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Workman et al.

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[54] **ADAPTIVE CONTROL OF MARINE SEISMIC STREAMERS**

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[21] Appl. No.: **771,049**

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[51] **Int. Cl.**[6] **G01V 1/38**

[52] **U.S. Cl.** **367/19**; 367/16

[58] **Field of Search** 367/16, 19, 20, 367/106, 130, 17; 114/253

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,931,608	1/1976	Cole	340/7 PC
4,033,278	7/1977	Waters	144/245
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4,463,701	8/1984	Pickett et al.	114/245
4,729,333	3/1988	Kirby et al.	114/244
4,809,005	2/1989	Counselman	342/352
4,890,568	1/1990	Dolengowski	114/246
4,912,682	3/1990	Norton, Jr. et al.	367/19
5,031,159	7/1991	Rouquette	367/130
5,353,223	10/1994	Norton et al.	364/421
5,443,027	8/1995	Owsley et al.	114/244
5,532,975	7/1996	Elholm	367/16

OTHER PUBLICATIONS

M. Schoenberger and J. F. Misfud, "Hydrophone Streamer Noise", Geophysics, vol. 39, No. 6, pp. 781–793.

Franklyn K. Levin in "Short Note: The Effect of Binning on Data from a Feathered Streamer", Geophysics, vol. 49, No. 8, pp. 1386–1387.

Mamdouh R. Gadallah, "Reservoir Seismology", Pennwell, 1994, pp. 209–237.

Manin et al., "Recent Developments in Source and Streamer Positioning" First Break, vol. 6, pp. 183–188, Jun. 1981.

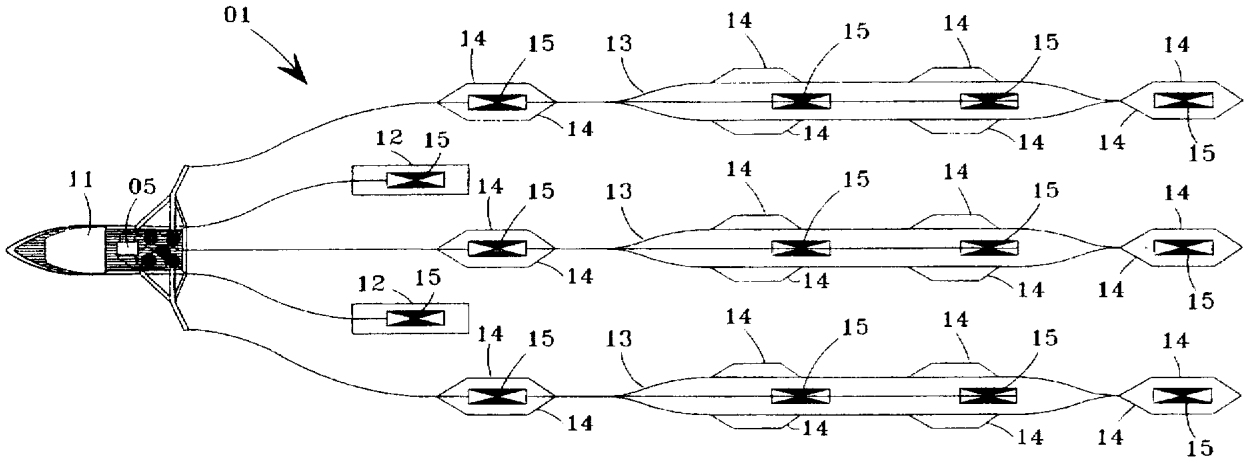
Primary Examiner—Ian J. Lobo

Attorney, Agent, or Firm—James Randall Allen; Charles R. Schweppe

[57] **ABSTRACT**

A method for controlling the position and shape of marine seismic streamer cables, whereby a plurality of real time signals from a marine seismic data acquisition system and a plurality of threshold parameters from an input device are received. The real time signals are compared to the threshold parameters to determine if the streamer cables should be repositioned. The streamer cables are repositioned when the real time signals exceed the threshold parameters.

10 Claims, 3 Drawing Sheets



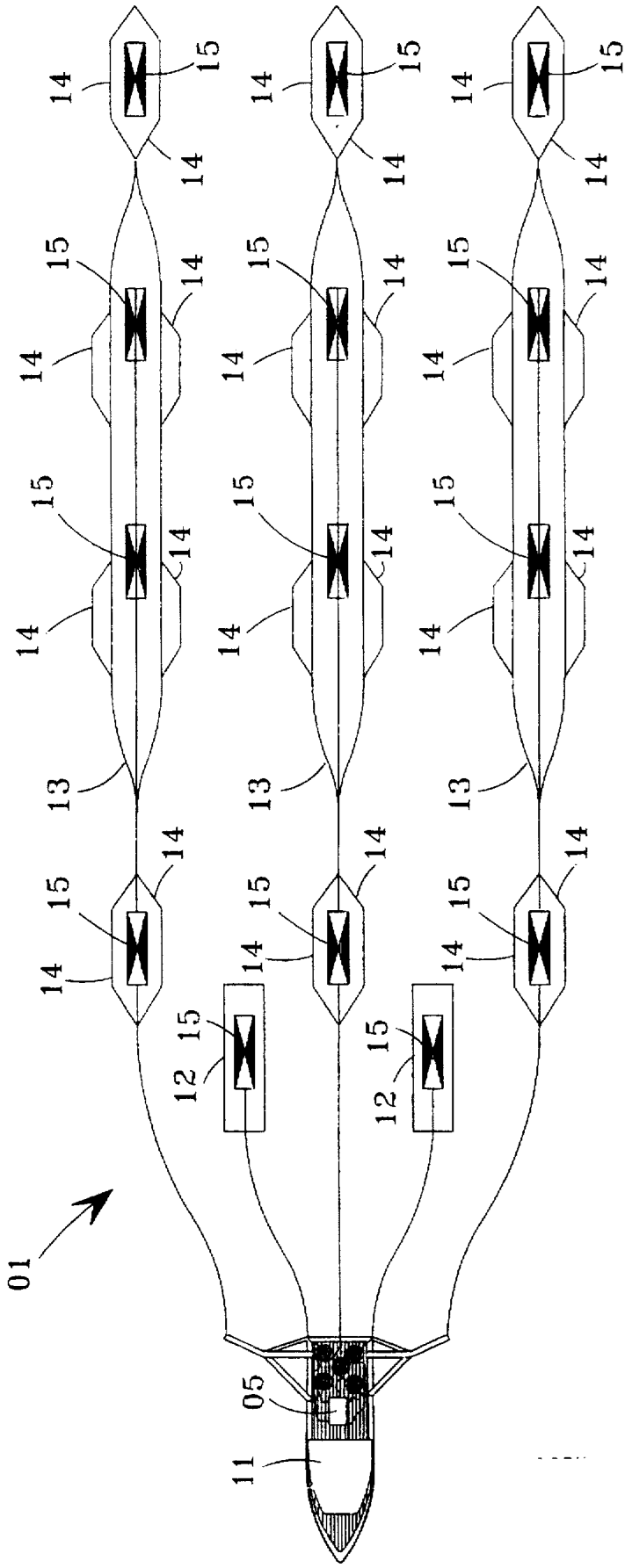


Fig. 1

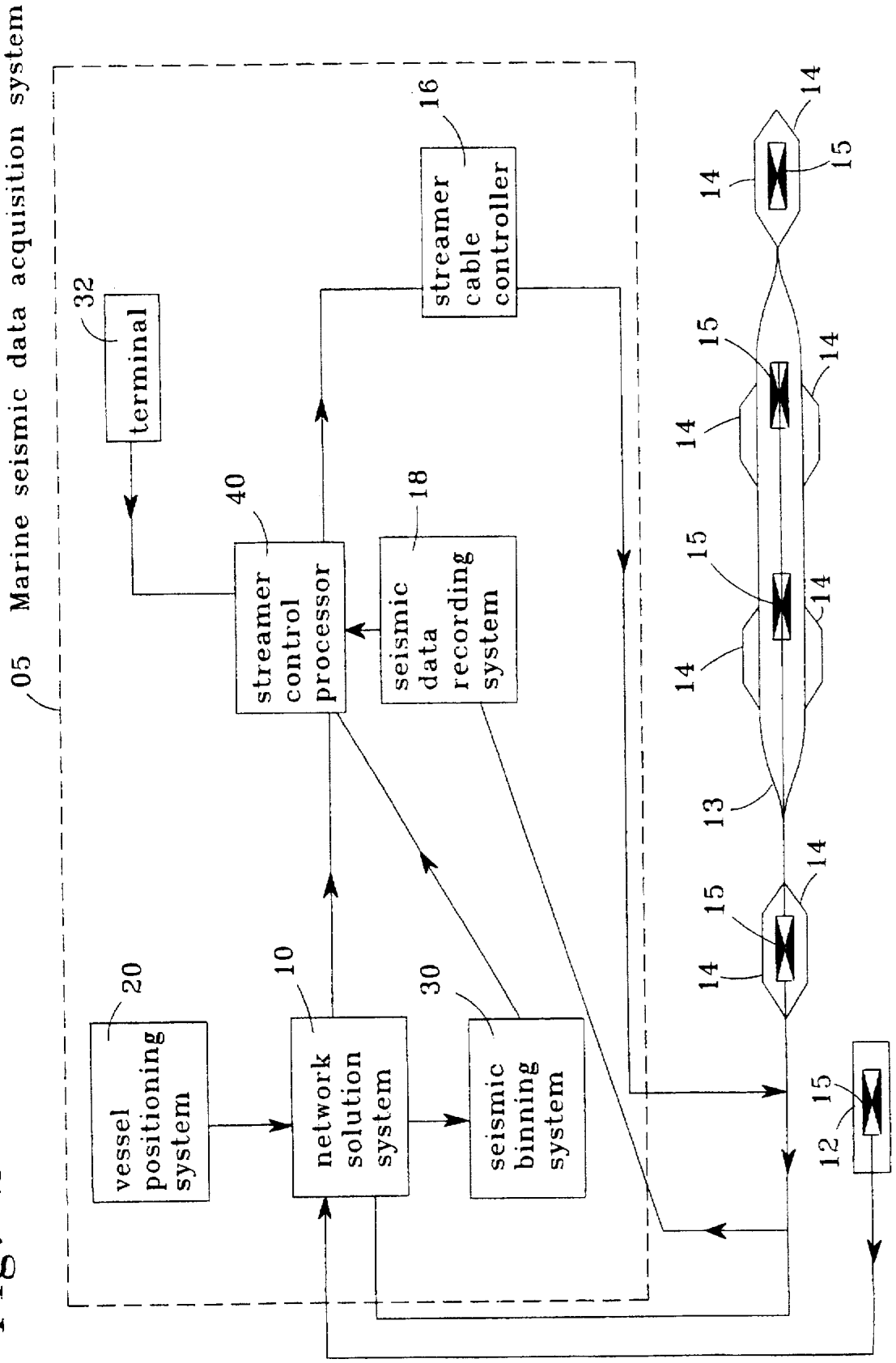


Fig. 2

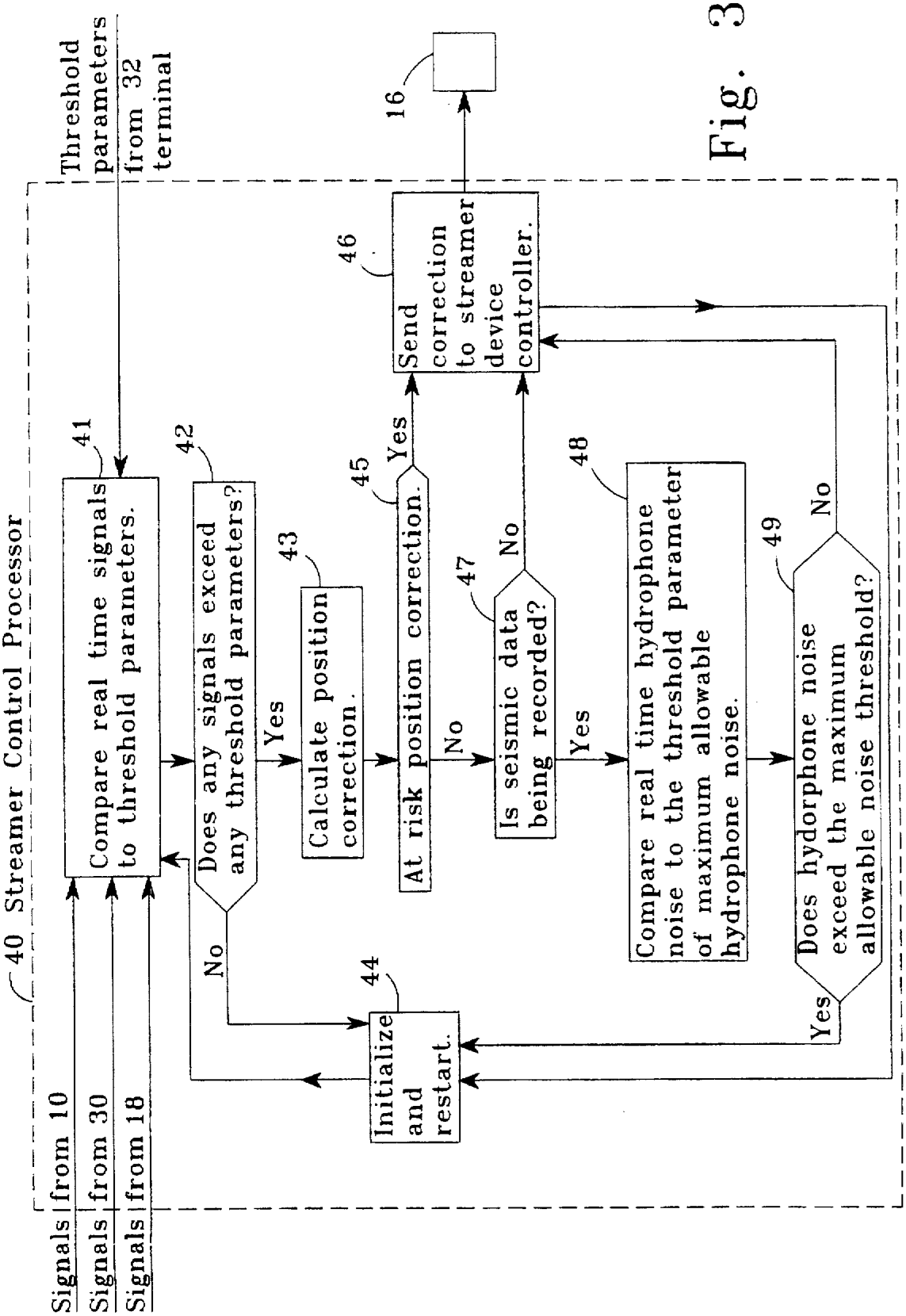


Fig. 3

ADAPTIVE CONTROL OF MARINE SEISMIC STREAMERS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to an improved system for controlling the position and shape of marine seismic streamers.

2. Description of the Related Art

During a typical marine seismic survey a seismic vessel traverses programmed tracks towing arrays of seismic sources and seismic streamer cables. A seismic streamer cable normally contains a plurality of hydrophones which convert seismic pressure waves, initiated by the sources and reflected from the subsurface geologic formations, into electrical signals which are recorded on a marine seismic data acquisition system located on the vessel. Due to the increasing use of marine 3-D seismic data, multi-cable marine surveys are now commonplace. During a typical marine 3-D seismic survey, a vessel may tow as many as ten streamer cables, each cable ranging in length between three to eight kilometers. As reported by Gadallah in "Reservoir Seismology" 1994, pp. 209–237, the goal of a normal marine 3-D seismic survey is to use these arrays of seismic sources and streamer cables to record a highly sampled grid of "bins" of subsurface seismic coverage.

A natural consequence of towing such streamer cable configurations in a marine environment is that currents, wind, and wave action will deflect the streamer cables from their intended paths. Streamer cable drift is a continuing problem for marine seismic surveys. See, for example, U.S. Pat. No. 5,532,975. The ability to control the position and shape of the streamer cables is desirable for preventing the entanglement of the streamer cables and for avoiding collisions with offshore hazards such as marine drilling rigs and platforms. It is also desirable to have the ability to control the position and shape of the streamer cables during marine 3-D seismic surveys because the 3-D seismic binning process acquires subsurface seismic coverage by combining seismic data from different lines. The need for this ability is taught by Franklyn K. Levin in "Short Note: The effect of binning on data from a feathered streamer," Geophysics, Vol. 49. No. 8, pp. 1386–1387.

Streamer positioning devices are well known in the art. Apparatus, such as those disclosed in U.S. Pat. Nos. 5,532,975, 4,729,333, and 4,463,701, have been devised for attachment to the front end of streamer cables for the purpose of maintaining them at a lateral offset to the pathway of the towing vessel. Steerable tail buoys, as described in U.S. Pat. No. 4,890,568, have also been designed for controlling the position of the tail end of towed seismic streamer cables. The prior art also discloses streamer positioning devices that may be attached externally to the streamer cables. For example, devices to control the lateral positioning of streamer cables by using camber-adjustable hydrofoils or angled wings are disclosed in U.S. Pat. Nos. 4,033,278 and 5,443,027. U.S. Pat No. 3,931,608 describes an apparatus, typically known as a "bird", to control the vertical positioning of streamer cables with diving planes and a preset depth control means.

The use of streamer positioning devices comes at the price of introducing increased noise onto the seismic streamer and hence into the hydrophones. The areas of greatest noise are from those hydrophones which are adjacent to externally attached streamer positioning devices, such as depth controlling birds. This problem has been described by Schoenberger and Misfud, "Hydrophone Streamer Noise" Geophysics, Vol. 39. No. 6, pp. 782–784. It is well known in the art that noise limits the resolution of a seismic survey. Consequently, a maximum allowable hydrophone noise level is typically established for each marine seismic surveying project. When this noise level is exceeded, seismic acquisition is usually suspended, resulting in lost time and additional cost. Data acquired under such conditions may need to be reshot.

Location sensing devices and methods for determining the positions of the seismic sources and seismic streamer cables are also well known in the art. For example, both a Global Positioning System, as described in U.S. Pat. No. 4,809,005, and a network of acoustic elements, as described in U.S. Pat. No. 4,912,682 may be deployed on the vessel, streamer cables, and tail buoy. These devices and methods may then be used to determine the real time position of the seismic sources and seismic streamer cables by computing a network solution to a Kalman filter, as disclosed by U.S. Pat. No. 5,353,223.

As is known to those familiar with the art of marine seismic surveying, during a typical survey a human operator monitors the survey's operational conditions, such as the extent of the subsurface seismic coverage, the adequacy of the separations between streamer cables, and the proximity of the streamer cables to obstructive hazards. When these conditions indicate the need to reposition the streamer cables, the operator may manually issue commands to the various individual streamer positioning devices in order to adjust the position and shape of the streamer cable, or order the helmsman to redirect the vessel, or suspend data acquisition.

While the prior art discloses a series of discrete devices for locating and controlling the positions of streamer cables, it does not teach any method or system wherein these individual devices are unified into a single system for controlling the position and shape of marine seismic streamer cables. Also, the prior art fails to disclose any method or system wherein the real time hydrophone noise on the streamer cables operates as a constraint on the control of the position and shape of marine seismic streamer cables.

The present invention overcomes the limitations of the prior art by providing an improved system for controlling the position and shape of marine seismic streamer cables.

SUMMARY OF THE INVENTION

The present invention is an improved system for controlling the position and shape of marine seismic streamer cables. First, a plurality of real time signals from a marine seismic data acquisition system and a plurality of threshold parameters from an input device are received. Second, the real time signals are compared to the threshold parameters to determine if the streamer cables should be repositioned. Finally, the streamer cables are repositioned when the real time signals exceed the threshold parameters.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a generalized schematic of a marine seismic survey system.

FIG. 2 shows a block diagram of a marine seismic data acquisition system in the improved system for controlling the position and shape of marine seismic streamer cables.

FIG. 3 shows a flow chart illustrating certain steps of a streamer control processor

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 illustrates a generalized schematic of a type of marine seismic survey system **01**. This system **01** has a

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