



US006932017B1

(12) **United States Patent**  
**Hillesund et al.**

(10) **Patent No.:** **US 6,932,017 B1**  
(45) **Date of Patent:** **Aug. 23, 2005**

(54) **CONTROL SYSTEM FOR POSITIONING OF MARINE SEISMIC STREAMERS**

4,890,568 A \* 1/1990 Dolengowski ..... 114/246

(75) Inventors: **Oyvind Hillesund**, Histon (GB); **Simon Hastings Bittleston**, Bury St Edmunds (GB)

FOREIGN PATENT DOCUMENTS

EP 613025 A1 \* 8/1994 ..... G01V/1/38

(73) Assignee: **Westerngeco, L.L.C.**, Houston, TX (US)

\* cited by examiner

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

*Primary Examiner*—Jesus D. Sotelo  
(74) *Attorney, Agent, or Firm*—Westerngeco, L.L.C.

(57) **ABSTRACT**

(21) Appl. No.: **09/787,723**

A method of controlling a streamer positioning device (18) configured to be attached to a marine seismic streamer (12) and towed by seismic survey vessel (10) and having a wing and a wing motor for changing the orientation of the wing. The method includes the steps of: obtaining an estimated velocity of the streamer positioning device, calculating a desired change in the orientation of the wing using the estimated velocity of the streamer positioning device, and actuating the wing motor to produce the desired change in the orientation of the wing. The invention also involves an apparatus for controlling a streamer positioning device including means for obtaining an estimated velocity of the streamer positioning device, means for calculating a desired change in the orientation of the wing using the estimated velocity of the streamer positioning device, and means for actuating the wing motor to produce the desired change in the orientation of the wing.

(22) PCT Filed: **Sep. 28, 1999**

(86) PCT No.: **PCT/IB99/01590**

§ 371 (c)(1),  
(2), (4) Date: **Jul. 2, 2001**

(87) PCT Pub. No.: **WO00/20895**

PCT Pub. Date: **Apr. 13, 2000**

(30) **Foreign Application Priority Data**

Oct. 1, 1998 (GB) ..... 9821277

(51) **Int. Cl.**<sup>7</sup> ..... **B63B 21/66**

(52) **U.S. Cl.** ..... **114/244; 114/253**

(58) **Field of Search** ..... 114/242, 244–246,  
114/253, 162, 163

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,676,183 A \* 6/1987 Conboy ..... 114/245

**26 Claims, 3 Drawing Sheets**

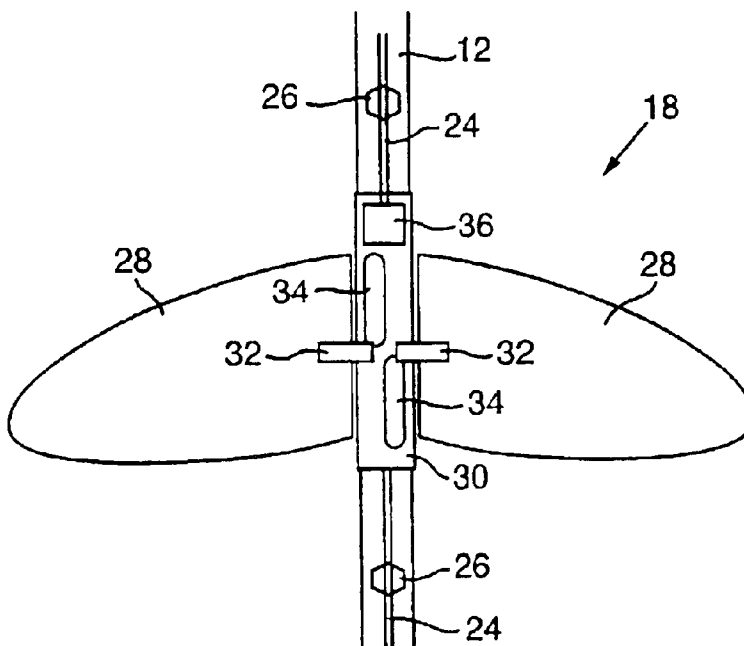


Fig. 1.

Prior Art

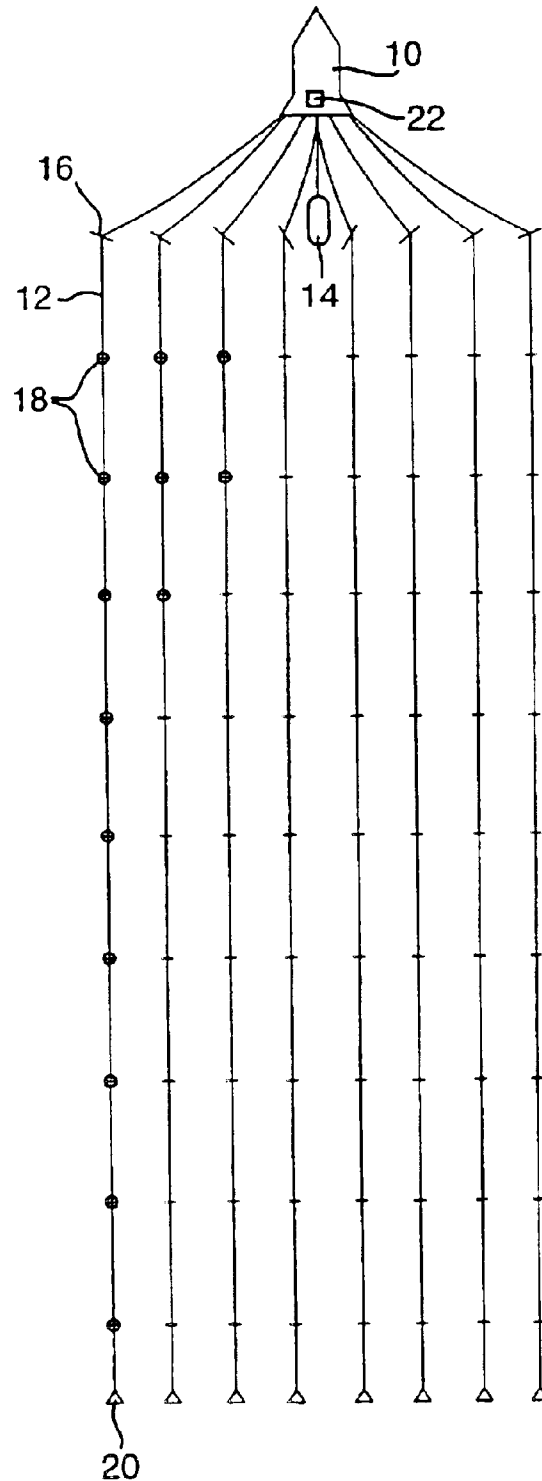


Fig.2.

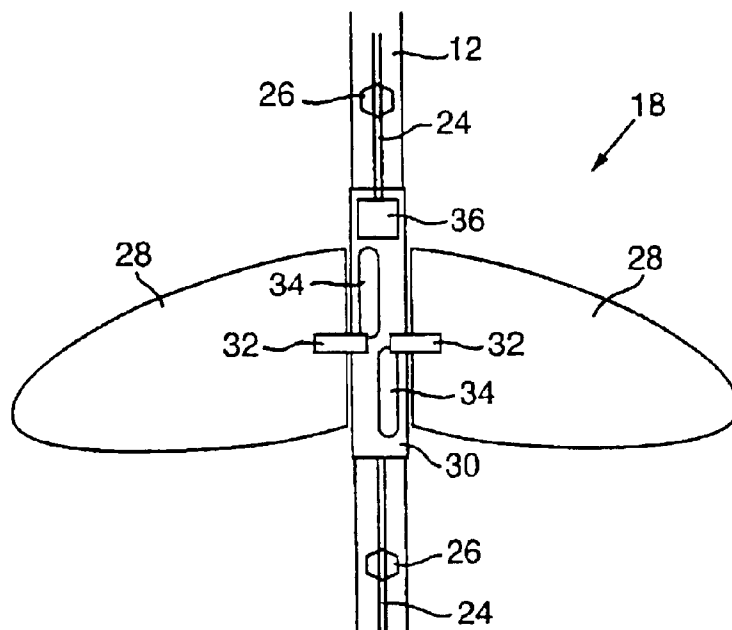
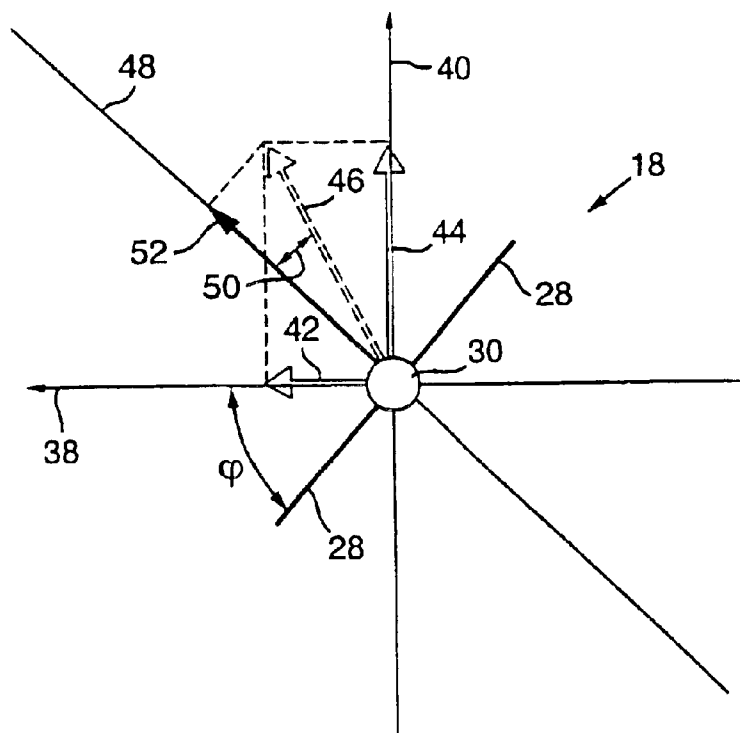


Fig.3.



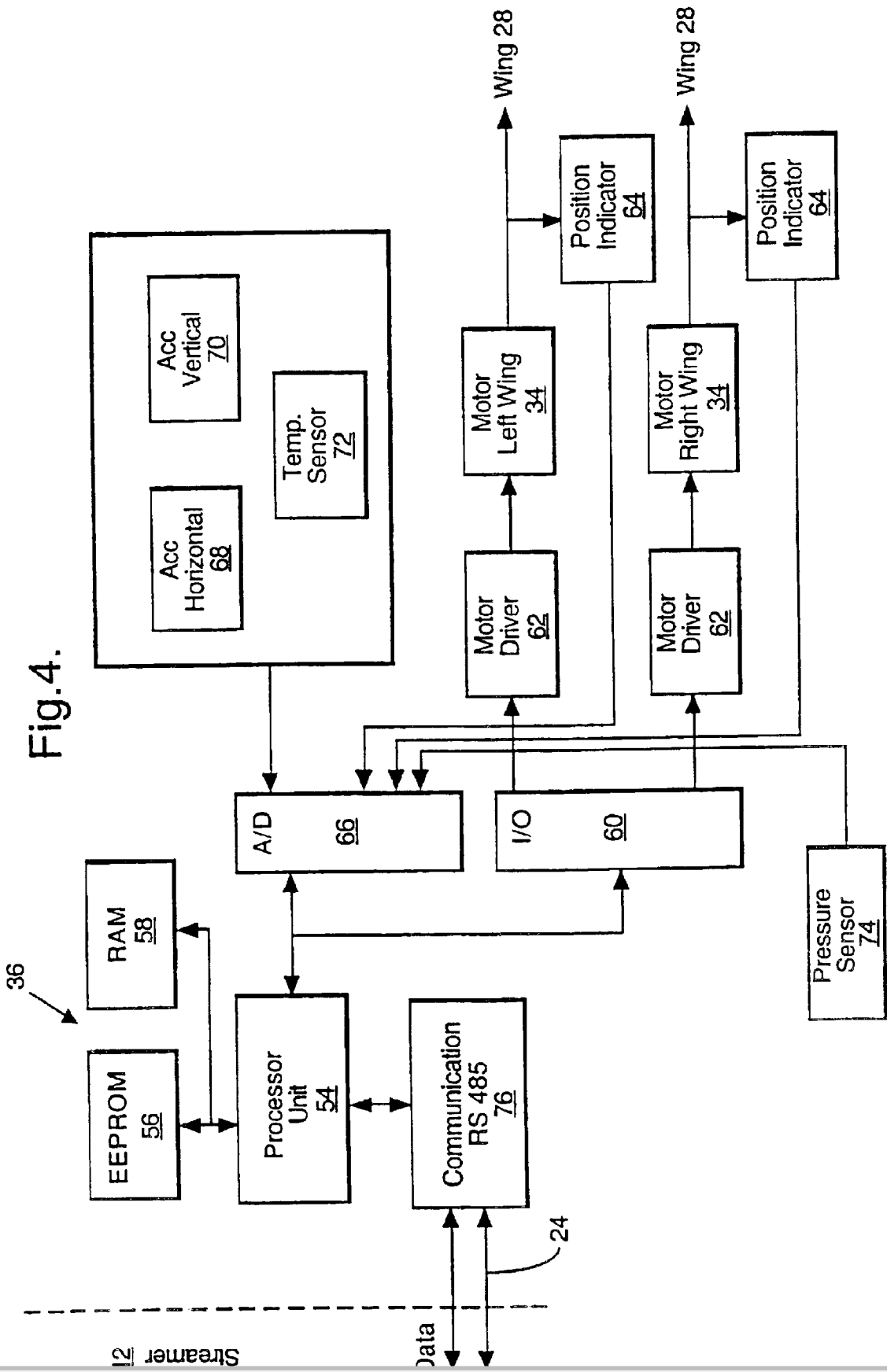


Fig. 4.

## CONTROL SYSTEM FOR POSITIONING OF MARINE SEISMIC STREAMERS

### BACKGROUND OF THE INVENTION

This invention relates generally to systems for controlling seismic data acquisition equipment and particularly to a system for controlling a marine seismic streamer positioning device.

A marine seismic streamer is an elongate cable-like structure, typically up to several thousand meters long, which contains arrays of seismic sensors, known as hydrophones, and associated electronic equipment along its length, and which is used in marine seismic surveying. In order to perform a 3D marine seismic survey, a plurality of such streamers are towed at about 5 knots behind a seismic survey vessel, which also tows one or more seismic sources, typically air guns. Acoustic signals produced by the seismic sources are directed down through the water into the earth beneath, where they are reflected from the various strata. The reflected signals are received by the hydrophones, and then digitized and processed to build up a representation of the subsurface geology.

The horizontal positions of the streamers are typically controlled by a deflector, located at the front end or "head" of the streamer, and a tail buoy, located at the back end or "tail" of the streamer. These devices create tension forces on the streamer which constrain the movement of the streamer and cause it to assume a roughly linear shape. Cross currents and transient forces cause the streamer to bow and undulate, thereby introducing deviations into this desired linear shape.

The streamers are typically towed at a constant depth of approximately ten meters, in order to facilitate the removal of undesired "ghost" reflections from the surface of the water. To keep the streamers at this constant depth, control devices known as "birds", are typically attached at various points along each streamer between the deflector and the tail buoy, with the spacing between the birds generally varying between 200 and 400 meters. The birds have hydrodynamic deflecting surfaces, referred to as wings, that allow the position of the streamer to be controlled as it is towed through the water. When a bird is used for depth control purposes only, it is possible for the bird to regularly sense its depth using an integrated pressure sensor and for a local controller within the bird to adjust the wing angles to maintain the streamer near the desired depth using only a desired depth value received from a central control system.

While the majority of birds used thus far have only controlled the depth of the streamers, additional benefits can be obtained by using properly controlled horizontally steerable birds, particularly by using the types of horizontally and vertically steerable birds disclosed in our published PCT International Application No. WO 98/28636. The benefits that can be obtained by using properly controlled horizontally steerable birds can include reducing horizontal out-of-position conditions that necessitate reacquiring seismic data in a particular area (i.e. in-fill shooting), reducing the chance of tangling adjacent streamers, and reducing the time required to turn the seismic acquisition vessel when ending one pass and beginning another pass during a 3D seismic survey.

It is estimated that horizontal out-of-position conditions reduce the efficiency of current 3D seismic survey operations by between 5 and 10%, depending on weather and current conditions. While incidents of tangling adjacent streamers are relatively rare, when they do occur they invariably result in prolonged vessel downtime. The loss of

typical estimates range from 5 to 10%. Simulations have concluded that properly controlled horizontally steerable birds can be expected to reduce these types of costs by approximately 30%.

One system for controlling a horizontally steerable bird, as disclosed in UK Patent GB 2093610 B, is to utilize a manually-operated central control system to transmit the magnitudes and directions of any required wing angle changes to the birds. While this method greatly simplifies the circuitry needed within the bird itself, it is virtually impossible for this type of system to closely regulate the horizontal positions of the birds because it requires manual input and supervision. This becomes a particularly significant issue when a substantial number of streamers are deployed simultaneously and the number of birds that must be controlled goes up accordingly.

Another system for controlling a horizontally steerable bird is disclosed in our published PCT International Application No. WO 98/28636. Using this type of control system, the desired horizontal positions and the actual horizontal positions are received from a remote control system and are then used by a local control system within the birds to adjust the wing angles. The actual horizontal positions of the birds may be determined every 5 to 10 seconds and there may be a 5 second delay between the taking of measurements and the determination of actual streamer positions. While this type of system allows for more automatic adjustment of the bird wing angles, the delay period and the relatively long cycle time between position measurements prevents this type of control system from rapidly and efficiently controlling the horizontal position of the bird. A more deterministic system for controlling this type of streamer positioning device is therefore desired.

It is therefore an object of the present invention to provide for an improved method and apparatus for controlling a streamer positioning device.

An advantage of the present invention is that the position of the streamer may be better controlled, thereby reducing the need for in-fill shooting, reducing the chance of streamer tangling, and reducing the time needed to turn the seismic survey vessel.

Another advantage of the present invention is that noise in marine seismic data associated with streamer position over-correction and streamer positioning errors can be significantly reduced.

### SUMMARY OF THE INVENTION

The present invention provides methods and apparatus for controlling the positions of marine seismic streamers in an array of such streamers being towed by a seismic survey vessel, the streamers having respective streamer positioning devices disposed therealong and each streamer positioning device having a wing and a wing motor for changing the orientation of the wing so as to steer the streamer positioning device laterally, said methods and apparatus involving (a) obtaining an estimated velocity of the streamer positioning devices, (b) for at least some of the streamer positioning devices, calculating desired changes in the orientation of their wings using said estimated velocity, and (c) actuating the wing motors to produce said desired changes in wing orientation.

The invention and its benefits will be better understood with reference to the detailed description below and the accompanying figures.

### BRIEF DESCRIPTION OF THE DRAWINGS

# Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

## Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

## Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

## Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

## API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

## LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

## FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

## E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.