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OXYGEN DEFICIENCY ALARM

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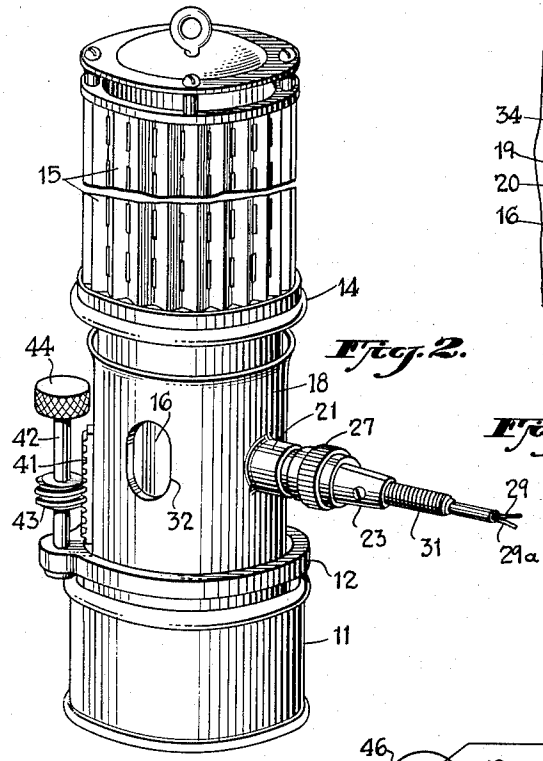


Fig. 2.

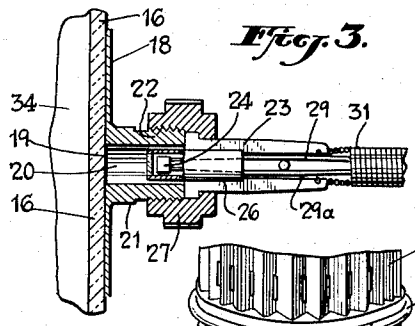


Fig. 3.

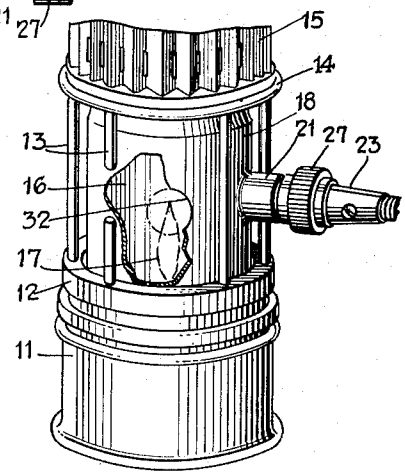


Fig. 1.

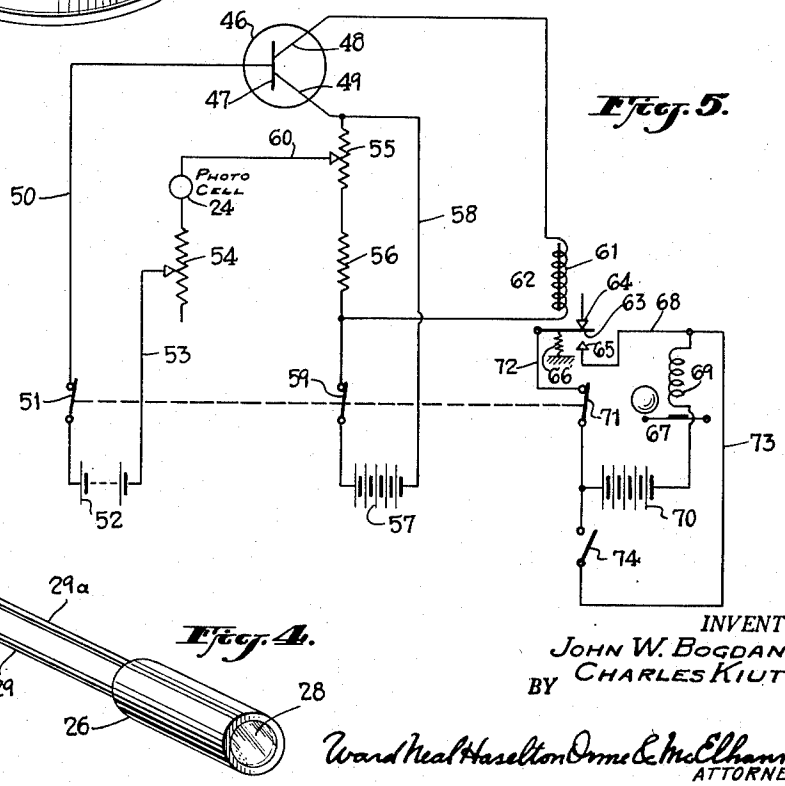


Fig. 5.

Fig. 4.

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OXYGEN DEFICIENCY ALARM

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2 Claims. (Cl. 340—228)

This invention relates to an oxygen deficiency alarm and more particularly to improvements in apparatus for audibly detecting a deficiency of oxygen in the atmosphere surrounding a flame.

One of the first devices taking advantage of the condition of a flame for detecting a deficiency of oxygen in the atmosphere was the safety lamp invented by Sir Humphrey Davy. By visually observing the small flame of this lamp, one is able to detect a deficiency of oxygen through reduction in the flame size, and also to detect the presence of a combustible mixture in the atmosphere by an increase in the size of the flame. The Davy lamp has been used successfully without substantial changes for well over a century. It is particularly well adapted because of its small size and portability for use in underground conduits and manholes. However, it is subject to the limitation that to be advised of the oxygen content of the air in the confined space, it is necessary that those working therein maintain a close watch over the flame. This necessity for visual inspection of course impairs the worker's efficiency. Furthermore, in certain underground operations, such as the splicing of electrical cables, the deficiency of oxygen might well result from the escape into the confined air space of some other gas under pressure, such as nitrogen, which is commonly employed as an inert surrounding for electrical conductors within a cable. Experience has shown that inhalation of air of unusually high nitrogen content, while not immediately fatal, very quickly impairs the mental processes involved in muscular mobility, making it difficult for the person so affected to escape from the confined space. Thus, a device for detecting decreases in the oxygen concentration should be very sensitive. The Davy lamp and its counterparts are sufficiently sensitive, but they are open to the serious objection that they must be constantly watched. Accordingly, a device employing the proved design of the Davy lamp, but transforming the information regarding oxygen deficiency relayed by the flame to an audible alarm, thus obviating visual inspection, would be highly desirable.

In an attempt to successfully and practicably solve the problem, several well-known temperature-sensitive devices and allied alarm circuits have been employed in conjunction with the Davy lamp. For example, a metal bulb, capillary tube and bellows assembly relying upon the expansion and contraction of gas within the bulb to open and close a micro-switch has been tried. Similarly, a bimetallic thermostat which closes an electrical contact on cooling, as well as thermistors, i. e., resistors with a high negative temperature coefficient of resistance which experience a large change in resistance with small changes in temperature, have been employed. Each of these three temperature-sensitive devices has proved unsatisfactory as means for actuating the alarm when the oxygen in the atmosphere surrounding the flame has been reduced to a point dangerous to life, because of the excessive time lag caused by the slow cooling of the lamp mass before the alarm is sounded.

In accordance with the present invention, apparatus is provided in conjunction with the safety lamp, including an alarm-actuating crystal photo-cell sensitive to changes in radiant energy, as distinguished from the heat energy, output of the flame. Associated with this cell is the requisite current amplifying alarm circuit. More specifically, the apparatus may include a shade for the chimney of the lamp, which shade has at least one perforation through which radiant energy from the flame is directed onto a crystal photo-cell, and preferably from the flame axis or an upward extension thereof. There is also provided a suitable housing externally of the shade for the crystal photo-cell. The cell is of such a character as to be responsive to and conducting in the presence of the radiant energy emitted by the flame burning in air. As the radiant energy output of the flame decreases through reduction in flame size caused by a deficiency of oxygen in the area surrounding the flame, the crystal photo-cell becomes sufficiently less conductive to actuate its associated alarm. The alarm is desirably an audible device such as a bell or buzzer. However, it may also consist of a warning light alone or in association with the audible means. The circuit may be so arranged as to actuate an alarm in the immediate vicinity of the lamp and also at a chosen remote control point.

In the drawings:

Fig. 1 is a fragmentary perspective, partially cut away view of a safety lamp to which there is attached a portion of the apparatus of the present invention;

Fig. 2 is a perspective of a lamp similar to that of Fig. 1, illustrating a modification of the apparatus of the present invention;

Fig. 3 is a vertical section through the photo-cell housing, a portion of the lamp shade and glass chimney;

Fig. 4 is a perspective view of a plastic-encased photo-cell; and

Fig. 5 is a diagram of a preferred photo-cell alarm circuit.

Referring first to Figs. 1 and 2, there is illustrated a conventional safety lamp with a fuel tank base **11**, a support ring **12**, support rods **13**, a strengthening ring **14**, corrugated shield **15** as well as a cylindrical glass chimney **16** surrounding flame **17**. In accordance with the present invention, the lamp is provided with a cylindrical shade **18**, preferably of metal, which completely surrounds chimney **16**. The shade is perforated as at **19** with the periphery of the hole flanged to form a hollow shade extension tube **21**, threaded as at **22** (Fig. 3) or similarly adapted to receive a photo-cell housing **23**, which is detachably positioned at the end of extension tube **21** by a collar **27**. A crystal photo-cell **24**, encased in plastic material **26**, together with its lead wires **29** and **29***a* is disposed within housing **23** so that the transparent end **23** (Fig. 4) of cell case **26** is directed through the interior **20** of tube **21** toward the interior of the lamp and the area of the flame **17**. The housing **23** is suitably adapted at its outer end as by a spring **31** to prevent fraying of the photo-cell lead wires.

The shade **18** is cut away as at **32** to provide at least one port for visual observation of the lamp flame. The port is preferably so disposed as to prevent extraneous radiant energy from directly striking the transparent end **28** of the photo-cell.

The photo-cell is directed at the axis of flame **17** and in the lamp of Fig. 1, its position normal to this axis is fixed. Preferably, the wick of the lamp is so adjusted that cell **24** is directed at the upper portion of the flame. It is important that the shade **18** be of a material which will not transmit energy of the wave length emitted by the flame, in order that the photo-cell be responsive only to radiant emissions of the flame. If the shade were of transparent material, extraneous radiation, visible or

infra-red for example, might influence the photo-cell to such an extent that it would be possible for the flame to be reduced in size or even extinguished by reason of a deficiency of oxygen and yet the alarm would not sound because the photo-cell continued to be conducting. In operation of the apparatus of Fig. 1, with the cell in a fixed position relative to the flame, the sensitivity of the device may in part be regulated by changing the height of the flame.

Referring now to Fig. 2, it will be observed that the shade **18** is slidable vertically, and is provided with a rack **41**. Support ring **12** is adapted to receive the journal end of a shaft **42** bearing a worm gear **43**, which engages rack **41**. By rotation of the knurled thumb screw **44** atop shaft **42**, the shade **18** may be raised or lowered. This adjustment may be used substantially to increase the sensitivity of the apparatus. For example, if it is desired that the device be particularly sensitive, the shade is elevated so that the photo-cell is directed at the uppermost part of the flame, or, if the cell is infra-red-sensitive, the shade might be elevated still farther so that the cell is directed at the space above the flame. Under these conditions, a very slight reduction in flame size by reason of a slight reduction in oxygen content of the surrounding air results in a reduction of infra-red radiation sufficiently great to render the cell non-conducting, and thus sound the alarm. It will be apparent that as an alternative to the slidable shade of Fig. 2, the same degree of sensitivity may be achieved with a fixed shade having only a vertically slidable extension tube portion for the cell.

We have found that crystal photo-cells sensitive to infra-red radiations are far superior to conventional selenium cells relying upon visible light to develop a current. Generally speaking, the visible light output of the flame of safety lamps of the character above described and illustrated is not sufficiently great, even with the interposition of a magnifying lens between flame and cell to cause the cell to develop a sufficiently high and reliable current to properly operate the alarm circuit. As indicated, crystal photo-cells sensitive to infra-red radiation are preferred, and one manufactured by Clairex Corporation, New York, New York, known to the trade as CL–2, which has a high response to infra-red radiation of the wave lengths between 5200 and 7500 Angstrom units, is particularly satisfactory.

In Fig. 5 there is illustrated a preferred electrical circuit for providing an audible signal when the flame decreases below a predetermined level. The circuit shown in Fig. 5 comprises a transistor **46** having a base electrode **47**, a collector electrode **48** and an emitter electrode **49**. The photo-cell **24** is connected between the base electrode **47** and the emitter electrode **49** by a lead **50**, a switch **51**, a battery **52**, a lead **53**, a variable resistor **54**, and a potentiometer **55**, one end of which is connected to the emitter electrode **49** and the other end of which is connected to a resistor **56**. The potentiometer **55** and the resistor **56** are connected in parallel with a battery **57** by means of a lead **58** and a switch **59**. Adjustment of the arm **60** of the potentiometer **55** adjusts the voltages applied to the electrodes of resistor **56** and hence varies the operating conditions and the currents in the various circuits connected to the electrodes.

The energizing coil **61** of a relay **62** is connected between one end of the resistor **56** and the collector electrode **48** so that the relay **62** is energized by the current flowing between the base electrode **47** and the collector electrode **48**. The relay armature **63** is shown in Fig. 5 as pulled up against the front contact **64** and hence the armature **63** is in the position it assumes when the coil **61** is energized as hereinafter described. Normally, the armature **63** rests against the back contact **65** and may be pulled thereagainst by a spring **66**. When the armature **63** rests against the contact **65**, the circuit for the energization of a bell or buzzer **67** is completed by way of a lead **68**, the coil **69** of the bell or buzzer **67**, a battery **70**, a switch **71**, and a lead **72**. A shunt path for testing the bell or buzzer **67** is provided by a lead **73** and a switch **74**. When the switch **74** is closed manually, the bell or buzzer **67** is energized and hence, if the battery has the correct voltage, and the bell or buzzer is in proper condition, the latter is operated.

The switch **51** serves to complete the circuit between the emitter electrode **49** and the base electrode **47**, whereas the switch **59** serves to complete the energizing circuit for the collector electrode **48**. A switch **71** prepares the energizing circuit for the bell or buzzer **67** for operation by the relay **62**. Switches **51**, **59** and **71** are manually operable and, as indicated in Fig. 5, these switches are preferably ganged together.

When the circuit is energized by manually closing switches **51**, **59** and **71**, the current flow between the emitter electrode **49** and the base electrode **47** will control the current flow between the collector electrode **48** and the base electrode **47**. The current flow between the emitter electrode **49** and the base electrode **47** is controlled by the potentiometer **55**, the resistor **54** and the voltage developed by the photo-cell **24** by the impingement of radiant energy thereon. After the switches **51**, **59** and **71** are closed manually, the flame **17** is adjusted to the desired height which may be indicated by markings on the chimney **16**, the lamp being operated in an atmosphere having the proper oxygen level. The radiant energy from the flame **17** will energize the photo-cell **24** and the arm **60** of the potentiometer **55** is adjusted until the current flowing in the coil **61** is slightly more than that required to draw the armature **63** up against the contact **64**. The resistor **54** is then adjusted until the desired current through the photo-cell **24** and the desired operating conditions are obtained. Of course, as will be understood by those skilled in the art, adjustment of the resistor **54** may require readjustment of the arm **60** so that the armature **63** will fall back against the contact **65** and operate the bell or buzzer **67** when the size of the flame **17** decreases to a predetermined value. Since the voltage developed by the photo-cell **24** and hence the current through the coil **61** varies with the size of the flame **17**, a decrease in the flame size producing a decrease in the current in the coil **61** and vice versa, it will be apparent that by proper adjustment of the arm **60** and the resistor **54**, the bell or buzzer **67** may be caused to operate when the flame decreases in size due to a dangerous deficiency or a decrease in oxygen level.

Although certain particular embodiments of the invention are herein disclosed for purposes of explanation, various further modifications thereof, after study of this application, will be apparent to those skilled in the art to which the invention pertains. Reference should accordingly be had to the appended claims in determining the scope of the invention.

What is claimed and desired to be secured by Letters Patent is:

1. In a safety lamp for detecting a deficiency of oxygen in the atmosphere surrounding the lamp flame sufficiently great to impair mental processes and endanger human life, means for audibly detecting slight reductions in flame size resulting from reduction in the oxygen content of the atmosphere, consisting of a vertically slidable, infra-red impermeable shade enclosing said flame, said shade having a perforation in its side, a crystal photo-cell responsive to and conducting in the presence of the infra-red radiations, including radiations of a wave length of about 5200 to 7500 Angstrom units emitted by the flame burning in air positioned at said perforation and directed at the axis of the flame, means surrounding said crystal photo-cell and detachably engaging said shade for retaining the cell in the aforemen-

tioned position, an amplifying circuit for said cell, audible alarm means in said circuit which when said cell is conducting are inoperative, and means associated with the lamp body and shade for adjusting the shade in a direction substantially parallel to the axis of the flame.

2. In a safety lamp for detecting a deficiency of oxygen in the atmosphere surrounding the lamp flame sufficiently great to impair mental processes and endanger human life, means for audibly detecting slight reductions in flame size resulting from reduction in the oxygen content of the atmosphere, consisting of an infra-red impermeable shade enclosing said flame, said shade having a portion thereof slidable along the axis of the lamp flame, said portion having a perforation therein, a crystal photo-cell responsive to and conducting in the presence

of the infra-red radiations, including radiations of a wave length of about 5200 to 7500 Angstrom units, emitted by the flame burning in air positioned at said perforation and directed at the axis of the flame, means surrounding said crystal photo-cell and detachably engaging said shade for retaining the cell in the aforementioned position, an amplifying circuit for said cell and audible alarm means in said circuit which when said cell is conducting are inoperative.

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