

[54] FIRE DETECTING APPARATUS
SENSITIVE TO REFRACTION

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[56]

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UNITED STATES PATENTS

2,404,147 7/1946 Strickland 250/205
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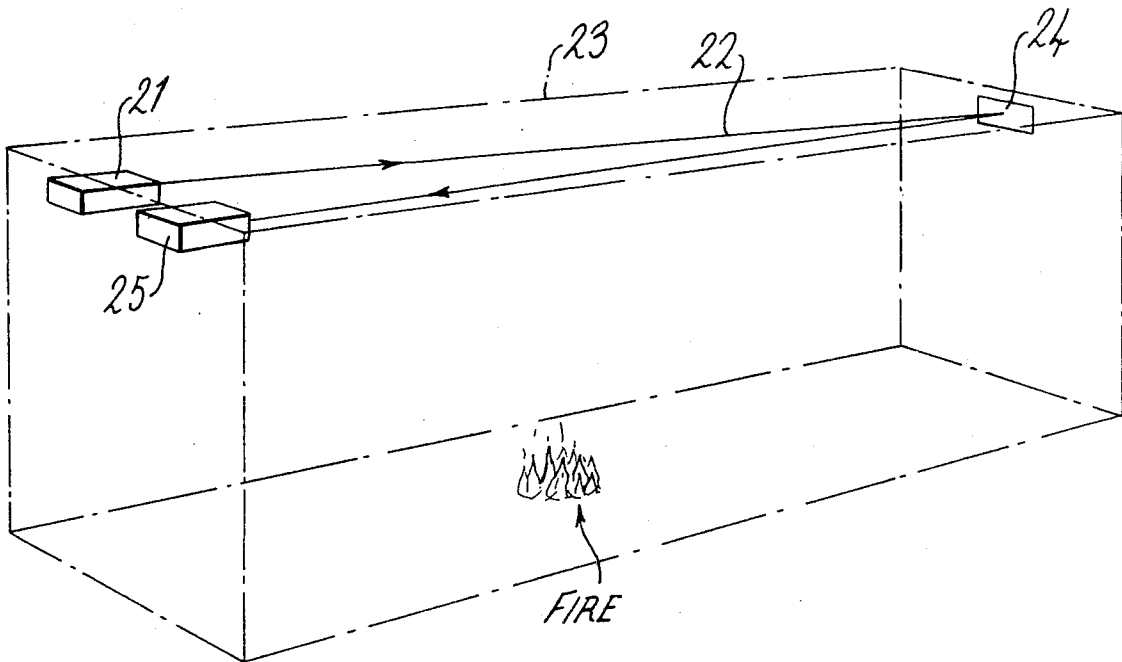
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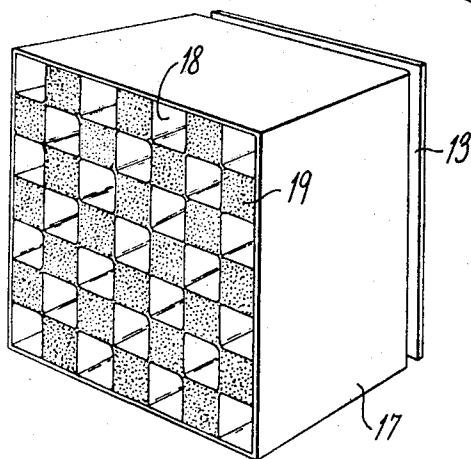
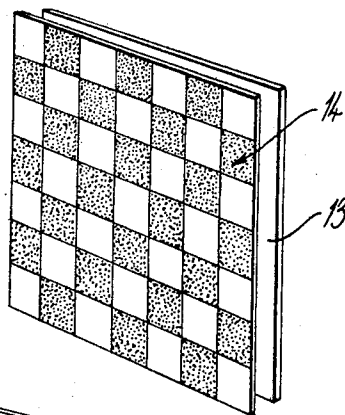
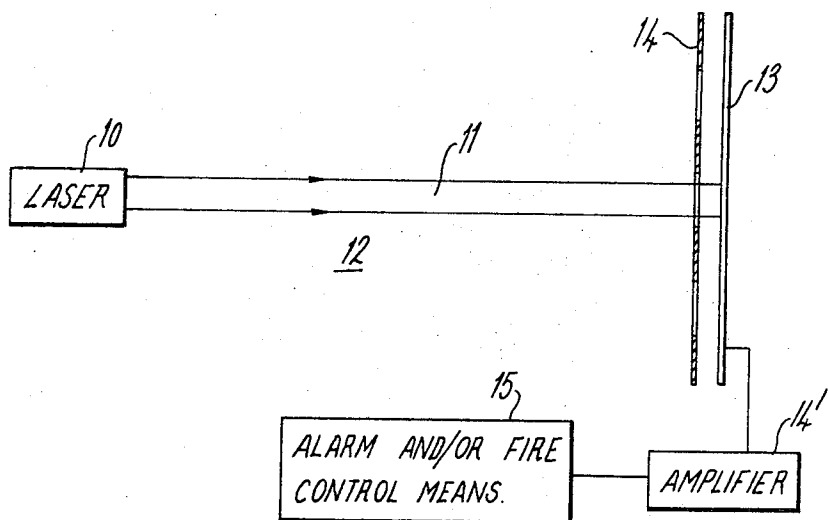
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ABSTRACT

Fire detecting apparatus comprises an emitter for generating a beam of electromagnetic radiation and a detector for producing an output signal dependent upon the amount of radiation incident thereon. The apparatus is arranged to be responsive to a fluctuating component in the output of a detector to operate an alarm or fire control means.

12 Claims, 6 Drawing Figures





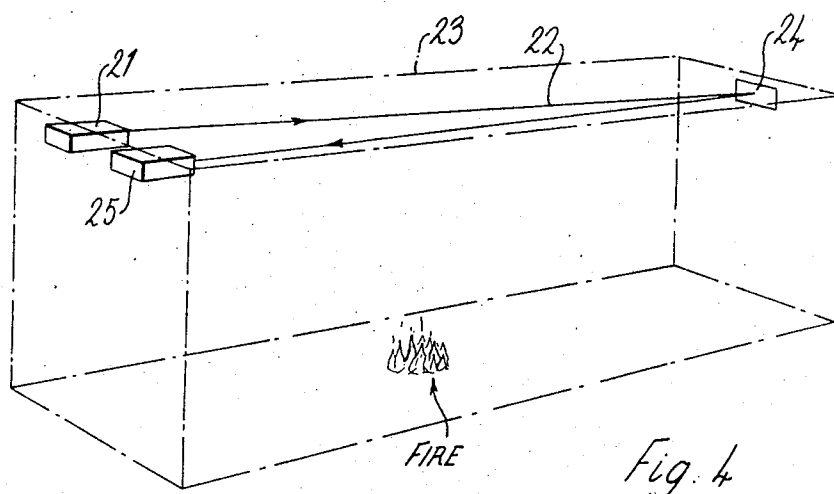


Fig. 4

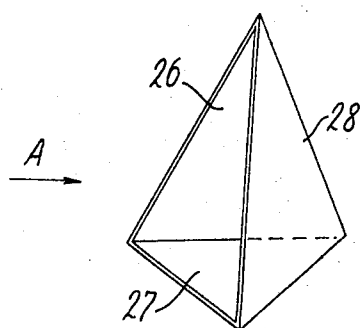


Fig. 5

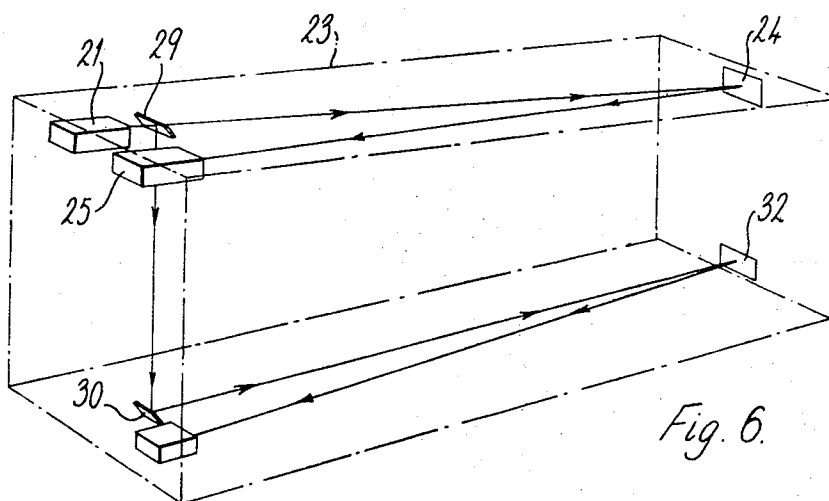


Fig. 6

FIRE DETECTING APPARATUS SENSITIVE TO REFRACTION

The invention herein relates to improvements in fire detection apparatus as disclosed in our U.S. Pat. No. 3,566,385 for Fire Detecting Apparatus Sensitive to Refraction, and the applications of O'Sullivan et al. Ser. No. 162,126, and Burry, Ser. No. 162,167, both filed July 13, 1971.

According to the present invention there is provided fire detecting apparatus comprising emitter means for generating a beam of electromagnetic radiation, photo-detector means, sensitive to the said radiation, and providing an output signal dependent upon the radiation falling thereon, and control means responsive to a fluctuating component in the output signal of the detector means for producing a control signal. The apparatus may be adapted to operate alarm and/or fire control means in response to detection of the said fluctuating component resulting from disturbances of the beam of radiation by a fire in the space through which the beam passes.

The photo-detector means may comprise a photo-sensitive surface in register with a mask bearing a checker board pattern with alternate squares of the checker board opaque and radiation transmitting, the beam of radiation being arranged to fall on the mask so that movement of the beam on the mask produces a fluctuating output signal at the photo sensitive surface.

The term "checker board pattern" as used herein, means a two-dimensional array comprising rows of alternate active and inactive areas. Adjacent rows are displaced with respect to one another so that an active element in one isle is aligned with inactive elements in the two immediately adjacent rows. In the case of a mask, the active elements are transparent to radiation and the inactive elements are opaque.

As an alternative, the mask and photocell arrangement may be replaced by an array of discrete photocells mounted in a checker board pattern on a support, with the space between the cells of the same order as the area of the cells. The outputs of the cells are summed, so that the movement of the beam spot over the array of cells in the presence of a fire produces a fluctuating output from the sum of the cell outputs.

Alternatively the photo-detector means may comprise a single photocell and the beam of radiation may be directed to fall on or adjacent the photocell in such a manner that occurrence of a fire in the space through which the beam passes between the emitter means and the detector means causes the beam to oscillate over a boundary of the photocell so that the output of the cell fluctuates.

It is preferred that the electromagnetic radiation is in the visible or near visible range of wavelength, and preferably the emitter is a laser. Alternatively the emitter means may include a semiconductor light-emitting diode in the infra-red or visible ranges, and the radiation used may be modulated with the various detecting circuits responsive only to the frequency of modulation.

Embodiments of the invention will now be described by way of example with reference to the accompanying drawings, in which:

FIG. 1 is a diagrammatic plan view of fire detecting apparatus according to the present invention;

FIG. 2 is a perspective view of part of the fire detecting apparatus of FIG. 1;

FIG. 3 is a perspective view of a modification of the part of the apparatus shown in FIG. 2;

FIG. 4 is a diagrammatic perspective view of an alternative form of fire detecting apparatus according to the invention;

FIG. 5 is a perspective view of a corner-cube reflector for use with the apparatus of FIG. 4; and

FIG. 6 illustrates a modification of the apparatus shown in FIG. 4 to provide an intruder alarm;

Referring to FIGS. 1 and 2, a fire detecting apparatus comprises an emitter 10 which directs a beam 11 of electromagnetic radiation across a space 12. There is provided a beam detector 13 which, if the beam is in the visible range of wavelengths, may be a photocell, the detector producing an output dependent upon the amount of illumination thereof by the beam.

It is preferred that the electromagnetic radiation be in the visible or near visible range of wavelength since such radiation can be more readily collimated and thereby employed over large areas by using, for example, reflection from reflectors. In this connection, it is to be noted that a laser is particularly suitable for providing a highly collimated beam.

Disposed between the emitter 10 and the detector 13 is a mask 14 which is shown in greater detail in FIG. 2. This mask 14 is of "checker board" configuration and has, in the particular example shown in FIG. 2, equal numbers of transmitting and absorbing portions which respectively allow or prevent the beam 11 falling on the detector 13.

The output from the detector 13 is amplified by an amplifier 14 which, is connected to and is adapted to actuate alarm and/or fire control means 15. The alarm and/or fire control means may provide an audible and/or visible warning of fire and may be operated locally or remote from the remainder of the fire detecting apparatus.

In the arrangement of FIG. 1 it will be appreciated that the beam 11 is permitted by the mask 14 to illuminate the detector 13. Fluctuations in the position of the beam 11 caused by, for example, changes in the ambient conditions in the space 12 may cause the beam to fall upon absorbing portions of the mask which prevent it from illuminating the detector 13. This will produce a slow change in the output from the detector 13 but the amplifier 14' is so arranged that these slow fluctuations in the output in the detector 13 do not cause actuations of the alarm and/or fire control means 15.

However, if there is a fire present in the space 12, more rapid fluctuations in the position of the beam 11 will cause the same to fall alternately on the transmitting and absorbing portions of the mask 14, and thus the beam 11 will alternately illuminate and be prevented from illuminating the detector 13. The amplifier 14' is so arranged that the resultant alternating output from the detector 13 causes actuation of the alarm and/or fire control means.

This arrangement has the advantage that the fire detecting apparatus is not affected by changes in ambient conditions within the space 12 and the alarm and/or fire control means are not actuated. However, the latter are actuated by the presence of fire in the space 12.

Referring now to FIG. 3 there is shown a modified form of mask 17 to that shown in FIG. 2. The mask 17

comprises a plurality (25 shown) of collimating elements 18 through which the beam 11 may pass and illuminate the detector 13. There are also provided a plurality (24 shown) of portions 19 which prevent the beam 11 from illuminating the detector 13. The purpose of the collimating portions 18 is substantially to prevent the detector 13 from receiving radiation other than the beam 11.

By way of example, the variations in refractive index of air in a fire are of the order of one per million per degree Celsius. A temperature gradient of 100° C per meter, for example, would cause the beam to follow a circular path of 10 km in radius and after transversing about 100 m, the deflections from fires are likely to be of the order of 10 mm. If a deflection of this magnitude is to be received and recorded by a photocell, it is necessary for the beam to be highly collimated. The spot of light after focusing the beam, should preferably not be greater in linear dimensions than the deflection of the beam caused by the fire and a laser beam is preferable for this degree of collimation.

Under no-fire conditions a laser beam may be focused to form a spot at a remote distance by means of a telescope. The spot has a diameter $(1.2/a) \lambda l$, where λ is the wavelength of the laser (0.6328 microns for the helium-neon laser) a is the diameter of the objective used to form the image, and l is the distance of the laser from the spot. Over a distance of 100 m and with an objective of diameter 50 mm, the spot would have a diameter of $(1.2 \times 0.6328 \times 10^{-3})/50 \times 10^5$ mm, i.e., of the order of 1 mm. The theoretical spot size is difficult to attain because of lens imperfections and 5 mm is a practical figure at this distance.

Even under quiet conditions the spot exhibits a slight movement of the order of a millimeter over a path of about 100 m.

Once a fire is lit under or to one side of the beam, the spot becomes violently agitated after a few seconds, the time lag depending on the height of the ceiling above the fire. This violent movement is a consequence of the turbulent plume of gas from the fire impinging on the ceiling and spreading out in much the same way as a torrent of water might strike and spread out over a floor. The turbulence causes the beam to deflect in a random manner about its rest position. If the fire progresses, the space immediately under the ceiling fills with hot gas, rather as a bath fills with water, and the laser beam traverses a layer of hot gas which is now less turbulent, the turbulent region at this time having moved below the beam. The agitation of the spot is less violent and it moves as a whole from its original undisturbed condition. As this may take considerably longer than the first indication of turbulence in the spot, it is important to develop a detection system using the turbulent movement of the spot. The deflection of the beam d , would be expected to fall off with height of compartment z , according to the law $d \propto z^{-2/3}$. The size of fire necessary to operate the detector increases proportionally with z .

If a simple detection system is constructed in which the beam from the laser traverses the space to be protected and is then received by a photocell, it suffers from the disadvantage of the beam being more sensitive to fires near to the laser than near to the photocell because of the optical lever effect.

The effect can largely be overcome by locating a mirror at the end of the protected space to return the beam on to a photocell placed near to the laser, so that the sensitivity due to the optical lever should never vary by more than a factor of two.

Referring to FIG. 4, an emitter means 21 directs a beam of electromagnetic radiation 22 along the ceiling of a room 23 to a mirror 24 which reflects the beam back to photo-detector means 25. The photo-detector 25 can take any of the forms previously described. This arrangement reduces the variation in sensitivity of the apparatus with distance of the fire from the laser but raises the problem of the stability of the mirror since any slight angular change of the reflected beam due to movement of the mirror mounting is magnified and recorded by the photocell as an alarm. This can be overcome by using a so-called corner-cube mirror system. As shown in FIG. 5, this consists of three mirrors 26, 27 and 28 disposed mutually at right angles with their reflecting surfaces directed inwards. Any ray of light incident on the reflecting surface of one of the mirrors is returned on a path parallel to the incident path irrespective of the orientation of the mirror system, subject only to the limitation that the angle of incidence does not differ from that indicated by the arrow A to such a large extent that the path of the reflected light would intercept one of the mirror planes beyond the boundary of that mirror.

There is always a small amount of fluctuation of the beam caused by ambient changes arising from convection in the area to be protected, but these occur at a lower frequency than those associated with fires. Thus, if the amplifier is tuned to receive a frequency of 40 – 70 Hz, it is possible to discriminate against ambient fluctuations. A delay is also incorporated into the system to prevent false alarms, should the beam be momentarily interrupted.

Referring to FIG. 6, part of the beam from laser 21 is diverted, by means of a half-silvered mirror 29, on to a reflector 30 just above floor level. The reflector 30 diverts the diverted part of the beam 31 across the room 23 and on to a further reflector 32 and thence to a photocell 33 which is used to control operation of an intruder alarm. The laser beam is invisible until viewed almost along the line of the beam and consequently it is unobtrusive.

By way of example, a system using a helium-neon laser installed in a building 41 m × 15 m × 12 m high (135 ft × 50 ft × 40 ft high) can be arranged to detect a fire (711 mm (28 in) in diameter) in liquid fuel at any point in the building within half-a-minute.

We claim:

1. Fire detecting apparatus comprising:
 - emitter means for generating a constant and stationary beam of electro-magnetic radiation,
 - photodetector means sensitive to said radiation and producing an output signal dependent upon the position of the beam of radiation incident thereon from said emitter means, and
 - control means responsive to an alternating component having a first predetermined frequency range and non-responsive to an alternating component having a second predetermined frequency range in the output of the photodetector means for producing a control signal.

2. Fire detecting apparatus as claimed in claim 1, in which the predetermined range is 40 to 70 Hz.

3. Fire detecting apparatus as claimed in claim 1, including an alarm arranged to operate in response to said control signal.

4. Fire detecting apparatus as claimed in claim 1, including fire control means arranged to operate in response to said control signal.

5. Fire detecting apparatus as claimed in claim 1, in which the photodetector means comprises: a photocell and a mask disposed between the emitter means and said photocell, said mask having transmitting and absorbing portions which respectively allow and prevent said beam illuminating said detector means and which are arranged in a checker board configuration, whereby fluctuations in the position of said beam cause the beam to alternately illuminate the respective portions of the mask thereby causing the output from the photocell to fluctuate.

6. Fire detecting apparatus as claimed in claim 5, in which each transmitting portion of the mask comprises collimator means.

7. Fire detecting apparatus as claimed in claim 1, in which the photodetector means comprises a plurality of discrete detectors arranged in an array with spaces between adjacent detectors of substantially the same area as the area of each detector and means for adding the outputs of the detectors to form a single output for

the detector means.

8. Fire detecting apparatus as claimed in claim 1, in which the photoconductor means comprises a single detector of substantially the same area as the area of cross-section of the beam of radiation at the detector, the emitter means being arranged to detect the beam on to the edge of the detector in such a manner that occurrence of a fire in the space through which a beam passes between the emitter means and the photodetector means causes the beam to oscillate over a boundary of the detector.

9. Fire detecting apparatus as claimed in claim 1, in which the photodetector means is disposed adjacent to the emitter means, reflector means comprising three adjacent mirrors disposed at right angles to one another, being arranged to reflect the beam of radiation on to the photodetector means.

10. Fire detecting apparatus as claimed in claim 1, in which a half-silvered mirror is disposed in front of the emitting means to divert a portion of the beam, said portion being directed on to subsidiary detector means which is arranged to operate an intruder alarm.

11. Fire detecting apparatus as claimed in claim 1, in which the emitter means is arranged to generate radiation in the visible range.

12. Fire detecting apparatus as claimed in claim 11 in which the emitter means is a laser.

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