

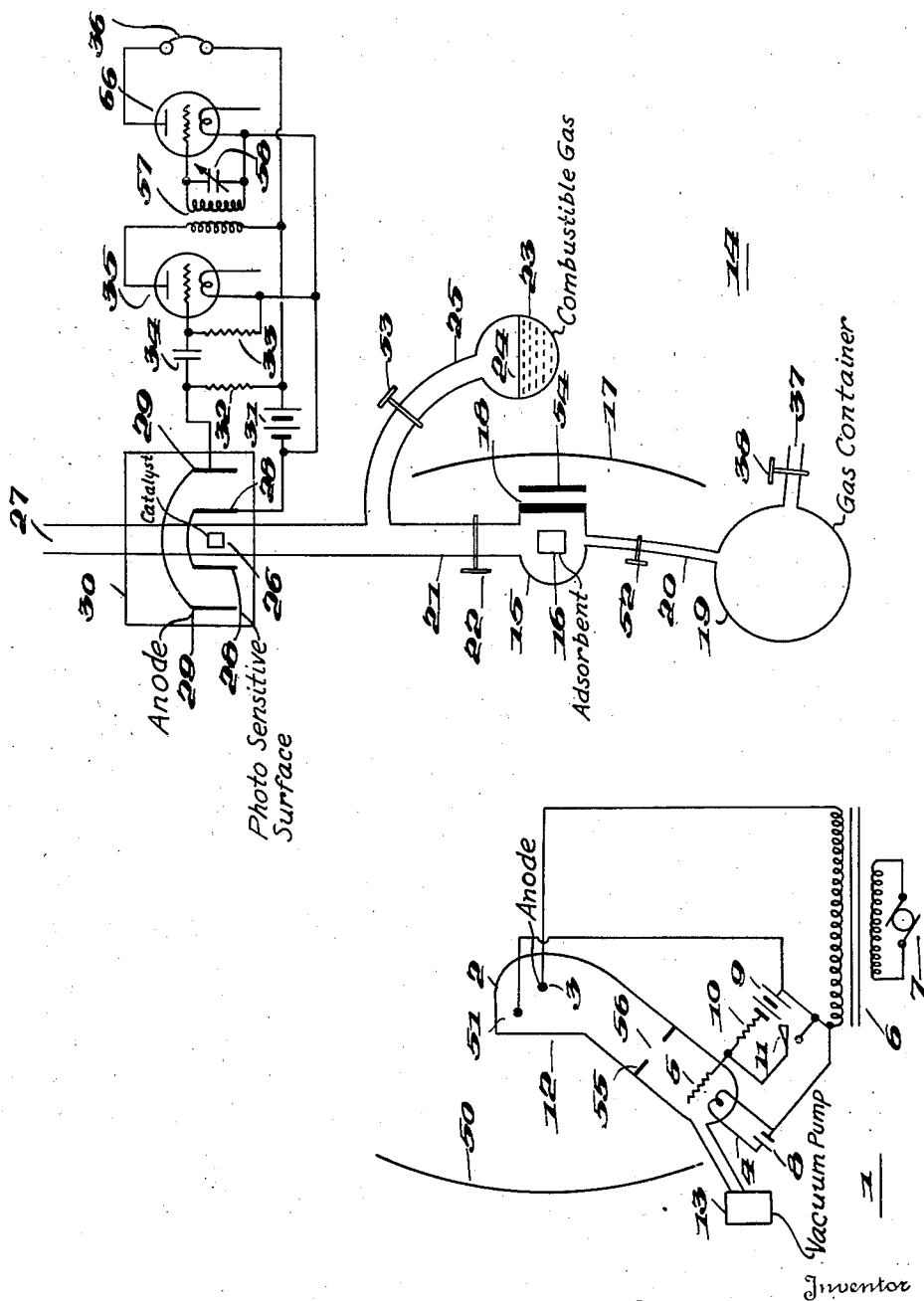
June 27, 1944.

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2,352,377

INFRA-RED CONTROL DEVICE

Filed June 29, 1939



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UNITED STATES PATENT OFFICE

2,352,377

INFRARED CONTROL DEVICE

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Application June 29, 1939, Serial No. 281,964

14 Claims. (Cl. 250-1)

This invention relates to light control devices, and more particularly to signal control by the longer infra-red radiations, or heat waves.

Various means of infra-red light control devices have been used. These means may be summarized as follows:

1. Devices using the thermocouple, or bolometer. While such devices are responsive to small changes in temperature, the heat capacity of such devices is usually of the order of several hundred ergs per degree. Consequently the response to weak sources of radiant energy is very slow, of the order of several seconds or more.

2. Photo-electric cell devices. While the dynamic response of some of these devices is excellent, and their sensitivity satisfactory, they are not responsive to radiations longer than 1.2 mu. While radiations of these wavelengths penetrate haze, they have little advantage over wavelengths in the visible spectrum in penetrating fog. A transmitting source must be of the order of 2000 degrees absolute before giving off appreciable amounts of energy of such short wavelengths, therefore such devices are useless in recording the presence of heat radiating objects such as airplanes, automobiles, and the human body.

3. Devices which utilize varying vapor pressures of gases in the presence of the liquefied gas. One type of such apparatus is the common furnace temperature control, utilizing mercury as the liquified gas and measuring the vapor pressure by a gage of the well known ionization gage type. Such devices can never be made responsive to changes in extremely small energy sources, due to the thermal capacity of the liquified gas and the fact that condensation of the gas on the various portions of the apparatus constitutes a further thermal load. The heat of vaporization of a molecule of mercury is given by Eldridge in "Physical Basis of Things," 1934 edition, page 83, as 57 atomic ergs. Since 96 atomic ergs equals one electron volt, as he states on page 381, the heat of vaporization of the mercury molecule equals approximately .6 electron volts of energy. As brought out by Zworykin and Wilson in "Photo-cells and their Application," 1932 edition, page 321, next to last formula on page —, .6 electron volt is approximately the amount of energy contained in a photon of 2 mu wavelength, and such wavelengths do not appear in appreciable magnitude until the transmitting source attains a temperature well over 1000 degrees absolute.

4. Devices which utilize varying vapor pressures of gas in the presence of an adsorbent,

usually charcoal, combined with the thermal expansion of the gas. Known devices of this type comprise means for transforming modulated waves of radiant energy into compressional waves, to move a diaphragm, and transforming the movements of said diaphragm into electrical vibrations, which are further amplified by vacuum tube amplifiers. Such devices, using oxygen as the adsorbent gas are responsive to the fog penetrating radiations between 5 and 15 mu. The heat of evaporization of oxygen is .08 electron volts or 15 mu per molecule, and the attraction of the charcoal for the oxygen is small and does not add much to this value. Published reports indicate that such devices are capable of picking up heat given off by an airplane, automobile steam boiler, etc., at distances of several miles. While such reports would seem to indicate sensitivity of such devices, further consideration shows that such is not the case. The energy given off by an airplane motor is often of the order of 1000 kilowatts. While the greater portion of this energy may be dissipated in convection current a considerable portion is radiated. The radiant energy received at a distance of twenty miles may be over several ergs per second per square foot. Radio receivers, and photo-electric cells are both responsive to less than a billionth of that amount of energy. The insensitivity of existing heat recording devices is therefore apparent. This lack of sensitivity is one of the causes of the very poor dynamic response at frequencies greater than one cycle per second, and limits the usefulness of the devices to burglar alarm systems, and similar purposes. Other causes of the poor dynamic response of this type of device is the relatively large amount of energy required for the movement of the diaphragm, the thermal capacity of the adsorbent, the fact that the condensation of the oxygen on the adsorbent is slowed up by allowing the inert gases present such as nitrogen, and the rare gases to form a shield around the adsorbent, until the oxygen diffuses through to the adsorbent.

It is an object of this invention to provide a radiant energy signalling device which shall be sensitive to the fog penetrating radiations between 5 and 15 mu and longer wavelengths, in which the dynamic response shall be rapid, which shall be rugged in construction, and easy to operate, and wherein the difficulties mentioned above shall not be present.

Another object is to provide a device which

shall be responsive to any desired heat wavelength.

Another object is to provide means for receiving quanta of low energy, and means for producing light quanta of higher energy corresponding in number to the low energy light quanta received, by evaporation of molecules of a gas with said low energy quanta, and releasing said high energy quanta by combustion of said molecules.

It has long been known that the vapor pressure of a gas existing over an adsorbent, varies as the temperature of the adsorbent. Charcoal at room temperature will adsorb 90 times its volume of ammonia gas, 35 times its volume of carbon dioxide, 19 times its volume of chlorine, 1.7 times its volume of hydrogen. As the temperature of the charcoal decreases the volume of the gas adsorbed increases until at minus 185 degrees centigrade, it will adsorb 135 times its volume of hydrogen. It is an object of this invention to vary the vapor pressure of a gas over charcoal in accordance with variations in radiant energy received, and to provide novel means for indicating said pressure variations.

Another object is to release molecules of gas from an adsorbent by low energy photons, to cause said molecules to produce high energy photons by chemically combining with molecules of another substance, and to provide photo-electric means for indicating the presence of said high energy photons.

It is well known that the charcoal in a gas mask will adsorb substantially all of the gas such as chlorine from a moving stream of air passing through it in an extremely short period of time, whereas if the charcoal were exposed to the air the time required for diffusion of the chlorine through the air would prevent rapid adsorption of the chlorine. The moving stream of air in the gas mask brings the chlorine into intimate contact with the charcoal particles, thereby permitting substantially instantaneous removal. It is an object of this invention to use a moving stream of gas over an adsorbent to circumvent the time delays required by diffusion in existing apparatus, and to further increase the dynamic response by the cooling effect of said stream on said adsorbent, by preventing build up of gas pressures. This cooling effect does not lessen the response of the device to radiant energy received due to the fact that it operates by the phenomenon of diffusion, to prevent build up of vapor pressures, which vapor pressures would promote condensation with resultant heating.

It is well known that the catalyst spongy platinum becomes incandescent when exposed to the gas of wood alcohol and the gas oxygen of the air. It is an object of this invention to vary the magnitude of one of said gases applied to said platinum, in accordance with a received signal, thereby varying the temperature of the surface of the platinum and to provide means for recording slight variations in said temperature.

Another object is to provide a novel light transmitting source which shall be rich in the longer heat waves, and capable of rapid dynamic response.

With these and other objects in view the invention will be more readily understood by reference to the figures taken in connection with the following description, wherein, the figure illustrates a light control device capable of penetrating fog.

Referring to the figure, light transmitting station 1 is composed of a high vacuum tube 2, containing an anode 3, a cathode 4, and a control

electrode 5. Anode 3 comprises a tungsten target of small dimensions, of the order of an eighth of an inch in diameter and is supported by a lead wire entering the evacuated enclosure 2 in the upper part of the bulb. The anode 3 is located at the focal point of a parabolic reflector 50, and is furnished current from the secondary of transformer 6, the primary of which is supplied with current from an alternating current source 7. The cathode 4 is heated by an A battery 8. Electrode 51, capable of dissipating considerable heat, has been placed near the anode and connected to the cathode. A disc 55 with a hole 56 has been provided to concentrate the electron beam to anode 3. C battery 9 impresses a high negative potential on control electrode 5, through resistance 10. When key 11 is closed this negative potential is removed and the plate current is allowed to flow from anode 3 to cathode 4. The portion of vacuum tube 2 nearest the reflector 50 is closed by a window 12 such as rock salt, fluorite, or sylvine, all of which substances are transparent to the far infra-red radiations. Since it is difficult to maintain high vacuum with seals of this type a vacuum pump 13 of conventional type is connected to tube 2 for use when necessary.

The receiving station 14, is composed of an infra-red sensitive device 15, containing an adsorbent such as charcoal 16, which is located at the focal point of parabolic reflector 17. The side of the device 15 nearest the reflector 17 is closed by a window 18 transparent to the far infra-red radiations. Since the device 15 is above atmospheric pressure no special precautions need to be taken with the seal of the window. The device 15 is supplied with a stream of gas from a large container 19 through a very small tube 20 and valve 52. This gas may be replenished from time to time through valve 38 and tube 37. The kind of gas used in container 19 depends upon the frequency of radiations to which it is desired to have the receiving station 14 respond, and the atmospheric temperature in which the device is operated. For the far infra-red radiations it is necessary to use a gas of low boiling point, since the energy required to evaporize a molecule of gas from the adsorbent in terms of electron volts is the sum of the energy required to evaporize the molecule plus the energy of attraction of the adsorbent. For the device to respond to 15 mu a mixture of oxygen and helium is satisfactory, oxygen being the adsorbed gas, the helium not being appreciably affected by the adsorbent at room temperatures. While it is possible to use oxygen alone, I prefer to use it in combination with an inert gas in order that the stream of inert gas may tend to maintain the adsorbent at a constant temperature in accordance with the principles of diffusion previously described as the adsorbed gas is condensed and evaporized from the adsorbent. Furthermore the use of pure oxygen is accompanied with an element of danger due to the possibility of explosion. Ordinary air may be used. For light quanta of energies higher than 3 mu it is possible to use a gas such as a hydrocarbon, whose molecular heat of evaporation is 4 or five mu. For extremely low energy light quanta it is necessary to use hydrogen, with low temperatures, the molecular heat of evaporation of hydrogen being 125 mu.

The gas from the sensitive device 15 proceeds through tube 21 past valve 22, where it joins gas from container 23 through tube 25 and valve 53. This latter gas may be wood alcohol, the liquid form of which is shown at 24.

Spongy platinum 26 is located in the path of these gases as a catalyst, and glows due to the heat of combustion of the oxygen and the wood alcohol. As indicated above the purpose of the spongy platinum is to act as a catalyst to produce ignition of the wood alcohol vapors. It therefore may be of small dimensions or omitted entirely where vapor pressures of the oxygen and wood alcohol are of optimum value to maintain a flame without a catalyst. The use of an auxiliary ignition means such as the spongy platinum has the advantage of re-igniting the gases when the flame goes out. The refuse gases are discharged at opening 27.

Surrounding the tube 21 is a photo-electric cathode 28, on the outer surface of which has been deposited a photo-active substance such as a thin layer of cesium oxide on the supporting glass. Anode 29 further surrounds cathode 28 and both are inclosed in a highly evacuated container 30. Anode 29 is supplied with voltage from battery 31 through a high resistance 32. Vacuum tube amplifier 35 with grid leak resistance 33 amplifies the voltage across the high resistance 32 through condenser 34. In the output circuit of the amplifier 35 is the primary of transformer 57, the secondary of which in parallel with condenser 58 forms a circuit tuned to the frequency of A. C. generator 7, the voltage across which is amplified by vacuum tube 66 in the output circuit of which is connected an electro-responsive device in the form of headphones 36.

In operation, when key 11 is closed high velocity electrons from cathode 4 heat anode 3 to incandescence at the frequency of A. C. generator 7. When the cathode side of the secondary of transformer 6 becomes positive, electrode 51 draws current from incandescent anode 3, thereby cooling it by electron evaporation, and reducing the thermal time lag of the anode 3. The high voltage electrons from cathode 4 striking 3 produce secondary electrons, as is well known. The charge of 51 being negative at that instant the majority of them are forced back to anode 3, thereby producing infra-red photons. At the higher frequencies of 7 the heating of anode 3 by electron bombardment from cathode 4 and the cooling by electron evaporation becomes a surface effect thereby largely doing away with the time lag due to the thermal capacity of the anode 3. The cooling effect of electron emission is utilized in U. S. Patent No. 1,976,120, issued to me October 9, 1934, to which reference is made.

The variations in radiations from anode 3 are concentrated by reflector 50 on to a collector consisting of parabolic reflector 17 at the receiving station 14, where they are focused on to adsorbent 16, thereby varying the adsorption of the oxygen in the stream of gas passing from gas container 19 through tube 20. Since tube 21 is much larger than tube 20 variations in pressure in sensitive device 15 will produce large variations in the magnitude of the stream of gas passing through the tube 21, and furthermore the oxygen content of the stream in the tube 21 will increase as the magnitude of the stream increases by reason of the oxygen set free from the adsorbent. Gas from wood alcohol 24, which may be heated to give optimum vapor pressure, flows into conduit 21. The combined gases in the tube 21 come in contact with spongy platinum 26 which is heated to the point of incandescence. A flame also forms around it under such conditions as is well known in experiments with spongy platinum as a catalyst. Photons from the spongy platinum 26 impinge on photo-active surface 28 after passing through the walls of the tube 21, and the transparent substance upon which cesium oxide has been deposited, thereby varying the photo-electric current from battery 31, through resistance 32, anode 29, to cathode 28, which current is amplified through vacuum tube amplifier 35, and controls electro-responsive device 36. By properly regulating the flow of gases through valves 52 and 53, it is possible to maintain the spongy platinum 26 at the point of incandescence, at which point very slight changes in the oxygen content of the gas due to variations in adsorption of adsorbent 16 in response to variations of radiant energy received from light source 3, at the transmitting station will produce appreciable response in electro-responsive device 36.

The adsorbent 16 is responsive to all radiations, visible and infra-red up to 15 mu. In daylight operation when fogs become heavy it is desirable to screen out the diffused light energy from the fog, and this may be accomplished by color filter 54 in front of the window to photo-responsive device 15 designated as 18.

One of the novel features of my invention constitutes a means for producing variations in adsorption of molecules of a gas in accordance with low energy photons, impressed on an adsorbent, means for causing said molecules of said gas to chemically combine with molecules of some other substance, thereby producing photons of higher energy, and means responsive to said higher energy photons.

While I have used the phenomenon of adsorption in illustrating my invention, it is to be noted that some authors on physics make no distinction between the phenomenon of adsorption and absorption, both involving the release of quanta of energy of low magnitude upon condensation of molecules, and where the word adsorption is used it will include within its meaning absorption.

While, in light transmitting vacuum tube 2, I have used a disc 55 as the means for focusing the electrons on the proper portion of the anode 3, it is evident that other means may be used, such as electro-static and electro-magnetic lenses.

While I have illustrated my device as a light signalling system it is obvious that it could be used as a means of indicating the breaking of the beam by an object instead of by modulating the light source, such as in burglar alarm systems.

It is therefore evident that the invention may take widely different forms from those illustrated without departing from its spirit. The invention is to be limited in scope only by prior art and as described in the following claims.

What is claimed is:

1. The method of indicating the presence of photons between 5 and 15 mu, received from a variable source of radiant energy, which consists in evaporizing molecules of gas from an adsorbent by said photons, in producing higher energy photons than 5 mu by combustion of said molecules, in producing variations in an electric current in accordance with the magnitude of said higher energy photons, and in translating said variations of electrical current into signals.

2. The method of indicating the presence of radiations between 5 and 15 mu which consists in varying the vapor pressure of a gas in accordance with variations in said radiations, in producing oxidation with said gas, in producing an electrical current by the shorter than 5 mu wavelength photons produced by said oxidation, and

in indicating the presence of said electrical current.

3. In a radiant energy control device, an adsorbent, a container containing gas capable of being adsorbed by said adsorbent, means for passing a current of said gas over said adsorbent, means for varying the amount of said gas adsorbed by said adsorbent, said last means comprising means for focusing radiant energy on said adsorbent, and means for indicating the amount of said gas adsorbed by said adsorbent.

4. In a radiant energy control device, an adsorbent, a container containing a gas capable of being adsorbed by said adsorbent, means for passing a current of said gas over said adsorbent, means for varying the magnitude of said gas current, said last means comprising means for focusing radiant energy on said adsorbent, a substance, means for producing a chemical reaction between said substance and said varying gas current, and means for indicating the magnitude of chemical energy released by the combining of said substance and said varying current of gas.

5. In a radiant energy control device, an adsorbent, a container containing gas for adsorption on said adsorbent, means for passing a current of said gas over said adsorbent, means for varying the adsorption of said current by said adsorbent, said last means comprising means for focussing radiant energy on said adsorbent, a second container, containing a gas capable of chemically uniting with said first gas, a catalyst for producing chemical reaction between said two gases, and means for indicating the temperature of said catalyst.

6. In a radiant energy control device, an adsorbent, a container containing a gas for adsorption on said adsorbent, means for passing a current of said gas over said adsorbent, means for producing variations in said current, said last means comprising means for focusing radiant energy on said adsorbent, a second container containing a second gas capable of uniting into chemical combination with said first gas, means for combining said second gas and said variable current of gas, a catalyst for producing said chemical combination, a photo-electric device, means for impressing radiant energy from said chemical combination of said gases on said photo-electric cell, and means for indicating the magnitude of electrical current through said cell.

7. In a radiant energy control device, an adsorbent, molecules of a gas absorbed on said adsorbent, means for applying infra-red photons to said adsorbent to evaporize the molecules of said gas from said adsorbent, a color filter for preventing visible radiations from reaching said adsorbent, a substance, means for causing chemical reaction between said gas and said substance, and a photo-electric means for indicating the presence of visible photons produced by said reaction.

8. In an infra-red device responsive to radiations longer than two mu, an adsorbent, means for passing a current of gas containing oxygen over said adsorbent, means for varying the magnitude of oxygen adsorbed by said adsorbent, said last means comprising means for focusing radia-

tions on said adsorbent, a source of wood alcohol vapors, means for combining said vapors with said oxygen not adsorbed by said adsorbent, a catalyst, comprising spongy platinum, means for applying said gases to said platinum, a photo-electric cell, means for applying radiations from said platinum to said cell, and means for indicating the magnitude of said current flowing in said cell.

9. In a radiant energy control device, a container containing gas, a source of radiant energy, means for varying the pressure of said gas in said container, said last means comprising means for focusing said radiant energy on said gas, a substance, means for producing a chemical reaction between said substance and said gas, and means for indicating the amount of energy produced by said chemical reaction.

10. In a radiant energy control device, a source of gas, a container, means for passing a current of said gas through said container, means for varying the magnitude of the current of gas passing out of said container, said last means comprising means for impressing photons on said container, a substance, means for producing a chemical reaction between said current of gas passing out of said container and said substance, and means for indicating the magnitude of energy released by said chemical reaction.

11. In a radiant energy control device, a container containing gas, an adsorbent, means for passing a current of said gas over said adsorbent, means for varying the magnitude of said current, said last means comprising means for impressing radiant energy on said gas passing over said adsorbent, a second gas, means for producing a chemical reaction between said gas current and said second gas, and means for indicating the magnitude of energy released in said chemical reaction.

12. The method of indicating the presence of radiations with a stream of gas passing over an adsorbent which consists in, applying said radiations to said adsorbent to produce compressional waves in said stream, in producing variations in light with said compressional waves and in indicating said variations in said light.

13. A radiant energy receiving device comprising: an adsorbent, means for passing a stream of gas over said adsorbent, means for focusing photons on said adsorbent to produce compressional waves in said stream, a source of light, a photo-electric cell, means for impressing light quanta from said source on said cell, means for varying said light quanta impressed on said cell with said compressional waves, and means for indicating the magnitude of said light quanta impressed on said cell.

14. A radiant energy control device comprising: an adsorbent, means for passing a stream of gas over said adsorbent, means for focusing photons on said adsorbent to produce variations in said stream, means for producing variations in light with said variations in said stream, a photo-electric cell, means for impressing said light variations on said cell, and means for indicating said variations in light impressed on said cell.

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