Sept. 8, 1964 A. J. NELSON ET AL 3,147,499

AUTOMATIC LIFE JACKET INFLATOR FOR SELF-CONTAINED UNDERWATER BREATHING APPARATUS

Filed Oct. 4, 1961 3 Sheets-Sheet 1

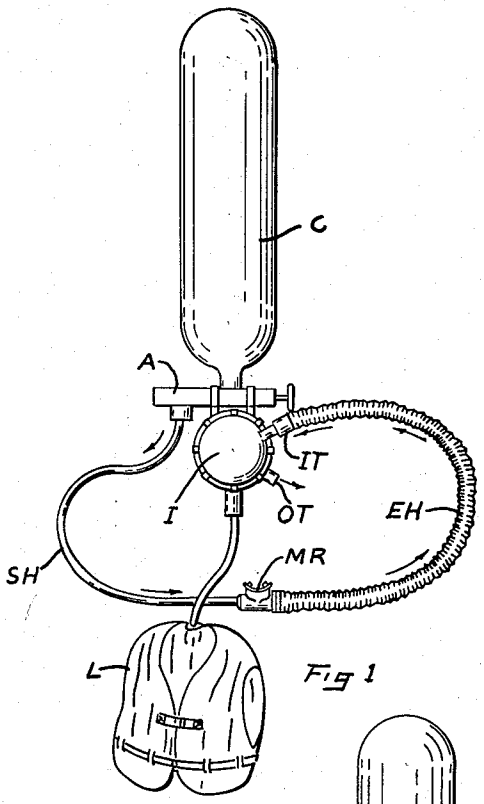


Fig 1

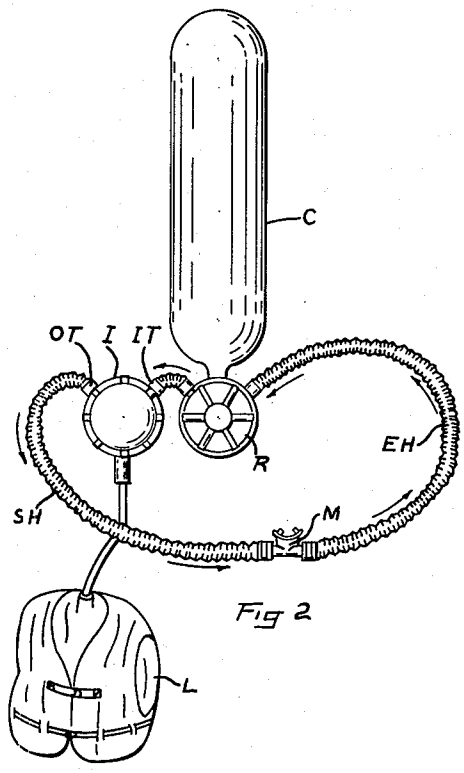


Fig 2

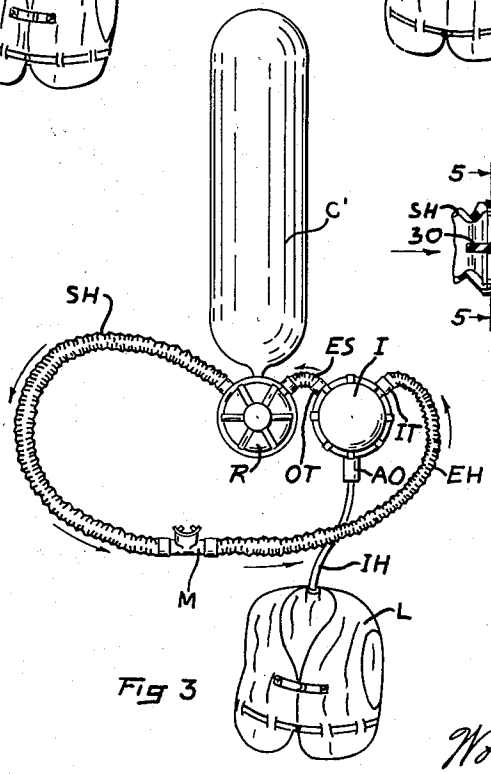


Fig 3

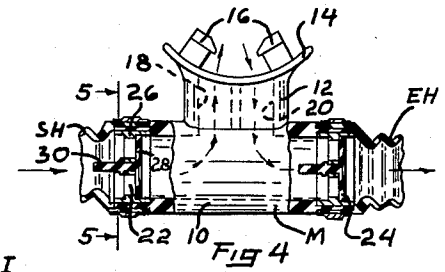


Fig 4

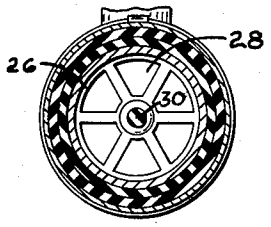


Fig 5

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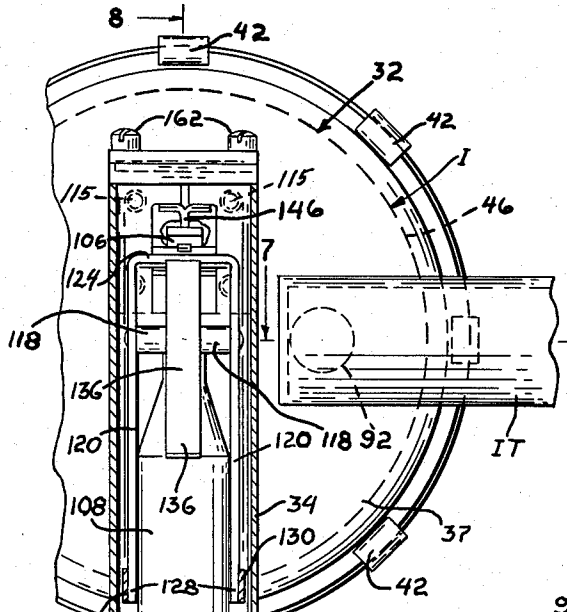


Fig. 10.

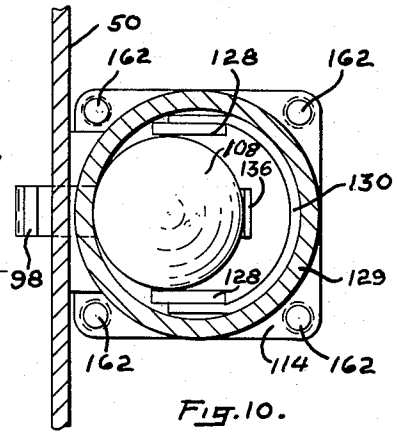


Fig. 6.

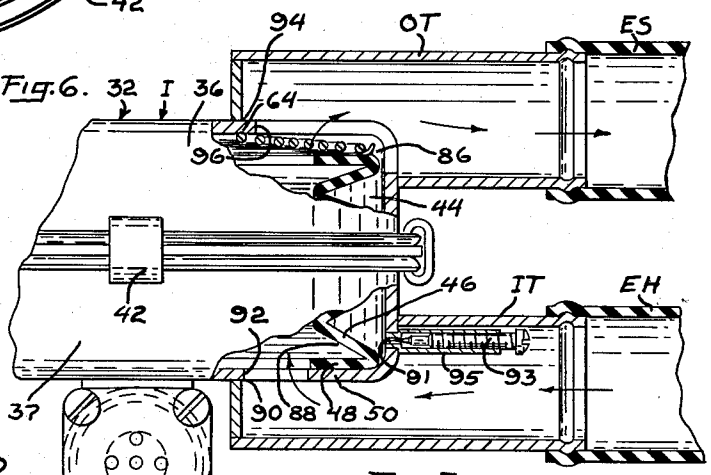


Fig. 7.

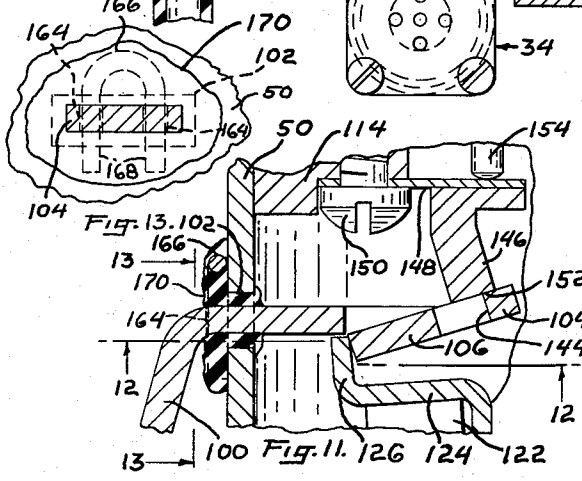


Fig. 13.

Fig. 11.

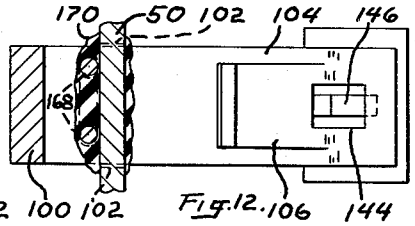


Fig. 12.

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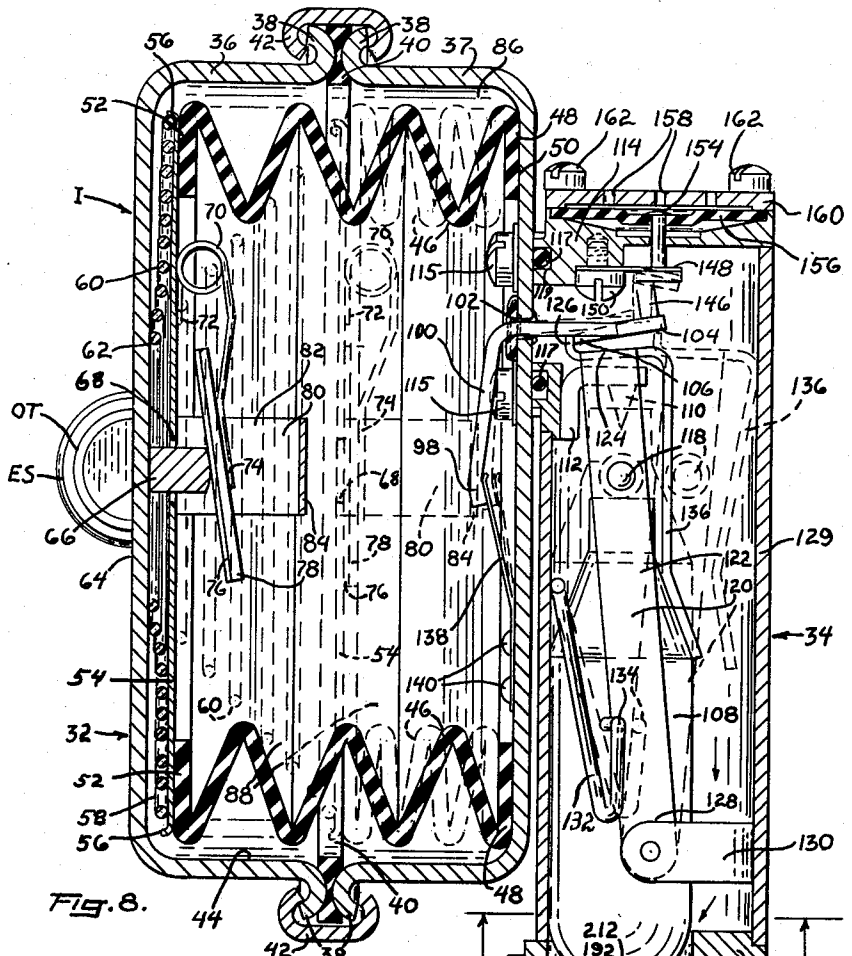


Fig. 8.

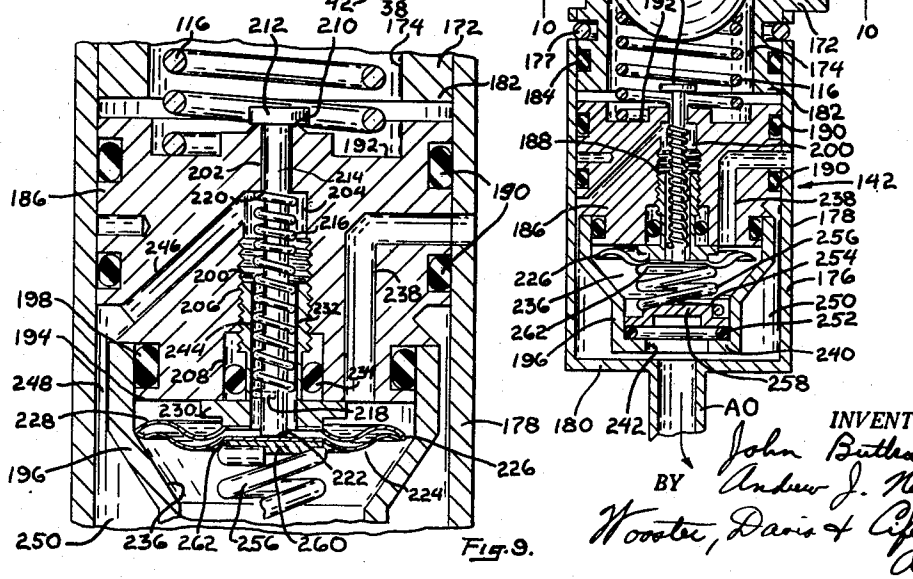


Fig. 9.

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3,147,499

AUTOMATIC LIFE JACKET INFLATOR FOR SELF-CONTAINED UNDERWATER BREATHING APPARATUS

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Filed Oct. 4, 1961, Ser. No. 142,816
9 Claims. (Cl. 9—313)

This invention relates to a safety device for use by free divers, commonly referred to as "skin divers," who utilize self-contained underwater breathing apparatus, such as the well known "aqua-lung."

Breathing, of course, is the principal problem in skin diving. The problem was compounded in the past by the desire to free a diver of a fixed source of air removed from him, and all the paraphernalia incident thereto, as was previously employed by so-called "deep sea" divers, who received their air from a fixed source located aboard ship or on land through long lengths of hose. The development of the aqua-lung has made available to devotees of underwater exploration a feasible means of providing for proper underwater breathing which is portable with the diver. A self-contained underwater breathing apparatus usually includes a cylinder of compressed air, ordinarily carried on the back of the skin diver by a harness mounted over and around the upper portion of his body; an air regulator to supply air to the skin diver at the proper pressure for safe breathing, dependent upon the depth of immersion of the skin diver and relative to the ambient pressure at such a depth; a mouthpiece with both inhaling inlet and exhaling outlet valves through which the skin diver both inhales and exhales, and appropriate flexible hose connecting the various elements of the underwater breathing apparatus just described. Such self-contained underwater breathing apparatus is well known in the skin diving art. Exemplary of such underwater breathing apparatus is U.S. Patent No. 2,485,039, Cousteau et al., which may be referred to for a fuller understanding of the construction and operation of such apparatus.

When utilizing self-contained underwater breathing apparatus during normal skin diving operation, the diver may for a variety of reasons terminate breathing, not necessarily the result of mechanical failure of the underwater breathing apparatus. It is, of course, essential if this should occur that the diver be surfaced as soon as possible and practicable in order that he may be treated and an attempt made to restore his respiration or, at the very least, if he is beyond saving, that his body be located promptly.

It is an object of this invention to provide a safety device for use and in association with underwater breathing apparatus which will automatically function in response to the termination of breathing by the diver to promptly surface him.

It is another object of this invention to provide a safety device as set forth in the preceding paragraph which is a self-contained unit that may be manufactured and sold as an accessory for a large variety of self-contained underwater breathing apparatus.

The objects of the invention are accomplished in one form by providing in association with underwater breathing apparatus of the above discussed type, an inflatable life jacket and an inflator for automatically inflating the life jacket in response to the termination of breathing by the diver.

The above and other objects and further details of that which we believe to be novel and our invention will be

clear from the following description and claims taken with the accompanying drawings wherein:

FIGS. 1, 2 and 3 are somewhat schematic, elevational views of three different arrangements of self-contained underwater breathing apparatus which incorporate our invention;

FIG. 4 is an enlarged elevational view with portions broken away and shown in section of the mouthpiece of the FIGS. 2 and 3 arrangements;

FIG. 5 is a sectional view taken substantially on line 5—5 of FIG. 4;

FIG. 6 is a fragmentary enlarged rear elevational view with portions broken away and shown in section of the inflator which forms a part of our invention;

FIG. 7 is a fragmentary partial plan view of the inflator with portions taken on line 7—7 of FIG. 6, and shown in section;

FIG. 8 is a further enlarged sectional view taken substantially on line 8—8 of FIG. 6;

FIG. 9 is a still further enlarged sectional view of a portion of FIG. 8;

FIG. 10 is a sectional view taken substantially on line 10—10 of FIG. 8;

FIG. 11 is an enlarged sectional view of a portion of FIG. 8;

FIG. 12 is a sectional view taken substantially on line 12—12 of FIG. 11, and

FIG. 13 is a sectional view taken substantially on line 13—13 of FIG. 11.

Our invention comprises the incorporation of an inflatable life jacket and an inflator for automatically inflating the life jacket in response to the termination of breathing on the part of a diver employing self-contained underwater breathing apparatus while engaged in underwater diving. The inflator with an associated life jacket may be incorporated into different underwater breathing apparatus arrangements, and in FIGS. 1, 2 and 3 we have illustrated three representative arrangements. The particular arrangement is not critical, it only being essential that it include either an air supply or air exhaust hose, though most arrangements will include both.

In FIG. 1 our life jacket inflator is generally designated I and the associated life jacket L is illustrated as being incorporated in an underwater breathing apparatus arrangement which includes cylinder C housing compressed air and appropriate valving mechanism, an adapter A connecting the cylinder to an air supply hose SH which communicates with a mouthpiece MR of the type having a pressure regulator incorporated into it and which ordinarily exhausts exhaled air at the mouthpiece; however, when incorporating our inflator I and life jacket L into this type of underwater breathing apparatus arrangement, an exhaust hose EH is connected to the mouthpiece at its exhaust side and communicates with the inlet tube IT of the inflator I, which also includes an outlet tube OT.

FIG. 2 shows our inflator I incorporated into a different underwater breathing apparatus wherein it is secured in the supply hose SH, one end of which is secured to a conventional air pressure regulator R, which may be of the known air demand type disclosed in the referred-to patent, that is operationally associated with the compressed air cylinder C in a known manner, and the other end of which communicates with mouthpiece M of the known type having a pair of check valves which permit air to flow in only one direction through the mouthpiece from air supply hose SH to exhaust hose EH, which is connected to the regulator R and exhausts thereat in a known way.

FIG. 3 shows our inflator I incorporated into a still different arrangement wherein it is secured in the exhaust hose EH of an underwater breathing apparatus ar-

rangement which is similar to the FIG. 2 arrangement in all other respects. The air exhaust hose EH connects the mouthpiece M and inflator inlet tube IT, and a small section ES of exhaust hose connects the outlet tube OT and regulator R.

The construction and operation of our inflator I will herein be described in great detail; the three arrangements illustrated in FIGS. 1, 2 and 3 should be clearly understood to be merely representative arrangements into which our inflator may be incorporated. It will be noted, however, that the manner of connecting the air hoses to the inflator depends upon the arrangement being employed. The important factor is that regardless of the type of arrangement into which our inflator is incorporated, the upstream section of air hose be connected to the inlet IT of the inflator, and the outlet tube OT of the inflator be connected to the downstream section of air hose. The presently preferred arrangement is the one illustrated in FIG. 3, and therefore, the detailed disclosure of our inflator I will proceed on the basis of its being incorporated in the FIG. 3 arrangement.

Our improved inflator is illustrated in FIGS. 6–13, and when incorporated in the FIG. 3 arrangement its inlet tube IT has the end of exhaust hose EH opposite the one connected to mouthpiece M firmly coupled to it in any suitable manner, as the illustrated friction fit in FIG. 7; however, if desired, suitable mechanical clamps may be employed. The outlet tube OT of the inflator has similarly firmly secured to it an end of short exhaust hose section ES, which has its other end suitably secured to the regulator R for exhausting thereat. The disposition of the inflator inlet and outlet tubes in FIGS. 6–13 is not identical to that in FIGS. 1–3; however, the latter are somewhat schematic, and the FIGS. 6–13 disposition will be described in detail, though the specific disposition of the tubes may vary. With the FIG. 3 arrangement, it will be understood by those skilled in the underwater breathing apparatus art, the diver will "bite" onto the mouthpiece M and breathe into it exclusively through his mouth with the result that on inhalation, fresh air flows from the cylinder C' through the pressure regulator R, which functions to reduce the pressure of the air to the point where it may safely be inhaled by a diver, automatically adjusted to the ambient pressure of the water dependent on the depth at which the diver is located; and on exhalation the spent breath of air exhausts out the exhaust hose EH.

With reference to FIGS. 4 and 5, the detailed construction of the mouthpiece M may be seen, wherein it will be observed that it includes a central, transverse tubular portion **10** made of a resilient material and including a perpendicular take-off tube portion **12** having an end **14** formed in a conventional manner to accommodate the mouth of the diver and including teeth grips **16** onto which the diver may bite to retain the mouthpiece in his mouth. The interior of tubular portion **10** comprises a chamber that communicates with a pair of perpendicular parallel passages **18**, **20** formed in the take-off tube portion **12**. At opposite ends of the tubular portion **10** there are disposed one-way air check valves **22**, **24**, respectively, which operate in response to vacuum and pressure in the same direction to permit a flow of air through the mouthpiece only in one direction, in FIG. 4 from left to right as indicated by the schematic arrows. In other words, check valves **22** and **24** operate to permit air to flow into the mouthpiece from the supply hose SH through the tubular portion **10**, passage **18**, into the mouth of the diver when he inhales, as a result of the vacuum created in the mouthpiece which causes valve **22** to open and valve **24** to close, and to permit air to be exhausted out of the diver's mouth, through passage **20**, tubular portion **10**, valve **24** and out exhaust hose EH on exhaling, as a result of the pressure created in the mouthpiece which closes valve **22** and opens valve **24**. The construction of mouthpiece M is conventional and known in the art; however, it is illustrated in FIGS. 4 and 5, the latter showing one valve (**22**) construction wherein perforated rigid disk **26**, which functions as a valve seat, and cooperating diaphragm valve member **28**, which is made of a resilient material and has a hub portion **30** for mounting the diaphragm **28** on the rigid member **26** which is received in a central hub in the latter.

With reference to the FIG. 3 arrangement, in the absence of the interposition of our inflator I and life jacket L, exhaled air would normally be exhausted through exhaust hose EH, which would have its end opposite the mouthpiece end attached to the regulator R for exhausting thereat, hence, exhaust hose section ES would be omitted. With our inflator I disposed in the exhaust line between the exhaust hose EH and exhaust section ES, the inflator I functions to automatically inflate the life jacket L on the occasion of termination of breathing on the part of the diver. The life jacket L may be of any conventional inflatable type that is normally contracted and which may be worn in the contracted position without rendering the wearer buoyant, but which on inflation renders the wearer buoyant. The lift jacket L has its interior connected to our inflator I by an inflator hose IH secured at one of its ends to the life jacket and at its other end to the inflator air outlet tube AO which forms a part of our inflator. From a purely operational point of view, at this point in the disclosure it should be understood that a diver equipped with the FIG. 3 arrangement will ordinarily operate under water in substantially the same manner as he would in the absence of our inflator I and lift jacket L; however, with these components added, in normal underwater operations, the only difference to the diver will be that he wears the life jacket L in its deflated condition, and his exhaled air passes through our inflator I on its way to the regulator R where it is exhausted, hence there is a slight resistance to exhaling. Our inflator I, however, automatically operates to inflate the life jacket L on the occurrence of termination of breathing of the diver, as will subsequently become apparent, and thereby greatly increases the safety of the diver.

With reference to FIGS. 6–13, a detailed understanding of the construction and operation of our inflator I will be understood. Our inflator I is a self-contained unit that comprises a main housing portion **32** which supports the previously referred-to inlet tube IT and outlet tube OT, and a secondary housing **34**. Main housing **32** (see FIG. 8) is formed by a pair of dish-shaped metal plates **36**, **37** which when assembled have opposed adjacent flanges **38** biased against an annular resilient gasket **40** to form a peripheral seal; the plates **36**, **37** are maintained in such assembled condition by a plurality of crimped C-shaped clips **42**. The main housing **32** is generally configured in the shape of a narrow section of a cylinder of substantial diameter, and interiorly defines a cylindrical chamber **44** of similar shape. Within the chamber **44** there is disposed a cylindrical bellows **46** made of a suitable resilient material, of lesser diameter than and coaxial with the chamber **44**, and which is open at both of its ends. One open end wall **48** is rigidly secured to the flat end wall **50** of plate **37** as by being cemented thereto. The other open end wall **52** of the bellows has a rigid disk-like plate **54** secured to it, as by cementing, which has its periphery bent over to form a curved flange **56** which receives and locates the outermost turn **58** of a conical coil spring **60**, the innermost turn **62** of which abuts the inner side of flat end wall **64** of housing plate **36** and is disposed about an axially inwardly extending pin **66** rigidly formed on the end wall **64**. Plate **54** has a circular central opening **68** in alignment with the pin **66** and large enough to allow it to pass therethrough. On the inner side of the plate **54** there is mounted a bent wire torsion spring **70** having one end **72** rigidly secured to the plate **54**, as by welding, and the other end **74** rigidly secured to a valve-like closure for opening **68** comprising a resilient sealing

plate 76 and a rigid back plate 78 which are planar and large enough to cover and seal the opening 68 in the plate 54 when normally biased by the spring 72 into closed position against plate 54. Also rigidly mounted on the inner side of the plate 54 is a U-shaped bracket 80 having a pair of parallel axially extending side legs 82, one of which is shown in FIG. 8, and transverse mounting flanges (not shown) which are rigidly secured to the inner side of the plate 54, and a transverse cross wall 84 connecting the free ends of the side walls 82 and being parallel to and spaced from the plate 54.

The main housing 32 has its internal chamber 44 subdivided into subchambers 86 and 88 by the bellows 46, the former (86) being disposed on the exterior of and around the bellows within the main housing 32, and the latter (88) being disposed within the bellows 46 between the plate 54 and flat end wall 50 of housing plate 37. With reference to FIG. 7, it will be observed that inlet tube IT is rigidly secured to housing plate 37, as by brazing, and includes a cut-away side-end portion forming an opening 90 which communicates with an opening 92 formed in the flat end wall 50 of the plate 37 at a point where it communicates with the subchamber 88 within the bellows 46. It will, therefore, be apparent that exhaled air ordinarily flows in the direction of the schematic arrows in FIG. 7 from the mouthpiece M through the exhaust hose EH, inlet tube IT, through aligned openings 90, 92 and into subchamber 88 within the bellows.

As can be seen in FIG. 7, the outlet tube OT is rigidly connected, as by brazing, to the flat end wall 64 of housing plate 36 and includes a cutaway side-end portion forming an opening 94 which communicates with an opening 96 formed in the end wall 64, thereby placing the outlet tube into communication with the subchamber 86 on the exterior of the bellows. In normal operation, exhaled air flows into the main housing 32, as illustrated by the schematic arrows in FIG. 7, and previously described, and it passes from the subchamber 88 to the subchamber 86, in a manner to be described, and exhausts from subchamber 88 out through the aligned openings 96, 94 through the outlet tube OT and into and through the exhaust hose section ES, as also shown by the schematic arrows in FIG. 7.

With reference to FIG. 8, the manner in which exhaled air normally passes from the subchamber 88 to the subchamber 86 will be described. In the inoperative condition of the inflator I, the strength of the spring 60 relative to that of the bellows 46 is sufficient to contract the bellows and move it and its end plate 54 to its dotted line position in FIG. 8. In this condition, it will be observed that the subchambers 88 and 86 do not communicate with each other, because the opening 68 in the bellows' end plate 54 at this time is closed and sealed by plates 76, 78. If the inflator is placed into use, on exhalation of a spent breath of air, it flows out the mouthpiece outlet valve 24, through exhaust hose EH into inlet tube IT of the inflator, through openings 90, 92 and into subchamber 88, which at this time is relatively small in volume because the bellows 46 is contracted. The exhaled breath of air, however, builds up pressure in subchamber 88 and forces the bellows 46 to expand and move axially to the left in FIG. 8 against resistance of spring 60 from its dotted line position toward and to its solid line position, at which time the pin 66 contacts the plates 76, 78 and forces them, against the bias of their spring 70, to uncover the opening 68 in the plate 54 and this places the subchambers 88 and 86 into communication through the opening 68 and permits the exhaled breath of air to pass from the subchamber 88 through the opening 68 to the subchamber 86, and to be exhausted out through the outlet tube OT and the exhaust hose section ES. On the escape of this breath of exhaled air out of subchamber 88, spring 60, which was forcibly compressed and stressed on the prior expansion of the bellows, strain-relieves itself and commences to expand axially and thereby contract the bellows and move it to the right in FIG. 8 toward its dotted line position. However, before it reaches its FIG. 8 dotted line position, the next succeeding breath of exhaled air enters the subchamber 88 through the route previously described, and expands the bellows against the resistance of spring 60 until the opening 68 is reopened by pin 66 causing plates 76, 78 to pivot away from plate 54, and that breath of air is permited to pass from subchamber 88 into and through the subchamber 86 to be exhausted out through outlet tube OT. As long as the diver breathes normally, each exhaled breath is intermittently and sequentially conveyed to the subchamber 88 on the interior of the bellows, expands the bellows until the opening 68 is uncovered and then escapes out into and through the subchamber 86. In normal operation, each succeeeding breath of exhaled air prevents the bellows from moving to its extreme right hand position in FIG. 8. If for any reason the diver stops breathing, the bellows will completely contract to its dotted line FIG. 8 condition and our inflator will automatically function to inflate his life jacket L, as will now become apparent.

If the diver terminates breathing, there will be no succeeding breath of exhaled air to enter the subchamber 88 and expand the bellows before it reaches its FIG. 8 dotted line condition, which represents a position for triggering a sequence of actions which result in inflation of the life jacket. Therefore, the bellows will continue to contract until it reaches its FIG. 8 dotted line position. In practice it takes approximately 30 seconds for the bellows to contract, a time delay in which a succeeding breath would be exhaled if a diver were breathing normally. This time delay is caused by a bleed orifice 91 which passes through the periphery of housing plate 37 and which connects the interior of inlet tube IT directly with the subchamber 86, and constitutes a bypass to allow the trapped air in the bellows to escape directly to subchamber 86 on contraction of the bellows. An adjustable screw 93 is mounted in bleed orifice tube 95 for selectively adjusting the size of bleed orifice 91 to vary the time delay. See FIG. 7.

When the bellows has contracted to its FIG. 8 dotted line position, the cross wall 84 of bracket 80 has contacted and pivoted depending leg 98 of L-shaped latch plate 100, which is pivotally mounted and sealed in opening 102 in end wall 50 of housing plate 37 in a manner to be described in greater detail, to trigger off the inflating sequence.

Latch member 100 has its other leg 104 disposed in the upper portion of secondary housing 34 and a part of it deformed into an angularly depending latching lug 106 that ordinarily functions to latch a compressed gas bottle 108 restraining mechanism in position to maintain the bottle in its FIG. 8 solid line position. In this condition, the bottle 108 of compressed air, which may be CO_2 or any equivalent suitable gas, is mounted in the mid-portion of the secondary housing 34 in a position and in a manner to be poised for subsequent thrusting toward a stationary piercing pin 110. Pin 110 is rigidly supported by an angle bracket 112 that is rigidly secured to secondary housing main section 114, which may conveniently be a casting and which is rigidly connected to the main housing 32 by screws 115 which pass through wall 50 and are anchored in section 114, and supports all of the rest of the inflator components. An O-ring seal 117 is disposed in a circular groove 119 in section 114, and contacts wall 50 to seal around opening 102. In this poised position, the bottle 108 is biased by a stressed strong coil spring 116 and constantly urged upwardly, relative to FIG. 8. Bottle 108 is ordinarily maintained in its loaded poised condition by a transverse retainer pin 118 that is rotatably secured to and between spaced side legs 120 of U-shaped bracket 122, and contacts the neck of the bottle and pre-

vents its upward movement. Bracket 122 includes a connecting cross leg 124 having a bent latching lug 126 formed at one side which normally is engaged by latching lug 106 of latch plate 100 (see FIG. 11). The free ends 128 of the bracket side legs 120 are pivotally secured to the ends of a C-shaped bracket 130 that, in turn, is rigidly secured in and to cylindrical metal housing section 129 of the secondary housing 34. Housing section 129 is rigidly secured at its upper end to the lower end of section 114, as by brazing. It will be noted in FIG. 8 that bottle 108 is disposed primarily in section 129. A bent wire spring 132 is disposed on one side of the bottle 108 (the left in FIG. 8) and includes bent leg end portions 134 that are secured to the bracket side legs 120 above their pivot points and normally function to bias bracket 122 to the right in FIG. 8 toward its dotted line position. Movement of the bracket 122 toward the right is ordinarily prevented by the latching of the bracket latch lug 126 by latching member lug 106 (see FIGS. 8 and 11). A depending flexible strip 136 is formed on or secured to the cross leg 124 of the bracket 122 and has its free end in engagement with the right hand portion of bottle 108 to assist in normally retaining the bottle in its solid line position in FIG. 8. When the latching mechanism is in the solid line FIG. 8 condition, the bottle 108 is poised for subsequent release and rapid movement toward the piercing pin 110 to rupture the neck of the bottle and release the compressed gas therein. To assist in retaining the latching mechanism in latched condition, and specifically to urge the latch plate 100 in a clockwise direction in FIG. 8, a leaf spring 138 is secured, as by rivets 140, to the inner side of end wall 50, and it has its free end stressed into biasing engagement with the lower leg 98 of latch plate 100 to urge it in a clockwise direction.

It will, therefore, be apparent that unlatching of the bottle 108 is effected by pivoting latch plate 100 counterclockwise, thereby moving it to its FIG. 8 dotted line position wherein its latching lug 106 has been moved upwardly and clears the latching lug 126 on bracket 122. On occurrence of unlatching lug 126, the bracket 122 is free to pivot and move to the right in FIG. 8, to its dotted line position, by biasing spring 132. This causes the retaining pin 118 to move to the right off of the neck of bottle 108 and it allows the stressed coil spring 116 to quickly unstress and thrust the bottle 108 upwardly toward the piercing pin 110, thereby rupturing the neck of the bottle and allowing the compressed gas to escape into the secondary housing 34 and downwardly through a pressure regulator and relief valve mechanism generally designated 142, to be described in detail subsequently, and out through the inflating air outlet tube AO to the life jacket L to inflate the latter.

Our inflator includes an interlock mechanism which disarms the inflator by preventing unlatching of the bracket latch lug 126 unless the diver is located at least approximately three feet below the surface of the water, where the ambient pressure is approximately 1.5 pounds per square inch. The necessity for this interlock mechanism is that when not in use, the bellows is contracted, and therefore, both initially and terminally, relative to use of our inflator, in the absence of an interlock the bellows would be contracted, before the diver submerged and on his emerging from the water, and this would unlatch the bracket latch lug 126 and allow the bottle restraining bracket 122 to pivot and release the gas bottle, thereby inflating the life jacket at times when it is not necessary. Therefore, our interlocking mechanism has been provided to disarm the unlatching mechanism at all times other than when the inflator is at least approximately three feet below the surface of the water.

With particular reference to FIG. 8 and FIG. 11, the interlock mechanism will be seen to comprise an opening 144 formed in leg 104 of the latching plate 100 and a cooperating interlock lug 146 that is carried at the free end of a leaf spring 148 which, in turn, is rigidly secured by screw 150 to the housing section 114. The normal unstressed condition of the leaf spring 148 is such as to cause the lower end of lug 146 to partially engage a rim portion 152 of the leg 104 about the opening 144 (see FIG. 11 and solid line showing in FIG. 8). This is the condition of the interlock mechanism at all times other than when the inflator is below three feet of water. As can be clearly seen in FIG. 11, counterclockwise pivoting of the latch member 100 is prevented by the interference of part of the interlocking lug 146 and the portion 152 of the leg 104. The interlocking lug 146 is moved along with its supporting leaf spring 148 clockwise out of interfering contact with the leg 104 to its FIG. 8 dotted line position on the occurrence of the downward movement of the interlock pin 154 in response to downward deflection of the resilient diaphragm 156, which centrally rigidly carries pin 154. This deflection results on the occurrence of approximately 1.5 pounds per square inch of pressure on the upper surface of diaphragm 156 which is produced by the water entering through the openings 158 in the cover 160 that is rigidly secured to the top of the housing section 114 by a plurality of mounting bolts 162.

It will, therefore, be apparent that the interlocking mechanism just described prevents unlatching of the bottle latching mechanism when the inflator is not in use; however, on descent of the diver below three feet, this interlocking mechanism automatically moves to its FIG. 8 dotted line position wherein it no longer obstructs upward unlatching movement of the leg 104 of the latching member 100. Therefore, the inflator is armed and in the event of the subsequent complete contraction of the bellows 36 and the counter-clockwise pivoting of latch plate 100 by the bracket 80, unlatching of the bottle restraining mechanism and the resultant rapid movement and rupturing of the bottle 108 to release the compressed gas therein can occur, all as mentioned above.

It is intended that this gas in bottle 108 when released be directed downwardly through the pressure regulator and relief valve mechanism 142 to the life jacket L. Therefore, it is imperative that the opening 102 be properly sealed where the latching plate 100 passes therethrough, As was pointed out above, the juncture of the flat wall 50 and housing section 114 around opening 102 is sealed by O-ring 117. It is also important that the latching plate 100 be mounted so as to be retained in its relative lateral position illustrated in FIG. 8, as it is constantly under the bias of the latching lug 126 of the bottle restraining bracket 122 to move toward the right in FIG. 8 and in the absence of a proper mounting it might ultimately move toward the right and inadvertently unlatch lug 126. Both the proper sealing of opening 102 and the proper mounting of the latch plate 100 are treated in our inflator by the manner in which the plate 100 is mounted.

With particular reference to FIG. 13, the structure for both sealing the opening 102 and mounting the latching plate 100 in this desired manner will be apparent. The opening 102 is rectangular and the upper leg 104 of latch plate 100 extends through it with clearance on all sides. A pair of spaced openings 164 extends through leg 104 and a U-shaped bent metallic wire member 166 has portions of its spaced legs 168 disposed in the openings 164. The latch plate 100 with the member 166 mounted in it is juxtaposed to the wall 50 with its leg 104 extending through the opening 102 in the wall and with the member 166 abutting one side of the wall (the left side in FIG. 11). The entire area surrounding the opening 102 on both sides thereof of wall 50 is sprayed with a rubber cement to form a solid mass 170 of rubber which effectively covers and seals opening 102 and member 166. The mounting of the latch plate 100 is such that any creeping movement to the right in FIG. 11 under the normal rightward bias of latching lug 126 is restrained by the U-shaped member 166 as it is in contact

with wall 50. However, because of the clearance between the legs 168 of member 166 and the openings 164, during latching and unlatching, the necessary pivoting of the latch plate 100 relative to wall 50 is permitted. It will, therefore, be apparent that the mounting of the latch plate 100 in the opening 102 is such as to effectively seal the opening and mount the latch plate so as to be free to pivot sufficiently to perform its latching function but to be laterally stationary.

The pressure regulating and relief valve mechanism 142 will now be described in detail. It is the function of this mechanism to insure that after the compressed gas escapes from the bottle 108, it will initially enter the life jacket and inflate it to a pressure of approximately four pounds per square inch above ambient pressure, and thereafter automatically function on a decrease in ambient pressure to release gas from the life jacket so as to prevent a relative build-up of pressure within the life jacket ever exceeding eight pounds per square inch over that of ambient.

A body section 172, which may be cast and has a vertical passageway 174, is rigidly secured at its upper end to the lower end of the body section 129, as by brazing. A cup-shaped body section 176 having a cylindrical vertical wall 178 and a flat, horizontal lower wall 180 centrally depending from which is the inflator air outlet tube AO, is secured at its upper end 178, as by a friction fit, to the cylindrical lower end 182 of the body section 172 and an O-ring 184 is appropriately disposed therebetween to effect a seal.

To render the body sections 172 and 176 separable, a peripheral groove is formed in body section lower end 182 and a pair of parallel spaced slots are formed in the upper end of body section 178, and the groove and slots are aligned to receive C-shaped retaining spring 177. Within and to the body section 176 there is rigidly secured, as by a friction fit, a body member 186 which supports a poppet valve stem and pressure regulator capsule assembly 188. A pair of O-rings 190 are suitably disposed between the body 186 and the inside of wall 178 to effect seals. The lower end of gas bottle biasing spring 116 is seated in an annular upwardly facing groove 192 in body member 186. To the lower end of the body 186 and rigidly seated on a reduced portion 194 thereof, as by a friction fit, is a cup-shaped member 196, an O-ring 198 being appropriately disposed between these parts to effect a seal.

Extending vertically centrally through the body 186 is an elongated passageway 200 of varying diameter, including an upper reduced diameter portion 202, an intermediate enlarged portion 204, an adjacent threaded portion 206 and a lower enlarged portion 208. The central upper portion 210 of the body 186 is formed into a valve seat. The subassembly 188 is mounted on the body 186 and includes a plurality of elements several of which extend through passageway 200. Subassembly 188 comprises a poppet valve 212 disposed above the valve seat 210 and having an integral valve stem 214 extending completely through the passageway 200. A coil spring 216 is disposed about the central portion of the valve stem, and has its lower end 218 turned in and anchored in an opening in the valve stem and its upper end 220 abutting a downwardly facing portion of the body 186 around the reduced passageway portion 202. The mounting of the valve stem and spring is such that the spring is stressed and compressed in mounting, and therefore, ordinarily biases the valve stem downwardly so as to have the poppet valve 212 contact the valve seat 210. The lower end 222 of the valve stem 214 is flat and bears against the inner side of the lowermost diaphragm 224 of a dual-diaphragm pressure regulating capsule 226. The capsule 226 also includes an upper diaphragm 228 which has a central opening and is rigidly secured, as by brazing, to a capsule mounting hub 230. Hub 230 includes an upwardly axially extending mounting portion 232, the upper exterior part of which is threaded and adjustably received in the threaded portion 206 of the passageway 200, and the lower external portion of which is plain and has an O-ring 234 disposed between it and the lower enlarged portion 208 of the passageway 200 to form a seal thereat. The mounting hub has a bore 244 which communicates with the interior of capsule 226 through the opening in diaphragm 228 and with the intermediate enlarged portion 204 of passageway 200. The pressure regulator capsule 226 and its mounting hub 230 may be secured to the body 186 from below after the valve stem 214 and spring 216 have been assembled to the body 186, the former from above and the latter from below. The pressure regulating capsule 226 comprises the two flexible diaphragms 224 and 228 which are made of flexible metal disks, secured about their peripheries and internally free of each other, whereby they may be flexed toward and away from each other in response to changes in the pressure differential between their interior and exterior. The exterior of the capsule 226 comprises the chamber 236 formed within cup-shaped member 196. Chamber 236 communicates with the exterior of the inflator, hence the ambient water, through a port 238. Therefore, the pressure within the chamber 236 senses and corresponds to ambient pressure, and this is utilized to regulate the relative pressure in the life jacket.

The lowermost end of the cup-shaped member 196 is formed by a flat wall 240 spaced above flat wall 180 and having a central opening 242 therein, being aligned with the passageway in inflator air outlet tube AO. The reduced portion 202 of the passageway 200 communicates with the interior of the capsule 226 through the intermediate portion 204 and bore 244 formed in the hub 230. Normally, i.e., before the gas bottle is ruptured, the capsule 226 is collapsed and the poppet valve 212 is spaced above the valve seat, as illustrated in FIG. 8. This condition is produced by the relative strength of capsule 226 and spring 216, which are designed to produce this condition. Reduced portion 202 of passage 200 communicates with inflator air outlet tube AO through a diagonal port 246 that extends completely through the body 186 and communicates with the annular space 248 between the upper end of cup-shaped member 196 and the inner side of wall 178 of body section 176, which, in turn, communicates with the rest of the space 250 between the lower end of the cup-shaped member and the lower end of the body section. Therefore, in the normal condition illustrated in FIG. 8, on the occurrence of rupturing of the bottle 108, gas is free to pass downwardly out of the body section 129 through passageway 174, past opened poppet valve 212—valve seat 210, through reduced portion 202 of passageway 200, through port 246, annular space 248, space 250 and into and through air outlet tube AO into the life jacket L. On the occurrence of the build-up of pressure in the life jacket in excess of four pounds per square inch over the ambient pressure, the interior of the capsule 226, which senses life jacket pressure through the bore 244 in its mounting hub 230, is subjected to the same amount of pressure in excess of ambient relative to the exterior of its capsule, which senses ambient, as was previously described, and therefore, it expands, as its spring rate is selected to allow expansion by such a differential of pressure. Expansion of the capsule 226 from its FIG. 8 condition to its FIG. 9 condition results in allowing the previously stressed spring 216 to unstress and move the valve stem 214 downwardly and thereby seat the poppet valve 212 on the valve seat 200 and shut off communication between the life jacket and the interior of the body section 129, wherein the expanded gas is disposed, hence prevent any more gas from entering the life jacket.

Therefore, the pressure regulating structure described thus far operates to initially automatically inflate the life jacket on rupturing of the gas bottle to a pressure of four pounds per square inch in excess of ambient pressure. It

will be understood by those skilled in the art that the pressure regulating capsule 226 will automatically cycle (expand and contract) in response to changes in the pressure differential across the capsule, that is, the differential between ambient pressure and life jacket pressure, to automatically open and close the poppet valve 212 to maintain the proper pressure in the life jacket. Therefore, if the ambient pressure increases sufficiently, the capsule collapses and the poppet valve opens to admit more air into the life jacket. It will be appreciated by those skilled in the art that the spring rate of the capsule 226 and of the spring 216 may be empirically determined to provide for the proper operation of the capsule, but that, in general, the spring rate of the capsule is greater than that of the spring 216. Therefore, absent external pressures, the capsule 226 is normally strong enough to overcome spring 216 and force the valve stem 214 upwardly to the normal open condition illustrated in FIG. 8.

Assuming that the life jacket has been inflated at a particular depth to a pressure of approximately four pounds per square inch in excess of ambient, the diver will commence to ascend, and his ascension will, of course, be accompanied by a reduction in ambient pressure for depth determines ambient pressure. In view of the fact that the capsule has already been expanded and the poppet valve closed as a result of the initial inflation of the life jacket to the requisite pressure, a further reduction in ambient pressure will have no direct effect on the opening or closing of the poppet valve. However, it is essential that means be provided for reducing the pressure in the life jacket as the diver ascends if the ultimate bursting of the life jacket is to be avoided. It has been determined in practice that the pressure in the life jacket should not be eight pounds per square inch in excess of that of ambient pressure. Therefore, as the diver ascends, it is essential that there be pressure relief means for automatically reducing the pressure in the life jacket. Such means has been incorporated in mechanism 142 and comprises a relief valving arrangement which in FIG. 8 can be seen to comprise an O-ring 252, which loosely sits on the upper side of the wall 240 of the cup-shaped member 196 around the opening 242, a disk-like plate 254 resting on the top of the O-ring and being biased downwardly by a coil spring 256 having its lower end seated about a raised protuberance 258 on the plate 254 and its upper end seated about a depending protuberance 260 which forms a part of rigid member 262 that is permanently secured to the under side of the lower diaphragm 224 of capsule 226. The strength of the spring 256 is such as to normally force the plate 254 downwardly to deform the O-ring 252 into a sealing condition around the opening 242. However, upon the occurrence of a differential of eight pounds per square inch or more across the plate 254, that is, the higher pressure in the space 250, which senses life jacket pressure, relative to the pressure in the chamber 236, which senses ambient pressure, the bias of the spring 256 will be overcome by this pressure differential, and air will escape from within the space 250 past the O-ring 252 and plate 254, through the chamber 236 and out the port 238, thereby reducing the pressure in the life jacket. It will be undertsood by those skilled in the art that the spring rate of spring 256 may be selected so it will allow for the unseating of plate 254 and escape of air when the desired pressure differential across the plate is reached, and that as the diver ascends and the ambient pressure continually reduces, the pressure relief valving mechanism just described will operate to relieve the pressure in the life jacket and assure that it never exceeds an excess of eight pounds per square inch over ambient pressure.

In view of the foregoing, a complete understanding of the construction and operation of our improved inflator should be had. It will be appreciated by those skilled in the art that various suitable materials may be selected for the various components in accordance with good engineering design practice; however, in general, that most of the metal parts should be made of corrosion-resistant material, such as stainless steel or chrome-plated brass, and the resilient parts made of natural or synthetic rubber materials or the like. It will also be appreciated that the bottle 108 of gas will be made of a suitable rupturable material such as a soft metal, and that it comprises an expendable, replaceable component which must be replaced each time the inflator is actually actuated to inflate the life jacket.

It will also be apparent that we have satisfied the objects of this invention by providing a life jacket inflator which is a self-contained unit, which may be incorporated in a large variety of self-contained underwater breathing apparatus arrangements and which when used operates automatically to inflate a life jacket in response to the termination of breathing by the diver to a pressure of approximately four pounds per square inch over that of the ambient pressure at the depth of the diver but never in excess of eight pounds per square inch relative thereto.

As will be evident from the foregoing description, certain aspects of our invention are not limited to the particular details of construction of the example illustrated, and we contemplate that various and other modifications and applications will occur to those skilled in the art. It is, therefore, our intention that the appended claims shall cover such modifications and applications as do not depart from the true spirit and scope of our invention.

Having thus set forth the nature of our invention, we claim:

1. An underwater breathing apparatus comprising: a breathing device through which a diver breathes; means for supplying air under regulated pressure to said breathing device; means for exhausting exhaled breaths of air from said breathing device; an inflatable life jacket for the diver; inflating means responsive to the termination of the diver's breathing for automatically inflating said life jacket; and interlocking means responsive to ambient water pressure to disarm said inflating means to prevent inflation of said life jacket whenever the ambient water pressure is less than that at a depth of approximately three feet, whereby said inflating means does not operate in response to the absence of breathing prior and subsequent to immersion of the diver, and is armed for operation only at depths below approximately three feet.

2. An underwater breathing apparatus comprising: a breathing device through which a diver breathes; means for supplying air under regulated pressure to said breathing device; means for exhausing exhaled breaths of air from said breathing device; an inflatable life jacket for the diver; a chamber; a rupturable bottle of compressed gas disposed in said chamber; passageway means connecting said chamber to the interior of said life jacket; a piercing member in said chamber; and means mounting said bottle spaced from said piercing member, said mounting means including mechanism for biasing said bottle and piercing member relatively toward each other and mechanism for normally restraining relative movement of said bottle and piercing member; and mechanism responsive to termination of the diver's breathing for actuating said restraining mechanism to allow said biasing mechanism to cause relative movement of said bottle and piercing member whereby said bottle is forced against said piercing member, rupturing the bottle and allowing the gas to escape out of said chamber, through said passageway means into said life jacket to inflate the latter.

3. An apparatus as defined in claim 2 wherein said restraining mechanism comprises latching means and a pivoted bracket that is biased toward a non-restraining position but latched in its restraining position by said latching means, said latching means being actuated by said breath termination responsive mechanism to unlatch said bracket.

4. An apparatus as defined in claim 2 wherein means is disposed in said passageway means which operates automatically in response to ambient pressure to regulate the pressure of the air in said life jacket at approximately four to eight pounds per square inch in excess of ambient pressure.

5. An underwater breathing apparatus comprising: a breathing device through which a diver breathes; means for supplying air under regulated pressure to said breathing device; means for exhausting exhaled breaths of air from said breathing device; an inflatable life jacket for the diver; a housing having a chamber; a bellows in said chamber and subdividing it into two subchambers, one within the bellows and the other between the bellows and housing; said housing connected to said means for supplying and exhausting air so as to permit charges of breathing air to intermittently flow into the subchamber within the bellows to expand it in response to normal breathing of the diver; valve means in the bellows operable on expansion of the bellows to a predetermined amount to open and permit the air in the bellows subchamber to pass to the other subchamber; said bellows being constructed to intermittently contract but at a rate that is timed to allow a succeeding charge of breathing air to enter the bellows subchamber and expand it; and mechanism responsive to the complete contraction of said bellows for inflating said life jacket.

6. An apparatus as defined in claim 5 wherein said mechanism includes a bottle of compressed gas; means mounting said bottle in a chamber that communicates with said life jacket; means for rupturing said bottle; means for actuating said rupturing means; and latch means for normally latching said actuating means in inoperative condition; and means on said bellows for unlatching said latching means on a complete contraction of said bellows.

7. An apparatus as defined in claim 6 wherein passageway means connects the chamber in which said bottle is mounted and said life jacket; and inflator air pressure regulating means is disposed in said passageway means to regulate the inflator air pressure in said life jacket.

8. An apparatus as defined in claim 5 wherein restricted air flow bypass means are provided which directly connect the two subchambers, whereby on termination of breathing, the air trapped in the bellows retards the contraction of said bellows and escapes through said bypass means, thereby timing the complete contracting of said bellows.

9. For use with a diver's self-contained underwater breathing apparatus including breathing air flow hose means and an inflatable life jacket for the diver to wear, an inflator device for automatically responding to the termination of breathing of the diver to inflate the life jacket comprising: a housing defining a first and a second chamber, said first chamber being connected in said air flow hose means and said second chamber communicating with said life jacket; a bellows mounted within said first chamber and dividing it into two subchambers, said bellows being arranged to be intermittently expandable and contractible in response to normal breathing of the diver, but responsive to termination of the diver's breathing to further contract into an actuating configuration; a bottle of compressed gas in said second chamber; a wall common to said first and second chambers; a latch member operatively mounted and sealed in said wall for actuation by said bellows upon such further contraction thereof; and means for rupturing said bottle normally latched in inoperative condition by said latch member but rendered operable on actuation of said latch member whereby said bottle is ruptured and the gas therein is freed and inflates said life jacket.

References Cited in the file of this patent

UNITED STATES PATENTS

2,818,858	Holm	Jan. 7, 1958
2,821,725	Harper	Feb. 4, 1958
2,828,741	Delest	Apr. 1, 1958