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[54] **ALARM SYSTEM FOR DIVERS**

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[51] **Int. Cl.** **G08b 23/00**

[58] **Field of Search** 340/279; 128/2.08, 142.2; 61/69, 71; 116/26; 325/116

[56] **References Cited**

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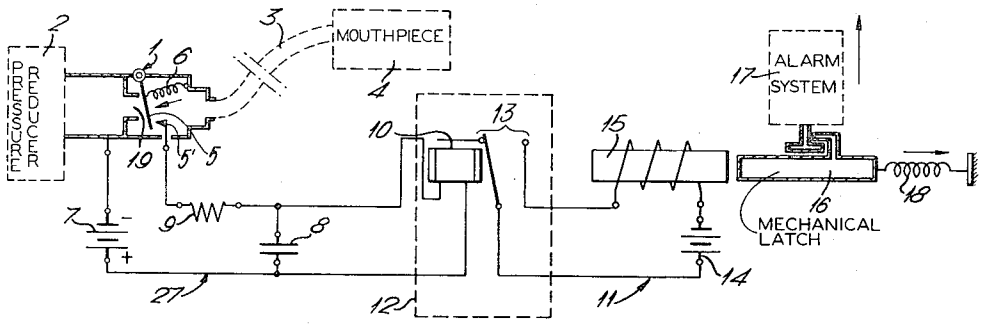
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[57] **ABSTRACT**

A floatable alarm device is normally restrained to the housing of a diver carried control. The control includes means for sensing respiration rate and causes release of the alarm if respiration rate substantially deviates from normal.

14 Claims, 3 Drawing Figures



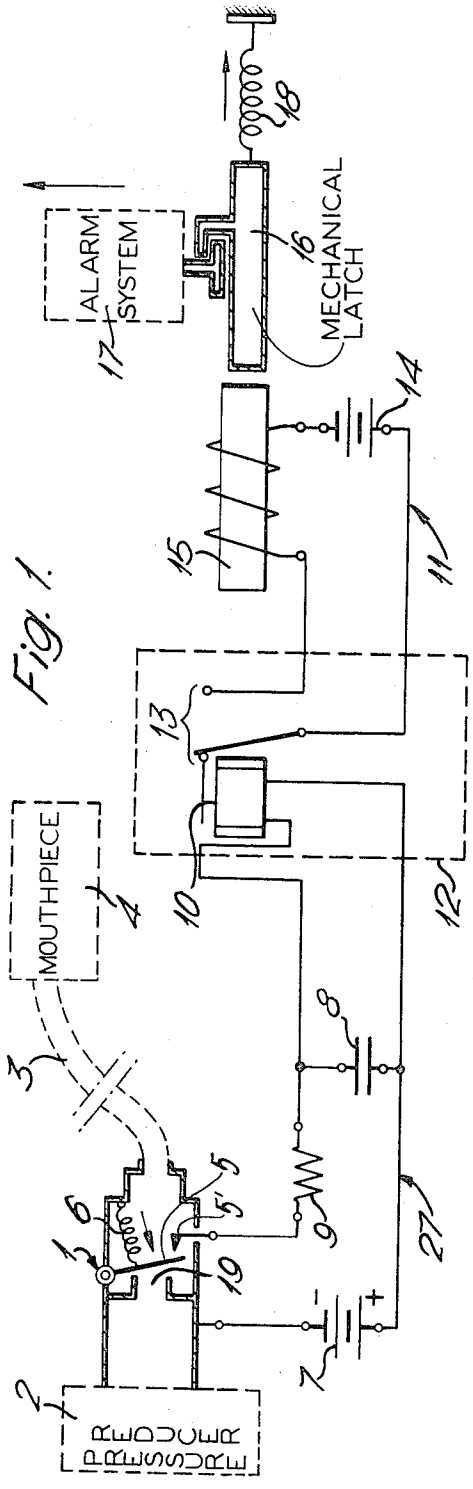

ALARM SYSTEM
MECHANICAL LATCH
MOUTHPIECE
BREATHALYZER

Fig. 1.

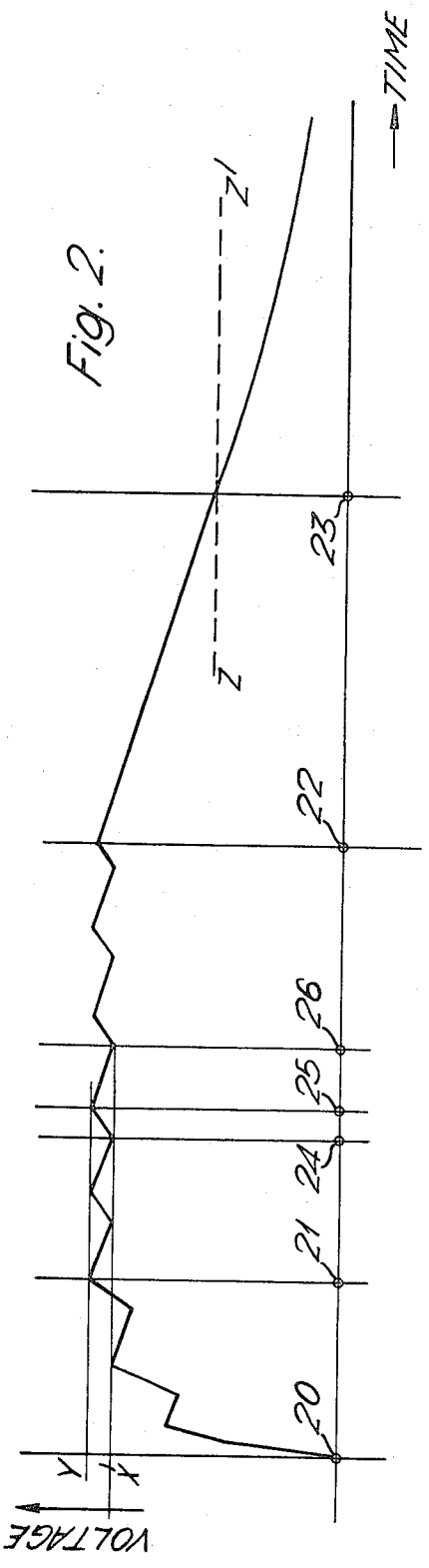
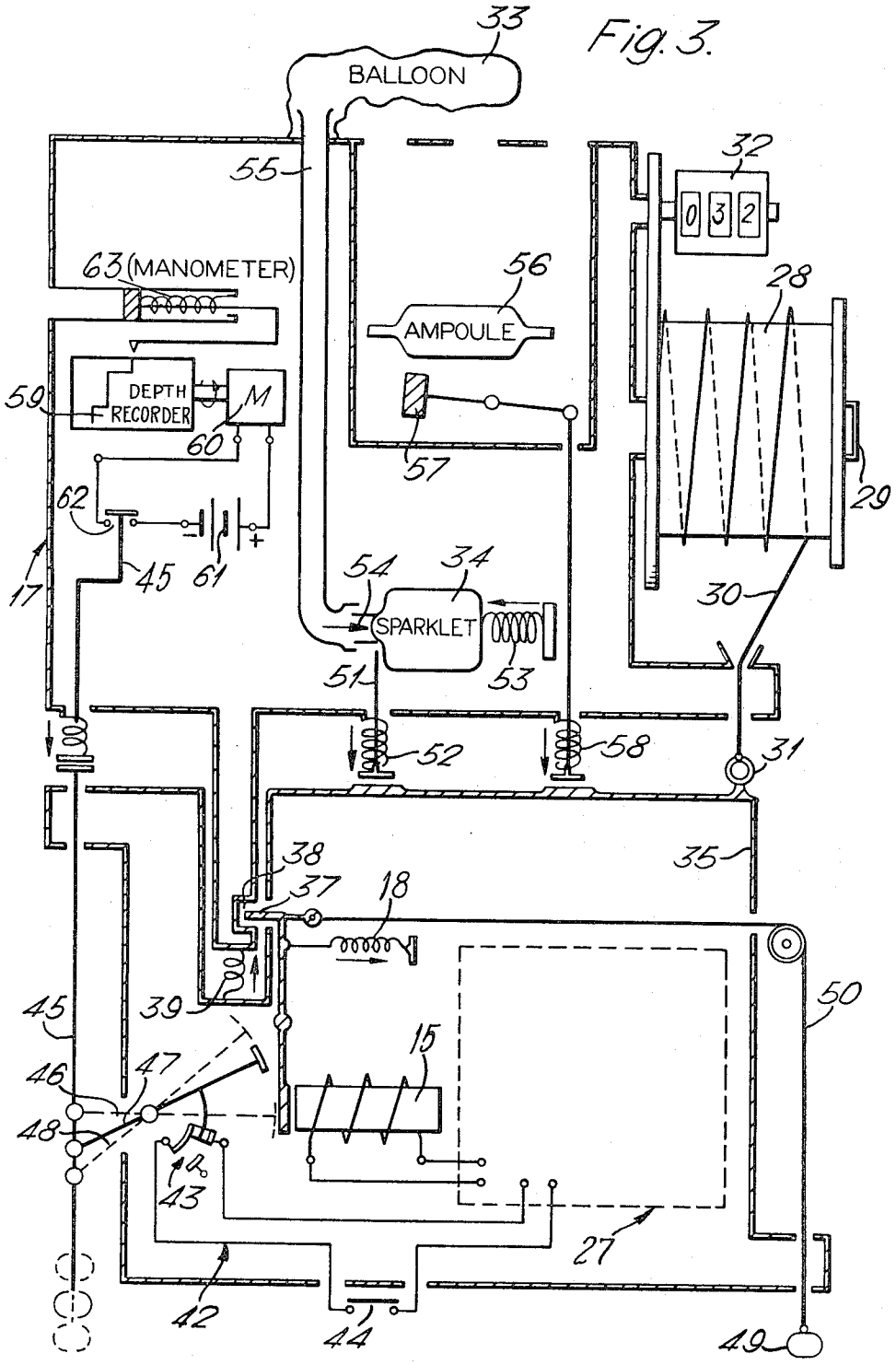

TIME
VOLTAGE
Z'
Z
X
Y

Fig. 2.

Fig. 3.


33
BALLOON
55
32
0 3 2
63 (MANOMETER)
56
AMPOULE
28
59
DEPTH RECORDER
M
60
57
62
29
45
61
17
54
34
30
SPARKLET
53
51
52
58
31
38
35
37
18
45
39
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ALARM SYSTEM FOR DIVERS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to enhancing the safety of individuals engaged in underwater activities. More specifically, this invention is directed to a manually or automatically operated device which provides an indication at the surface of the water of the position of a diver having mechanical or physiological difficulities. Accordingly, the general objects of the invention are to provide novel and improved methods and apparatus of such character.

2. Description of the Prior Art

In the prior art divers have had no means at their disposal which could be employed to indicate at the surface their position and the need for assistance in the case of severe or sudden uneasiness or physical or mechanical trouble. In the case of sudden uneasiness it is especially important that the diver be easily located so that proper assistance can be brought to him. Other than employment of a "buddy" system, the best technique available in the prior art for monitoring diving activity comprised the visual observance, from a patrol vessel, of the divers exhaust air bubble stream. When a number of divers were operating simultaneously the sudden disappearance of one of these air bubble streams at most revealed to the observers that an accident had happened to one of the divers. However, in addition to the obvious possibility of human error, monitoring of the air bubble stream provided no indication of the nature of the diver's trouble, very inexact information with respect to location of the diver and no informaton of the time which had elapsed since the problem or accident occured. In the case where a single diver was exploring a large zone, air bubble monitoring necessarily results in too great a time elapsing between an accident and its detection to enable adequate assistance to be brought to the diver.

SUMMARY OF THE INVENTION

The present invention overcomes the above discussed and other deficiencies of the prior art by providing apparatus for indicating at the water surface the precise position of a diver experiencing some difficulty. Apparatus in accordance with the invention is carried by the diver and is operated automatically should the diver encounter a mechanical or physiological problem. Apparatus in accordance with the invention may also be operated manually by the diver.

The present invention comprises a floatable alarm device which is normally held in or on a control device carried by the diver. Retention of the alarm device with the diver carried control is accomplished electrically by a circuit which is responsive to the diver's respiration rate. This circuit is adjusted whereby a preselected deviation from normal respiration rate will cause release of the floatable alarm.

BRIEF DESCRIPTION OF THE DRAWING

The present invention may be better understood and its numerous objects and advantages will become apparent to those skilled in the art by reference to the accompanying drawing wherein like reference numerals refer to like elements in the several figures and in which:

FIG. 1 is a schematic showing, partly in functional form, of a preferred embodiment of the present invention;

FIG. 2 is a graphical representation of the operating sequence of the device shown in FIG. 1; and

FIG. 3 is a detailed schematic of a preferred embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to FIG. 1, it is envisioned that the invention may, for example, be mounted on a normal diver's helmet of commercial size. A small auxilary attachment indicated generally at 1 is connected between the outlet of an intermediate pressure reducer 2 and a flexible hose 3 which leads either directly to the diver's mouthpiece 4 or to the mouthpiece via a further low pressure reducer. Accordingly, air at reduced pressure flows through the attachment 1 to the diver as the diver breathes. The attachment 1 comprise a movable flap 5 which is rotatable about a shaft and which is held in a first position against an air port 19 by a compression spring 6. With each inhalation of the diver, the movable flap 5 is shifted by the air flow and in the direction of such flow; i.e., toward the mouthpiece 4. Flap 5 will include a conductive element which is in turn electrically connected to a conductive portion of attachment 1. It will be understood that all of the conductive elements of the invention are suitably insulated from the aqueous environment in which the invention is utilized. The movement of flap 5 during inhalation caused the flap to assume a second position wherein it is in contact with an electrical contact 5'. The connection established between flap 5 and contact 5' will complete an electrical circuit indicated generally at 27. The flap 5 will stay in the second position with circuit 27 completed during the entire inhalation portion of the diver's breathing cycle. When the diver exhales the air flow to the mouthpiece 4 is interrupted and spring 6 moves flap 5 back to its first position against port 19.

During the period of time that flap 5 is in its second position; i.e., with circuit 27 completed; current from a first direct current source 7 will flow through series connected resistor 9 and coil 10 of a relay 12. With current flowing through the circuit a capacitor 8 will charge to a level determined by the size of resistor 9. The contacts 13 of relay 12 are connected in a second circuit, indicated generally at 11, which includes a second direct current source 14 and series connected solenoid 15. When energized, solenoid 15 holds a mechanical latch or retaining device 16 against a release spring 18 and thereby prevents liberation of the floatable alarm system 17. Alarm system 17 will be described in detail below in the course of the discussion of FIG. 3. As noted, the force provided by energized solenoid 15 is greater than that of tension spring 18. Upon de-energization of solenoid 15, and after a predetermined time lapse, the force of spring 18 will move the retaining means 16 out of its latching position thereby releasing alarm system 17 which ascends to the surface of the water due to its buoyancy.

Operation of the invention may be better understood from the joint consideration of the FIGS. 1 and 2. FIG. 2 depicts the charge on capacitor 8 as a function of time and the diver's breathing rhythm. After a first period of time 20–21, which may be considered as the start time, a period of normal breathing 21–22 follows.

A single breathing cycle 24–26 comprises inhalation time 24–25 and exhalation time 25–26. During inhalation time 24–25 movable flap 5 assumes its second position and completes the electrical circuit 27. Accordingly, during time period 24–25 the voltage across capacitor 8 and also the voltage across coil 10 of relay 12 will increase from level X to level Y. During exhalation period 25–26 the movable flap 5 is returned to its first position and circuit 27 is open. Accordingly, during time period 25–26 the voltage across capacitor 8 will decrease from level Y to level X. During this exhalation period the charge stored in capacitor 8 maintains the voltage across the coil 10 of relay 12. Thus, it may be seen that the voltage across capacitor 8 and coil 10 cycles during normal breathing between maximum and minimum levels which are dependent upon the diver's respiration rate and the size of capacitor 8 and resistor 9. The size of the components comprising circuit 27 are selected so that during the exhalation portions of the diver' s breathing cycle the voltage across capacitor 8 will, under normal conditions, always exceed a preselected level indicated as Z–Z'. The selection of the value of the components of the circuit 27 should further permit non-breathing of the diver during a period of time extending over several normal breathing cycles without triggering the alarm system. The voltage level Z–Z' represents the minimum voltage required for energization of relay 12 to hold contacts 13 of circuit 11 in the closed position to thereby keep solenoid 15 energized. Below voltage level Z–Z' the contacts 13 of relay 12 will be opened thus de-energizing solenoid 15 and permitting spring 18 to release the floatable alarm system 17.

At the time indicated at 22 in FIG. 2 the normal breathing of the diver has stopped. Thus, beginning from time 22, capacitor 8 will discharge through coil 10 and at time 23 the charge on capacitor 8 will be insufficient to hold relay 12 closed and contacts 13 will open thereby de-energizing solenoid 15, through the opening of circuit 11, and permitting release of floatable alarm 17.

As will be obvious to those skilled in the art, in order to reduce the size and weight of the invention the relay 12 may be replaced by an electronic switch. Use of an electronic switch, of course, will also reduce the system power requirements thereby permitting employment of a smaller battery 7 and a smaller capacitor 8.

It is also to be noted that in the FIG. 1 scheme, should compression spring 6 break the movable flap 5 would stay in its second position whereby circuit 27 would be permanently completed and the automatic control loop would be rendered ineffective. If deemed desirable this problem may be obviated by including the spring 6 as an integral part of the conductive path of circuit 27.

Referring now to FIG. 3, the preferred embodiment of apparatus in accordance with the present invention is shown schematically. The apparatus comprises two major subsystems; the floatable alarm system 17 and control circuitry located within housing 35. As discussed above the invention includes means for connecting alarm system 17 to housing 35 and means for manually or automatically liberating the alarm system from the housing.

In FIG. 3 alarm system 17 is retained on housing 35 by means of a pin 37 corresponding to retaining device 16 of FIG. 1, which is received in an aperture 38 in an extension of the alarm system housing; the alarm system housing extension being received in a channel in the control loop housing.

In its normal position pin 37 engages aperture 38 thus preventing the release of the buoyant alarm system. In case of emergency, pin 37 is retracted, either automatically or manually, from aperture 38. Upon retraction of pin 37 a compression spring 39 will assist in the separation of the alarm system from the control loop housing. As described above in the discussion of FIGS. 1 and 2, a solenoid 15 energized through the action of the automatic control circuit acts on the retaining means 37 and is opposed by a spring 18.

The embodiment of FIG. 3 includes a third control circuit 42 which comprises a main three position switch 43 and a series connected push button type switch 44. Series connected switches 43 and 44 select the mode of operation of the apparatus and, in so doing, completes a circuit between one of the terminals of battery 7 of FIG. 1 and the remainder of circuit 27. Accordingly, the energy supply to circuit 27 is switched on or off by third control circuit 42. The main switch 43 is operated by hand through the intermediary of lever means 45 whereby the movable contact arm of switch 43 may be cause to assume a first position 46, a second position 47 or a third position 48. In position 46, indicated by a broken line, switch 43 will open the electrical control circuit 42 thereby de-energizing circuit 27 and placing the automatic control loop out of service. However, with switch 43 in first position 46 the pin 37 is mechanically locked against solenoid 15 and the floatable alarm system 17 cannot be released. Position 46 of switch 43 is employed when the safety apparatus is not used.

In its second position, indicated by the solid line 47, switch 43 closes third control circuit 42 thereby energizing automatic control circuit 27 and placing it in normal operation.

In its third position 48, also indicated by a broken line, switch 43 opens third control circuit 42 and de-energizes control circuit 27. However, unlike first position 46, in position 48 of switch 43 the retaining means 16 is not mechanically blocked against solenoid 15 and the alarm will be released through the operation of spring 18. Position 48 of switch 43 thus constitutes a manually operable alarm release.

The push button type switch 44 may also be employed to de-energize the automatic control circuit 27. With switch 43 in position 47 the operation of the switch 44 for a sufficient time period, for example a time period equivalent to period 22–23 of FIG. 2, will result in the release of the alarm. Accordingly, it may be seen that switch 44 is included as a second manually operable emergency alarm release device.

A further manually operable alarm release device may be included in the invention. This further or third emergency device comprises a handle 49 and a line 50 which is connected directly to pin 37. Except when switch 43 is in its first position 46, the diver may release alarm system 17 by pulling pin 37 out of engagement with aperture 38 manually via line 50.

The alarm system 17, in its most basic version, is comprised of a floatable body comprised of a material which is distinctively colored and easily visable. Alarm system 17 may further comprise a reel 28 which is mounted on a shaft 29 and which serves as a storage medium for a line 30. The first end of line 30 is connected to reel 28 and the other end of line 30 is con-

nected to control loop housing **35** at point **31**. Line **30** may be graduated in feet whereby the diver's depth may be immediately ascertained when the alarm device **17** reaches the surface from visible observation of the unwound line remaining on reel **28**. However, rather than graduating line **30**, a counter **32** may be added to the alarm system; counter **32** will be driven by reel **38** as line **30** is unwound.

In a preferred embodiment of the invention the floatable alarm system **17** further comprises an inflatable balloon **33** which will be inflated by a sparklet **34**. The sparklet **34** is retained in its normal position by a safty pin **51**. Pin **51** will be withdrawn through the intermediary of a spring **52** if alarm system **17** becomes separated from control loop housing **35**. Upon withdrawal of pin **51** a furnther spring **53** pushes the sparklet **34** against a striker **54** and gas under reduced pressure flows through tube **55** and inflates balloon **33**. Balloon **33** will, of course, be chosen of a material having a color which is easily visible against the surface of the water.

The alarm system **17** may also comprise an ampoule **56** containing a concentrated liquid dye. The ampoule **56** is broken by a small hammer **57** activated by a spring **58** when alarm device **17** separates from control loop housing **35**. The liquid from ampoule **56** is released from the housing of alarm system **17** via small openings and will dye the water.

A bathymetric recorder **59** may also be mounted on alarm system **17**. Recorder **59** is driven, for example, by and electric motor **60** energized by a battery **61** and is switched on by switch **62**. Switch **62** is connected to the operating device or lever means **45** of switch **43**. Pressure readings are provided to recorder **59** by a spring loaded manometer **63**. When energized, the recorder **59** gives useful information about the different periods of time the diver has stayed at different depth levels where by decompression procedures for the diver can, if necessary, later be determined.

While a preferred embodiment has been shown and described, various modifications and substitutions may be made thereto without departing from the spirit and scope of the invention. Accordingly, it is to be understood that the present invention has been described by way of illustration and not limitation.

What is claimed is:

1. A diver's safety applicance comprising:
- means responsive to the diver's respiration rate for generating an electrical signal commensurate therewith;
- a housing carried by a diver;
- floatable alarm means;
- latch means attached to said housing for releasably retaining said alarm means on said housing;
- solenoid means for operating said latch means in a first direction with respect to said alarm means;
- resilient means operating in opposition to said solenoid means for operating said latch means in a second direction with respect to said alarm means; and
- means responsive to said respiration rate signal for changing the state of energization of said solenoid means whereby said latch means will be operated to release said alarm means from said housing upon disruption of the diver's normal respiration rate.

2. The apparatus of claim **1** further comprising:
- means for manually separating said alarm means from said housing.

3. The apparatus of claim **1** wherein said respiration rate signal generating means comprises:
- a direct current source;
- first switch means, said first switch means including a movable member responsive to the delivery of air to the diver, said first switch means movable member being operated in response to the diver's respiration rate to complete and interrupt a current path through said first switch means, said first switch means being connected in series with said current source;
- capacitor means connected in parallel with said current source and first switch means; and
- second switch means connected in parallel with said capacitor means, said second switch means controlling the operation of said solenoid means.

4. The apparatus of claim **3** further comprising:
- means for manually separating said alarm means from said housing.

5. The apparatus of claim **2** wherein said respiration rate signal generating means comprises:
- a direct current source;
- switch means, said switch means including a movable member situated in the path through which air is delivered to the diver, said switch means movable member being operated in response to the diver's respiration rate to complete and interrupt a current path through said switch means, said switch means being connected in series with said current source;
- capacitor means connected in parallel with said current source and switch means; and
- relay means connected in parallel with said capacitor means, said relay means controlling the energization of said solenoid means.

6. The apparatus of claim **1** wherein said alarm means comprises:
- a buoyant container;
- means mounted on said buoyant container for releasably storing a line, a first end of the line being connected to said storing means; and
- means connecting the second end of the line to said housing whereby said line will be pulled from said storage means upon separation of said alarm means from said housing.

7. The apparatus of claim **2** wherein said alarm means comprises:
- a buoyant container;
- means mounted on said buoyant container for releasably storing a line, a first end of the line being connected to said storing means; and
- means connecting the second end of the line to said housing whereby said line will be pulled from said storage means upon separation of said alarm means from said housing.

8. The apparatus of claim **3** wherein said alarm means comprises:
- a buoyant container;
- means mounted on said buoyant container for releasably storing a line, a first end of the line being connected to said storing means; and
- means connecting the second end of the line to said housing whereby said line will be pulled from said storage means upon separation of said alarm means from said housing.

9. The apparatus of claim **6** wherein said alarm means further comprises:

means responsive to the separation of said buoyant container from said housing for enhancing the visibility of said container when it reaches the water surface.

10. The apparatus of claim **8** wherein said alarm means further comprises:

means responsive to the separation of said buoyant container from said housing for enhancing the visibily of said container when it reaches the water surface.

11. The apparatus of claim **1** wherein said alarm means comprises:

a buoyant container; and

extendable means connecting said container to said housing, said extendable means providing an indication at the water surface of the diver's depth.

12. A diver's safety appliance comprising:

means responsive to the diver's respiration rate for generating an electrical signal commensurate therewith;

a housing carried by the diver;

a buoyant container;

extendable means connecting said container to said housing, said extendable means providing an indication at the water surface of the diver's depth;

releasable retaining means positioned within said housing, said retaining means normally engaging said buoyant container to prevent the surfacing thereof;

electrically actuated holding means for maintaining said retaining means in its normal position, said holding means being normally energized and responsive to the magnitude of said respiration rate signal; and

means for operating said retaining means to a container release position when said holding means is de-energized.

13. The apparatus of claim **12** wherein said respiration rate signal generating means comprises;

a direct current source;

switch means, said switch means including a movable member responsive to the delivery of air to the diver, said switch means movable member being operated in response to the diver's respiration rate to complete and interrupt a current path through said switch means, said switch means being connected in series with said current source;

capacitor means connected in parallel with said current source and switch means; and

actuator means connected in parallel with said capacitor means and responsive to the potential thereacross for controlling the operation of said holding means.

14. The apparatus of claim **13** further comprising:

means for manually overriding said holding means to thereby release said container from said housing.

* * * * *