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United States Patent [19]

Neeley

[11] **4,231,111**

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[54] **MARINE CABLE LOCATION SYSTEM**

[75] Inventor: **Walter P. Neeley,** Irving, Tex.

[73] Assignee: **Mobil Oil Corporation,** New York, N.Y.

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

[52] **U.S. Cl.** ..... **367/19;** 114/253; 343/5 EM; 367/106; 367/130

[58] **Field of Search** ..... 340/3 T, 7 R, 7 PC, 340/15.5 DS; 114/244, 253; 367/19, 106, 130; 343/5 EM

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,840,845	10/1974	Brown	340/7 R
3,953,827	4/1976	Moal et al.	340/7 R
3,981,008	9/1976	Mann	343/5 EM
4,068,208	1/1978	Rice, Jr. et al.	340/7 R
4,086,632	4/1978	Lions	343/112 PT

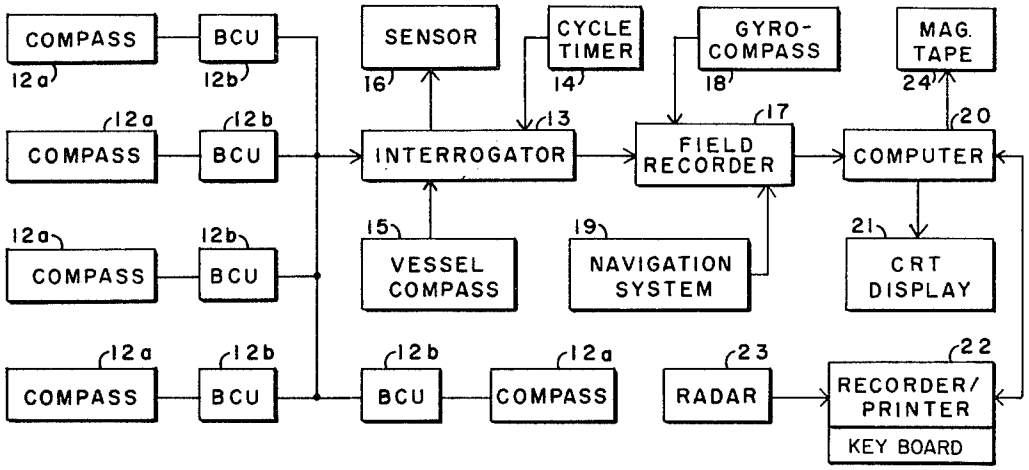
Primary Examiner—Stephen C. Buczinski

Attorney, Agent, or Firm—C. A. Huggett; William J. Scherback

[57] **ABSTRACT**

A marine cable location system includes a plurality of magnetic compasses located at known spaced intervals along a cable being towed by a marine vessel. These compass readings are recorded along with an onboard magnetic compass reading, an onboard gyrocompass reading, and satellite navigational information. From these recordings, the X-Y coordinates of cable compasses with respect to vessel heading are determined. These X-Y coordinates are recorded along with the vessel's position and heading on magnetic tape and a cathode-ray tube so as to provide a visual display of the cable position with respect to the vessel.

6 Claims, 5 Drawing Figures



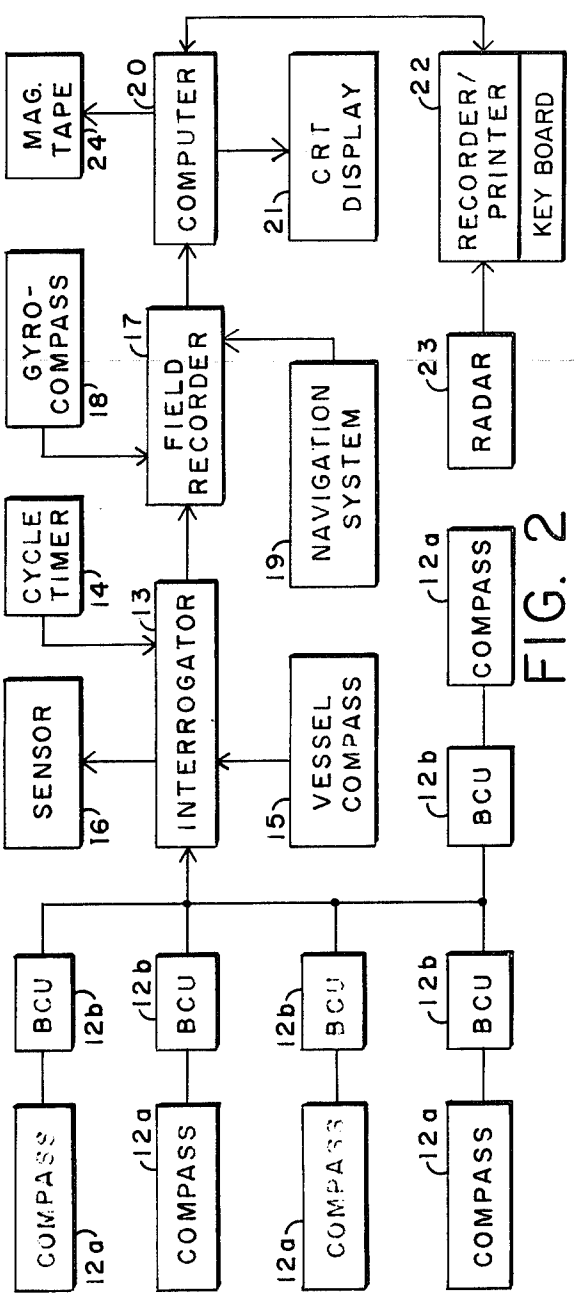


FIG. 2

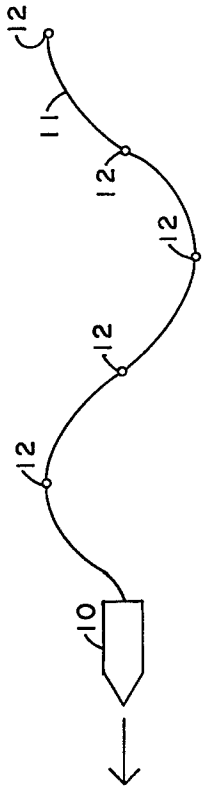


FIG. 1

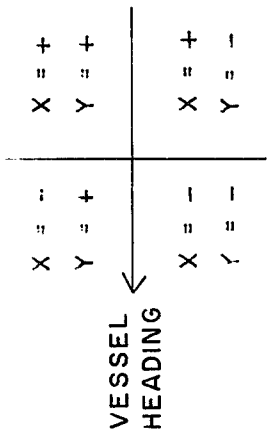


FIG. 5

FIG. 4

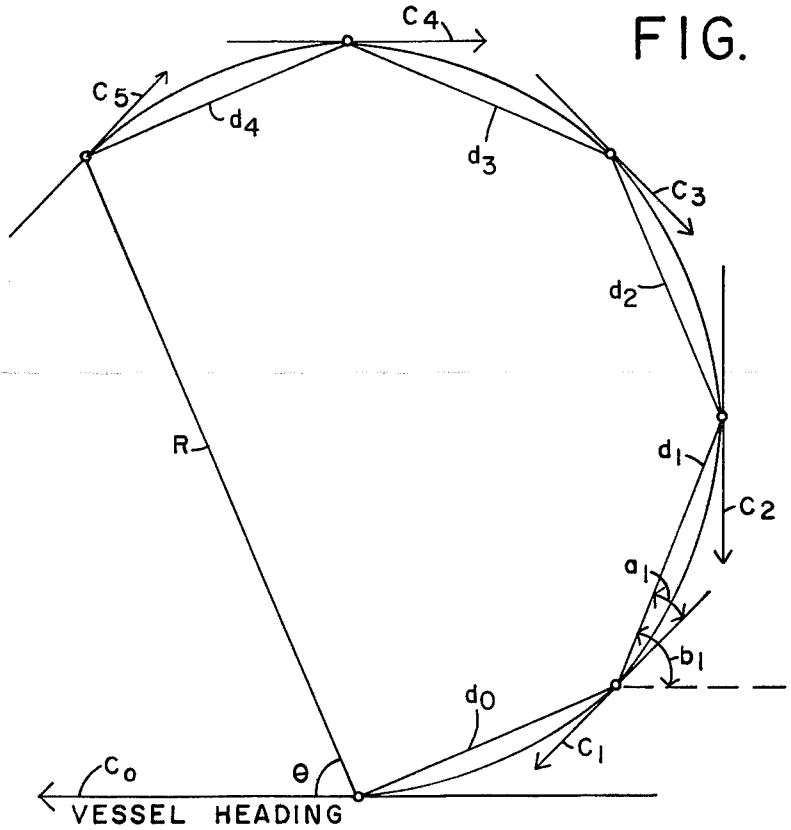
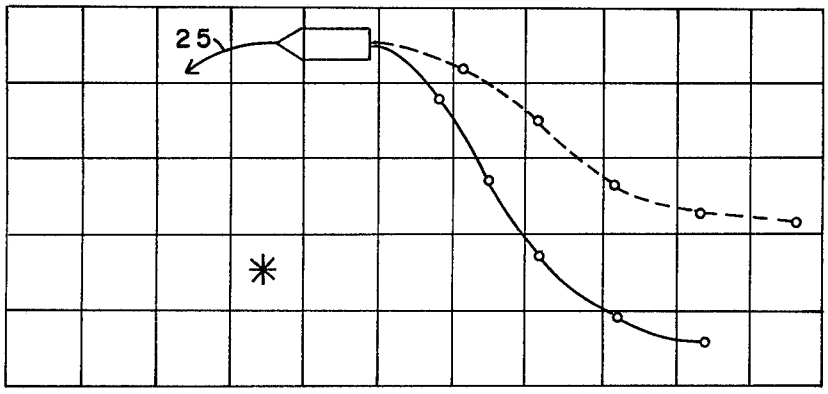


FIG. 3



✳ = OBSTACLE LOCATION

MARINE CABLE LOCATION SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to seismic exploration and more particularly to marine exploration. In marine exploration, seismic energy is generated in the water and reflections of such energy from subsurface interfaces are detected by a linear string of detectors or hydrophones. The seismic energy sources and the detectors are towed through the water by means of cables extending from a marine vessel. Signals received by the detectors are transferred to the vessel through the cable wiring. In many instances, groups of detectors are combined to form arrays within the cable, and the signals received by each such array are combined and transferred to the vessel.

One method for determining the instantaneous position of each detector or array of detectors along the cable as the cable is towed through the water is disclosed in U.S. Pat. No. 3,953,827 to Le Moal et al. A plurality of detectors or hydrophones are distributed along a towed cable. The position of each detector is determined by the interpolation of values of the angle of the tangents to the cable with a fixed and known direction, such as magnetic north, at a plurality of measuring points. At each measuring point along the cable there is located preferably a magnetic compass. There is also provided means for coding and transmitting the measured values by means of electronic pulses to a central station. Such means includes a multiplex device. The position of each measuring point is determined by assimilating that part of the towed cable located between compasses to an arc of a circle, the length of which is known from the construction of the cable, while the angular value of the arc is determined from the differences between the angles measured by the compasses between the tangent to the cable and the fixed and known direction. The positions of the detectors along the cable are then determined by interpolation between the positions of the compasses along the cable.

SUMMARY OF THE INVENTION

In accordance with the present invention there is provided a system for determining the position in X-Y coordinate a plurality of points along a cable towed by a marine vessel and for visually displaying such points for use by the vessel's operator in steering the vessel past other vessels or obstacles.

In the development of marine exploration, the seismic detector cables have become quite long, extending for one mile, two miles, or even farther behind the marine vessel. Such lengths can cause problems in accurately determining the position and configuration of the cable as it is towed through the water since it is unlikely that cables of such lengths will extend in a straight line behind the towing vessel or even be configured in the shape of a single arc of curvature. Rather, the cable may have one or more inflection points in its curvature and may extend laterally to one or even both sides of the towing vessel simultaneously as illustrated in FIG. **1**.

One of the primary concerns in towing such a long and curved cable is in the steering of the towing vessel past other marine vessels or obstacles such as drilling towers, etc., in such a way that the projected path of the cable does not intersect such other vessels or obstacles. This is true not only when the vessel passes such obstacle in a straight line but also when the vessel is in a directional turn. Under certain conditions the vessel could even turn sharply enough to cross the cable itself as it extends one or more miles behind the vessel.

It is therefore a specific aspect of the present invention to provide a system for visually displaying the position of a towed cable for use by the towing vessel's operator. A plurality of sensors are located at select points along the towed cable to provide signals representative of the heading of tangents to the cable at such select points. A sensor located onboard the vessel provides a signal representative of the heading of the vessel itself. A navigational system onboard the vessel provides signals identifying the X-Y coordinate of the vessel. The heading signals from the cable sensors and the vessel sensor along with the vessel's X-Y coordinate signal from the navigational system are used to determine the X-Y coordinates for the cable sensors. A visual display having a matrix of display squares records the X-Y coordinates of the vessel and the cable sensors.

In one aspect of the invention the vessel sensor and the cable sensors are magnetic compasses producing signals representing headings with respect to a direction of magnetic north. In this aspect, there is also included a gyrocompass onboard the vessel for producing a signal representative of the true north heading of the vessel. The magnetic variations of the vessel compass and the cable compasses from true north of the vessel's heading are determined in identifying the X-Y coordinates of the select points along the cable. These X-Y coordinates are displayed in a plus X direction off the stern of the vessel and a plus Y direction off the starboard of the vessel.

In a further aspect, the X-Y coordinates of obstacles in the path of the cable as it is being towed are identified. These X-Y coordinates are entered into the matrix of squares of the visual display along with the X-Y coordinates of the vessel and of the select points along the towed cable as illustrated in FIG. **3**.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a seismic exploration system employing a marine vessel and towed seismic cable.

FIG. **2** illustrates seismic recording equipment employed with the marine exploration system of FIG. **1**.

FIG. **3** illustrates a visual display of cable-positioning data determined by the recording equipment of FIG. **2**.

FIG. **4** illustrates the geometric configuration utilized in determining cable compass X-Y coordinates.

FIG. **5** represents a truth table for locating the bearing of the farthest compass from the vessel.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In seismic marine exploration, the marine vessel **10** of FIG. **1** tows a seismic detector cable **11** along a line of exploration. Such a cable **11** conventionally employs a plurality of detectors, or hydrophones, (not shown) spaced along its length for receiving seismic reflections from the subsurface layer below the ocean floor. The cable also employs a plurality of magnetic heading sensors **12** equally spaced along its length, five such sensors being illustrated in FIG. **1**. Each sensor provides a signal representing the magnetic heading or direction of the tangent to that particular point of the cable. By knowing the heading of the tangents to the cable at such plurality of points along the cable and the distances

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