Jan. 30, 1962 D. T. GLOVER ET AL 3,019,423

OXYGEN BREATHING SYSTEMS

Filed Nov. 26, 1956

FIG.1

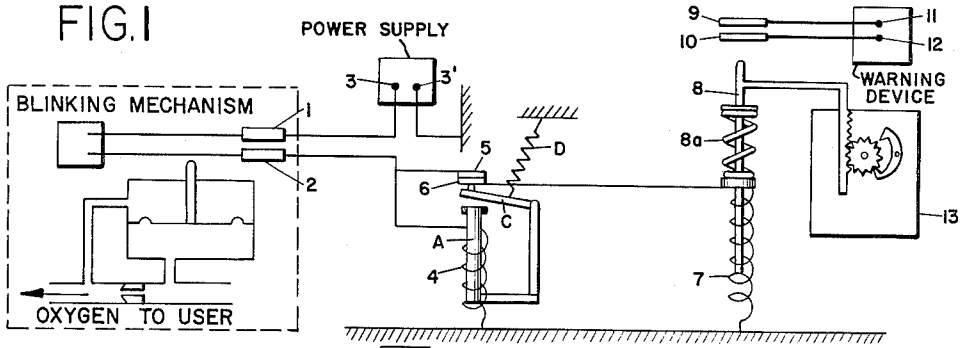


FIG.2

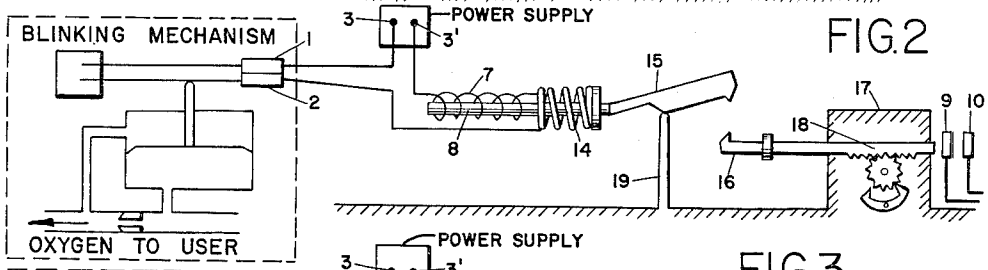


FIG.3

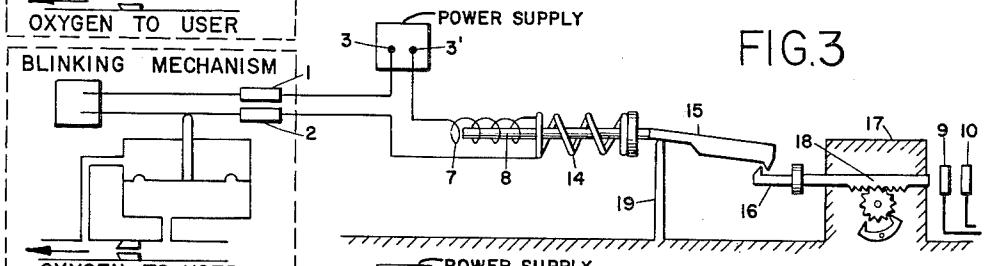


FIG.4

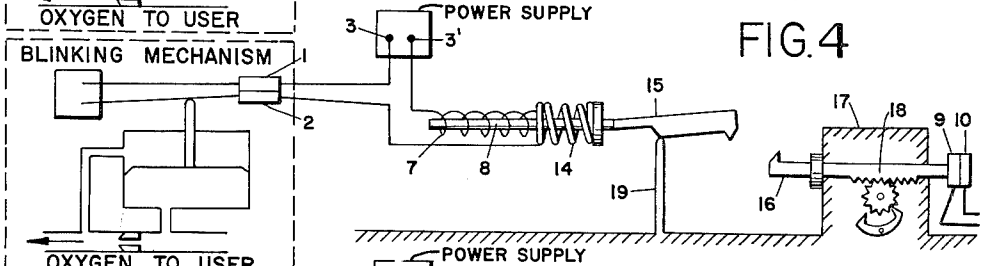
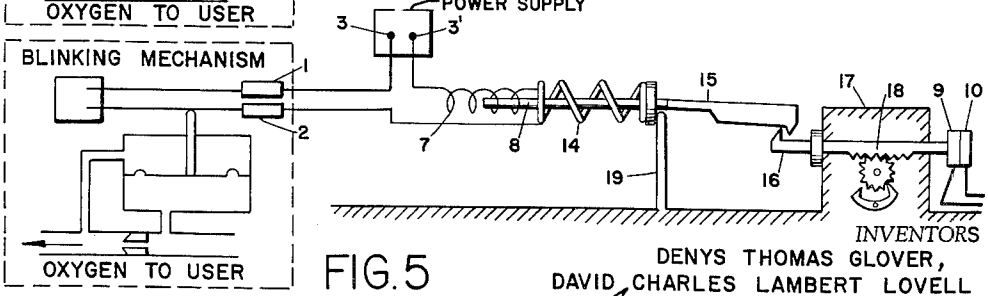


FIG.5



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OXYGEN BREATHING SYSTEMS

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This invention relates to oxygen breathing systems of the kind employing a breathing mask fed with oxygen from a container under control of a demand regulator and furnished with a blinker device operated periodically by the acts of inhaling by a user of the mask so as to indicate oxygen flow on each inspiration.

An oxject of the present invention is to provide a warning system brought into operation when (*a*) the regulator fails to function in the normal manner and allows unrestricted flow of oxygen to the breathing mask, or if the breathing tube between the regulator and the mask leaks or breaks, unrestricted flow of oxygen will again occur; this is termed constant flow, if (*b*) a mechanical failure of the regulator occurs and no oxygen is supplied, if (*c*) the rate of breathing of the user falls to a dangerous frequency.

The case referred to when the breathing rate falls to a dangerous frequency occurs in one instance, when atmospheric air leaks into the breathing mask, by way of a loose connection, improperly adjusted mask etc. The dilution of the oxygen supply by ambient air would then cause the user's breathing rate to fall perhaps unnoticeably, and therefore a warning of a dangerous condition is necessary.

A further object of the present invention is to provide a warning system not appreciably susceptible to temperature, atmospheric density or supply voltage variations.

The invention consists in an oxygen breathing system of the kind indicated wherein the electrical contacts attached to the flow indicator are associated with means so constructed and arranged as to produce impulses in response to the user's breathing, said means being associated with a time delay mechanism so arranged as to bring about the operation of a warning device in the event of the period between the impulses exceeding a predetermined time interval.

The invention will be more completely understood from the following detailed description which is given in conjunction with the accompanying drawing, in which:

FIGURE 1 is a diagram of a circuit arrangement illustrating the invention;

FIGURE 2 is a diagram of a circuit arrangement illustrating a second exemplification of the invention, and showing the apparatus during inspiration;

FIGURE 3 is the same circuit arrangement illustrating the condition of the apparatus during expiration; and

FIGURES 4 and 5 are circuit arrangements showing the condition of the apparatus when two different kinds of fault occur.

Referring first to FIGURE 1 of the accompanying drawing, a pair of contacts **1**, **2** are provided in a blinker mechanism. This blinker mechanism is of a type known per se and forms no part of the present invention. This blinker mechanism is adapted to be operated periodically by the act of inhaling by the use of a breathing mask (not shown). When the user of this mask inhales oxygen flows from a container (not shown) under the control of a demand regulator, this action causes a pressure differential to be set up between the sides of a diaphragm situated in a chamber forming an integral part of the blinker mechanism. This diaphragm is associated with a leaf spring member upon which the contact **2** is mounted. The pressure differential causes the diaphragm to move the leaf spring upwards. A second contact **1** is mounted

on a further leaf spring and movement of the diaphragm causes the contacts **1** and **2** to be made. **3**, **3'** are the supply voltage terminals which are connected to the contacts **1**, **2**. A slugged relay device **4** is provided, the circuit of which is controlled by the contacts **1**, **2** situated in the blinker mechanism. Contacts **5** and **6** are provided, these contacts lead to a solenoid **7**. The slugged relay **4** controls the contacts **5** and **6** and upon actuation causes these contacts to be made for a predetermined period of time. The solenoid **7** has a spring loaded core **8** which controls contacts **9**, **10** of a warning circuit **11**, **12**. This spring-loaded core **8** is under the control of a clockwork delay mechanism **13** (which may be a clockwork mechanism).

The slugged relay **4** may consist in a relay wherein (see FIGURE 1) the solenoid core A is embraced at one end by a copper band B. In operation, when current flows in the winding of the relay, a transient current is induced in the copper band, said transient current being of such a sense to oppose the growth of magnetic flux in the iron circuit of the relay. As the transient current decays, the magnetic flux grows until it is strong enough to actuate the armature C of the relay, whereupon said armature C opens the contacts **5** and **6**. It will be apparent, therefore, that the opening of the contacts occurs some time after the current begins to flow in the winding of the relay. A spring D is provided normally urging the armature to close the contacts **5** and **6**.

In operation, when the user of the mask inhales oxygen flows from the container to the mask, this causes the blinker mechanism contacts **1**, **2** to be made and current is accordingly supplied to the slugged relay **4**, this relay makes the contacts **5**, **6** and current flows to the solenoid **7**. After the predetermined delay time of the relay **4** has elapsed, the contacts **5**, **6** are broken cutting off the current to the solenoid **7**, thus forming a pulse of predetermined duration which current is supplied to the solenoid. The duration of the pulse is thus governed by the delay time of the relay **4** and not by the time during which the blinker mechanism contacts **1**, **2** are made. When current is supplied to the solenoid **7** the core **8** is caused to retract compressing its spring **8***a*. When each pulse ceases, i.e. when the contacts **5** and **6** are broken, the spring **8***a* urges the core **8** towards the contacts **9**, **10** of the warning system circuit **11**, **12**. This core is, however, under the control of a time delay mechanism **13** and before the core **8** reaches a position where the contacts **9**, **10** would be made the next inhalation occurs and the solenoid **7** is again energized and the core **8** is drawn away from the contacts **9**, **10**.

The clockwork mechanism **13** may (as shown) consist in a gear wheel engaging with a tooth rack, the gear wheel being restrained by a pivoted ratchet, the arms of which must both pass up and over a cog of the gear wheel to permit the gear wheel to revolve by one tooth.

In the case of constant flow, which would be caused by a broken oxygen supply pipe between the regulator and mask, the blinker electrical contacts will remain closed. The initial current pulse will be received by the slugged relay **4** and the solenoid **7** as before, but the relay **4** will remain energised with its contacts **5**, **6** open and no further pulses will be produced. The solenoid **7** is thus de-energised and the core **8** is urged towards the warning contacts **9**, **10** by the spring and these contacts are closed as soon at the time delay period imposed by the mechanism **13** expires, thus completing the warning circuit.

In the case of the regulator failing to deliver oxygen due to mechanical failure, the contacts **1**, **2** will remain open. In this case no current pulse will be received by the solenoid **7** as relay **4** will never be energised with the result that the solenoid core will again act upon the contacts **9**, **10** to complete the warning circuit.

In the event of the user's breathing rate falling to a dangerous frequency, the time elapsing between the pulses supplied to the solenoid 7 will increase until this time is greater than that required for the solenoid core 8 to reach and operate the warning contacts 9, 10 and a warning will again be given.

Any convenient form of warning device may be employed, e.g. an electric bell, buzzer or warning lamp.

A modified form of the invention is shown in FIGURES 2 to 5 of the accompanying drawings, in this form of the invention the slugged relay 4 of the first embodiment described is dispensed with, and the pulse effect required for bringing about the operation of the warning circuit is produced by means of a latch mechanism interposed between the spring controlled solenoid core and the time delay mechanism. As in the embodiment previously described, one of the supply voltage terminals 3, 3' is connected to the system through contacts 1, 2 in a blinker mechanism of a kind known per se. The other terminal is connected to one end of a solenoid winding 7, the other end of which is connected through the contacts 1, 2 to the first terminal. The solenoid 7 has a core 8 which is urged to its fully extended position by a spring 14. This core 8 has a latch member 15 pivotally mounted thereon. The latch member 15 is adapted to engage with an abutment or detent member 16 attached to or forming part of a clockwork mechanism 17. This clockwork mechanism 17 has a movable element 18 which is adapted to make contacts 9, 10 of a warning circuit when the core 8 is in its fully extended position as shown in FIGURE 5.

With this arrangement, when the user inhales, the blinker contacts are in the position shown in FIGURE 2, i.e. they are made. This causes the solenoid 7 to be energised and the core 8 to be withdrawn, against the action of the spring 14, into the solenoid 7. As the core retracts, the latch member 15 pivotally attached thereto, pulls with it the abutment or detent member 16 of the clockwork mechanism 17. At a selected point of the travel of the core 8 and of the latch member 15, a release device 19 is engaged by the latch member 15, causing the latter to pivot upwards, as shown in FIGURE 2, and to disengage the abutment or detent member 16. Upon disengagement from the latch member 15, the clockwork mechanism begins to retract the member 16 and cause the associated member 18 to start to move towards the contacts 9, 10 of the warning circuit. Assuming that exhalation now occurs, i.e. the contacts 1, 2 are broken, as shown in FIGURE 3, and the core 8 is thrust outwards by means of the spring 14. When the latter action takes place the latch member 15 overtakes the detent or abutment 16 which is withdrawn into the clockwork mechanism 17, and reaches a predetermined rest position. Upon the next inhalation, the core 8 is again withdrawn into the winding 7 taking the member 16 with it until the predetermined release position is reached. These operations then recur during each normal breathing cycle.

If "constant" flow should occur, however, the blinker contacts 1, 2 will be held together and the solenoid energised for an indefinite period thereby causing the solenoid core 8 to retract and remain restricted as shown in FIGURE 4. When this occurs, the clock mechanism runs down in an unrestricted manner, and on reaching a predetermined position, the member 18 engages with and closes the contacts 9, 10 of the warning circuit.

Such circuit conveniently comprises a warning lamp connected to an electric supply source by one of a pair of fixed push button contacts and a pair of relay contacts in series. The push button contacts are normally closed while the relay contacts are normally open and are closed only when the relay circuit is closed by the aforesaid run down of the clockwork mechanism. The push button contacts are opened when resetting of the mechanism is required after breathing has commenced. Alternatively the warning circuit may comprise a horn, bell, buzzer or other audible device.

If by a mechanical fault or otherwise oxygen supplies stop, the blinker contacts 1, 2 will remain opened and the solenoid core will remain in its extended position as shown in FIGURE 5. The clockwork mechanism will then run down until the member 18 again engages with the contacts 9, 10 of the warning circuit. It will thus be seen that an alarm will be given if the blinker contacts of the demand regulator are held either open or closed on account of the faults hereinbefore described.

Apparatus employing the present invention is particularly applicable for use with aircraft oxygen breathing systems, but has many other applications.

It is to be understood, however, that the invention is not to be regarded as being limited to breathing systems since it may be readily applied to other systems where it is desirable to provide some means for detecting any variation in regulator or periodic operations or movements. Thus the invention may be employed for detecting any variation in the rate at which a plurality of articles are conveyed on a moving belt, in which case a photo-electric cell or other like sensitive device may be used in place of the blinker attachment or flow indicator hereinbefore referred to so that the electric contacts employed for generating the pulses in the circuit may be closed and opened by the interruption of a light beam falling on the photo-electric cell by the passage of the articles on the moving belt.

Other applications of the invention will become apparent to those skilled in the art.

We claim:

1. An alarm device for breathing apparatus including a source of electric power, comprising a circuit including a normally open switch, solenoid means to produce an electromagnetic impulse when said switch is closed, means operated by each inhaled breath of a user to close said switch, a warning device, a mechanism for operation of said warning device including a spring biased core normally biasing said warning device into warning position, said solenoid means operating to withdraw said mechanism for operating of said warning device from warning position, and time delay means comprising a clockwork mechanism, latching means mounted on said spring biased core, a corresponding latching element mounted on said clockwork mechanism whereby said clockwork mechanism will be wound by movement of said core when said core is moved by said solenoid when said switch is closed, and means to unlatch said latching means when said clockwork mechanism is wound, whereby if said normally open switch remains either open or closed for a time in excess of the time delay means the warning device will be biased into warning position.

2. An alarm device for breathing apparatus including a source of electric power, comprising a circuit including a normally open switch, solenoid means to produce an electromagnetic impulse when said switch is closed, means operated by each inhaled breath of a user to close said switch, a warning device, a mechanism for operation of said warning device including a spring biased core normally biasing said warning device into warning position, said solenoid means operating to withdraw said mechanism for operating of said warning device from warning position when said normally open switch is closed by inhaled breath of the user, a normally closed switch in series with said normally open switch and said solenoid means, and a time delay device to open said normally closed switch a predetermined time after closing of said normally open switch whereby if said normally open switch remains closed for a time equal to the time delay of said time delay device said normally closed switch will be opened.

3. An alarm device for breathing apparatus including a source of electric power, comprising a circuit including a normally open switch, solenoid means to produce an electromagnetic impulse when said switch is closed, means operated by each inhaled breath of a user to close

said switch, a warning device, a mechanism for operation of said warning device normally biasing said warning device into warning position, means operated by said solenoid means to withdraw said mechanism for operating of said warning device from warning position, and time delay means operating for a time slightly in excess of the normal time of successive inhaled breaths to delay said mechanism from moving said warning device again into warning position unless said switch should fail to open or close within the time of said delay.

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