Ex. PGS 1056

United States Patent [19]

Dolengowski

[11] **Patent Number: 4,890,568**

[45] **Date of Patent: Jan. 2, 1990**

[54] **STEERABLE TAIL BUOY**

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[73] Assignee: **Exxon Production Research Company**, Houston, Tex.

[21] Appl. No.: **236,107**

[22] Filed: **Aug. 24, 1988**

[51] **Int. Cl.**[4] **B63B 21/00**

[52] **U.S. Cl.** **114/246**; 114/253; 114/163

[58] **Field of Search** 114/162, 163, 242, 244, 114/246, 253

[56] **References Cited**

U.S. PATENT DOCUMENTS

1,717,286	6/1929	Ward	114/163
3,125,980	3/1964	Anderson	114/235
3,469,552	9/1969	Patrick	114/246
3,560,912	2/1971	Spink et al.	340/
3,605,674	9/1971	Weese	114/235 B
3,710,749	1/1973	Duryea	114/163
3,774,570	11/1973	Pearson	114/235
3,896,756	7/1975	Pearson et al.	114/235 B
4,033,278	7/1977	Waters	114/245
4,063,213	12/1977	Itria et al.	340/
4,087,780	5/1978	Itria et al.	340/7 R
4,130,078	12/1978	Cholet	114/244
4,290,124	9/1981	Cole	367/18
4,323,989	4/1982	Huckabee et al.	367/181
4,350,111	9/1982	Boyce, II	114/245
4,404,664	9/1983	Zachariadis	367/19
4,463,701	8/1984	Pickett et al.	114/245
4,506,352	3/1985	Brandsaeter et al.	367/21
4,574,723	3/1986	Chiles et al.	114/253
4,729,333	3/1988	Kirby et al.	114/244
4,763,126	8/1988	Jawetz	441/16

FOREIGN PATENT DOCUMENTS

2047406B	9/1983	United Kingdom .

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[57] **ABSTRACT**

A remotely controllable tail buoy for use in marine geophysical prospecting operations is disclosed. The tail buoy is attached to the trailing end of one or more seismic streamers towed by the vessel. The tail buoy is provided with rudders that are controlled by a steering mechanism and communication system. The communication system collects and processes radio signals emitted from a radio transmitter located on the towing vessel. The processed signals control the steering mechanism which includes a hydraulic pump for directing fluid into a hydraulic cylinder. The fluid flow rotates the rudders. The tail buoy will travel toward the direction that the rudders are turned and thus avoid hooking or entangling of the tail buoy on other like tail buoys or structures.

15 Claims, 2 Drawing Sheets

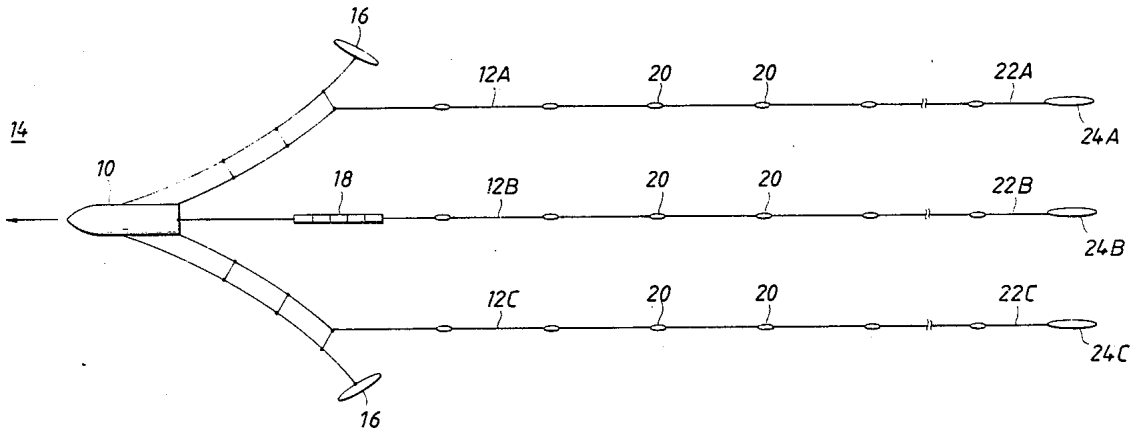

FIG.1

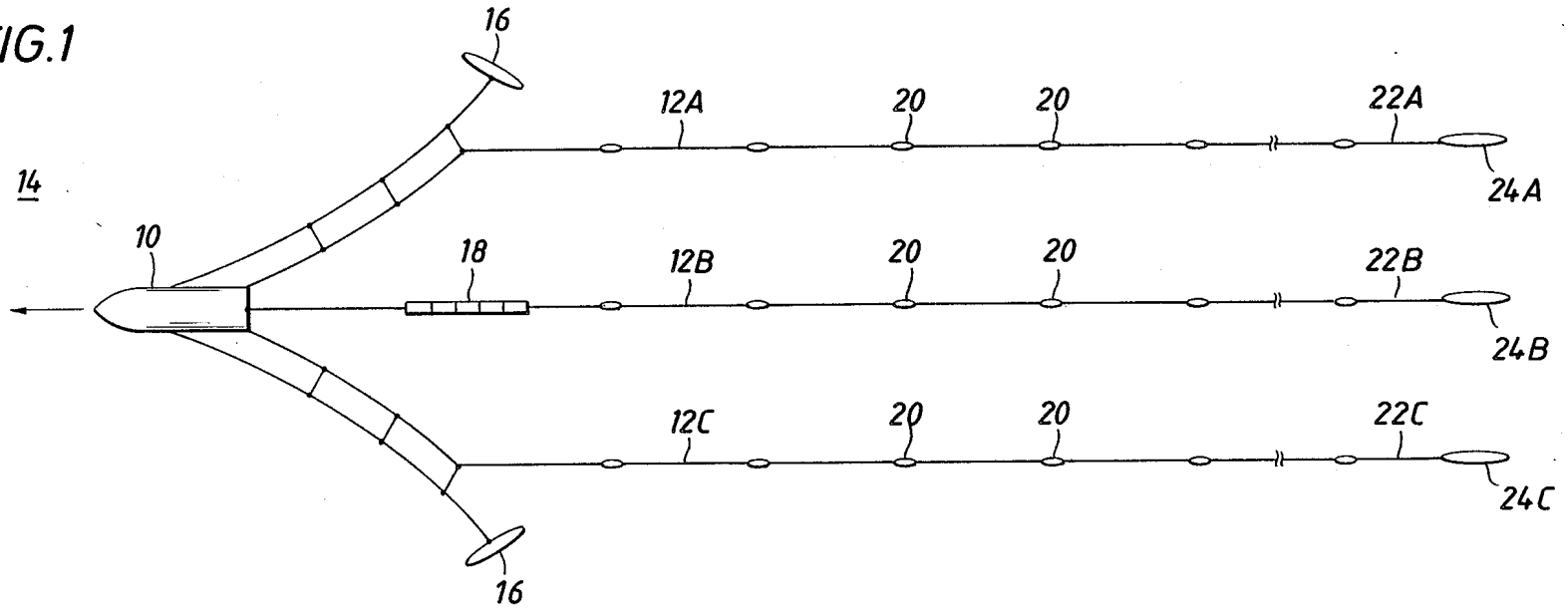

FIG. 2

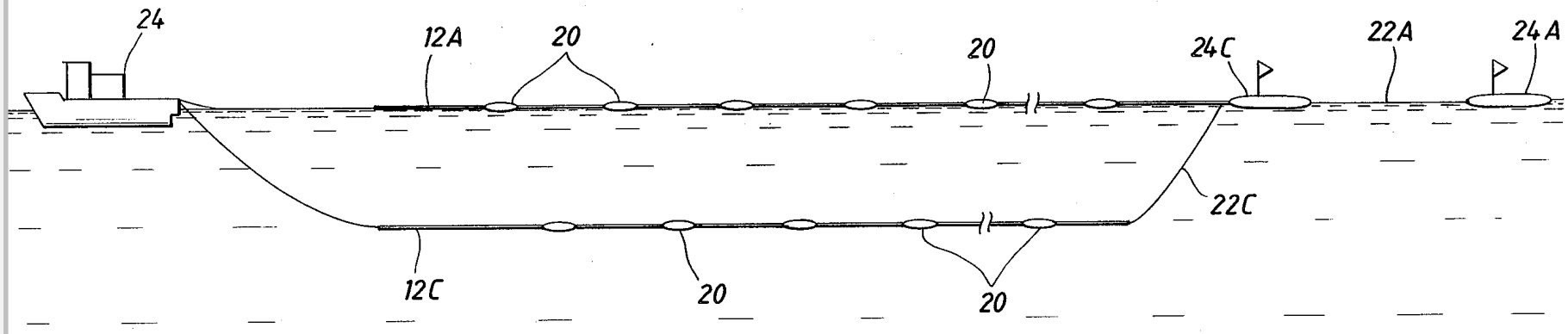

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FIG. 3

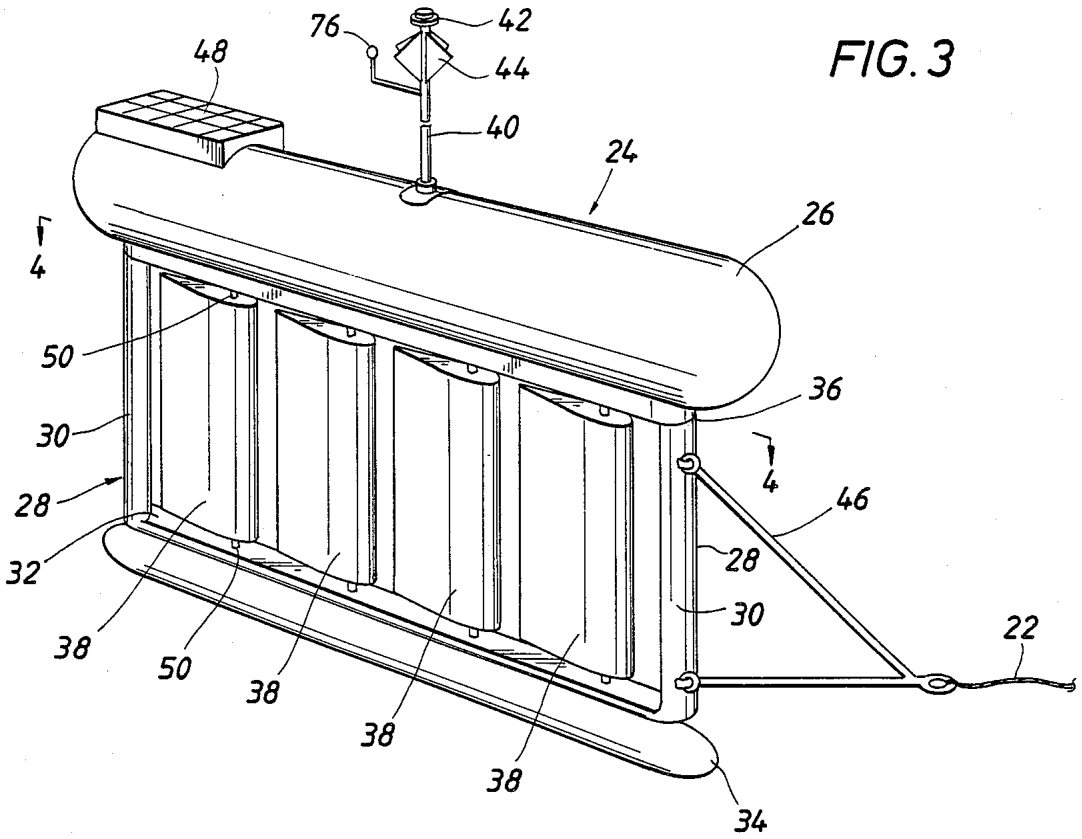
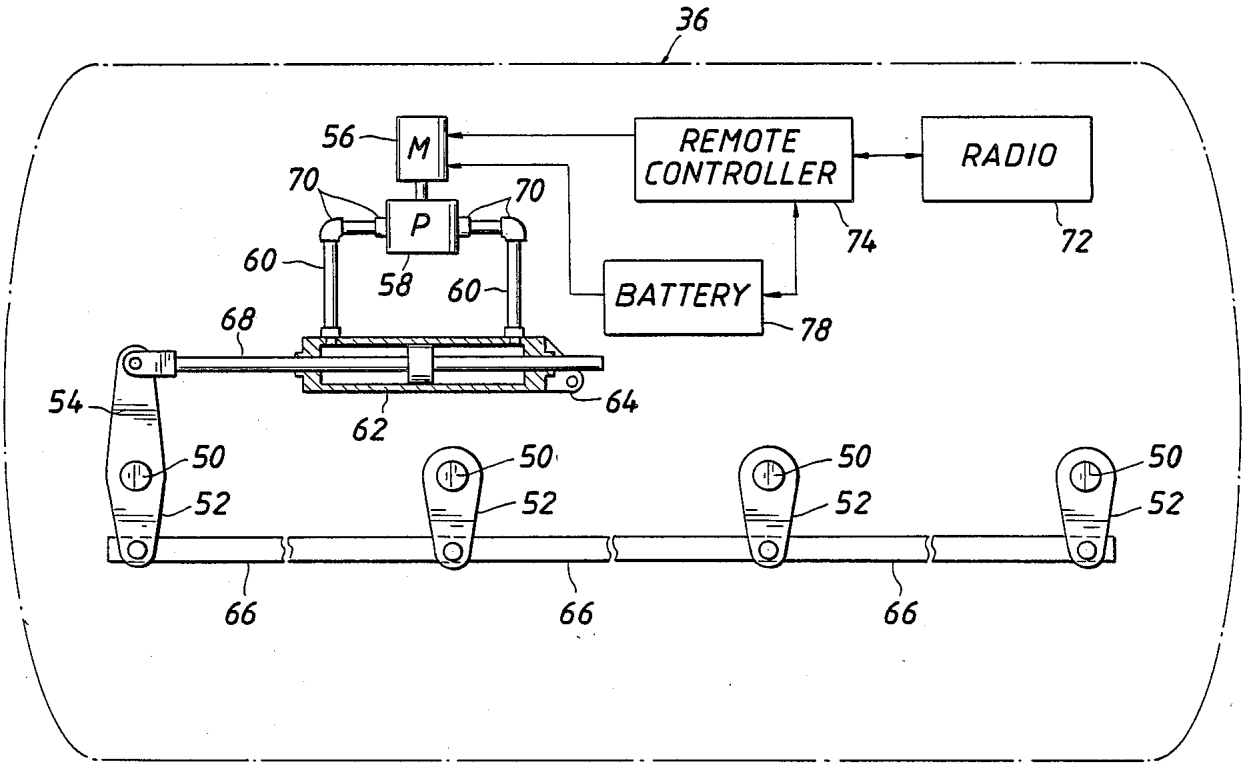


FIG. 4



STEERABLE TAIL BUOY

FIELD OF THE INVENTION

This invention relates generally to marine towing operations. More specifically, but not by way of limitation, it relates to a steerable tail buoy for use while gathering marine seismic data using one or more seismic streamers.

BACKGROUND OF THE INVENTION

In recent years the search for oil and gas has moved offshore. In order to locate potential offshore oil and gas reservoirs, it has been necessary to develop new devices and techniques for conducting marine geophysical prospecting operations. Due to the hostile environment in which they are conducted, such operations are typically quite difficult and costly to perform.

The primary method for conducting marine geophysical prospecting operations involves the use of towable marine seismic sources and seismic receiver cables. The basic principles of this prospecting method are well known to those skilled in the art. The seismic source(s) introduce seismic signals into the body of water. The signals travel downwardly through the water, across the water-floor interface, and into the subterranean geological formations, and are, to some extent, reflected by the interfaces between adjacent formations. The reflected signals travel upwardly through the geological formations and the body of water to a seismic receiver cable located near the surface of the body of water. The seismic receiver cable typically contains a number of hydrophones spaced along its length which record the reflected signals. Analysis of the signals recorded by the hydrophones can provide valuable information concerning the structure of the subterranean geological formations and possible oil and gas accumulation therein.

Seismic receiver cables, commonly known as "streamers", are usually towed below the water surface. The streamers are preferably of neutral buoyancy and can be balanced by filling them with a liquid having a specific gravity less than 1 to add flotation, or by removing excess liquid or taping lead strips to the outer surfaces of the streamers to reduce flotation. As is well known to those skilled in the art, a properly balanced streamer should maintain approximately the same depth along its entire length while it is being towed. Balancing the streamer is often a difficult process as it is possible for the streamers to be 6 kilometers (3.7 miles) long or more.

The depth of the streamers during tow is usually controlled by winged devices known as "birds" which are attached to the streamers typically every 300 to 500 meters (about 1000 to 1600 feet). The birds are provided with remote depth controls which enable them to maintain the streamer at a uniform running depth or to raise or lower the streamer. A typical bird looks like a torpedo, being about 0.6 meters (2 feet) long, with two short winglike fins. It usually separates into halves, along its length, and is hinged on one side so that it can be opened and clamped onto the cable. One example of a bird is described in U.S. Pat. No. 3,605,674 which issued on Sept. 20, 1971 to Weese.

At the trailing end of the streamer, away from the vessel, a tail buoy is attached to the streamer, typically by a rope. The tail buoy enables the vessel operators to determine and mark the approximate location of the end of the streamer. It also serves as a warning device for other vessel operators to indicate that a streamer is being towed. The tail buoy is usually a catamaran raft provided with tubular floats, lights and radar reflectors. The rope, which may range in length from 30 to 300 meters (about 100 to 1000 feet), allows the tail buoy to float on the surface of the water without raising the trailing end of the streamer.

In recent years, it has become feasible to tow a plurality of streamers, laterally spaced apart, behind a single vessel. As a result, a greater survey area may be covered in a shorter period of time, resulting in a lower overall survey cost. When a plurality of streamers are towed behind a single vessel, paravanes, being attached to the lead end of each streamer, are often used to laterally seperate the lead end of each streamer. One example of a paravane is described in U.S. Pat. No. 4,463,701 which issued Aug. 7, 1984 to Pickett, et al. A remotely controlled paravane is disclosed in U.S. Pat. No. 4,729,333 which issued Mar. 8, 1988 to Kirby, et al.

A particular difficulty has arisen when towing a plurality of streamers. In routine turns, all streamers normally tow in concentric circles. However during deployment or repair of the streamers or in non-routine turns such as slow speed turns or sharp turns, it is common for the streamers to cross and become tangled. It is possible to prevent entanglement of the streamers by diving one streamer while surfacing the other with the aid of the remotely controllable birds. Although this keeps the streamers from tangling, the tail buoys, which at all times remain on the water's surface, are likely to cross and become hooked, or the ropes that connect the buoys to the streamers may become tangled. Unhooking the tail buoys or untangling the ropes requires the use of a small auxiliary boat, if available. Otherwise, the streamers and ropes must be reeled toward the vessel to be untangled by the vessel operators.

Another difficulty arises when data is being collected near an offshore structure. As one or more streamers are towed behind a vessel, the wind and water current may cause the trailing end of the streamer to feather outwardly from the vessel's path. If data is being collected along a path near an offshore structure, the wind and current may push the streamer and tail buoy into the structure. As a result the buoy or the streamer may become damaged or they may become hooked to the structure.

Accordingly, in marine seismic exploration the need exists for a remotely controllable tail buoy which can be attached to a seismic streamer so as to indicate the approximate location of the trailing end of the streamer, and which can be remotely steered away from other tail buoys attached to other streamers or from offshore structures and other obstructions in order to prevent tangling of the tail buoys or damage to the tail buoys or streamers.

SUMMARY OF THE INVENTION

The present invention is a remotely controllable tail buoy that may be directed from a remote location such as from a towing vessel to prevent damage to the tail buoys, hooking of the tail buoys or tangling of the ropes when one or more streamers are being towed by the towing vessel. Additionally, the inventive tail buoy may be used when towing one or more streamers to direct the trailing ends of the streamers away from offshore

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