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Schmidt et al.

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[54] **METHOD AND APPARATUS FOR CONTROLLING THE ADDITION OF A COMBUSTION ASSISTING FLUID TO A FLARE**

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[52] **U.S. Cl.** **250/342**; 250/338; 250/340

[51] **Int. Cl.** **G01j 5/00**

[58] **Field of Search** 250/338, 340, 341, 342

[56] **References Cited**

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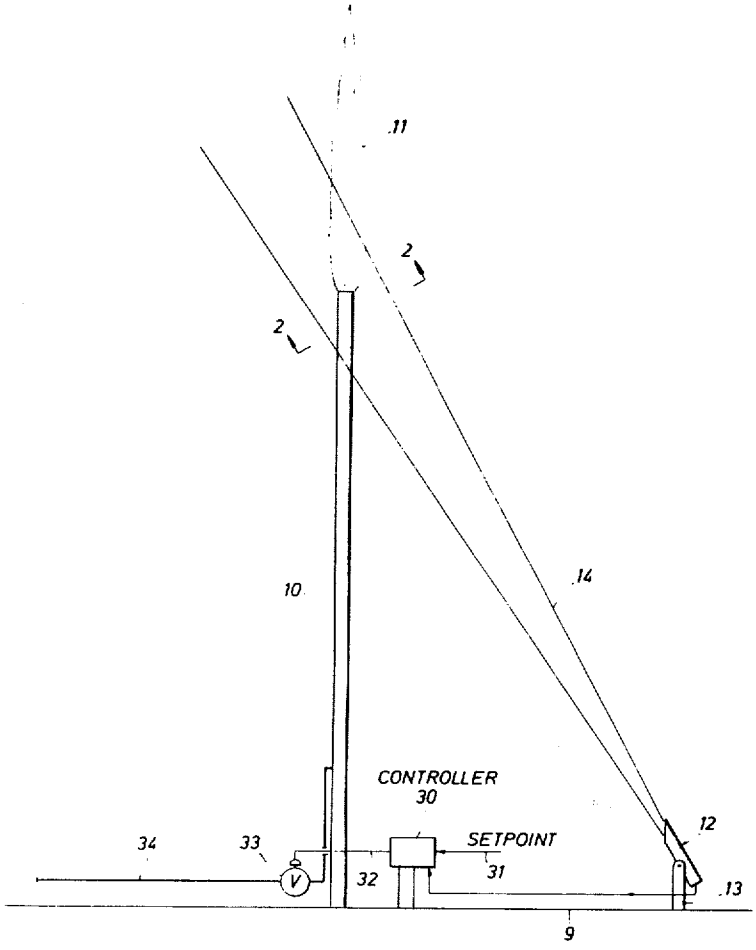
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Primary Examiner—Archie R. Borchelt

[57] **ABSTRACT**

A method and apparatus for controlling the flow of a combustion assisting fluid to a flare stack by detecting the radiation emitted by the flare and using the resulting signal to control the flow.

10 Claims, 5 Drawing Figures



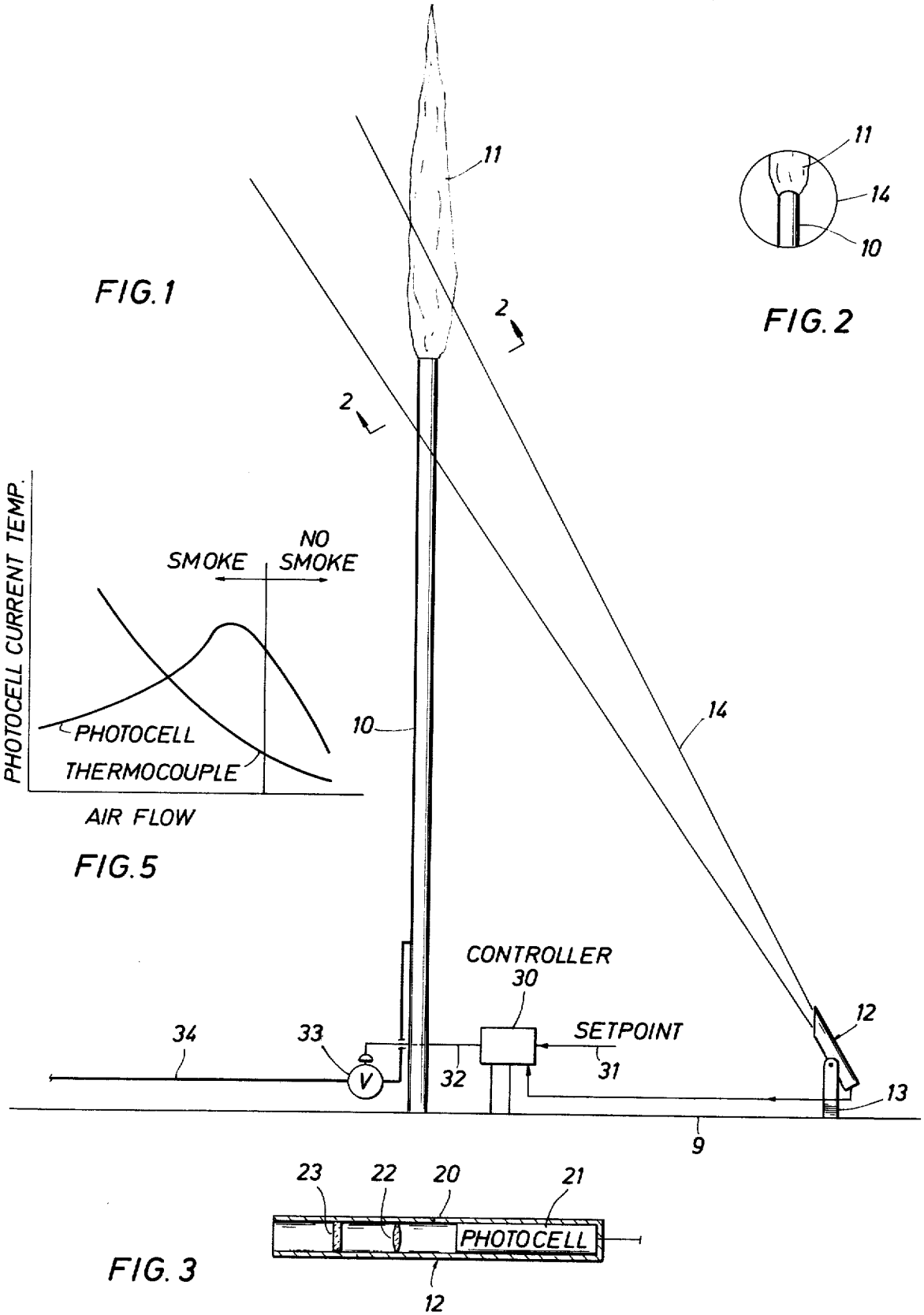


FIG. 1

FIG. 2

FIG. 5

FIG. 3

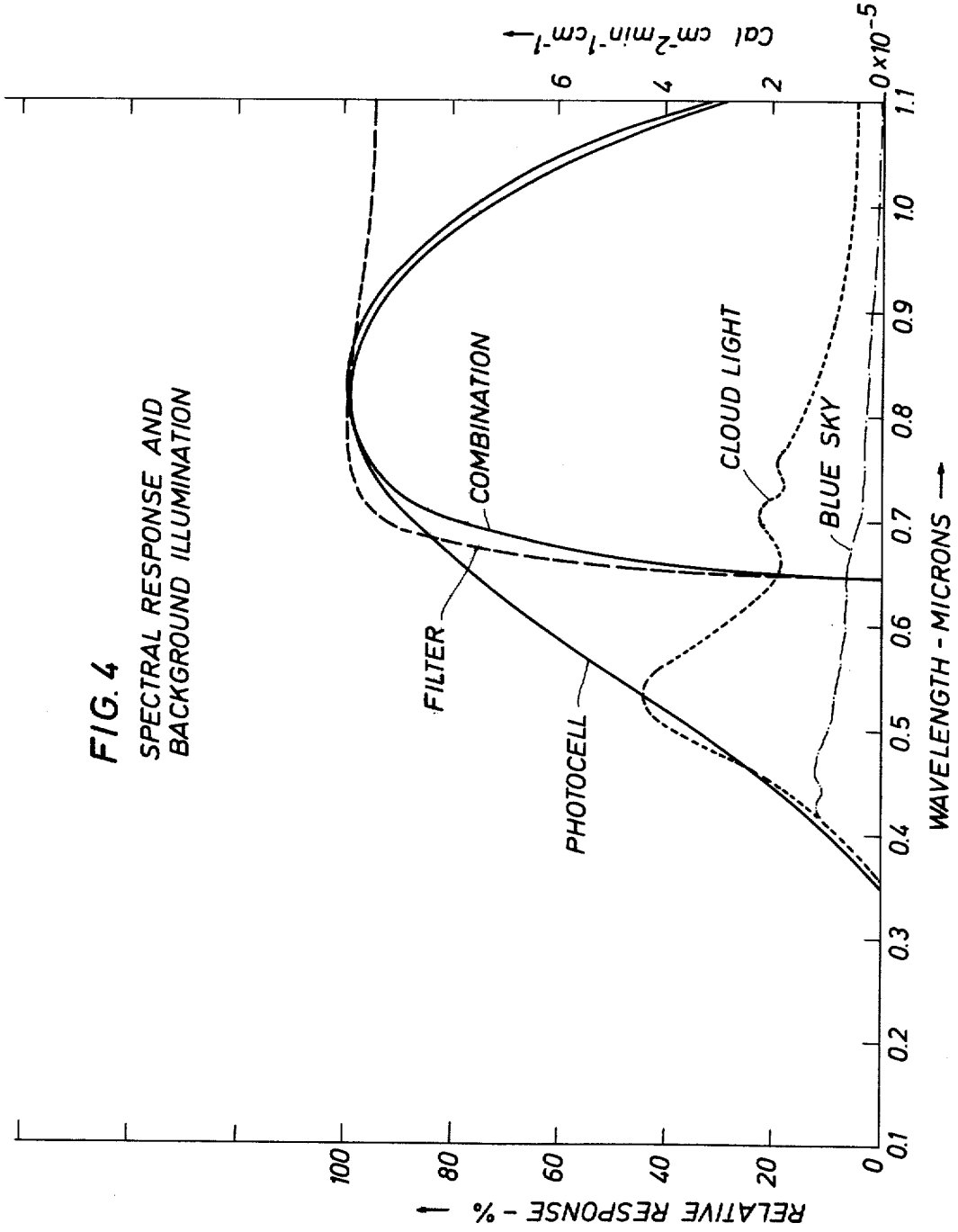


FIG. 4
SPECTRAL RESPONSE AND BACKGROUND ILLUMINATION

METHOD AND APPARATUS FOR CONTROLLING THE ADDITION OF A COMBUSTION ASSISTING FLUID TO A FLARE

BACKGROUND OF THE INVENTION

The present invention relates to a method and apparatus for controlling the flow of a combustion assisting fluid to a flare used for disposing of combustible gases in refineries and petrochemical plants. In refineries and petrochemical plants, it is a common practice to use a tall stack as a flare for burning combustible effluents resulting from an upset of the plant. The flare is an emergency device for disposing of combustible effluents particularly gases, during upsets or malfunctioning of a portion of the plant when the process stream or a portion of the process stream must be disposed of rapidly to prevent physical damage to the plant. The feed rate of combustible effluents to the flare stack thus varies from substantially zero to substantially the full capacity of the stack. As a result of the large variation in feed rates, it is difficult to ensure completely smokeless combustion of the emergency flares. It is common practice to introduce a fluid particularly steam, into the flare when it is necessary to burn a large quantity of effluents as a means for reducing the smoke. The steam or other fluid is injected at the base of the flare and assists in mixing the combustible effluents so that more complete combustion is obtained.

In the past, it has been common practice to rely upon manual control for introducing steam into the flare stack as required. In the normal practice when the operator detects an upset in the plant which results in the venting of combustible effluents to the flare stack and he opens the steam valve to ensure smokeless or complete combustion. Normally, no attempt is made to adjust the steam flow in relation to the quantity of effluents but rather full steam flow is used. Also, it is often the case that the operator forgets to turn off the steam flow after the upset or malfunctioning of the plant has been corrected and the venting of effluents to the stack has ceased.

In an attempt to provide some types of control, various flow measuring devices have been installed in the vent lines to the stack to measure the flow to the stack and then control the steam in relation thereto. Flow measuring devices are not entirely satisfactory since the density of the materials being vented varies greatly and, thus, controls responsive to flow measurements are not satisfactory. Likewise, certain materials require more steam to ensure complete combustion and controls responsive to effluent flow do not provide smokeless combustion.

Another control method uses thermocouples positioned near the top of the stack to measure the temperature of the flare and control the steam flow in relation thereto. The use of thermocouples provides a more accurate control of steam flow but has several disadvantages, for example, the thermocouples must be shielded from the wind and other air currents so that an accurate measurement of the flame or flare temperature is obtained. Likewise, the thermocouples must be placed close enough to the stack to respond to the changes in the temperature of the flame or flare while at the same time being located a sufficient distance so that they are not destroyed by the heat of the flame. This is difficult since the flame can vary considerably in size depending upon the amount of effluent being vented to the flare stack. A still further difficulty arises from the location of the thermocouples near the top of the stack which renders them inaccessible for normal servicing. Since the flare stack is used as an emergency device for disposing or venting of combustible effluents during upsets or malfunctioning of the plant, it is normally impossible to shut down unless the complete plant is secured. In the case of refineries or chemical plants, they are seldom, if ever, completely shut down.

BRIEF SUMMARY OF THE INVENTION

The present invention solves the above problems by utilizing a photocell positioned on the ground to view the flame or flare at the top of the stack. In particular, the photocell is a self-generating type of photocell, for example, a silicon photocell. The photocell is mounted in a housing which is provided with an optical system for limiting its field of view to a small angle of view, i.e. less than 20° and a filter for limiting the photocell's response to discriminate against light reflected from clouds. The field of view is limited to the lower portion of the flame or flare plus an additional portion of the top of the stack. This ensures that the photocell accurately views the bottom of the flame or flare even though the flare may tend to migrate down the top of the stack during the burning of a large quantity of material or to one side during high wind conditions. By placing the photocell mounting to the south of the stack and viewing the stack to the north, the photocell is not subject to direct sunlight. Thus, the radiation from the flame when the flare is ignited to burn effluents will be the primary radiation detected and used as a control signal.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be more easily understood from the following detailed description of a preferred embodiment when taken in conjunction with the attached drawings, in which:

FIG. **1** is an elevation view of the control system installed on a flare stack;

FIG. **2** is an elevation view of a cross-section of the field of view of the detector;

FIG. **3** is a vertical section of the detector in its housing;

FIG. **4** is a plot of the response of the detector and the filter and the combination of the two and background light; and

FIG. **5** is a plot of the response of a photocell detector compared to a thermocouple detector at various air flows.

PREFERRED EMBODIMENT

Referring to FIG. **1**, there is shown a flare stack **10** and a flare **11** at the top of the stack. The flare **11** results from the venting of effluents particularly gases from a chemical or a refinery to the flare stack and burning the effluents at the top of the stack. The flare stacks normally ranged from a few feet to 300 or 400 feet in height and are located in isolated areas removed from the plant proper. Also, stacks come in various sizes being capable of disposing of up to 800 thousand cubic feet per minute of effluents. The detector system **12** is mounted on a suitable support or mounting **13** with its field of view aimed or directed to observe the lower portion of the flare **11** and the top portion of the

stack **10.** More particularly, as shown in FIG. **2,** the detector system should be directed so that the field of view of its optical systems observes the lower portion of the flare and at least a portion of the top of the stack. This is necessary since at times wind conditions are such that the flare tends to extend downwardly along the top of the stack or is blown sideways instead of extending vertically upward, as shown in FIG. **1.** Also, as will be explained more fully below, the flare **11** when steam is admitted, tends to move upwardly from the top of the stack and the lower portion of the flare and particularly the lower third becomes transparent or at least partially transparent. The placement of the detector system can vary over reasonable limits although a location where the detector is aimed at a 45° angle with the ground has produced good results. It must be remembered that while radiation decreases as the square of the distance visible light remains substantially constant. Thus, the greater the distance between the detector and the top of the stack, the smaller will be the ratio between the radiation energy and light energy falling on the detector. The ratio between the radiation and light energy can also be improved by blanking off a portion of the optical system. For example, the bottom half of a circular lens could be blanked-off to eliminate a large portion of the light falling on the detector without materially reducing the amount of radiation.

It is also possible to improve the response of the system under high wind conditions by using two detector systems positioned to view the stack from different positions. The largest signal could then be used to control the steam flow.

The output signal from the detector system is coupled by a suitable lead to the controller **30** which is provided with a set point **31.** The controller may be a conventional process controller having proportional, derivative and integral actions and further should be of the type which accepts electrical signals and provides a pneumatic output signal. The set point of the controller is adjusted to provide smokeless operation of the flare. This can be done after the system is installed and in operation by an operator viewing the flare while effluents are being burned. The pneumatic output signal is coupled by the line **32** to operate the valve **33** disposed in the steam flow line **34.** Of course, other types of valves may be used which may require a different type of controller output signal. The steam line enters the flare stack and terminates in suitable nozzles at the top of the stack.

Referring to FIG. **3,** there is shown a vertical section of the detector system **12.** The detector system is provided with a suitable elongated tubular housing **20.** The housing **20** should have sufficient length to screen or shield the detector system from substantially all external light except that entering through the field of view of the optical system. Within the housing, there is preferably disposed a filter **23** which passes predominantly only infrared radiation. For example, the filter can be designed to predominantly pass radiation having a wavelength of 0.7 microns. A suitable filter is a filter manufactured by Corning Glass and known as a Corning No. 2030I–R filter. Also positioned within the housing is a lens or optical system which is capable of restricting the field of view of the detector system to the lower portion of the flare and the upper portion of the stack. The actual field of view will, of course, depend upon the height of the stack and the distance between the stack and the detector. Normally, the field of view will have an included angle of 3° to 15°. The detector cell **21** comprises a photocell mounted in the bottom portion of the detector housing and is preferably of the self-generating type to eliminate the need to provide a power supply to the detector. Good results have been obtained when the field of view was limited to lower third of the flare and 5 to 10 feet of the upper portion of the stack. A suitable detector cell is a silicon solar photocell which is sensitive to infrared radiation, for example a S2900 E–5M manufactured by International Rectifier.

As shown in FIG. **4,** the response of the photocell is primarily in the infrared region and this, in combination with the filter provides a detector system which has its maximum response in the infrared region. As explained above, the only source of naturally occurring infrared radiation is direct sunlight. Thus, by placing the detector system **12** so that it is not subjected to direct sunlight, it will respond almost exclusively to the infrared radiation contained in the flare **11.** For example, in the Northern Hemisphere, the detector system would conventionally be placed to the south of the stack to view of the flare to the north.

Referring to FIG. **5,** there is shown a comparison between the response of the photocell of the present invention and the thermocouples shown in the prior art. The response is plotted in relation to air flow which, of course, is substantially the same as steam flow. As explained, the steam supplied to the flare causes the flare to be agitated, which in turn, increases the natural air flow into the flare and eliminates the smoke. Also shown in FIG. **5** is a line which indicates that to the left smoke would occur and to the right there is no smoke. As seen, the response of the photocell increases as the air flow approaches the point where smoke is eliminated and then falls as the smoke is eliminated. This can be readily appreciated by the fact that as the steam flow to the flare is increased and thus the air flow, the flame or flare **11** tends to move upwardly from the top of the stack. This provides a relatively clear or substantially transparent portion of the flame at the top of the stack. Since this is the portion of the flare viewed by the detector, the detector signal will decrease substantially as the no smoke condition is achieved. This reduction in the detector signal, of course, results from the upward movement of the visible portion of the flame which contains the majority of the infrared radiation of the flame.

OPERATION

As explained above, the detector system **12** must be mounted or aimed to view the lower portion of the flare **11** and the top of the flare stack **10.** Further, the detector system must be positioned so that direct sunlight is excluded or shielded from the detector. This will normally be to the south of the stack in the Northern Hemisphere. After the detector system is properly positioned and aimed, the signal can be supplied to a conventional process controller. The process controller will then control the steam flow by manipulating the valve in the steam flow line. Of course, it will be necessary to adjust the response of the controller as well as its set point to achieve optimum results. Once the controller is adjusted, the system will control the steam flow to obtain the optimum results. For example, when an upset occurs and a large amount of effluent must be

disposed of rapidly, it will be vented to the flare stack. Initially, this large flow will be ignited by the ignition means at the top of the flare stack and burned with a substantially yellow to reddish flame as shown by the flare **11.** This type of flame will contain a large quantity of infrared radiation which will be easily detected by the detector **12.** This, in turn, will cause the controller to open the steam flow valve to admit steam to the flare. As the steam is admitted, it will cause additional air to be mixed with the burning effluent and reduce the color or illumination of the flare. The reduced color also reduces the infrared radiation contained in the flare. The steam flow also causes the flare or flame to move from the top of the stack providing a transparent portion at the bottom of the flare or flame. Since this is the portion viewed by the detector, the detector signal will then be reduced which will then cause the steam flow to be cut back. Finally, an equilibrium point will be reached depending upon the set point of the controller with the equilibrium point being the point at which the fire is substantially smokeless.

After the upset or malfunction of the plant has been corrected and the venting of effluent is no longer necessary, the detector system will again view the normal pilot flame at the top of the stack and cut back the steam flow or substantially eliminate it.

We claim as our invention:

1. A method for controlling steam flow to a flare stack for improving combustion comprising:

detecting the radiation existing at the base of the flare while substantially discriminating against reflected light;

producing a signal proportional to said detected radiation; and

controlling the steam flow in response to said signal.

2. The method of claim **1** in which the detected radiation originates at the top of the stack and the bottom of the flare.

3. The method of claim **2** in which the radiation is predominantly in the infrared region.

4. An apparatus for controlling the steam flow to a flare stack comprising:

a housing;

a photocell device, said device being mounted in said housing;

an optical system having a restricted field of view, said optical system being mounted in said housing to restrict the field of view of said photocell device to the top portion of the flare stack and the bottom portion of the flare;

a controller having a set point, said photocell device being coupled to said controller; and

valve means disposed to control the flow of steam to the flare, said controller being coupled to said valve means to position the valve means in response to the signal from the photocell device.

5. The apparatus of claim **4** wherein said housing is an elongated tubular structure disposed to exclude light from sources outside the field of view of the optical system from falling on said photocell device.

6. The apparatus of claim **5** wherein said housing is disposed at ground level and aimed so that the field of view of the optical system includes the top portion of the stack and the bottom portion of the flare.

7. The apparatus of claim **4** wherein said optical system limits the field of view to bottom one third of the flare.

8. The apparatus of claim **4** wherein said optical system includes a filter to limit the light falling on the photocell device to the infrared wavelengths.

9. The apparatus of claim **4** wherein said photocell device is self-generating.

10. The apparatus of claim **9** wherein the photocell device is silicon photocell.

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