US006671223B2

(12) **United States Patent**
Bittleston

(10) **Patent No.: US 6,671,223 B2**
(45) **Date of Patent: Dec. 30, 2003**

(54) **CONTROL DEVICES FOR CONTROLLING THE POSITION OF A MARINE SEISMIC STREAMER**

(75) Inventor: **Simon Hastings Bittleston**, Slependen (NO)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1 day.

(21) Appl. No.: **09/893,234**

(22) Filed: **Jun. 26, 2001**

(65) **Prior Publication Data**

US 2002/0126575 A1 Sep. 12, 2002

Related U.S. Application Data

(63) Continuation of application No. 09/284,030, filed on Apr. 6, 1999, now abandoned.

(30) **Foreign Application Priority Data**

Dec. 20, 1996 (GB) 9626442

(51) **Int. Cl.**[7] **B63G 8/14**
(52) **U.S. Cl.** **367/19**; 114/245
(58) **Field of Search** 367/19, 18; 114/244

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,605,674 A	9/1971	Weese		114/235
3,774,570 A *	11/1973	Pearson		114/235
4,711,194 A *	12/1987	Fowler		114/245
4,745,583 A *	5/1988	Motal		367/18
4,912,684 A	3/1990	Fowler		367/76
4,992,990 A *	2/1991	Langeland		367/19
5,402,745 A	4/1995	Wood		114/244
5,443,027 A *	8/1995	Owsley		114/244
5,619,474 A *	4/1997	Kuche		367/17
6,011,753 A *	1/2000	Chien		367/21

FOREIGN PATENT DOCUMENTS

EP	0193215 A2 *	9/1986		G01V/1/38
GB	2331971 A *	6/1999		G01V/1/38
WO	WO 96/21163 *	7/1996		G01S/5/14
WO	WO 97/30361 *	8/1997		G01V/1/38
WO	WO 98/28636 *	7/1998		G01V/1/38

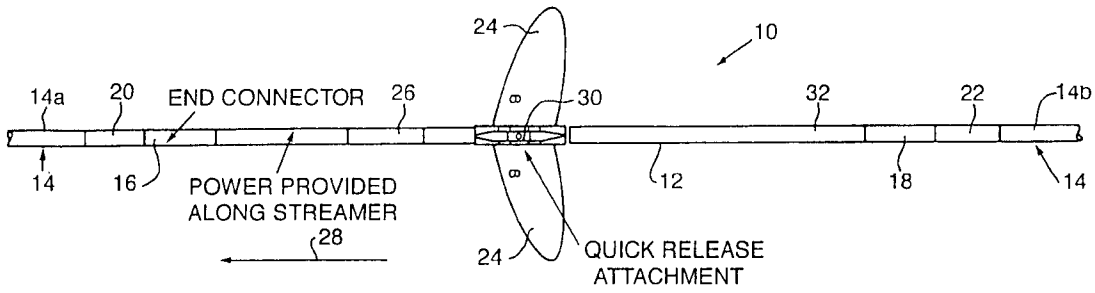
* cited by examiner

Primary Examiner—John Barlow
Assistant Examiner—Victor J. Taylor
(74) *Attorney, Agent, or Firm*—Streets & Steele; David S. Figatner

(57) **ABSTRACT**

A control device or "bird" for controlling the position of a marine seismic streamer is provided with an elongate, partly flexible body which is designed to be electrically and mechanically connected in series with a streamer. In its preferred form, the bird has two opposed wings which are independently controllable in order to control the streamer's lateral position as well as its depth.

29 Claims, 2 Drawing Sheets



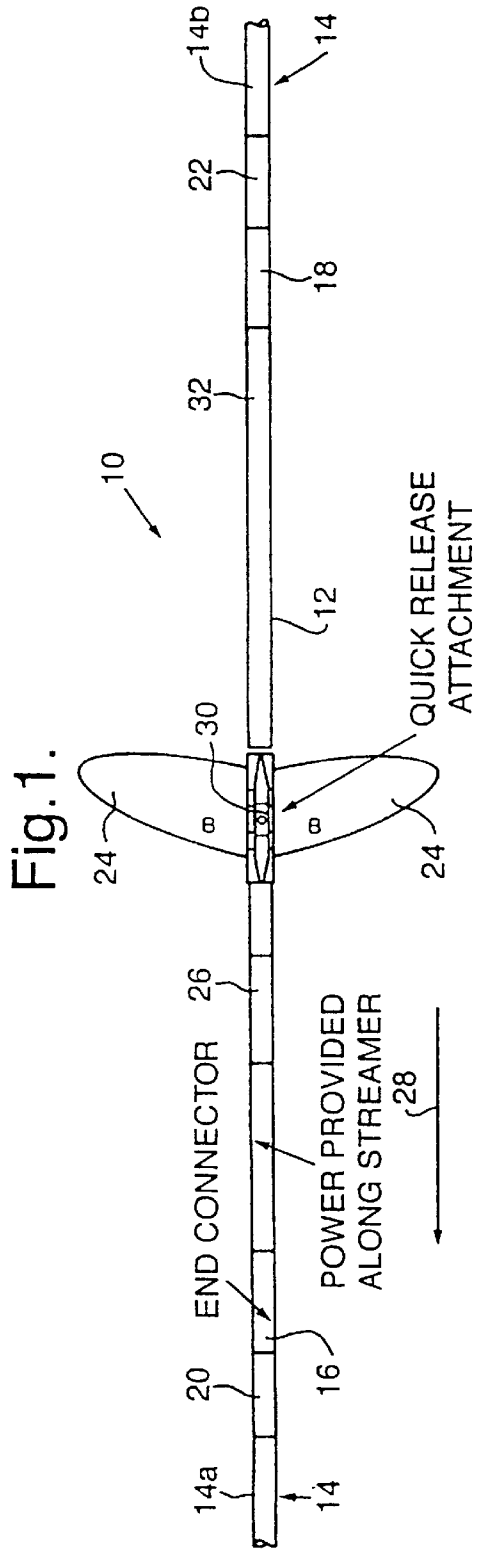


Fig.1.

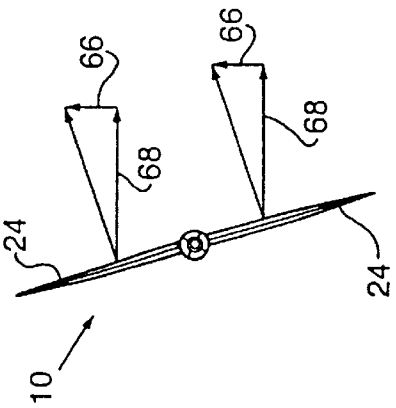


Fig.5.

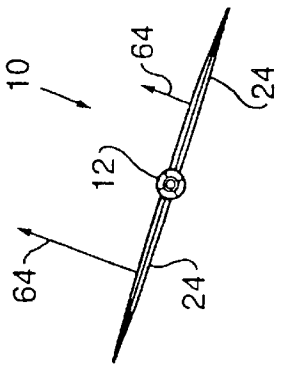


Fig.4.

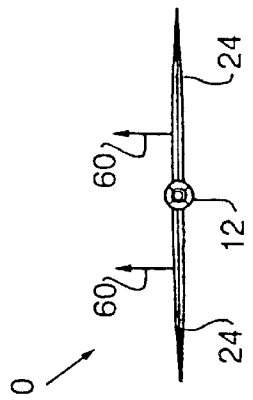


Fig.3.

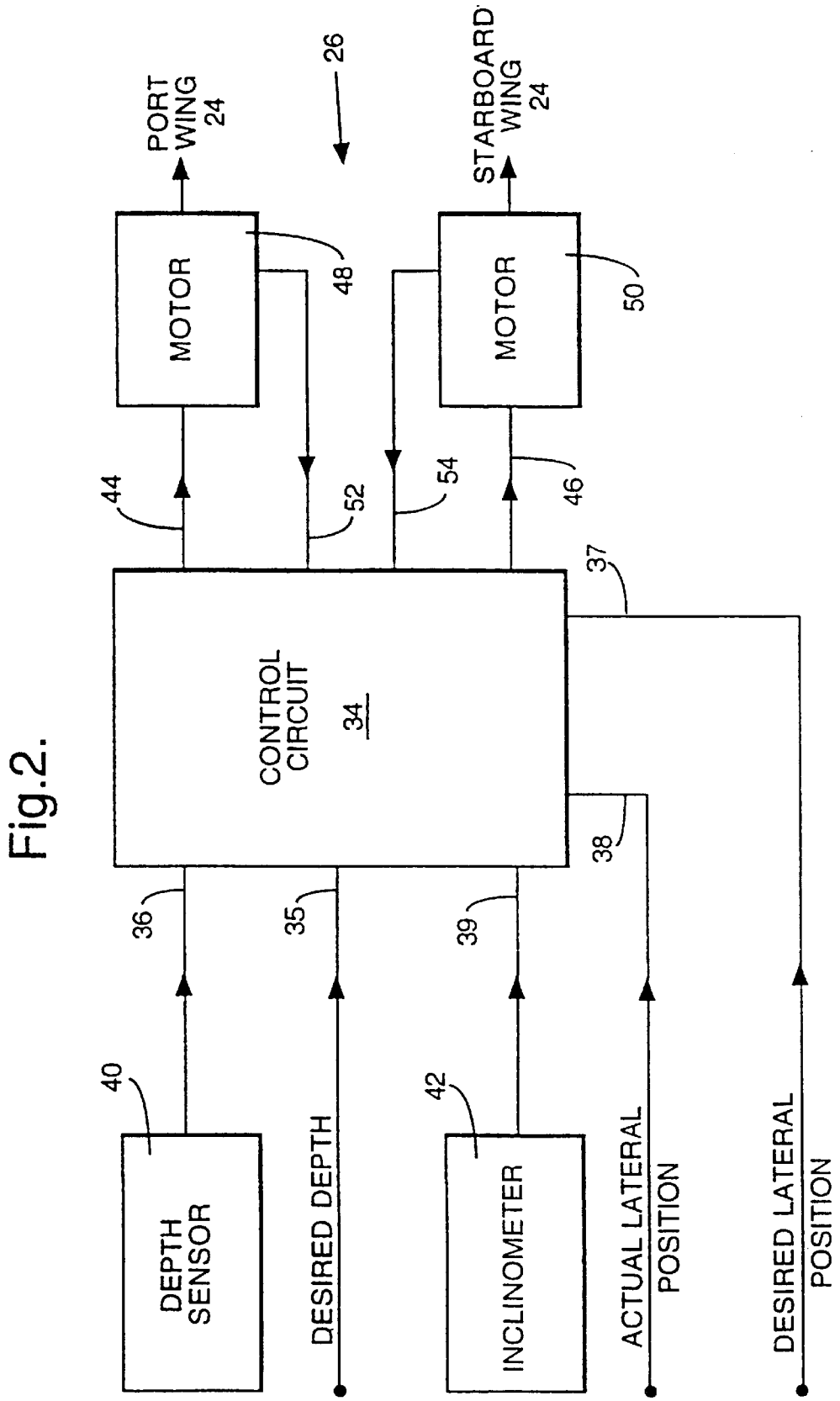

PORT WING 24
26
STARBOARD WING 24
MOTOR
48
MOTOR
50
44
52
54
46
37
CONTROL CIRCUIT
34
38
36
35
39
40
42
DEPTH SENSOR
DESIRED DEPTH
INCLINOMETER
ACTUAL LATERAL POSITION
DESIRED LATERAL POSITION

Fig.2.

CONTROL DEVICES FOR CONTROLLING THE POSITION OF A MARINE SEISMIC STREAMER

This is a Continuation of U.S. patent application Ser. No. 09/284,030 filed on Apr. 6, 1999, now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to control devices for controlling the position of a marine seismic streamer.

A marine seismic streamer is an elongate cable-like structure, typically up to several thousand meters long, which contains arrays of 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 digitised and processed to build up a representation of the earth strata in the area being surveyed.

The streamers are typically towed at a constant depth of about 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", attached to each streamer at intervals of 200 to 300 meters, are used.

Current designs of birds are battery-powered, and comprise a relatively heavy body which is suspended beneath the streamer, and which has a pair of laterally projecting wings (hence the name "bird"), one on each side. The combination of streamer and birds is arranged to be neutrally buoyant, and the angle of attack of both wings is adjusted in unison from time to time to control the depth of the streamer.

Birds in accordance with these current designs suffer from a number of disadvantages. Because they are battery-powered, the batteries can run out before the survey is completed, necessitating either retrieval of the streamer for battery replacement, or deployment of a work boat to replace the battery in the water. The former operation is very time consuming, while the latter can be hazardous. Further, because the birds hang beneath the streamer, they produce considerable noise as they are towed through the water, which noise interferes with the reflected signals detected by the hydrophones in the streamers. The hanging of the birds from the streamers also means that the birds need to be detached each time the streamer is retrieved and re-attached each time it is re-deployed, which is again rather time consuming.

During the seismic survey, the streamers are intended to remain straight, parallel to each other and equally spaced. However, after deploying the streamers, it is typically necessary for the vessel to cruise in a straight line for at least three streamer lengths before the streamer distribution approximates to this ideal arrangement and the survey can begin. This increases the time taken to carry out the survey, and therefore increases the cost of the survey. But because of sea currents, the streamers frequently fail to accurately follow the path of the seismic survey vessel, sometimes deviating from this path by an angle, known as the feathering angle, of up to 10°. This can adversely affect the coverage of the survey, frequently requiring that certain parts of the survey be repeated. In really bad circumstances, the streamers can actually become entangled, which though rare, causes great damage and considerable financial loss. Current designs of birds can do nothing to alleviate any of these lateral streamer positioning problems.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide novel streamer control devices which alleviate at least some of the disadvantages of the current designs, and/or which possess more functionality than the current designs.

According to the present invention, there is provided a control device for controlling the position of a marine seismic streamer, the device comprising a body mechanically connected in series between two adjacent sections of the streamer, sensor means in the body for determining its angular position in a plane perpendicular to the longitudinal axis of the streamer, two opposed control surfaces projecting outwardly from the body, each control surface being rotatable about an axis which in use extends transversely of the streamer, and control means responsive to control signals and the sensor means for independently adjusting the respective angular positions of said two control surfaces so as to control the lateral position of the streamer as well as its depth.

In a preferred embodiment of the invention, for use with a multi-section streamer which includes an electric power line, the control means is at least partly electrical and arranged in use to receive electric power from said electric power line.

When the streamer also includes a control line, the control means is preferably arranged in use to receive control signals from the control line.

The control means preferably includes at least one electrical motor, and may also include means for sensing the respective angular positions of the two control surfaces.

Conveniently, said two control surfaces rotate about a common axis.

Advantageously, each of the two control surfaces comprises a respective wing-like member which is swept back with respect to the direction of tow of the streamer.

Preferably, said control surfaces are releasably secured to the body, which may be adapted to be non-rotatably coupled to the streamer.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described, by way of example only, with reference to the accompanying drawings, of which:

FIG. **1** is a somewhat schematic representation of a preferred embodiment of a streamer control device in accordance with the present invention;

FIG. **2** is a simple schematic of a control system forming part of the streamer control device of FIG. **1**; and

FIGS. **3** to **5** illustrate the operation of the streamer control device of FIG. **1**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The streamer control device, or "bird", of FIG. **1** is indicated generally at **10**, and comprises an elongate streamlined body **12** adapted to be mechanically and electrically connected in series in a multi-section marine seismic streamer **14** of the kind which is towed by a seismic survey vessel and which is used, in conjunction with a seismic source also towed by the vessel, to conduct seismic surveys, as briefly described hereinbefore. To permit such connection, each end of the body **12** is provided with a respective mechanical and electrical connector **16**, **18**, these connectors being complementary to, and designed to interconnect with, streamer end connectors **20**, **22** respectively which are normally used to join together adjacent sections **14***a* and **14***b* of the streamer **14**.

The bird **10** is provided with two opposed control surfaces, or wings, **24**, typically moulded from a fibre-reinforced plastics material, which project horizontally outwardly from the body **12** and which are independently rotatable about a common axis extending substantially perpendicularly through the longitudinal axis of the body. Rotation of the wings **24** is effected under the control of a control system **26** sealingly housed within the body **12**. The wings **24** are generally ogival (ie rounded) and swept back with respect to the direction of tow of the streamer **14** (which direction is indicated by the arrow **28**), in order to reduce the possibility of debris becoming hooked on them. To facilitate their rapid removal and reattachment, the wings **24** are secured to body **12** by a quick-release attachment **30**.

As mentioned hereinbefore, the streamer **14** includes hydrophones distributed along its length; it also includes control and conversion circuitry for converting the outputs of the hydrophones into digital data signals, longitudinally extending control and data lines for conducting control and data signals to and from the control and conversion circuitry, and electrical power supply lines for supplying electrical power from the vessel to the circuitry. All these lines are coupled together from the streamer section **14***a* to the streamer section **14***b* via respective corresponding lines **32** which extend through the body **12** of the bird **10** between the connectors **16**, **18**. Additionally, the control system **26** is connected to receive control signals and electric power from respective ones of the lines **32**.

The greater part of the length of the body **12** of the bird **10** is flexible, the only rigid parts being the connectors **20**, **22**, and a short central section which houses the control system **26** and from which the wings **24** project. This central section, which is made of aluminium or titanium and has holes passing longitudinally therethrough for the passage of Kevlar or other stress members which bear the longitudinal loads on the body **12**, is kept as short as possible, typically around 40 cm, so that once the wings **24** have been detached from the body **12**, the streamer **14** can be wound onto and unwound from the large drum used for storing the streamer, with the body **12** still connected in the streamer. The quick-release attachment **30** permits the removal and attachment of the wings **24** to be at least partly automated as the streamer **14** is reeled in and out during the survey.

The reason for providing the elongate flexible parts of the body **12** is to provide enough length for the inclusion of one or more hydrophones or hydrophone groups, should this be necessary to preserve a desired uniform hydrophone spacing along the length of streamer **14**. If no hydrophones need to be included, the flexible parts of the body **12** can be omitted altogether, along with the aforementioned stress members.

The control system **26** is schematically illustrated in FIG. **2**, and comprises a microprocessor-based control circuit **34** having respective inputs **35** to **39** to receive control signals representative of desired depth, actual depth, desired lateral position, actual lateral position and roll angle of the bird **10** (ie the angular position of the body **12** in a plane perpendicular to the longitudinal axis of the streamer **14**). The desired depth signal can be either a fixed signal corresponding to the aforementioned 10 meters, or an adjustable signal, while the actual depth signal is typically produced by a depth sensor **40** mounted in or on the bird **10**. The lateral position signals are typically derived from a position determining system of the kind described in our U.S. Pat. No. 4,992,990 or our International Patent Application No WO9621163. The roll angle signal is produced by an inclinometer **42** mounted within the bird **10**.

The control circuit **34** has two control outputs **44**, **46**, connected to control respective electrical stepper motors **48**, **50**, each of which is drivingly connected to a respective one of the wings **24**. The stepper motors **48**, **50** have respective outputs at which they produce signals representative of their respective current angular positions (and therefore of the current angular positions of the wings **24**), which outputs are connected to respective control inputs **52**, **54** of the control circuit **34**.

In operation, the control circuit **34** receives between its inputs **35** and **36** a signal indicative of the difference between the actual and desired depths of the bird **10**, and receives between its inputs **37** and **38** a signal indicative of the difference between the actual and desired lateral positions of the bird **10**. These two difference signals are used by the control circuit **34** to calculate the roll angle of the bird **10** and the respective angular positions of the wings **24** which together will produce the necessary combination of vertical force (upwardly or downwardly) and lateral force (left or right) required to move the bird **10** to the desired depth and lateral position. The control circuit **34** then adjusts each of the wings **24** independently by means of the stepper motors **48**, **50**, so as to start to achieve the calculated bird roll angle and wing angular positions.

FIGS. **3** to **5** illustrate the operation of the bird **10** in the case where the streamer **14** is slightly heavy (slightly negative buoyancy), and the bird **10** thus needs to produce lift to maintain the streamer at the desired depth. This lift is produced by the flow of the water over the wings **24** of the bird **10**, resulting from the 5 knot towing speed of the streamer **14** through the water, and can be changed by changing the angle of attack of the wings with respect to the flow. The magnitude of the lift required for the situation envisaged by FIG. **3** is indicated by the length of the arrows **60**.

If the streamer **14** now needs to be moved laterally to the right (as viewed in FIGS. **3** to **5**), the angular position of the left wing **24** of the bird **10** is first adjusted to increase its lift, while the angular position of the right wing is adjusted to decrease its lift, as represented by the length of the arrows **64** in FIG. **4**, thus causing the bird **10** to roll clockwise from the position shown in FIG. **3** to the position shown in FIG. **4**. This clockwise roll continues until the bird **10** reaches the steady state condition shown in FIG. **5**, where it can be seen that the vertical component of the lift produced by the wings **24**, indicated by the arrows **66**, is equal to the lift represented by the arrows **60** of FIG. **3** required to maintain the streamer **14** at the desired depth, while the much larger horizontal component, represented by the arrows **68**, moves the streamer **14** to the right.

While adjusting the angular positions of the wings **24** of the bird **10**, the control circuit **34** continuously receives signals representative of the actual angular positions of the wings from the stepper motors **48**, **50**, as well as a signal representative of the actual roll angle of the bird from the inclinometer **42**, to enable it to determine when the calculated wing angular positions and bird roll angle have been reached. And as the aforementioned difference signals at the inputs **35** to **38** of the control circuit **34** reduce, the control circuit repeatedly recalculates the progressively changing values of the roll angle of the bird **10** and the angular positions of the wings **24** required for the bird and streamer reach the desired depth and lateral position, until the bird and streamer actually reach the desired depth and lateral position.

The body of the bird **10** does not rotate with respect to the streamer **14**, and thus twists the streamer as it rolls. The streamer **14** resists this twisting motion, so acting as a kind of torsion spring which tends to return the bird **10** to its normal position (ie with the wings **24** extending horizontally). However, this spring returning action, though beneficial, is not essential, and the bird **10** can if desired be designed to rotate to a certain extent with respect to the axis of the streamer **14**.

It will be appreciated that the bird **10** has several important advantages with respect to prior art birds. Its in-line connection in the streamer **14** not only reduces the noise it generates as the streamer is towed through the water, but also enables it to derive power and control signals via the streamer and so obviates the need for batteries (although they may still be provided if desired for back-up purposes). But most importantly, it enables the horizontal or lateral position of the streamer **14** to be controlled, and not just its depth.

Another significant advantage of the bird **10** is that by virtue of the shortness of the stiff parts of the respective body **12** and the easily detachable wings **24**, it does not need to be removed from the streamer **14** during winding and unwinding. This saves a considerable amount of time when carrying out the seismic survey.

Many modifications can be made to the bird **10**. For example, the wings **24** can be staggered slightly along the length of the body **12**, in order to provide slightly more room for their respective drive trains. Additionally, the electric motors **48**, **50** can be replaced by hydraulic actuators.

What is claimed is:

1. A control device for controlling the position of a marine seismic streamer, the device comprising:

a body mechanically adapted to be connected in series between two adjacent sections of the streamer;

sensor means in the body for determining its angular position in a plane approximately perpendicular to the longitudinal axis of the streamer;

two opposed control surfaces projecting outwardly form the body, each control surface being rotatable about an axis which extends transversely of the streamer; and

control means responsive to control signals and the sensor means for independently adjusting the respective angular positions of said two control surfaces so as to control the lateral position of the streamer as well as its depth.

2. The control device of claim **1**, wherein the marine seismic streamer is a multi-section streamer that includes an electric power line, the control device further comprising an electrical connection means capable of connecting to the electric power line, wherein the control means is at least partly electrical and arranged in use to receive electrical power from the electric power line.

3. The control device of claim **1**, wherein the marine seismic streamer includes a control line, the control device further comprising a control line connection, wherein the control means is arranged in use to receive control signals from the control line.

4. The control device of claim **1**, wherein the two control surfaces are releasably secured to the body.

5. The control device of claim **1**, wherein the two control surfaces are secured to the body by quick-release attachments.

6. The control device of claim **5**, wherein the body is adapted to be wound onto a streamer drum while still connected to the steamer.

7. The control device of claim **1**, wherein the body is at least partly flexible.

8. The control device of claim **1**, wherein the body is of approximately the same diameter as the streamer.

9. The control device of claim **1**, wherein the control means includes at least one electrical motor.

10. The control device of claim **1**, wherein the control means includes at least one hydraulic actuator.

11. The control device of claim **1**, wherein the control means includes means for sensing the angular position of each of the two control surfaces.

12. The control device of claim **1**, wherein the two control surfaces rotate about a common axis.

13. The control device of claim **1**, wherein each of the two control surfaces comprises a respective wing-like member that is swept back with respect to the direction of tow of the streamer.

14. The control device of claim **1**, wherein the body is adapted to be non-rotatably coupled to the streamer.

15. The control device of claim **1**, wherein the central section is constructed of material selected from aluminum, titanium, and combinations thereof.

16. The control device of claim **1**, wherein the one or more elongate sections providing length for inclusion of one or more hydrophones.

17. The control device of claim **1**, wherein the control means further comprises:

a control circuit in communication with means for determining a depth of the control device, means for determining a lateral position of the control device, and means for determining a roll angle.

18. The control device of claim **17**, wherein the control circuit is microprocessor-based.

19. The control device of claim **17**, wherein the control circuit comprises at least two control outputs, each control output being connected to respective means to independently adjust the angular positions of each of the control surfaces.

20. A control device for controlling the position of a marine seismic streamer, the device comprising:

a body mechanically adapted to be coupled to the streamer;

two opposed control surfaces projecting outwardly form the body, each control surface being rotatable about an axis which extends transversely of the streamer; and

control means responsive to control signals for independently adjusting the respective angular positions of said control surfaces so as to control the lateral position of the streamer as well as the depth.

21. The control device of claim **20**, further comprising:

sensor means in the body for determining the angular position of the body in a plane approximately perpendicular to the longitudinal axis of the streamer, wherein the control means is responsive to the sensor means.

22. The control device of claim **20**, wherein the two control surfaces are releasably secured to the body.

23. The control device of claim **20**, wherein the two control surfaces are secured to the body by quick-release attachments.

24. The control device of claim **23**, wherein the body is adapted to be wound onto a streamer drum while still connected to the streamer.

25. The control device of claim **20**, wherein the control means includes at least one electrical motor.

26. The control device of claim **20**, wherein the control means includes at least one hydraulic actuator.

27. The control device of claim **20**, wherein the two control surfaces rotate about a common axis.

28. The control device of claim **20**, wherein each of the two control surfaces comprises a respective wing-like member that is swept back with respect to the direction of tow of the streamer.

29. The control device of claim **20**, wherein the body is adapted to be non-rotatably coupled to the streamer.

* * * * *

US006671223C1

(12) INTER PARTES REEXAMINATION CERTIFICATE (0065th)
United States Patent
Bittleston

(10) Number: US 6,671,223 C1
(45) Certificate Issued: May 12, 2009

(54) **CONTROL DEVICES FOR CONTROLLING THE POSITION OF A MARINE SEISMIC STREAMER**

(75) Inventor: **Simon Hastings Bittleston**, Slependen (NO)

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

Reexamination Request:
No. 95/000,078, Feb. 23, 2005

Reexamination Certificate for:
Patent No.: **6,671,223**
Issued: **Dec. 30, 2003**
Appl. No.: **09/893,234**
Filed: **Jun. 26, 2001**

Related U.S. Application Data

(63) Continuation of application No. 09/284,030, filed as application No. PCT/GB1997/003507 on Dec. 19, 1997, now abandoned.

(30) **Foreign Application Priority Data**

Dec. 20, 1996 (GB) 9626442

(51) **Int. Cl.**
G01V 1/38 (2006.01)
B63G 8/14 (2006.01)

(52) **U.S. Cl.** **367/19**; 114/245
(58) **Field of Classification Search** 367/16, 367/17, 18, 19
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,375,800	A	4/1968	Cole et al.
3,412,705	A	11/1968	Nesson
3,434,446	A	3/1969	Cole
3,434,451	A	3/1969	Brainard, II
3,440,992	A	4/1969	Chance
3,560,912	A	2/1971	Spink et al.
3,605,674	A	9/1971	Weese
3,648,642	A	3/1972	Fetrow et al.
3,896,756	A	7/1975	Pearson et al.
3,931,608	A	1/1976	Cole
3,943,483	A	3/1976	Strange
3,961,303	A	6/1976	Paitson
4,033,278	A	7/1977	Waters

(Continued)

FOREIGN PATENT DOCUMENTS

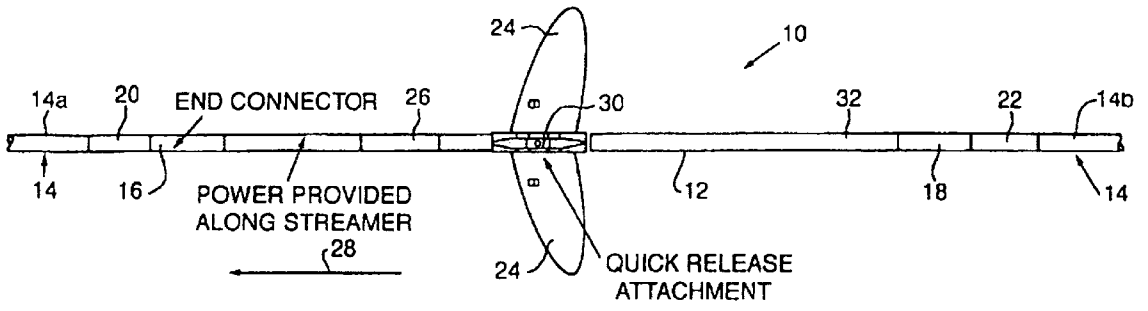
AU	734810	7/1998
CA	2270719	7/1998
DE	69702673	4/2001
EP	0193215	1/1986
EP	0319716	6/1989
EP	0321705	6/1989
EP	0390987	10/1990
EP	0525391	2/1993
EP	0581441	2/1994
EP	0613025	8/1994
EP	0613025	9/1998
EP	0909701	4/1999
GB	2093610	9/1982
GB	2122562	1/1984
GB	9656442.9	12/1998
GB	2331971	6/1999
GB	2342081	4/2000
NO	992701	6/1999
WO	WO 95/31735	11/1995
WO	WO 96/21163	7/1996
WO	WO 97/11395	3/1997

(Continued)

Primary Examiner—Peter C. English

(57) **ABSTRACT**

A control device or "bird" for controlling the position of a marine seismic streamer is provided with an elongate, partly flexible body which is designed to be electrically and mechanically connected in series with a streamer. In its preferred form, the bird has two opposed wings which are independently controllable in order to control the streamer's lateral position as well as its depth.



U.S. PATENT DOCUMENTS

4,063,213	A		12/1977	Itria et al.
4,087,780	A		5/1978	Itria et al.
4,222,340	A		9/1980	Cole
4,227,479	A		10/1980	Gertler et al.
4,290,124	A		9/1981	Cole
4,313,392	A		2/1982	Guenther et al.
4,323,989	A		4/1982	Huckabee et al.
4,404,664	A		9/1983	Zachariadis
4,463,701	A		8/1984	Pickett et al.
4,484,534	A		11/1984	Thillaye du Boullay
4,676,183	A		6/1987	Conboy
4,694,435	A		9/1987	Magneville
4,709,355	A		11/1987	Woods et al.
4,723,501	A		2/1988	Hovden et al.
4,729,333	A		3/1988	Kirby et al.
4,766,441	A		8/1988	Phillips et al.
4,767,183	A		8/1988	Martin
4,843,996	A		7/1989	Darche
4,890,568	A		1/1990	Dolengowski
4,890,569	A		1/1990	Givens
5,042,413	A		8/1991	Benoit
5,052,814	A		10/1991	Stubblefield
5,507,243	A		4/1996	Williams et al.
5,517,202	A		5/1996	Patel et al.
5,517,463	A		5/1996	Hornbostel et al.
5,529,011	A		6/1996	Williams, Jr.
5,532,975	A		7/1996	Elholm
5,642,330	A		6/1997	Santopietro
5,790,472	A		8/1998	Workman et al.
5,927,606	A		7/1999	Patterson
6,011,752	A		1/2000	Ambs et al.
6,016,286	A		1/2000	Olivier et al.
6,142,091	A	*	11/2000	Henriksen 114/245
6,144,342	A		11/2000	Bertheas et al.
6,459,653	B1		10/2002	Kuche
6,525,992	B1		2/2003	Olivier et al.
6,549,653	B1		4/2003	Osawa et al.
6,879,542	B2		4/2005	Soreau et al.

FOREIGN PATENT DOCUMENTS

WO	WO 97/30361		8/1997
WO	WO 97/45006 A1	*	12/1997
WO	WO 97/45006		12/1997
WO	WO 98/28636		7/1998
WO	WO 99/04293		1/1999

* cited by examiner

INTER PARTES REEXAMINATION CERTIFICATE ISSUED UNDER 35 U.S.C. 316

THE PATENT IS HEREBY AMENDED AS INDICATED BELOW.

Matter enclosed in heavy brackets [ ] appeared in the patent, but has been deleted and is no longer a part of the patent; matter printed in italics indicates additions made to the patent.

ONLY THOSE PARAGRAPHS OF THE SPECIFICATION AFFECTED BY AMENDMENT ARE PRINTED HEREIN.

Column 1, lines 5–6:

This is a Continuation of U.S. patent application Ser. No. 09/284,030 filed on Apr. 6, 1999, now abandoned, *which is a National Stage of International Application No. PCT/GB97/03507, filed Dec. 19, 1997.*

AS A RESULT OF REEXAMINATION, IT HAS BEEN DETERMINED THAT:

Claims **10**, **15** and **26** are cancelled.

Claims **1**, **16** and **20** are determined to be patentable as amended.

Claims **2–9**, **11–14**, **17–19**, **21–25** and **27–29**, dependent on an amended claim, are determined to be patentable.

New claims **30–66** are added and determined to be patentable.

1. A control device for controlling the position of a marine seismic streamer, the device comprising:

a body mechanically adapted to be connected in series between two adjacent sections of the streamer;

sensor means in the body for determining its angular position in a plane approximately perpendicular to the longitudinal axis of the streamer;

two opposed control surfaces projecting outwardly **[**form**]** *from* the body, each control surface being rotatable about an axis which extends transversely of the streamer; and

control means responsive to control signals and the sensor means for independently adjusting the respective angular positions of said two control surfaces so as to control the lateral position of the streamer as well as its depth.

16. The control device of claim **1**, wherein the *body includes* one or more elongate sections providing length for inclusion of one or more hydrophones.

20. A control device for controlling the position of a marine seismic streamer, the device comprising:

a body mechanically adapted to be coupled to the streamer;

two opposed control surfaces projecting outwardly **[**form**]** *from* the body, each control surface being rotatable about an axis which extends transversely of the streamer; and

control means responsive to control signals for independently adjusting the respective angular positions of said control surfaces so as to control the lateral position of the streamer as well as the depth.

30. The control device of claim 1, wherein the body is flexible except for portions that connect the body to the streamer and a central section which houses said control means.

31. The control device of claim 1, wherein the control surfaces project horizontally outwardly from the body.

32. The control device of claim 1, wherein the control surfaces rotate about a common axis extending substantially perpendicularly through a longitudinal axis of the body.

33. The control device of claim 29, wherein said control signals are received from lines which extends through said body and are adapted to connect with control lines within the streamer.

34. The control device of claim 33, further comprising an electrical connector adapted to connect with and receive electrical power from the electrical power lines within the streamer.

35. The control device of claim 29, further comprising an electrical connector adapted to connect with and receive electrical power from the electrical power lines within the streamer.

36. The control device of claim 20, wherein said body is adapted to be connected in series between two adjacent sections of the streamer.

37. The control device of claim 36, wherein said body includes respective end portions each provided with a mechanical connector adapted to connect to one of said two adjacent sections of the streamer, thereby joining together said two adjacent sections of the streamer.

38. The control device of claim 37, wherein said control signals are received from the lines which extend through said body and are adapted to connect with control lines within the streamer.

39. The control device of claim 38, further comprising an electrical connector adapted to connect with and receive electrical power from electrical power lines within the streamer.

40. The control device of claim 37, further comprising an electrical connector adapted to connect with and receive electrical power from electrical power lines within the streamer.

41. The control device of claim 36, wherein said control signals are received from lines which extend through said body and are adapted to connect with control lines within the streamer.

42. The control device of claim 41, further comprising an electrical connector adapted to connect with and receive electrical power from electrical power lines within the streamer.

43. The control device of claim 36, further comprising an electrical connector adapted to connect with and receive electrical power from electrical power lines within the streamer.

44. The control device of claim 20, wherein the body is flexible except for portions that connect the body to the streamer and a central section which houses said control means.

45. The control device of claim 20, wherein the control surfaces project horizontally outwardly from the body.

46. The control device of claim 20, wherein the control surfaces rotate about a common axis extending substantially perpendicularly through a longitudinal axis of the body.

47. A control device for controlling the position of a marine seismic streamer, the device comprising:

a body mechanically adapted to be connected in series between two adjacent sections of the streamer, wherein said body includes respective end portions each pro-

vided with a mechanical connector adapted to connect to one of said two adjacent sections of the streamer, thereby joining together said two adjacent sections of the streamer;

sensor means in the body for determining its angular position in a plane approximately perpendicular to the longitudinal axis of the streamer;

two opposed control surfaces projecting outwardly from the body, each control surface being rotatable about an axis which extends transversely of the streamer; and

control means responsive to control signals and the sensor means for independently adjusting the respective angular positions of said two control surfaces so as to control the lateral position of the streamer as well as its depth.

48. The control device of claim 47, wherein the marine seismic streamer is a multi-section streamer that includes an electric power line, the control device further comprising an electrical connector adapted to connect to the electric power line, wherein the control means receives electrical power from the electric power line.

49. The control device of claim 47, wherein the marine seismic streamer includes a control line, the control device further comprising a control line connection, wherein the control means is configured to receive control signals from the control line.

50. The control device of claim 47, wherein the two control surfaces are releasably secured to the body.

51. The control device of claim 47, wherein the two control surfaces are secured to the body by quick-release attachments.

52. The control device of claim 51, wherein the body is adapted to be wound onto a streamer drum while still connected to the streamer.

53. The control device of claim 47, wherein the body is at least partly flexible.

54. The control device of claim 47, wherein the body is of approximately the same diameter as the streamer.

55. The control device of claim 47, wherein the control means includes at least one electrical motor.

56. The control device of claim 47, wherein the control means includes means for sensing the angular position of each of the two control surfaces.

57. The control device of claim 47, wherein the two control surfaces rotate about a common axis.

58. The control device of claim 47, wherein each of the two control surfaces comprises a respective wing-like member that is swept back with respect to the direction of tow of the streamer.

59. The control device of claim 47, wherein the body is adapted to be non-rotatably coupled to the streamer.

60. The control device of claim 47, wherein the body includes one or more elongate sections providing length for inclusion of one or more hydrophones.

61. The control device of claim 47, wherein the control means further comprises:

a control circuit in communication with means for determining a depth of the control device, means for determining a lateral position of the control device, and means for determining a roll angle.

62. The control device of claim 61, wherein the control circuit is microprocessor-based.

63. The control device of claim 62, wherein the control circuit comprises at least two control outputs, each control output being connected to respective means for independently adjusting angular positions of each of the control surfaces.

64. The control device of claim 47, wherein the body is flexible except for the mechanical connectors that connect the body to the streamer and a central section which houses said control means.

65. The control device of claim 47, wherein the control surfaces project horizontally outwardly from the body.

66. The control device of claim 47, wherein the control surfaces rotate about a common axis extending substantially perpendicularly through a longitudinal axis of the body.

* * * * *