Ex. PGS 1031

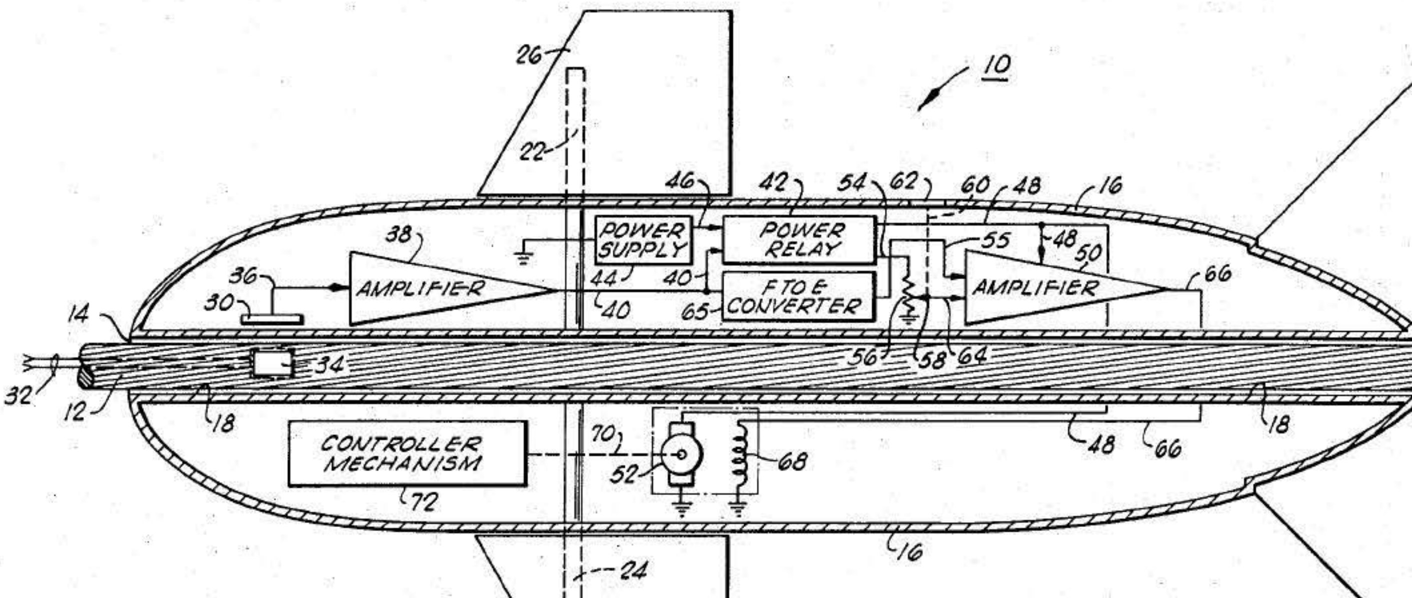

FIG-1

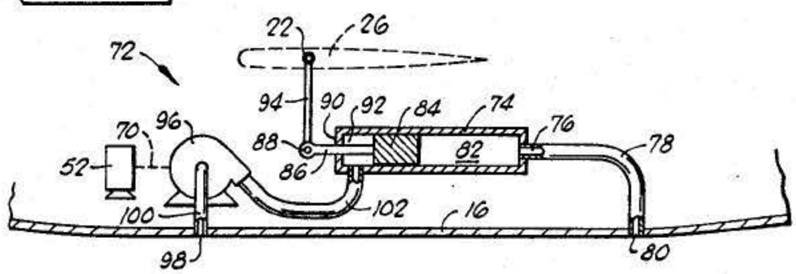

FIG-2

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CABLE DEPTH CONTROLLER

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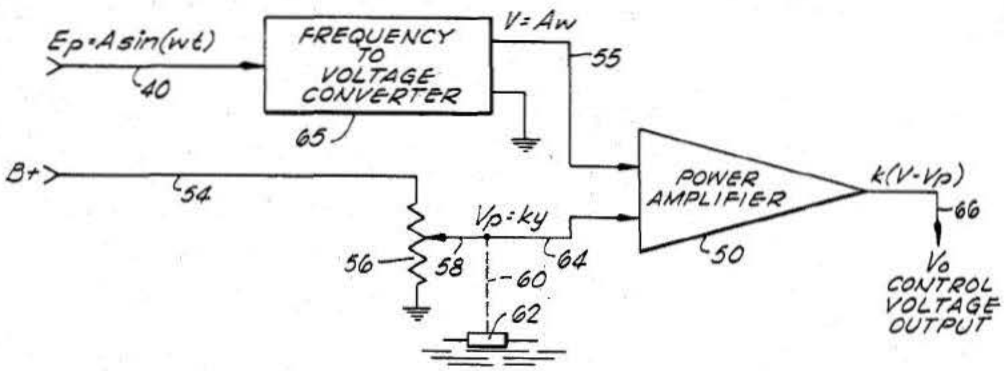

Fig-3

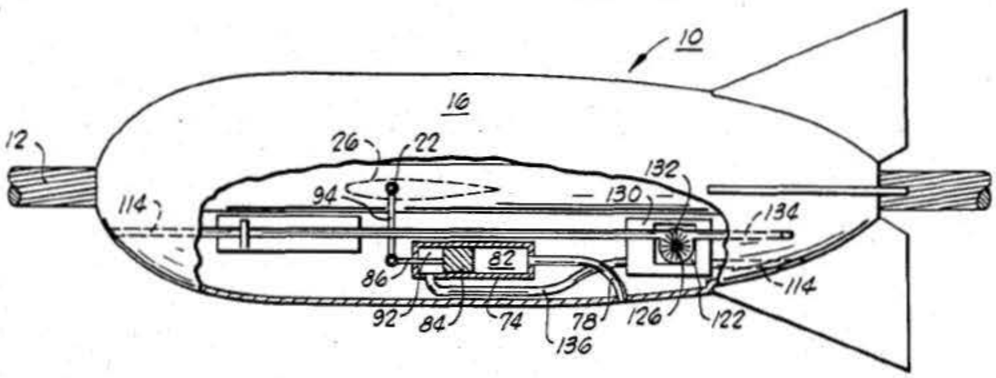

Fig-4

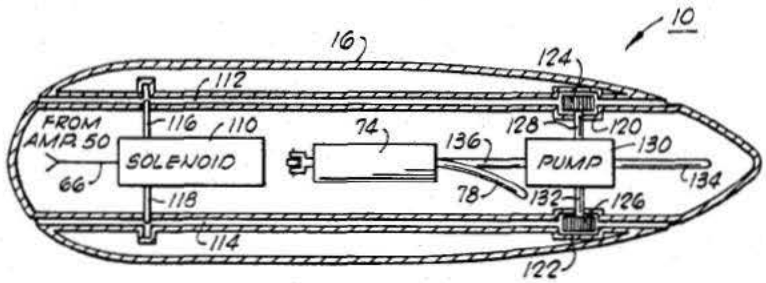

Fig-5

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United States Patent Office

3,412,704
Patented Nov. 26, 1968

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3,412,704

CABLE DEPTH CONTROLLER

Paul L. Buller and William L. Chapman, Ponca City, Okla., assignors to Continental Oil Company, Ponca City, Okla., a corporation of Delaware

Filed Nov. 6, 1967, Ser. No. 680,752
13 Claims. (Cl. 114—235)

ABSTRACT OF THE DISCLOSURE

Apparatus for remotely adjustable cable depth control wherein one or more paravanes employed to maintain a cable or seismic streamer at a predetermined depth are adjustable by means of a remotely energized transmission linkage. A paravane having adjustable diving planes connected for positive or negative attack angles, and wherein a remotely generated signal transmission is detected at the paravane and the detected signal is employed to energize and to operate depth adjusting structure which will respond to a different, predetermined ambient water pressure to maintain the paravane at a different desired depth.

Cross reference to related applications

This invention is particularly suited for use in a paravane of the type used on a marine seismic cable, such paravane being the particular subject matter of the copending application of Jimmy R. Cole and Paul L. Buller entitled, "Seismic Cable Depth Control Apparatus," Ser. No. 629,276, filed on Apr. 7, 1967, and assigned to the present assignee. Another closely related application is that of Jimmy R. Cole entitled "Remotely Controllable Pressure Responsive Apparatus," Ser. No. 672,341 filed on Oct. 2, 1967, and also assigned to the present assignee.

Background of the invention

Field of the Invention.—The invention relates generally to pressure-responsive actuating devices and, more particularly, but not by way of limitation, it relates to an improved actuating device in which the operating depth of the paravane is remotely adjustable.

Description of the prior art.—The prior art includes various teachings directed to different types of paravanes which have adjustable diving plane or planes and which provide additional facility to enable operation at a predetermined depth when towed through the water. It is known to provide mechanism for assessing the depth of operation of a paravane and to attempt to provide for automatic plane adjustment in response to such continuous depth assessment. Various depth control devices of varied effectiveness are known, but none of the prior art proposals supplies the degree of reliability and accuracy which has been found necessary in the marine seismic prospecting art.

Summary of the invention

The present invention contemplates a control system for one or more depth keeping paravanes having pressure responsive depth control mechanisms integral therein. In a more limited aspect, the invention consists of a means for remote generation of a control signal which is detected at the paravane as a signal representing a degree of adjustment. The detected signal is then compared to a reference signal derived from ambient water pressure to generate a control signal which, in turn, is applied to bias or vary the reference setting of the depth control mechanism so that it functions about a new, predetermined null point to maintain the paravane or paravanes at a newly selected depth.

Therefore, it is an object of the present invention to provide depth keeping structure for use with paravanes which is relatively simple and therefore extremely reliable in operation.

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It is also an object of the invention to provide apparatus which enables accurate and continual control of the operating depth of a paravane and cable.

It is a further object of the present invention to provide apparatus which is remotely actuatable from a vessel or surface position to change the operating depth of the paravane and cable to another different selected depth within a wide range of depths.

Finally, it is an object of the present invention to provide remotely controllable depth adjusting structure which reacts quickly and accurately with very little power requirement.

Other objects and advantages of the invention will be evident from the following detailed description when read in conjunction with the accompanying drawings which illustrate the invention.

Brief description of the drawings

FIG. 1 is a side view of a paravane in vertical section showing one form of the invention;

FIG. 2 depicts one form of controller mechanism which may be employed in the device of FIG. 1;

FIG. 3 is a functional block diagram illustrating the electrical interconnection within the paravane;

FIG. 4 is a side view of an alternative form a paravane control mechanism having parts shown in partial cutaway; and

FIG. 5 is a horizontal section taken in the plane of lines **5—5** of FIG. 4.

Description of the preferred embodiment

Referring to the drawings in detail, FIG. 1 illustrates a paravane **10** which is rotatably connected about a cable **12**. The paravane **10** has a central, axial bore **14** through which the cable **12** is received, and means (not specifically shown) are employed to restrain paravane **10** from sliding along cable **12** without hindering its ability to rotate freely therearound. This allows the cable **12** or streamer to rotate inside of the paravane **10** without causing the paravane **10** itself to rotate. It is necessary that the paravane **10** maintain a normal attitude, i.e., keeping the axis of the diving planes horizontal or parallel to the surface of the water throughout all maneuvers of the towing vessel.

The paravane **10** consists of a torpedo-like housing **16** having an axial, cylindrical wall **18** extending therethrough to form the axial bore **14**. The paravane **10** is fitted with vertical and horizontal fixed stabilizers **20** which are arranged in quadrature about the after end of housing **16**, and a pair of horizontally disposed planing control shafts **22** and **24** extend outward on opposite sides through housing **16**. The shafts **22** and **24** are connected to respective diving planes **26** and **28** and they are rotatable to impart planing control in a manner which will be further described below.

Various features such as the transverse framing and other internal structure of housing **16** are not shown, such being the subject matter of the aforementioned related patent applications. Similarly, the journaling and support of shafts **22** and **24** as well as the mounting of internal control chassis would come within the skill of the art. Remaining void spaces within the housing **16** may be filled with well-known weighting or buoying materials or a combination of both to attain a desired buoyancy characteristics.

A pressure responsive device **30** is suitably mounted within the cylindrical wall **18** and in a selected position to respond to vibratory pressure waves or such. Thus, a pair of energizing leads **32** may be extended down through the cable **12** for connection to a pressure transducer **34** which may be suitably imbedded within the cable **12**. The transducer 34 may be a commercially available form of piezo electric device which provides a vibrational output in response to energization via control leads 32. The vibration detector 30 may be a similar type of complementing electrical device which responds to the vibrational energy to provide an electrical output on a lead 36 for input to an amplifier 38. The amplifier 38 is a standard type of A-C amplifier which provides an amplified replica of the input signal on an output lead 40.

The voltage on output lead 40 is then conducted to control a power relay 42 which applies operating power to the system from a power supply 44. The power supply 44 may be a conventional D-C source such as storage battery or such which is connected to apply power via a lead 46 to various components of the system with return through ground or common as equipped. This function of enabling power application only upon receipt of a control signal on lead 40 effects a great saving in power and extends the life and reliability of power supply 44 accordingly. Thus, power relay 42 can be energized to apply energizing power via lead 48 to energize an amplifier 50 and a control motor 52, return being through ground or common in each case. A similar output lead 54 from power relay 42 applies power to a pressure responsive resistance 56.

The pressure-responsive resistance 56 may be such as a commercially available type of pressure actuated potentiometer having its wiper contact 58 connected for proportional movement by means of a linkage 60 connected to a diaphragm 62 affixed in contact with the water surrounds. Thus, the resistance element 56 is connected between the power lead 54 and ground or common, and external water pressure exerts proportional movement through diaphragm 62 and linkage 60 to tap off a predetermined voltage through wiper contact 58 for input via lead 64 to amplifier 50. A parallel branch of output lead 40 from amplifier 38 is also applied through a conventional frequency-to-voltage converter 65 to an input of amplifier 50. Thus, the amplifier 50, a D-C amplifier or conventional form of differential amplifier, provides a control signal output on a lead 66 to energize a control winding 68 to control rotation of motor 52, as will be further described.

The rotational output from motor 52 is transmitted on a mechanical linkage 70 to operate a suitable controller mechanism 72. The controller mechanism 72 then converts the rotational input on linkage 70 to a proportional rotational movement of plane shafts 22 and 24 in concert. The controller mechanism 72 may be any of various controller mechanisms which have been described in the aforementioned copending applications as well as in an additional related application entitled "Compressed Air, Pressure-Sensing Actuator," Ser. No. 635,861 filed on May 3, 1967, in the name of Chapman and assigned to the present assignee.

FIG. 2 shows an exemplary form of controller mechanism 72 which will serve to provide the continual depth keeping function as well as to enable remotely controllable adjustment of the reference operation point. Thus, a cylinder 74 is suitably positioned within the housing 16, here shown as a lower portion of housing 16, and one end 76 is connected to communicate through a tube or hose 78 and through orifice 80 to the external surrounds of the housing 16. Thus, water at ambient pressure is allowed to fill a chamber 82 to exert force on a piston 84 which is slidably moveable within cylinder 74 in sealed relationship. The piston 84 extends a piston shaft 86 having a coupling 88 out through an opposite end 90 of cylinder 74; here again, slidable but sealed connection is made between end wall 90 and piston shaft 86 such that a chamber 92 may contain a predetermined air pressure which counteracts water pressure within chamber 82.

Piston shaft 86 is movably connected to a lever 94 which, in turn, is rigidly connected to the diving plane shaft 22. Thus, it can be seen that pressure differentials as between water pressure in chamber 82 and air pressure in

chamber 92 will cause a longitudinal movement of piston 84 and this will then exert an angular movement of lever 94 about the axis or shaft 22 and the diving plane 26 is moved accordingly. Similarly, shaft 24 and diving plane 26 (FIG. 1) would be moved through an equal angular movement.

The air pressure within chamber 92 can be varied to set the reference point or desired depth about which the controller mechanism 72 will tend to stabilize. This may be varied by energizing the motor 52 in one direction or the other such that the appropriate rotational motion on linkage 70 operates a water pump 96, e.g., a conventional gear-type pump, to vary the pressure within the chamber 92. That is, pump 96 communicates from the external surrounds through an orifice 98 and tube 100, and its other end is connected through a tube 102 in communication with chamber 92. The chamber 92 will contain some partial amount of water in accordance with initial calibration and then the pump 96 can be energized in one direction or the other to pump in or remove water from within the chamber 92 so that it increases or decreases, respectively, the air pressure therewithin.

It should also be understood that the controller mechanism disclosed in the aforementioned copending application, Ser. No. 672,341, entitled "Remotely Controllable Pressure Responsive Apparatus," may also be directly controlled by the remote actuation apparatus of the present invention. This application would allow direct motor control over the spring bias type of depth reference setting as used in that particular controller mechanism.

Referring now to FIG. 3, a command signal input as derived from detector 30 through amplifier 38 may be represented as a constant frequency, A-C voltage E_p. The voltage E_p may be further represented as $A \sin (wt)$ wherein A is the amplitude and $\sin (wt)$ represents frequency with w equal to the radians per second. The command voltage E_p is then applied to the frequency-to-voltage converter 65 to derive a D-C voltage signal having an amplitude representative of the particular frequency of the A-C command voltage E_p. Thus, the D-C output voltage V is equal to amplitude A as varied in proportion to w, the radians per second characteristic. There is various well-known circuity which may be employed as the frequency-to-voltage converter stage 65, e.g. a Schmitt trigger circuit operating into an integrator is one suitable form of circuit, or a series diode-capacitor network with hold and smooth integrating circuitry.

A reference voltage V_p is also derived from wiper output 58 of the pressure responsive variable resistor 56. The positive voltage is supplied from lead 54 across the resistance element 56 and either the voltage or the resistance may be adjusted to properly calibrate the pressure-responsive resistance 56 for use as a reference element. The diaphragm 62 adjusts the position of wiper 58 and therefore the amount of reference voltage V_p which may be represented as the product (ky), k being a calibration constant and y being the actual depth variable. Thus, the instantaneous depth of the paravane is represented by the voltage V_p for comparison with the command voltage V and a difference correction voltage is derived therefrom.

The reference voltage V_p on lead 64 and the voltage V on lead 55 are applied to respective inputs of power amplifier 50, e.g. a differential amplifier, and its output on lead 66 represents a control voltage V_o which is equal to $k(V-V_p)$, k being the calibration constant. This voltage difference indication, the V_o control voltage, represents a quantity of correction which must be introduced into the paravane control system in order to bring it from its actual operating depth to a newly selected depth as signalled from the surface or remote position.

In operation, the paravane 10 may be trailed in the water such that it will keep a predetermined depth due to the action of controller mechanism 72 (FIG. 2). An adjustment of the air pressure in chamber 92 will provide depth adjustment since a preset air pressure will

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