

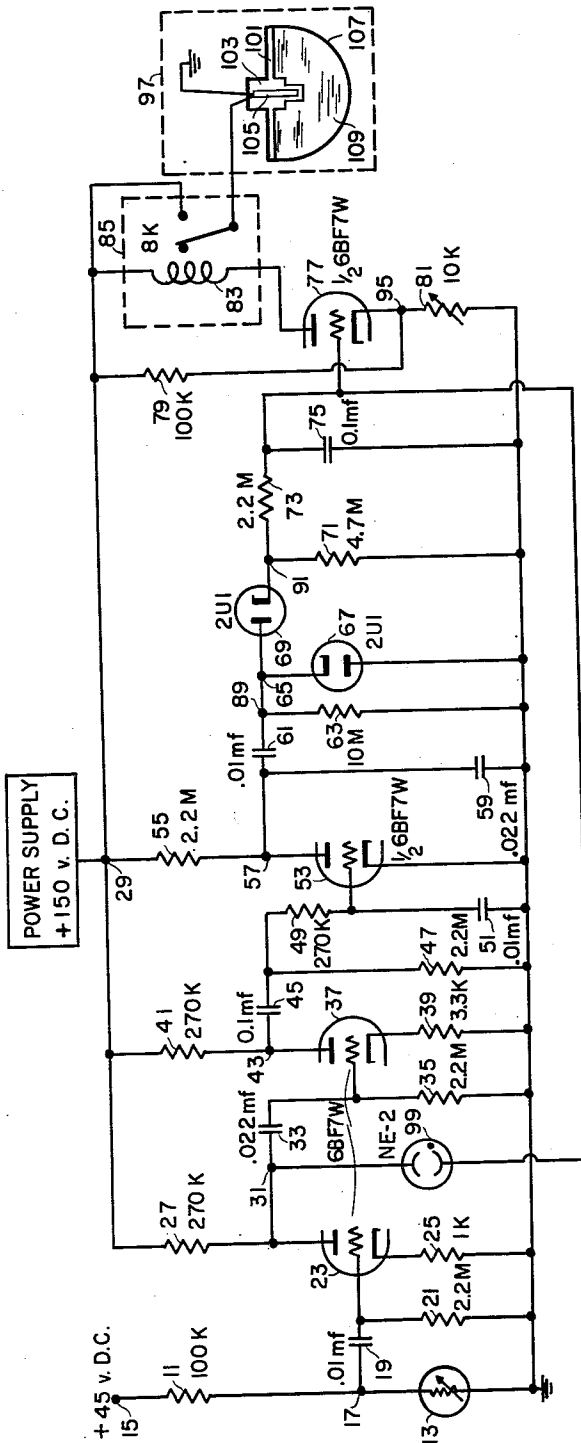
Sept. 4, 1956

B. T. JOYCE ET AL

2,762,034

FIRE AND EXPLOSION DETECTION APPARATUS

Filed Feb. 12, 1954



INVENTORS
BRADFORD T. JOYCE
ALBERT F. KRUEGER

BY: Jean C. Chapman
ATTORNEY

1

2,762,034

FIRE AND EXPLOSION DETECTION APPARATUS 5

Bradford T. Joyce, Concord, and Albert F. Krueger,
Needham, Mass., assignors to Electronics Corporation
of America, a corporation of Massachusetts

Application February 12, 1954, Serial No. 410,016 11

4 Claims. (Cl. 340—227)

This invention relates to apparatus for the detection of 15
fire and of explosions. It is designed to operate in con-
junction with an extinguishing device to suppress fires
and explosions before they have reached dangerous
proportions.

In order not to be subject to false alarms, a fire de- 20
tector must detect some physical phenomenon exclusively
associated with fires in the environment in which the
detector is to operate. One of the properties of flames
is that the radiant energy emanating therefrom is modu-
lated in amplitude. In other words, flames flicker, and 25
this flicker occurs at frequencies in the sub-audio and
lower audio ranges. A very satisfactory fire detector
distinguishes flames from other sources of flickering ra-
diation by means of a band-pass filter which makes the
detector sensitive only to flicker within lower and upper 30
frequency limits. The lower frequency limit, which may
be of the order of five cycles per second, prevents the
actuation of the fire detector by very low frequency
transients occurring, for instance, when venetian blinds
are lowered. The upper frequency limit, which may be 35
of the order of twenty-five cycles per second, prevents
the actuation of the fire detector by the flicker of lamps
energized by alternating current. An integrating device
is also provided to prevent the actuation of the fire de-
tector until the occurrence of several cycles of flicker 40
within the band-pass frequencies.

One of the properties of an explosion of a mixture of
a combustible vapor with air, as compared with the ex-
plosion of a substance which carries its own oxygen, is
that it begins with a relatively slow build-up of energy,
with correspondingly slow rises of pressure, heat, and 45
radiation. This rise may be spread over several hun-
dredths of a second before a critical energy level is
reached and a dangerous explosive pressure is developed.

An explosion detector and suppressor system has been 50
proposed in which the detector comprises a pressure-
responsive device which detects the rise in pressure oc-
curring in an incipient explosion. This detector operates
a suppressor which is designed to release an explosion or
fire-suppressing fluid. The suppressor comprises a frangi-
ble container for the explosion-suppressing fluid. A fast-
acting detonator, which is actuated by the detector, is
arranged to burst the container and thus scatter the ex-
plosion or fire suppressing fluid which it contains. This 55
explosion-detecting and suppression system is described
in detail in British Patent No. 643,188, published Sep-
tember 15, 1950.

It has been proposed to replace the pressure-responsive
explosion detector by a faster-acting detector which is
responsive to the rate of rise of electromagnetic radiation
which occurs in an incipient explosion. This explosion
detector of the radiation type comprises a photocell the
output of which is connected to an electronic valve through
a differentiating network. This valve, which is normally 60
nonconductive, conducts when the photocell detects a
rise of radiation of the type found in incipient explosions.

2

Conduction through the valve actuates the explosion
suppressor.

It is an object of the present invention to provide ap-
paratus which is capable of detecting both fires and ex-
plosions and of operating an extinguishing device before
such fires or explosions have reached dangerous proportions.

In accordance with the illustrated embodiment of the
present invention, the output of a radiation-sensitive cir-
cuit is used to operate an extinguishing device in the
presence of a flame and in the presence of an incipient
explosion. The flame detector channel between the photo-
cell and the extinguishing device comprises a band-pass
amplifier and an integrating circuit. The extinguishing
device operates only after several cycles of flicker within
the band passed by the amplifier have impinged on the
photocell. An explosion-detector channel, also connected
between the photocell and the extinguishing device, by-
passes most of the amplifier and the integrating circuit
and operates the extinguishing device in the presence of
a steep rise of radiation impinging upon the photocell 13.

Other and incidental objects of the present invention
will be apparent to those skilled in the art from a read-
ing of the following specification and an inspection of
the accompanying drawing which shows a circuit diagram
of an embodiment of the present invention.

Referring to the drawing, there is shown a resistor 11
and a photoconductive cell 13 connected in series be-
tween a power-supply terminal 15 and ground. The
photoconductive cell 13 may be a lead sulfide cell, and
its resistance at room temperature may be of the order
of half a million ohms. The resistor 11 and the photo-
cell 13 form a potential divider, and the potential at their
junction point 17 is a function of the radiant energy
impinging upon the photocell 13.

The junction point 17 is connected through a first RC
circuit comprising capacitor 19 and resistor 21 to a first
amplifier comprising tube section 23, biasing resistor 25
and a load resistor 27 one end of which is connected to
power-supply terminal 29. The anode terminal 31 of tube
section 23 is connected through a second RC circuit
comprising capacitor 33 and resistor 35 to a second
amplifier comprising tube section 37, biasing resistor 39
and a load resistor 41. The anode terminal 43 of tube
section 37 is connected through a third RC circuit comprising
capacitor 45 and resistor 47 and a fourth RC circuit
comprising resistor 49 and capacitor 51 to a third ampli-
fier comprising tube section 53 and load resistor 55.

The anode terminal 57 of tube section 53 is connected
to ground through a capacitor 59, and through an RC
circuit comprising capacitor 61 and resistor 63 to the
junction 65 of diodes 67 and 69. The cathode of diode
67 is connected to junction point 65, and its anode is
connected to ground. The anode of diode 69 is con-
nected to junction point 65, and its cathode is connected
to ground through resistor 71 and through an RC circuit
comprising resistor 73 and capacitor 75 to a fourth ampli-
fier comprising tube section 77, biasing resistors 79 and
81, and a load 83 which is the coil of relay 85.

The operation of the fire detector is as follows: in the
presence of a flame, the flickering radiation which ema-
nates therefrom and impinges upon photocell 13 causes
a corresponding fluctuation in the potential at junction
point 17. This flicker comprises a plurality of frequencies
having different amplitudes, the lower frequencies usually
having greater amplitudes than the higher frequencies.
A very rough estimate of the relationship between the
amplitude and the frequency of flicker components ema-
nating from a "typical fire" would be that, above one
cycle per second, the amplitude of a flicker component is
halved when its frequency is doubled. As the fire de-
tector shown in the drawing is designed to be responsive to

flicker in the range from 5 to 25 cycles per second, means are provided to attenuate the high-magnitude, low-frequency flicker components.

The fluctuating potential at junction 17, hereinafter termed "signal," goes through three stages of amplification, i. e., through tube sections 23, 37, and 53, before it reaches the anode 57 of tube section 53. The low-frequency flicker components are attenuated by means of the three RC circuits comprising capacitors 19, 33, and 45 and resistors 21, 35, and 47, respectively. The RC circuit comprising resistor 49 and capacitor 51 is a low-pass filter designed to attenuate any residual ripple in the power supply: in the embodiment shown in the drawing, this RC circuit is designed to attenuate the ripple found in standard aircraft power supplies, which are energized by a 400 cycle line.

Thus, even though at junction 17 the low-frequency flicker components have a considerably greater magnitude than flicker components of higher frequencies, the low-frequency attenuation introduced between junction 17 and the anode 57 of tube section 53 is such that at the anode 57 flicker components in the band from 5 to 25 cycles appear to have magnitudes of the same order.

Tube section 53 clips the amplified signal applied thereto, and the signal at its anode 57 would look like a series of square waves but for the presence of capacitor 59. Capacitor 59 charges slowly when tube section 53 is non-conductive and discharges rapidly when tube section conducts, so that the waveform of the signal at the anode 57 of tube 53 resembles a saw-tooth. This saw-tooth is differentiated over the RC circuit comprising capacitor 61 and resistor 63, the resulting waveform comprising positive and negative-going pulses. However, the negative-going pulses do not appear in the circuit, as they are shortcircuited to ground by diode 67. The positive-going pulses are passed by the diode 69.

The signal at the cathode 91 of diode 69 thus comprises a series of positive pulses. For a low-frequency signal, these pulses are spaced farther apart than they are for a signal of higher frequency, in which case these pulses are bunched together. These pulses are integrated over the RC network comprising resistor 73 and capacitor 75 and build on capacitor 75 a positive potential which is applied to the control grid of the relay tube 77. However, due to the presence of resistor 71, the charge built up on capacitor 75 is allowed to leak through resistors 73 and 71 to ground.

Tube section 77 is held in a normally nonconductive state by applying a biasing potential to its cathode 95 by means of biasing resistors 79 and 81 connected in series between power-supply terminal 29 and ground. Resistor 81 is shown as a variable resistor to adjust the bias on tube section 77. Conduction through tube section 77 closes the relay 85 which operates the extinguishing device 97.

Before tube 77 conducts (and operates the extinguishing device 97), a positive potential of sufficient magnitude must be built up on the capacitor 75. If the signal is a low-frequency signal (1 to 4 cycles per second, for instance), the pulses at cathode 91 are not close together, and not enough charging energy is applied to capacitor 75 to overcome the leak to ground through resistors 73 and 71 and thus build up enough of a positive potential on capacitor 75 to overcome the bias on tube section 77. If, on the other hand, the signal is of higher frequency (5 to 25 cycles, for instance), the pulses at cathode 91 are bunched together and build up enough of a potential on capacitor 75, in spite of the leak to ground through resistors 73 and 71, to overcome the bias on tube section 77. With its bias overcome, tube section 77 conducts, the relay 85 closes, and the extinguishing device 97 operates. Signal frequencies over 25 cycles usually have low amplitudes at point 17 to start out with, and are attenuated by the capacitor 59 between anode 57 and ground. Thus, the fire detector of the drawing is respon-

sive only to flicker in the range of 5 to 25 cycles per second, and several cycles of flicker in that range have to be integrated before the extinguisher operates.

In order to detect and suppress explosions, the extinguishing device 97 must be actuated very fast in the presence of a sudden rise in radiation impinging upon the photocell 13. For this purpose, a neon lamp 99, which is normally nonconductive, is connected between the anode terminal 31 of tube section 23 and the control grid of tube section 77.

In the presence of a steep rise in radiation, such as those occurring in incipient explosion, the sudden drop in resistance of photocell 13 causes a sharp negative-going pulse to occur at junction point 17. This pulse, which is sharp enough to be passed by the differentiating circuit comprising capacitor 19 and resistor 21, greatly reduces or completely cuts off the conduction in tube section 23. This causes a sharp rise in the potential at the anode terminal 31 of tube section 23. The neon lamp 99 is part of a potential divider connected between supply terminal 29 and ground and comprising resistor 27, the neon lamp 99, and resistors 73 and 71. The sharp rise in potential at the anode terminal 31 increases the potential across the neon lamp 99 which fires, thus applying a high positive potential to the control grid of tube section 77. Tube section 77 conducts, relay 85 closes, and the extinguishing device 97 operates.

The extinguishing device 97 may comprise a relatively stiff backing plate 101 which includes a housing 103 for a detonator 105. The wall of the housing 103 is reduced in thickness at the working end of the detonator 105. A frangible cup 107, made of phenolic-impregnated fabric, is securely attached to the backing plate 101 and forms a sealed cavity 109 in which an extinguishing agent is placed. These construction details, which are not shown in the drawing, are illustrated in British Patent No. 643,188, supra.

The detonator is connected through the relay 85 to the supply terminal 29 in such a way that it is operated when relay 85 closes. When the detonator operates, it shatters the frangible container 107, scattering the extinguishing agent which it contains and suppressing a fire or explosion in the vicinity of the extinguishing device 97. In a practical installation, both the photocell 13 and the extinguishing device 97 are placed in the volume to be protected, which may be, for instance, the interior of a wing of an aircraft.

The fire detector operates the extinguishing device after several cycles of flickering radiation have impinged upon the photocell 13. This is attained by means of a band-pass amplifier and an integrating circuit. The explosion detector also utilizes photocell 13 and by-passes most of the band-pass amplifier and the integrating circuit: it operates the extinguishing device within a small fraction of a second in the presence of a steep rise in the amount of radiant energy impinging upon the photocell 13.

We claim:

1. A fire and explosion detector comprising a radiation-sensitive circuit, an output device, a flame-detector channel comprising a band-pass amplifier and an integrating circuit, means connecting said flame-detector channel between said radiation-sensitive circuit and said output device, an explosion-detector channel responsive only to a steep rise in radiant energy impinging upon said radiation-sensitive circuit, and means to connect said explosion-detector channel in shunt with said flame-detector channel.

2. A fire and explosion detector comprising: a radiation-sensitive circuit including a photoelectric cell, a band-pass amplifying circuit comprising a plurality of amplifiers connected in series, a differentiating circuit connected between said radiation-sensitive circuit and the input of the first amplifier of said band-pass amplifying circuit, an output device, an integrating circuit connected between said output device and said amplifying circuit, and a gas-filled tube connected between the output of said first am-

5

plifier and said output device and in shunt with part of said band-pass amplifying circuit.

3. A fire and explosion detector comprising: a radiation-sensitive circuit including a photoelectric cell, an amplifier tube having an input electrode and an output electrode, a differentiating circuit connected between the radiation-sensitive circuit and the input electrode of said amplifier tube, an output tube, a band-pass amplifier and an integrating circuit connected between the output electrode of said amplifier tube and said output tube, an explosion-detector channel responsive only to a steep rise in radiant energy impinging upon said photocell, and

10

6

means to connect said explosion-detector channel in shunt with said band-pass amplifier and said integrating circuit.

4. A fire and explosion detector according to claim 3 wherein said explosion-detector channel comprises a normally nonconductive neon lamp.

5

References Cited in the file of this patent

UNITED STATES PATENTS

2,570,280	Roffman	Oct. 9, 1951
2,579,884	Thomson et al.	Dec. 25, 1951
2,621,239	Cade	Dec. 9, 1952