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This collection of information is required by 37 CFR 1.53(6). The information is required to obtain of retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450, DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450. If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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IN THE UNITED STATES PATENT & TRADEMARK OFFICE

United States Patent Application

For

CONTROL SYSTEM FOR POSITIONING OF MARINE SEISMIC STREAMERS

By: Oyvind Hillesund and Simon Hastings Bittleston

CONTROL SYSTEM FOR POSITIONING OF MARINE SEISMIC STREAMERS Cross-reference to Related Applications

[0001] Applicant claims priority under 35 U.S.C. § 120 from co-pending serial number 11/070,614, filed March 2, 2005, which was a continuation of parent application serial no. 09/787,723, filed July 2, 2001, now Patent No. 6,932,017, which was a 35 U.S.C. § 371 national stage filing from Patent Cooperation Treaty application number PCT/IB99/01590, filed September 28, 1999, which in turn claimed priority from Great Britain patent application number 9821277.3, filed October 1, 1998, from which Applicant claims foreign priority under 35 U.S.C. § 119, all of which are incorporated herein by

10 reference. This application is also related to co-pending application serial numbers 11/_____ and 11/_____, filed simultaneously herewith, which also are both incorporated herein by reference.

Background of the Invention

[0002] 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.

[0003] 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 25 digitized and processed to build up a representation of the subsurface geology.

[0004] 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.

[0005] 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.

15 [0006] 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 20 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.

[0007] 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 efficiency associated with turning the seismic survey vessel will depend in large part on the seismic survey layout, but typical estimates range from 5 to 10%. Simulations have

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