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Blenkarn

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[54] **UNDERWATER BUOY FOR A RISER PIPE**

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[73] Assignee: **Amoco Production Company**, Tulsa, Okla.

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[52] **U.S. Cl.** .... **9/8 R,** 114/0.5 D, 166/0.5, 175/7

[51] **Int. Cl.** **E21b 17/00**

[58] **Field of Search** .... 114/0.5 D; 9/8 R; 175/5, 175/6, 7; 166/.5

[56] **References Cited**

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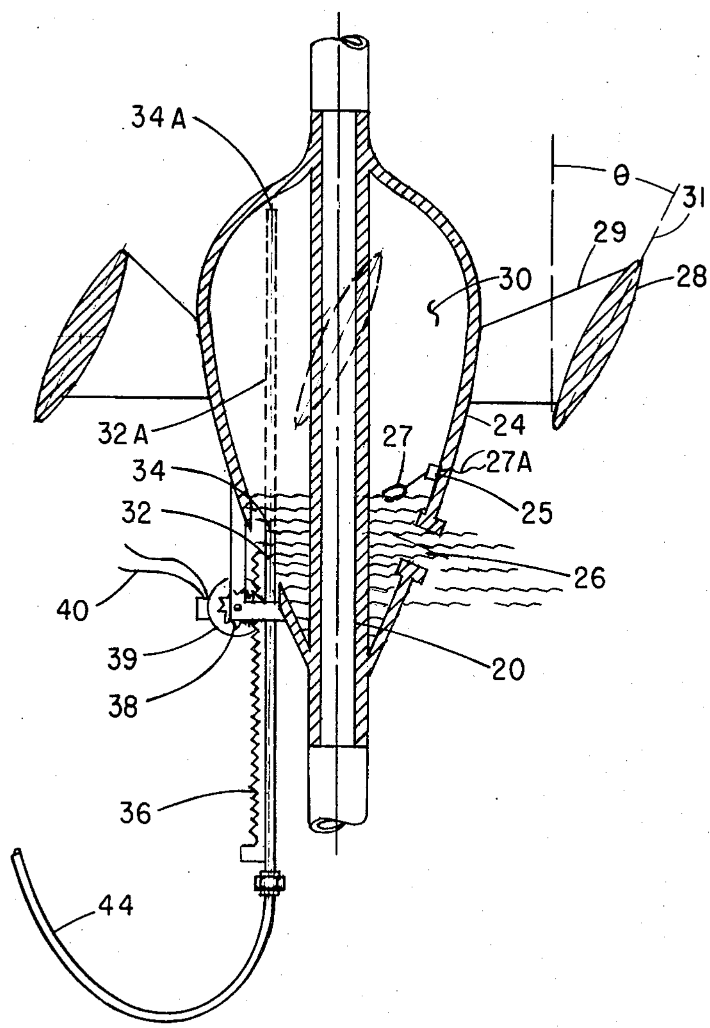
[57] **ABSTRACT**

This describes an underwater buoy for a riser pipe which extends from a deep water subsea well to a vessel supported by a body of water. A hollow shell is attached to the riser to give an upper buoyant force. The water depth may be as deep as 10,000 feet and the buoy may be 600 feet or more beneath the surface of the body of water. Non-vertically directed hydrofoils are attached to the outer wall of the shell. The chord of each hydrofoil makes an angle of attack with the vertical such that should the riser pipe break beneath the buoy, the buoy would be propelled or rise at an angle and surface away from the vessel instead of rising vertically and having a collision with the vessel.

12 Claims, 5 Drawing Figures



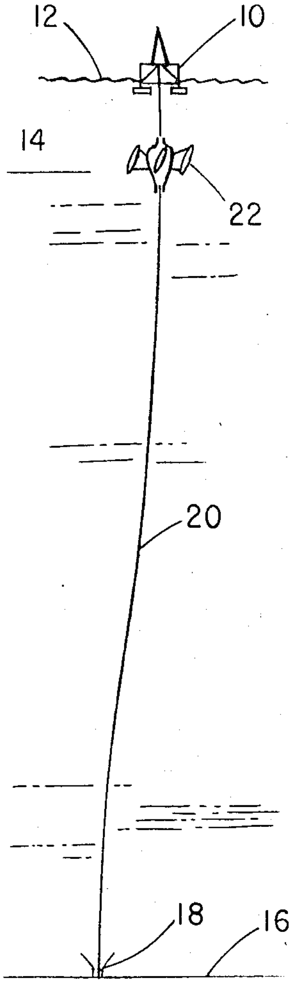


FIG. 1

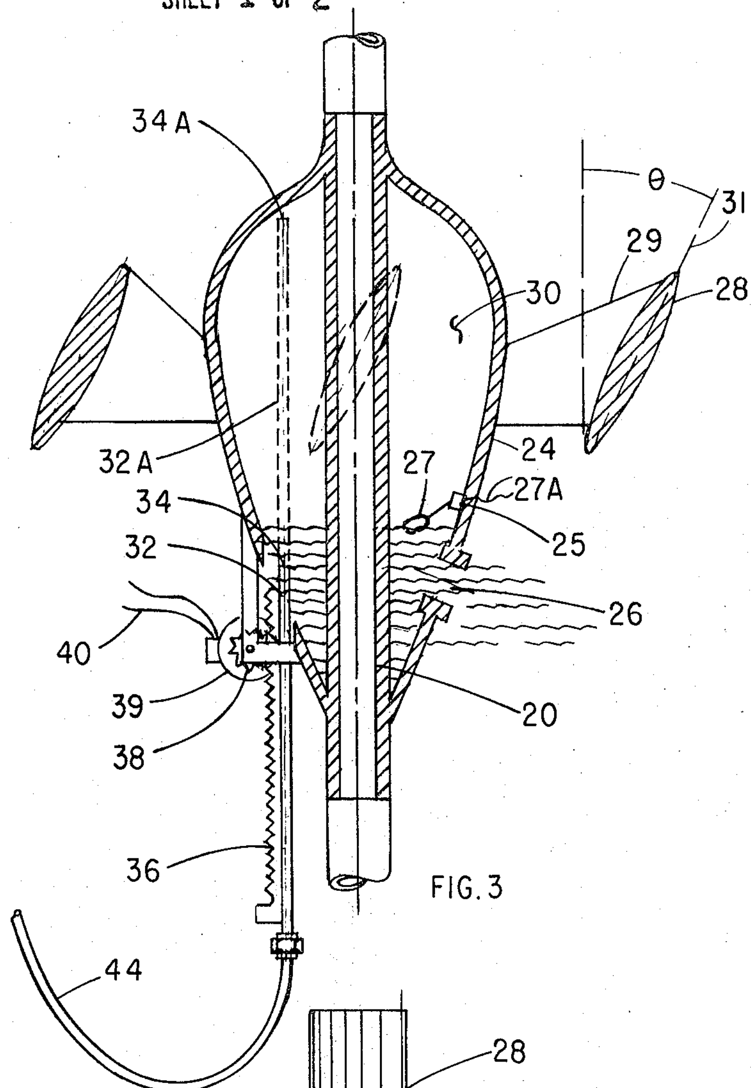


FIG. 3

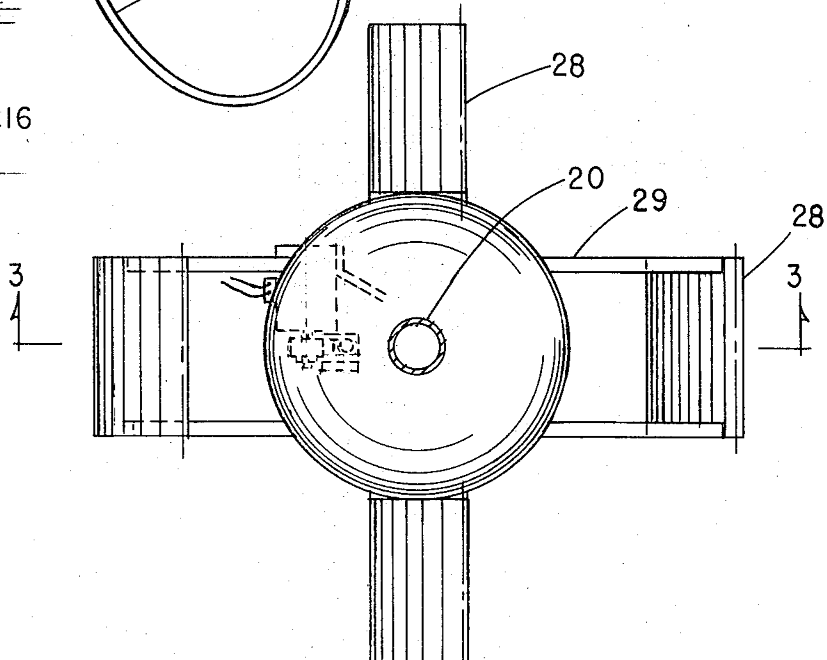


FIG. 2

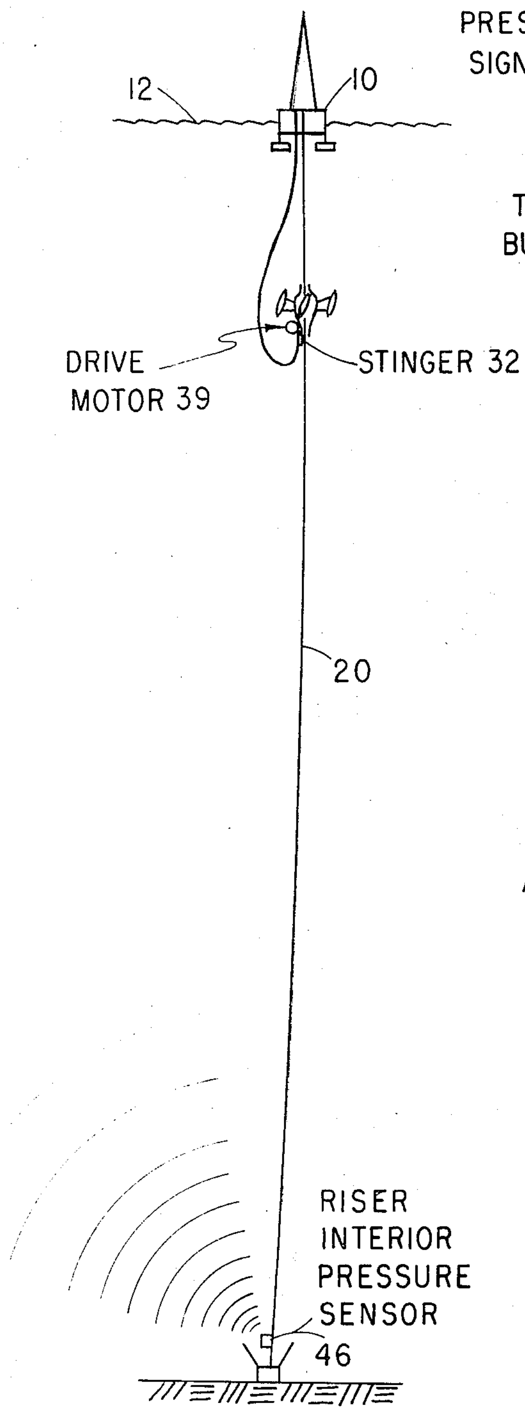

12
10
DRIVE MOTOR 39
STINGER 32
20
RISER INTERIOR PRESSURE SENSOR
46

FIG. 4

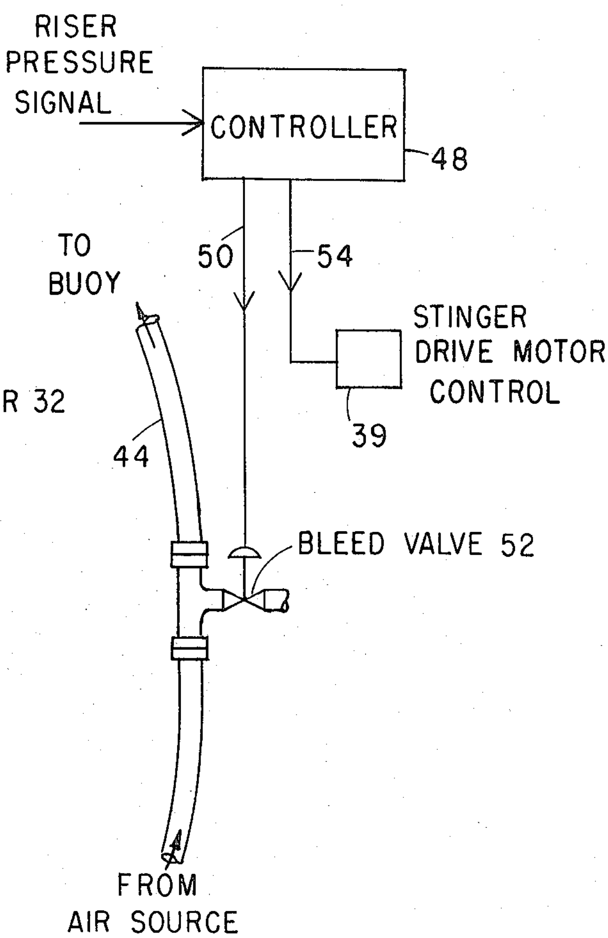

RISER PRESSURE SIGNAL
CONTROLLER
48
TO BUOY
50
54
STINGER DRIVE MOTOR CONTROL
39
44
BLEED VALVE 52
FROM AIR SOURCE

FIG. 5

UNDERWATER BUOY FOR A RISER PIPE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to drilling wells in the bottom of water covered areas from a drilling vessel supported by the body of water and in which a riser pipe extends from the underwater well site to the vessel. It relates especially to a method of using a special buoy for applying an upward force to the riser pipe. Special means are provided so that should the riser break beneath the buoy, the buoy would rise at an angle and surface away from the vessel. Means are provided so that the air inside the buoy can be at ambient water pressure so that relatively thin walls can be used for the buoy.

2. Prior Art

One method which has been suggested in the prior art to avert a catastrophe is to provide a plate over an opening in the top of the shell of a buoy and have it attached by explosive bolts. Suitable sensors were suggested to explode the bolts in the event the riser should break. Removal of the plate is supposed to result in fast flooding of the buoy. If the buoy is flooded fast enough, it would lose its buoyancy before it hits the ship.

The search for oil and gas has in recent years moved more and more to water covered areas. At first, these wells at offshore locations were drilled from fixed platforms, which were in reality a deck held 50 feet or more above the surface of the water by a plurality of legs which extended from the deck into the primary body of water. In these operations, drilling was more or less merely an extension of dry land techniques. However, as the search for oil moved more and more into deeper and deeper water, it became impractical and in some cases impossible to use fixed platforms. Thus, it has become more and more desirable to use a floating vessel from which to drill wells in marine locations having deep water. In such operations the floating vessel is usually connected to a submerged wellbore by a long tubular member through which drilling tools, drilling fluid, etc., passed between the vessel and the wellbore. This long tubular member is commonly referred to as a riser pipe.

The submerged wellhead usually includes a blowout preventer and other control equipment. In one embodiment the upper part of the wellhead assembly includes a ball connector which provides a flexible connector between the wellhead assembly and the riser pipe. The lower end of the riser pipe is connected to this ball joint and is free to pivot thereabout. This is commonly called a flexjoint. Other types of flexjoints are commercially available. However, the ball and socket joint is enjoying increasing popularity. Although a vessel is anchored, it can have vertical movement from a few feet up to 20 to 30 feet or more. To compensate for this vertical movement, a slip or telescopic joint is provided in the riser pipe. If the conventional riser pipe is supported solely at the lower end, its own effective weight, i.e., weight in water, causes it to be in a state of axial compression increasing from zero at the top to maximum at the bottom support. When drilling in deep water, the compressive stress in the wall of the riser pipe from this source alone is sometimes sufficient to buckle the riser pipe. This causes failure of the riser pipe. To counteract this buckling effect it has become a practice to apply a tensile force to the top of the riser pipe. Special tensioning devices are mounted on the ship and have their cables attached to the upper end of the riser pipe but below the slipjoint. These tensioning devices are commonly referred to as constant tensioning devices so that they can maintain a constant tension on the riser pipe although the ship may rise and fall with respect to the riser pipe. These constant tensioning systems are helpful but are also costly and must be maintained.

Function of these constant tensioning devices has the effect of pulling the riser pipe taut. Tensioners have worked well, but as drilling depths increase their limits are being approached. As the length of the riser pipe gets longer, e.g., 1,000 feet or more, the riser has an increasing tendency to act like a string of spaghetti. In order to supplement the tensioners, it has been suggested that flotation systems or jackets be fitted around the riser pipe at selected depths to help support the riser pipe and relieve the tensioning system of a considerable portion of the pipe weight.

For a discussion of using flotation jackets around riser pipes, attention is directed to an article in the *Offshore* magazine, June 5, 1971, p. 33, entitled "Floating Riser Helps Extend Drilling to 1,700-ft Depths," by David Cook.

The present flotation systems apparently have reasonable engineering basis, but are subject to difficulty. For one thing, most of them to date are rather costly and their life expectancy is shorter than desired. A problem with attaching a buoy to the riser underwater is that if the riser should break beneath the buoy, the buoy would rise vertically due to its large upward buoyant force. The buoy with a large part of the riser pipe still attached would then have a catastrophic collision with the drilling vessel. My present invention provides underwater buoyancy to riser pipes which (1) is believed to be less costly than present flotation systems through its unique design and (2) is provided with means so that if the riser pipes break beneath the buoy, the buoy is caused to rise at an angle and surface away from the vessel.

BRIEF DESCRIPTION OF THE INVENTION

This invention relates to an underwater buoy for a riser pipe which extends from an underwater well to a vessel supported by the body of water which comprises a hollow shell which is attached to the riser pipe to give an upper buoyancy force thereto. Non-vertically directed hydrofoil means are attached to the outer wall of the shell, so that should the riser pipe break beneath the shell, the shell is directed upwardly at an angle and surfaces away from the vessel. A unique system is provided so that relatively thin walls can be used to fabricate the shell. The air in the shell is at ambient water pressure. This is accomplished by having a port in the lower portion of the shell so that sea water can enter this shell, but having an air source provide air to the interior of the shell above the port at ambient water pressure so that the shell will be buoyant. Liquid level means are provided so that the interface between the seawater and the air in the shell is known. If this is known then the buoyant force of the shell can be accurately determined.

BRIEF DESCRIPTION OF THE DRAWING

Various objects and a better understanding can be had of the invention by the following description taken in conjunction with the drawing, in which:

FIG. 1 illustrates schematically the noval buoy connected to a riser pipe.

FIG. 2 shows a vertical view of my novel buoy connected to a riser pipe.

FIG. 3 is a section taken along the line 3—3 of FIG. 2.

FIG. 4 is simular to FIG. 1 but illustrates a riser interior pressure sensor used to control the amount of buoyancy in the buoy.

FIG. 5 illustrates schematically means for automatically bleeding air from its buoy in response to pressure within the riser pipe.

DETAILED DESCRIPTION OF THE INVENTION

Attention is first directed to FIG. 1 which shows drilling vessel **10** supported at the surface **12** of a body of water **14.** A wellhead **18** is indicated on the bottom **16** of the body of water. A riser pipe **20** extends from vessel **10** to subsea wellhead **18.** My novel buoy **22** is positioned about riser pipe **20.** Typically the depth of water **14** for which my invention is especially useful is 1,000 t0 10,000 feet or more in depth. Typically my buoy **22** is positioned sufficiently deep so that it is not subjected to surface currents and waves to any appreciable degree. Typically buoy **22** can be 600 feet or more from the surface. Although I have shown only one buoy **22** positioned along riser pipe **20,** additional buoys can be placed at different depths if desired.

Attention is next directed to FIG. **3** which shows details of my buoy. Shown thereon is riser pipe **20** which has shell **24** of my buoy **22** attached thereto. Shell **24** can be attached to the riser by welding or any other way so that it is fixed to the riser pipe at the required depth. I provide port **26** in the lower portion of shell **14.** Air is in the interior portion designated **30** which is above the water in the buoy.

For purpose of illustration, I show four hydrofoils **28** which are positioned at 90° spacing around shell **24,** and attached to the shell **24** or to adjacent sections of riser **20.** These hydrofoils **28** are supported by arms or brackets **29.** Each hydrofoil **28** has a chord **31** which makes an angle θ with a vertical. The angle θ is selected such that if riser pipe **20** should break beneath the shell, that the shell would rise at an angle and surface away from ship **10.** Many factors would be considered in determining the actual value of the angle θ such as the depth at which shell **24** is positioned and the known current. However, typically the angle θ wound normally be in the range from 30° to 60°.

Attention will now be directed toward those means for supplying air to interior **30** of shell **24.** This includes an air hose **44** which extends to an air source, not shown, on vessel **10.** Air hose **44** is connected to a vertical stinger pipe **32** which has an upper end **34** which opens into shell **24.** Stinger **32** is connected to a rack **36** which is driven by a motor means **39** having pinion gears **38.** This is controlled by means **40** which can be either electric or hydraulic lines which extend to the surface. Vertical stinger **32** can be moved so that it takes the position of dotted line **32A** having opening **32A** which is at the top space **30** of shell **24.**

Means are also provided so that the interface between the air in space **30** and the water in the lower part of shell **24** can be accurately determined. This includes liquid level indicator or sensor **25** having a float **27** and lead wires **27A** which extends to vessel **10.**

When the buoy is placed at its required depth, the shell **24** is filled with water. Then when the buoy is in position on the riser pipe and it is desired to give it buoyancy, all that is necessary to do is to supply the necessary volume of air at the proper pressure to line **44.** The proper pressure would be the ambient pressure or slightly in excess of the ambient pressure so that the water would be driven out of the shell through port **26.** Then the pressure could be maintained at about the ambient water pressure so that the interface between the water and the air would be at or above port **26.** After I have achieved the desired buoyancy, I move pipe **32** to where it is slightly above the desired air-water interface. My reason for this is that should hose **44** break, I would maintain the captured air in the upper part of the shell **24** and thus retain my buoyancy until repairs could be made. Also by observing the readings from liquid level indicator **25** I can determine if there are any excessive leaks of air anywhere in the system. If the interface rises too rapidly, I can maintain buoyancy by adding more volume of air to hose **44.** I then can check for leaks.

Sometimes it may be desired to reduce the buoyancy of buoy **22.** This can be accomplished by raising the stinger pipe **32** so that its end **34** is at the desired level of the air-water interface and then releasing air through hose **44.**

As I mentioned above, if there were no provisions made to protect against it, a riser break below shell **24** would result in a catastrophe by the buoy and a part of the riser, moving rapidly upwardly, hitting the vessel. As I have explained, I provide hydrofoils so that in such event my buoy would surface at a position away from the vessel.

While I have not given any specific dimensions to shell **24** and size of hydrofoils **28,** these can be calculated by marine design engineers in relation to the environment in which they are placed. Typically though, shell **24** may be 20 feet in diameter and 30 feet high. Typically the wall thickness can be one-half inch or less. Typically the chord of the hydrofoil **28** can be to about 5 feet to about 15 feet.

The weight or density of the drilling fluid within riser **20** is an important factor in determining the amount of tension which would be applied to riser **20** by the subsurface buoy and/or surface tensioning devices. We can adjust the upward force which buoy **22** will apply by varying the liquid level therein so that there is either a greater or lesser amount of air.

During drilling operations, the density of the drilling mud will ordinarily be varied considerably. If I know in advance when the density is being varied, I can adjust the amount of air in buoy **22** to compensate for change in tensioning required. I can either bleed off air from the buoy or add air thereto as necessary. However, there are situations which arise rather rapidly which necessitate a quick change in the amount of buoyancy applied to riser **20.** For example, if a drilling crew is using a very heavy drilling mud, I would ordinarily have applied a relatively high tensioning value of the pipe **20** through the buoyancy means **22.** If the drilling proceeds through a "theft" zone, it is possible that a large amount of my heavy drilling fluid will be lost, and its loss may occur rather quickly. The loss will be reflected by greatly reduced pressure at the lower end of the riser pipe. If this occurs, I would wish to change the upward buoyancy force rather quickly so that excessive stresses are not applied to the riser pipe. Modifications of my device, as shown in FIGS. **4** and **5**, permit this rapid compensation of upward force on the riser pipe **20**.

Shown in FIG. **4** is ship **10** connected by riser pipe **20** to the subsea wellhead **18** with the riser pipe buoyancy support **22** positioned on the riser pipe **20**. This is just like that shown in FIG. **1**. However, I modify FIG. **1** by adding a pressure sensor **46** at the lower end of riser pipe **20**. This sensor detects the pressure within the riser pipe. Such sensors are well known and will not be described in detail here. The pressure detected by this sensor is transmitted to a controller **48** located on the ship, as shown in FIG. **5**. Pressure control means **48** has two outputs. The first output **50** controls bleed valve **52** which bleeds air from buoy through air line **44**. The second output **54** from controller means **48** is connected to pinion-drive motor **39**. As I taught earlier, pinion means **38** raises or lowers vertical input pipe or stinger **32** into the interior of the buoy means **22**. Control means **48** is so calibrated and programmed so that any pressure within a selected pressure range will cause the motor of the pinion means **38** to raise or lower vertical pipe **32** to a selected level for that particular pressure.

If there is a sudden drop in pressure detected by pressure sensor **46** in the bottom of the riser pipe **20**, then control means **48** will have an output on line **54** to activate drive control motor **39** and raise the top **34** of stinger pipe **32** to the new desired elevation of the air-water interface in buoy **22**, then output on line **50** opens valve **52**, which bleeds the air off rather rapidly from air hose **44**. Valve **52** is made sufficiently large so that it is nearly like cutting the hose **44** in two insofar as venting operations are concerned.

In the event pressure in the riser increases at sensor **46**, the controller **48** is programmed to lower the elevation of stinger **32**, and to supply air to the buoy **22** to increase buoyancy.

While the above invention has been described in detail, it is to be understood that various modifications can be made thereto without departing from spirit or scope of the invention.

I claim:

1. An underwater buoy for a riser pipe which extends from an underwater well to a vessel supported by a body of water which comprises:

- a hollow shell attached to said riser to give an upward buoyancy force thereto;
- non-vertically directed hydrofoil means attached to said shell for directing said shell upwardly through said water in a non-vertical direction to avoid striking said vessel in event said riser pipe fails below said shell.

2. A buoy as defined in claim **1**, including:

- a port in a lower portion of said shell,
- means to supply gas to the interior of said shell above said port.

3. A buoy as defined in claim **2**, including means to detect loss of gas from said shell.

4. A buoy as defined in claim **3** in which said means to detect loss of gas comprises a liquid level indicator positioned on the inside of said shell above said port and including means to transmit information concerning the position of said level to said vessel.

5. A buoy as defined in claim **4** in which said means to supply gas includes variable position discharge means to change the level in said shell at which said gas is discharged into or released from the interior of the shell independent of vertical movement of said liquid level indicator.

6. A buoy as defined in claim **5** in which said variable position discharge means includes a hollow pipe vertically disposed within said shell and means to move said pipe vertically therein.

7. A buoy as defined in claim **1** in which said hydrofoil means includes a plurality of hydrofoils in which the chord of each hydrofoil makes an angle of attack θ with the vertical which is in the range of between about 30° and 60°.

8. An apparatus as defined in claim **1** including

- pressure sensing means for detecting pressure of fluid inside said riser pipe near the bottom of said body of water,
- means to adjust the buoyancy of said shell in response to pressure detected by said pressure sensing means.

9. In an apparatus as defined in claim **2** including

- a hollow stinger pipe vertically disposed within said shell, the lower end of said stinger pipe connecting said means to supply gas,
- pressure sensing means for detecting the pressure of fluid inside said riser pipe at a level near the lower end of said riser pipe,
- means to adjust the level of the top of said stinger pipe in response to the pressure detected by said pressure sensing means.

10. An underwater buoy as described in claim **1** wherein said hydrofoil means is attached to the outer wall of said shell.

11. A buoy system for a riser pipe which extends from an underwater well to a vessel supported by a body of water which comprises

- a hollow shell attached to said riser pipe to give an upward buoyancy force thereto,
- pressure sensing means for detecting pressure of fluid inside said riser pipe,
- means to adjust the buoyancy of said shell in response to the pressure detected by said pressure sensing means.

12. A buoy system as defined in claim **11** including

- hydrofoil means for directing said shell away from said vessel in event said riser pipe breaks beneath said shell when said shell is positioned beneath the surface of said body of water.

* * * * *