a gas collecting ring operates to withdraw the gas from the bag.

BACKGROUND OF THE INVENTION

Relatively inflexible and costly pipeline systems are presently used to transport natural gas from a source of supply to the consumer. The high cost of gas pipeline systems requires that the lines be continuously used for maximum efficiency with the result that the supply sources are over used and becoming depleted. To hedge against short supply, distributors store gas in tanks under pressure or in rock domes under the earth. The pipeline is not feasible for use to transport gas from smaller remote gas fields large distances to the consumer.

The method and apparatus for transporting gas of the present invention is a flexible and relatively inexpensive system for transporting gas long distances from a source of supply to the consumer in a flexible and efficient manner. Relatively small and remote sources of supply can be efficiently utilized, making gas available to new industrial and population centers. The more economical use of gas supplies will conserve gas reserves.

SUMMARY OF THE INVENTION

The invention relates to a method and apparatus for transporting gas, as natural gas and other lighter than air gases. The apparatus is comprised of a large flexible gas impervious bag capable of being transported through the air. Attached to the bottom of the neck of the bag is a temperature control unit operable to regulate the temperature and pressure of the gas in the bag and to function as a ballast for the bag. The bag is used in conjunction with a loading station where the bag may be filled with gas through an inlet passage leading to the neck of the bag. The gas is removed from the bag through the use of a pump which wtihdraws gas from a gas receiving pipe in communication with the bag.

In the drawings:

FIG. 1 is an elevational view of the apparatus for transporting gas of the invention located on a gas filling and unloading station;

FIG. 2 is an enlarged sectional view taken along the line 2—2 of FIG. 1;

FIG. 3 is an enlarged sectional view taken along the line 3—3 of FIG. 2;

FIG. 4 is a view of the apparatus of the invention being transported in the atmosphere;

FIG. 5 is a plan view of the gas unloading structure; and

FIG. 6 is a sectional view of the gas regulator valve.

Referring to the drawing there is shown in FIG. 1, an apparatus for transporting gas of the invention indicated generally at **10** attached to a gas filling and unloading

station indicated generally at **11**. The apparatus **10** comprises a large flexible bag made of gas impervious plastic material as polyethylene and the like. The material is strong and relatively light in weight and may include numerous plastics, rubber, and coated fabric materials. The bag **12** has a large spherical shaped body **13** joined to a downwardly tapering neck **14** providing the bag with a generally inverted bulbar shape. For example, bag **12** can be a large thin film polyethylene plastic bag of a size to enclose about 7,000,000 cubic feet of gas when fully expanded at atmospheric pressure. A circumferential band **16** reinforces the mid-section of the body **13** and provides a fastening member for a plurality of circumferentially spaced tie-down lines **17** used to hold the apparatus **10** on the station **11**. The lower portion of neck **14** has an inlet member or umbilical cord **18** used to provide a passage into the interior of the bag. In filling the bag, inlet hose **19** is connected to the cord **18** so that the gas from the source can be supplied to the bag. When the bag is full as shown in FIG. 3, a closing means **21**, as a cord or other fastener, is used to the cord trapping the gas in the bag. The pressure of the gas in the bag is at substantially atmospheric pressure.

The unloading station **11** comprises an annular mound or dike **22** forming a recess or nest **23** in the ground or other support **27**. Projected outwardly from the mound **22** are a plurality of anchor rods **24**. The tie-down lines **17** are secured to the upper end of the rods **24** to hold the bag on the station **11**.

Located centrally in recess **23** is a pit **26** accommodating a temperature control unit indicated generally at **28** mounted on the lower end of neck **14**. Control unit **28** has a bowl **29**, of metal such as aluminum, closing neck **14**. As shown in FIG. 3, the upper edge of bowl **29** has an outwardly and downwardly curved lip **31**. The open end of the neck **14** of the bag **12** is attached to the bowl **29** with a flexible O-ring **32**. When the neck **14** is in assembled relation with the bowl **29** the O-ring **32** is rolled about the neck **14**. The rolled portion of the neck is retained in the annular recess formed by the curved lip **31**.

Located within the bowl **29** is a liquid **33**, as salt water, oil or similar liquid heavier than air, to provide a ballast for the bag. The temperature of the liquid is controlled by a heating means or burner **34** mounted on the bottom of the bowl **29**. Burner **34** has an inlet **36** and discharge flame ports **37** positioned immediately below the bowl **29**. Mounted on the side of the burner is a standing pilot **38** to provide a continuous flame for the burner. Both the burner **34** and the pilot **38** are connected to a gas pressure regulator valve indicated generally at **39** which controls the supply of gas from the bag to the burner. A line **41** leads upwardly from the valve **39** to the neck portion of the bag **14** to supply the valve with gas stored in the bag.

Referring to FIGS. 2 and 5, the unloading station **11** has a gas receiving pipe or collar **42** mounted in a horizontal position on upwardly projected support rods **43** anchored in a cylindrical base **44** formed from rigid material, as concrete. Collar **42** has a plurality of circumferentially spaced inwardly directed holes **46**. As shown in FIG. 5, a pipe **48** connects collar **42** to a valve **49** leading to a pump **51**. A motor **52** drives the pump to withdraw gas from the collar **42** and discharge the gas to a discharge line **53** leading to a storage container or a distribution pipe line (not shown).

On operation of pump **51** the gas flow is indicated by arrows **54** in FIG. 2. A reduction of pressure in collar **42** causes the bag to rupture adjacent ports **46** thereby creating openings **47**. The gas flows downwardly from the bag **12** through the openings **47** and ports **46** into the collar **42**. In this manner theg as is withdrawn from the bag in a continuous manner without the introduction of atmospheric air. With the neck of the bag **14** projected

through the opening of collar **42** the pressure of the gas in the bag forces the bag into sealing engagement with the collar **42** so that external air is not drawn into the evacuating system.

Shown in FIG. 4, bag **12** is being towed in the atmosphere by a tow line **55** attached to a power vehicle (now shown), as an airplane, helicopter, blimp or the like. The line **55** may be attached to a powered vehicle on the ground or water such as a truck or ship. An additional line **60** attached to the control unit **28** is used to add ballast and as a retrieving line. The weight of the control unit **28** as well as the shape of the bag **12** maintains the upright flight position of the bag. The burner **34** is operable to maintain the pressure of the gas in the bag by controlling the temperature of the gas in the bag. The burner is automatically operated by operation of the gas regulator valve **39**.

As shown in FIG. 6 valve **39** has a first housing **56** with a passage **57** leading to the line **41** connected to the gas source in the bag **12**. Joined to housing **56** is a second housing **58** having a passage **59** joined to the inlet member **36** of the burner. A port or hole **61** connects the passages **57** and **59** so that the gas flows through the passages to the burner. A cylindrical valving member **62** located in passage **57** is operable to open and close the port **61**. A spring **63** engages the top of the valving member **62** to bias valving member to the closed position against the bottom of housing **56**. Secured to and projected downwardly from valving member **62** is a control rod **64** slidably mounted in a casing **66** attached to the lower side of housing **58**. Casing **66** has a plurality of holes **67** open to the atmosphere to provide for the free flow of air into and out of the casing **66**. Located within casing **66** is a bellows **68** connected to a lever **69** adjustably attached to the control rod **64**. A portion of the lever **69** is pivotally mounted on a fulcrum **71**. A threaded sleeve **72** adjustably connects the lever **69** to the control rod **64**. On rotation of the rod **64** the position of the sleeve along the rod may be changed to adjust the location of the valving member **62** relative to the port **61**.

The valve **39** is operable to stabilize the pressure of the gas during periods of low external energy, as at night or an extremely cloudy day. In order to obtain a balance of energy the burner **34** operates to heat the metal dish to increase the temperature of the liquid **33**. The liquid **33** functions as a heat exchanging medium to increase the temperature of the gas without the danger of igniting the gas. Bellows **68** is controlled by the ambient or atmospheric pressure. On a decrease pressure the bellows will expand thereby closing the valving member **62** decreasing the flame and burning rate at the discharge ports **37**. The burner will not increase the temperature of the liquid. The bag will stay at the flight elevation determined by the atmospheric pressure.

As the apparatus **10** falls the increase in ambient pressure opens the gas valve **39**. This supplies gas to the burner heating the liquid **33**. The increase in temperature of the gas in the bag will cause the bag to rise thus reduce the pressure on the valve. With the reduction of pressure on the valve the bellows **68** will expand closing the valving member **62**. In this manner the flight elevation of a bag will be automatically maintained by the operation of the burner.

Terms of a method of transporting natural gas are included in the invention comprising the steps of initially holding a flexible gas impervious bag **12** in a fixed location and filling the bag with gas. After the bag is filled it is released and allowed to rise in the air against the weight of a ballast comprising the control unit **28** along with the heat transfer liquid **33**. The floating bag in flight is moved to an intended designation by a towing vehicle. The bag could be transported mainly by air currents without a towing vehicle by placing the bag in wind patterns of a favorable direction.

The elevation of the bag is automatically regulated by

controlling the temperature of the gas in the bag. To increase the elevation of the bag the burner attached to the control unit **28** is ignited heating the heat transfer liquid **33**. The result is that the temperature of the gas will be increased in the bag with the result that the altitude of the bag will be increased.

When the bag **12** has reached the intended designation the bag full of gas is lowered to an unloading station **11** where the gas is continuously withdrawn from the bag by the use of a negative or pressure. During the withdrawal of the gas from the bag, the bag is secured to the station.

In use, as shown in FIG. 1, the bag is initially inflated with gas by connecting the supply hose **19** to the inlet cord **18**. Since natural gas has a specific gravity of about 65% of that of air the bag **12** will expand to its bulbar shape as shown in FIG. 1. Tie-down lines **17** anchor the bag to station **11**. The bag can be expanded in any desired location such as a location which is closed to the source of a remote gas supply.

As shown in FIG. 4, the bag **12** filled with gas may be towed to an intended designation by a powered vehicle. The elevation of the bag is automatically maintained to the operation of the temperature control unit **28**. The burner **34** of the control unit is operated to the use of a regulator valve **39** operable in response to changes in the ambient pressure. As the ambient pressure decreases the bellows expand thereby closing the valving member **62**. This stops the supply of gas to the inlet **36** of the burner. An increase of ambient pressure opens the valving member **62**. Since the pilot **38** is in continuous fluid connection with the supply line **41** the pilot light is on at all times. As soon as gas is supplied to the burner the pilot **38** will ignite the burner heating the bottom of the bowl **29**. As the temperature of the heat transfer liquid **33** increases heat is discharged to the gas in the bag **12**. The increase in the temperature of the gas in the bag **12** causes the bag to rise thereby maintaining the flight elevation of the apparatus **10**.

At the discharge station or unloading station **11** the control apparatus as well as the neck of the bag is lowered through the collar **42** into the pit **26**. As shown in FIG. 2, the peripheral portion of the neck **14** is in sealing engagement with the collar **42** preventing the entrance of the atmospheric air into the gas receiving area of the collar. The openings **47** in the bag are created by reducing the pressure in collar **42** sufficient to rupture the bag to provide passageways from the interior of the bag into the collar **42**. Pump **51** operates to remove gas from the bag by a partial vacuum pressure and discharge the gas into a gas discharge line **53**. The pump **51** continues to operate until all of the gas has been removed from the bag. As the bag is emptied it folds down over the collar **42** as shown in broken lines in FIG. 2. Thus, the bag as it collapses does not interfere with the pass of the flow of gas from the bag into the collar **42**. The bag **12** can be shipped back to the gas source and reused or disposed of at the unloading station.

While there has been shown and described a preferred embodiment and method of transporting gas with a flexible gas impervious bag be it understood that various changes in the bag and temperature control unit may be made by those skilled in the art without departing from the spirit of the invention. The invention is defined in the following claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined are as follows:

1. A method of transporting a mass of combustible gas comprising: confining the combustible gas in a large gas impervious bag, allowing the gas confining bag to rise into the atmosphere, heating the gas in the bag with heating means outside the bag operable with gas from the bag to regulate the temperature of the gas in the bag

to maintain the altitude of the bag, moving the gas confining bag in the atmosphere to a desired location, and removing the gas from the bag.

2. The method of claim **1** wherein the gas is moved into a large thin film plastic bag and confined in the plastic bag at substantially atmospheric pressure.

3. The method of claim **1** including controlling the supply of gas from the bag to the heating means in accordance with the ambient pressure.

4. The method of claim **1** wherein the gas is removed from the bag by withdrawing the gas under partial vacuum into a gas receiving line.

5. An apparatus for transporting a mass of lighter than air gas, said gas being combustible including: a large gas impervious bag for confining a mass of lighter than air gas, a ballast unit attached to a portion of the bag for maintaining the upright position of the bag, said unit having a burner operable to heat the gas confined in the bag for maintaining the flight altitude of the bag, a container attached to the bag, a heat transfer medium located in said container in communication with the gas in the bag, said burner located outside the container and operable to heat the container, a control valve and a line connecting the valve to the bag and burner whereby gas in the bag is supplied to the burner, said control valve having a pressure control means operable to open the valve on an increase of pressure to provide the burner with a supply of gas.

6. The apparatus of claim **5** wherein said bag has a large generally spherical body and a downwardly converging funnel shaped neck.

7. The apparatus of claim **6** including a reinforcing band around the spherical body and tie-down lines secured to the band.

8. The apparatus of claim **5** wherein said bag is made of thin plastic film.

9. The apparatus of claim **5** wherein said bag has a downwardly extended neck having an opening, said ballast unit attached to the neck closing said opening.

10. An apparatus for transporting a mass of lighter than air gas including: a large gas impervious bag for confirming a mass of lighter than air gas, said bag having an opening in the lower portion thereof, a ballast unit attached to a portion of the bag, heat transfer means connected to the bag and in substantial surface contact with

the gas confined in the bag, said heat transfer means closing said opening to prevent the escape of gas from the bag, and heating means outside the bag associated with heat transfer means to supply heat to heat transfer means to increase the temperature of the gas.

11. The apparatus of claim **10** wherein said heat transfer means comprises a container attached to the bag, a heat transfer medium located in said container in communication with gas in the bag, said heating means comprising a burner located outside the container and operable to heat the container.

12. The apparatus of claim **10** wherein: said gas confined in the bag is combustible and including means for carrying gas from the bag to the heating means whereby heating means is operable with gas from the bag.

13. The apparatus of claim **12** including: a control valve for controlling the supply of gas from the bag to the heating means, and the means for carrying the gas to the heating means comprised of a line connecting the valve to the bag and heating means.

14. The apparatus of claim **10** wherein: the heat transfer means includes a substance in contact with the gas in the bag, said substance normally in a liquid phase and changeable to a gas phase when subjected to heat generated by the heating means.

15. An apparatus for transporting a mass of combustible gas including: a large enclosed gas impervious bag for confining a mass of lighter than air gas, a ballast unit attached to a portion of the bag, heating means outside the bag, and means for carrying gas from the bag to the heating means whereby heating means is operable with gas from the bag.

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