May 9, 1950 P. WEISZ 2,507,359

NOW BY CHANGE OF NAME
P. B. WEISZ
AUTOMATIC FIRE ALARM

Filed Jan. 27, 1943 2 Sheets-Sheet 1

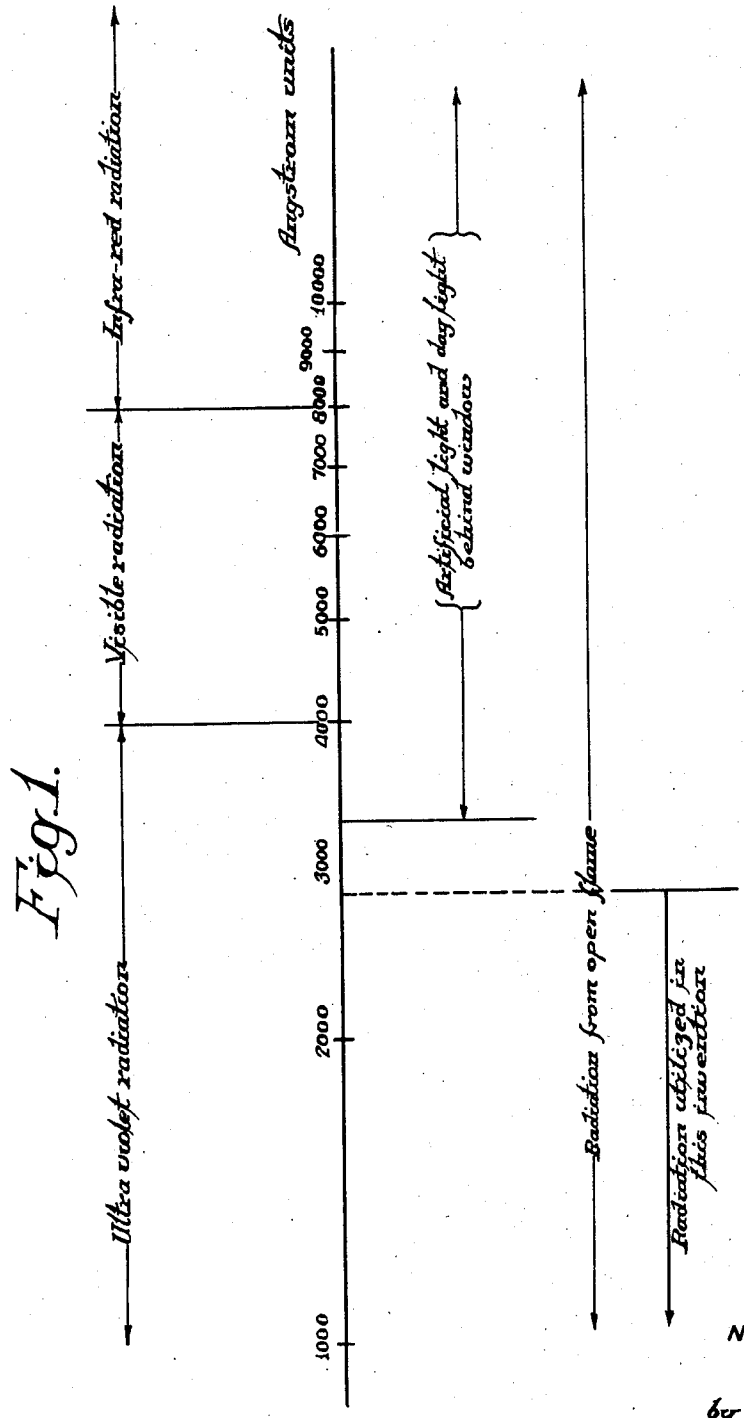

Fig. 1.

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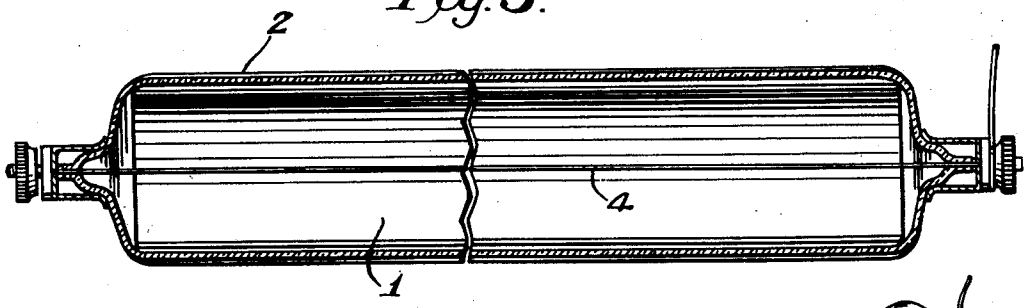
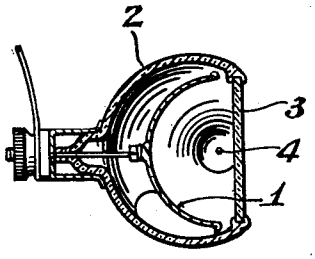
Fig. 3.



Fig. 4.

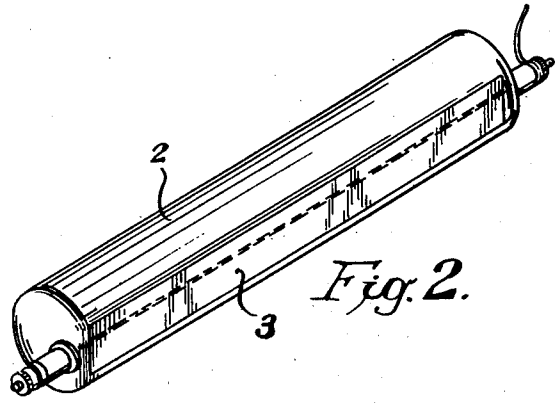
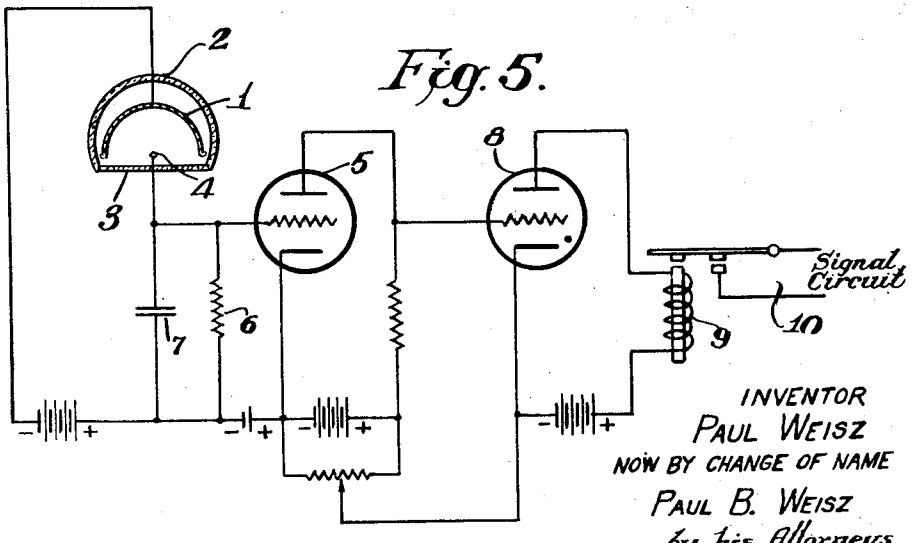


Fig. 2.

Fig. 5.



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Patented May 9, 1950 2,507,359

UNITED STATES PATENT OFFICE

2,507,359

AUTOMATIC FIRE ALARM

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Application January 27, 1943, Serial No. 473,757

3 Claims. (Cl. 177—355)

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This invention relates to automatic fire alarm systems, and more particularly to a novel system of this character embodying the features hereinafter described. The invention further relates to a novel photo-sensitive tube which is particularly adapted for use in such a system.

Various systems have been devised in the past to give an alarm or perform some electrical or mechanical operation as a result of the presence of a fire. Best known are those systems which rely on the fact that the temperature of the atmosphere in the vicinity of a fire will increase, and thus devices can be constructed which detect this increase of temperature, and the response thus obtained may be utilized to perform the desired operation. Other systems make use of the fact that a fire will radiate heat in the form of infra-red radiation, which can be detected by various known methods such as, for example, a sensitive thermo-couple.

Such prior systems, however, are not very sensitive. If the temperature rise of the air in the neighborhood of the fire is relied upon, there will be a considerable time delay between the time the fire originates and the time the heat detector responds, because of the time it takes the air to be heated, and this time delay will be greater the greater the distance between the fire and the heat detecting device.

When the infra-red radiation is utilized, the sensitivity is limited by the intrinsic efficiency of such devices as are known and used for infra-red detection. It is a well-known fact that such devices are by far less sensitive to infra-red radiation than, for instance, some of the known photo-electric cells are to radiation in the visible or ultra-violet region of the radiation spectrum.

The principal object of the present invention is to provide an improved system which is highly sensitive to the presence of a fire or open flame.

In accordance with the invention, a photo-sensitive electronic tube is utilized for the detection of a certain part of the light radiation emitted by an open flame, a part of the radiation which contains wave-lengths which are not present in the light emitted by artificial light sources used for illumination, nor which are contained in the daylight shining through windows into the localities which are to be protected. A study of the daylight spectrum reveals that there is no appreciable amount of radiation present which has wave-lengths smaller than about 3000 Å. On the other hand, the presently employed methods of electrical illumination do not yield any radiation appreciably below the low

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wave-length limit of the visible spectrum which it at about 4000 Å., mainly because of the glass envelopes of such devices as light bulbs which do not allow passage of radiation appreciably below 4000 Å.

Thus, this invention utilizes the fact that an open flame radiates light having wave-lengths reaching far into the ultra-violet region, and far below wave-lengths of approximately 3000 Å., while sources of light other than open flames do not emanate such radiation. This invention furthermore provides practical means and apparatus for the detection of that part of the radiation such that the response obtained can be utilized to set off an alarm signal or perform any desired electrical or mechanical operation.

While, in general, the invention contemplates the use of any photo-electric detectors such as are known to be sensitive to radiation in the ultra-violet region together with provisions such that the same will not respond to radiation of wave-lengths above approximately 3000 Å., for example, by the use of appropriate filters, in connection with an instrument or circuit which will transform the response of the photo-electric detector into the desired electrical or mechanical operation, the preferred form of the invention is that described hereinafter with reference to the accompanying drawings.

In the drawings:

Figure 1 is a chart showing a portion of the radiation spectrum and indicating the radiation employed by this invention;

Figure 2 is a perspective view of a photo-electric tube employed as a detector;

Figure 3 is a longitudinal sectional view of the tube;

Figure 4 is a transverse sectional view taken centrally of the tube; and

Figure 5 is a diagrammatic illustration of a system embodying the invention.

In the preferred form of the invention, an electronic tube, as shown in Figs. 2 to 4, is constructed so that it will respond only to radiation below a certain wave-length, such as 3000 Å. To this end, the tube has a photo-electric surface comprising material whose photo-electric threshold is of the order of a predetermined wave-length limit and which is responsive to wave-lengths below said limit. Some examples of such material are copper, gold and carbon.

The amount of ultra-violet light in the region below the wave-length limit suggested above which emanates from an open fire or flame is rel-

atively small compared to the amount of visible infra-red and near ultra-violet light emitted at the same time. Therefore, the photo-sensitive tube should not only be capable of discriminating between the different wave-lengths but should also be sensitive to the small amount of ultra-violet light to which it is intended to respond. I have found that a method of tube operation known as the Geiger counter principle is adaptable to these requirements. The Geiger counter principle ordinarily applied for the detection of radioactive radiations utilizes the fact that under certain potential and pressure conditions existing in a gas-filled two-electrode tube, any initial electrons produced by any agency such as radiation will lead to an instantaneous gas-discharge, and thus to an electrical pulse which can be measured, or the number of occurring pulses can be counted. This method of operation which is characteristic of a Geiger counter tube, provides for the production of a readily detectable current pulse for each individual light quantum detected by the tube. The pulse thus produced for only one detected quantum has experienced such internal amplification that it is readily measurable with presently available equipment. If such a tube is used properly for the detection of the ultra-violet radiation according to this invention by measuring the total current resulting from the integration of the individual pulses, it constitutes a photo-electric detector having an enormous amplification. As a consequence, it is not necessary to employ a very sensitive circuit in conjunction with the tube.

According to this invention, a half-cylinder 1 (see Figs. 2 to 4) of copper, or any other suitable material, is placed inside a vacuum tight chamber 2, preferably a glass tube. The chamber is provided with a window 3 of a material transparent to the radiation to be detected, for example, quartz. A wire 4, known as the "counter wire" in similar Geiger counter tubes, is extended along the axis of the half-cylinder 1, and the window is placed very closely to the wire, and is provided with dimensions nearly equal to or greater than the dimensions of the projected half-cylinder. By the use of the half-cylinder and a large window area, and by placing the window close to the cylinder, a great angle of aperture is achieved, representing a solid angle of nearly 180° of arc. Suitable terminals for the elements 1 and 4 are provided, as illustrated. The gas filling of the tube, and the treatment to obtain cleanliness can be the same as are known in connection with Geiger counter tubes.

The photo-sensitive tube is operated with an applied potential, and with a type of gas-filling such that these factors produce the well-known Geiger Müeller tube type operation; i. e. an electron, or electrons, produced on the photo-sensitive surface are accelerated sufficiently towards the wire (positive) electrode that multiplication of the electron, or electrons, in the gas occurs, thus producing effectively a very high gas amplification.

Such a tube may be operated in such a way that the applied potential is above the so-called "Geiger threshold" where due to an additional gas discharge mechanism in the tube the gas amplification begins to be increased by another large factor, or it may be used in connection with a more sensitive circuit in the so-called "proportional counter region," i. e. below the Geiger threshold.

There are two types of Geiger Müeller tube operation, the so-called self-quenching type, and the non-self-quenching type of operation, both differing in some of the fundamental modes of gas discharge process involved during the multiplication of electrons. The type of operation obtained depends almost entirely on the nature of the gas-filling. In the preferred mode of operation of this invention, as illustrated in Fig. 5, a self-quenching type tube is used. For example, a gas-filling of about 12 cm. Hg pressure of argon, with an admixture of .2% of butane has been used successfully, the tube being operated at about 800 volts electrode potential.

The photo-sensitive tube is connected to a circuit, as shown in Fig. 5, which responds to the output of the tube. The circuit includes a vacuum tube 5 which constitutes a vacuum-tube-voltmeter and responds to any sudden voltage drop produced along its grid resistor 6, due to a sudden photo-tube current when an open flame is present. The grid of tube 5 will change its potential to a more negative value, as may be seen from the polarity of the potential applied to the photo-sensitive tube. Consequently, the grid of the following thyratron 8 will be raised to a more positive potential, and adjustments can be made in well-known manner, to fire the thyratron when the described action occurs. The thyratron may operate a relay, such as shown at 9, to close an alarm or signal circuit 10, or it may perform any other function.

It is necessary that the grid elements 6 and 7 of the first vacuum tube be adjusted so that the system will operate properly. This is done by giving the condenser 7 and resistance 6 such values that it will take a certain number of discharge pulses of the photo-sensitive tube to change the value of the grid-potential by the amount which is just sufficient to cause the thyratron to fire and set off whatever action is desired. For example, a typical photo-sensitive tube of the type described above will yield an electrical pulse containing a charge of 5×10^{-10} coulombs, when one light quantum is detected. The presence of an open flame will easily lead to the reception of 20 detectable light quanta per second, so that the average current from the tube during the first second is $20\times5\times10^{-10}$ coulombs/sec, which is equal to 10^{-8} amperes. This current will produce a potential variation of approximately 0.1 volt along a grid resistor 6 of 10^7 ohms resistance. Obviously, this variation is amplified by the tube 5 to many volts variation on the grid of the thyratron 8. It is essential for this operation, however, that the time constant of the grid circuit of the first vacuum tube be somewhat larger than, say, one second, which is achieved by the capacitance 7, which may be .02 microfarad in this example.

The grid circuit of the vacuum tube 5 controlled by the photo-sensitive detector can also be utilized to control the sensitivity and response time of the alarm apparatus, by changing the value of the grid resistance 6, the value of the capacitance 7, or both. For example, with a resistance and capacitance such as described in the above example, the apparatus will respond to the presence of an open flame within approximately one second from its appearance. It may be desirable to delay the response in such a manner that no response will be obtained from the apparatus due to the presence of an open flame which makes its appearance for a very short time only, for instance, the striking of a match, or the appearance of an electric spark or arc for some

necessary industrial operation in the room to be protected. In such a case, the time constant of the grid circuit can be increased, preferably by increasing the capacity 7 to such a value that the instrument will not respond to the presence of an open flame unless the flame is present for a period of time of the order of magnitude of the time constant, or at least determined by it.

From the foregoing description, it will be seen that the invention provides a novel photo-electric tube which utilizes the Geiger counter principle of high internal amplification and which is particularly adapted for detection of radiations below a certain wave-length. It is to be understood that it is within the purview of the invention to use the tube for any purpose for which it may be adapted.

The structure of the tube may be varied widely. For example, the entire tube envelope may be formed of a single material, such as quartz. The photo-electric surface or electrode may take the form of a screen or grid. If desired, this element may be in the form of a cylinder, and the radiation may be admitted to the tube from all sides. Instead of an electrode separate from the tube envelope, a surface of photoelectric material may be deposited on the inside of the envelope, for example, by painting or sputtering.

It will be understood, therefore, that the invention is capable of various modifications within the scope of the appended claims.

I claim:

1. In an automatic fire alarm system, an alarm device, a photosensitive Geiger counter tube responsive only to light radiations of wave-lengths below approximately 3,000 Angstrom units, said tube being characterized in that it supplies internally amplified current pulses for individual light quanta and comprises an envelope at least a portion of which is permeable to said light radiations, a cathode within said envelope having a photo-electric surface responsive to said light radiations, an anode wire within said envelope in cooperative association with said cathode, a gas filling within said envelope to effect Geiger counter operation of said tube when a predetermined potential is applied to the electrodes, an electron tube circuit between said electrodes and said alarm device, and a capacitor and a resistor connected in said circuit to integrate the output current pulses of said Geiger counter tube.

2. In an automatic fire alarm system, an alarm device, a photoelectric tube responsive only to light radiations of wave-lengths below approximately 3,000 Angstrom units, said tube comprising an envelope at least a portion of which is permeable to said light radiations, a cathode within said envelope having a photoelectric surface which is responsive to ultra-violet light radiations of wave-length below approximately 3,000 Angstrom units and is substantially insensitive to ultra-violet, visible, or infra-red radiations of wave-length above approximately 3,000 Angstrom units, means within said envelope cooperating with said cathode to produce electric current in response to the light radiations to which said tube is responsive, means for integrating said current with reference to a predetermined time constant, and means for actuating said alarm device when the integrated current reaches a predetermined magnitude.

3. In a light radiation responsive apparatus, an indicating device, a photoelectric tube responsive only to light radiations of wave-lengths below approximately 3,000 Angstrom units, said tube comprising an envelope at least a portion of which is permeable to said light radiations, a cathode within said envelope having a photoelectric surface which is responsive to ultra-violet light radiations of wave-length below approximately 3,000 Angstrom units and is substantially insensitive to ultra-violet, visible, or infra-rad radiations of wave-length above approximately 3,000 Angstrom units, means within said envelope cooperating with said cathode to produce electric current in response to the light radiations to which said tube is responsive, means for integrating said current with reference to a predetermined time constant, and means for actuating said indicating device when the integrated current reaches a predetermined magnitude.

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