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(19)

(54) IMPROVEMENTS IN OR RELATNG TO RADIATION DETECTING ARRANGEMENTS

(71) We, EMI LIMITED, a British company of Blyth Road, Hayes, Middlesex, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to apparatus for detecting the presence of flames.

Apparatus used, for example, to detect flames in the presence of strong sunlight, i.e. in circumstances such as may be encountered on an offshore drilling flatform or in an oil refinery, is required on the one hand to have sufficient sensitivity to reliably detect flames despite the presence of the sunlight, and on the other hand to resist the generation of false alarm signals in response to radiation other than that emanating from flames. These two requirements tend to be mutually incompatible, but it is an object of this invention to provide radiation detecting apparatus which performs both requirements well.

According to the invention from one aspect there is provided flame detection apparatus arranged to detect the presence of flames, the apparatus including a detector means arranged to receive radiation from flames, the detector means being responsive substantially only to radiation having a wavelength in the range from 4.19 μ to 4.45 μ inclusive.

According to the invention from another aspect there is provided apparatus for detecting the presence of flames, the apparatus including a first detector means responsive substantially only to radiation having wavelengths in a first range from 4.19 μ to 4.45 μ inclusive, to produce a first output signal including a component indicative of radiation from flames, a second detector means responsive substantially only to radiation having wavelengths in a second range different from the first to produce a second output signal including components indicative of radiation from flames and similar radiation from another source, means for correlating the first and second output signals to detect the presence in said first and second signals of correlated signal components due to flames, and means for providing an indication of the presence of flames in dependence upon the correlation.

The wavelength(s) in the range from 4.19 μ to 4.45 μ are chosen because solar radiation in that range is strongly absorbed by the earth's atmosphere, whereas infra-red radiation emitted from hydrocarbon flames exhibits a peak within the same range.

The correlating means may be a multiplier or another device (such as a phase-sensitive detector) which can detect correspondence (for example in time) between signal components due to flames in said first and second output signals.

In order that the invention may be clearly understood and readily carried into effect, one embodiment thereof will now be described, by way of example only, with reference to the drawings filed with the provisional specification of which:

Figure 1 shows, in block diagrammatic form, apparatus in accordance with one example of the invention, and

Figure 2 shows in more detail a mixing device suitable for use in the apparatus of Figure 1.

It will be assumed that the example of the invention about to be described is arranged to detect flames in the presence of strong sunlight. Because, in these circumstances, the detection of infra-red radiation has been found to be more reliable than the detection of ultra-violet radiation, principally because the latter tends to be absorbed to a substantial extent by smoke, infra-red sensitive detectors are used.

Solar radiation in the infra-red part of the spectrum and lying between the wavelengths 4.19 μ and 4.45 μ is strongly absorbed by the earth's amosphere, whereas

infra-red radiation emitted from hydrocarbon flames exhibits a peak within the same range. Thus, in order to take advantage of these characteristics, a first radiation sensitive detector 1 is arranged to receive radiation, from a predetermined field of view, through a filter 2 having a pass band of $\pm 0.10\ \mu$ about a central wavelength of $4.35\ \mu$. The use of this arrangement in itself increases the ratio of flame radiation to solar radiation detected by detector 1 by about two orders of magnitude compared with the corresponding ratio for conventional detectors working in other wavelength bands, for example, $2.70\ \mu$ to $3.20\ \mu$.

However, the kind of radiation detector which has been found most suitable for use as a detector device 1, namely, a pyroelectric detector, has been found in practice to suffer from microphony, this causing spurious noise signals to be included in the output signals provided thereby. In order to reduce this problem, the apparatus in accordance with this example of the invention utilises a second detector device 3, of different type to detector device 1, and which may be, for example, a silicon photo-diode or a lead sulphide cell. The device 3 is arranged to receive, via a filter 4, radiation from a field of view which overlaps the field of view of device 1 at least sufficiently that both fields of view contain the region of interest from which radiation is being monitored. The filter 4 can, for example, have a pass band extending from $0.80\ \mu$ to $1.10\ \mu$ in the event that device 3 is a silicon photo-diode or a pass band extending from $1.60\ \mu$ to $2.80\ \mu$ in the event that device 3 is a lead sulphide cell.

The output signals from both devices 1 and 3 are applied, via respective frequency selective amplifiers 5 and 6, (the latter also operating as an inverter) to a correlating device 7, which comprises a multiplier or a phase sensitive detector. When the device 7 is a multiplier its output is arranged to comprise a.c. signal components with no d.c. components and thus have a zero average value unless the output signals from devices 1 and 3 contain components which correlate with one another. If correlation exists, the output signals from the correlating device 7 include a d.c. component the magntiude of which is proportion to the amplitudes of the correlated components in the output signals from detector devices 1 and 3.

Since, broadly speaking, the output signals from detector device 1 contain components relating to flame radiation and noise, whilst the output signals from detector device 3 contain components relating to flame radiation, solar radiation and noise, it will be appreciated that correlated signals can only be produced by radiation from flames (or from other sources having similar spectral characteristics).

The output signals from the correlating device 7 are integrated and compared with a threshold level in a circuit indicated by block 8 and integrated signals exceeding the threshold level give rise to an alarm output on a lead 9.

A simple phase-sensitive detector comprising a transistor switch has been used successfully to constitute the correlating device of the Figure 1 apparatus. Such a device is shown in more detail in Figure 2.

Signals from detector device 1 (Figure 1) are applied via a capacitor 10 and a resistor 11 to the collector electrode of an n-p-n transistor 12, which is operated with its emitter electrode connected to earth potential. The base electrode of transistor 12 is supplied with a bias potential +VB from a terminal 13 and also receives the inverted output signals from detector device 3 (Figure 1) via a capacitor 14 and a resistor 15. The output of the device, generally indicated by the reference numeral 7, is taken between the collector and emitter electrodes of transistor 12.

The arrangement as shown in Figure 2 is such that the output is zero (i.e. the collector-emitter path of the transistor 12 is a short circuit) until the output signals from detector device 3 applied to the base of the transistor 12 assume a level sufficiently negative to turn the transistor off, i.e. to open circuit the collector-emitter path.

The detector can also be arranged to detect correlated signals due to flames in preference to other signals by arranging for the output signals from the amplifiers 5 and 6 to be in phase quadrature with one another at frequencies other than those indicative of flames.

From the foregoing description, it will be realised that because the noise components in the output signals of the two detector devices are uncorrelated, the correlating device produces no d.c. output in response to such components. This, of course, renders it possible to operate with signals which are below the detector noise levels.

It will also be realised that, unlike some existing arrangements which rely on determining the difference between output signals derived from two detector devices, the apparatus in accordance with the present invention does not require the two detector sensitivities to be compensated for temperature differences.

It has been discovered that the overall sensitivity of the arrangement to radiation emitted from non-incandescent, hot bodies can be greatly reduced by rendering the device 3 sensitive to radiation of shorter wavelength, i.e. about $1\ \mu$.

WHAT WE CLAIM IS:—

1. Flame detection apparatus arranged to detect the presence of flames, the apparatus including a detector means arranged to receive radiation from flames, the detector means being responsive substantially only to radiation having a wavelength in the range from 4.19 μ to 4.45 μ inclusive.

2. Apparatus for detecting the presence of flames, the apparatus including a first detector means responsive substantially only to radiation having wavelengths in a first range from 4.19 μ to 4.45 μ inclusive, to produce a first output signal including a component indicative of radiation from flames, a second detector means responsive substantially only to radiation having wavelengths in a second range different from the first to produce a second output signal including components indicative of radiation from flames and similar radiation from another source, means for correlating the first and second output signals to detect the presence in said first and second signals of correlated signal components due to flames, and means for providing an indication of the presence of flames in dependence upon the correlation.

3. Apparatus according to Claim 2, wherein the second range extends substantially from 0.8 μ to 1.1 μ.

4. Apparatus according to Claim 2 wherein the second range extends substantially from 1.6 μ to 2.8 μ.

5. Apparatus according to Claim 3, wherein the second detector means includes a detector device comprising a silicon photo-diode.

6. Apparatus according to Claim 4, wherein the second detector means includes a detector device comprising a lead sulphide cell.

7. Apparatus according to any one of Claims 2 to 6, wherein the first detector means includes a pyroelectric detector device.

8. Apparatus according to Claims 5, 6 or 7 wherein the, or each, detector means further includes a filter.

9. Apparatus according to any one of Claims 2 to 8, wherein the correlating device includes an n-p-n transistor, means for coupling the first output signal to the collector electrode of the transistor and means for coupling the second output signal to the base electrode of the transistor, the output of the correlating device being derived from the collector electrode of the transistor, the emitter electrode of the transistor being common and connected to a reference potential.

10. Apparatus for detecting the presence of flames substantially as hereinbefore described with reference to the drawings filed with the provisional specification.

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