Ex. PGS 1011

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French

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[54] **CIRCULAR SEISMIC ACQUISITION SYSTEM**

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[51] **Int. Cl.**[3] **G01V 1/38**

[52] **U.S. Cl.** **367/15;** 367/130; 367/19; 367/117; 367/16

[58] **Field of Search** 367/15, 16, 19, 20, 367/21, 17, 117, 106, 130, 14

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Attorney, Agent, or Firm—Vaden, Eickenroht, Thompson, Bednar & Jamison

[57] **ABSTRACT**

A marine seismic survey is disclosed in which a plurality of steerage centers are selected for circular traversal thereabout by a marine vessel towing a streamer cable. While the vessel and the streamer are following a circular track about a steerage center, the feathering of the cable creates a separate concentric track line for each of the mid-points between the receivers included in the cable and the source. In this manner an areal coverage is assured which requires no reliance on unpredictable and uncontrollable currents for the desired feathering. An additional important feature of the current disclosure is that there is little wasted time in which the survey vessel moves outside of the overall surveyed area. A preferred course tracking for the vessel is to move from the arc of one steerage course line to another in tangential fashion.

6 Claims, 4 Drawing Figures

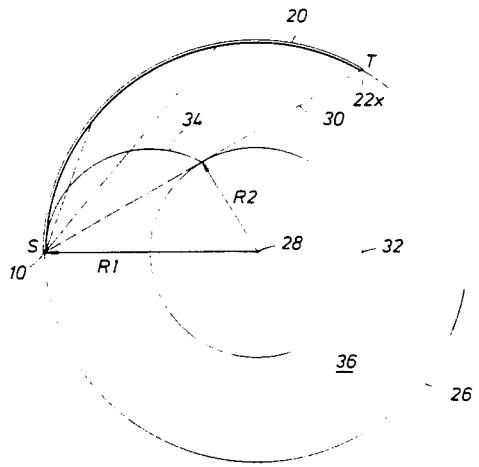


FIG.1

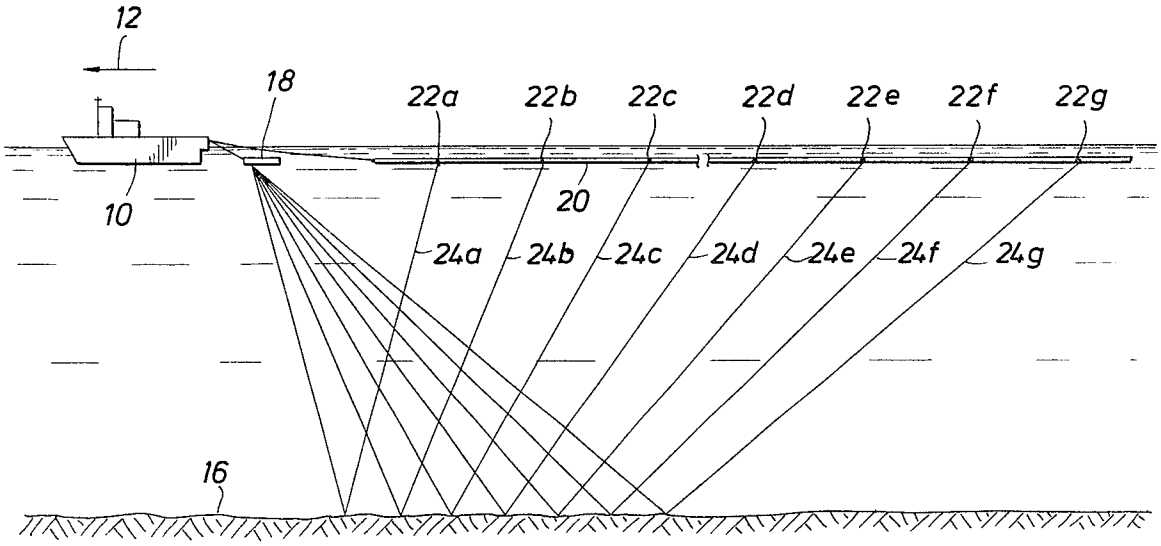
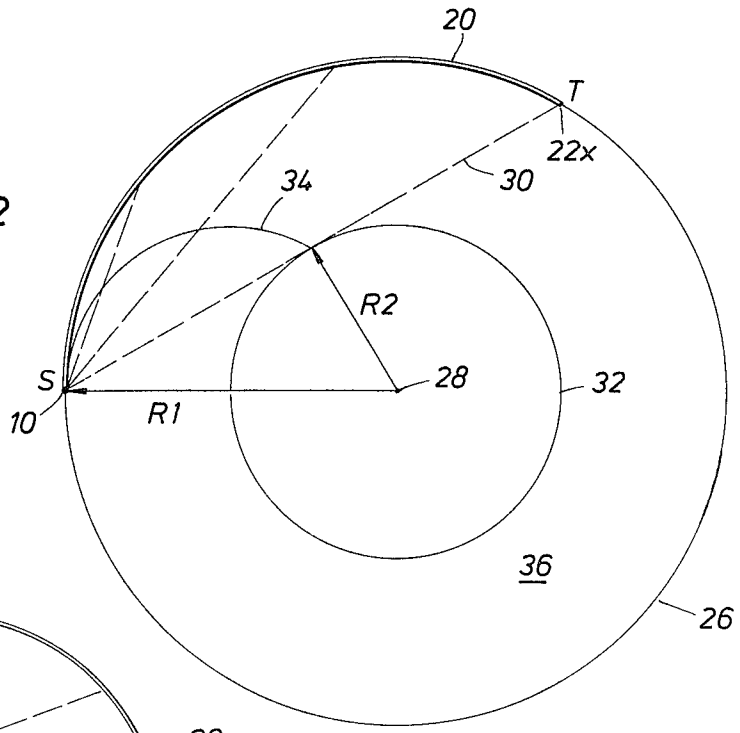


FIG.2



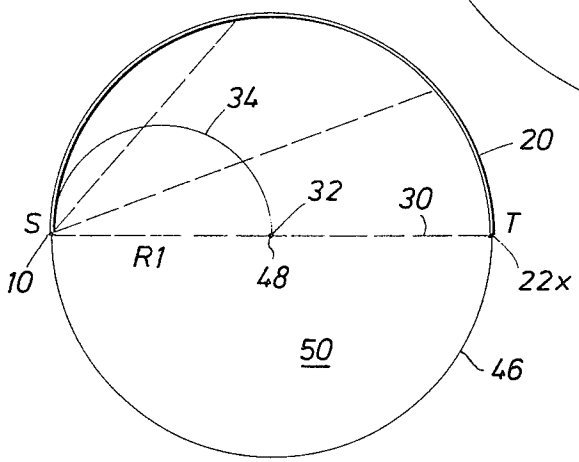
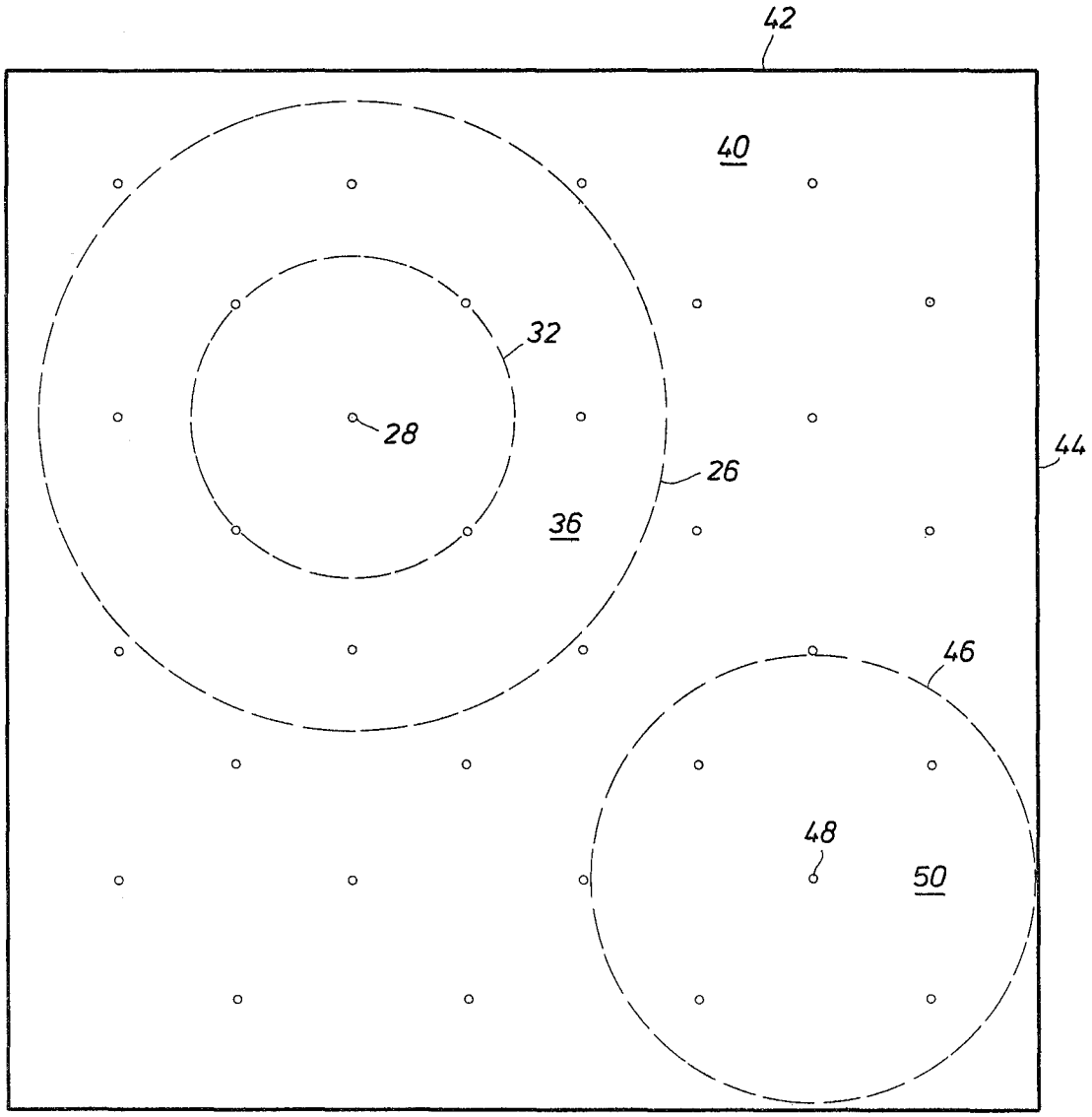


FIG.3

FIG. 4



CIRCULAR SEISMIC ACQUISITION SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention pertains to marine seismic acquisition procedures employing a towed streamer cable having a plurality of data receivers spaced therealong.

2. Description of the Prior Art

Marine seismic reflection surveys are traditionally developed by steering a marine vessel in a straight line while periodically firing an acoustic source closely associated with the vessel, usually towed just behind the vessel and positioned slightly below the surface of the water. A streamer cable towed by the vessel is also played out behind the vessel. The cable includes along its length a plurality of suitable acoustic receivers known as hydrophones for receiving and detecting acoustic seismic reflections. The hydrophones are normally clustered or grouped together, the groups of receivers usually being evenly spaced along the cable. The data gathered by the receivers reveals the condition of the geophysical terrain between the source and the respective receivers as the source is fired and the vessel traverses its course.

The processing of the developed data initially assumed that the ship, the source and the respective receivers spaced along the streamer cable were all located in a straight line with respect to the sea floor.

However, it was obvious that in practice, sea and wind currents caused the streamer cable to "feather" to one side or the other and not be towed directly behind the vessel. Therefore, the data line of tow for each of the data gathering elements had to be corrected for this feathering phenomenon or some erroneous data results would occur.

It was recognized, however, that when feathering did occur, there was an effective areal coverage to the data, rather than just a linear coverage. That is, the receivers tracked along parallel lines, and the mid-points, (assuming horizontal reflection layers in the terrain) between the source and the respective receivers also tracked parallel lines. Hence, schemes were developed to select line spacing, ship heading and speed with respect to the currents to take advantage of the areal coverage caused by feathering. Complex positioning schemes were developed to determine the actual location of each "receiver", which is understood to apply herein to what is really a group of individual receiver detectors, of the streamer. The design of surveys (line spacing, shooting direction and speed, number of lines, etc.) was made based upon assumptions of the currents.

The details of the ocean currents and, hence, the true streamer configuration are unfortunately unpredictable. Many surveys have failed to provide adequate areal coverage when based on predicted currents because the actual feathering of the streamer cable during the survey departed significantly from what was expected before the survey. To overcome the bad experience resulting from erratic feathering, acquisition of data has been performed by positioning the receivers and by tracking adjacent shot line courses of the vessel much closer together than is actually required by data processing. Of course, this significantly increases the cost of data acquisition in order to insure an adequate distribution of receiver locations over a surveyed area.

As mentioned above, areal marine seismic reflection surveys are presently conducted using a number of substantially equally spaced parallel vessel course lines. Usually, one-half of the lines are shot in one direction and one-half of the lines are shot in the opposite direction. Thus, upon finishing the shooting along one line, for example, west to east, the marine vessel comes about and a line is shot from east to west. The turns are made outside of the area of interest for the survey in order to acquire data from the entire area of interest. The time that the vessel is outside of the survey area represents wasted ship time as far as data acquisition is concerned.

Therefore, it is a feature of the present invention to gather marine seismic data in an improved manner wherein feathering of the streamer cable is controlled independently of sea and wind currents to insure accuracy of areal coverage.

It is another feature of the present invention to provide for the gathering of marine seismic data in an improved manner wherein the marine vessel rarely traverses outside of the area of survey interest during the taking of the survey and, therefore, there is little waste time as with prior art surveys, when the vessel is coming about.

SUMMARY OF THE INVENTION

The preferred method of gathering marine seismic data disclosed herein employs a marine vessel having associated therein a marine seismic source and a streamer cable having hydrophone or similar seismic receivers spaced therealong, in conventional fashion. Steerage centers are determined throughout the survey area. The vessel then tracks in at least partial circular arcs about such centers while creating seismic signals and detecting or receiving seismic reflections at each of the receivers along the streamer cable. Assuming horizontal geophysical reflecting properties, the mid-points between the source and each of the receivers track a circular or arcuate line about the steerage center, each mid-point tracking a slightly different concentric arc to thereby give areal coverage. The limits of the areal coverage about a single steerage center is determined by the line tracked by the mid-point between the source and the rearmost receiver carried by the cable.

Unpredictable ocean and wind currents will produce variations in ship and streamer positioning from the ideal circular design, but those variations will have a minor effect. The actual position of ship and streamer are recorded during the survey using commercially available technology, and such position information is used to correct the recorded data during subsequent processing.

Although it is acceptable to complete a circumferential circular coverage about a first steerage center and then the next until a complete areal survey has been taken, a preferred manner is to steer the vessel first partly around one center and then, in a tangential continuum around a successive steerage center in "S" like fashion and so forth until the entire area is covered. This is believed to be the quickest and easiest way to obtain comprehensive coverage of the entire survey area.

BRIEF DESCRIPTION OF THE DRAWINGS

So that the manner in which the above-recited features, advantages and objects of the invention, as well as others which will become apparent, are attained and can be understood in detail, more particular description of the invention briefly summarized above may be had by reference to the embodiment thereof which is illus-

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