United States Patent [19]

Daniels et al.

[11] **3,731,263**

[45] **May 1, 1973**

[54] **UNDERWATER GUIDANCE METHOD AND APPARATUS**

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[22] Filed: **Ap. 28, 1971**

[21] Appl. No.: **138,037**

[52] **U.S. Cl.** ....**340/3 R**, 340/3 E

[51] **Int. Cl.** **G01s 9/66**

[58] **Field of Search** ....340/3 E, 3 R, 6 R, 340/8 FT

[56] **References Cited**

UNITED STATES PATENTS

3,458,853	7/1969	Daniels et al.	340/3 R
3,222,634	12/1965	Foster	340/3 R
3,409,868	11/1968	Salathiel	340/3 R

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[57] **ABSTRACT**

Equipment, such as a drill string, is guided from an ocean platform to a submarine wellhead by an acoustical energy system including a corner reflector at the wellhead, a pulse transmitter and associated transponder near the lower end of the drill string, and a receiver at the platform. The transmitter, operating at a first frequency, transmits pulses to the reflector, which reflects the pulses to the transponder. Energy is sent by the transponder to the platform receiver at a second frequency. When the transmitter and the receiver are in line with the wellhead reflector, energy at the first frequency is reflected directly to the receiver to produce a "go" signal.

15 Claims, 3 Drawing Figures

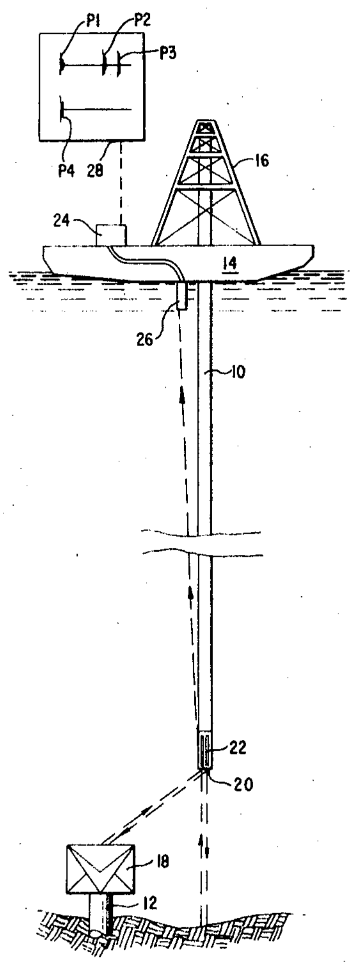

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FIG. 1

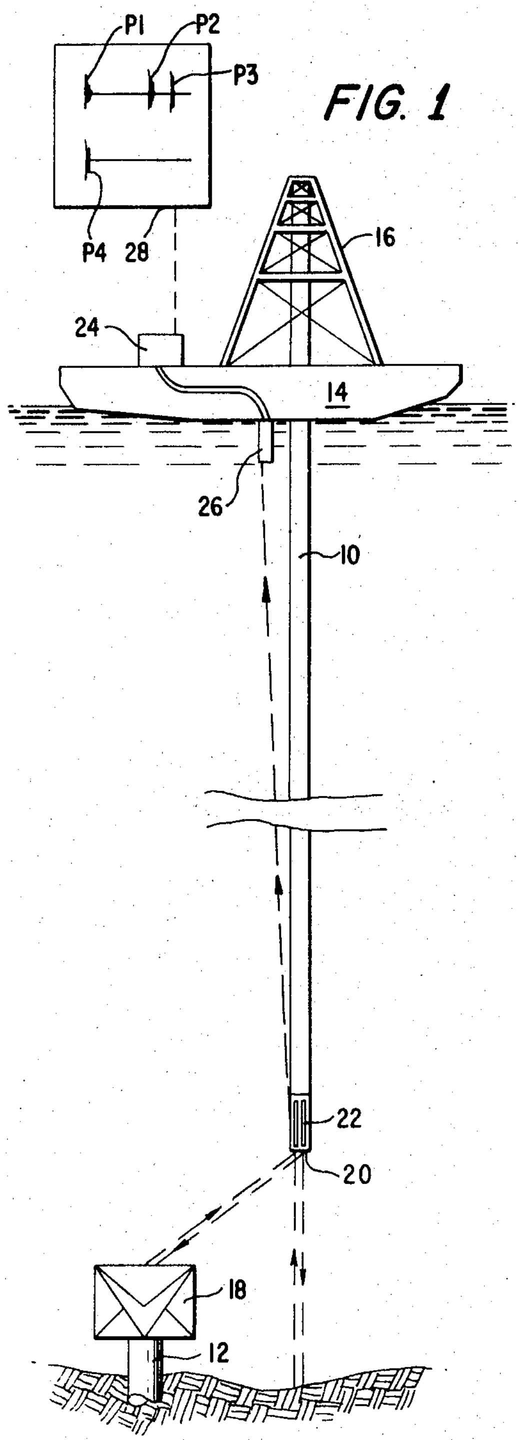
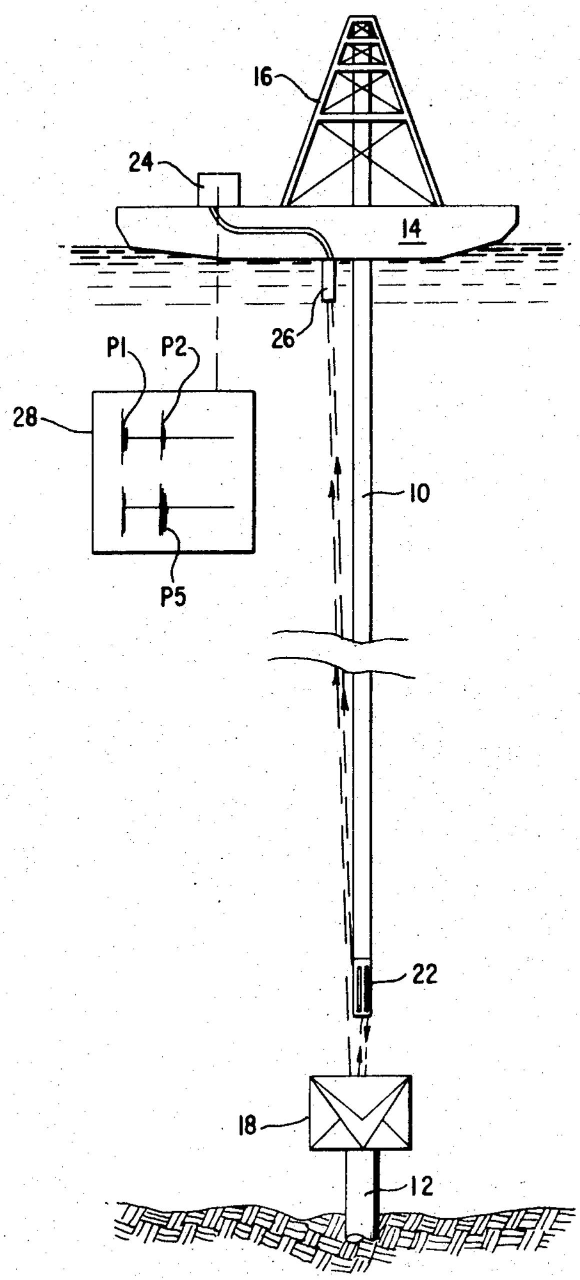


FIG. 2



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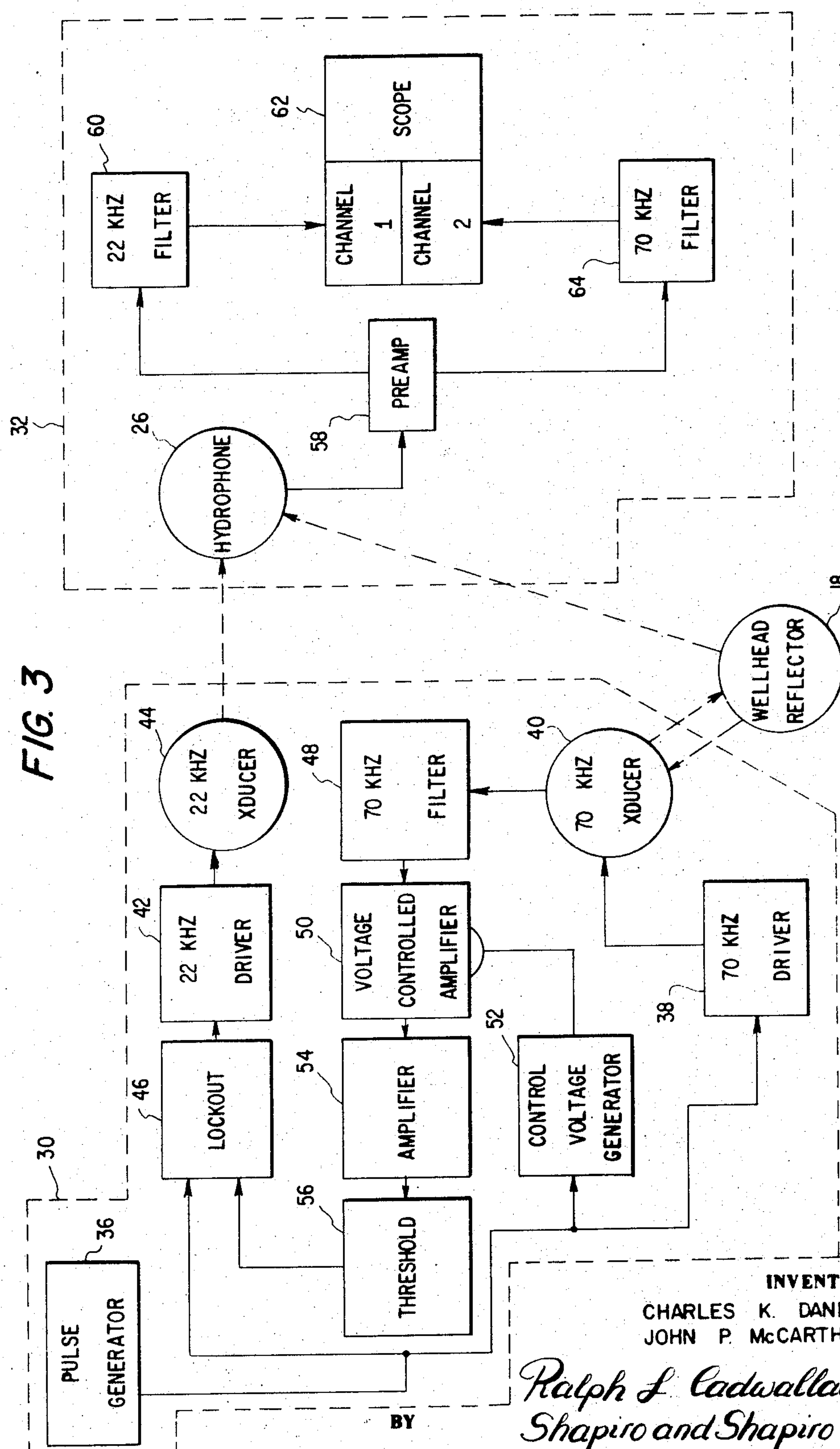

FIG. 3

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UNDERWATER GUIDANCE METHOD AND APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to guidance methods and apparatus and more particularly to a method and apparatus for guiding equipment from a vessel positioned on the surface of a body of water to an underwater target. The invention finds particular utility in guiding drill strings into submarine wellheads.

In drilling underwater oil wells, drilling crews often remove drill strings from submarine wellheads which must later be reinserted. It may also be necessary to lower other equipment to the wellheads. U.S. Pat. No. 3,458,853, assigned to the same assignee as the present application, sets forth an underwater guidance method and apparatus employing acoustical energy for this purpose. In accordance with one embodiment described in that patent, an acoustical pulse transmitter is located at the lower end of the drill string. Acoustical energy transmitted to the wellhead produces a first signal at a receiver, as by a transponder at the wellhead, which varies as a function of the distance from the transmitter to the wellhead. If the platform is maneuvered until the transmitter and the receiver are in line with a corner reflector at the wellhead, a second signal will be produced at the receiver.

BRIEF DESCRIPTION OF THE INVENTION

The present invention is an improvement of that set forth in the aforesaid patent.

It is accordingly a principal object of the invention to provide improved method and apparatus of the foregoing type.

A further object of the invention is to provide such a method and apparatus in which a single transponder, supported upon the drill string or the like, may serve any number of wellheads and may be retrieved when desired, and in which only passive reflection is provided at the wellheads.

Briefly stated, the foregoing and other objects of the invention are accomplished through the provision of a transponder associated with the transmitter adjacent to the lower end of the drill string. The transmitter transmits a pulse at a first frequency to the wellhead reflector and simultaneously causes the transponder to transmit a pulse at a second frequency to a receiver at the platform. An echo from the reflector to the transponder causes the transponder to send another pulse at the second frequency to the receiver on the platform, the separation between the first and second pulses received being a function of the slant range from the transmitter to the reflector. The platform is maneuvered to reduce this range, and when the transmitter, reflector, and receiver are substantially in line, a further pulse, at the first frequency, will be reflected directly from the well-head reflector to the receiver. The reception of this pulse will constitute a "go" signal for the lowering of the equipment into the wellhead.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be further described in conjunction with the accompanying drawings, which illustrate a preferred and exemplary embodiment, and wherein:

FIG. 1 is a diagrammatic view illustrating the utilization of the invention, with the drill string shown misaligned with respect to the wellhead;

FIG. 2 is a similar view showing alignment of the drill string with the wellhead; and

FIG. 3 is a block diagram of the electro-acoustical system of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the drawings, and initially to FIGS. 1 and 2 thereof, the invention may be applied to the underwater guidance of a drill string **10** or other equipment to a wellhead **12** located on the bottom of the ocean or other body of water from a vessel or ocean-going platform **14**, the drill string being suspended from the platform by means of a conventional rig **16**. For the purposes of the present invention the term "drill string" is intended to embrace any appropriate equipment which it may be desired to lower from the platform to a wellhead, which term is intended to embrace any other appropriate underwater target. As set forth in the aforesaid patent, the disclosure of which is incorporated herein by reference, the wellhead is provided with a reflector **18**, which is preferably a corner reflector, a type which reflects incident energy preferentially in the direction opposite to the direction of incidence. The reflector may be supported upon the top of the wellhead and may be provided with a hole at the bottom vertex, so that the walls of the reflector, which diverge upwardly, may serve as a funnel for the insertion of the drill string into the well-head.

Within the drill string, adjacent to the lower end thereof, are a transmitter of pulsed acoustical energy and an associated transponder of such energy. Energy from the transmitter may be emitted from the bottom **20** of the hollow drill string, and the transducer of the transmitter at the bottom may also serve as the receiving transducer of the transponder. Energy from the transponder may be emitted through the slotted section **22** adjacent to the bottom. The transmitter and transponder are preferably self-contained battery-powered apparatus, centered within the drill string by means of springs and capable of being pulled up through the drill string by a cable, for retrieval.

At the platform **14** a receiver **24** of acoustical energy is provided, including a hydrophone **26**. The receiver is provided with a display device producing the displays **28**.

FIG. 3 illustrates the electro-acoustical system employed in the invention. The portion within the large block **30** is located within the drill string adjacent to the lower end, while the portion within the large block **32** is located at the platform **14**. The wellhead reflector **18** is shown diagrammatically. A free-running pulse generator **36** sets the repetition rate of the system, such as one to five pulses per second. It triggers the 70 kHz driver **38**, which drives the 70 kHz transducer **40**. This produces a "down pulse", which is emitted from the bottom **20** of the drill string. At the same time, the pulse generator **36** triggers the 22 kHz driver **42**, which drives the 22 kHz transducer **44** and produces an initial "up pulse", which is emitted through the slotted section **22** of the drill string. The 22 kHz driver **42** is triggered through a lockout circuit **46**, which triggers the driver **42** immediately but allows no more pulses to trigger it for a short interval of time, allowing the circuitry to recover.

When an echo of the "down pulse" is received by the 70 kHz transducer **40** by reflection from the wellhead reflector **18**, it is filtered by the 70 kHz filter **48** and fed into a voltage controlled amplifier **50**. The control voltage generator **52** is synchronized with the pulse generator **36** such that there is minimum gain initially and such that the gain increases linearly with time up to its maximum value. This is to compensate for the decrease in echo strength with time (range). The signal is then further amplified by the amplifier **54**, the output of which is fed to the threshold circuit **56**. When the signal exceeds the threshold value, the 22 kHz driver **42** is triggered, through the lockout circuit, driving the 22 kHz transducer **44**, which produces an "up pulse" corresponding to the echo. Thus, whenever there is an echo of sufficient strength, the **22** kHz transducer **44** will put out an echo "up pulse". However, these pulses cannot be produced any more closely than the time determined by the lockout circuit.

The "up pulses" are received by the hydrophone **26**, amplified in the pre-amplifier **58**, filtered by the 22 kHz filter **60** and displayed on channel 1 of an oscilloscope **62**. The initial "up pulse" is used to trigger the scope. Echo "up pulses" are displayed on channel **1** displaced in time from the initial "up pulse". This time Is directly proportional to the range.

When the drill string is aligned with the wellhead reflector, the echo of the 70 kHz pulse will be reflected directly to the hydrophone, amplified in the preamplifier **58**, filtered by the 70 kHz filter **64**, and displayed on channel **2** of the oscilloscope **62**. The display of this echo is the "go signal" to stab the drill string into the wellhead reflector.

In the use of the invention, the platform **14** is moved to the general vicinity of the wellhead and the drill string is lowered until it comes within range of the reflector and/or the bottom, as indicated by subsequent pulses. As shown by the upper line of data in the display **28** of FIG. **1**, which represents channel **1** of the oscilloscope, there is an initial "up pulse" **P1**, an echo "up pulse" **P2** from the reflector, and perhaps an echo "up pulse" **P3** from the bottom. The lower horizontal line of the display, for channel **2**, shows an initial pulse **P4** of no significance. The drill string is lowered, while observing the channel **1** display, until the nearest echo is at a distance of approximately 50 feet (20 milliseconds on the time scale). The platform or vessel is then maneuvered forward while observing the echos. The one which shows no change is probably the bottom, while the one which changes is the reflector. If the reflector echo gets closer by moving forward, the forward motion is continued in increments, waiting for the drill string to respond, until the closest range is achieved. If the reflector echo gets farther away by the forward movement, the vessel is moved backward in increments until the closest range is achieved. Then the vessel is maneuvered sideways in the same manner until the closest point is achieved. At this point the drill string should be nearly aligned with the reflector. The drill string is then lowered, if necessary, until the range is approximately ten feet, and the procedure is repeated to find the closest range. When the end of the drill string is directly over the reflector, a maximized "-go" signal will appear on channel **2**, as shown by the pulse P5 in the display **28** of FIG. **2**, and the drill string may then be dropped enough to enter the funnel of the reflector.

While a preferred embodiment of the invention has been shown and described, it will be apparent to those skilled in the art that changes can be made in this embodiment without departing from the principles and spirit of the invention, the scope of which is defined in the appended claims.

The invention claimed is:

1. A method of aligning eQuipment between an ocean platform and a submarine wellhead comprising:

providing a reflector at said wellhead which preferentially reflects incident acoustical energy in a direction substantially opposite to the direction of the incident energy;

providing a transmitter and an associated transponder of pulsed acoustical energy;

suspending said transmitter and said transponder from said platform;

providing a receiver of pulsed acoustical energy substantially at said platform;

transmitting pulsed acoustical energy from said transmitter to said reflector and reflecting such energy from said reflector to said transponder;

receiving the reflected energy at said transponder and transmitting a signal from said transponder to the said receiver in response to the said reflected energy;

maneuvering said platform until said transmitter, reflector and receiver are substantially in line; and

reflecting acoustical energy from said reflector to said receiver when said transmitter, said receiver, and said reflector are substantially in line.

2. A method in accordance with claim **1**, wherein the energy transmitted by said transmitter is substantially at a first frequency and the energy transmitted by said transponder is substantially at a second frequency.

3. A method in accordance with claim **1**, further comprising extending said equipment to said wellhead when the energy reflected from said reflector to said receiver is maximized.

4. A method in accordance with claim **1**, further comprising preventing the sending of energy from said transponder to said receiver for a predetermined period of time from the transmitting of an acoustical pulse by said transmitter.

5. A method in accordance with claim **1**, further comprising increasing the gain of said transponder as a function of time after the transmitting of a pulse of acoustical energy by said transmitter.

6. A method in accordance with claim **1**, further comprising concurrently displaying signals in response to said energy received by said receiver from said transponder and from said reflector.

7. Apparatus for guiding equipment from an ocean platform or the like to a submarine wellhead or the like comprising:

a drill string suspended from said platform;

a transmitter of pulsed acoustical energy supported upon said drill string adjacent to the lower end thereof;

a transponder of said energy supported upon said drill string adjacent to said transmitter; and a receiver of said energy supported upon said platform.

8. Apparatus in accordance with claim 7, further comprising a reflector located at said wellhead.

9. Apparatus in accordance with claim 8, wherein said reflector is of the type which preferentially reflects incident acoustical energy in a direction opposite to the direction of incidence.

10. Apparatus in accordance with claim 7, wherein said transponder has receiving means for receiving acoustical energy at a frequency transmitted by said transmitter and has transmitting means operating at a different frequency, and wherein said receiver has means for separating energy received at said frequencies.

11. Apparatus in accordance with claim 10, wherein said receiver has means for displaying the separated energy concurrently as a function of time.

12. Apparatus in accordance with claim 7, wherein said transponder has means for preventing the transponding of energy thereby for a predetermined period of time from the transmitting of a pulse of acoustical energy by said transmitter.

13. Apparatus in accordance with claim 7, wherein said transponder has means for increasing the gain of the receiving means thereof as a function of time after the transmission of a Pulse of acoustical energy by said transmitter.

14. Apparatus for guiding equipment from an ocean platform or the like to a submarine wellhead or the like comprising:

reflector means located at said wellhead for preferentially reflecting incident acoustical energy in a direction opposite to the direction of incidence;

means for transmitting pulsed acoustical energy;

means associated with said transmitting means for transponding pulsed acoustical energy;

means for receiving pulsed acoustical energy substantially at said platform; and

means for supporting said transmitting means and said transponder upon said equipment adjacent to the lower end thereof.

15. A method of aligning equipment between a vessel an an underwater location, which comprises:

transmitting energy to said location from a transmitter spaced between said vessel and said location and remote from said vessel;

reflecting energy from said location to the vicinity of said transmitter;

receiving said reflected energy at said vicinity and producing a first signal in response to said reflected energy;

reflecting further energy from said location to a region adjacent to said vessel, when said region, said transmitter, and said location are substantially in line; and

producing a second signal in response to said further energy.

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