

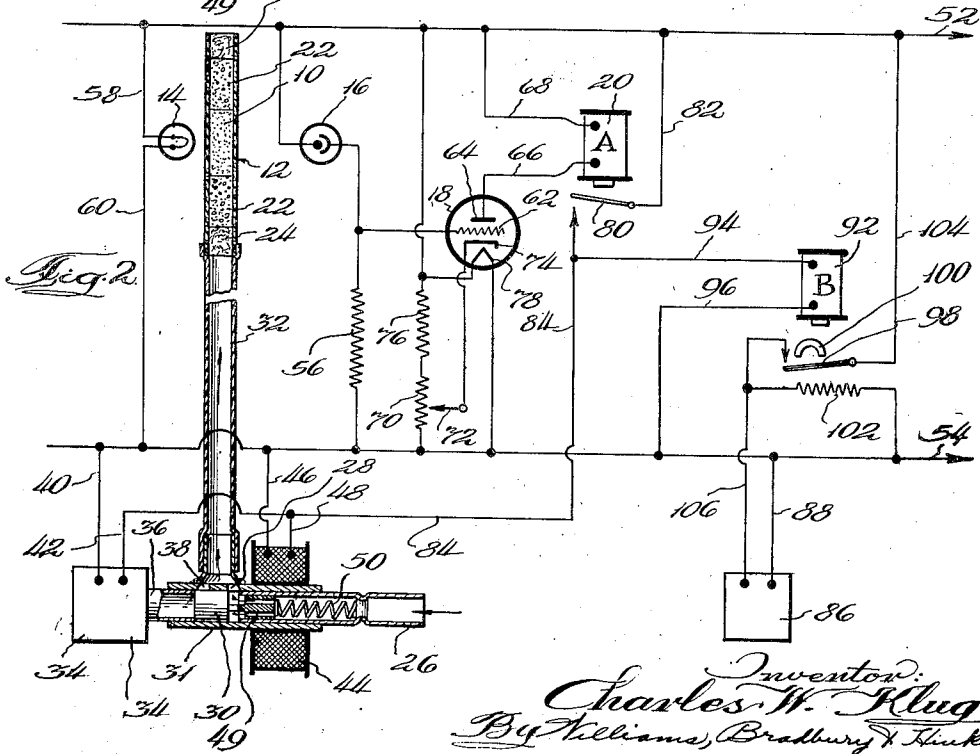
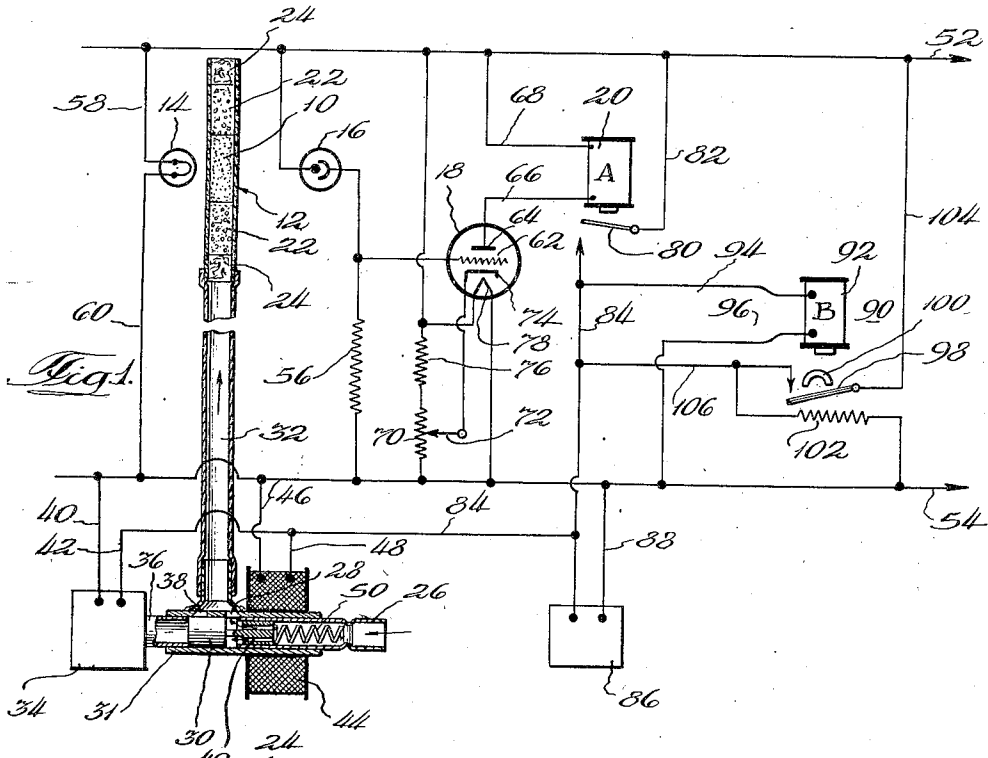
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GAS DETECTION APPARATUS

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GAS DETECTION APPARATUS

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The present invention relates to gas detection apparatus and particularly to apparatus for the detection of carbon monoxide in heated spaces, such as the heated interior of an airplane cabin.

This application is a continuation in part of my prior application Serial No. 481,425, filed April 1, 1943, now abandoned.

The primary object of the present invention is to provide a new improved gas detection apparatus wherein a controlled device, which may be a warning device, valve, or the like, is maintained in operated condition for a certain length of time upon the detection of the gas.

A further object of the present invention is to provide a new and improved gas detection apparatus wherein a controlled device is operated and maintained in operated position for a certain length of time, and wherein an attempt is made to restore the detection apparatus to its initial condition during the time the device is maintained in its operated state.

A further object of the present invention is to provide new and improved gas detection apparatus of the character wherein a gas sensitive substance is normally supplied with a medium in which the presence of gas is to be detected and, wherein upon detection of the gas, a gas counteracting the effects of the first gas is supplied at least a predetermined length of time to counteract the effects of the gas to be detected.

Other objects and advantages of the present invention will become apparent from the ensuing description, in the course of which reference is had to the accompanying drawings, in which:

Fig. 1 is a diagrammatic representation of one embodiment of the invention; and

Fig. 2 is a similar representation of a second embodiment of the invention.

The apparatus of the present invention utilizes a substance having a photocharacteristic that varies in response to the presence of the gas to be detected. More particularly, the photo characteristic is the light transmitting characteristic and the gas to be detected is carbon monoxide. It is well-known that carbon monoxide is a very deadly gas and that its presence in a space occupied by people should be immediately detected, particularly when the space is the heated interior of an airplane into which carbon monoxide may be injected along with heated air. Under usual conditions the heated air supplied to the interior of the cabin would not contain any carbon monoxide, but should the heat exchanger be, for instance, of the exhaust gas type, and should it be punctured as by a bullet, then the carbon

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monoxide present in the exhaust gases enters the interior of the cabin.

In the copending application of Willard H. Farr, William F. Fagen and Frank A. Fanta, Jr., application Serial No. 479,710, filed March 19, 1943, and in my copending application Serial No. 481,426, filed April 1, 1943, both now abandoned, there are disclosed methods of and apparatus for detecting the presence of toxic gases, especially carbon monoxide. The apparatus utilizes a substance sensitive to the presence of carbon monoxide known as the "National Bureau of Standards Colorimetric Carbon Monoxide Indicating Gel." The chemical description and method of making this gel are fully disclosed in an article under the title of "Rapid Determination of Small Amounts of Carbon Monoxide" (Preliminary Report on the NBS Colorimetric Indicating Gel) by Martin Shepherd. This article appeared in "Industrial and Engineering Chemistry" (Analytical Chemistry), volume 19, page 77, February 1947. This gel is yellow in color until exposed to carbon monoxide when its color changes from yellow progressively toward a dark blue-green. Thus, in the event there is carbon monoxide present in the air to be tested, the substance changes from a yellow to a dark blue-green color. The apparatus also includes a light source and a photosensitive device upon which impinges light passing through the sensitive substance to change the conductivity of the device. This change in conductivity of the photosensitive device is utilized to control the conductivity of an electron tube controlling a relay, which in turn controls either a signal or some suitable device controlling the operation of the heater, or of a valve controlling the supply of heated air to the interior of the cabin.

The sensitive substance may be returned from its dark blue-green color to its initial yellow color, and from a nonsensitive to its initial sensitive condition by the restorative action of another gas. Ozone is one of the gases and the oxides of nitrogen are other gases having this restorative effect, all as disclosed and claimed in the two aforementioned applications.

The present invention relates to apparatus of the character described above, and more particularly to the arrangements for controlling the restoring or counteracting operations.

Referring now to Fig. 1, the sensitive substance, indicated by the reference character 10, is located within the central portion of a transparent glass tube 12 so that light from a lamp 14 passes through it and impinges upon a photosensitive

device, such as the photoelectric cell 16. The photoelectric cell controls the conductivity of an electron tube 18, which has a control relay 20 connected in its plate or anode circuit and which relay is normally in its operated position, as indicated.

The sensitive substance, hereafter to be referred to as the carbon monoxide indicating gel, has at its opposite ends some silica gel 22, while the ends of the tube are filled with some flow restricting material, such as glass wool 24, which also serves to keep the indicating and silica gel in place.

Under normal conditions of operation, air from within the heated cabin of an airplane or the heated air to be supplied to the airplane is passed slowly through the tube 12. The air to be tested flows through a conduit 26 having a normally open passageway 28 controllable by a two-position valve 30, movably mounted within a fitting 31, and a conduit 32.

The sensitivity maintaining or restoring gas supplying means is normally ineffective, i. e., none of the restoring gas is passed through the tube. The restoring gas, such as the heretofore referred to ozone or oxides of nitrogen, may be supplied by any suitable apparatus, which has been illustrated diagrammatically as a block indicated by reference character 34. The apparatus may be a tank containing a supply of the restoring gas, or it may be apparatus for producing ozone or the oxides of nitrogen. Its outlet end is connected by conduit 36 to the fitting 31. In the indicated position of valve 30, the conduit 36 is closed to prevent passage of the restoring gas through the tube 32 and the tube 12, while conduit 26 is open to tube 32. When, however, the valve 30 is moved, as will be described hereinafter, the restoring gas flows through the passageway 38 and thence through the tube 32 to the indicating gel-containing tube 12.

The means for supplying the restoring gas is rendered effective to supply the gas when the concentration of carbon monoxide reaches some predetermined value. At this time electric energy is supplied to the apparatus 34 through the conductors 40 and 42. At the same time, the valve 30 is shifted by the energization of a solenoid 44 which is supplied with energy through conductors 46 and 48 and moves valve 30 through an apertured armature 49 secured to the valve and slidable in conduit 26. When energized, the solenoid moves valve 30 to the right, as viewed in Fig. 1, against a suitable biasing means, such as a spring 50.

The energization of the gas supplying means 34 and solenoid 44 is under the control of a photoelectric cell 16, and the tube 18 and the relay 20 associated therewith. The photoelectric cell is connected across a pair of power supply conductors 52 and 54 through a resistor 56 connected to the negative power supply line 54 and to the cathode of the photoelectric cell. The light 14 is connected directly across the power supply lines by the conductors 58 and 60.

The electron tube 18 controlled by the photoelectric cell is preferably arranged to be conductive under normal conditions, i. e., when the concentration of carbon monoxide is below a predetermined value, which may be a toxic value, so that the relay 20 is in its operated position. The grid 62 of the tube is connected to the junction of the resistor 56 and cathode of the photoelectric cell so that it becomes more negative as less light impinges upon the cell. As the grid

swings more negative, less current flows through the tube until at some value of current flow, the relay 20 is released. The relay is connected across the anode 64 of the tube and the positive power supply line 52 by the conductors 66 and 68.

The grid bias is supplied by a bias resistor 70 adjustably connected through a connection 72 to the cathode 74 of the tube. To provide the desired normal grid bias, the bias resistor 70 is connected to the positive power supply line through a bleeder resistor 76. The cathode heater 78 is connected directly across the power supply lines.

The relay 20, which is normally in its operated position, controls the position of a switch 80 connected by conductor 82 to the positive power supply line. The circuit controlled by the switch is normally open, but when the relay is released, the switch 80 completes a circuit across conductor 82 and a conductor 84 leading to the previously mentioned restoring gas supplying means 34 and valve operating solenoid 44. Thus, when the switch is closed, in response to the presence of a predetermined concentration of carbon monoxide, the flow of air through the indicating gel tube is stopped by movement of valve 30 and the tube is supplied with restoring gas from apparatus 34 until the energizing circuit is opened.

At the same time that the restoring means is rendered effective, a controlled device 86 is operated. This device may be a warning signal or a heat exchanger operation controlling device, or a valve controlling the supply of heated air to the interior of the cabin. The energizing circuit for this device includes the conductor 82, switch 80, conductor 84 and a conductor 88 connected to the negative power supply line 54.

Once the restoring gas supplying means, the solenoid 44 and the control device have been operated, they are maintained in their operated conditions for at least a certain time interval by a relay, indicated generally by the reference character 90. This relay includes a relay winding 92 energized by the closure of switch 80. Its energizing circuit includes conductor 82, switch 80, a conductor 94 leading to one terminal of the winding, and a conductor 96 leading from the other terminal of the winding to power supply line 54. When the relay is energized, it closes a switch 98 preferably made of bimetallic material and which, once operated, is maintained in its operated position by some suitable means, such as a permanent magnet 100. The switch 98 is in parallel with switch 80 and is arranged periodically to be opened by a heater 102 located in proximity thereto. The switch is connected across conductors 52 and 84 by conductors 104 and 106. Heater 102 is connected across conductors 106 and 54.

In operation the power supply lines 52 and 54 are connected to some suitable source of direct current, which may be the usual 24 volt source found in the airplane. When the indicating gel is in its initial condition, the light passing therethrough from the lamp 14 to the photoelectric cell 16 renders the grid 62 of tube 18 positive to an extent sufficient to maintain relay 20 in its operated position with the result switch 80 is opened and the various devices controlled by that switch are de-energized. These devices include the restoring gas supplying means 34, the solenoid 44, controlled device 86 and the relay 92. Under these normal conditions, the bimetallic switch 98 is also open.

Air from within the interior of the cabin passes

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through conduit 26 and passage 28 and conduit 32 to the indicating gel tube 12. As long as no carbon monoxide is present in the air to be tested, the indicating gel maintains its initial color. Should there be slight amounts of carbon monoxide present sufficient over a period of time to change the color of the indicating gel, or should there be a considerable concentration of carbon monoxide present, thereby to change the color of the gel, the grid of the electron tube 18 is rendered more negative to decrease the current flow through the tube. At a predetermined concentration, determined by the adjustment of grid bias control 72, the relay 20 is released and the switch 80 closed. The closure of the switch immediately operates the controlled device 86, places the restoring gas supplying means 34 into operation, and connects its output to the indicating gel tube and at the same time cuts off the further supply of air from within the interior of the cabin to the tube. Simultaneously the relay 92 is energized and operates switch member 98 to its circuit closing position wherein it is held by the magnet 100 for at least a certain length of time, depending upon the effect of the heater 102 which heats the switch to open it.

Should the change in color of the indicating gel have resulted from a cumulative effect of slight concentrations of carbon monoxide, then the indicating gel will be cleared by the first operation of the apparatus. Upon clearance, the relay 20 is again energized sufficiently to open switch 80. However, the opening of the switch does not de-energize the various apparatus for the reason that the switch 98 is in parallel with switch 80 and it is maintained closed by magnet 100. However, the heater 102, which is connected across the power lines through switch 98, finally effects the opening of switch 98 with the result that the apparatus as a whole is returned to its initial condition.

Should the concentration of carbon monoxide be of a higher predetermined or toxic value, then the restoring means is not effective to restore the indicating gel to its initial condition even though continuously operated. The result is that relay 20 remains in its released position and switch 80 closed. During the continued operation of the restoring means, the switch 98 is periodically opened by the action of the heater, but such periodic opening has no effect on the operation of the apparatus since the switch 80 remains closed.

However, when the indicating gel has been cleared, as a result of the repair of the heater, or because of the passage of the airplane from a region wherein considerable carbon monoxide might be present, the relay 20 is again operated to open switch 80, after which the bimetallic switch 98 opens the energized circuit for the device 86, the solenoid 44 and the restoring means 34. The apparatus is thus returned to its initial condition ready for further detection operations.

The apparatus illustrated in Fig. 2 corresponds for the most part with the apparatus illustrated in Fig. 1, and like parts have been indicated by like reference characters. The primary distinction between the two embodiments resides in the arrangement of the second in such manner that the restoring means 34 and solenoid 44 are controlled by the relay 20, whereas the controlled device 86 alone is controlled by the relay 92.

The controls are so arranged that upon a pre-

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determined change in color of the indicating gel the relay 20 is energized to place the restoring means in operation and to operate the valve 30. At the same time relay 20 energizes relay 92, and the latter effects operation of the controlled device 86. In this arrangement, the restoring means is arranged to be effective to clear the indicating gel in a short period, such as about thirty seconds, even in the presence of toxic concentrations of carbon monoxide. Upon such clearance the relay 20 is released to render ineffective the restoring means and to de-energize relay 92. The controlled device 86, however, is not released as it is maintained in its operated condition by the bimetallic switch element 98, which is held in its closed position by magnet 100, and which is heated by the heater 102 until opened. Switch 98 is thus maintained in its closed position for a length of time after the de-energization of relay 92 upon subsequent operation of relay 20.

Referring now more particularly to Fig. 2, it may be noted that relay 20 is normally operated and switch 80 is open. When closed, switch 80 connects conductors 82 and 84 to complete energizing circuits for solenoid 44 and the restoring means 34 through conductors 82 and 84. Upon closure switch 80 also completes an energizing circuit for relay 92 through conductors 94 and 96. Relay 92 is effective when operated to close the bimetallic switch element 98, thereby to complete a circuit across conductors 104 and 106, the latter of which is connected to one terminal of the controlled device 86, the other terminal of which is connected by conductor 88 to the negative power supply line 54. When the switch 80 is closed by release of relay 20, the heater 102 is also energized as it is connected in parallel with device 86. The bimetallic switch element is so arranged that the heat from heater 102 tends to open against the force exerted thereon by magnet 102, with the result that switch opens a certain time interval after de-energization of relay 92 but remains closed as long as relay 92 is energized.

The apparatus is placed in operation in the same manner as that of the embodiment of Fig. 1, and under normal conditions the relay 20 is in its operated position while relay 92 is released.

When the air flowing from within the interior of the cabin through and in contact with the indicating gel contains carbon monoxide, the indicating gel 10 is discolored and the electron tube 18 is rendered less conductive until at a predetermined current value relay 20 is released. Switch 80 is thereupon closed to place the restoring means in operation and to operate the valve 30. At the same time, relay 92 is energized to close bimetallic switch 98 and the heater 102 is also energized to provide heat tending to open switch 98.

The restoring means is effective shortly to restore the indicating gel to its initial condition. If the discoloration of the indicating gel resulted from a cumulative effect of slight concentrations of carbon monoxide over a period of time, then the relay 20 is operated and remains in its operated position so that, when switch 98 is opened by the application of heat, the apparatus is returned to its initial condition. If, on the other hand, the change in color resulted from a predetermined concentration of carbon monoxide, then the indicating gel would be restored to its original condition only temporarily, with the result that relay 20 would be operated and

then released prior to the opening of switch 98, so that relay 92 would again be operated. It may be seen, therefore, that in this embodiment, the controlled device remains in its operated condition if carbon monoxide is present in a predetermined concentration, and the restoring means is periodically rendered effective to "test" the condition of the air supplied to the interior of the cabin.

From the foregoing detailed description of the present invention, it may be noted that it may be embodied in various forms and that while the invention is directed more particularly to the detection of the presence of carbon monoxide, its principles may be applied to the detection of other gases.

It will thus be apparent to those skilled in the art that numerous modifications and variations may be made without departing from the underlying principles of the invention. I therefore desire, by the following claims, to include within the scope of the invention all such modifications and variations by which substantially the results thereof may be obtained by substantially the same or equivalent means.

I claim:

1. An apparatus for detecting the presence of a gas constituent in a medium by the use of a substance in gas permeable form, which undergoes a photocharacteristic change in the presence of said gas, said apparatus comprising: a light transmitting container constructed to support said substance for passage of gas therethrough, a conduit connected to said container having two openings at one end thereof, a tube for conducting the medium to be tested to the container connected to one of said openings, said tube including a valve, a source of restoring gas including an outlet tube connected to the other of said openings, said valve so arranged that when in a first position it closes the opening connected to the source of restoring gas and when in a second position it closes the opening connected to the tube for conducting the medium to be tested, a lamp and a photoelectric cell arranged to receive light from the lamp through the container, and electrical valve shifting means operated by said photoelectric cell to shift said valve.

2. An apparatus for detecting the presence of a gas constituent in a medium by the use of a substance in gas permeable form, which undergoes a photocharacteristic change in the presence of said gas, said apparatus comprising: a light transmitting container constructed to support said substance for passage of gas therethrough, a conduit connected to said container having two openings at one end thereof, a tube for conduct-

ing the medium to be tested to the container connected to one of said openings, a source of restoring gas including an outlet tube connected to the other of said openings, a valve so arranged that when in a first position it closes the opening connected to the source of restoring gas and when in a second position it closes the opening connected to the tube for conducting the medium to be tested, a lamp and a photoelectric cell arranged to receive light from the lamp through the container, and electrical valve shifting means operated by said photoelectric cell to shift said valve.

3. An apparatus for detecting the presence of gas constituent in a medium by the use of a substance in gas permeable form, which undergoes a photocharacteristic change in the presence of said gas, said apparatus comprising: a light transmitting container constructed to support said substance for passage of gas therethrough, a conduit connected to said container having two openings at one end thereof, a tube for conducting the medium to be tested to the container connected to one of said openings, a source of restoring gas including an outlet tube connected to the other of said openings, a valve so arranged that when in a first position it closes the opening connected to the source of restoring gas and when in a second position it closes the opening connected to the tube for conducting the medium to be tested, a lamp and a photoelectric cell arranged to receive light from the lamp through the container, and electrical valve shifting means operated by said photoelectric cell to shift said valve from the first position to the second position when the intensity of the light received by said cell reaches a predetermined value, and timing means for shifting said valve from said second position to said first position after the expiration of a predetermined time interval.

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