

[54] RATE OF ASCENT GUIDE DEVICE FOR UNDERWATER DIVERS

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[58] Field of Search 58/152 R, 152 A, 152 G, 58/145 R; 73/432 R, 300, 291, 389, 411; 116/129 R

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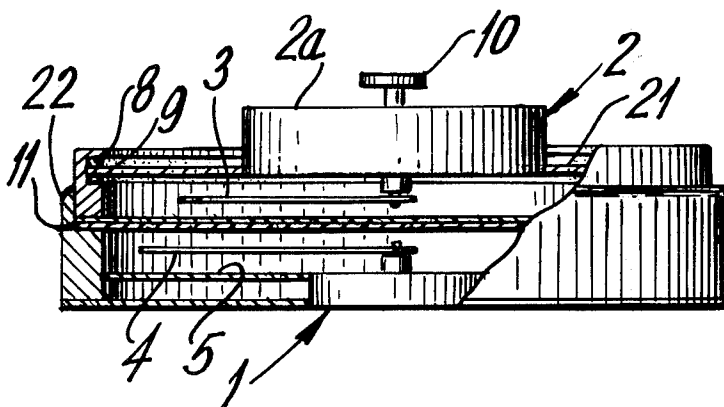
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[57] ABSTRACT

The present invention is an ascent rate guide device for underwater divers, capable of being worn in the manner of a wrist watch, and useful in regulating a diver's ascent rate to aid in the avoidance of air embolism sickness. The device comprises depth indicating means and ascent rate timing guide means. The latter includes an indicator rotated at a predetermined rate to simulate the rotation of the depth meter indicator during an ascent at a predesignated, safe rate. By controlling his ascent to maintain synchronization between the two indicators, the diver is assured that his rate of ascent will be at the predesignated rate which is specified to minimize the danger of air embolism.

23 Claims, 5 Drawing Figures



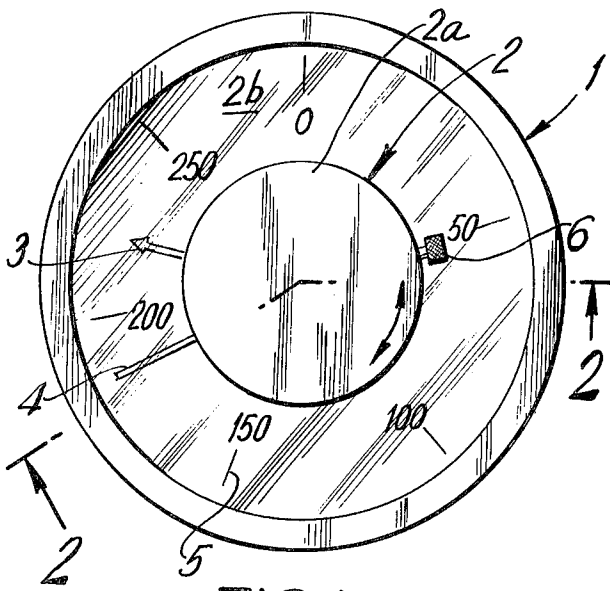


FIG. 1

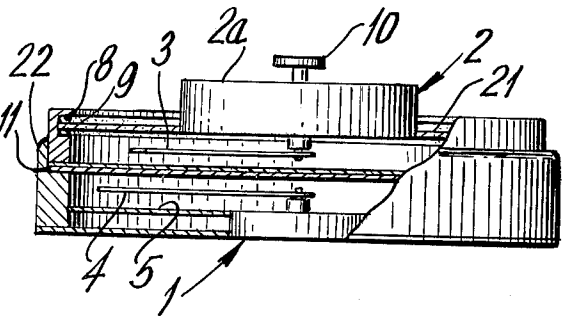


FIG. 3a

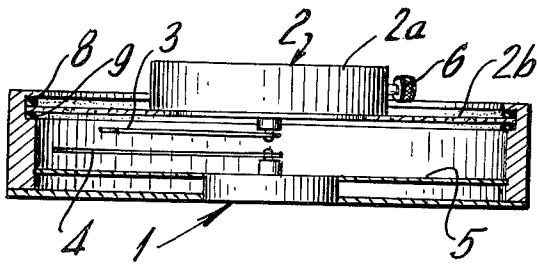


FIG. 2

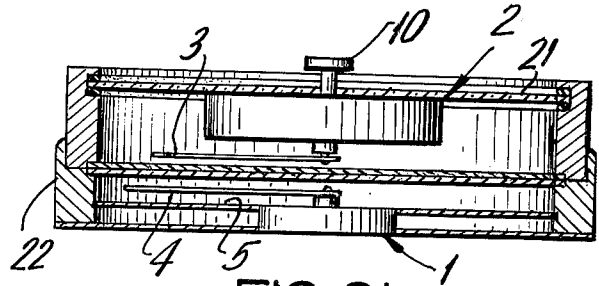


FIG. 3b

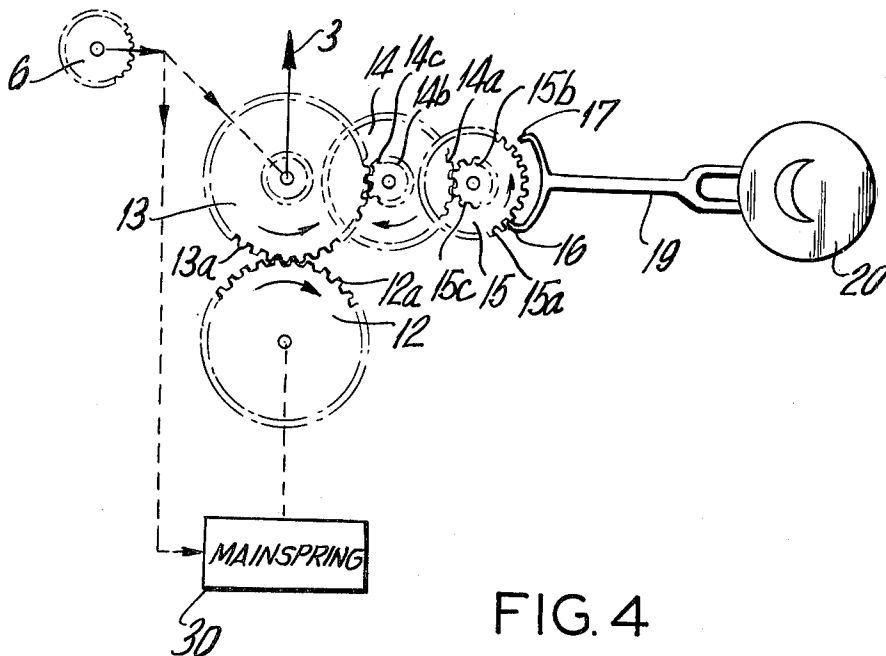


FIG. 4

RATE OF ASCENT GUIDE DEVICE FOR UNDERWATER DIVERS

BACKGROUND AND SUMMARY OF THE INVENTION

One of the principal causes of death in underwater diving is air embolism wherein air bubbles are created within the body in the blood vessels. If a diver ascends too rapidly from a dive, the air in the diver's lungs expands so rapidly, because of the sudden decrease in hydrostatic pressure, that the increased pressure within the lungs ruptures the air sacs and blood vessels. Air bubbles are forced into the lung blood vessels, carried to the heart, and from there pumped into the arteries. As a consequence, a plug (embolus) forms in the artery supplying the brain, depriving the brain of its blood supply. Death or serious brain damage can result.

Air embolism can also occur in another manner. During a dive the increased pressure causes air to dissolve in the tissues and blood of the diver; if the diver's approach to the surface is sufficiently gradual, the air will similarly come out of solution in a gradual manner as the reduced pressure associated with the ascent is experienced. If, however, the rate of ascent is too rapid and the pressure drop correspondingly too rapid, the air may form bubbles in the blood stream much as bottled carbonated water does when the bottle cap is popped off. In traversing the blood stream, these bubbles can lodge at vital points forming plugs (emboli) which can cut off the blood supply to limbs, organs, or the brain, thereby causing serious injury or death.

To prevent the occurrence of air embolism, divers are taught to ascend at an average rate no faster than 60 feet per minute. At this rate of ascent the air in the lungs, tissues and blood of the diver does not expand so rapidly as to cause the introduction of air bubbles into the blood stream. Divers are also instructed by some authorities not to ascend any slower than an average rate of 60 feet per minute as this would cause absorption of too great an amount of nitrogen. This could result in decompression sickness.

Since there is no simple way to determine rate of ascent, divers are told by some authorities to follow their exhalation bubbles. This is frequently impractical due to lateral movements in the stream of bubbles caused by underwater currents. The technique is also hampered by the darkness encountered at deeper depths and by the fact that such a stream of bubbles is comprised of a mass of bubbles, each travelling at a different speed and each a different size. (Sometimes divers are instructed to follow the smallest bubbles.)

Another technique of measuring rate of ascent used by underwater divers involves judging the rate of ascent by referring to both a depth gauge and a watch. This is an awkward and very imprecise method for controlling ascent.

It is, accordingly, an object of the present invention to provide a simple, effective, rugged, durable and water proof instrument which overcomes the aforementioned difficulties, which permits a diver to accurately control his rate of ascent, and which in some embodiments may be worn in the manner of a wrist watch.

It is a further object of the present invention to provide a rate of ascent guide instrument for underwater divers which will permit a diver to regulate his ascent at an average rate of 60 feet per minute so as to avoid

air embolism and reduce his susceptibility to decompression sickness.

It is a particular object of the present invention to provide a rate of ascent guide device for use in underwater diving comprising: depth indicating means such as a conventional depth meter with a dial calibrated in feet or other lineal measure and having a depth indicator; a rate of ascent timing guide mechanism having an indicator such that the rate of ascent timing guide indicator simulates the operation of the depth indicating means during an ascent at a predesignated rate, e.g. an average rate of 60 feet per minute, and is driven by the rate of ascent timing guide mechanism; and means for orienting the depth and rate of ascent indicators whereby a diver can maintain synchronization of the depth indicating means with the rate of ascent timing guide means in ascending, thereby assuring that his rate of ascent will be at an average rate of 60 feet per minute.

It is a further object to provide an ascent controlling instrument whereby a diver can achieve a non-linear ascent rate, such that the instantaneous rate of ascent becomes slower as the diver nears the surface.

These objects as well as other objects and advantages of the present invention will be more fully understood by practice with the invention and by reference to the following detailed description of embodiments illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a first embodiment of the invention in top plan view employing a unitary housing containing both the depth gauge and ascent rate mechanism;

FIG. 2 is a cross-sectional view of the embodiment of the invention depicted in FIG. 1, taken along the lines 2-2 of FIG. 1;

FIGS. 3a and 3b are cross-section views of another embodiment of the invention in which the rate of ascent instrument and depth gauge are each self contained, but adapted to be coupled to each other.

FIG. 4 is a schematic diagram illustrating a rate of ascent timing guide mechanism suitable for use in the embodiments of FIGS. 1-4.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to FIGS. 1 and 2, the instrument employs a depth gauge, 1, which may be of the Bourdon oil-filled type or other known construction. Connected to depth gauge, 1, is a rate of ascent timing guide mechanism, 2, which includes a rate of ascent timing guide indicator, 3, arranged coaxially with the depth indicator, 4, of depth gauge 1. Both the depth indicator, 4, and the rate of ascent timing guide indicator, 3, are rotatable relative to a scale, 5, of the depth gauge. The rate of ascent timing guide indicator, 3, is rotatably driven by driving means within the rate of ascent timing guide mechanism, 2, as described below.

The rate of ascent timing guide mechanism, 2, may incorporate known driving means, e.g., a battery or spring operated watch mechanism, activated by a control, 6, for rotating the rate of ascent timing guide indicator in the counter-clockwise direction toward the zero depth position on the depth scale. Such a watch mechanism may illustratively include a mainspring, standard balance wheels and escapement, and the gearing necessary to cause the rate of ascent timing guide

indicator to rotate at the required rate, all as shown in FIG. 4.

Referring to FIG. 4, there is illustrated therein a mainspring, 30, which rotatably drives the main wheel, 12, in the clockwise direction. As the wheel rotates, its teeth, 12a, engage the teeth, 13a, of the center wheel, 13, and thereby cause the center wheel, 13, to rotate in the counter-clockwise direction. The timing guide indicator, 3, is radially attached to the center wheel, and thus, the counter-clockwise rotation of the center wheel causes it to rotate in the counter-clockwise direction also. For setting, winding and starting, the control, 6, typically a crown and stem, is coupled in known manner to the indicator, 3, and mainspring, 30.

As the center wheel rotates, its teeth, 13a, mesh with the leaves, 14c, of pinion 14b. As a result, wheel 14, fixed to pinion 14b, is caused to rotate in the clockwise direction. As wheel 14 so rotates, its teeth, 14a, engage the leaves, 15c, of pinion 15b, thereby causing the escape wheel, 15, fixed to pinion 15b, to rotate in a counter-clockwise manner. The rotation of wheel 15 is regulated by entry/escape pallet 16 and exit/escape pallet 17 in known manner.

As in conventional time pieces, the balance wheel, 20, is connected to the escape pallet mount by lever 19 and oscillates at a frequency which is a function of system parameters including those of the balance wheel spring (not shown). As the balance wheel oscillates, it imparts a reciprocating motion to the lever which causes the entry and exit pallets to alternately engage and disengage the teeth of the escape wheel, thereby governing the rotation and speed of the escape wheel and controlling the rotational speed of the rate of ascent timing guide indicator. In order for the rate of ascent timing guide indicator to rotate so as to simulate the operation of the particular depth meter illustrated in FIG. 1 during an ascent at an average rate of 60 feet per minute, system parameters are chosen so that the wheel 13 rotates at 0.23529 revolutions per minute. In general, of course, the designated rate of rotation of wheel 13, necessary to effect the simulation of the operation of a depth meter during an ascent at an average rate of 60 feet per minute, will vary according to the calibration of the particular depth meter.

Again referring to FIGS. 1 and 2, the rate of ascent timing guide mechanism, 2, includes a case, 2a, which encloses the driver, e.g. a battery or the spring operated watch mechanism of FIG. 4. The case, 2a, is mounted on and sealed to a transparent disc, 2b; rate of ascent timing guide indicator, 3, extends below the disc. Disc 2b is mounted on the rim of the depth gauge, 1, and is sealed by appropriate means such as O-rings 8 and 9. Thus, both the ascent rate guide indicator, 3, and the depth indicator operate coaxially and can be viewed together through the transparent disc, 2b.

To initially synchronize the timing indicator, 3, and depth indicator, 4, the control, 6, may be rotated. Alternatively, the entire rate of ascent timing guide housing including the rate of ascent timing guide indicator, 3, and the rate of ascent timing guide mechanism, 2, may be manually rotated relative to the depth gauge, 1, by twisting the case, 2a, and the disc, 2b; seals 8 and 9 are configured to permit rotation in this instance. By thus twisting the housing 2a, 2b or rotating control 6 at the beginning of his ascent, a diver can align or synchronize the rate of ascent timing guide indicator with the depth indicator.

The starting movement of control 6 may then be actuated, causing the rate of ascent timing guide indicator to rotate in a counter-clockwise direction at a pre-designated rate approximately equal to the rate of counter-clockwise rotation of the depth indicator during an ascent at an average rate of 60 feet per minute. In this way the rate of ascent timing guide indicator simulates the operation of the depth indicator during an ascent at an average rate of 60 feet per minute. As the rate of ascent timing guide indicator, 3, rotates, the diver commences his ascent whereby the depth indicator, 4, also begins to rotate. By regulating his rate of ascent to keep indicator, 4, continuously aligned or synchronized with indicator, 3, the diver will be controlling his rate of ascent so that it is safely below the rate which could cause air embolism, and rapid enough to minimize susceptibility to decompression sickness.

It should be noted that the scale, 5, of the depth gauge may be non-linear having a greater angular displacement of the depth indicator at lower values of depth than at higher values. As a consequence, the rate of ascent, controlled as described above, will decrease as the surface is approached and this is considered by some authorities in the art of diving to be particularly important in avoiding air embolism.

An equivalent embodiment consists of a linear depth gauge and a timing indicator which rotates, at a non-linear rate, i.e. more slowly as it approaches the zero depth marking on the depth scale.

It should also be noted that the starting control, 6, for the rate of ascent timing guide indicator is not essential. In some embodiments the rate of ascent timing guide indicator, 3, can be rotating constantly and the ascent begun when indicators 3 and 4 are aligned.

In other embodiments, as illustrated in FIGS. 3a and 3b, the depth gauge and the housing for the timing mechanism, 2, and timing indicator, 3, are separate sealed self-contained units, adapted to be positioned one above the other, and having their respective sealed transparent interfaces, 11, in face-to-face relationship. In this embodiment, setting and winding means, 10, for manually winding and/or setting the rate of ascent timing guide indicator are also provided and the top surface 21 of the ascent rate mechanism is also transparent. Clamps 22 or other suitable means for clipping the ascent rate unit to the depth indicator may be provided.

What is claimed is:

1. A rate of ascent guide device for underwater divers comprising:

- a. depth indicating means;
- b. rate of ascent timing guide means which simulate the operation of said depth indicating means during an ascent at a pre-designated rate;
- c. means for powering the rate of ascent timing guide means;
- d. means adapted for synchronizing the depth indicating means with the rate of ascent timing guide means; and
- e. viewing means for maintaining the depth indicating means in synchronization with the rate of ascent timing guide means in ascending from underwater so that a diver's rate of ascent will be at the pre-designated rate of ascent reflected by the operation of the rate of ascent timing guide means.

2. A rate of ascent guide device as claimed in claim 1 wherein: the depth indicating means are a depth gauge and depth gauge indicator; the depth gauge is

circular and mounted on a disk; the rate of ascent timing guide means includes a rate of ascent timing guide mechanism and rate of ascent timing guide indicator; the rate of ascent timing guide mechanism is enclosed in a case; said case is mounted on a transparent disk with the rate of ascent timing guide indicator extending below the disk; the transparent disk is mounted on the rim of the depth gauge so that the depth gauge indicator and the rate of ascent timing guide indicator can operate coaxially and can be viewed together through the transparent disk; the rate of ascent timing guide indicator and the depth gauge indicator are rotatable relative to the scale of the depth gauge; the rate of ascent timing guide indicator is rotatably driven by the rate of ascent timing guide mechanism; the rate of ascent timing guide indicator simulates the operation of the depth gauge indicator during an ascent at a predesignated rate; the depth gauge indicator and the rate of ascent timing guide indicator can be synchronized by an underwater diver; the depth gauge indicator and the rate of ascent timing guide indicator can be maintained in synchronization by an underwater diver in ascending, thereby assuring that his ascent will be at the predesignated rate of ascent reflected by the rate of ascent timing guide indicator.

3. A rate of ascent guide device as claimed in claim 1 wherein the rate of ascent timing guide means is activated by a starting mechanism.

4. A rate of ascent guide device as claimed in claim 2 wherein the rate of ascent timing guide indicator is activated by a starting mechanism.

5. A rate of ascent guide device as claimed in claim 2 wherein the entire rate of ascent timing guide housing, including the rate of ascent timing guide mechanism and the rate of ascent timing guide indicator, is manually rotatable relative to the depth gauge.

6. A rate of ascent guide device as claimed in claim 2 wherein means are provided for independently manually rotating the rate of ascent timing guide indicator to a start position.

7. A rate of ascent guide device as claimed in claim 1 wherein the depth indicating means and the rate of ascent timing guide means are separately housed in independent, self-contained units, positioned one above the other, and separated by a transparent interface.

8. A rate of ascent guide device as claimed in claim 2 wherein the depth gauge and the housing for the rate of ascent timing guide mechanism and indicator are separate, independent, self-contained units, positioned one above the other, and separated by a transparent interface.

9. A rate of ascent guide device as claimed in claim 1 wherein the rate of ascent timing guide means simulates the operation of a depth indicating means during an ascent at an average rate of sixty feet per minute.

10. A rate of ascent guide device as claimed in claim 2 wherein the rate of ascent timing guide indicator simulates the operation of a depth gauge indicator during an ascent at an average rate of sixty feet per minute.

11. A rate of ascent guide device as claimed in claim 3 wherein the rate of ascent timing guide means simulates the operation of the depth indicating means during an ascent at an average rate of 60 feet per minute.

12. A rate of ascent guide device as claimed in claim 4 wherein the rate of ascent timing guide indicator simulates the operation of a depth gauge indicator during an ascent at an average rate of 60 feet per minute.

13. A rate of ascent guide device as claimed in claim 5 wherein the rate of ascent timing guide indicator simulates the operation of the depth gauge indicator during an ascent at an average rate of 60 feet per minute.

14. A rate of ascent guide device as claimed in claim 6 wherein the rate of ascent timing guide indicator simulates the operation of the depth gauge indicator during an ascent at an average rate of 60 feet per minute.

15. A rate of ascent guide device as claimed in claim 7 wherein the rate of ascent timing guide means simulates the operation of the depth indicating means during an ascent at an average rate of 60 feet per minute.

16. A rate of ascent guide device as claimed in claim 8 wherein the rate of ascent timing guide indicator simulates the operation of the depth gauge indicator during an ascent at an average rate of 60 feet per minute.

17. A rate of ascent guide device as claimed in claim 2 wherein the depth gauge is non-linear so that there is a greater angular displacement of the depth indicator per unit of depth change at lower values of depth than at higher values.

18. A rate of ascent guide device as claimed in claim 4 wherein the depth gauge is non-linear so that there is a greater angular displacement of the depth indicator per unit of depth change at lower values of depth than at higher values.

19. A rate of ascent guide device as claimed in claim 5 wherein the depth gauge is non-linear so that there is a greater angular displacement of the depth indicator per unit of depth change at lower values of depth than at higher values.

20. A rate of ascent guide device as claimed in claim 6 wherein the depth gauge is non-linear so that there is a greater angular displacement of the depth indicator per unit of depth change at lower values of depth than at higher values.

21. A rate of ascent guide device as claimed in claim 8 wherein the depth gauge is non-linear so that there is a greater angular displacement of the depth indicator per unit of depth change at lower values of depth than at higher values.

22. A rate of ascent guide device as claimed in claim 10 wherein the depth gauge is non-linear so that there is a greater angular displacement of the depth indicator per unit of depth change at lower values of depth than at higher values.

23. A rate of ascent guide device for underwater divers comprising:

- a. depth indicating means;
- b. rate of ascent timing guide means which simulate the operation of said depth indicating means during an ascent at a predesignated rate;
- c. means for powering the rate of ascent timing guide means;
- d. means adapted for synchronizing the depth indicating means with the rate of ascent timing guide means; and
- e. viewing means for maintaining the depth indicating means in synchronization with the rate of ascent timing guide means in ascending from underwater;

wherein: the depth indicating means are a depth gauge and depth gauge indicator; the rate of ascent timing guide means includes a rate of ascent timing guide mechanism and rate of ascent timing guide indicator; the rate of ascent timing guide indicator simulates the operation of the depth gauge indicator during an ascent at a predesignated rate; said viewing means for main-

taining the depth indicating means in synchronization with the rate of ascent timing guide means provide for the synchronization of the depth gauge indicator and the rate of ascent timing guide indicator by an under-

water diver in ascending from underwater so that the ascent will be at the predesignated rate of ascent reflected by the rate of ascent timing guide indicator.

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