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[54] **ELECTROHYDRAULIC CONTROL ARRANGEMENT FOR HYDRAULIC ACTUATORS**

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[51] **Int. Cl.** **F16k 11/00**

[58] **Field of Search** 137/625.64, 625.66, 137/625.65, 625.69, 554, 487.5; 251/131, 251/130, 14, 25, 63, 78

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Attorney—Striker, Striker, Kontler & Stenby

[57] **ABSTRACT**

A control arrangement for hydraulic actuators in which two hydraulic transmission lines communicating with the actuator are closed when the control slide of a control valve is in neutral position. Inlet and return lines communicate with the hydraulic transmission lines in alternate operative positions of the control slide. The control slide is actuated by a piston moving within a control cylinder. Working fluid is applied to the control cylinder through electromagnetically actuated valves. A remote control lever provides an adjustable input parameter through a transducer. The electromagnetically actuated valves are operated by a regulating amplifier as a function of the input parameter established by the remote control lever. Two flow lines communicate with the control cylinder and are connected to the inlet and return lines by two electromagnetically actuated valves. Threshold switching circuits are connected between the signal amplifiers used to energize the electromagnetically actuated valves and the regulating amplifier.

17 Claims, 5 Drawing Figures

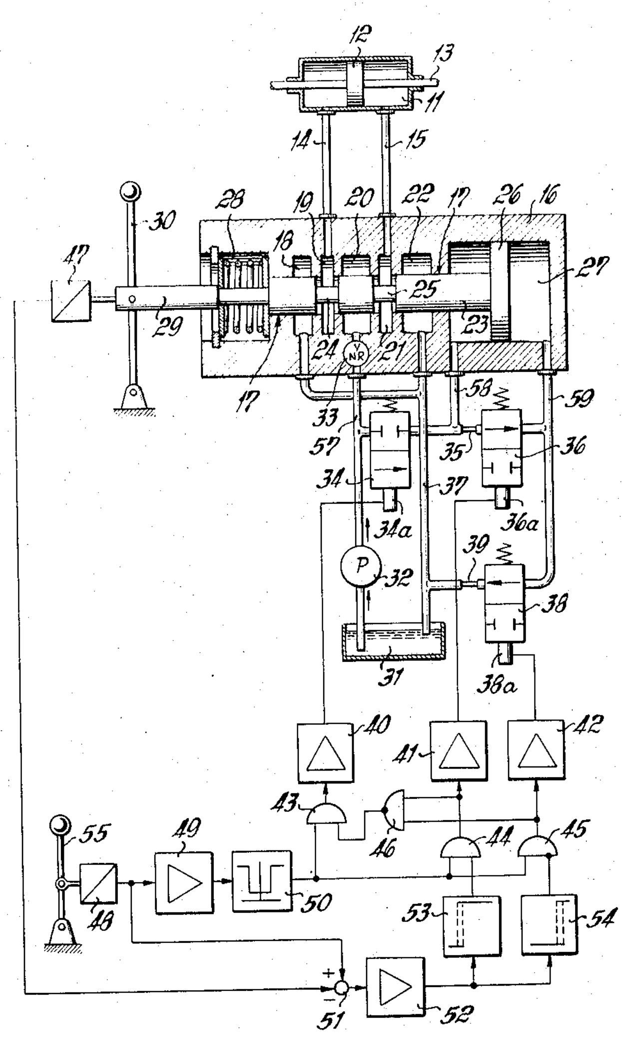

FIG. 1

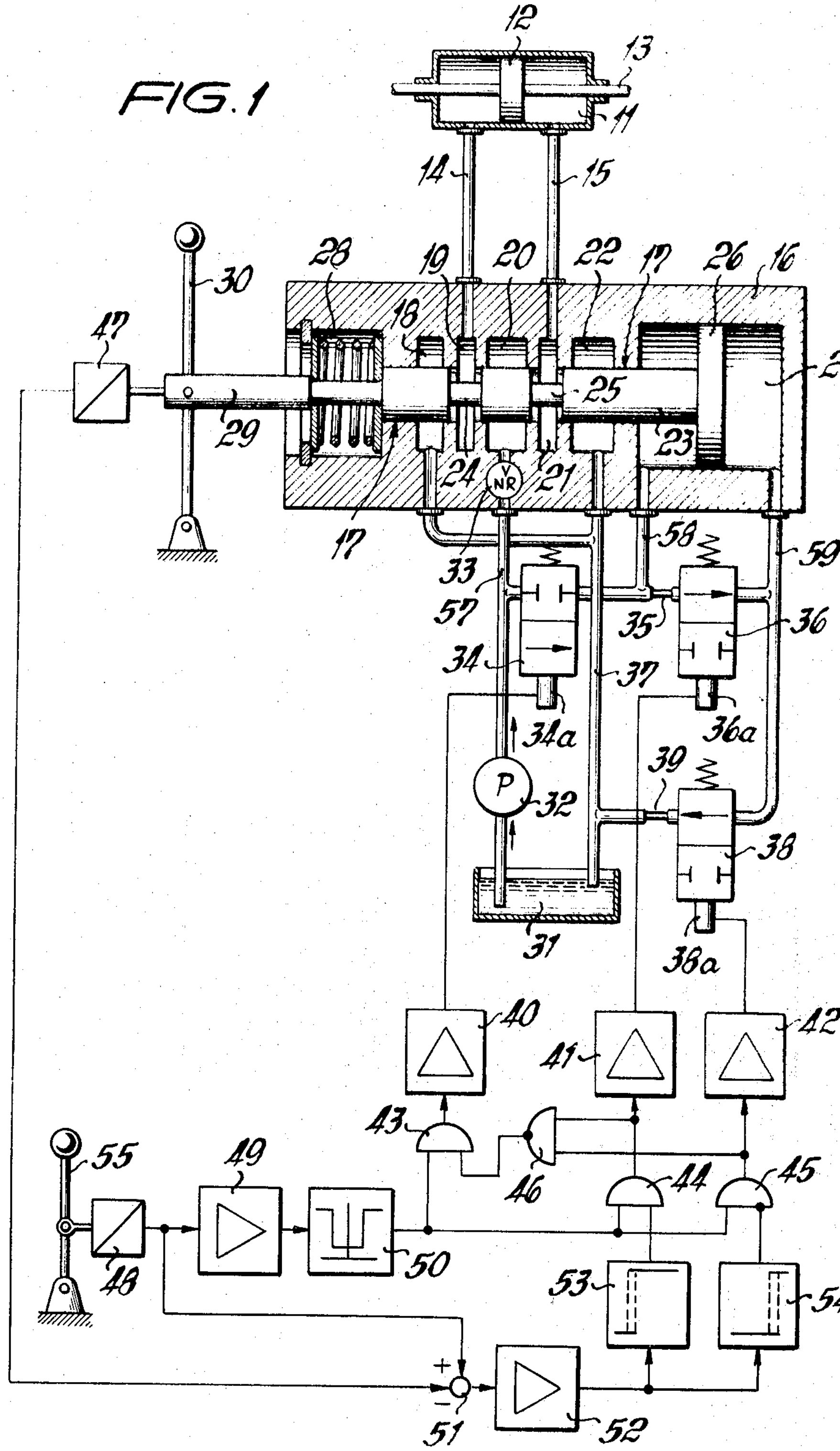
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FIG. 2

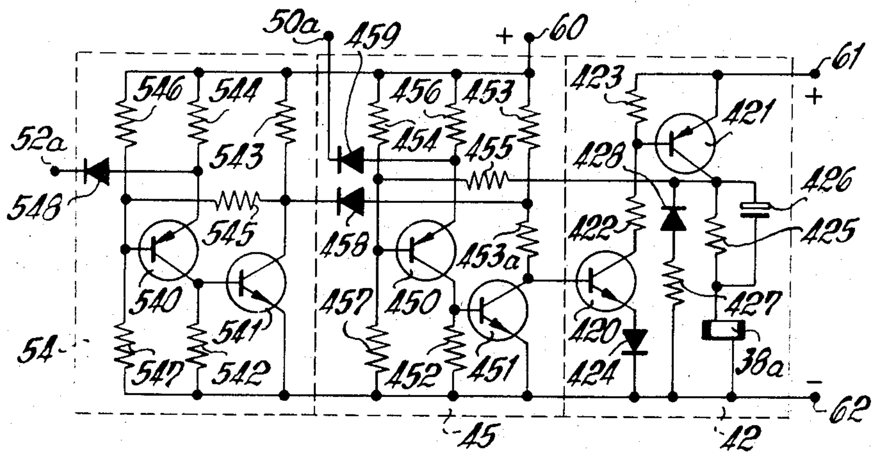


FIG. 3

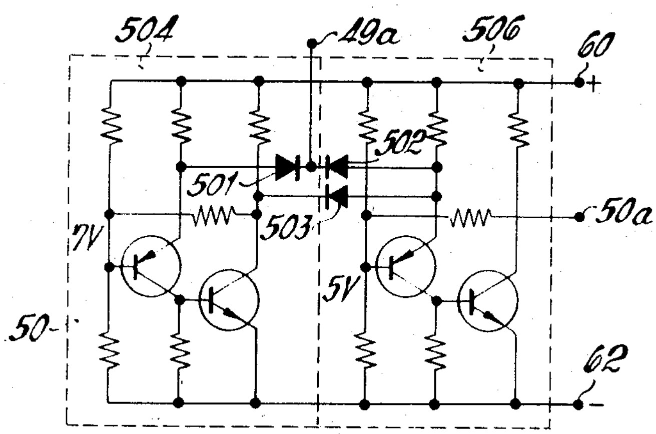


FIG. 4

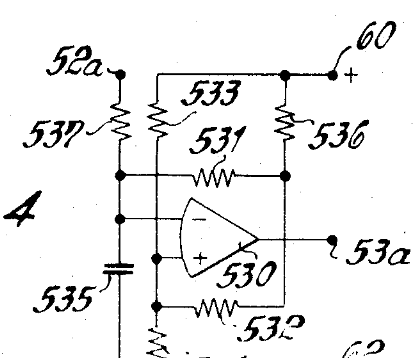
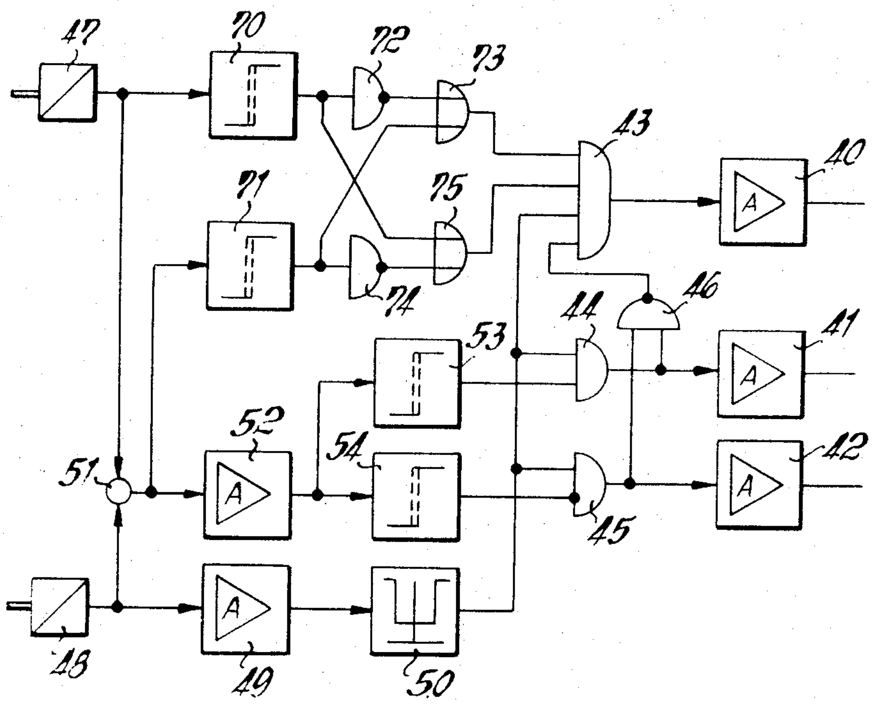


FIG. 5



ELECTROHYDRAULIC CONTROL ARRANGEMENT FOR HYDRAULIC ACTUATORS

BACKGROUND OF THE INVENTION

The present invention relates to an electrohydraulic control arrangement for use in conjunction with a hydraulic actuator which is operable in two directions. A control valve is provided with a control slider which closes two lines to the actuator when in neutral position. A regulating amplifier controls the precontrol valves as a function of an input parameter set by a remote control lever.

A control arrangement of the preceding known species is already known in the art for actuating the altitude rudder or flaps of an aircraft. In such an arrangement known in the art, the output parameter or value from the deflection angle of the rudder is applied to a second input of the regulating amplifier, so that for every position of the remote control lever, a predetermined deflection angle of the rudder is attained. In other hydraulic actuators, as for example in automotive cranes, which are driven by double acting hydraulic cylinders or by a hydraulic motor with radial head, it is desired, however, to regulate the velocity rather than the final position.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a control arrangement in which a predetermined velocity of the hydraulic actuator corresponds to every position of the remote control lever. In the use of an automotive crane, for example, the velocity of the load fork or distributor is to be set or established.

Another object of the present invention is to provide an arrangement for controlling a hydraulic actuator, as set forth, which is simple and design and may be readily fabricated.

A still further object of the present invention is to provide an arrangement of the foregoing character which may be economically manufactured and economically maintained in service.

Another object of the present invention is to provide an arrangement of the foregoing character which is reliable in operation.

The objects of the present invention are achieved by providing that the control cylinder is in the form of a double acting cylinder with two communicating lines. A second and a third precontrol valve connect the two communicating lines with inlet and return lines. Each precontrol valve may be actuated through a magnetic winding which, in turn, is energized by a signal amplifier. The signal amplifiers are connected, through threshold switching circuits, to the output of the regulating amplifier.

In an automotive crane it is advantageous when the operating personnel of the crane, can operate the crane directly when on the vehicle for the crane, as well as from a remote location through a cable. Such possibility is realized with a further embodiment of the present invention, in which a first precontrol valve lies between the inlet line and the two other precontrol valves. The first precontrol valve is closed when the remote control lever is in its 0 position. When the first precontrol valve is closed, furthermore, the control slide may be actuated by a close control lever.

The velocity of the hydraulic actuator or operating arrangement may be precisely regulated or set, in accordance with a further embodiment of the present invention, by providing that an output parameter or value transducer may be actuated by the control slide. The output transducer and the input transducer are both connected to a summing device in front of the regulating amplifier.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** is a schematic diagram of the hydraulic arrangement in conjunction with the electronic control circuitry, in accordance with the present invention;

FIGS. **2–4** are electrical circuit diagrams of operating circuits shown in block form in FIG. **1**;

FIG. **5** is a block diagram of a second embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawing and in particular to FIG. **1**, a hydaulic operating unit has a double-acting cylinder **11** in which a piston head **12** moves with a piston rod **13**. The cylinder **11** is connected to a control valve through lines **14** and **15**. Within a housing **16** of the control valve, is a slider bore **17** which guides closely a control slide **23**. The slide bore **17** communicates with five chambers **18, 19, 20, 21, 22** and a control cylinder **27**. The central chamber **20** is connected with an inlet line **57** through a check valve **33**. The two chambers **19, 21** on both sides of a central chamber **20**, are connected with the lines **14, 15**, while the outer chambers **18**, and **22** are connected to the return line **37**.

The control slide **23** is subdivided into three slider sections by two necked-down portions **24, 25**. In the neutral position of the control slide **23**, the three slider sections lie closely opposite the chambers **18** to **22**, as shown in FIG. **1**. At the right end of the control slide **23**, is a control piston head **26** which is designed in the embodiment in the form of a differential piston, and is movable within the control cylinder **27**. At the left end of the control slide **23**, is an extension **29** which actuates, on the one hand, a double-acting return or resetting arrangement. This extension **29** also is connected, on the other hand, mechanically with a control lever **30** and an output transducer **47**.

The inlet line **57** is provided with pressurized fluid from a storage reservoir **31**, by means of a pump **32**. A hydraulic series-connected circuit between the inlet line **57** and the return line **37**, consists of the series combination of a first control valve **34**, a first throttle **35**, a second control valve **36**, a third control valve **38**, and a second throttle **39**. The control cylinder **27** is, on one hand, connected through a first line **58**, to the connecting line between the first control valve **34** and the first throttle **35**. The control cylinder **27** is also connected, on the other hand, through a line **59**, to the connecting line between the second control valve **36** and the third control valve **38**.

The control valves **34, 36** and **38** become actuated by the electromagnet windings **34*a*, 36*a*** and **38*a***. Each winding becomes controlled from an amplifier **40, 41, 42**, respectively.

A remote control lever **55** actuates an input transducer **48** which has an output connected to a dead-center element **50**, through an amplifier stage **49**. Connected with the output of the dead-center element **50**, are the first inputs of three AND-gates **43, 44** and **45**. These AND-gates are, in turn, connected to amplifiers **40, 41** and **42**, with their outputs. The second input of the first AND-gate **43** is connected, through a fourth AND-gate **46**, with the outputs of the second and third AND-gates, **44** and **45**, respectively. The AND-gate **46** is constructed in the form of a NAND-gate.

The second inputs of the second and third AND-gate **44, 45** are connected each, by way of threshold switches **53, 54**, to the output of a regulating amplifier **52**. A summing device **51** is connected to the input of this regulating amplifier **52**. The input transducer **48** and the output transducer **47** are connected to the inputs of the summing device **51**.

FIG. **2** shows the circuit diagram of the second threshold switch **54**, the third AND-gate **45** and the third amplifier **42**. The second threshold switch **54** is designed in the form of a two-stage, feedback-coupled amplifier with two transistors **540, 541** of opposite conductivity type. The first transistor **540** has a base voltage divider **546, 547**, an emitter-resistor **544**, and a collector resistor **542**. The collector of the first transistor **540** is connected to the base of the second transistor **541**. The collector of the second transistor **541** is connected, through a feedback resistor **545**, to the base of the first transistor **540**. This collector of the second transistor **541** is also connected, through a collector resistor **543**, to the positive voltage supply line **60**. The emitter of the first transistor **540** forms the input of the second threshold switch **54**, and is connected, through a diode **548**, to the output terminal 52a of the regulating amplifier **52**.

The third AND-gate **45** is similar to the second threshold switch **54** in the form of a feedback-coupled amplifier with two transistors of opposite conductivity type. Modifications in the circuit design are realized in the respect that the third AND-gate **45**, as shown in FIG. **1**, is designed in the form of a blocking or inhibiting gate which has a noninverting and one inverting input. In addition, the second transistor **451** in the third AND-gate **45**, has two collector resistors **453, 453a** connected in series. The junction of these two resistors is connected to the second noninverting input of the third AND-gate **45**. This junction, furthermore, is connected through a diode **458**, to the output of the second threshold switch **54**. All remaining components are the same as in the second threshold switch **54**, and are thereby not further described. The reference numerals are lower by **90**, than in the second threshold switch **54**.

The third amplifier **42** has a transistor **420** and a power transistor **421**. The preamplifying transistor **420** is connected with its base, to the output of the third AND-gate **45**. The emitter of the preamplifying transistor **420**, is connected, through a diode **424**, to the negative voltage supply line **62**. The collector of this transistor **420**, furthermore, is connected through two resistors **422, 423**, to a nonstabilized positive voltage supply line **61**. The base of the power transistor **421** is connected to the junction between the resistors **422** and **423**. The emitter of the transistor **421** is connected directly with the non-stabilized voltage supply line **61**. The collector of the power transistor **421** is connected, furthermore, through a resistor **425** and electromagnetic winding **38***a*, to the negative voltage supply line **62**. A series circuit, moreover, leads from the collector of the power transistor **421**, to a diode **428** and a resistor **427**, and from there to the negative voltage supply line **62**, as well as a junction to the feedback resistor **455** within the third AND-gate **45**. Connected in parallel with the resistor **425**, is a storage capacitor **426**.

The remaining AND-gates **42, 44** and **46**, as well as the first threshold switch **53** are constructed precisely the same as the second threshold switch **54**. The latter is universally insertable, since it is possible to connect as many inputs as desired, to the emitter of the first transistor, through diodes. At the same time, the threshold level can be set simultaneously with the aid of the base voltage divider of the first transistor.

The dead-center circuit **50**, shown in FIG. **3**, consists of two threshold switches **505, 506** which are also constructed and designed in the form described above. The threshold level of the switch **505** is set at 7 volts, in the embodiments, and the other threshold switch is set to 5 volts. The output of the switch **505** is connected, through a diode **503**, to a second output of the other threshold switch **506**. With this arrangement, a positive signal is emitted at the output terminal **50***a* of the dead-center circuit **50**, when the input voltage at the terminal **49***a* is either below 5 volts or above 7 volts. Within this region, the output terminal **50***a* is substantially at the potential of the negative voltage supply line **62**.

FIG. **4** shows the circuit diagram of a pulse stretcher modulator, which can be used in place of the threshold switch **53** or **54**. an operational amplifier **530** serves as the active component, and has a noninverting input at the junction of two resistors **533, 534**, which form a voltage divider. The inverting input of this operational amplifier **530**, is connected, through an input resistor **537**, to an input terminal **52a**. A resistor **531** is connected between the output of the operational amplifier **530** and the inverting input of the amplifier. A resistor **532**, furthermore, is connected between the output of the operational amplifier **530**, and the noninverting input. The output of the operational amplifier **530** is, furthermore, connected directly to an output terminal **53***a*, and to the positive voltage supply line **60**, through a resistor **536**. A capacitor **535** is connected between the inverting input of the operational amplifier **530**, and the negative voltage supply line **62**.

The second embodiment shown in FIG. **5**, is extensively the same as the first embodiment. The components and circuits that are the same in FIG. **5**, as they are in FIG. **1**, have the same reference numerals, and are also not further described. In the second embodiment, the first AND-gate **43** has four inputs, of which two are connected the same as in the first embodiment. The other two inputs of the first AND-gate **43** are connected with the outputs of a first OR-gate **73** and a second OR-gate **75**. A third threshold switch **70** is connected to the output of the output transducer **47**, and a fourth threshold switch **71** is connected to the output of the summing device **51**. A first inverter **72** is connected to the output of the third threshold switch **70**, and a second inverter **74** is connected to the fourth threshold switch **71**. The two inputs of the first OR-gate **73**, are connected with the output of the first inverter **72** and the output of the fourth threshold switch **71**. In a similar manner, the two inputs of the second OR-gate

75 are connected to the output of the third threshold switch 70 and the output of the second inverter 74.

For the purpose of describing the functional operation of the electro-hydraulic control arrangement, the arrangement of the hydraulic valves is described first. Each position of the control slide 23 corresponds to a predetermined fluid flow from the inlet line 57 to one of the lines 14, 15. With this arrangement, a predetermined speed or velocity of the piston head 12 can be established corresponding to a predetermined position of the control slide.

The control valves 34, 36, 38, each have two controlled connections and two positions, and are thereby constructed in the form of 2/2-way valves. In the normal inoperative position, the first control valve 34 is closed, and the two other control valves 36, 38 are open. It is possible, thereby, to bring the control slide 23 into any desired position, with the aid of the control lever 30. As a result, any desired velocity of the operating piston head 12 may be attained. Should the control slide 23 be actuated through the electro-hydraulic remote control unit with the aid of the remote control lever 55, then the first control valve 34 becomes opened. When the control piston 26 is to be moved toward the left, then the third control valve 38 must be closed, and the second control valve 36 must be opened. In the reverse situation, the second control valve 36 must be closed and the third control valve 38 must be opened, in the case that the control piston 26 is to be moved toward the right. When, finally, the control piston 26 is to be held at a predetermined position outside of its neutral position, then the second control valve 36 and the third control valve 38 must be closed.

These four different valve positions are set or established by the electronic circuit in dependency on the position of the remote control lever lever 55 and the output signal of the output transducer 47. In the following description of the functional operation, the digital circuitry is described in conjunction with the designations of a 1 signal and 0 signal as in common usage. When an AND-gate provides a 1 signal, it is implied that its output is substantially at the potential of the positive supply line 60. Conversely, when the output of the AND-gate emits a 0 signal, then the potential of the output of the AND-gate is substantially at the negative voltage supply line 62. The output transducer 47, the input transducer 48, the amplifying stage 49 and the regulating amplifier 52, all provide analog signals. These analog signals are converted to digital signals in the dead center circuit 50, as well as in the two threshold switches 53, 54. The remaining circuitry operates, then, on the basis of only digital signals.

The summing device 51 is designed so that the output signal of the input transducer 48 is negative, and the output signal of the output transducer 47 is positive. This summing device 51, therefore, computes the difference between the input value and the output value as provided by the transducers. In a practical design, the input transducer 48 and the output transducer 47 are connected to the two inputs of a difference amplifier, which serves simultaneously as the regulating amplifier 52. It is also possible to design the regulating amplifier 52 so that the latter has an input, as shown in FIG. 1. With such an arrangement, an inverting stage must be connected to either the output of the input transducer 48 or the output of the output transducer 47. Such inversion is required in the event that the transducer does not provide already such an inverted signal, relative to the other transducer. Once such inversion has been realized the two signals from the two transducers may be applied, through summing resistors, to the input of the regulating amplifier 52.

The input transducer 48 and the output transducer 47 are designed so that their output potentials become shifted in the negative region, when the associated control lever is moved toward the left. The dead-center circuit 50 provides a 0 signal within a small region about the 0 position of the remote control lever 55 —within the so-called dead zone. In all other positions of the remote control lever 55, a 1 signal is emitted. In the embodiment, the threshold level of the first threshold switch 53 is set to 5 volts, and the second threshold switch 54 is set to 7 volts. At the same time, the output voltage from the regulating amplifier 52 is established at 6 volts, provided the difference between the input value and output value is zero. When the input value is equal to the output value, the first threshold switch 53 provides a 1 signal, and the second threshold switch 54 provides a 0 signal.

When the remote control lever 55 is moved toward the right, then the dead-center circuit 50 provides a 1 signal, when the dead zone is exceeded. The output voltage from the regulating amplifier 52 is shifted, thereby, in the positive direction to the extent that the threshold level of the second threshold switch 54 becomes exceeded. At this point, the three circuits 50, 53, 54 each provide a 1 signal. At the output of the second AND-gate 44 is a 1 signal and at the output of the third AND-gate 45 is a 0 signal. At the output of the NAND-gate 46, is, thereby, a 1 signal which is applied to the second input of the first AND-gate 43. A 1 signal is, henceforth, also available at the output of the AND-gate 43. As a result, the first two control valves become actuated by the amplifiers 40 and 41. The control piston 26 moves, consequently, in the same direction as the remote control lever 55—namely toward the right.

In view of this arrangement, the output potential of the output transducer 47 is shifted in the positive direction, and the output potential of the regulating amplifier 52 is shifted in the negative direction, until the threshold level of the second circuit 54 is higher. Then the third AND-gate 45 also provides a 1 signal which, in turn, actuates the third control valve 38 and, at the same time, the AND-gate 43 by way of the NAND-gate 46. The first amplifier 40 of the first control valve is thereby switched off. As a result, some control valves are now closed, so that the control piston 26 becomes blocked in its position. A predetermined velocity of the operating piston 12 is thereby established, and this piston 12 corresponds precisely to the position of the remote control lever 55, as is required.

If, now, the remote control lever 55 is moved toward the left, then, after passage through the 0 region and the dead zone, the threshold level of the first switch 53 becomes the higher value. Both threshold switches provide, thereby, 0 signals. Since the third AND-gate 45 is constructed in the form of a blocking or inhibiting gate and is provided with an inverting input, the output of this AND-gate 45 provides a 1 signal which is applied to the third amplifier 42 and thereby the third control valve 38. As a result, this valve 38 is closed. Since the second control valve 36 becomes simultaneously opened, through the AND-gate 44 and the amplifier 41, and the first control valve 34 also becomes opened through the NAND-gate **46**, the AND-gate **43** and the amplifier **40**, the control piston **26** is moved toward the left.

In summary, the functional operation of the first embodiment can be described with the following characteristics: When the remote control lever **55** is deflected past the dead zone, either the second control valve **36** or the third control valve **38** is closed, depending upon the direction of deflection of the lever. Aside from this, the first control valve **34** becomes opened, through the AND-gate **43** and the NAND-gate **46**. When the remote control lever **55** is deflected, the first control valve **34** is again closed, through the NAND-gate **46**, only until the two other control valves **36** and **38** are simultaneously closed, when the input value is equal to the output value and the control piston **26** is to be held in its position.

A particular advantageous of the control arrangement described above resides in the condition that all digital components of the circuitry can be constructed from the same circuit elements, as shown in FIGS. **2** and **3**. In the second threshold switch **54**, according to FIG. **2**, the base voltage divider **546, 547** of the first transistor **540**, is adjusted so that a voltage of 7 volts is available at the tap. The first transistor **540** becomes then turned off, as soon as the potential of the input terminal **52*a*** drops below 7 volts. The voltage drop across the diode **548** and the emitter-base diode of the first transistor **540** become compensated. As a result of the positive feedback coupling of the resistor **545**, no continuous collector current of the first transistor is available when the potential of the input terminal **52*a*** is slowly taken off. Instead, a rapid switching takes place in the threshold voltage established by the base voltage divider. From the circuit of the threshold switch **54**, a NAND-gate can be produced in a simple manner, in that several input terminals can be connected to the emitter of the first transistor **540**, by way of several diodes. Such a NAND-gate **506** is shown in FIG. **3** as a component of the dead-center circuit **50**. A blocking or inhibiting gate with an inverting and a noninverting input, as required for the third AND-gate **45**, is obtained when the emitter of the first transistor **450** is used as the first input and the collector of the second transistor **451** is used as the second input, as shown in FIG. **2** with respect to the blocking gate **45**.

The emitter potential of the transistor **420** in the second power amplifier **42** is raised by substantially 0.7 volts, through the diode **424**, relative to the potential of the negative voltage line **62**. In this manner, the transistor **420** is securely turned off when the transistor **451** conducts. Power transistor **421** is also turned off, since the latter is of opposite conductivity type relative to the transistor **420**. In front of the electromagnetic winding **38*a***, is the parallel circuit including the resistor **425** and the capacitor **426**. Upon turning on the power transistor **421**, full operating voltage is applied, through the capacitor **426**, to the winding **38**, until the capacitor **426** has become charged. As a result, a rapid energizing of the magnet winding **38*a*** is realized. After switching off the power transistor **421**, the energy stored within the winding **38*a*** is dissipated in the two resistors **427** and **425**, and the resistance within the winding **38*a***. This results from the condition that the turn-off current of the winding **38*a*** can flow further through the diode **428**.

The dead zone is the allowable deviation or difference between the input value and output value, or is the region in which the output signal from the switch **53** is a 1 signal and the output from the switch **54** is a 0 signal. The dead zone is provided so that continuous switching or oscillation of the valves is prevented. The dead zone together with the dead time of the control valves, determines the maximum allowable displacement velocity of the control slide **23**. This velocity is dependent on the pressure in the inlet line **57**, the dimensions of the throttles **35** and **39**, and on the surfaces of the control pistons. The displacement velocity and thereby the acceleration of the operating piston **12**, is thereby constant. As a result, reverse accelerations or delays arise under predetermined conditions, when the remote control lever **55** is deflected, or when the input value is attained by the output value. These displacement transitions become softer when the two threshold circuits **53, 54** become replaced by pulse stretcher modulators.

Such a pulse stretcher modulator is shown in FIG. **4**. When the input terminal **52*a*** has applied to it the potential of the negative voltage supply line **62**, the capacitor **535** is extensively discharged, and the input potential of the inverting input of the operational amplifier **130** is below the potential of the noninverting input, so that the output of the operational amplifier **530** is at positive potential. Thus, the output of the operational amplifier provides a 1 signal. The potential of the noninverting input of the operational amplifier **530** is high, and is determined through the resistors **532, 533, 534**, whereby the resistor **532** is in parallel, in this case, with the resistor **533**. The resistor **536** is substantially small in relation to the resistors **532, 533** and **534**. When a predetermined potential prevails at the input terminal **52*a***, the capacitor **535** becomes charged to the potential of the positive voltage supply line, through the resistors **536, 531** and **537**. As a result, the potential of the inverting input of the operational amplifier **530** rises. When this potential exceeds the potential prevailing at the non-inverting input, the operational amplifier **530** switches state through the coupling resistor **532**, and a 0 signal prevails at the output of this amplifier. At the same time, the potential at the noninverting input shifts in the direction toward a negative value which is, in turn, determined by the resistors **533, 534** and **532**, whereby the resistor **532** is, in this case, in parallel with the resistor **534**. The capacitor **535** discharges from the original input potential of the input terminal **52a** in direction to the potential of the negative voltage supply line **62**, through the resistors **537** and **531**. When the potential at the inverting input is below the potential of the noninverting input, then the operational amplifier **530** switches again state, and provides at its output a 1 signal.

This process is repeated periodically, whereby the pulse repetition frequency of the output pulses of the operational amplifier **530** is dependent upon the magnitude of the input potential prevailing at the terminal **52*a***. When this input potential is sufficiently high, then the capacitor **535** can no longer discharge sufficiently through the resistor **531**, so that the output of the operational amplifier **530** remains continuously at negative potential.

The pulse stretcher modulator in accordance with FIG. **4** operates similarly to a threshold switch. Thus, when the input voltage drops below a predetermined threshold level, then the output provides a continuous 1 signal. When, on the other hand, the output voltage exceeds an upper threshold level, then the output provides a continuous 0 signal. When the input voltage lies between the lower and upper threshold levels, the pulse stretcher modulator provides pulses having a repetition frequency dependent upon the magnitude of the input voltage. The potential difference between the lower and upper threshold levels is determined through the relationship between the two resistors **531** and **537.** The absolute magnitude of the two threshold levels is, on the other hand, determined by the voltage divider **533, 534, 532.**

When two pulse stretcher modulators in accordance with FIG. **4,** are used in place of the two threshold switches **53, 54,** then the three control valves **34, 36** and **38** are controlled in a pulse-wise manner when the output value differs by small amounts from the input value. As a result, the displacement velocity of the control slide **23** and thereby the acceleration of the operating piston **12** become essentially smaller. With this arrangement, softer transitions in the motion are realized. For a smaller dead zone and corresponding larger positional accuracy, larger final velocities of the control slides are possible. The rest of the functional operation is precisely the same as when using the threshold switches.

The dead zone is to be as small as possible for attaining a large positional accuracy of the control slide **23.** At the same time, the displacement velocity of the control slide is to be, on the other hand, as large as possible. In order that a stable operation of the arrangement may be obtained, the dead zone and the dead time of the valves must be matched. The two requirements of maximum possible displacement velocity and smallest possible dead zone are in conflict.

In the first embodiment of FIG. **1,** the displacement velocity of the control slide **23** is larger than the velocity when the control slide is moved from its 0 position in direction of greater deflection, in the return process. This results from the condition that upon deflection or movement from the 0 position, the spring force is opposed against the hydraulic force in the return arrangement **28,** whereas the spring force adds to the hydraulic force during the return process. The displacement velocity in the return process must, therefore, take into account the dead zone.

In order to make possible a smaller dead zone, other force relationships are selected in the circuit embodiment of FIG. **5.** Thus, the hydraulic force acts on the differential piston **26** only upon deflection or movement from the 0 position, but not during the return process. This may be attained because in the return process the first control valve **34** is basically closed.

To determine whether a deflection process or a return process prevails, the components **70** to **75** are used. The third threshold switch **70** determines whether the control slide **23** is either to the right or to the left of the 0 position, whereas the fourth threshold switch **71** determines whether the regulating deviation is either positive or negative, i.e., whether the output value has already attained the input value or not.

In order that the first control valve **34** becomes opened, all four inputs of the first AND-gate **43** must have 1 signals. The manner in which the 1 signals at the first two inputs are derived, is already described above. These first two inputs are connected with the outputs of the dead center circuit **50** and the third AND-gate **56.** Assume, now, as an example, that the control slide **23** becomes moved towards the left, and has not as yet attained the input value. Then the third threshold switch **70** provides a 0 signal and the fourth threshold switch **71** also provides a 0 signal, since the output voltage of the output transducer **47** as well as from the summing device, are negative. In this case, both inverters **72** and **74** provide 1 signals which are transmitted, through the OR-gates **73** and **75,** to the two remaining inputs of the first AND-gate **43.** As soon as the input value is attained, the regulating error or deviation becomes 0 or positive, and the fourth threshold switch **71** provides a 1 signal. At this point, a 0 signal lies at the third input of the AND-gate **43,** which is connected with the second OR-gate **75,** whereas a 1 signal still lies at the fifth input. As a result, the first control valve **34** becomes closed. This closing of the valve also remains when the remote control lever **55** is again returned to the 0 position. Upon return of the control slide **23,** the control cylinder **27** can thereby have applied fluid from the first control valve **34.**

In the second embodiment of FIG. **5,** it is also possible to use pulse stretcher modulators in accordance with FIG. **4,** instead of the first two threshold switches **53** and **54.**

The control arrangement described above, fulfills, consequently, all of the imposed requirements. The velocity of the operating piston **12** is set to a constant value through the remote control lever **55** as well as through the control lever **30.** This constant value depends on the deflection or displacement of the remote control lever or of the lever **30.** When using both stretcher modulators, it is possible to avoid furthermore accelerations or delays which are too large for small regulating errors or deviations. When the remote control lever **55** is at its normal inoperative position, then the control slide **23** can be actuated with the aid of the control lever **30.** An output value-return is then made possible to maintain precisely the velocity for the operating piston **12,** which is set by the remote control lever. The control arrangement is, thereby, particularly adaptable for automotive cranes, although its area of application is not limited to this field.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of electro-hydraulic control arrangements differing from the types described above.

While the invention has been illustrated and described as embodied in an electro-hydraulic control arrangement, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims:

1. An electrohydraulic control arrangement for hydraulic operating means operative in two directions comprising, in combination, a control valve with control slides; two hydraulic transmission lines communicating with said operating means and closed by said control slide when in neutral position in said control valve; inlet line means communicating with one of said hydraulic transmission lines when said control slide is in a first operative position; return line means communicating with the other one of said hydraulic transmission lines when said control slide is in a second operative position; control piston means movable within a control cylinder and actuating said control slide; electromagnetically actuated valves for applying working fluid to said control cylinder; remote control lever means for providing an adjustable input parameter; regulating amplifier means actuating said electromagnetic valves as a function of said input parameter; two flow lines communicating with said control cylinder and connected to said inlet line means and said return line means by two of said electromagnetically actuated valves; signal amplifying means connected to said electromagnetically actuated valves for actuating said electromagnetically actuated valves; and threshold switching means connected between said signal amplifying means and said regulating amplifying means.

2. The arrangement as defined in claim 1 wherein a first one of said electromagnetically actuated valves is connected between said inlet line means and said two electromagnetically actuated valves, said first one of said electromagnetically actuated valves being closed when said remote control lever means is in 0 position.

3. The arrangement as defined in claim 2 including a close control lever for actuating said control slide when said first one of said electromagnetically actuated valves is closed and said two electromagnetically actuated valves are open.

4. The arrangement as define in claim 2 including a dead center circuit; an input parameter transducer actuated by said remote control lever means; and a first amplifier in said signal amplifying means connected to said first one of said electromagnetically actuated valves, the input of said first amplifier being connected through said dead center circuit to said input parameter transducer.

5. The arrangement as defined in claim 4 wherein said dead center circuit comprises two threshold switching circuits having different threshold levels, the input of one threshold switching circuit being connected with a first input of the other threshold switching circuit, the output of said one threshold switching circuit being connected to a second input of the other threshold switching circuit.

6. The arrangement as defined in claim 4 including AND-gates connected to a second amplifier and a third amplifier in said signal amplifying means; a threshold switching circuit connected to a first input of each AND-gate, the second inputs of said AND-gates being connected to said dead center circuit.

7. The arrangement as defined in claim 6 including an AND-gate connected to the input of said first amplifier, a first input of said AND-gate connected to said first amplifier being connected to said dead center circuit, said AND-gate connected in front of said first amplifier being a first AND-gate and said AND-gates connected to said second and third amplifiers being respectively second and third AND-gates; a fourth AND-gate connected between the second input of said first AND-gate and the outputs of said second and third AND-gates.

8. The arrangement as defined in claim 4 including an amplifying stage connected in series with the input of said dead center circuit.

9. The arrangement as defined in claim 1 including output parameter transducer means actuated by said control slide; input parameter transducer means actuated by said remote control lever means; and summing means with inputs connected to said input and output parameter transducer means, the output of said summing means being connected to said regulating amplifying means.

10. The arrangement as defined in claim 7 wherein said threshold switching circuits and said AND-gates are two-stage, positive feedback-coupled transistor amplifiers with two transistors of complementary conductivity type.

11. The arrangement as defined in claim 10 including base voltage divider means connected to a first one of said two transistors in said threshold switching circuits for setting the threshold voltage of said threshold switching circuit; and diode means for applying to the emitter of said first transistor the input voltage signal.

12. The arrangement as defined in claim 10 including diode means connected to the emitter of a first transistor of said AND-gates for applying input voltage signals to the emitter of said first transistor of said AND-gates.

13. The arrangement as defined in claim 4 including second and third AND-gates connected to second and third amplifiers in said amplifying means; and pulse stretcher modulator means connected to first inputs of said second and third AND-gates, the second inputs of said AND-gates being connected to said dead center circuit, said pulse stretcher modulator means controlling intermittently said electromagnetically actuated valves when the output signals of said regulating amplifier means are substantially small, said electromagnetically actuated valves being continuously unactuated when the output signals of said regulating amplifier means are substantially large.

14. The arrangement as defined in claim 13 wherein said pulse stretcher modulator comprises an operational amplifier with a first resistor connected between the output of said amplifier and one input thereof, and a second resistor connected between the output of said operational amplifier and a circuit input thereof; an input resistor connected to the inverting input of said operational amplifier, on terminal of said input resistor being the input signal terminal; and a capacitor connected between said input resistor and ground potential.

15. The arrangement as defined in claim 9 including a third threshold switch connected to the output of said output parameter transducer means; and a forth threshold switching circuit connected to the output of said summing means.

16. The arrangement as defined in claim 15 including a first OR-gate and a second OR-gate, the output of said third threshold switching circuit being connected to said second OR-gate and to said first OR-gate; a first inverter circuit connected between said output of said third threshold switching circuit and said first OR-gate; a second inverter circuit connected between the output of said fourth threshold switching circuit and said second OR-gate, the output of said fourth threshold switching circuit being also connected to said first OR-gate, the outputs of said OR-gates being connected to the inputs of said first AND-gate.

17. The arrangement as defined in claim 7 wherein said fourth AND-gate comprises a NAND-gate.

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