United States Patent

Fishel

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[54] **HYDRAULIC CLAW CONTROL SWITCHING ARRANGEMENT**

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[73] Assignee: **The United States of America as represented by the Secretary of the Navy**

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[52] **U.S. Cl.** ..... **294/88,** 214/1 CM

[51] **Int. Cl.** **B25j 15/02**

[58] **Field of Search** ..... 214/1 CM; 294/88

[56] **References Cited**

UNITED STATES PATENTS

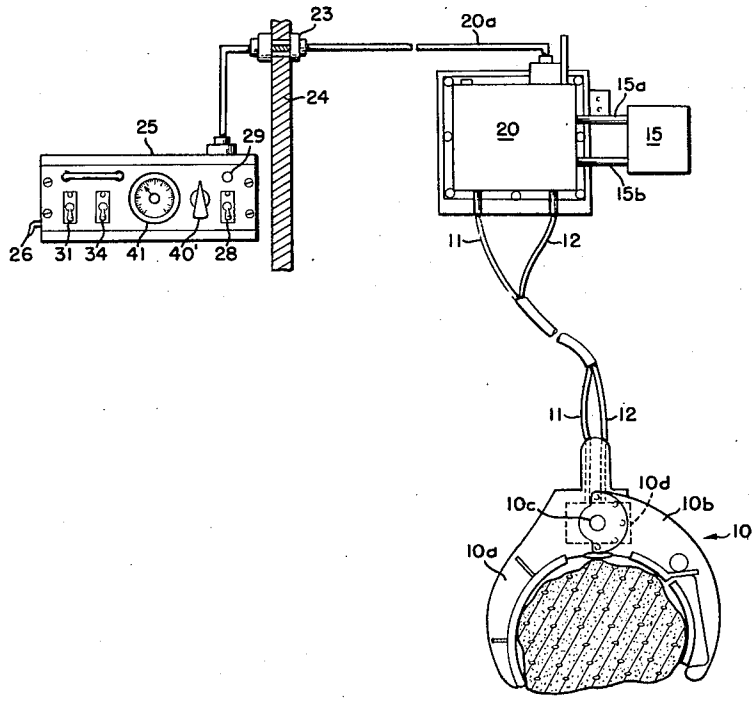
3,414,136	12/1968	Moore	214/1 CM
3,371,254	2/1968	Hagfors	317/135 A

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[57] **ABSTRACT**

A remotely disposed electro-hydraulically actuated claw is controllable from the interior of a submersible by a switching arrangement which minimizes the possibility of inadvertently switching the claw to exert a crushing, gripping force on a fragile object. Two physically separated switches are independently actuated to position the claw in the open or closed position, or to exert a grip-no grip force, respectively. Once the grip force has been exerted through a closed claw, a separate dial is included to allow an increase or decrease of the gripping force as determined by the object's weight or its fragility. Being thusly physically disposed and electrically interconnected, the possibility of the claw's being inadvertently switched to an unwanted mode of operation is minimized.

3 Claims, 2 Drawing Figures



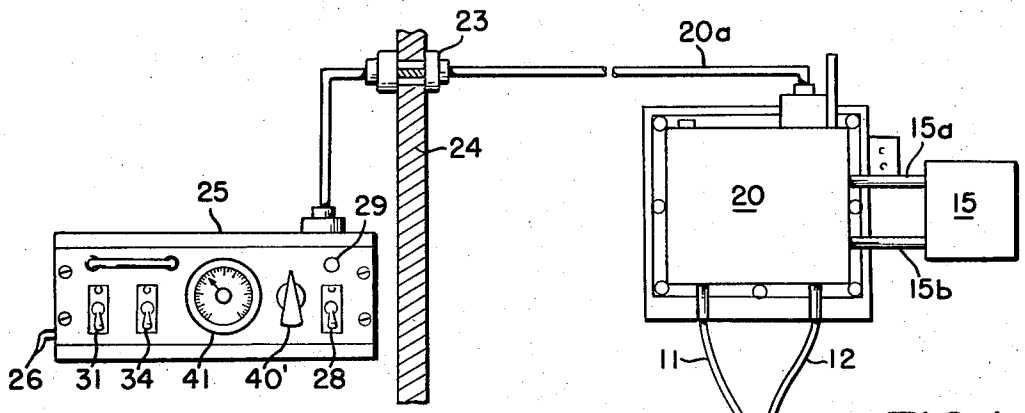


FIG. 1

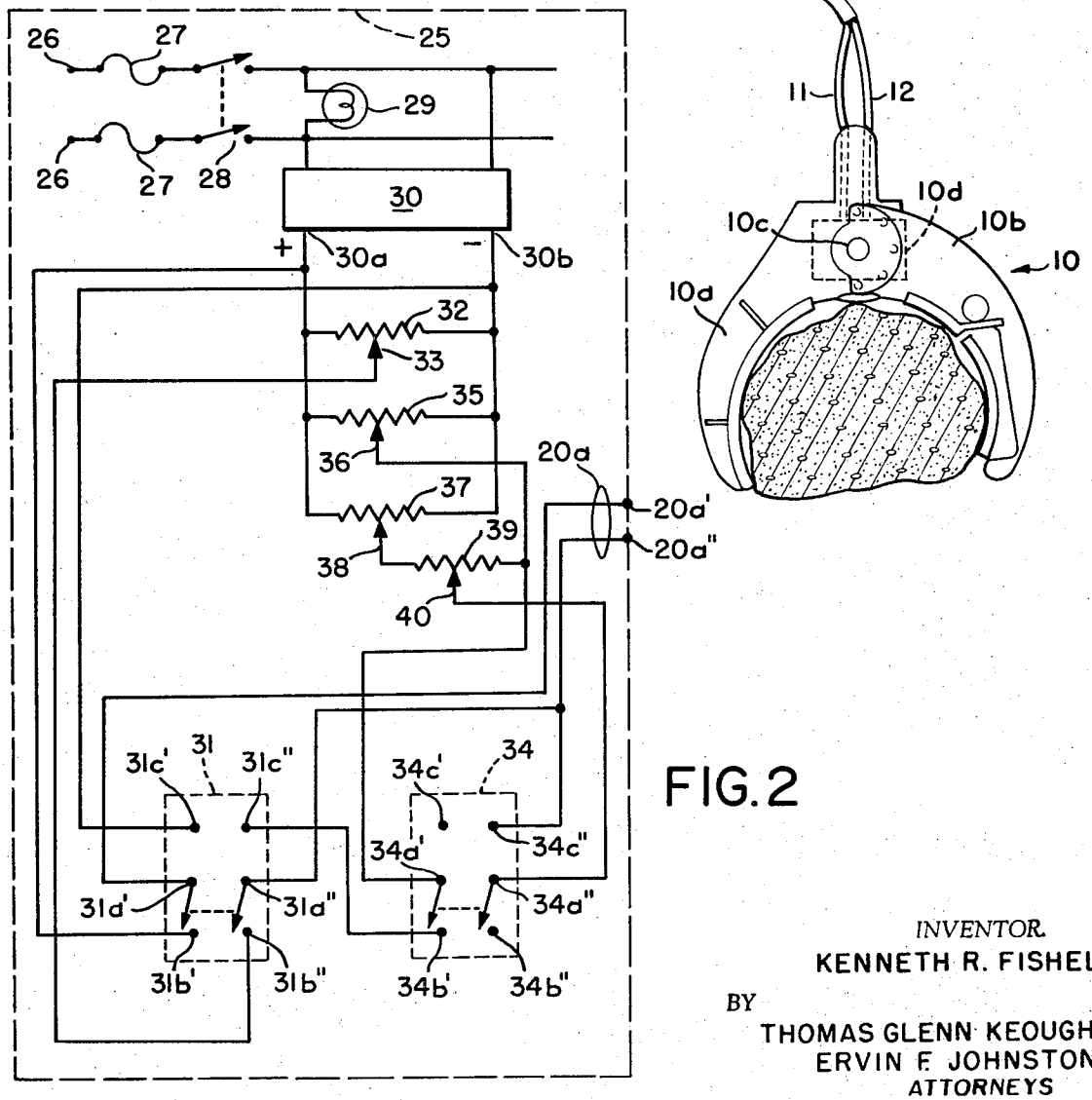


FIG. 2

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HYDRAULIC CLAW CONTROL SWITCHING ARRANGEMENT

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

Using a hydraulically actuated device, such as a claw, a press, a jack, or similar device in a marine environment, presents problems not confronting operators on land. The opportunity for close inspection and clear visability are often nonexistent, especially at great depths, and an operator's full attention must be given to manipulating the claw with little attention being directed to the effect a hydraulically actuated claw has on a gripped object. When an object is to be lifted or moved about underwater, the claw operator runs the risk of crushing or dropping the object simply because he is unable to watch gauges or pressure responsive devices indicating the gripping force exerted. Another hazard facing the crew of a submersible is the untimely detonation of underwater ordnance during recovery if too much pressure is exerted by a claw. Within the confined interior of a submersible a distinct possibility is ever present that too much or too little force will be exerted by the claw should the control mechanism be inadvertently switched to an unwanted mode. One attempt at remedying this possibility calls for including a single rotary switch having arcuately disposed positions corresponding to the open, close, grip, and increase-grip mode of operation. However, with this scheme it is quite possible to override the desired positioning of the switch and cause the jaws to either lose or crush the gripped object.

Another switching technique uses a single potentiometer to control the claw's gripping force. This is inherently a risky approach since an operator having his attention diverted elsewhere is unable to closely watch a meter or the position of the slider on a resistance element, be it in a rotary or a linear configuration.

SUMMARY OF THE INVENTION

The present invention is directed to providing a switching system for controlling an electro-hydraulically actuated claw having a DC power source and a servo valve unit hydraulically actuating the claw to an open, closed, and grip position with a minimum possibility of inadvertently switching the claw to an unwanted mode of operation. An open-close switch is physically separated from a grip-no grip switch to positively open or to close the claw with just enough force to hold the claw on the object and to conform to the object's outer configuration. After the claw has closed, it is actuated to grip the object by the operator's switching the separate grip-no grip switch to eliminate the possibility of losing the object once the jaws have been closed about it. After the object has been gripped, the gripping force is selectively decreased or increased by a third control, separate and distinct from either the open-close switch or the grip-no grip switch to eliminate the possibility of crushing a fragile recoverable object or to increase the force should there be a heavy object to be recovered.

The prime object of the invention is to provide a switching system for ensuring more reliable electro-hydraulic claw operation.

Another object of the invention is to provide a switching system minimizing the possibility of inadvertently dropping or crushing an object.

A further object is to provide a hydraulically actuated claw control which allows an operator to direct his full attention to observing the claw's performance since the control's conditions are determined by touch.

Yet another object is to provide a hydraulically actuated claw control capable of exerting a variable gripping force.

Still another object is to provide a switching arrangement having three switches, each with its own function and physically separated, allowing undistracted observation of a remotely controlled device while it is controlled by a switch which tactily indicates the devices condition and having lateral guards to prevent accidental switching.

These and other objects of the invention will become more readily apparent from the ensuing specification when taken with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic representation of the invention operatively deployed.

FIG. **2** is a schematic circuital diagram of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, FIG. **1** depicts a representative hydraulically actuated claw or manipulator **10** normally carried on the exterior of a submersible and used to pick up objects or move them about. The supporting framework, structure joining the claw and the submersible, and the means for positioning the claw with respect to the object to be grasped are not shown in the drawings since their inclusion is beyond the scope of the disclosure necessary for pointing out the present invention. Furthermore, while a claw is shown, any hydraulically actuated device optionally is substituted, the only requirement being that the device is actuated by a supply line **11** and a return line **12** hydraulically transferring forces.

In the representative claw shown, a pair of jaws **10*a*** and **10*b*** are pivotually mounted on a pin **10*c*** for opposed pivotual motion. The pivotual motion is imparted by a hydraulic actuator **10*d*** carried behind the jaws which is responsive to the internal hydraulic pressure in lines **11** and **12**.

In a simple form, the actuator is no more than a pair of hydraulic pistons suitably interconnected and mechanically joined to the jaws. Whether the jaws open, close, or transfer a variable force is established by the hydraulic pressure differential between the internal pressures in the supply line and the return line. The hydraulic pressure differential acting on the actuator, rotates the jaws about their pivot to transmit a proportional gripping force on the object, shown in cross section, permitting its retrieval. By varying the pressure differential, the jaws assume the open, the close or the grip mode of operation.

Hydraulically upstream from the claw, a conventional source of hydraulic pressure **15** provides a suita-

ble level of hydraulic pressure for articulating the claw. A feeder supply line **15***a* and a feeder return line **15***b*, extending from appropriate fittings, serve as conduits for transferring an "on" or "off" supply of hydraulic pressure preferably at constant magnitudes to an electric signal-controlled, hydraulic servo-valve unit **20**.

The servo-valve unit is fabricated according to contemporary electro-hydraulic design critera to ensure selective variation of the pressure received from source **15** and to feed it through the pair of lines **11** and **12** as required. Elaboration on the exact hydraulic manifold, valving, and servo controls is not felt to be necessary at this point, since a suitable combination is selectable from a wide variety of commercially available units once the magnitudes of source pressure and the supply and return pressures are determined. In the selection of the servo valve unit due consideration must also be given to the magnitude of the control signals fed to the unit, via servo valve control leads **20***a*, to ensure the proper, responsive pressure variations.

After a servo valve unit is fabricated, once the foregoing parameters are known, it is selectively controllable by control leads **20***a* reaching through a packing or hull penetrator **23** provided in a submersible pressure hull **24** to the present invention, remote control unit **25**.

Inside the submersible a conventional source of AC power is coupled to the control unit through a pair of input leads **26**. A pair of serially connected fuses **27**, preventing circuit overload, separate the input leads from a double-pole, single-throw switch **28**. Following the switch, an indicator lamp **29** gives a positive visual indication when AC power is received by remote control unit **25**.

Incoming AC power is fed to other electric and electronic functions inside and outside of the submersible through the remote unit; however, the immediate concern of the present disclosure is that the AC power is electrically coupled to a combination inverter-source of DC power **30**.

The inverter functions to change the alternating current to direct current and regulates it to a positive DC potential at source output terminal **30***a* and a negative DC potential at a source output terminal **30***b*. The exact magnitudes of the positive and negative DC potentials are set to be a function of the values of the following circuit components and a function of the control signal strengths fed to servo valve control leads **20***a* necessary to actuate the servo valve unit. A representative potential used in one embodiment of the invention called for DC potentials of ±5.6 volts at the terminals **30***a* and **30***b* respectively.

An open-close switch, a first double-pole, double-throw switch **31**, is provided having a pair of center contacts **31***a'* and **31***a''* respectively connected to lead input points **20***a'* and **20***a''* of the control leads **20***a*.

To effect the generation and transfer of a control signal which will drive the servo valve unit to open the claw, the center contacts are switched to the open position connecting them to a pair of open contacts **31***b'* and **31***b''*. A positive DC potential appearing at source output terminal **30***a* is fed to lead input point **20***a'* and a negative potential from DC source output terminal **30***b* appears at lead input point **20***a''*. The magnitude of the open control signal appearing across control lead **20***a* is precisely adjusted by including a potentiometer **32** across the DC output terminals having its slider **33** positional thereon to deliver the proper open control signal. Switching center contact **31***a'* and **31***b''* to the close position connecting them to contacts **31***c'* and **31***c''* creates a partial circuit for a close control signal of substantially the same magnitude as the open control signal, but at the opposite polarity.

By switching the first switch to the open position, the negative DC potential appearing at source output terminal **30***b* is fed to lead input point **20***a''* via the center contact **31***c''*.

A complete circuit ensuring the transfer of the close control signal relies on having a grip-no grip switch, a second double-pole, a double-throw switch **34** having center contacts **34***a'* and **34***a''*. Connecting these center contacts to the no grip position in electrical communication with no grip contacts **34***b'* and **34***b''* creates a path joining the positive DC potential appearing on source output terminal **30***a* to lead input point **20***a''*. This path follows the circuit defined by potentiometer **35**, its slider **36**, center contact **34***a'*, no-grip contact **34***b'* close contact **31***c''* and center contact **31***a''*. Slider **36** is appropriately positioned on potentiometer **25** to ensure that the close control signal is of the proper magnitude to actuate the servo valve unit to close the claw. Although any relative values are given to the open signals and close signals, having them equal but of opposite polarity was found to be preferable.

Switching the first switch to the close position, that being with center contacts **31***a'* and **31***a''* switched to abut close contacts **31***c'* and **31***c''*, the jaws are articulated to close and come in contact with the object, shown in cross section in FIG. **1** of the drawings.

Should recovery of the object be called for, the operator reaches to the separately disposed second switch **34** and switches it to the grip position to electrically engage center contacts **34***a'* and **34***a''* and grip contacts **34***c'* and **34***c''*.

This manner of electrical interconnection sets up a conductive path for a gripping signal from DC negative source terminal **30***b* to close contact **31***c'*, to center contact **31***a'*, and to lead input point **20***a'* of lead **20***a*. Simultaneously, lead input point **20***a''* is electrically connected to a positive DC source output terminal **30***a* through another potentiometer **37** connected in parallel across the two output terminals of the DC source through a slider **38**. Slider **38**, in turn, is a serial extension of a variable control potentiometer **39** having a wiper **40** directly connected to center contact **34***a''* of the second switch. From this center contact the circuit to the lead input point **20***a''* is completed via the grip contact **34***c''*.

The polarity of the gripping signal calling for the claw's exerting a gripping force is the same as the close signal but of greater magnitude due to the settings of slider **38** and wiper **40** on their respective potentiometers, **37** and **39**.

Snapping switch **31** to the close position and second switch **34** to the grip position, slider **40**, mechanically connected to a separate control knob **40'**, is selectively adjustable to control the magnitude of the grip signal being fed to the servo valve unit to selectively vary the gripping force exerted by the jaws.

With the first switch in its open position an open signal is coupled to the servo valve unit and the jaws are spread apart. Should second switch **34** be accidentally switched from its no grip position to its grip position while the first switch is in the open position, the grip signal standing by itself is of an insufficient magnitude to overcome the open signal and the jaws remain open. Such is the case because of the predetermined settings of sliders **33, 38** and **40**, to thusly prevent the inadvertent closing of the jaws.

Spacially separating first switch **31**, second switch **34**, and grip control knob **40'** significantly reduces the possibility of damage or accident due to the untimely actuation of one or the other control. Lateral guards extending outwardly from the front of the control unit housing are mounted parallel to the direction the three switches are thrown (switched from one position to another) to further reduce the possibility of accidental switching.

A pressure readout dial **41** also included in the remote unit, and via electrical leads joined to a pressure readout device disposed in the servo valve unit, provides an indication of pressure exerted.

When pressure sensitive ordnance is to be gripped by the claw, a hazard is ever present that it may detonate and rupture the submersible's pressure hull. Using the invention minimizes this hazard. The submersible crew approaches the ordnance, positions the open claw around it, and by switching the open-close switch to the close position, the claw lightly abuts the ordnance's outer surface. The submersible is mechanically separated from the claw and it retires a safe distance trailing the supply and return lines. The ordnance is gripped by the claw in response to a grip signal without exposing the submersible to the danger of explosion. Upon recoupling the claw and submersible, the ordnance is safely transported.

Obviously many modifications and variations of the present invention are possible in light of the above teachings, and, it is therefore understood that within the scope of the disclosed inventive concept, the invention may be practiced otherwise than specifically described.

What is claimed is:

1. In a switching system for controlling an electro-hydraulically actuated claw having a DC power source and a servo valve unit hydraulically actuating said claw to open, to close, and to grip, an improvement therefor is provided comprising:

an open-close circuit including a first double-pole, double-throw switch having its open contacts connected across said source in one polarity, its close contacts connected across said source in the opposite polarity, and its center contacts connected to said servo valve unit, upon switching to said open contacts, passing a signal of said one polarity to said servo valve unit to actuate said claw to the open position and upon switching to said close contacts passing a signal of said opposite polarity to said servo valve unit to actuate said claw to the close position;

a grip-no grip circuit including a second double-pole, double-throw switch having one of its no-grip contacts connected to one of said close contacts and its other no-grip contact open-circuited, one of its grip contacts open-circuited and its other grip contact connected to one of said center contacts and to said servo valve unit, the center contacts of the second switch being coupled across said source, upon switching to said no-grip position when the first switch is in the open position, the second switch is open circuited and said claw remains in said open position, upon switching to said no-grip position when said first switch is in said close position, a conductive path for said signal of said opposite polarity is completed to maintain said close position, upon switching to said grip position when said first switch is in said open position, a signal of less magnitude than said signal of said one polarity is fed to said servo valve unit to maintain said claw in said open position, and upon switching to said grip position when said first switch is in said close position, a grip signal of a magnitude greater than the magnitude of said signal of said opposite polarity is fed to said servo valve unit to actuate said claw to exert a gripping force; and

a variable impedance coupled between the center contacts of said second switch to selectively vary the magnitude of said grip signal to change said gripping force.

2. A system according to claim **1** in which said open contacts are coupled across a first potentiometer connected across said source to precisely regulate the magnitude of said signal of said one polarity and said close contacts are coupled across a second potentiometer when said second switch is in the no-grip position to precisely regulate the magnitude of said signal of said opposite polarity.

3. A system according to claim **2** further including:

an AC source;

a double-pole, single-throw switch for connecting said AC source to said DC source, said DC source having the capability to convert AC energy to DC energy to provide control signals for said servo valve unit

and an indicator coupled to said AC source to provide a visual indication of the pressure of AC power.

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