United States Patent [19]

Reed et al.

[11] **3,901,643**

[45] **Aug. 26, 1975**

[54] **TEMPERATURE-PRESSURE ACTIVATED PURGE GAS FLOW SYSTEM FOR FLARES**

[75] Inventors: **Robert D. Reed; John S. Zink; Robert E. Schwartz,** all of Tulsa, Okla.

[73] Assignee: **John Zink Company,** Tulsa, Okla.

[22] Filed: **Aug. 30, 1974**

[21] Appl. No.: **502,159**

[52] **U.S. Cl.** ..... **431/202;** 23/277 C

[51] **Int. Cl.** **F23d 13/20**

[58] **Field of Search** ..... 431/202, 5, 29, 89; 23/277 C

[56] **References Cited**

UNITED STATES PATENTS

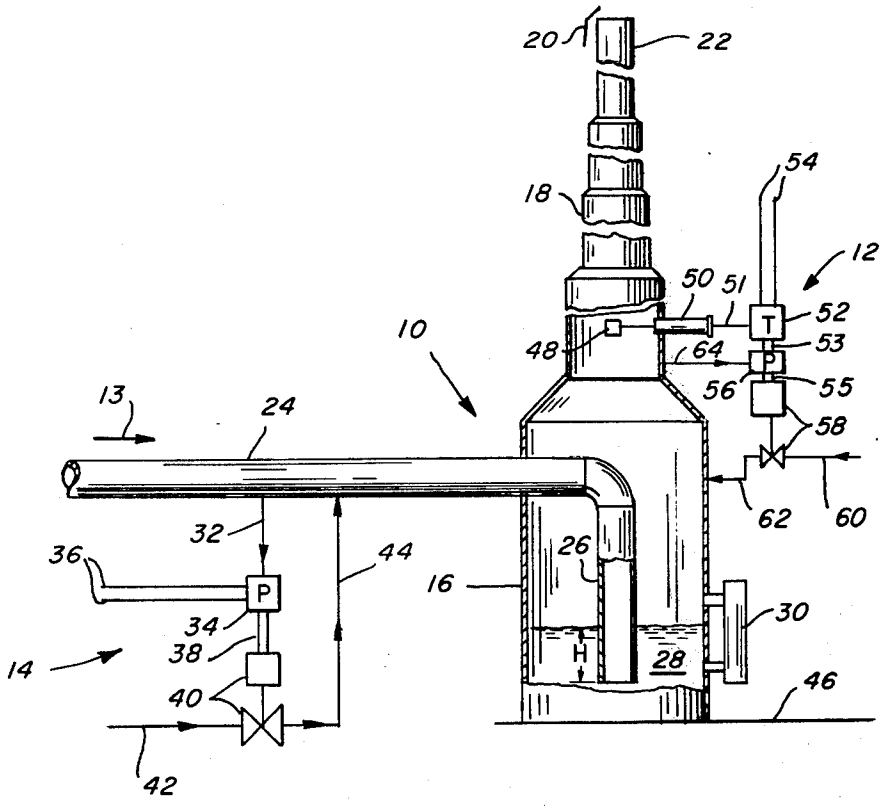
2,779,399	1/1957	Zink et al.	431/202
3,578,892	5/1971	Wilkinson	431/202
3,658,482	4/1972	Evans et al.	23/277 C

Primary Examiner—Edward G. Favors

[57] **ABSTRACT**

A system for supplying purge gas to a flare system depending upon the temperature and the pressure in the flare, to control the flow of purge gas through the flare during the period when flaring of gas is discontinued. The rate of flow of purge gas is determined by temperature measuring means. However, the control of flow depends upon the pressure in the flare as well as the temperature so that when gas is being flared and the temperature is high and the pressure is above normal the purge gas is cut off, whereas when the temperature is high and the pressure is normal the purge gas is flowed.

9 Claims, 3 Drawing Figures



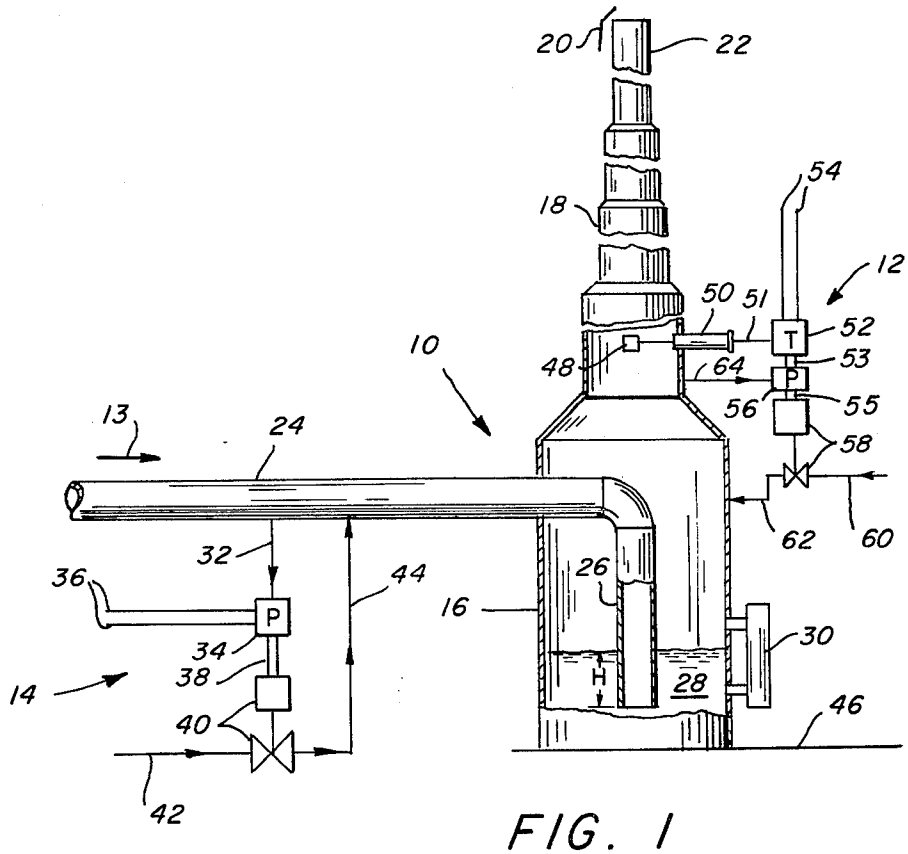


FIG. 1

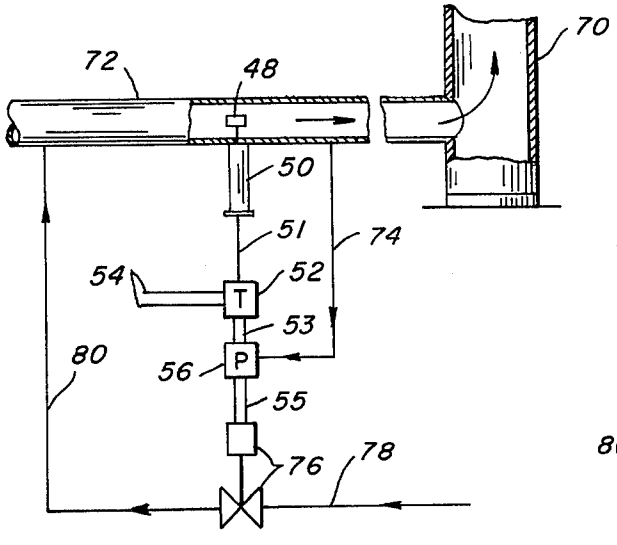


FIG. 2

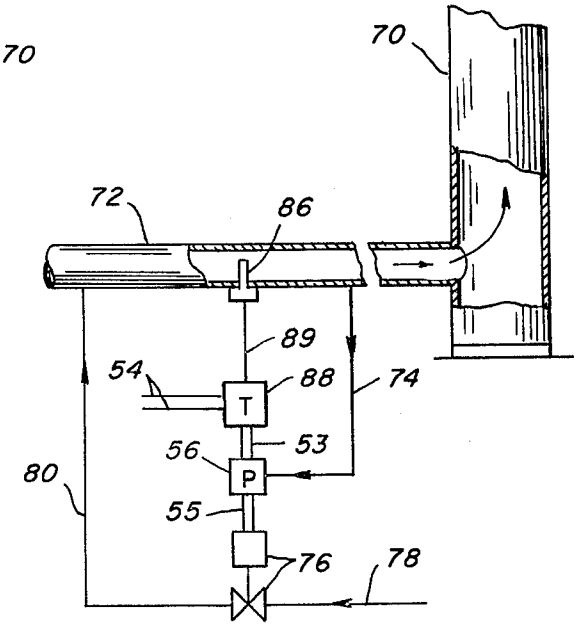


FIG. 3

TEMPERATURE-PRESSURE ACTIVATED PURGE GAS FLOW SYSTEM FOR FLARES

CROSS REFERENCE TO RELATED PATENTS

This invention is related to U.S. Pat. No. 3,741,713 issued June 26, 1973, entitled: PURGE GAS ADMISSION CONTROL FOR FLARE SYSTEM.

BACKGROUND OF THE INVENTION

In chemical and petroleum refining systems it is necessary to maintain a flare stack through which waste combustible gases can be released and burned in such a way as safely to be disposed of, with a minimum of pollution. Often very large quantities of flare gas become available in emergency situations, which gases are, at times, at a temperature in excess of 250° to 300° F. A constantly burning pilot flame is provided so that any gas introduced into the flare stack will be ignited without fail at exit.

When the flaring of gas is stopped at the conclusion of the emergency, the stack, and the gases in the stack, which have been at an elevated temperature, begin to cool to ambient temperature. As a result, the pressure of the gas in the stack reduces proportionately to the absolute temperature of the gas. This reduction in pressure permits atmospheric air to be drawn into the top of the flare stack since flow has stopped. This creates a dangerous situation. When the next flaring of gas is required, because of the combustible nature of the flared gas, the presence of the air can provide an explosive mixture which is easily ignited because of the constantly burning pilot.

In order to keep the system air free at all times, it is common to admit to the system a continuous flow of purge, or sweep gases, to maintain constant slow movement of gases through the system and out to the exit point. Two factors govern the purge or sweep gas movement. One factor is due to the passage of wind blowing across the open discharge end of the stack. To counter this effect it is common to use what is called a molecular seal in which there are two flow reversals. Such seals are described in U.S. Pat. Nos. 3,289,729 and 3,055,417. This allows entry of outside air only to the structure downstream of the molecular seal which is placed generally immediately below the point at which ignition occurs. For large flare stacks this is an expensive addition to the stack and does not provide a complete solution to the problem.

The second factor is temperature change within the system, due to either meteorological conditions, or due to the flaring of waste gases at significant temperature level. For example, in a flare stack **30** inches in diameter and 500 feet tall the system volume is approximately 2400 cubic feet. Assuming such a volume is filled with flare gases at 250° F. during a flaring period and when the discharge of hot gases is stopped, the system will cool to ambient temperature in about 15 minutes.

The volume of gases within the flare stack at atmospheric pressure would decrease proportionately to the absolute temperature to approximately 1700 cubic feet. Thus, air will be drawn into the stack in the amount of 2400 minus 1700 or approximately 700 cubic feet. This would cause an air penetration down the stack of approximately 150 feet. Since this column of air would travel for approximately 15 minutes it corresponds to a velocity of 0.15 feet per second. Thus, a

30 inch stack would require about 700 cubic feet of purge gas, or to provide a margin of safety, approximately 800 cubic feet each 15 minutes. The hourly volume would be about 3200 SCFH.

When the system is at ambient temperature there is no longer need for this large flow of purge gas at 0.15 feet per second. A nominal flow velocity of about 0.03 feet per second is adequate to insure that air is kept out of the stack at all times.

DESCRIPTION OF THE PRIOR ART

The prior art, as represented by the patent U.S. No. 3,741,713 is inadequate for several reasons:

1. Wastefulness of purge gases, which generally are hydrocarbon gases, or fuel gases. This waste is contrary to present day fuel-heat energy conservation requirements.

2. The prior art systems do not respond to small temperature changes in flare contained gases, which can be shown to be dangerous.

3. The prior art systems do not prevent the entry or use of purge gases when there is flow within the flare system and purge gases are not required for flare safety.

4. In the case of flare systems which operate with liquid seals at the flare base, constant purge or sweep gas flow is not required to further benefit fuel-energy conservation.

SUMMARY OF THE INVENTION

The terms purge or sweep gas are used interchangeably. Such gas can be any substance which is in gaseous phase at any temperature to which it may be subjected in this system. Commonly used purge gases are methane, ethane, propane, and nitrogen, but other gases such as argon can be used.

The purpose of the use of purge gases in flare systems is to avoid allowing a static, or reversed flow, in the entire flare system and to always maintain some small flow toward the discharge point of the flare system. The flare system does not become dangerous until such time as air or oxygen is present within the system. If the system flow is allowed to reverse, air is drawn into the system and there is immediate hazard of explosion or detonation, whenever normal forward flow is reestablished and the air-gas mixture meets the pilot flame.

Practice in the process industries where flares are used, has been to admit purge gas to the flare system to cause movement within the system toward the flare at commonly accepted flow velocity of 0.05 feet per second, as a minimum. This flow may seem small, but for such movement in a 24 inch flare system the purge gas required is 540 SCFH. For a 36 inch system the gas required is 1,237 SCFH, and for a 48 inch system the gas required is 2,215 SCFH. All of these are common system sizes. In some cases this volume of purge gas can be saved, and in the case of methane the saving is a startling $2,365 per year for a 24 inch system or $9,700 per year for a 48 inch system. Some process plants may have as many as five flares.

The purge rate of 0.05 feet per second is considered satisfactory for a drop in system temperature of 20°F in 15 minutes (such as from 80°F. to 60°F.) But, if the temperature drop should be 40° F. in 15 minutes it is necessary to increase purge gas volume to maintain the same condition of flare safety because the gas volume is proportional to absolute temperature at the same

pressure condition. Ambient conditions of sunshine, or chilling rain or wind action, plus a drop in atmospheric temperature, combined with above-ambient stack gas temperature, can produce 15 minute temperature drops as great as 90°F. under summer conditions. At 90°F. drop in 15 minutes the purge gas movement must be 0.083 feet per second for safety maintenance.

The data just shown are justified by calculation of the decrease in flare gas volume when there is a drop in temperature of the gas contained in the flare system when there is no flow. For example, in a drop of temperature from 80°F. to 60°F. the volume V within the flare system drops to 0.963V. With a drop from 150°F. to 60°F. the volume V is reduced to 0.852 V at the same pressure. In the case of drop in temperature from 80°F. to 60°F. this requires a volume of purge gas of 0.037 V or a flow of purge gas at the rate of 0.050 feet per second. For the case of drop from 150°F. to 60°F. a volume of purge gas of 0.148 V is required or a flow rate of purge gas of 0.083 feet per second.

It is thus to be seen that in normal meteorological changes, safety requires that purge gas volume be modulated to suit the temperature condition of the gas content of the flare system when relief venting of waste gases is not present. This is according to normal weather conditions, but in relief of hot gases from process operations the gas temperature can be as high as 500°F. or more and purge gas demand is greatly increased to 0.619 feet per second to further add to the need for gas modulation according to the system temperature.

The prior art such as illustrated by Patent 3,741,713 is directed to the higher temperature condition but it makes no provision for normal weather changes when, as shown, there is need for added purge rate. The prior art also makes no provision for purge rate modulation according to the flare system gas temperature for purge gas conservation.

SUMMARY OF THE INVENTION

It is a primary object of this invention to provide a purge gas system which conserves fuel heat-energy by controlling the rate of purge gas flow in accordance with the temperature of the gas in the flare system, and the pressure in the flare system. When the temperature is above normal and the pressure is normal purge gas is supplied in accordance with the temperature. When the temperature is high and the pressure is also high the flow of purge gas is not allowed to occur.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and advantages of this invention and a better understanding of the principles and details of the invention will be evident from the following description taken in conjunction with the appended drawings in which:

FIG. 1 represents a situation in which a water seal is provided in the flow system of the flare.

FIGS. 2 and 3 illustrate the situation where there is no water seal in the flare system, but the flare gas is controlled specifically by the temperature in the flare system and the pressure in the flare system.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Before explaining the present invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced and carried out in various ways.

Also it is to be understood that the phraseology, or terminology, employed herein is for the purpose of description and not of limitation.

Referring now to the drawings and in particular to FIG. 1 there is shown a flare system indicated generally by the numeral **10**, a purge gas system indicated generally by the numeral **12**, and a pressure control system indicated generally by the numeral **14**. The system of FIG. 1 includes as part of the flow system, a water seal in the base of the flare stack wherein a column of water **28** has immersed in it, the flare gas conduit **24** which has a downwardly depending portion **26** immersed in the water to a depth H. The depth H is sufficient so that there is substantially no danger that the water level will be drawn down to the point where gas in the stack can leak back into the conduit **24**.

The base of the stack **16** rests on the grade surface **46** and comprises a plurality of sections **18** terminating at the top opening **22**. There is a pilot fixture providing a constant flame for igniting the waste combustible gases that will flow in accordance with the arrow **13** through the conduit **24–26** and bubble up through the water **28** and flow upwardly through the flare stack **18** to the top opening **22** where it will be ignited and will burn.

When the flow of gas stops, the water seal at **28** prevents any of the gases in the stack **18** from re-entering the pipe **24**. However, to further prevent this flow backward there is a pressure connection **32** from the conduit **24** to a pressure sensitive switch **34** which is supplied with electrical power over leads **36**. When the pressure in the conduit **24** is low, power is applied through two leads **38** to the electrically controlled valve **40** which permits purge gas from input pipe **42** to pass through the valve **40** and through line **44** into the conduit **24** to maintain the pressure in the conduit at a preselected pressure level. With this pressure at the selected level there is no tendency for gas to be withdrawn from the stack back into the conduit **26**.

In accordance with the teachings of this invention, measurements are made of the gas temperature in the flare stack and the pressure of the gas in the flare stack to so control the flow of purge gas as to prevent any entry of air into the stack through the opening **22**, and to provide this control with a minimum total flow of purge gas, for the purpose of fuel and cost saving.

A temperature sensor **48** which can be of a thermistor, thermocouple, capillary, or other type in accordance with the teachings of U.S. Pat. No. 3,741,743 is inserted into the flare stack **16 – 18**. With a suitable control means **50**, as well known in the art, a signal is sent to a thermal controlller T indicated by numeral **52**. Power supplied by leads **54** to the thermal controller is connected by the controller through leads **53** and **55** to an electrically controlled valve **58**. Purge gas in the conduit **60** is controlled by valve **58** to flow through lead **62** into the base of the flare stack **16** and above the level of the water **28**. In other words when the temperature in the stack is above normal, purge gas could be permitted to flow through the valve **58** into the stack.

Although the prior art indicates that this thermal control is satisfactory, it is in fact not fully satisfactory and, therefore, it becomes desirable to control the gas

further by means of a pressure switch P indicated by numeral 56. This is connected by conduit 64 to the flare stack 18 and the pressure switch 56 is interposed between the leads 53 and 55. When the temperature at 48 is above normal the temperature control device T 52 provides a signal to the valve 58 to cause purge gas to flow through lead 62. However, when the flare gas is flowing, there is no need for purge gas because there is flow upwardly in 18 and the pressure in 18 is greater than normal. Thus when the temperature indicated by thermal sensor 48, and the pressure on conduit 64 are both above normal, the pressure switch 56 prevents the passage of signal from the temperature controller 52 to the valve, so the valve remains closed. However, when the flow of flare gas stops, the pressure will reduce to normal, while the temperature still remains high. Therefore, under these conditions it is necessary to flow purge gas, and the pressure switch 56 then closes permitting the signal from the thermal control 52 to control the valve 58 and cause purge gas to flow into the flare stack. As the purge gas flows and as the gas in the flare stack cools the temperature indicated by sensor 48 eventually reaches normal value and the thermal control 52 causes the valve 58 to close and cut the flow of purge gas to the stack.

In FIG. 1 the control system indicated by numeral 12 employing thermal and pressure switches provides a more controlled flow of purge gas in accordance with the temperature and pressure in the stack than does the prior art. FIG. 1 shows also an additional feature which has been used in prior art systems namely of the water seal at 28. However, in FIG. 1 there is a further control indicated by numeral 14 which, as needed, delivers a flow of purge gas in to the conduit 24 to maintain pressure. This involves the pressure switch 34 and control valve 40.

When flared gas flow in conduit 24 ceases, the immediate resting pressure in 24 is H inches water-column and if the gas inside 24 is at ambient temperature and if there is no leakage from 24, the resting pressure does not change. But if the gases inside 24 are at elevated temperature, there is reduction in both volume and pressure due to cooling or pressure in 24 is reduced by leakage, correction is immediately needed.

Pressure in 24 should always be above atmospheric pressure to avoid leakage-entry of air to 24; also to avoid withdrawing water 28 from the base of 16 which can occur if initial gas temperature is high enough as gas flow ceases. Normal pressure in 24 is greater than atmospheric.

The system indicated by 14 incorporates means to admit purge gas from substantial pressure to 24 when the pressure internal of 24 falls to just above atmospheric pressure. Pressure switch P senses the internal pressure of 24 through 32. As the pressure internal of 24 falls for any reason to near-atmospheric pressure, the switch P (34) closes. Power from 36 then is applied through 38 to a gas valve 40 which then opens to allow passage of purge gas from 42 to 44 and thence to 24 for immediate restoration of pressure within 24.

The control valve 58 is preferably one in which the rate of flow of purge gas through the valve from pipe 60 to pipe 62 is variably controlled in accordance with the temperature difference between the sensor temperature and the preselected ambient temperature, so that as the temperature difference increases the rate of flow of purge gas increases proportionately. The type of control instrumentation shown is well known, and instruments are available on the market, so that further detail of the instrumentation is not required.

In conduit 24, when there is flow of flare gas the pressure is always above the normal and, therefore, there is no flow of purge gas from line 42 through valve 40 to line 44. However, when flow ceases in 24 and pressure inside 24 falls to just above atmospheric for some reason, controls 14 immediately admit purge gas from 42 through 40 and 44 to 24 for immediate restoration of pressure in 24. Control of the rate of flow of purge gas through valve 40 is not precisely controlled as is the fb w through valve 58.

In FIGS. 2 and 3 there is shown a modification of the system of FIG. 1 in which the water trap comprising the water column 28 and inverted conduit 26, is not present and the entire control of purge gas is by a system similar to that indicated generally by numeral 12 in FIG. 1. There is in FIG. 2 for example, the same sensor 48, sensor control 50, lead 51 to a temperature controller 52 supplied with power on leads 54 and connected to leads 53, and 55 to a flow valve 76 connected between the line 78 carrying the purge gas and line 80 connected to the conduit 72, through which the waste flare gas passes into the flare stack 70. In addition, there is a pressure lead 74 connected from the conduit 72 to a pressure switch 56 interposed between the temperature controller 52 and the valve 76.

As in FIG. 1 the temperature sensor 48 controls the valve 76 as a function of the temperature measured. However, the control signal from the thermal controller 52 is controlled further by the pressure switch 56 responsive to the pressure in the conduit 72 which is indicated on lead 74.

Here again, when the temperature of the flare gases moving into the stack 70 is high, and the pressure is low, the pressure switch 56 is closed and transmits the signal from the thermal controller 52 to the valve 76 permitting a controlled flow of purge gas through line 80 into the conduit 72 and to the stack. On the other hand, if the pressure in the conduit 72 is high and the temperature at 48 is also high, indicating that there is a flow or flare gas at that time, there is no need for purge gas so that the pressure switch 56 will open and prevent the signal from the thermal controller reaching the valve 76.

As in FIG. 1 there are two main differences between this system and the conventional prior art system, namely that the control of purge gas is made dependent upon both the gas temperature in the flare stack and the pressure in the flare stack, whereas in the prior art the control of purge gas was made solely in the basis of temperature. Furthermore, there is the improvement of having a variable flow valve to control the purge gas, the rate of flow being a selected function of the temperature difference between the existing stack gas temperature and normal temperature depending upon the season and the weather and other local factors.

In FIG. 3 is shown a system similar to that of FIG. 2 except that it uses a type of thermal sensor which is a liquid-filled capillary type of sensing device well known in the art. The type of thermal control 88 would be different from the control 52 inasmuch as the thermal sensor 86 is different from that of 48. However, the commercial devices which are available on the market provide the proper control between temperature and switch opening and closing, so that with the proper

control device any one of the conventional types of thermal sensors can be used, as is well known in the art.

While the control system is shown as a series of separate elements, such as sensor **48**, sensor control **50**, lead **57**, temperature controller **52**, pressure switch **56** and valve **76**, these elements could be combined in any desired way to provide the equivalent, overall system. Irrespective of the individual elements and their names, etc., the novelty of this system resides in the dual control of purge gas based on the temperature and the pressure in the flare system. It also includes proportional control of the purge gas based on temperature difference.

In FIG. **1** where there is a water-seal formed by immersion of **26** in **28** to depth H, immersion is critical to avoid reversed gas flow from the interior of **16** above **28**. To provide evidence of the existance of **28** a level indicating device **30** is provided. Visual check of level at **30** is a gesture toward safety but in the absence of visual check, an alarm can be sounded when the level of **28** falls because of leakage, drainage or other cause. Any typical alarm device can be used. The element **30** can also be adapted, by means commercially available, for addition of water to **28** if it is needed for any reason and as it is needed normally.

While the invention has been described with a certain degree of particularity, it is manifest that many changes may be made in the details of construction and the arrangement of components. It is understood that the invention is not to be limited to the specific embodiments set forth herein by way of exemplifying the invention, but the invention is to be limited only by the scope of the attached claim or claims including the full range of equivalency to which each element or step thereof is entitled.

What is claimed:

1. The temperature-pressure activiated purge gas flow system for waste gas flares comprising;

a. a flare gas system including flare stack conduit means to introduce flare gas into said stack, pilot ignition means and means to introduce purge gas into said system;

b. means to measure the temperature and the pressure in said flare gas system and to determine the temperature difference between said temperature and a selected ambient temperature; and

c. means responsive to said temperature difference and to said pressure to control the flow of purge gas into said flare gas system.

2. The system as in claim **1** including control valve means responsive to said means to control the flow of purge gas into said system.

3. The system as in claim **2** in which, when said temperature difference is greater than a selected value, said control valve tends to open.

4. The system as in claim **3** in which when said pressure is higher than a selected valve, said control valve is prevented from opening.

5. The system as in claim **3** in which, when said pressure is lower than a selected valve, said control valve is permitted to open.

6. The system as in claim **2** in which said control valve is controlled proportionately by said temperature difference.

7. The system as in claim **1** including water trap means between said conduit means to introduce flare gas into said stack, and said flare stack.

8. The system as in claim **7** including in addition means to maintain a selected minimum gas pressure in said conduit means.

9. The system as in claim **7** including means for maintenance of said water trap.

* * * * *