SWELL COMPENSATOR FOR A DRAG SUCTION DREDGER

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5 Claims

ABSTRACT OF THE DISCLOSURE

A swell compensator for the suction pipe of a drag suction dredger has an indicating device which rises and falls opposite to the direction of the dredger in the swell. Switches on either side of the median position of the indicator actuate an integrator so that upon excessive frequency and/or direction of oscillation of the switches on one side of the median position, the motor for the suction pipe winch is actuated in a direction to return the indicator to its median position.

The invention relates to a swell compensator for the suction pipe of a drag suction dredger, which compensator is provided with an indicating device by means of which the winch motor of the winch is controlled on which the suction pipe is suspended.

In the conventional drag suction dredgers the function of the swell compensator consists in keeping constant the pressure exerted on the seabed by the suction head, irrespective of any swell and varying depth of suction. This is achieved by keeping constant the tension in the winch rope on which the suction pipe is suspended. If this tension is kept constant, the suction head indeed will always rest with the same pressure on the seabed, which promotes the steady sucking away of a given layer thickness. The tension in the winch rope is kept constant by a partly hydraulically operating device, which is adapted to move a pulley, over which the winch rope passes, in the vertical direction. The winch rope further passes from the pulley downwards and over a second pulley to the winch drum which is driven by the winch motor.

When the suction pipe touches the seabed at a given depth, owing to the tension in the winch rope, the first-mentioned pulley will be in a given median position and in case of a swell, as long as the winch motor is not switched on and the suction pipe remains hanging at the same depth, will oscillate about a different median position. Thus the end position of the compensator pulley finally may be reached.

To prevent this, use is made of the indicating device connected with the swell compensator, e.g. with the first-mentioned pulley. This device supplies information about the distance travelled by the pulley. When the indicating device, which, for instance, indicates at once the oscillations of the pulley, exceeds a given limiting value during the oscillation, the winch motor must be switched on in order to return, through the shortening or lengthening of the winch rope, the swell compensator to its original median position and to restore its full compensating possibility.

In the known drag suction dredgers, the winch motor is controlled by the dredging master by reference to the indications on board the drag suction dredger, such as adjustment of the optimum pressure of the swell compensator, adjustment of the optimum output of the dredge pumps, adjustment of the optimum speed, etc. are not always properly performed, so that the optimum production is not attained. If his attention for the indicating device should fail, there is a risk that a suction pipe may be lost.

The object of the invention is to furnish an automatically operating control device for the winch motor, which is actuated as soon as the indicating device of the compensator exceeds a given limiting value.

According to the invention therefore on either side of the median position of the indicating device are mounted one or more switches to be actuated by the indicating device, while a circuit is present which operates in such a way that it is only after the sum of a number of signals has been exceeded and a given duration of the separate signals, resulting from the closing of the upper or the lower switches respectively, has been exceeded that an error signal is produced, which induces a correction signal for switching on the winch motor in one direction of rotation or the other, owing to which the position of the suction pipe is changed in the sense that the indicating device is returned to the median position, while furthermore means are present for the maintenance of the correction signal during a given period after the disappearance of the error signal.

The invention will now be explained more fully with reference to the drawing.

FIG. 1 shows a drag suction dredger with a suction pipe dragging over the seabed and provided with a diagrammatically shown swell compensator;

FIG. 2 shows the wiring diagram of the circuit and further means for operating the winch motor;

FIG. 3 shows the voltage wave form occurring in point T in FIG. 2;

FIG. 4 shows further signal wave forms occurring in the circuit according to FIG. 2.

In FIG. 1, Z is the suction pipe hanging down from the ship to the seabed, and D is the diagrammatically shown swell compensator with pulley K. The winch rope passes over this pulley and then over a second pulley to the winch drum H. The hoisting part may also be designed to be double, with a pulley on the suction pipe. The pulley K is adapted to move up and down vertically and is fastened to a piston in a cylinder which contains a non-compressible medium, which may enter a pressure vessel containing, for instance, compressed air, which exerts a substantially constant pressure on the medium, and thus also a constant force on the pulley K.

Connected mechanically with this pulley K is a compensator plate, which can therefore be moved vertically up and down together with the pulley. Close beside the path of movement (FIG. 2) of the compensator plate there are four switches, viz. 2 and 3 above the normal median position of the compensator plate 1 and the switches 4 and 5 below the normal median position of compensator plate 1. The switches 3 and 4 are so positioned that they are actuated before the switches 2 and 5, i.e. in case of oscillations with smaller amplitudes. The number of switches naturally is not limited to four. Preferably use will be made of so-called reed switches, actuated by a change of the strength of a magnetic field due to the movement of the compensator plate 1.

The distance from the switches 3 and 4 to the normal median position of the compensator plate 1 has been so chosen that below a predetermined swell these switches are not closed, or only too shortly so, for them to operate the winch motors. These motors are not switched on until by a change of the level of the seabed the compensator plate 1 will no longer oscillate about its normal median position, in consequence of which one or more of the
switches are closed repeatedly and for a longer time period. Of each of the switches 2-5 one contact is connected to a source of voltage, viz. the output of the switches 2 and 3 to the positive terminal 6 of this source with a voltage of +13 volts with respect to earth, and the contacts of the switches 4 and 5 to the negative terminal 7 of this source, with a voltage of -13 volts with respect to earth. The other contacts of these switches are all connected to the input terminal N of a direct current amplifier 18, the other input terminal of which is earthed. The resistors 8-11 have such values that with greater displacement of the compensator plate 1 from the median position, higher currents are supplied to the input terminal N of the amplifier 18. In the circuit shown in the drawing the resistors 8 and 11 therefore have lower values than the resistors 9 and 10, resistor 9 being equal to resistor 10 and resistor 8 being equal to resistor 11.

The output terminal of the amplifier 18 is coupled back via a parallel network, consisting of capacitor 17 and resistor 16, to its input terminal N, the output of an integrating circuit is obtained. The amplifier 18 operates in such a way that as soon as one of the switches 2-5 closes a current will flow to the input terminal N, and the polarity in this terminal is returned to earth potential via the feed-back path with capacitor 17 and resistor 16. This results in a current of opposite polarity in the output terminal T of amplifier 18, rising practically linearly owing to the presence of capacitor 17. FIG. 3's uninterrupted line shows the voltage wave form in point T upon a constant current flowing to input terminal N of amplifier 18. In addition to the value of the capacitor 17 and the resistor 16, the inclination of the leading edge of the shown wave form mainly will be determined by the current strength in the input terminal N, and thus by the displacement of the compensator plate 1, because in case of a greater displacement in a direction away from the median position current pulses of longer duration, and in case of even greater displacement moreover stronger current pulses will flow to the input terminal so that in the output terminal of the amplifier 18 a stronger voltage of opposite polarity occurs. This implies that the voltage in the output terminal T of the amplifier 18 will sooner tend to exceed a given threshold value with increasing displacement of the compensator plate 1 upwards or downwards with respect to its normal median position. In the circuit according to FIG. 2 this threshold value lies at a voltage of plus and minus 8 volts.

The values of the resistors 8-11, 16, and of the capacitor 17, and the adjustment of the amplifier 18 have been made exactly so chosen that with oscillations about the normal median position of the compensator plate, when the switches 2-5 are periodically closed for a short time, e.g. in case of a strong swell, the above-mentioned limiting value is not attained. This will be obvious because upon the closure of the switches, alternately short positive and negative current pulses are fed to terminal N, in consequence of which also the output voltage in terminal T begins to oscillate about the zero potential, but without attaining the threshold value. This oscillating voltage is shown in FIG. 3 in dashed lines.

When owing to the rising of the seabed the suction pipe reaches a higher position in a swell, as long as the winch motor is inoperative, the compensator plate 1 will no longer oscillate about the median position, so that, for instance, switch 3 is closed for a longer period than switch 4, or switch 4 is not closed at all. In that case positive pulses of a longer duration than the negative pulses are fed to the input terminal N, or no negative pulses at all. As a result the voltage in the output terminal owing to the periodic closure of switch 3 stepwise will approach the said threshold value of minus 8 volts. When in addition to switch 3 also switch 2 for shorter or longer periods will be closed owing to the lower resistor 8, the threshold value will be attained much sooner. The rise of the voltage in point T when switches 2 and 3 are closed is shown constant is shown in FIG. 3 by the line of dots and dashes. P3 is the time period elapsed before the closure of switch 3, while P2 is the period time elapsed between the closure of switch 3 and switch 2.

The output terminal T of amplifier 18 is connected to an intermediate tap of a voltage divider consisting of four series-connected resistors 19-22. The end terminals of said divider are connected respectively to the output terminal of plus 13 and minus 13 volts. The connecting point between the resistors 19 and 20, located on the positive side of the voltage divider, is connected to an input terminal of a trigger circuit 23, while the connecting point between the resistors 21 and 22, located on the negative side of the voltage divider, is connected to an input terminal of trigger circuit 24. The two other input terminals of these trigger circuits 23 and 24 are earthed. Connected between each of the input terminals connected to the voltage divider and the earth is a voltage limiter consisting of two oppositely parallel-connected diodes 25, 26 and 27, 28 respectively. These diodes limit the input voltage for the trigger circuits 23 and 24 in the example according to FIG. 2 to plus and minus 0.5 volt, while already at plus and minus 0.2 volt they are completely saturated, their output voltage switching from plus 12 volts to minus 12 volts for trigger 23 and from minus 12 volts to plus 12 volts for trigger 24.

The voltages generated by the voltages of plus 13 and minus 13 volts in the connecting points between the resistors 19 and 20 on the one hand and the resistors 21 and 22 on the other hand, i.e. the input voltages of the trigger circuits 23 and 24 respectively, are affected by the voltage in the output terminal T of amplifier 18. As soon as in point T the threshold value of minus 8 volts or plus 8 volts is exceeded, the input voltage on the triggers 23 and 24 respectively exceeds a voltage of 0.2 volt, so that these triggers will be switched according to the potential of the voltage in point T.

The output terminals of the trigger circuits 23 and 24 are likewise coupled back to the input terminal N of amplifier 18 via series-connected resistors and diodes 12, 14 and 13, 15 respectively. This feed-back path ensures that, in the positive half of the circuit for instance, as soon as one of the switches 2 and 3 has been closed for a sufficiently long time, the threshold value at point T is exceeded and the output voltage of trigger circuit 23 switches from plus 12 volts to minus 12 volts. The capacitor 17 is discharged through diode 14 and resistor 12, owing to the disappearance of the blocking voltage of plus 12 volts on diode 14, so that the voltage at point T is lowered again to a level below the threshold voltage of minus 8 volts. In FIG. 3 the negative voltage has been plotted upwards, for which reason a lowering of the voltage is here spoken of. The rate at which the voltage in point T is lowered depends, apart from the value of capacitor 17, on the values of the resistors 16 and 12. When the voltage in point T has lowered to minus 7 volts, the trigger circuit 23 switches again to minus 12 volts. The time constant during the discharging of capacitor 17 has been so chosen in respect to the time constant during the charging of this capacitor that upon continuous supply of the strongest input voltage to terminal N of amplifier 18 a voltage oscillating substantially symmetrically about the threshold value is obtained in point T, so that the trigger circuit 23, or if in point N the maximum negative current is supplied, the trigger circuit 24, will be switched from the one condition to the other and vice versa seconds period of duration of about 1 second, the positive half having about the same length as the negative half.

Thus, according as the switches 3 and 2 or 4 and 5 are closed for a shorter or longer duration in the output terminal of the trigger circuit 23 and 24 respectively,
a series of more or less rapidly succeeding pulses will be generated.

These series of pulses, or separate pulses, are fed to delay circuits 33 and 34 respectively via resistor 31 and reversing circuit 32 respectively. The reversing circuit 32 ensures that pulses of equal polarity are fed to the delay circuits 33 and 34.

The output signal of the delay circuits 33 and 34 consists of a pulse which commences simultaneously with the arrival of the leading edge of a pulse produced by the trigger circuit, but only ends after a given time period after receipt of the trailing edge of the last pulse of a series of pulses.

FIG. 4 shows on line a the input pulses for delay circuit 33 and on line b, plotted in the same time, the output signal of delay circuit 33. The time t which elapses between the trailing edge of the last pulse and the end of the output signal of delay circuit 33, which is the correction signal, is adjustable between 0.2 and 20 seconds.

Following the delay circuits 33 and 34 are the NOR-gates 36 and 37 and the amplifiers 38 and 39 respectively. The output signals of these latter amplifiers are fed to the switches for the hauling and the unwinding respectively of the winch motor or motors. These motors are switched on at once as soon as one of the trigger circuits 23 and 24 switches to the other state since the leading edge of the input pulse for the delay circuit is immediately followed by the leading edge of the correction signal fed to the switches for the winch motors. The delay of the end of the correction signal is necessary because the control signal of the switch 3 or 4 already ceases before the compensator plate has returned to the median position. Without this delay the compensator plate would get no opportunity to return to the original median position. In the present example the delay shown in FIG. 4 is 4 seconds.

The NOR-gates 36 and 37 prevent the simultaneous operation of the switches for the hauling as well as those for the unwinding. In consequence, expensive motor-protection circuits are not needed. As soon as one of the NOR-gates has been opened, the output signal of this NOR-gate serves not only to energize the switches, but also as an input signal for the other NOR-gate, in consequence of which the latter is blocked. The NOR-gates 36 and 37 further receive an input signal from a protecting circuit 35. This prevents the winch motor beginning to rotate at once when the complete apparatus is switched on. The input voltage for the NOR-gates 36 and 37 produced by the protecting circuit 35 disappears after about 10 seconds. It is only after this that the winch motor can be energized by the feeding of a correction signal by one of the delay circuits 33 or 34.

Having described my invention, I claim:

1. In a drag suction dredger having a suction pipe, winch means by which the suction pipe is suspended, a motor for driving the winch means in either direction, and an indicating device movable in opposite directions past a median position as the dredger rises and falls with swell, the improvement comprising switch means disposed on opposite sides of said median position of the indicating device and operable by movement of the indicating device beyond said median position, means responsive to the actuation of said switch means for producing an error signal when the sum of the number and duration of the actuations of the switch means on one side of said median position exceeds a predetermined value, said means for producing an error signal comprising an integrator having an output terminal which produces a signal the strength of which increases or decreases from ground potential in consequence of the frequency and duration of actuation of the switch means, a trigger which is set, when the integrator output terminal signal strength exceeds a predetermined threshold value to feed a voltage in the form of a pulse, a delay circuit for receiving said pulse and for thereupon producing a correction signal that begins after the reception of the leading edge of the pulse and that ends a length of time after reception of the trailing end of the pulse, means for adjusting said length of time, and means responsive to said correction signal to actuate said motor to drive the winch means in a direction to return the indicating device to said median position.

2. Apparatus as claimed in claim 1, said integrator comprising a direct current amplifier coupled back via a parallel network of a capacitor and a resistor.

3. Apparatus as claimed in claim 1, said integrator having a capacitor, said trigger closing a discharge path for said capacitor so that the trigger is reset after the voltage supplied to the output terminal of the integrator has decreased below said threshold value.

4. Apparatus as claimed in claim 1, and NOR-gate block each other, and means for feeding the output signals of the delay circuit to the NOR-gates so that it is not possible for the winch motor to receive signals to drive the winch means simultaneously in both directions.

5. Apparatus as claimed in claim 4, and a protecting circuit for sending input signals to the NOR-gates and for maintaining said input signals for a predetermined period of time.

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