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M. H. A. LINDSAY ET AL

2,332,154

RADIANT ENERGY ALARM SYSTEM

Original Filed April 8, 1939

FIG. 1

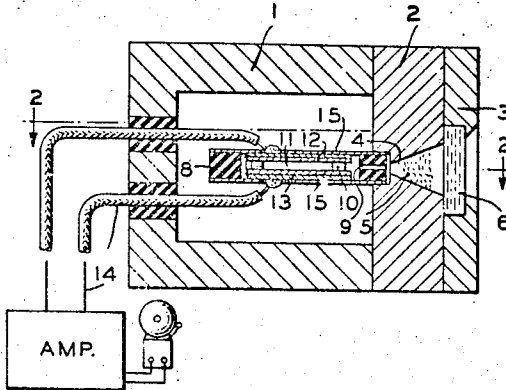


FIG. 2

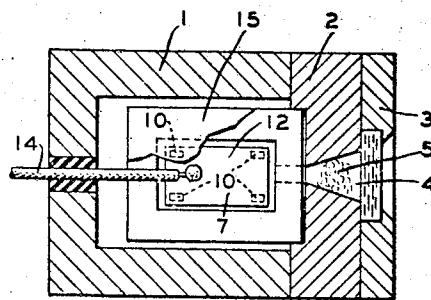


FIG. 3

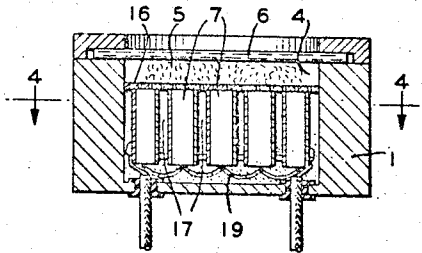


FIG. 4

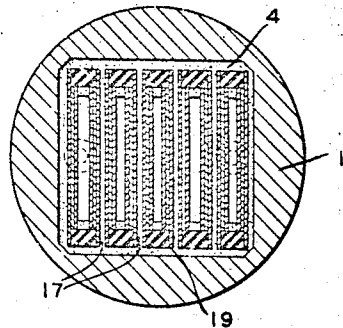


FIG. 5

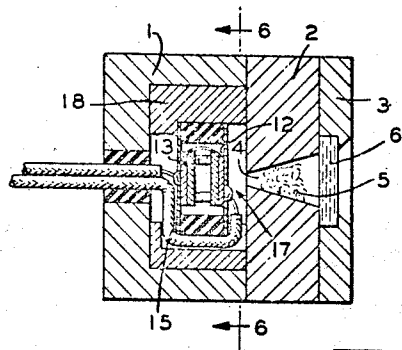


FIG. 6

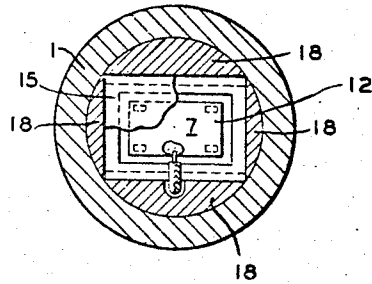
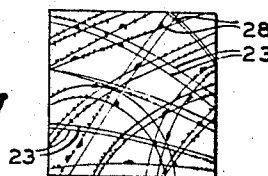


FIG. 7



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2,332,154

RADIANT ENERGY ALARM SYSTEM

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Original application April 8, 1939, Serial No. 266,738. Divided and this application July 27, 1940, Serial No. 347,328

14 Claims. (Cl. 250—83.3)

This invention relates generally to burglar alarm systems and apparatus and more particularly to receiving apparatus employing infrared radiant energy. A sensitive detector of radiant energy permits detection of burglars over long distances. Such systems are particularly useful since a compact apparatus can be used for protecting offices, stores and the like where it is necessary that the detection apparatus be easily concealed and occupy a minimum amount of space, and where it has previously been necessary to provide extensive wiring and multiple detectors. Furthermore, the radiant energy system is inherently secret and not easily defeated for that reason. Such systems are further advantageous in that they create invisible barriers through which an intruder may penetrate without realizing the existence of any sort of detection system. The radiant energy system also presents the advantage that is capable of viewing and thus protecting large areas with the use of a single transmitter and receiver whereby very little apparatus and very little wiring is necessary.

This application is a division of the application of Maxwell H. A. Lindsay and Howard J. Pearson, Serial No. 266,738, filed April 8, 1939.

Radiant energy detection systems are particularly useful in outdoor applications such as waterfronts, prison walls and the like where peculiar problems arise in that weather conditions defeat ordinary apparatus such as that of the photoelectric type. However, the system or apparatus disclosed herein utilizes radiant energy within that portion of the infrared band which is capable of penetrating heavy fogs and even heavy snow storms thus providing protection during all conditions of weather. Heretofore it has been necessary to employ physical barriers involving the use of extended circuits in protecting large outdoor areas but by means of the infrared beam it is possible to operate a single beam of invisible radiant energy, which must be penetrated or interrupted by intruders, and thereby create an intangible barrier of great length with a minimum amount of apparatus.

The principal object of this invention is to provide a burglar alarm system that is capable of viewing and thus sensing or detecting the presence of a burglar independently of any act of commission or omission on his part other than his entrance into and natural movements about a forbidden area or locality.

It is also an object of this invention to provide a burglar alarm system for viewing an area and

thus detecting the presence of a burglar by detecting the heat energy given off or absorbed by his own body, or absorbed or reflected by objects carried by the intruder as distinguished from so-called beam protection systems involving the use of a light source or other source of radiant energy.

Still another object of this invention is to provide a radiant energy detector capable of detecting minute changes in radiant energy over long distances and which is practicable in commercial use, cheaply manufactured and positive in operation.

A still further object of this invention is to provide an infrared energy receiver for outdoor use and sensitive enough to respond to alarm conditions during fog or any other state of the weather.

It is also an object of this invention to provide a sensitive material capable of responding to minute quantities of radiant energy and controlling a signal generating apparatus to obtain useful signals.

Another object of this invention is to provide an infrared energy receiver of a rugged construction which is extremely sensitive to heat energy and non-responsive to interfering mechanical vibrations.

Other objects and advantages of this invention will appear from consideration of the following description taken in connection with the accompanying drawing wherein:

Fig. 1 is a diagram showing an alarm circuit together with a cross section of a radiant energy detecting unit constructed in accordance with this invention;

Fig. 2 is a top plan section of the detector of Fig. 1 on line 2—2 of Fig. 1;

Fig. 3 is a plan view in section of a modification of the unit shown in Fig. 1;

Fig. 4 is a top plan view of Fig. 3 taken on the section at line 4—4 of Fig. 3;

Fig. 5 is a cross section of another modification of the detecting unit shown in Fig. 1;

Fig. 6 is an end view of Fig. 5 taken in section on line 6—6;

Fig. 7 shows the appearance of the heat sensitive material when seen under high magnification.

In accordance with the objects of this invention, we provide a radiant energy receiving device of great sensitivity by using a gas-occluding substance in a chamber containing a gas for causing pressure variations therein in response to changes in total energy and by arranging a

voltage generating element for converting pressure changes into variations in voltage in operative relation to said chamber.

It is well known from thermodynamic laws that the relation between the pressure and temperature of a gas is expressed by the equation:

$$PV=RT$$

where P is the pressure, V the volume, T the absolute temperature, and R the universal gas constant. Now if V is kept constant, P will be proportional to T. Any sealed cavity then, containing a gas, and having a window for the admission of radiant energy and means for indicating the resulting pressure change, would constitute a radiometer. Unfortunately this combination does not have sufficient sensitivity for practical purposes where small quantities of radiation, such as are emitted by a remote human body, are concerned. If, however, a substance is introduced into the cavity which has, first, the property of occluding relatively large quantities of the gas and, second, the ability of discharging the gas and thus raising the pressure a proportionate amount when heat is applied to the substance, a major improvement results. It also follows that a material which expands appreciably when heated will result in still further improvement. Such substances are herein to be disclosed.

The property of occluding gas is termed adsorption and in order that a material have considerable adsorptive capabilities, it is believed necessary both that the extent of its surface be great and that the degree of unsaturation of the surface atoms be high. The first condition is favored by a decrease in particle size or increase in the volume of capillaries for a given weight of material, and the second, in addition, by the presence of crystal fragments and by a decrease in crystal size, so that the atoms which are less saturated by their neighbors, such as the corner atoms, form a greater percentage of the total.

These requirements are met by employing hydrocarbons or soot obtained from the flame of burning camphor or of an acetylene lamp. This carbon is very finely divided and therefore has exceptional capability of occluding gas and then evolving the gas again when subjected to radiant energy. In order to support the finely divided carbon in the most effective manner, it is deposited on very small fibers such as quartz wool, steel wool, glass wool or fine mesh wire gauze. It has been found that the efficiency of the soot in converting radiant energy into pressure energy increases as the diameter of the supporting fibers is decreased, and that the extremely fine fibers of quartz wool offer the best means of support for the soot. In addition, these supporting materials, particularly quartz wool, are believed to enhance the response of a radiant energy receiving device of the type referred to above by expanding appreciably under the influence of received heat energy and causing more pronounced pressure changes within the gas chamber of the receiving device.

The process of sooting the various forms of wool and the wire gauze merely involves holding a small tuft of wool or a small piece of gauze in the flame of a camphor or of an acetylene lamp in such a manner that small particles of carbon are deposited in an amount sufficient to cover the fibers. Fig. 7 of the drawing shows the filamentary quartz wool 23 having particles of soot or carbon 23 deposited thereon, as seen through

a microscope. Only a few separated fibers are shown, the wool being employed in the detecting unit in a relatively compact form. The sooted material is then placed within the gas chamber of the heat detecting device where variation in the quantity of infrared energy impinging on the material may cause absorption or adsorption and evolution of the enveloping gas.

In order for material to readily discharge the adsorbed gas when heat is applied, the material or its surface must be capable of absorbing a large proportion of the incident radiation, the thermal capacities must be negligible and the specific density must be low. It is readily seen that the above mentioned material possesses, in addition to its high adsorptive properties, characteristics which meet these three conditions.

The successful radiant energy receiving device of the type described above must not dissipate the received heat energy thereby depriving the gas occluding substance of any appreciable amount of the received heat energy. Furthermore, the energy converting element must be of rigid construction and have a minimum amount of electrical leakage since the currents generated are necessarily very small in magnitude and it is further necessary to reduce current losses in order to reduce the possibility of false signals or loss of signals. It is also advantageous to utilize a minimum amount of wiring whereby the expense of installation of alarm systems is reduced to a minimum.

It is possible to use several different converting elements such as the carbon microphone, the electromagnetic or dynamic type of microphone, the condenser microphone or the piezoelectric microphone. The first two types of microphonic elements lack a sufficient degree of sensitivity to respond effectively to the minute pressures generated by a gas occluding substance. The condenser microphone, while it is sufficiently sensitive, involved the use of polarizing potentials, is liable to leakages for various reasons and requires the running of heavy multi-wire cables. The piezoelectric crystal microphone is a self-contained, pressure-responsive, voltage generating element which overcomes the above mentioned disadvantages and meets the requirements outlined above.

Fig. 1 of the drawing illustrates the application of gas occluding materials and piezoelectric converting elements to detection of radiant energy within the frequency range which includes visible and invisible heat rays. The converting unit or radiant energy detecting device includes a heavy metal casing 1 which serves as a mechanical protection and also attenuates external pressure waves such as sound which might interfere with reception of the useful radiant energy. The casing 1 is covered by a cover 3 which includes therein a window 6, the purpose of which is to admit radiant energy waves of the desired frequency.

A window of rock salt is suitable where radiant energy in the infrared range of wave lengths between 0.78 micron and 30 microns is transmitted for signaling purposes. Radiant energy in this range is desirable for penetrating atmosphere containing fog, rain or snow.

Between casing 1 and cover 3 is located a non-metallic and heat insulating member 2 having a conical chamber 4 therein which contains a gas occluding substance 5 of the types described above. It is preferred that a small tuft of quartz wool, sooted as described above, be used as the

substance 5. The casing 1 has a chamber therein for supporting and protecting the piezoelectric crystal element 7 in any suitable manner and for maintaining a constant pressure on the exterior parts of the crystal. The crystal element 7 is composed of two pairs of crystal plates 12 and 13 which are separated by insulating members 10 to form chamber 11. The crystal elements are supported by thin paper members 15 from the insulating frame 8 which has a passage 9 for connecting the conical chamber 4 with the chamber 11 between the crystal elements 12 and 13. The space between the paper members 15, the frame 8 and the edges of the plates 12 and 13 is filled with wax, the space between the plates forming a chamber 11. The piezoelectric converting element may be constructed in accordance with the general theory and principles as taught by the following patents of Charles B. Sawyer: Nos. 1,802,780, 1,802,781, 1,802,782, 1,802,783, 1,803,273, 1,803,274 and 1,803,275, dated April 28, 1931; No. 1,995,257, dated March 19, 1935.

When increased radiant energy is directed through the rock salt window 6, the material 5 expands and discharges gas contained or absorbed therein causing an increase in pressure within the chamber 4. The pressure increase is transmitted through the passage 9 in frame 8, to the chamber 11 between the crystal elements 12 and 13. If the radiant energy received by material 5 is decreased, the material contracts and absorbs gas whereby a pressure decrease occurs. The crystal elements are bent or otherwise deformed by all pressure changes whether they be increases or decreases in pressure, the deformation causing generation of voltages in proportion to the amount of pressure change or change in the received radiant energy. These voltage changes are communicated to a suitable amplifier through the conductors 14, as shown in Fig. 1, the resulting signal being amplified and utilized for alarm purposes or other measurement purposes.

Figs. 3 and 4 show another modification of a detecting unit wherein a plurality of piezoelectric crystal elements 7 are used for converting changes in gas pressure to changes in electrical voltage. The construction of this modification is somewhat similar to that shown in Fig. 1, except that the external casing 1 includes an elongated chamber 4 which contains the gas-occluding material 5. A large rock salt window 6 is supported at one side of the casing for admitting waves of radiant heat energy. A plurality of piezoelectric crystal elements 7 are embedded in wax 19 and generate higher potentials than a single unit. The gas-occluding substance 5 is supported by grid 16 which allows the pressure changes to penetrate spaces 17 and bend the crystal elements 7 inwardly. The remaining steps in the operation of this modification of the invention are obvious from the description of the unit described in connection with Fig. 1.

Figs. 5 and 6 show a further modification of the detecting unit wherein the piezoelectric element 7 is supported in a large chamber within the casing 1. This modification also includes a conical chamber 4 which contains the gas-occluding substance 5. This unit also includes spacers 18 which fill the dead air space surrounding the crystal 7. Chamber 17 is exaggerated for purposes of illustration but should be very small. Pressure changes resulting from reception of radiant energy are communicated di-

rectly to the small chamber 17 within casing 1 and cause the crystal elements 12 and 13 to be deformed inwardly as in Figs. 3 and 4. Otherwise the operation of this modification and its construction are the same as described above in connection with Fig. 1.

One of the most useful applications of this invention is in the detection of burglaries and it removes the necessity of extensive wiring as well as being readily installed or removed from the protected premises. The device may be easily concealed and consequently is invisible to an intruder who would not know of the presence of a burglar detecting system. In Fig. 1, we show a system for detecting burglars merely by heat given off from or absorbed by the body or any objects which the burglar may be carrying. The system includes the detector element which may be supported within the enclosure or premises to be protected in such a position that the window 6 views an entire room or any selected zone of an either indoor or outdoor area. The detecting unit may be provided with suitable lenses or reflectors for efficiently collecting radiant energy from the zone to be protected. The output of the detecting unit is connected to suitable amplifying apparatus, the output of which operates any form of an alarm device such as a bell which may be located at a central point within the protected premises or at the central office.

Upon the entry of a burglar into the protected premises, the radiant energy in the form of heat given off or absorbed by his body or objects carried by him will cause either increases or decreases in pressure within the detecting unit 12 as described above in connection with Fig. 1. These pressure changes are converted into electrical impulses which are amplified and operate the alarm device as indicated in Fig. 1.

It will be obvious to those skilled in the art that the radiant energy detectors shown in Figs. 1 to 6 may also be utilized in conjunction with a source of heat energy for forming a protective beam whereby interruption of the beam of heat energy will decrease the amount of heat received and thereby cause a signal impulse. Such a beam of energy may be arranged to cover or protect any desired area either within an enclosure or within an outdoor premise.

Because of the peculiar conditions of the heat reflection and absorption which are encountered in different rooms of buildings and in outdoor applications, the radiant energy detecting system described above may not always detect an increase in heat from an intruder's body. The intruder may possibly enter a room, the temperature of which will cause absorption of heat from the intruder's body. It is also possible that due to the color of the walls in an enclosure and to the color of the intruder's clothing that heat will be absorbed or the reflected heat will be altered when the intruder enters or moves about the enclosure. In the case of the system described and shown in Fig. 1 of the drawing, the detector unit will always detect a change in the amount of heat or radiant energy received by it. In other words, entrance or movement of an intruder is certain to change the amount of heat or radiant energy affecting the detecting unit. The same phenomena may occur in systems such as those employing a protective beam of energy and even though the beam of radiant energy is directed into the detecting unit it is entirely possible that an intruder may increase

the amount of radiant energy in the beam because of the color of his clothing or because of heat reflected from the walls and again reflected by the intruder's body. In any case the apparatus provided by this invention will detect both increases and decreases in the amounts of radiant energy received because of the inherent gas adsorbing properties and gas discharging properties of the material 5 in the radiant energy receiver unit. The piezoelectric crystal element follows decreases and increases in gas pressure since any deformation of the crystal element will generate an electrical voltage. For the above mentioned reasons the radiant energy receiving apparatus is capable of detecting all changes of radiant energy within the infrared band which may occur because of movements of a burglar or other intruder.

The above described apparatus has a number of further advantages. Because of the inherent characteristics of the piezo-electric crystal element it is not necessary to provide any energizing or polarizing potentials such as would be necessary in other forms of microphone elements. It follows that since there are no high potentials or minute discharge currents there will be no electrical leakage present which would necessitate the use of a preamplifier adjacent the detecting unit or heavy multi-wire cables. The piezoelectric crystal element also presents the advantage of having no low frequency cut-off and therefore it will respond to less than one cycle per second.

Another advantage of the detector element is that it is inherently airtight and moistureproof whereby changes in humidity and temperature do not affect the response characteristics thereof. A further advantage is that the heavy casing surrounding the crystal element attenuates all pressure or other mechanical interfering impulses whereby the occurrence of false signals is reduced to a minimum.

The radiant energy burglar alarm system presents the inherent advantage that it is unaffected by weather conditions such as fog, or heavy snow storms or any other changing conditions of the weather. On the contrary, signaling systems such as those employing photoelectric cells are incapable of operating through heavy fogs and the like since they respond to light energy of short wave lengths in the visible portion of the spectrum which does not penetrate fogs. Therefore the system embodying the invention is particularly useful in outdoor applications such as waterfronts, prison walls and the like, where extended areas may be protected with a minimum quantity of apparatus and wiring. It is also true that this system may be used for fire detection as well as burglar protection since it is highly sensitive to all radiant energy variations. Supervision has also been provided so that the system meets all commercial requirements concerning frequent tests of operativeness of the system.

This form of detecting system has the added advantage that it prevents false alarms by compensating for ambient energy changes such as those caused by local heating apparatus, solar rays, or atmospheric temperature changes because such changes are slow and the electrical circuits associated with the piezoelectric crystal will not respond.

Since there may be any number of variations in adapting this system to a burglar alarm application or to a fire alarm system by those skilled

in the art, and, as it is applicable to any kind of signaling system, it is not desired that this invention shall be limited to the exact embodiments illustrated and described herein, but only by the extent of the prior art and the appended claims.

We claim:

1. In a radiant energy receiver, a housing member adapted to attenuate sound or other pressure waves, a rock salt window in said member for admitting radiant energy waves, a cover plate having a chamber therein, said chamber being aligned with said window, a gas-occluding substance responsive to changes of radiant energy within said chamber comprising sooted quartz wool, a pair of piezo-electric crystals separated from each other by insulating elements to form a pressure chamber and supported within said housing member by an insulating frame and a restricted passage through said insulating frame for connecting said chamber to said pressure chamber whereby gas pressure generated by said gas-occluding substance will deform said piezo-electric crystals to generate an electrical impulse.

2. In a radiant energy receiver, a housing member adapted to attenuate sound or other pressure waves, a window pervious to heat energy supported in said housing member, a chamber aligned with said window and containing mineral wool having deposited thereon a gas-occluding substance, a voltage generating element having a pressure chamber therein and supported within said housing member and a restricted passage within said housing member for connecting the voltage generating element to the chamber containing the gas-occluding substance whereby gas pressure generated by said gas-occluding substance will cause generation of an electrical impulse.

3. In a radiant energy receiver, a housing member containing a gas, a rock salt window in said member, a plurality of piezo-electric crystal elements within said member, a plurality of chambers between said piezoelectric elements and a heat responsive pressure changing substance in operative relation to said crystal elements whereby changes in radiant energy are converted into electrical energy.

4. In a radiant energy receiver, a housing member, a window in said member which is pervious to radiant energy, a series of spaced voltages generating elements within said member, said elements generating different voltages in response to changes in mechanical pressure to which said elements are subjected, and a gas-occluding substance in operative relation to said voltage generating elements for applying varying degrees of mechanical pressure to said generating elements whereby changes in radiant energy impinging on said substances are converted into electrical energy variations.

5. In a radiant energy receiver, a housing member containing a gas, a window in said member for admitting radiant energy, a chamber within said member having a heat-responsive pressure changing substance therein, an expansion chamber within said member and communicating with said chamber and a piezoelectric crystal element within said expansion chamber for converting changes in pressure to electrical impulses.

6. In a radiant energy receiver, a housing member containing a gas, a window therein pervious to waves of radiant energy, a voltage gen-

erating element within said member, a chamber containing a filamentary material which has been sooted for changing the gas pressure within said chamber and exposed to said window whereby changes in gas pressure act upon said voltage generating member to convert changes in radiant energy into electrical energy.

7. In a radiant energy receiver, a housing member, a window pervious to radiant energy and located in said housing member for admitting waves of radiant energy, a chamber within said housing member containing a gas-occluding substance comprising a filamentary material which has been sooted and a second chamber within said member containing a voltage generating element sensitive to pressure changes within said first chamber whereby changes in radiant energy are converted into electrical energy.

8. A radiant energy signaling device comprising a housing member, a window in said housing member pervious to radiant energy, a gas-occluding substance within said member and within the view of said window, comprising a filamentary material which has been sooted and a voltage generating element cooperating with said gas-occluding substance for converting pressure changes within said member to electrical impulses.

9. In a radiant energy receiver, a housing member, a chamber therein containing a gas, a gas-occluding substance in said chamber comprising sooted quartz wool and means for converting changes in gas pressure in the chamber to changes in electrical energy.

10. In a radiant energy receiver, a housing member, a chamber therein containing a gas, a

gas-occluding substance in said chamber comprising sooted glass wool and means for converting changes in gas pressure to changes in electrical energy.

11. In a radiant energy receiver, a housing member, a chamber therein containing a gas, a gas-occluding substance in said chamber comprising sooted steel wool and means for converting changes in gas pressure to changes in electrical energy.

12. In a radiant energy receiver, a housing member containing a gas, a gas-occluding substance in said housing member comprising sooted filamentary material and means for converting changes in gas pressure within said housing member to changes in electrical energy.

13. In a radiant energy receiver, a housing member containing a gas, and means responsive to changes in radiant energy for converting changes in radiant energy to changes in gas pressure comprising a sooted filamentary material.

14. In a radiant energy receiver, a housing member containing a gas, a window therein pervious to waves of radiant energy, a voltage generating element within said housing member, a chamber containing a gas-occluding substance comprising a quantity of an inorganic filamentary material which has been sooted for changing the gas pressure within said chamber, said gas-occluding substance being exposed to waves of radiant energy admitted through said window, and means for causing changes in gas pressure in said chamber to act upon said voltage generating element to convert changes in radiant energy into electrical energy.

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