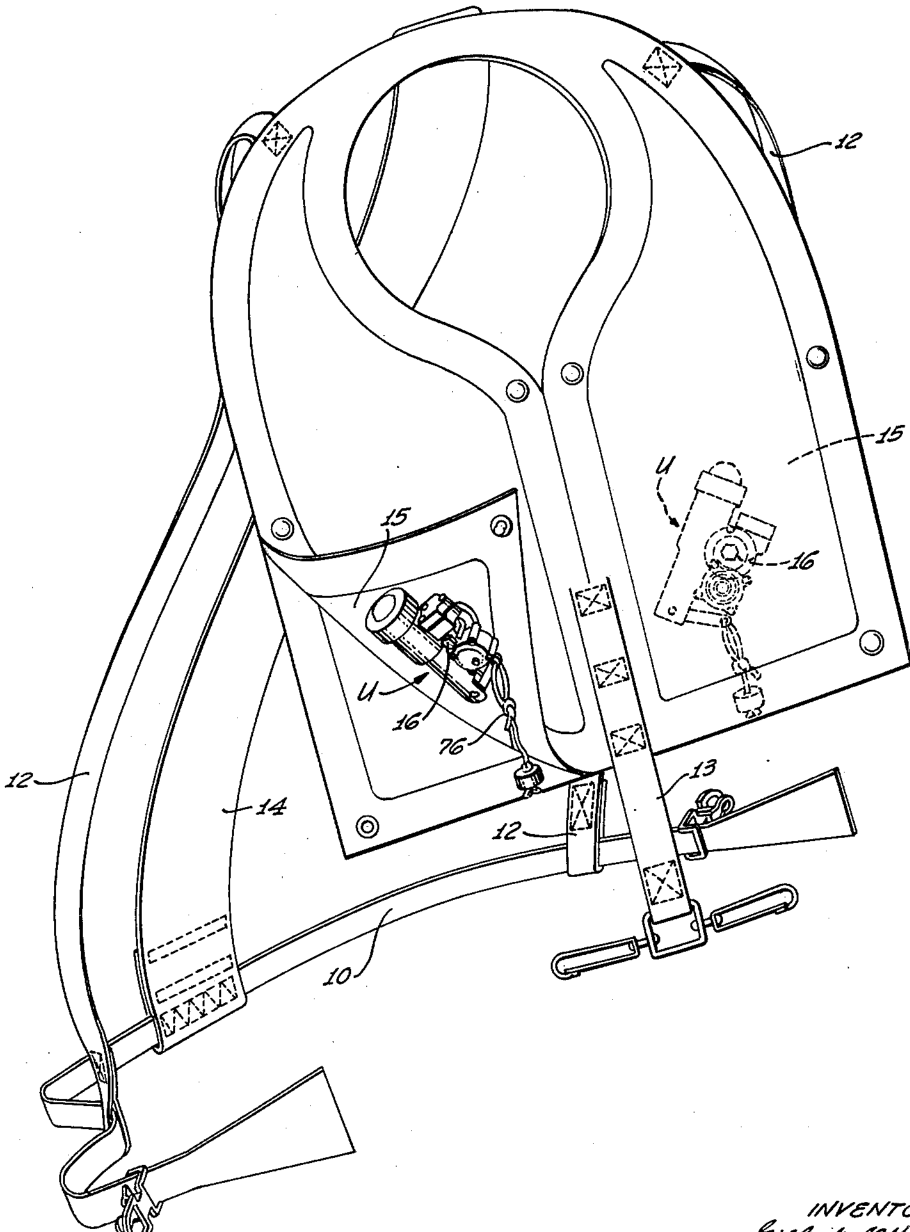
Feb. 12, 1963 G. A. HENRY 3,077,288

AUTOMATIC INFLATION UNIT FOR FLOTATION DEVICES

Filed March 23, 1959

3 Sheets-Sheet 1

Fig. 1



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3 Sheets-Sheet 2

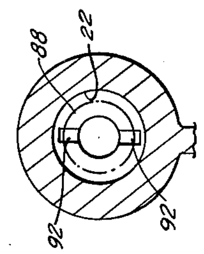

Fig. 5

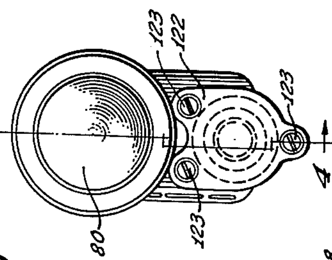

Fig. 3

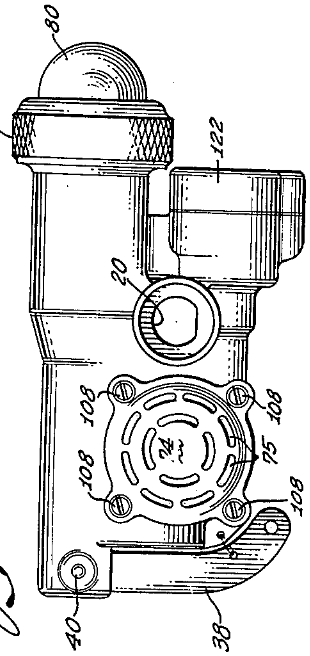

Fig. 2

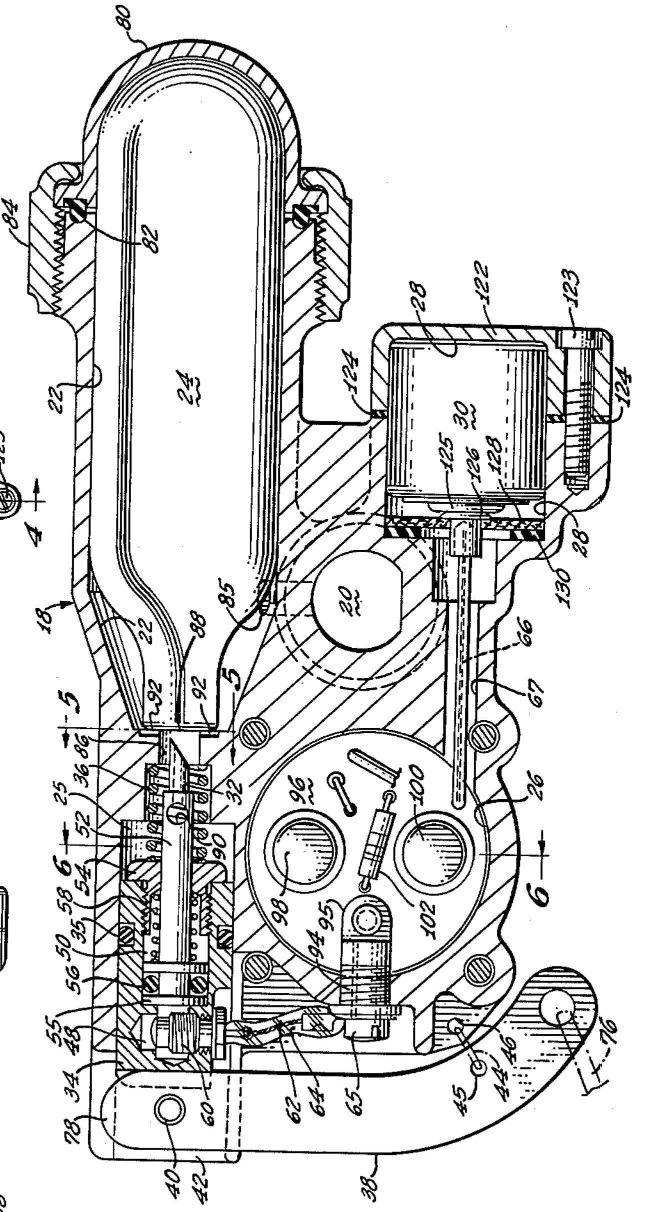

Fig. 4

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Fig. 6

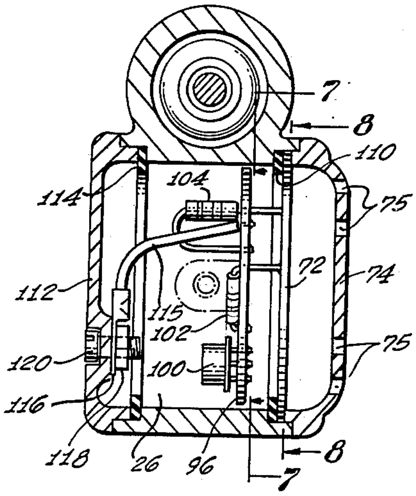


Fig. 7

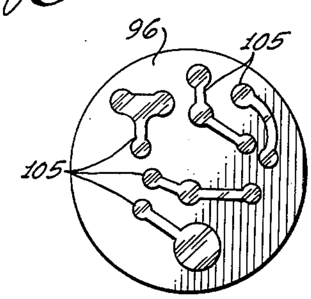


Fig. 8

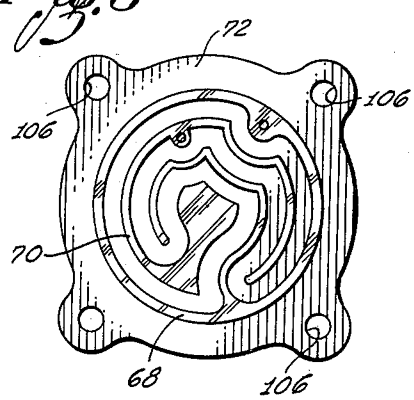
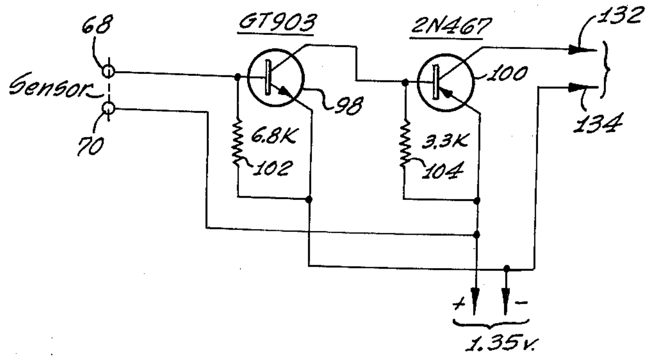


Fig. 9



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3,077,288
AUTOMATIC INFLATION UNIT FOR FLOTATION DEVICES

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8 Claims. (Cl. 222—5)

This invention relates to an automatic actuator that is responsive to the presence of a predetermined quantity of moisture. Such an actuator may be used in various ways in various installations wherein it is desirable for some operation to be carried out automatically in the event of water encroachment. In marine usage, for example, it may be used to energize controls to close bulkheads in response to leakage of water into the hold of a ship. As another example, it may be used to arm a military device automatically when the device is dropped into water. The invention may also be used on a float to turn on a radio when the float is launched, or may be used on a life raft to release fluid to repel sharks when a life raft is launched. As a further example, the device may be used for automatic inflation of an inflatable life raft when the deflated life raft is dropped into the water.

The initial embodiment of the invention is an automatic inflation unit for life jackets. This particular embodiment has been selected for the present disclosure and will provide adequate guidance for those skilled in the art who may have occasion to apply the same principles to other specific purposes.

The conventional inflatable life jackets presently widely used on commercial aircraft are adapted for manual inflation instead of automatic inflation and, therefore, impose on the users the necessity of timing the inflation operation. If a user jumps into the water or is involuntarily thrown into the water and inflates the life jacket in advance, the life jacket gets in the way and may subject the wearer to serious shock forces. On the other hand, undue delay in inflating the life jacket after the user is submerged may be serious. In too many instances, the wearer of a life jacket panics and fails to inflate the life jacket while submerged. In other instances, the wearers when submerged are incapacitated by injuries or are unconscious or are otherwise prevented from inflating their life jackets, with fatal results, whereas automatically inflatable life jackets would inflate promptly and turn the wearers face up in the water to save their lives.

The problem, then, is to provide an adequately compact inflation unit which operates automatically in response to submersion in water. One solution heretofore advanced is to use an effervescent tablet that disintegrates in the presence of water with liberal generation of gaseous fluid. The generated gaseous fluid is confined to build up sufficient fluid pressure to drive a puncturing element into a cartridge containing highly compressed CO_2, the fluid released from the cartridge being employed to inflate the life jacket. A fresh effervescent tablet will carry out the puncturing operation in two seconds or less. Unfortunately, however, after a time lapse of as short as two weeks, such a tablet will require twelve seconds or more to release the pressurized gas and such a time delay is much too long.

The present invention meets this problem with complete satisfaction by using electric circuitry to sense the presence of water and to cause the life jacket to be inflated in response to submersion in water. It is a simple matter to design an electric control system of this general character for automatic actuation in response to the presence of water but it is difficult to provide such a control system in sufficiently compact form to serve the present purpose and especially so because of the magnitude

of the mechanical force that is required to puncture a cartridge containing compressed CO_2. In this regard, an important feature of the invention is the concept of employing circuitry with minimum components and of using an explosive charge to generate the puncturing force. This concept makes possible an exceedingly compact control system as required for practical use on life jackets.

In the preferred practice of the invention, the components comprise essentially miniature battery means, a pair of resistors and a pair of transistors. The circuitry includes a sensing circuit that is powered by the battery and has a gap which normally prevents any significant flow of current. When the device is immersed, the water forms a conductive path across this gap for effective energization of the sensing circuit. A second actuating circuit also powered by the same battery is triggered by the sensing circuit to apply the full voltage of the battery to means for igniting the explosive charge for puncturing the compressed gas cartridge.

Such circuitry may be made as sensitive as desired, for example by varying the values of the resistors. It is a simple matter to so adjust the sensitivity that the device will operate quickly when immersed but will not respond to water vapor alone and will not respond to only one or two drops of water.

In the presently preferred practice of the invention, a miniature mercury battery is employed for the current source. One advantage of such a battery is that it maintains full voltage throughout its service life. Another advantage is that such a battery has a relatively long service life on the order of 200 days. It is completely safe to renew such a battery as infrequently as every three months.

A further problem met by the invention is to provide for manual operation of the inflation unit in an emergency when, for some reason, the automatic provision fails. For this purpose, the cartridge puncturing element, together with the explosive charge and the means for utilizing the force of the explosion to drive the puncturing element, are carried by a common movable structure. The cartridge may be punctured independently of the explosive charge simply by manually shifting this movable support structure to advance the puncturing element into the cartridge.

The various features and advantages of the invention may be understood from the following description considered with the accompanying drawings.

In the drawings, which are to be regarded as merely illustrative:

FIG. 1 is a perspective view of a typical inflatable life jacket embodying a pair of inflation units of the present invention;

FIG. 2 is a side elevation of one of the inflation units of FIG. 1;

FIG. 3 is an end elevation of the same device;

FIG. 4 is a longitudinal section taken as indicated by the angular line 4—4 of FIG. 3;

FIG. 5 is a fragmentary transverse section taken as indicated by the line 5—5 of FIG. 4 and showing channels for flow of the released gaseous fluid past the nose of the cartridge;

FIG. 6 is a transverse section taken as indicated by the line 6—6 of FIG. 1 showing how the circuitry and the associated sensing means are incorporated in the device;

FIG. 7 is an elevation of the rear face of a disk for supporting components of the circuitry, the disk being seen along the line 7—7 of FIG. 6;

FIG. 8 is an elevational view of the sensing element as seen along the line 8—8 of FIG. 6; and

FIG. 9 is a diagram of the circuitry employed in the preferred practice of the invention.

GENERAL ARRANGEMENT

FIG. 1 shows a conventional life jacket having a harness that includes a belt 10, narrow side straps 12, a front strap 13 and a wide back strap 14. The lift jacket has two inflatable bags or envelopes 15 on its opposite sides and two corresponding inflation units of the present invention, each designated by the letter U. Each of the two inflation units U is equipped with a fitting or passage member 16 for delivering the released gaseous fluid to the corresponding bag 15 for inflation thereof.

FIG. 4 shows the principal parts of the presently preferred embodiment of an inflation unit U. These principal parts include: a support structure or housing, generally designated 18, in the form of a casting having a passage 20 therethrough to receive the previously mentioned fitting or passage member 16; a gas chamber 22 formed by the housing to enclose a conventional capsule 24 containing a compressed gaseous fluid such as CO_2; an actuation chamber 25 formed by the housing for the capsule-puncturing mechanism; a circuitry chamber 26 formed by the housing to contain circuit components; and a compartment 28 formed by the housing for a battery 30.

The actuation chamber 25 is of cylindrical configuration and has an open outer end. Slidably mounted in the actuation chamber is a cylindrical body 34 that is equipped with an O-ring 35 to seal the chamber. This cylindrical body is normally held by a suitable spring 36 in a retracted position against an emergency lever 38. The emergency lever 38 is mounted by suitable pivot means 40 in a slot 42 of the housing casting and is normally held at its retracted position by a frangible lock cord element 44 that extends through an aperture 45 in the lever and through a second aperture 46 in the housing casting 18.

The cylindrical body 34 is hollow to form a combustion chamber 48 and a power cylinder 50 in communication therewith. The puncturing element 32 has a shank 52 that slidingly extends through a guide bushing 54 at the outer end of the power cylinder and this shank is unitary with a piston 55 inside the power cylinder. The piston 55 is shown equipped with an O-ring 56. A suitable coil spring 58 acting in compression between the guide bushing 54 and the piston 55 holds the puncturing element 32 in a retracted position relative to the cylindrical body 34.

Mounted in the combustion chamber 48 in a conveniently replaceable manner is an explosive squib 60 of a well-known type which includes a resistor filament and an explosive charge for ignition by the filament. One side of the ignition circuit for the squib 60 is grounded by contact of the squib with the surrounding cylindrical body 34. The other side of the circuit includes a conductor 62 in an insulating plastic sheath 64, the conductor extending from the squib 60 to an insulated terminal screw 65 that extends into the circuitry chamber 26. An insulated wire 66 extends from the battery compartment 28 through a bore 67 into the circuitry chamber 26 for energization of the sensing circuit and for energization of the ignition circuit for detonating the explosive squib 60.

In this particular embodiment of the invention, the sensing means comprises a pair of conductors 68 and 70 (FIG. 8) mounted on the face of a disk 72 of non-conducting material that forms an outer wall of the circuitry chamber 26. As can be seen in FIG. 8, the two conductors 68 and 70 form a labyrinth pattern in spaced relation to each other so that the individual conductors are relatively long but are confined to a relatively small area. The disk 72 is covered by a protective shield 74 which has numerous openings or perforations 75 for the admission of water.

Operation

The manner in which the inflation unit serves its purpose may be understood from this general description. High humidity across the face of the sensing disk 72 will not cause sufficient flow of current between the conductors 68 and 70 to trigger the firing circuit and neither will one or two drops of water on the sensing disk 72. In the event the life jacket is exposed to rain, the protection of the inflation device by the overlying flap of the life jacket will prevent undue encroachment of water into the region of the sensing disk.

Immediately upon the wearer of the life jacket being submerged in water, the wetting of the sensing disk 72 results in sufficient conductivity between the two conductors 68 and 70 to cause the sensing circuit to trigger the actuating circuit for detonation of the explosive squib 60. The consequent generation of combustion gases under high pressure in the combustion chamber 48 forces the piston 55 along the power cylinder 50 to advance the puncturing element 32 into the nose of the capsule 24. The pressurized gas released from the capsule 24 is fed into the previously mentioned fitting or passage member 16 for inflation of the corresponding bag 15. If, for any reason, the desired automatic puncturing of the capsule 24 does not occur, the wearer may pull on a lanyard 76 that is connected to the outer end of the emergency lever 38 to rupture the element 44 and to swing the emergency lever downward. This swinging movement of the emergency lever 38 causes the shorter arm 78 of the lever to kick the cylindrical body 34 inward in opposition to the spring 36 thereby causing the puncturing element 32 to penetrate the capsule 24.

Structural Details

The chamber 22 for housing the capsule 24 is closed by a rounded cap 80 which is pressed against a sealing gasket 82 by a suitable threaded retaining ring 84. The retaining ring 84 may be conveniently removed whenever required for inspection or replacement of the capsule 24. A bore 85 forms a fluid passage from the chamber 22 to the passage 20 for communication with the previously mentioned fitting 16, which fitting delivers the released gas to the corresponding bag or envelope 15. The chamber 22 is in communication with the actuation chamber 25 through a bore 86 which forms an annular shoulder 88 for abutment by the nose of the capsule 24.

The puncturing element 32 is of tubular construction and is provided with a radial port 90 in its shank 52 to release the pressurized gaseous fluid into the inner end of the actuation chamber 25. There must be freedom for flow of the released gaseous fluid from the actuation chamber 25 back into the gas chamber 22. For this purpose, the annular shoulder 88 is provided with a diametrical pair of recesses 92 as indicated in FIGS. 4 and 5 to permit the released gaseous fluid to pass around the nose of the capsule 24.

The previously mentioned terminal screw 65 that is included in the firing circuit is insulated by a surrounding bushing 94 of non-conducting material such as nylon and is threaded into an angular bracket 95 that is rigidly connected to a non-conducting disk 96 to support the disk at an intermediate position in the circuitry chamber as shown in FIGS. 4 and 6. The non-conducting disk 96 carries a pair of transistors 98 and 100 and a pair of resistors 102 and 104 which are components of the control circuitry. These various components are interconnected by conductors 105 on the opposite face of the disk 96, as indicated in FIG. 7.

The previously mentioned sensing disk 72 which is shown in FIG. 8 and which carries the two spaced conductors 68 and 70 has four apertures 106 to receive four corresponding screws 108 which are shown in FIG. 2 and which serve to secure both the sensing disk and the associated protective shield 74. The sensing disk 72 closes one side of the circuitry chamber 26 as indicated in FIG. 6 and presses against a suitable sealing gasket 110 to make a fluid-tight joint. In like manner, the other side of the circuitry chamber 26 is closed by a metal cover 112 which is secured by a second set of screws (not shown) and which presses against a sealing gasket 114 to make a fluid-tight joint. As may be seen in FIG. 6, the circuit components on the non-conducting disk 96 are connected to the conductors on the sensing disk 72 by a pair of wires and are connected to the metal cover 112 by a ground wire 115. The ground wire 115 is equipped with a terminal fitting 116 which is engaged by a nut 118 on a suitable screw 120 that extends through the metal cover 112.

The battery compartment 28 is closed by a cup-shaped cover 122 that is releasably secured by a set of suitable screws 123, a suitable sealing gasket 124 being provided to make the cover fluid-tight. The cup-shaped cover 122 holds the battery 30 in position with the end terminal 125 of the battery touching a contact member 126 in a non-conducting disk 128. The pressure of the battery against the contact member 126 forces the non-conducting disk 128 against a suitable sealing gasket 130. The battery is grounded by the surrounding walls of the battery compartment 28 to complete the circuit.

The Control Circuitry

The control circuitry of the presently preferred embodiment of the invention is shown diagrammatically in FIG. 9. The circuitry includes the previously mentioned transistor 98 of the NPN type which may be of the kind presently designated GT903. The conductor 68 on the sensing disk 72 is connected to the base of the transistor 98 and the other conductor 70 on the sensing disk is connected to the negative terminal of the previously mentioned mercury battery. This mercury battery is rated at 1.35 volts for one ampere hour. A current of only 50 milliamperes is necessary to detonate the explosive squib.

The previously mentioned resistor 102 which is rated at 6.8 kilohms is connected between the base of the transistor 98 and the emitter, the emitter being connected to the negative terminal of the battery. The collector of the transistor 98 is connected to the base of the second transistor 100 which is a PNP type presently designated 2N467. The base of the second transistor 100 is connected to the previously mentioned resistor 104 which has a rating of 3.3 kilohms and this resistor, together with the emitter of the transistor 100 are connected to the positive terminal of the battery.

When the sensing disk 72 is in its dry state, the relatively high resistance across the gap between the sensing conductors 68 and 70 causes the transistor 98 to be non-conductive. When the transistor 98 is non-conductive, it transmits a relatively high voltage to the base of the transistor 100 so that this second transistor is also non-conductive.

When the sensing disk 72 becomes wet, however, and thus exhibits a relatively low resistance, the transistor 98 becomes conductive. The resulting current flow through the transistor 98 causes the potential at the base of the second transistor 100 to drop below the voltage of the emitter of the second transistor. The resulting conduction through the transistor 100 causes current to flow through the ignition element of the explosive squib 60, which ignition element is connected across the two contacts 132 and 134 of the wiring diagram. The resistance across these two contacts afforded by the ignition element and the associated conductors is approximately 1 ohm but may be as high as 5 to 10 ohms.

It is apparent that the sensing means comprising the two spaced conductors 68 and 70 is in series with the first transistor 98 and with the battery to form a triggering circuit. It is further apparent that the battery is also in series with the second transistor 100 and the squib to form a firing circuit. When the triggering circuit is opened the second transistor 100 keeps the firing circuit inoperative. Closing the triggering circuit makes the second transistor operative to pass current to fire the squib. It is important to note that the sensing means is not in the firing circuit and therefore does not provide resistance to current flow from the battery to the squib.

The circuit arrangement avoids a troublesome dilemma. If the sensing means is too sensitive a relatively small amount of moisture may cause the squib to explode prematurely when the device is not actually immersed in water. On the other hand, if the sensing means is not sensitive it must inherently have high resistance when immersed in water and if it has high resistance it necessarily reduces the flow of current from the battery to the squib. With the triggering circuit separate from the firing circuit the battery does not have to overcome the resistance of the sensing means in firing the squib and therefore the battery may be a relatively small battery. The described transistor arrangement includes no working parts and is exceedingly compact.

My description in specific detail of the selected embodiment of the invention will suggest various changes, substitutions and other departures from my disclosure within the spirit and scope of the appended claims.

I claim:

1. Means to supply compressed gaseous fluid in response to the presence of a conductive liquid, comprising: a thin-walled cartridge confining a gaseous fluid under pressure; a housing forming a chamber for said cartridge and a first cylinder in communication with said chamber, said housing providing a battery compartment and a fluid tight circuitry compartment; a second cylinder slidably mounted in said first cylinder for movement from a retracted position towards said cartridge; a piston mounted in said second cylinder for movement from a retracted position towards said cartridge; a puncturing element in the path of movement of said piston to rupture said cartridge either in response to advance of the piston while the second cylinder is in its retracted position or by advance of the second cylinder while the piston is in its retracted position; an explosive charge carried by said second cylinder to generate gases therein for advancing said piston; a battery in said battery compartment; a transistor firing circuit to ignite said explosive charge by current from said battery and a triggering circuit, said two circuits including components in said circuitry compartment and said firing circuit being responsive to said triggering circuit and said triggering circuit including two conductors exposed for shorting by the conductive fluid to close the circuit, said circuitry compartment having a non-conductive wall with said components mounted on the inner face of the wall and said conductors mounted on the outer face of the wall; and a guard covering said outer face of the wall to prevent inadvertent shorting of the two conductors.

2. In combination for inflating a normally deflated envelope to obtain a flotation of the envelope on water, including,

a pair of conductors disposed in a substantially uniformly spaced relationship to each other along an extended length to provide a resistance value in accordance with the amount of moisture between the conductors and in accordance with the length at which the moisture is disposed along the conductors,

a source of voltage,

a current control member having at least first and second terminals and constructed to be non-conductive and to become conductive upon the production of a particular voltage across the first and second terminals,

the source of voltage being connected in an electrical circuit with the pair of conductors and the first and second terminals of the current control member to obtain the production of a voltage across the first and second terminals of the current control member in accordance with the resistance across the first and second conductors and to obtain the production of the particular voltage across the first and second terminals of the current control member upon the production of a particular resistance across the first and second conductors, and

means holding a fluid under pressure, and

means operatively coupled to the fluid-holding means and to the current-control member for obtaining a release of the fluid from the fluid-holding means into the envelope upon the production of a state of conductivity in the current control member.

3. The combination set forth in claim 2 in which the pair of conductors are annular and are disposed in a concentric relationship and in which the current control member is a semi-conductor.

4. In combination for inflating a normally deflated envelope to obtain a flotation of the envelope on water, including,

a pair of conductors having an extended length and substantially uniformly displaced from each other along the extended length to provide a resistance having a value dependent upon the amount of moisture between the conductors and upon the length of disposition of the moisture along the conductors,

a current control member having at least first and second electrodes, the current control member being normally non-conductive and being constructed to become conductive upon the introduction of a particular voltage between the first and second electrodes,

a source of voltage connected in an electrical circuit with the pair of conductors and the first and second electrodes in the current control member to obtain the introduction of the particular voltage across the first and second electrodes of the current control member upon the production of a particular resistance across the pair of conductors,

detonating means operatively coupled to the current control member to become detonated upon the production of a state of conductivity in the member,

means for holding a fluid under pressure, and

means operatively coupled to the detonating means for operating upon the fluid-holding means upon the detonation of the detonating means to obtain the introduction of the fluid from the fluid-holding means to the envelope.

5. The combination set forth in claim 4 in which the source of voltage, the first and second conductors and the first and second electrodes of the current control member are in a series circuit.

6. The combination set forth in claim 5 in which a resistance is connected across the first and second electrodes of the current control member to provide a control over the voltage produced across the first and second electrodes in accordance with the resistance across the first and second conductors.

7. In combination for inflating a normally deflated envelope to obtain a flotation of the envelope on water, including,

a pair of annular conductors disposed in a substantially concentric relationship to each other to provide a resistance having a value dependent upon the amount of moisture between the conductors and upon the length of disposition of the moisture along the conductors,

a current control member having first, second and third electrodes and constructed to provide a flow of current between the first and third electrodes upon the production of a particular voltage between the first and second electrodes,

a source of voltage connected in a circuit with the first and second electrodes of the current control member and with the pair of annular conductors to obtain the production of the particular voltage across the first and second electrodes of the current control member upon the production of a particular resistance across the pair of annular conductors,

detonating means connected in electrical circuitry between the first and third electrodes of the current control member to become detonated upon the flow of current between the first and third electrodes of the current control member,

means for holding fluid under pressure, and

means operatively coupled to the detonating means and to the fluid-holding means for obtaining a passage of the fluid into the envelope upon the detonation of the detonation means.

8. The combination set forth in claim 7 in which the current control member is a semi-conductor and in which a resistance is connected between the first and second electrodes of the current control member to control the value of the particular resistance for obtaining a conductivity of the current control member and in which the source of voltage and the pair of annular conductors and the first and second electrodes of the current control member are in series.

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