United States Patent

Jasinsky et al.

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[54] FLARE STACK

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[52] **U.S. Cl.**.....**110/119,** 431/202

[51] **Int. Cl.**.....**F23j 15/00**

[58] **Field of Search**.....110/119; 431/202

[56] **References Cited**

UNITED STATES PATENTS

3,456,606	7/1969	Withorn	110/119
3,512,488	5/1970	Withorn	110/119
2,891,607	6/1959	Webster et al.	431/202 X

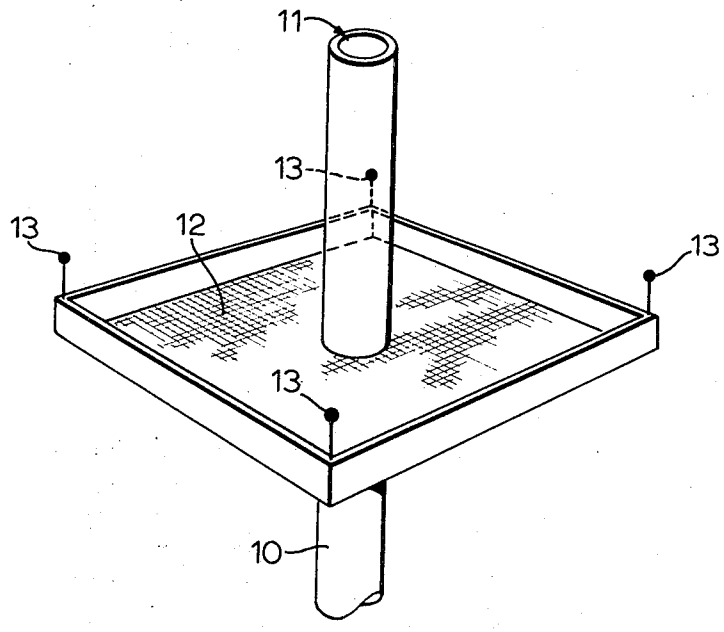
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[57] **ABSTRACT**

Flare stack smoke is reduced or eliminated by controlling the temperature of the flare. Said temperature is sensed by a sensing element e.g. one or more thermocouples connected in parallel and located in the vicinity of the flare; the sensing element produces a signal which directly or indirectly activates steam control valve to adjust the flow of steam to the tip of the flare stack so as to raise or lower the flare temperature to the temperature of optimum combustion of flare stack effluent.

7 Claims, 2 Drawing Figures



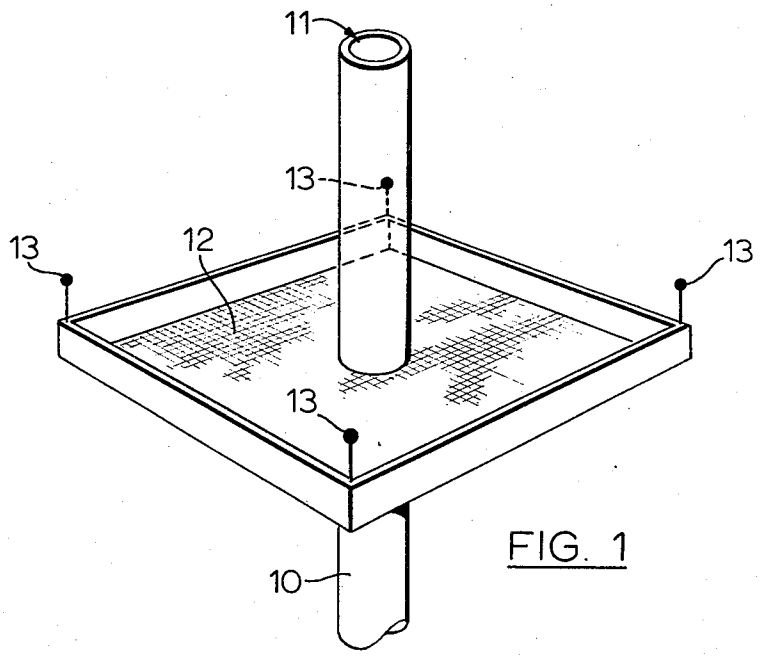


FIG. 1

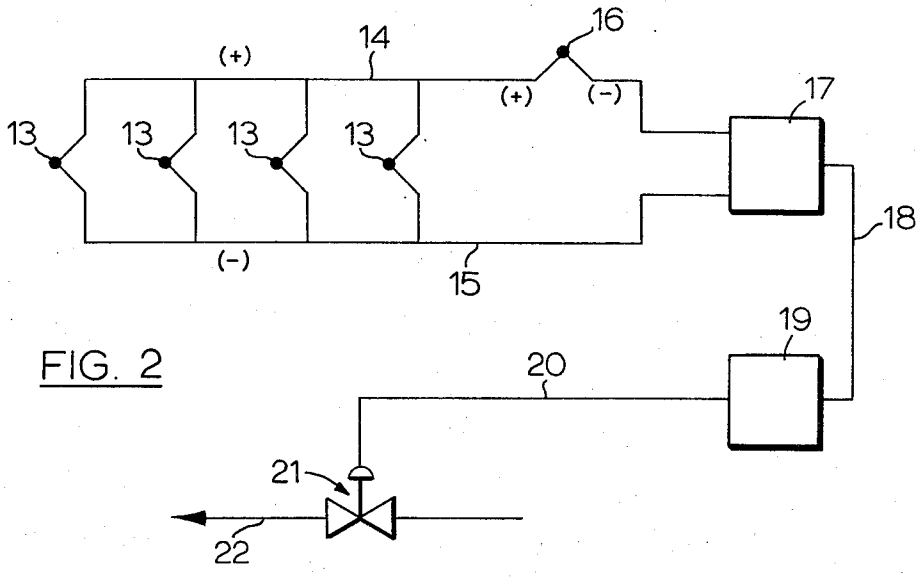


FIG. 2

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FLARE STACK

This invention relates to a flare stack and in particular to the smokeless combustion of flare stack gases.

Many industries and particularly petrochemical industry rely on combustion to decompose by flame objectionable gaseous effluents. Such effluents are piped to flare stacks of suitable height where they are mixed with steam and/or air and burnt. The feed rate of effluents varies depending on many factors and as a result the flare varies in size. Occasionally, during upsets in the operation, large amounts of combustible gases are directed to flare stacks to be burned causing the flare to increase. As the flare increases, its temperature rises and large amounts of black smoke are produced. To control smoke, steam is introduced at the tip of the stack; it reduces the flare temperature and facilitates complete combustion of gases. At the present time, the supply of steam is manually controlled. Under normal conditions, the steam usage is too high and inefficient. In the time of upset operations, however, it is used in inadequate amounts and the combustion of effluents is incomplete.

It is an object of this invention to provide an apparatus for automatic control of the combustion in the flare. A further object is to provide a process for controlling flare stack smoke. And yet another object is to reduce air pollution caused by flare stack operation.

This invention provides an apparatus for controlling flare stack smoke which comprises (1) a steam line leading to the flare, (2) a flow control means in said line, (3) a sensing element in the vicinity of the flare, capable of producing a signal proportional to the temperature of said flare, and (4) a transducer between said flow control means and said sensing element, said transducer being capable of converting the signal to a force acting on said flow control means. The process of controlling flare stack smoke in accordance with the invention comprises the steps of (a) sensing the temperature of the flare, (b) producing a signal, said signal being proportional to said temperature, and (c) adjusting steam flow to flare stack, the adjustment being proportional to said signal, whereby the flare temperature is caused to correspond to the predetermined temperature and the combustion of flare stack effluent is improved.

The invention will be more fully described with reference to the attached drawings in which

FIG. 1 is a side view of the upper part of flare stack and

FIG. 2 is a schematic view of the control apparatus.

Referring to FIG. 1, reference numeral **10** denotes a flare stack ending with a tip **11**. The tip **11** is provided with an outlet of a steam line, usually in the form of multiple steam nozzles, and pilot light, neither of which is shown in FIG. 1. A short distance below the tip **11** there is a platform **12**. At the periphery of the platform there are located four thermocouples **13**, all of them in unobstructed view of, and preferably equidistant from the tip **11**. The distance between thermocouples and the tip is shown in FIG. 1 to be 7 feet, but it may vary from 0 to about 25 feet.

The flare stack, usually a metal tubular structure, carries gaseous effluent of e.g. petrochemical plant to the stack tip, high above the ground level, where they are mixed with air and steam and burnt. The height of the stack should be sufficiently high to protect surrounding process equipment from the heat of combustion, and to properly disperse the products of combustion in the atmosphere.

The number of thermocouples in accordance with this invention may vary. If one thermocouple was used, the temperature measurement would not be consistent; depending on wind conditions, the thermocouple would measure either the temperature of the flare which would be very high or the temperature of the atmospheric air. The measurement would be better if the thermocouple was attached to a vane and moved with the wind so as to be always in the flare. Two thermocouples in diametrically opposite positions at the tip would be better. In the absence of wind, they would measure approximately a temperature which would not be as high as that at the

center of the flare, but nevertheless indicative of the flare temperature. In the case of wind blowing parallel to the line formed by the two thermocouples, one thermocouple would record a low temperature of ambient atmosphere and the second thermocouple would be close to the center of the wind-diverted flare and would record a high temperature. The average of two temperatures would be indicative of the flare temperature. In the case of a wind blowing perpendicular to the line formed by the two thermocouples, both thermocouples would record a low temperature of the oncoming wind and that temperature would not be truly indicative of the flare temperature.

In accordance with this invention, it is preferred to have three or more thermocouples located around the flare so that an average temperature indicative of the flare temperature is measured irrespectively and independently of wind conditions. At least one of the thermocouples would be in the line of the wind-diverted flare and would record a high temperature which would be then averaged with the temperature of the other thermocouples to produce an electric signal proportional to the average temperature, said average being indicative of the flare temperature and indirectly of the flare size.

Any conventional thermocouple can be used provided it will stand the maximum temperature to which it may be exposed. If the thermocouple is to be located in the flare, above the tip of the stack, then a sheathed chromel-alumel thermocouple may be used. It is preferred to locate thermocouples some distance from the flare where the temperature will be considerably lower than in the flare but sufficiently high above the ambient temperature; in such case, iron-constantan thermocouple is quite satisfactory.

FIG. 2 shows schematically how the thermocouples are connected to produce a signal which actuates corrective action on the valve so as to adjust the steam flow to a predetermined optimum value. The four flare stack thermocouples **13** are connected in parallel with all the positive leads connected to a conductor **14** and the negative leads to another conductor **15**. The conductors are connected to a transducer: the positive conductor is connected indirectly through an additional thermocouple **16** measuring ambient temperature and connected in series so as to counteract the effect of the flare stack thermocouples. The transducer **17** produces a pneumatic signal which is fed through line **18** to an indicator and/or controller **19** provided with automatic and proportional adjustments. The controller **19** is connected via line **20** to the control valve **21** on steam line **22** leading to the stack tip **11**.

Each flare stack thermocouple produces a signal, an electromotive force which is proportional to the temperature to which it is exposed. The electromotive force of each thermocouple is averaged as a result of their parallel arrangement and the average electromotive force which is proportional to the average temperature of all flare stack thermocouples is transmitted to the terminals of the transducer. In locations where the seasonal temperature fluctuates widely and where the temperature sensed by the flare stack sensing elements is significantly affected by the ambient temperature, it is desirable to compensate for that disturbing variable. For that purpose, an additional thermocouple is connected to the system as hereinabove described. The additional thermocouple measures ambient temperature and produces an electromotive force which counteracts the average electromotive force produced by all flare stack thermocouples. Thus, the resulting electromotive force of the above circuit is independent of seasonal or day variations of temperature; it is proportional only to the heat of combustion as manifested in the flare temperature and indirectly to the flow rate of effluents to the flare stack.

The electromotive force fed to the transducer is converted to a pneumatic signal such as an air or nitrogen pressure which is then transmitted to recorder/controller **19**. When the flow of effluent is increased, the flare temperature as detected by the flare stack thermocouples is also increased. This produces an error signal in the controller as the output pressure from

the transducer moves away from the set point. The error signal activates pneumatically or electrically the steam control valve to open it wider so as to reduce the flare temperature. Enough steam is added to bring back the temperature to the set point. As the flow of effluent decreases, the temperature is reduced and again an error signal is produced which activates the steam valve to reduce the flow of steam. Similarly when the ambient temperature falls as at night time, an error signal is produced whereby the steam flow is reduced so that the flare temperature is maintained at the set point at which the combustion of effluent is complete without excessive usage of steam.

The above described system was tested on a flare stack fired by gaseous $C_2 - C_5$ hydrocarbon mixture. Smoke was practically eliminated and steam consumption was reduced by about 20 percent compared with the previously conventional manner of operation.

As has been said before, the described system is applicable to flare stacks fired by obnoxious fumes, vapors and/or gaseous effluents such as are used in various industries. Various modifications of the system and process are possible with respect to the number and location of thermocouples or other sensing elements such as resistance temperature detectors, use of a compensating thermocouple, types of transducers and controlling elements without departing from the invention herein described.

What is claimed is:

1. An apparatus for controlling flare stack smoke which comprises:
   1. a steam line leading to the flare,
   2. a flow control means in said line,
   3. a sensing element in the vicinity of the flare, said element consisting of at least three thermocouples and being capable of producing a signal proportional to the temperature of said flare, and
   4. a transducer between flow control means (2) and sensing element (3), said transducer being capable of converting said signal to a force acting upon said flow control means.

2. The apparatus according to claim 1 in which the thermocouples are uniformly distributed around the flare.

3. The apparatus according to claim 2 in which the thermocouples are substantially equidistant from the flare at a distance of 0 to 25 feet.

4. The apparatus according to claim 1 in which all thermocouples are connected so as to produce a single electrical signal.

5. The apparatus according to claim 4 in which there is an additional thermocouple capable of producing a signal proportional to ambient temperature and counteracting the single signal from the flare thermocouples.

6. A process of controlling flare stack smoke which comprises:
   a. sensing and averaging the radiant heat in at least three directions equidistantly from the flare, said heat being proportional to the temperature of the flare,
   b. producing a signal, said signal being proportional to the averaged radiant heat, and
   c. adjusting steam flow to the flare stack, the adjustment being proportional to said signal, whereby the averaged radiant heat is caused to correspond to the predetermined value and the combustion of flare stack effluent is improved.

7. The process according to claim 6 in which the signal is an electric signal corrected for the effect of variable ambient temperature.

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