

[54] **ELECTRO-HYDRAULIC TOUCH
CONTROL SYSTEM FOR
EARTHMOVING VEHICLES**

[72] Inventors: **Russell D. Page; Dean C. Klingaman**, both of Decatur; **Rolland D. Scholl**, Peoria, all of Ill.

[73] Assignee: **Caterpillar Tractor Co.**, Peoria, Ill.

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Primary Examiner—Robert E. Pulfrey

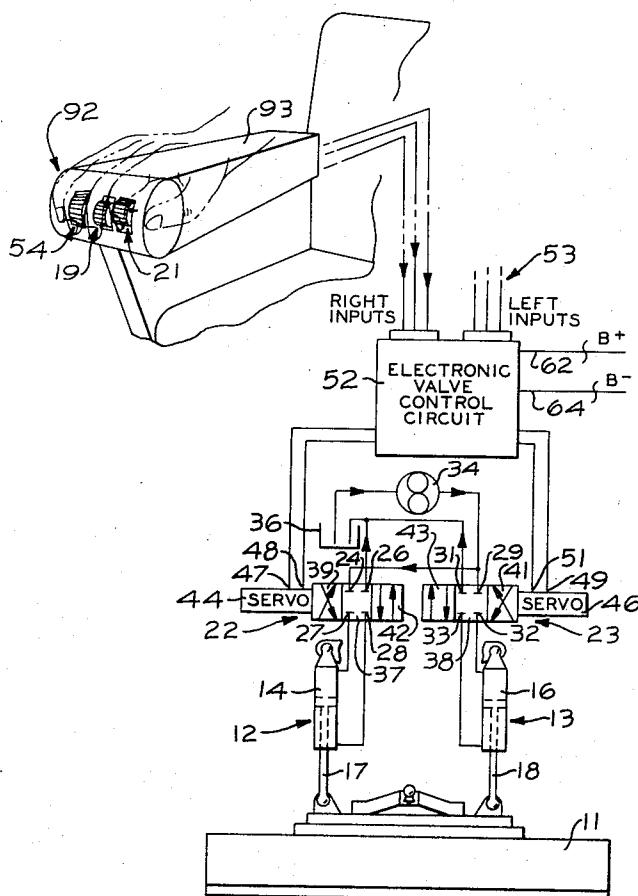
Assistant Examiner—R. T. Rader

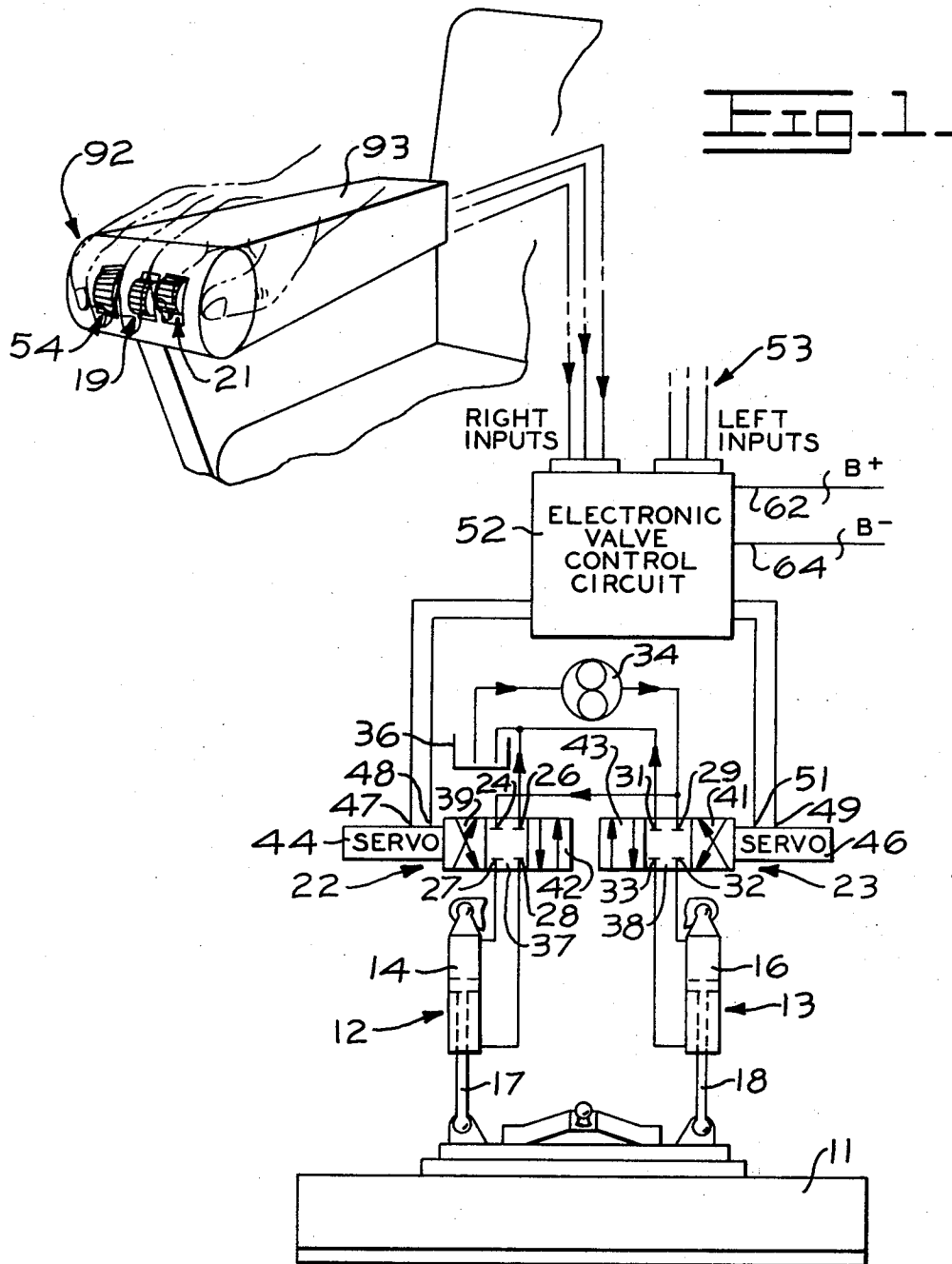
Attorney—Fryer, Tjensvold, Feix, Phillips & Lempio

[57] **ABSTRACT**

An implement control for an earthmoving vehicle comprising an electro power unit, electro-hydraulic valves and complementing hydraulic equipment for raising or lowering the right and lefthand sides of the implement responsive to electrical control signals, control switches preferably actuatable by operator touch for selectively operably connecting the power unit to the valves to thereby apply the electrical control signals thereto, and an operator manipulatable potentiometer associated with the power unit to selectively influence the system to permit operators to individually select desired degrees of control response. Such arrangement enables vital control components to be more satisfactorily located to enhance operator convenience and machine efficiency and makes possible more effective and economical remote control systems for earthmoving applications.

15 Claims, 6 Drawing Figures

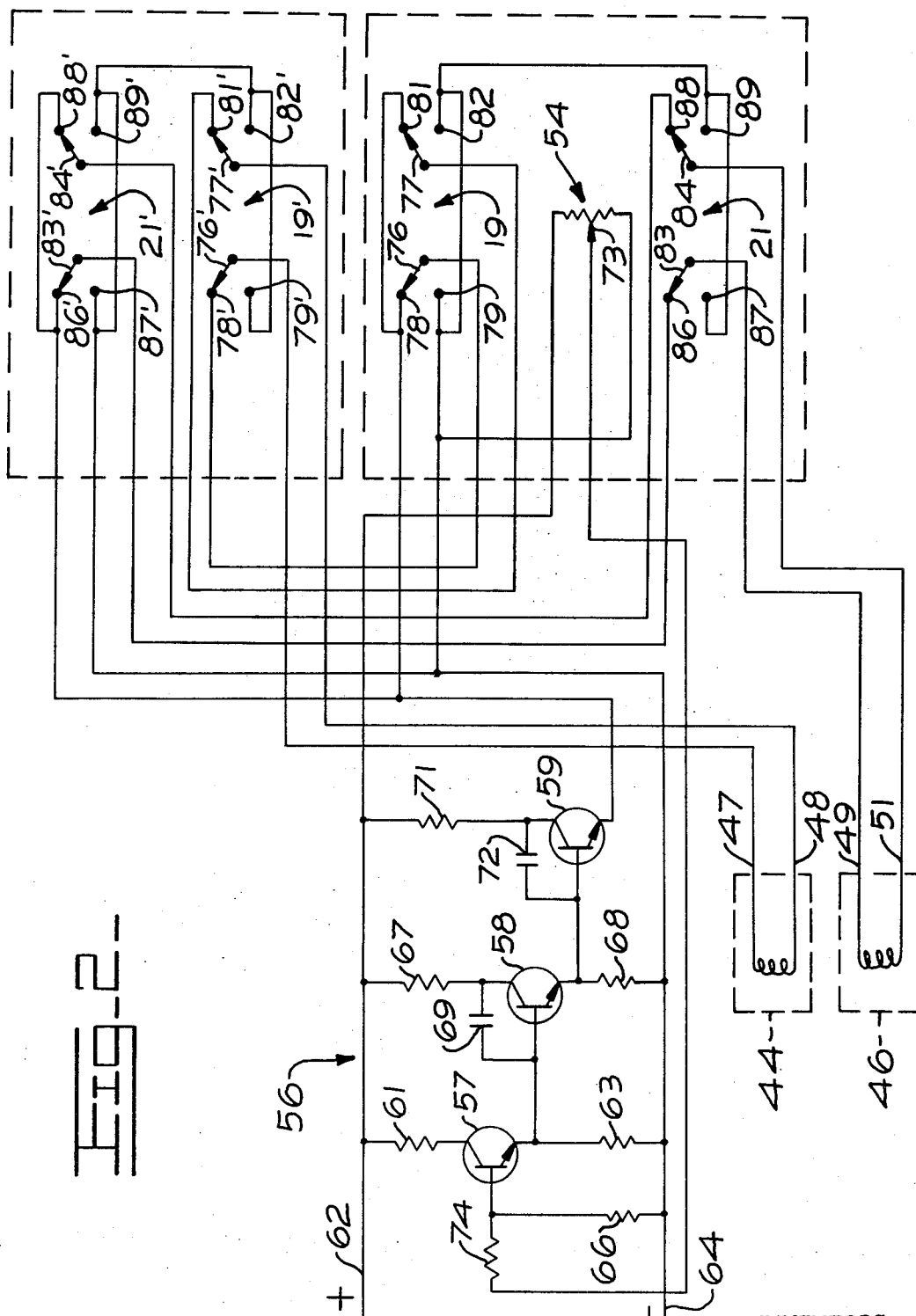




INVENTORS
 RUSSELL D. PAGE
 DEAN C. KLINGAMAN
 ROLLAND D. SCHOLL

BY

Fryer, Tjensvold, Feist, Phillips & Lempie
 ATTORNEYS



INVENTORS
RUSSELL D. PAGE
DEAN C. KLINGAMAN
ROLLAND D. SCHOLL

BY

BY
Fryer, Tenswood, Feix, Phillips & Lempie
ATTORNEYS

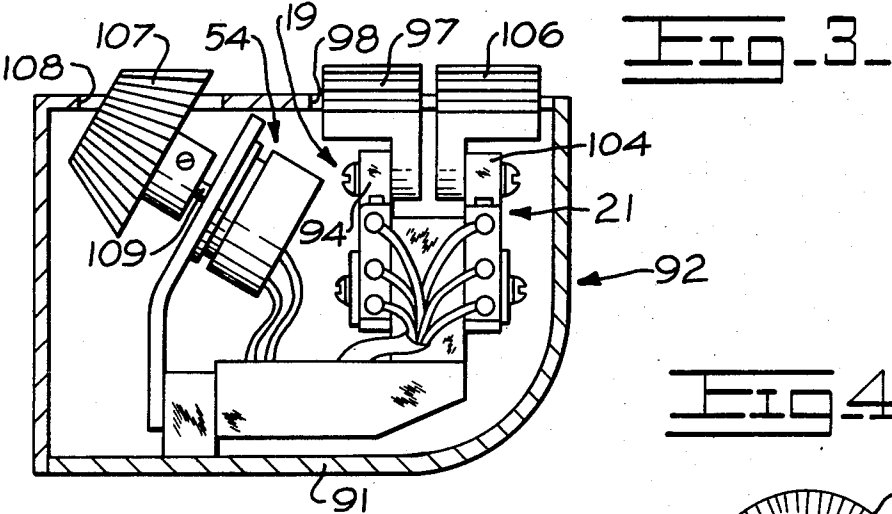
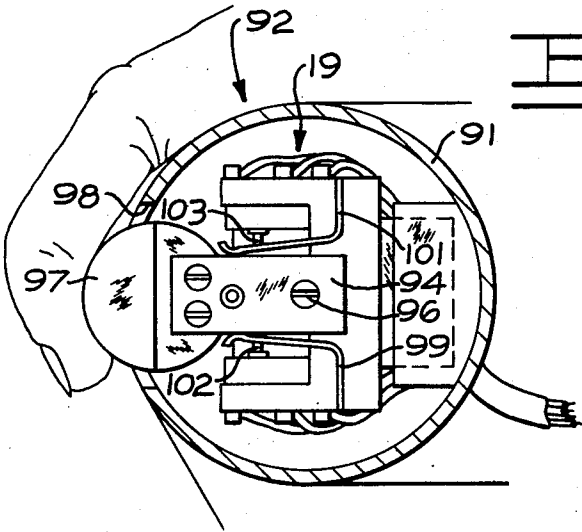
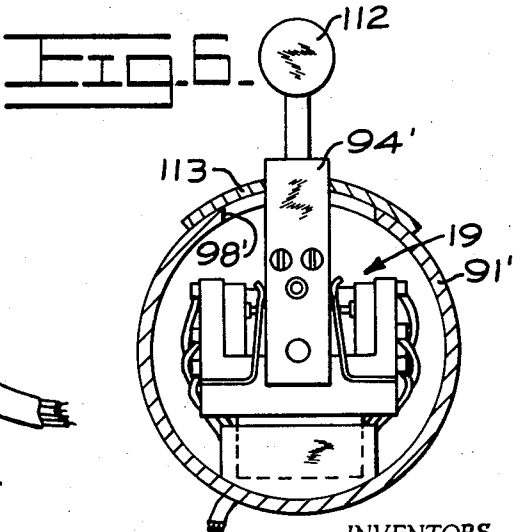


Fig. 5.



INVENTORS
RUSSELL D. PAGE
DEAN C. KLINGAMAN
ROLLAND D. SCHOLL

BY
Fryer, Ginevold, Fair, Phillips & Lampie
ATTORNEYS

ELECTRO-HYDRAULIC TOUCH CONTROL SYSTEM FOR EARTHMOVING VEHICLES

BACKGROUND OF THE INVENTION

Earthmoving vehicles, in particular motors graders employing mechanical and hydraulic controls, have long required excessive operator effort to maintain satisfactory machine control. Because of the urgent need for increased productivity, it has become ever increasingly desirable to simplify existing complex control systems to obtain greater ease of operation and increased response from both the machine and the operator. More particularly, mechanical controls require a fixed gear ratio between the engine and control function such that the only way a control function may be modulated is through changes in engine speed. This is not always possible or desirable and in any event is seldom sufficient to overcome overshoots due to high control speeds, or lags due to low control speeds.

Hydraulic controls, on the other hand, generally utilize manually operatable valves which permit a measure of proportional control over a given function. However, high lever effort and necessary large throws of the valve levers prevent an operator from selecting or maintaining consistently any given response. In addition, difficulty is encountered in positioning hydraulic valves in suitable proximity for convenient multiple control function usage.

The development of solid state electronic circuitry suggests a possible solution to the foregoing control problems; however, operating characteristics peculiar to motor graders necessitate that such electro-hydraulic circuitry be highly adaptable, versatile and relatively economical. These features heretofore have not been readily compatible in existing circuits nor sufficiently durable for heavy-duty applications.

SUMMARY OF THE INVENTION

The present invention relates to an electro-hydraulic blade control for earthmoving vehicles, especially motor graders, which is reliable and of relatively simplified electrical and hydraulic circuit design while providing the operator of the grader with convenient, easy-operating, precision controls compatible with increased response from both the machine and operator.

An important object of the invention is the provision of a blade control of the class described which may advantageously include touch control switches compactly and symmetrically grouped and conveniently positioned to permit an operator to exercise simultaneous control of several motor grader functions with operational movement of the control switches and associated machine function effecting elements being correlated to reduce the possibility of confusion.

Another object of the invention is to provide an electro-hydraulic blade control which facilitates the use of simple compact control switches, thereby eliminating the necessity of introducing hydraulic valves and hoses, or mechanical linkages, into the operator's compartment and providing more space, improved operator visibility, and greater flexibility in the design of the operator's compartment.

It is a further object of the invention to provide a control arrangement of the class described having means for fingertip control over the rate at which control of the blade lift functions is accomplished to

thereby match such control to the reaction time of the individual operator, particular job conditions, or motor grader ground speed. As an important result, overshoots or lags in control responses are eliminated, making operator and machine more productive, while reducing operator fatigue.

In the accomplishment of the foregoing and other objects and advantages, an electro-hydraulic blade control in accordance with the present invention generally includes a pair of electro-hydraulic valves associated with a pair of right and left-hand hydraulic blade lift jacks to control the direction of pressurized hydraulic fluid flow to and from the opposite ends of the jacks and thereby cause same to undergo blade lifting retraction, or blade lowering extension strokes in accordance with the valve controlled flow directions.

The valves are arranged to control the flow directions, and thus the stroke directions of the jacks, in accordance with the relative polarities of electrical control signals applied to opposite terminals of actuating servos of the valves. The control signals are selectively applied to the servo terminals of the valves from a solid-state DC amplifier in response to actuation of electrical control switches. The amplifier is provided with a potentiometer or equivalent means for effecting touch control of amplifier gain to thereby vary the amplitudes of the control signals applied to the valves and thus the degree of response of the hydraulic control functions to the switch closures.

The control switches are advantageously arranged for touch manipulation and mounting on the arm rests of the operator's seat. In addition, the switches are preferably positioned and adapted for operational movement in correlation with the desired operational movements of the grader blade.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a combined schematic electric and hydraulic circuit diagram of an electro-hydraulic motor grader blade control system in accordance with the present invention.

FIG. 2 is a detailed schematic electrical circuit diagram of an electronic valve control circuit of the system of FIG. 1.

FIG. 3 is a bottom view of a touch control switch assembly of the embodiment of FIG. 1.

FIG. 4 is a side view of a potentiometer control knob of the switch assembly for varying the rate of control response of the system, high and low rate positions being respectively depicted in full and phantom lines.

FIG. 5 is a side sectional view of a touch control switch of the switch assembly.

FIG. 6 is a side sectional view of a modified form of control switch of the switch assembly.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to FIG. 1 in detail, there is shown a blade 11 of a motor grader with right and left hydraulic lift jacks 12 and 13 connected thereto to effect lifting or lowering of the right and left sides of the blade. The jacks 12 and 13 respectively include cylinders 14 and 16 coupled to the grader frame and piston rods 17 and 18 connected to the blade on right and left sides of its center. Upon the application of pressurized hydraulic fluid to the upper ends of the jack cylinders and porting

of fluid from the lower ends thereof, the rods of the jacks are extended to thereby lower the respective sides of the blade. Conversely, when fluid is applied to the lower ends of the cylinders and ported from the upper ends thereof, the rods are retracted to lift the respective sides of the blade. Thus, by controlling the directions of fluid flow to and from the opposite ends of the jack cylinders, the right and left sides of the blade are raised or lowered to correspondingly control blade position.

In order to accomplish the foregoing control over blade position there is provided an electro-hydraulic blade control system in accordance with the present invention which is adapted to control the directions of pressurized hydraulic fluid flow to and from the opposite ends of the right and left jack cylinders 14 and 16 in response to actuation of right and left electrical control switches 19 and 21, preferably arranged for touch controlled manipulation in a manner subsequently described.

The control system includes right and left electro-hydraulic, three-position, four-way valves 22 and 23, preferably of the servo-controlled variety, respectively associated with the right and left lift jacks 12 and 13. More particularly, valve 22 includes inlet and outlet ports 24 and 26 and a pair of control ports 27 and 28, while valve 23 includes inlet and outlet ports 29 and 31 and control ports 32 and 33.

The inlet ports 24 and 29 are communicated with the outlet side of a pump 34, the inlet side of which is communicated with a hydraulic fluid reservoir 36, and the outlet ports 26 and 31 are communicated with the reservoir. The control ports 27 and 28 of valve 22 are respectively communicated with the upper and lower ends of cylinder 14 of right lift jack 12, and the control ports 32 and 33 of valve 23 are similarly respectively communicated with the upper and lower ends of cylinder 16 of left lift jack 13.

In first positions 37 and 38 of valves 22 and 23 no communication is established between the inlet and outlet ports and the control ports thereof and thus no blade positioning movement of the jacks is effected. In a second position 39 of valve 22, inlet port 24 is communicated with control port 28 and control port 27 is communicated with outlet port 26. Pressurized fluid from pump 34 is thus delivered to the lower end of cylinder 14 and fluid is returned from the upper end thereof to reservoir 36, to thereby effect a retraction stroke of rod 17 of right jack 12 which lifts the right side of the blade. Similarly in a second position 41 of valve 23, inlet port 29 is communicated with control port 33 and control port 32 is communicated with outlet port 31, to thereby deliver pressurized fluid to the lower end of cylinder 16 and return fluid from the upper end thereof. A retraction stroke of rod 18 of left jack 13 is consequently effected to lift the left side of the blade. Conversely, in third positions 42 and 43 of the valves, the flow conditions are reversed and the right and left jacks are caused to undergo extension strokes productive of lowering of the right and left sides of the blade respectively.

Valves 22 and 23 preferably include servos 44 and 46, or equivalent electrical actuating means, for actuating the valves between the various positions thereof responsive to electrical control signals. In this regard

servo 44 includes opposite electrical input terminals 47 and 48 while servo 46 includes opposite electrical input terminals 49 and 51.

When no signals are applied to the input terminals of the servos, valves 22 and 23 are in the previously noted first positions 37 and 38 thereof. When positive signals are applied to terminals 47 and 49 relative to the signals applied to terminals 48 and 51, valves 22 and 23 are actuated to the second positions 39 and 41 thereof to thereby respectively effect lifting of the right and left sides of the blade. Conversely, when positive signals are applied to terminals 48 and 51 relative to the signals applied to terminals 47 and 49, valves 22 and 23 are actuated to the third positions 42 and 43 thereof to respectively effect lowering of the right and left sides of the blade.

The previously noted electric signals for actuating servos 44 and 46 of valves 22 and 23 are generated by means of an electronic valve control circuit 52 which is associated with the control switches 19 and 21 and coupled to the servo input terminals 47, 48 and 49, 51.

More particularly, the control circuit is so arranged that responsive to actuation of the switches 19 and 21 from neutral positions to lift positions thereof, relatively positive signals are applied to servo terminals 47 and 49 to effect the previously noted lifting action of the right and left sides of blade 11. Conversely, actuation of the switches 19 and 21 from the neutral positions to lower positions thereof, places relatively positive signals on terminals 48 and 51 to effect the previously noted lowering action of the right and left sides of the blade.

Although, a single set of switches 19 and 21 may be employed in the inventive blade control system it is preferred for reasons subsequently described that a second set of dual switches be also associated with the control circuit 52 as denoted by the input lines 53 in FIG. 1. In addition a control function response control element 54 is preferably associated with circuit 52 to facilitate variation of the amplitudes of the control signals applied to the valves 22 and 23, thereby enabling adjustment of response rate to suit the individual operator, job conditions, etc.

Considering now the control circuit 52 in greater detail with reference to FIG. 2, the circuit will be seen to include a solid-state DC amplifier 56 comprising in the illustrated case three emitter-follower transistor stages 57, 58 and 59 coupled in cascade. More particularly, the collector of input transistor 57 is coupled by means of a bias resistor 61 to a positive bias bus 62 while the emitter of such transistor is coupled by means of a load resistor 63 to a negative bias bus 64. A bias resistor 66 is likewise connected between the base of the input transistor and negative bus 64.

The emitter of transistor 57 is in turn connected to the base of transistor 58, the collector and emitter of which are respectively coupled by means of bias and load resistors 67 and 68 to buses 62 and 64. A decoupling capacitor 69 is connected between the base and collector of transistor 58. The emitter of transistor 58 is then connected to the base of transistor 59. A bias resistor 71 is connected between the collector of transistor 59 and positive bus 62 and a decoupling capacitor 72 is connected between the base and collector of such transistor. The emitter of transistor 59 comprises the output of the amplifier.

As regards the input of the amplifier, it is to be noted that a potentiometer, serving as the control function response control element 54 of previous mention, is connected between the positive and negative buses 62 and 64, and such potentiometer is provided with a variable wiper 73 connected by means of a coupling resistor 74 to the base of input transistor 57. Thus, a positive DC output signal is generated at the emitter of transistor 59 having a magnitude determined by the setting of the wiper 73 of potentiometer 54.

The right and left switches 19 and 21 are arranged to controllably connect the output and negative bias bus of amplifier 56 to the terminals of the servos of valves 22 and 23. In addition a dual set of switches 19' and 21' are provided for this purpose, such switches being connected in series with switches 19 and 21 to afford proper sequencing through the similar switches of the respective sets.

More particularly, switch 19 includes a pair of contactors 76 and 77 respectively movable between contacts 78 and 79 and between contacts 81 and 82. The neutral position of the switch is defined by contactors 76 and 77 contacting contacts 78 and 81. The switch is arranged such that either contactor, but not both simultaneously, may be actuated from its neutral position into engagement with its opposite contact.

Switch 21 is similarly provided to include a pair of contactors 83 and 84 respectively movable between contacts 86 and 87 and between contacts 88 and 89. Switches 19' and 21' are identical to switches 19 and 21 and therefore like parts of switches 19' and 21' are identified by like primed numerals.

Contacts 78 and 81 of switch 19 are connected together and to the emitter of output transistor 59, while contacts 79 and 82 are connected together and to the negative bias bus 64. The contactors 76 and 77 of this switch are respectively connected to contacts 78' and 81' of dual switch 19'. Contacts 79' and 82' of the dual switch are connected together and to negative bus 64, while the contactors 76' and 77' thereof are respectively connected to the opposite terminals 47 and 48 of right valve servo 44.

Contactors 83 and 84 of switch 21 are respectively connected to the opposite terminals 49 and 51 of left valve servo 46. Contacts 87 and 89 are connected together and to negative bus 64. Contacts 86 and 88 are respectively connected to contactors 83' and 84' of dual switch 21'. Contacts 86' and 88' of the dual switch are connected together and to the emitter of output transistor 59, while contacts 87' and 89' are connected together and to negative bus 64.

With the switches connected as just described to the amplifier output and the valve servos, and the contacts of dual switches 19 and 19' in their neutral positions, the positive output signal at the emitter of transistor 59 is applied to both servo terminals 47 and 48 of right valve 22. Hence, there is no voltage drop across the servo and the valve is unactuated. Similarly, if the contactors of dual switches 21 and 21' are in their neutral positions, the positive output signal at the emitter of transistor 59 is applied to both servo terminals 49 and 51 of left valve 23 such that there is no voltage drop thereacross and the valve is unactuated.

However, if contactor 76 of switch 19 is actuated from its neutral position into engagement with contact 79, the potential of negative bias bus 64 is applied via

contactor 76' of dual switch 19' to terminal 47 of servo 44. The positive output signal of the amplifier is still applied to terminal 48 of servo 44 via the contactors 77 and 77' of switches 19 and 19' in their neutral positions, whereby the direction of the voltage drop across the servo is such as to cause valve 22 to effect lowering of the right side of blade 11.

Similarly, if contactor 76' of switch 19' is actuated from its neutral position into engagement with contact 79', the potential of negative bus 64 appearing at contact 79' is applied to terminal 47 of servo 44, while the positive output signal is applied to terminal 48 via the path previously described. As a result, the right side of the blade is lowered. Thus, the contactors 76, 76' of either or both dual switches 19 and 19' may be actuated to effect lowering of the right side of the blade.

Now assume that the contactor 77 of switch 19 is actuated from its neutral position into engagement with contact 82. As a result the negative bus potential on contact 82 is applied via contactor 77 and contactor 77' of switch 19' to terminal 48 of servo 44. The positive output signal of the amplifier is applied to terminal 47 of the servo via unactuated contactors 76 and 76' of switches 19 and 19'. The direction of the voltage drop across servo 44 is thus reversed such that valve 22 is caused to effect lifting of the right side of the blade.

Similarly, if contactor 77' of switch 19' is actuated from its neutral position into engagement with contact 82', the negative bus potential appearing on this contact is applied via contactor 77' to terminal 48 of the servo, while the positive output signal is applied to terminal 47 via the previously described path, and the right side of the blade is lifted. Thus, the contactors 77, 77' of either or both switches 19 and 19' may be actuated to effect lifting of the right side of the blade.

The connections of the dual left switches 21 and 21' are such as to effect lowering or lifting of the left side of blade 11 in a manner analogous to that described above with respect to control of the right side of the blade by switches 19 and 19'. In this regard, the connections are such that responsive to actuation of either or both contactors 83, 83' of switches 21 and 21' from their neutral positions into engagement with contacts 87, 87', a voltage drop is established across terminals 49 and 51 of servo 46 of a direction to cause valve 23 to effect lowering of the left side of blade 11.

Likewise, upon actuation of either or both contactors 84, 84' from their neutral positions into engagement with contacts 89, 89', the direction of the voltage drop across the servo is reversed to cause valve 23 to effect lifting of the left side of blade 11.

Although the switches 19, 19', 21, and 21' may be variously provided, it is preferred that same be arranged for touch controlled manipulation compactly and symmetrically grouped and conveniently positioned to permit an operator to exercise simultaneous control of the right and left blade lifting and lowering functions with operational movement of the switches being correlated to the lifting and lowering functions of the blade. More particularly, it is desirable that touch control switches be provided with actuating elements disposed to the right and left with respect to the operator and arranged such that movement of an element downward or forward effects lowering of the blade while movement of the element upward or rearward ef-

fects lifting of the blade on the side thereof corresponding to the position of the actuated element.

To the foregoing ends, the control switches are preferably provided in the manner detailed in FIGS. 3 and 5. More particularly, right and left switches 19 and 21 are preferably mounted as a pair within a cylindrical housing 91 of a cartridge-like handle 92 adapted for securance to the forward end of the right arm rest 93 of the operator's seat, as shown in FIG. 1, to facilitate one-hand control. The assemblies of contactors 76 and 77 and their associated contacts 78, 79 and 81, 82 of switch 19 are supported within housing 91 individually opposite a lever 94 pivotally supported as indicated at 96 and having an operating knob 97 at its free end extending forwardly through a slot 98 formed in the forward portion of the housing.

A pair of leaf springs 99 and 101 are mounted within the housing to resiliently bear against the upper and lower surfaces of the lever 94 and thereby hold same in a neutral centered position between the springs. The springs 99 and 101 respectively bear against a pair of opposed contact plungers 102 and 103 respectively associated with switch contactors 76 and 77.

When the lever is in neutral position and the springs are undeflected, the plungers are extended to maintain contactors 76 and 77 in their neutral positions of engagement with contacts 78 and 81. However, when the lever is pivoted downward by touch manipulation of operating knob 97 with the finger tips, in the manner shown in FIGS. 1 and 3, the leaf spring 99 is deflected to in turn depress the plunger 102, which action urges the contactor 76 into engagement with contact 79 and effects lowering of the right side of the blade 11.

Conversely, when the lever is pivoted upward, leaf spring 101 is deflected to in turn depress plunger 103 which thereby urges the contactor 77 into engagement with contact 82 whereupon lifting of the right side of the blade is effected. Thus, touch manipulation of operating knob 97 down or up correlatively effects lowering or lifting of the right side of the blade.

Switch 21 is similarly provided to include a lever 104 and operating knob 106 protruding through a slot in the forward portion of housing 91 to the left of knob 97. Like switch 19, switch 21 includes leaf springs and contact plungers (not shown) associated with contactors 83 and 84 to urge the former from neutral position into engagement with contact 87 responsive to downward movement of knob 106, and to urge the latter from neutral position into engagement with contact 89 responsive to upward movement of the knob. Thus, the left positioned knob 106 may be touch manipulated down or up to effect lowering or lifting of the left side of blade 11.

With the correlatively positioned and manipulatable control knobs 97 and 106 of switches 19 and 21 so provided, the operator may readily exercise touch control over the blade functions with one hand by feel or instinct. The dual switches 19' and 21' are similarly provided in a cartridge-like handle (not shown) adapted for securance to the left arm rest of the operator's seat to lend further convenience and flexibility to the overall control system.

As previously noted, potentiometer 54 is provided to afford a variable control rate for the system which is needed for rough and fine grading. A high rate assures

maximum response for rough cuts while a low rate provides for more precise valve and blade adjustment. In order to afford a similar correlation to the potentiometer in its variable rate function as afforded by the touch control switch arrangement, the potentiometer is mounted within housing 91 and provided with an operating knob 107 which protrudes through a slot 108 in the forward portion thereof.

The knob 107 is eccentrically mounted on a rotary shaft 109 connected to the variable wiper 73 of the potentiometer. The knob is so disposed that maximum projection of the lobe or eccentric thereof beyond the surface of housing 91 corresponds to shaft rotation of wiper 73 to a position of maximum potentiometer resistance productive of a high control rate of the system. A relatively small protrusion of knob 107 corresponds to decreased potentiometer resistance productive of a low control rate. FIG. 4 depicts the high and low rate positions of knob 107 respectively in full and phantom lines.

In some instances hand-size levers are considered a more effective and convenient way of manipulating operating controls than is possible with button or finger-type actuating elements. Accordingly, the control switches may be modified as indicated in FIG. 6 for switch 19. More particularly, the orientations of the switch parts are shifted 90° from those of FIGS. 3 and 5 and the lever elongated. The elongated lever 94' then projects through a slot 98' formed in the upper portion of housing 91'. An upright operating knob 112 then projects from the upper end of lever 94' for grasping by the hand of the operator.

Forward and rearward movement of the knob then respectively effects lowering and lifting of the blade in a manner analogous to that previously described. In addition, an arcuate cover 113 may be integrally secured to the protruding end of lever 94' to slidably engage the exterior of housing 91' and thereby seal the slot 98' during movement of the lever.

Although the invention has been hereinbefore described and illustrated in the accompanying drawings with respect to several preferred embodiments thereof, it will be appreciated that numerous modifications and changes may be made therein without departing from the true spirit and scope of the invention, and thus it is not intended to limit the invention except by the terms of the appended claims.

What is claimed is:

1. In an earthmoving vehicle including an implement and right and left hydraulic lift jacks coupled between the vehicle frame and right and left sides of said implement, said jacks being arranged to effect implement lowering extension strokes responsive to the application of pressurized hydraulic fluid from a pump to first ends of said jacks and porting of fluid from second ends of said jacks to a hydraulic fluid reservoir coupled to said pump, said jacks being arranged to effect implement lifting retraction strokes responsive to the application of pressurized hydraulic fluid from said pump to said second ends of said jacks and porting of fluid from said first ends of said jacks to said reservoir, an electro-hydraulic implement control system comprising right and left electro-hydraulic four-way valves each having inlet and outlet ports and first and second control ports, each of said valves having electrically actuated control

means including first and second input terminals for selectively shifting said valve between a first position wherein communication is blocked between said inlet and outlet ports and first and second control ports, a second position wherein communication is established between said inlet and second control ports and between said outlet and first control ports, and a third position wherein communication is established between said inlet and first control ports and between said outlet and second control ports, said valve control means being arranged to maintain said valve in said first position responsive to identical electrical signals at said first and second input terminals and to shift said valve to said second position responsive to said first input terminal being positive relative to said second input terminal while shifting said valve to said third position responsive to said second input terminal being positive relative to said first input terminal, said input ports of said valves being communicated with said pump and said outlet ports thereof being communicated with said reservoir, said first and second control ports of said right and left valves being respectively communicated with said first and second ends of said right and left jacks, an electronic valve control circuit generating a positive DC output signal, and right and left control switch means respectively coupling said control circuit output to said first and second input terminals of said control means of said right valve and to said first and second input terminals of said left valve, said right and left switch means respectively having neutral positions and implement lifting and lowering positions, said right and left switch means being arranged to connect said control circuit output to said first and second input terminals of said right and left valves in said neutral positions of said switches, said right and left switch means being arranged to connect said control circuit output to said first input terminals of said right and left valves in said lifting positions of said switches, said right and left switch means being arranged to connect said control circuit output to said second input terminals of said right and left valves in said lowering positions of said switches.

2. The combination of claim 1, further defined by function response control means associated with said electronic valve control circuit for selectively varying the magnitude of said DC output signal.

3. The combination of claim 1, further defined by said right and left control switch means respectively including actuating elements disposed rightwardly and leftwardly with respect to the position of an operator in said vehicle, said actuating elements being movable from a neutral position upwardly or rearwardly to establish said lifting positions of said switches, said actuating elements being movable from said neutral position of said switches downwardly or forwardly to establish said lowering positions of said switches.

4. The combination of claim 3, further defined by function response control means associated with said electronic valve control circuit for selectively varying the magnitude of said DC output signal, said response control means having an actuating element disposed adjacent said actuating elements of said right and left switch means.

5. The combination of claim 1, further defined by said electronic control circuit comprising a solid-state

DC amplifier having a gain varying potentiometer for selectively varying the magnitude of said output signal, whereby the function response of said control system is selectively variable.

6. The combination of claim 1, further defined by said right switch means having first and second contactors respectively movable between contacting engagement with first and second contacts and between contacting engagement with third and fourth contacts, said first and second contactors engaging said first and third contacts of said right switch means in said neutral position thereof and being movable only one at a time into engagement with said second and fourth contacts, said first contactor engaging said second contact in said lowering position of said right switch means, said second contactor engaging said fourth contact in said lifting position of said right switch means, said left switch means having first and second contactors respectively movable between contacting engagement with first and second contacts and between contacting engagement with third and fourth contacts, said first and second contactors of said left switch means engaging said first and third contacts thereof in said neutral position of said left switch means and being movable only one at a time into engagement with said second and fourth contacts of said left switch means, said first contactor of said left switch means engaging said second contact thereof in said lowering position of said left switch means, said second contactor of said left switch means engaging said fourth contact thereof in said lifting position of said left switch means, said control circuit having a negative bias bus, said first and second contactors of said right switch means being respectively coupled to said first and second input terminals of said right valve means, said first and third contacts of said right switch means being coupled to said control circuit output, said second and fourth contacts of said right switch means being coupled to said negative bus, said first and second contactors of said left switch means being respectively coupled to said first and second input terminals of said left valve means, said first and third contacts of said left switch means being coupled to said control circuit output, said second and fourth contacts of said left switch means being coupled to said negative bus.

7. The combination of claim 6, further defined by said right and left switch means respectively having actuating elements disposed rightwardly and leftwardly with respect to the position of an operator in said vehicle, said actuating element of said right switch means being associated with said first and second contactors thereof and being operable to maintain said first and second contactors of said right switch means in engagement with said first and third contacts thereof in a neutral position of said actuating element of said right switch means, said actuating element of said right switch means being movable from said neutral position thereof downwardly or forwardly to engage said first contactor of said right switch means with said second contact thereof, said actuating element of said right switch means being movable from said neutral position thereof upwardly or rearwardly to engage said second contactor of said right switch means with said fourth contact thereof, said actuating element of said left switch means being associated with said first and

second contactors thereof and being operable to maintain said first and second contactors of said left switch means in engagement with said first and third contactors thereof in a neutral position of said actuating element of said left switch means, said actuating element of said left switch means being movable from said neutral position thereof downwardly or forwardly to engage said first contactor of said left switch means with said second contact thereof, said actuating element of said left switch means being movable from said neutral position thereof upwardly or rearwardly to engage said second contactor of said left switch means with said fourth contact thereof.

8. The combination of claim 7, further defined by said right and left switch means being mounted within a housing adapted for securance to the forward end of an arm rest of an operator's seat of said vehicle, said actuating elements of each of said right and left switch means including a lever pivotally supported within said housing and having an operating knob at its free end protruding through a slot in the forward portion of said housing, each of said right and left switch means including first and second leaf springs resiliently engaging upper and lower sides of said lever to retain same in said neutral position thereof, and first and second opposed contact plungers respectively engaging said first and second leaf springs and coupled to said second and first contactors, said first plunger urging said second contactor into engagement with said fourth contact responsive to deflection of said first leaf spring, said second plunger urging said first contactor into engagement with said second contact responsive to deflection of said second leaf spring.

9. The combination of claim 7, further defined by said right and left switch means being mounted within a housing adapted for securance to the forward end of an arm rest of an operator's seat of said vehicle, said actuating elements of each of said right and left switch means including a lever pivotally supported within said housing and extending through a slot in the upper portion of said housing, said lever having an upright operating knob projecting upwardly from its free end, each of said right and left switch means including first and second leaf springs resiliently engaging rearward and forward sides of said lever to retain same in said neutral position thereof, and first and second opposed contact plungers respectively engaging said first and second leaf springs and coupled to said second and first contactors, said first plunger urging said second contactor into engagement with said fourth contact responsive to deflection of said first leaf spring, said second plunger urging said first contactor into engagement with said second contact responsive to deflection of said second leaf spring.

10. The combination of claim 6, further defined by said electronic control circuit comprising a solid-state DC amplifier having a gain varying potentiometer for selectively varying the magnitude of said output signal, whereby the function response of said control system is selectively variable.

11. The combination of claim 8, further defined by said electronic control circuit comprising a solid-state DC amplifier having a gain varying potentiometer for selectively varying the magnitude of said output signal, said potentiometer having a rotary operating knob

disposed within said housing with a portion protruding through a slot in the forward portion thereof adjacent said operating knobs of said right and left switch means.

12. The combination of claim 11, further defined by said operating knob of said potentiometer being eccentrically mounted on a rotary shaft connected to a variable wiper of said potentiometer, said potentiometer knob being positioned to provide maximum projection of the protruding portion thereof in correspondence with shaft rotation of said wiper to a position of maximum potentiometer resistance and relatively small projection of said protruding portion in correspondence with shaft rotation of said wiper to a position of small potentiometer resistance.

13. The combination of claim 1, further defined by said right switch means including first and second dual right switches, said left switch means including first and second dual left switches, said first and second right and left switches each having first and second contactors respectively movable between contacting engagement with first and second contacts and between contacting engagement with third and fourth contacts, said first and second contactors engaging said first and third contacts in a neutral position of each switch and being movable only one at a time into engagement with said second and fourth contacts, said first contactor engaging said second contact in a lowering position of each switch, said second contactor engaging said fourth contact in a lifting position of each switch, said control circuit having a negative bias bus, said first contactor of said first right switch being connected to said first contact of said second right switch, said second contactor of said first right switch being connected to said third contact of said second right switch, said first and third contacts of said first right switch being connected to said control circuit output, said second and fourth contacts of said first right switch being connected to said negative bus, said second and fourth contacts of said second right switch being connected to said negative bus, said first and second contactors of said second right switch being respectively connected to said first and second input terminals of said right valve means, said first and second contactors of said first left switch being connected to said first and second input terminals of said left valve means, said first contact of said first left switch being connected to said first contactor of said second left switch, said third contact of said first left switch being connected to said second contactor of said second left switch, said second and fourth contacts of said first left switch being connected to said negative bus, said first and third contacts of said second left switch being connected to said control circuit output, said second and fourth contacts of said second left switch being connected to said negative bus.

14. The combination of claim 13, further defined by said first and second right and left switches each having an actuating element associated with said first and second contactors thereof and being operable to maintain same respectively in engagement with said first and third contacts in a neutral position of said actuating element of each switch, said actuating element of each switch being movable from said neutral position thereof downwardly or forwardly to engage said first contactor with said second contact of each switch, said

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actuating element of each switch being movable from said neutral position thereof upwardly or rearwardly to engage said second contactor with said fourth contact of each switch, said actuating elements of said first right and left switches being adapted for respective right and left disposition on one arm rest of an operator's seat of said vehicle, said actuating elements of said second right and left switches being adapted for respective right and left disposition on the second arm rest of

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said seat.

15. The combination of claim 14, further defined by said electronic control circuit comprising a solid-state DC amplifier having a gain varying potentiometer for selectively varying the magnitude of said output signal, said potentiometer having an actuating element adapted for disposition adjacent said actuating elements of said first right and left switches.

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