Jan. 25, 1966 N. D. BIRRELL 3,230,622

PLOTTING APPARATUS

Original Filed Dec. 24, 1963

FIG. 2

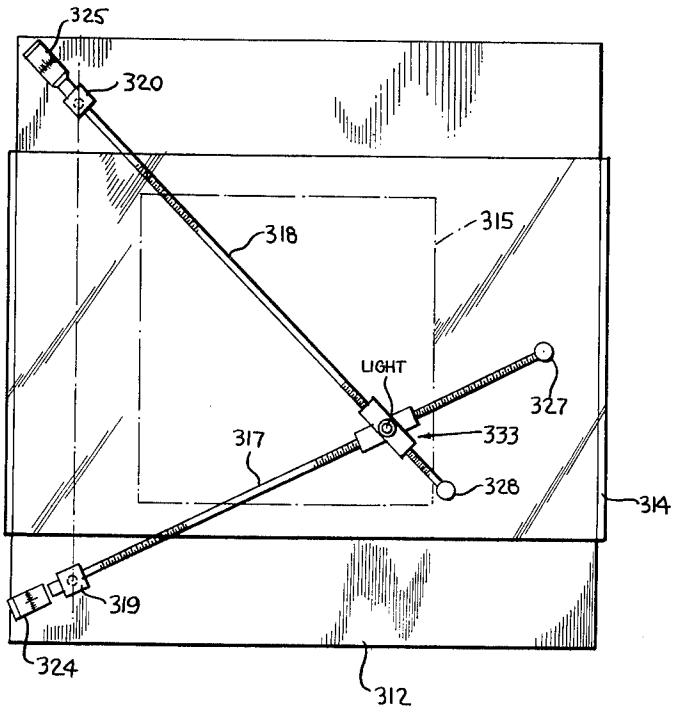
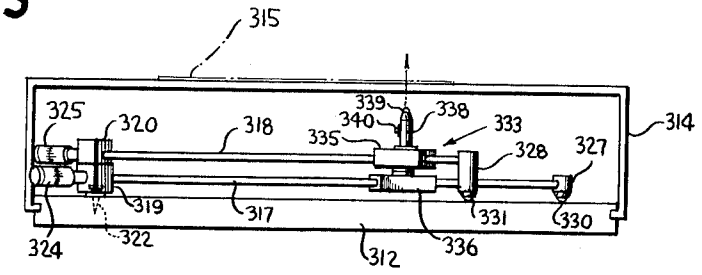


FIG. 3



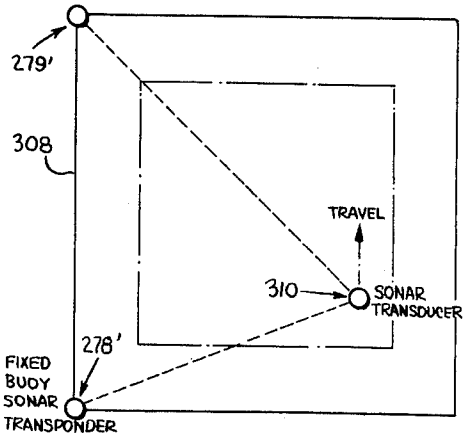


FIG. 1

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PLOTTING APPARATUS

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Original application Dec. 24, 1963, Ser. No. 332,999. Divided and this application Dec. 21, 1964, Ser. No. 420,065

2 Claims. (Cl. 33—1)

The present invention relates to new and novel plotting apparatus, and more particularly to the apparatus for plotting the position and heading of a collecting means utilized in an underwater mining operation at great depths beneath the surface of the sea.

The present application is a division of copending U.S. patent application Serial No. 332,999, filed December 24, 1963.

The present invention is especially adapted for use with apparatus employed for the recovery of solid substances disposed at the bottom of the sea such as manganese nodules which are resting on the sea bottom and which are found in quantities sufficient for commercial mining at depths ranging generally from 400 feet to 12,000 feet or more beneath the surface of the sea.

Apparatus employed for mining of such substance includes a ship adapted to move along the surface, this ship being operatively connected with a suitable collecting means which moves along the sea bottom and collects the desired solid bodies.

It is apparent that when the collecting means is disposed at such great depths, it becomes a major problem in carrying out the mining operation to determine the exact location of the collecting means with respect to a known reference position. The present invention is particularly directed to the plotting apparatus employed for providing a visual indication of the exact location of the collecting means.

The collecting means is provided with suitable electronic equipment which cooperates with other electronic equipment disposed at fixed locations in the sea which provides a means for determining the position of the collecting means of the underwater mining apparatus with respect to a relatively fixed reference base line.

It is accordingly a principal object of the present invention to provide a means for plotting the position and heading of the collecting means with respect to a base line.

Other objects and many attendant advantages of the invention will become more apparent when considered in connection with the specification and accompanying drawings wherein:

FIG. 1 is a diagrammatic illustration of the basic arrangement and interrelationship of certain components of the system employed for locating the collecting means at the bottom of the sea;

FIG. 2 is a top view of the plotting apparatus for plotting the position and heading of the collecting means with respect to a base line; and

FIG. 3 is a front elevation of the structure shown in FIG. 2.

Referring now to the drawings wherein like reference characters designate corresponding parts throughout the several views, there is shown in FIG. 1 a schematic illustration of the general setup of the system for locating the collecting means. As seen in this figure, a particular surface area of the sea or the sea bottom is illustrated schematically, and the outer square as defined by the solid lines may include for example an area of 15 miles x 15 miles, while the inner square indicated by phantom lines may encompass an area having sides of 10 miles. These

figures represent the area within which the system is expected to operate within the desired degree of accuracy.

The position of two fixed buoy means is indicated by reference numerals 278′ and 279′. Each of these buoy means includes an anchor means for holding it in a relatively fixed position with respect to the bottom of the sea, the buoys including a sonar receiver transducer and sonar receiving mechanism which cooperates with a radio transmitter which in turn is connected with a transponder buoy including radio antenna means for sending a signal back to the mining ship.

The collecting means is provided with a sonar transducer indicated by reference numeral 310, the sonar transducer accordingly moving along with the collecting means and sending out periodic signals to provide a means for locating the collecting means. As seen in FIG. 1, the direction of travel of the collecting means and its associated sonar transducer is indicated by an appropriate arrow, and a base line extending between the buoys is indicated by reference numeral 308.

The dotted lines between the sonar transducer and the buoy means indicate the path along which signals from the sonar transducer will travel to the two buoy means, it being noted that the path to the buoy means 278′ is shorter than to the other buoy means 279′ whereby less time will be required for the signal to travel from the transducer to the buoy means 278′ than from the transducer to the buoy means 279′. The system as described will provide satisfactory results assuming that for all intents and purposes the two buoy means are in fact stationary with respect to the sea bottom, and further assuming that the velocity of sound at the sea bottom will be substantially constant over the working area, and furthermore assuming that with the collecting means traveling at a maximum speed of approximately 5 knots along the sea bottom, Doppler effects will be negligible.

A suitable keying pulse such as a 1 kilocycle pulse is generated by a sonar transmitter on the ship and may be repeated at a rate of 2 pulses per minute in a typical example. This keying pulse is adapted to trigger two electronic counters on the ship and also serve to trigger the sonar transducer on the collecting means. The sonar transducer creates a sound pulse which radiates symmetrically from the collecting means and which is received by the sonar receiver transducer means of the two fixed buoy means after a period of time depending on the distance between the collecting means and the fixed buoy means, and also according to the speed of sound in this environment.

The sonar receivers at each of the buoys then trigger the radio transmitters thereat which send radio pulses back to the ship at the speed of light. These received radio pulses are then adapted to gate the associated counters on the ship which thereby register the total time for the initial keying pulse to the gating pulse. Since the time required to transmit the signal back to the ship from the buoys is negligible compared to the amount of time involved in transmitting the signals through the water, the counters will essentially register the acoustic transit time from the sonar transducer on the collecting means to the sonar receiver transducers of the fixed buoy means.

Accordingly, the two counters on the ship will provide a reading indicative of the distance of the collecting means from each of the fixed buoy means, each of the counters being triggered by one of the two buoy means.

Referring to FIGS. 2 and 3 of the drawing, the plotting apparatus of the present invention is illustrated. A suitable support or base means 312 is provided which in turn supports a transparent shield member 314 formed of plastic or a suitable material which is adapted to support

a sheet of plotting paper or a chart thereon as indicated by phantom line **315**.

A pair of precision lead screws having precision screw threads formed thereon are indicated by reference numerals **317** and **318**, these lead screws being threaded within complementary threaded holes provided in support members **319** and **320** respectively. The two support members are each mounted for pivotal movement about a vertically extending axis as seen in FIG. 3, the two support members being indicated as being held in operative position by tapered pin means such as illustrated at **322** extending downwardly into the support means **312**. It will accordingly be apparent that the lead screws **317** and **318** are adapted to swing about pivot axes extending vertically upwardly through the central part of the support members **319** and **320**, and the two lead screws can each be rotatably adjusted for movement through the support members.

Micrometer dial means **324** and **325** are mounted at the outer ends of the two lead screws **317** and **318** respectively, these two micrometer dial means being calibrated in suitable time intervals such as seconds, and utilizing the information from the two counters on the ship, the micrometer dial means of the two lead screws may be adjusted to indicate the suitable time interval as indicated by the counter means which in turn will be translated into a distance measurement due to the calibration of the lead screws and the associated micrometer dials.

Bearing means **327** and **328** are mounted at the outer ends of lead screws **317** and **318** respectively, these bearing means including roller bearings **330** and **331** extending downwardly therefrom and adapted to rest upon and glide along the upper surface of the support means **312** whereby the lead screws can be readily adjusted in position.

A movable cross head is indicated generally by reference numeral **333** and includes an upper portion **335** and a lower portion **336**, these two portions being pivotally interconnected with one another and each having a hole formed therethrough having precision threads thereon for receiving therein the lead screws **318** and **317** respectively.

A small upwardly projecting portion **338** serves to support an illuminating means such as a light bulb **339** which may be turned on or off with a conventional switch means **340**. It is apparent that the upwardly directed light bulb will serve to provide a small point of light which will shine upwardly through the transparent shield means **314** and through the chart or plotting paper **315**.

It should be understood that the fixed pivot axes of the support means **319** and **320** for the two lead screws **317** and **318** respectively represent the fixed positions of the buoy means **278'** and **279'** as for example illustrated in FIG. 1, while the position of the light bulb **339** of the movable cross head represents the position of the sonar transducer or the collecting means **310** as seen in FIG. 1.

It is accordingly apparent that after obtaining suitable readings from the counter means on the ship, an operator will adjust the micrometer dials **319** and **320** which will cause the movable cross head to move into such a position that the small light shining upwardly therefrom will produce a dot on the plotting paper indicating the position of the collecting means whereby the location of the collecting means with respect to a known reference base line is readily determined. The collecting means may also be provided with a magnetic compass means which provides a signal to a compass repeat means provided on the ship to provide a heading reading for the collecting means. The operator may then place a small arrowhead on the chart, this arrowhead being positioned over the dot of light on the chart and extending in a direction representing the heading of the collecting means.

It is apparent from the foregoing that there is provided according to the present invention plotting apparatus for accurately locating the position and heading of a collecting means with respect to a fixed reference base line.

As this invention may be embodied in several forms without departing from the spirit or essential characteristics thereof, the present embodiment is therefore illustrative and not restrictive, and since the scope of the invention is defined by the appended claims, all changes that fall within the metes and bounds of the claims or that form their functional as well as conjointly cooperative equivalents are therefore intended to be embraced by those claims.

I claim:

1. Apparatus for plotting the position and heading of a collecting means utilized in an underwater mining operation at great depths beneath the surface of the sea comprising base means, a pair of elongated precision lead screws having precision screw threads formed thereon, a pair of support members, each of said support members being pivotally supported by said base means for pivotal movement about a fixed axis extending substantially normally to said base means, said support members being spaced a substantial distance from one another, each of said lead screws being supported adjacent one end thereof by one of said support members, each of said lead screws being rotatably adjustable with respect to the associated support member for movement therethrough, each of said lead screws having micrometer dial means disposed at said one end thereof and calibrated to permit adjustment to translate such adjustments into a distance measurement, bearing means disposed at the opposite end of each of said lead screws, the bearing means at the end of each lead screw extending downwardly therefrom and including anti-friction means at the lower end thereof adapted to rest upon and glide along the upper surface of said base means, said lead screws each being supported in spaced relationship to said base means solely by the associated support member and bearing means, a movable cross head including an upper portion and a lower portion, said upper and lower portions being pivotally interconnected with one another, each of said portions having a hole formed therethrough having precision threads therein, each of said holes receiving one of said lead screws threaded therethrough, said cross head being supported solely by the threaded interconnections with said lead screws, and indicating means on said cross head for indicating the position of said collecting means.

2. Apparatus as defined in claim **1** wherein said indicating means comprises illuminating means projecting upwardly from said cross head, and a transparent support member supported by said base means and disposed in overlying relationship to said cross head for supporting plotting paper thereon on which can be indicated the position of the collecting means.

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