

[54] **MIMIC POSITIONING CONTROLLER FOR A HYDRAULICALLY ACTUATED BACK HOE**

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[58] Field of Search **214/138 R, 1 CM; 74/388 R, 74/491, 469**

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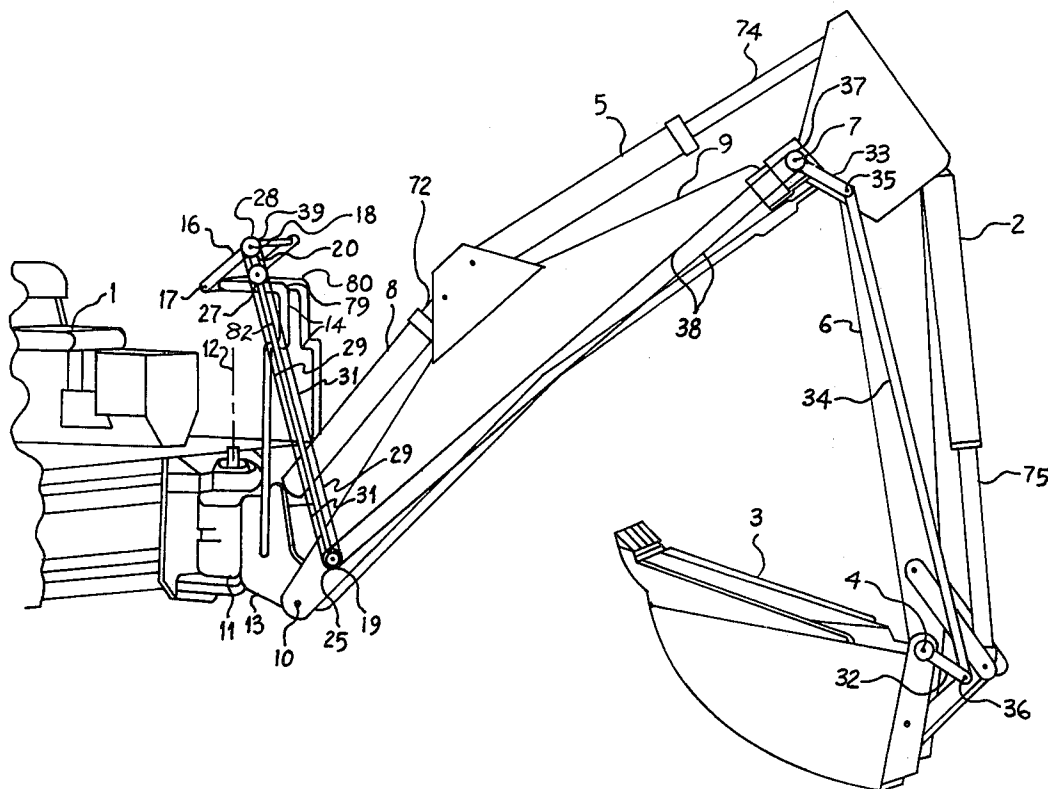
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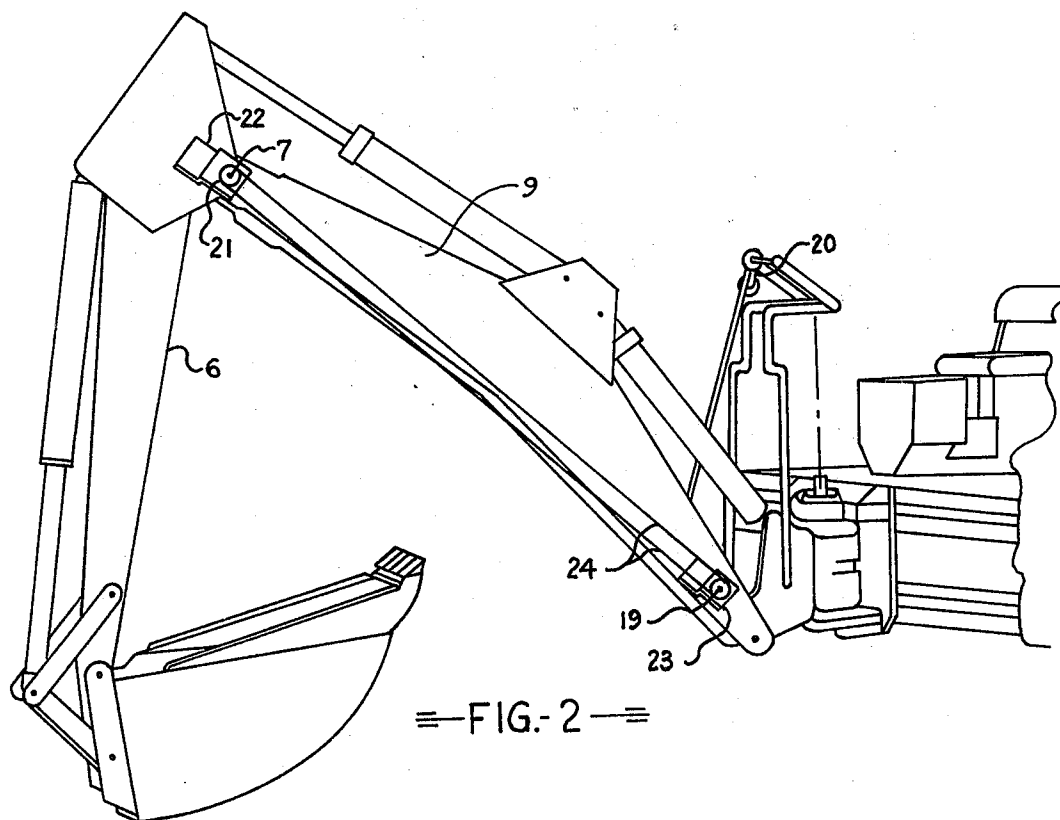
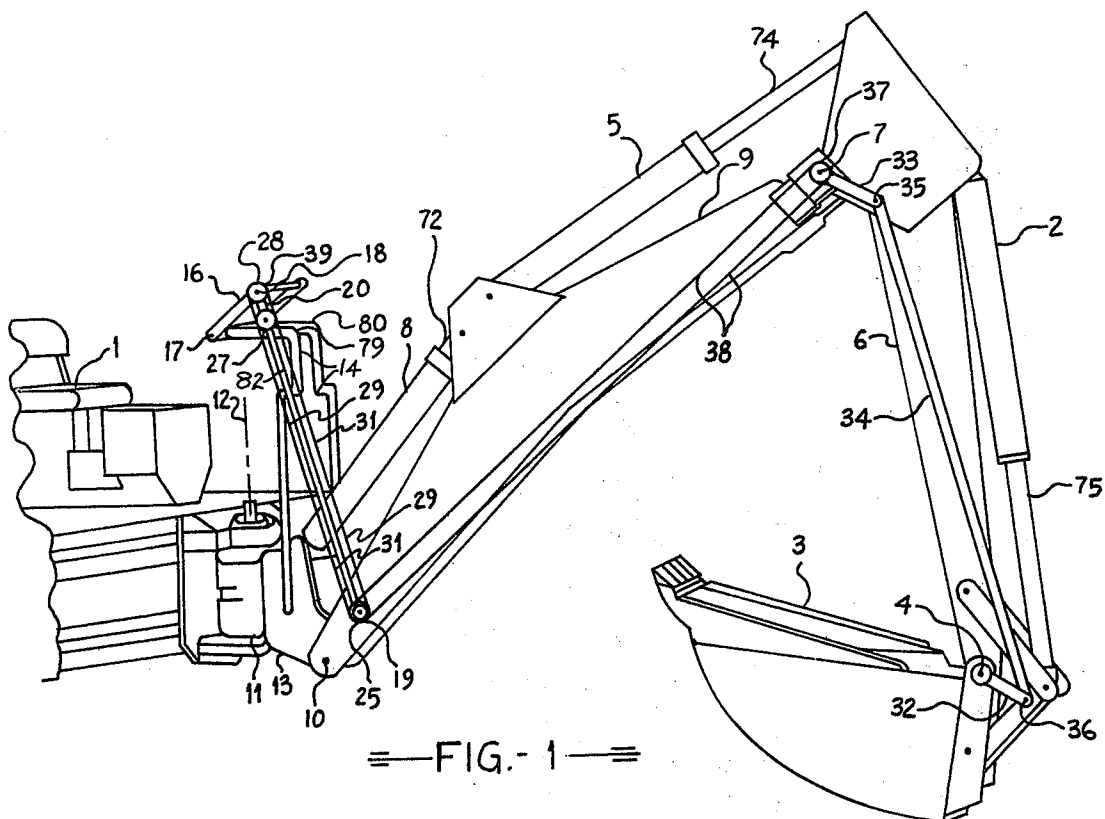
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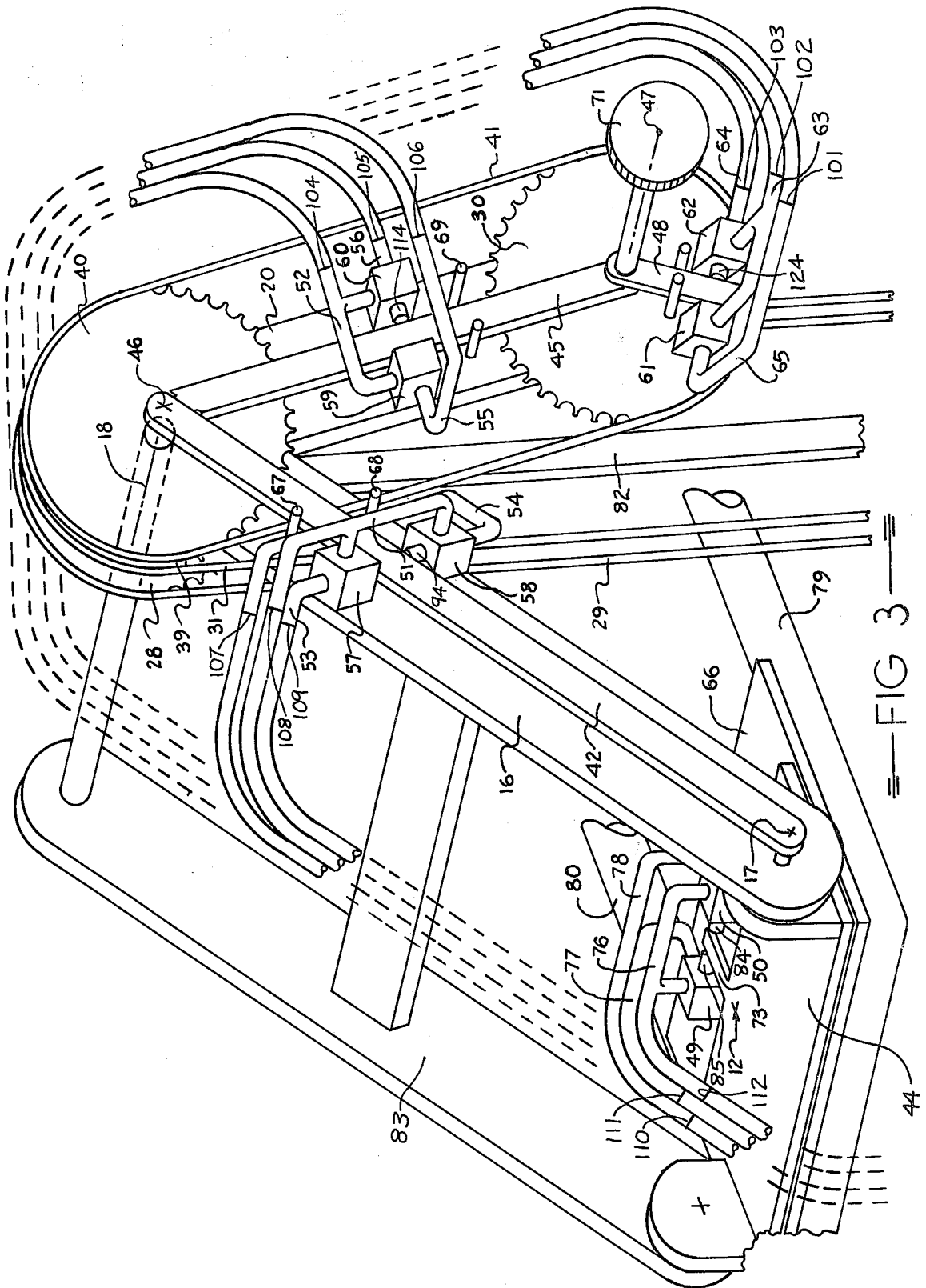
[57] **ABSTRACT**

A mimic positioning control system for a hydraulically powered back hoe which utilizes present day devices such as; the main engine driven hydraulic pumps; hydraulic work cylinders for powering the dipper, dipper arm, and crowd arm main digging members, and fluid motor for swinging that entire digging assembly; pilot actuated directional valves for controlling the direction and flow of fluid between the main pump(s) and the work cylinder or motor; and separate pilot signal devices, requiring small movement, for controlling each separate directional valve; the signal devices then being mounted on a unique arrangement of small scale members which are driven by mechanical linkage, to continuously mimic the position of the main digging members and swing assembly; the signal devices then being actuated by the operator through unique small scale pattern members with the pattern control knob representing the pivot joint position of the main dipper to the main dipper arm so that differences in equivalent position of the control knob from the main dipper cause pattern members and signal devices to actuate respective main, and mimic members through positive mechanical feedback, to move to eliminate the position difference.

5 Claims, 3 Drawing Figures







MIMIC POSITIONING CONTROLLER FOR A HYDRAULICALLY ACTUATED BACK HOE

This disclosure is similar to U.S. Pat. No. 3,144,146 but differs from that patent in that I here describe the means of applying a mimic positioning controller to a hydraulically actuated back hoe instead of an electrically powered shovel or drag line.

DESCRIPTION OF DRAWINGS

FIG. 1 is a rear elevational view of the backhoe as mounted on the rear of a tractor. Main digging members dipper, dipper arm, crowd arm and swing assembly are shown together with the mechanical linkage means of transmitting the dipper angle and crowd arm angle to the small scale mimic members which are mounted on a structure above the swing motor.

FIG. 2 shows the opposite side of the backhoe together with mechanical linkage means to transmitting the dipper arm angle to the mimic dipper arm.

FIG. 3 is a rear side elevational view of the mimic members, signal devices, pattern members and control knob together with some of the mechanical linkage used to drive the mimic members to the equivalent position of respective main members.

Please refer to FIG. 1, which is an illustration of a typical, present day back hoe as might be mounted at the rear end of a tractor. The tractor engine is normally used to power hydraulic pumps. Normally four hydraulic valve reversible controllers are located immediately adjacent, to the right, and to the left, of the operators seat 1, (sometimes foot pedal controlled valves are located in front of the operators seat for the "swing motion". Thus the four separate lever controller hydraulic valves would: (a) regulate the flow of oil to hydraulic cylinder 2 causing dipper 3 to rotate about axis 4; (b) regulate the flow of oil to hydraulic cylinder 5 causing the rotation of dipper arm 6 about axis 7; (c) regulate the flow of oil to hydraulic cylinder 8 causing rotation of crowd arm 9 about axis 10 and; (d) regulate the flow of oil to hydraulic rotary motor 11 causing the entire digging assembly on swing base to rotate "swing" about axis 12.

It takes a good deal of aptitude to coordinate the movements of the dipper, dipper arm, crowd arm, and swing base 13 to remove earth from the bottom of a ditch and place it in a pile, parallel to the ditch in an efficient manner. Other jobs assigned to a back hoe such as picking up a section of drainage tile with a sling and placing the drainage tile accurately so that it butts against an adjoining tile; requires concentrated effort, mature aptitude, and extended practice.

The reason that the control of the hydraulic valve lever requires a great deal of skill is that the horizontal movement of the levers is arbitrary and in no way bio mechanically associated or similar to the separate angular movement of each of the back hoe (dipper, dipper arm, crowd arm and base assembly) members.

In order to make the back hoe control job easy, and natural, this disclosure outlines a method by which the operator can control the movements of a small, model size, back hoe whose members at all times represent the positions of the main digging members of the machine. Thus the controlled three dimensional "flight" path required of the dipper would be as easy to accomplish by the following disclosed scheme as the 3 dimensional path traced by an eating utensil, such as a spoon,

held in a mans hand. A typical hardware arrangement might be as follows:

With reference to FIG. 1, tubular support 14 is mounted on swing base 13 and establishes a support point in line with swing axis 12 and immediately in front of the operators seat. Member 16 is a small scale representation of crowd arm 9 which pivots around axis 17 adjacent to support point 12 and always stays parallel to the crowd arm 9 because the distance between axes 10 and 19 is the same as the distance between axes 17 and 18 and the connecting rod 82 between axes 18 and 19 is made to be the same as the distance between axes 17 and 10.

With reference to FIG. 2 the small scale representation 20 of dipper arm 6, is arranged to assume the constant, step by step rotary position of dipper arm 6 about axis 7. Sprocket 21 is affixed to bracket 22 so that it too rotates with dipper handle 6 about axis 7. Sprocket 21 causes equal sized sprocket 23 to rotate through the same arc around axis 19 by means of chain 24. Sprocket 23 drives a shaft, with same axis 19. Axes 19, 10, 18, 17, 27, 7, and 4 are all parallel. Axis 19 shaft, drives a sprocket 25, on the opposite side of crowd arm 9. Sprocket 25 in turn drives the same diameter sprocket 28 through the same arc by means of chain 29. Sprocket 28 fixed to arm 20 then in turn, causes mimic dipper arm 20 to rotate step by step in coordination with the rotation of the dipper arm 6. The ratio of lengths of dipper arm 6 to mimic dipper arm 20 is the same as the ratio of crowd arm 9 to mimic crowd arm 16. The length of dipper arm 6 is between axes 4 and 7. The length of mimic dipper arm 20 is between axes 27 and 18. The length of crowd arm 9 is between axes 10 and 7. The length of mimic crowd arm 16 is between axes 17 and 18.

In a similar manner, we will see how mechanical linkage drives sprocket 30 as shown in FIG. 3 through step by step representation of the angular movement of dipper 3 about axis 4. A lever 32 is affixed to dipper 3 and causes lever 33 on sprocket 37 to move simultaneously through the same angular position as lever 32 by means of connecting rod 34. Connecting rod 34 is the same length, between axes 35 and 36 as the distance between axes 7 and 4. Sprocket 37 causes an equal diameter sprocket 26 to rotate the same number of degrees as sprocket 37 by means of chain 38. Sprocket 37 is affixed to lever 33. Sprocket 26 rotates about axis 19. Sprocket 26 is a double (locked side by side) sprocket which turns free with respect to axis 19 shaft and causes an equal diameter sprocket 39 to rotate about axis 18 by means of chain 31. Sprocket 39 is affixed to sprocket 40. Sprocket 40 (same diameter) causes sprocket 30 to rotate the same number of degrees around axis 27 by means of chain 41. Valves 61 and 62 are affixed to sprocket 30.

We can now see that small mimic member 16 is always at the same angular position, and thus represents crowd arm 9. Small mimic member 20 is always in the same angular position and thus represents dipper arm 6. Also, small mimic member 30 is always in the same angular positions and thus represents dipper 3.

With reference to FIG. 3, the driven, small scale mimic members 16, 20, and 30 will be used to mount the crowd arm, dipper arm, and dipper hydraulic pilot valve assemblies respectively. The crowd arm valves 57 and 58 are mounted on mimic crowd arm member 16. Dipper arm valves 59 and 60 are mounted on mimic

dipper arm member 20. Dipper valves 61 and 62 are mounted on mimic dipper member 30. The main, pilot operated, reversing, spool spring centered, hydraulic valves which supply fluid to main members 2, 5, 8, and 11, are of present commercial design such as Vicker's DG18S4-06 if air pilot actuated; or DG3S4-044D-20 oil pilot actuated; or DG5S4-06 if electric solenoid, pilot actuated.

Signal devices 49, 50, 57, 58, 59, 60, 61, and 62 are also of present commercial design. If the pilot operated, spring centered, main valves are air pilot actuated, the signal devices could be pilot valves such as Airmatic three way, spring return, plunger operated model 38251 or Vicker's C-572-E (with plugs inserted to eliminate "P open to T" while extended, and "P open to 2" while depressed options, thus making it a three way valve. Reference Vicker's industrial catalog page f17, and Airmatic catalog 2000 pg. 6.

Those valve type signal devices have preloaded springs which hold the plungers in the extended positions. Thus, when two pilot valves are mounted on each mimic member 66, 16, 20, and 30, so that each set of valves, with plungers fully extended, touch the forward and reverse sides of respective pattern members 73, 42, 45, and 48, the pattern members are said to be forced to a "spring centered, neutral position" — as long as the operator is exerting no directional force on control knob 71.

As an alternate to the standard commercial equipment line-up indicated on pages 2, 3, 4, and 5, stepless speed control movement of the main digging members may be obtained by utilizing alternate Glarban Corp. signal devices and intermediate valves. In this case, where intermediate valves are to be utilized, the standard commercial reversing hydraulic, pilot operated, spool spring offset, main valves which supply hydraulic fluid to the main work cylinder 2,5,8 or hydraulic motor 11 may be similar to Vickers DG3S4062-50.

Intermediate standard commercial control valves for use between signal devices 49, 50, 57, 58, 59, 60, 61, 62 and the main valves may be similar to Glarban Corp. model 5001 electro-hydraulic or Glarban Corp. model 3002, proportional control valves.

The signal devices can be oil or air valves similar to Glarban's series 250. In this case, the valve body would be mounted on the mimic member so that the valve handle stem would be parallel to the pattern member. The pattern member might have two projections that would project at right angles from the pattern member and be, on each side of the valve handle stem so that when the pattern member moves, the movement would be transferred immediately to the valve handle, and the pattern member would be spring centered by the same springs that keep the valve handle spring centered. As an alternate to the stepless Glarban series 250 oil or air signal devices, electro signal devices can be standard, commercial linear potentiometers, with spring extended push rods.

The three leads or tubes to each pair of signal devices as shown in FIG. 3 would be, if using an intermediate valve between the signal device and the main valve, (a) supply source of air, hydraulic fluid, or electrical current (b) return line to the source of power, and (c) adjustable pressure or voltage line to the intermediate Glarban valve. Electric signal devices can use ground return from the intermediate valve by means of the controller metal parts. Each pair of standard commer-

cial potentiometer (valves) are connected with 2.5 volt output in neutral; with 2.5 to 0 volts when one device is actuated or 2.5 to 5 volts if the other potentiometer signal device is actuated.

If step-less speed is required and no intermediate valve is to be utilized between the signal device and main valve, then a connection between signal device and the main valve can be made as shown in the Glarban series 700 arrangement.

The above described commercial hardware would allow the positive feedback, and signal device mounting arrangement with signal control knob — to cause the main members to be moved either by less expensive single step speed control or more expensive and elaborate step-less speed control. In either case, the signal device or devices used with one "motion" have two spring extended plungers which are used to keep the pattern member in the spring centered, zero output, control position with respect to each associated mimic member — as long as the operated is exerting no directional force on the control knob.

If the main pilot operated, spring centered, hydraulic valves are electric solenoid operated, like Vicker's DG5S4-06, then the signal devices could be electrical, commercially available short stroke linear potentiometers or Microswitches with spring force extended plungers like the valves mentioned above. Those step-less or step type switches would be positioned on the mimic members in a manner similar to the description above and as shown in FIG. three. The Microswitch brand switches would each have a standard, form C internal contact that would, when forward switch (alone) was actuated, make the circuit to the forward main valve solenoid and break the circuit to the reverse solenoid.

The control leads or tubes entering or leaving each pair of control signal devices, as shown in FIG. 3, best represents an air or electrical pilot installation in that only three leads or tubes are shown — one for the power source and the other two for connecting that power source to the separate forward and reverse sides of the pilot, spool control, end of the main directional valves. Exhaust air can be vented to atmosphere, so no fourth "tank return" tube is required. With electrical pilot circuitry, the entire machine and control members are metal, so that metal can be the ground return between the power source and the forward and reverse solenoids. No fourth lead would be required to a pair of signal devices.

If the pilot system uses oil, a fourth tube should be used to each pair of signal devices to vent the low pressure side of the main reversing spring centered valve, pilot section to sump.

Immediately adjacent to the small scale, mimic crowd arm 16, (to the right as viewed from above) crowd arm pattern member 42 is mounted so as to pivot around the same axis 17 used by member 16. Crowd arm pattern member 42 has dipper arm pattern member 45 pivoted on it at top point 46 and has no connection to sprocket 40 or axis 18. The distance between axes 18 and 17 is the same as the distance between axes 46 and 17. Member 42 is allowed to be displaced slightly from its spring centered angular position in line with member 16 until it hits pin stops 67 or 68. Angular movement of member 42 with respect to member 16 causes pattern member 42 to actuate either the "crowd-in" valve 57 or "crowd-out" valve 58. If the

"crowd-in" valve 57 is actuated, air under pressure in supply line 51 is allowed to flow out of crowd-in hydraulic line 53 to a pilot end of a crowd reversing valve (like Vicker's DG18S4-06), and from that pilot end exhausted through line 54 and valve 58 to atmosphere. Thus, shaft 72 (as shown in FIG. 1) of hydraulic crowd cylinder 8 would be retracted by oil from main crowd reversing valve causing crowd arm 9 to crowd-in toward the operator. As crowd arm 9 rotated counter clock wise about axis 10 (as viewed in FIG. 1) in a crowd-in direction, the small scale mimic crowd handle member 16 would follow step by step, and thus valve 57 would tend to move away from pattern member 16, stopping the crowd-in motion, if pattern member 42 were no longer rotated in a counter clock wise direction.

The operators right hand grabs pattern knob 71 as shown in FIG. 3. The axis 47 of pattern knob 71 is the same distance from pattern axis 46 as axis 27 (as shown in FIG. 1) is from axis 18 of the mimic members. If the operators hand signaled a crowd-in motion on knob 71, that signal force would be transmitted through pattern member 45 to pivot point 46, attached to pattern member 42. Thus pattern member 42 would rotate counter clock wise until it hits pin stop 67, and in so doing, pattern member 43 would actuate the crowd in valves 57 as previously described. As soon as the operators hand stops the counter clock wise motion, member 45 and 42 would become stationary, but members 9 and 16 would continue their counter clock wise motion by a small amount until crowd-in valve 57 pulls away from the stationary pattern member 42.

The mimic members 16, 20, and 30, on which the respective control valves are mounted, provide positive feed back of position desired — 0 as patterned by the signal linkage pattern member 42 crowd, 45 dipper arm, and 48 dipper respectively.

The operator by grasping pattern knob 71 and rotating pattern member 45 has no connection with sprocket 30 and is tied to knob 71 through a shaft with axis 47 moves member 45 about pivot 46 in a counter clock-wise motion away from spring centered alignment with member 20 until the pin stop 69 on member 20 restricts further signal motion. When signal member 45 moves counter clock-wise with respect to member 20, member 45 actuates the dipper arm control valve 60 causing air in line 56 to actuate air pilot, dipper arm reversing hydraulic valves (like Vicker's DG18S406), thus causing shaft 74 of hydraulic cylinder 5 to retract moving dipper arm 6 in a counter clock-wise motion about axis 7; and also moving mimic dipper arm 20 in a counter clock-wise motion about axis 18. As soon as the operators counter clock-wise movement of pattern knob 71 and pattern member 45 about axis 46 stops, pressure of 45 against control valve 60 stops and dipper arm 6 and mimic dipper arm 20 continue to rotate slightly further in a counter clock-wise direction until the dipper arm valves 59 and 60 are equally distant from member 45.

In a similar manner, by rotation of pattern control knob 71 about its own axis the operator can cause rotation of extension arm 48 affixed to knob 71, and counter clock wise motion of 71 and 48 will actuate pilot valve 62 allowing the air in supply line 63 to flow out of line 64 to the pilot end of hydraulic reversing, main (dipper) valve (like Vicker's DG18S406) and exhaust through line 65 and valve 61 to atmosphere. Oil

from dipper valve thus causing shaft 75 (as shown in FIG. 1) of hydraulic cylinder 2 to retract — moving the dipper 3 in a counter clock-wise direction about axis 4 and simultaneously by means of linkage described moving mimic member 30 in a counter clock-wise direction. When the operator stops rotation of pattern knob 71 and extension arm 48, valve 62 is no longer actuated more than valve 61 and so retraction of shaft 75 of hydraulic cylinder 2 stops dipper rotation.

Again, in a similar manner, the operator when sitting on seat 1 can grasp pattern control knob 71 and apply pressure in a horizontal, counter clock-wise direction about axis 12 (FIG. 1) so that swing pattern plate 44 and plate finger 73 applies more pressure to swing pilot valve 49 than to valve 50 and therefore in a manner similar to the other motions described above, the main swing, air operated, reversing valve sends oil to the hydraulic rotary actuator so that the hydraulic rotary actuator 79 will swing the entire digging assembly counter clock-wise about axis 12 with respect to stationary seat 1 and plate 66. Valves 49 and 50 are mounted on plate 66. When the operator's pattern knob 71 plate 44 and finger 73 stop horizontal motion and pressure, pilot valves 49 and 50 will regain equal (spring) force neutral position and so both digging members and mimic members swing motion also stops.

Tubes 51, 53, and 54 are rigid as shown connected to crowd signal devices 57 and 58 up to joints 108, 109 and 107 respectively. Tubes 52, 55, and 56 are rigid from dipper arm signal devices 55 and 56 to joints 104, 106 and 105 respectively. Tubes 63, 64, and 65 are rigid from dipper rotational signal devices 61 and 62 to joints 102, 103 and 101 respectively. Tubes 76, 77 and 78 are rigid from swing signal devices 49 and 50 to joints 112, 111, and 110 respectively. From the above tube joints to their respective crowd, dipper arm, dipper and swing main pilot actuated control valves, the tubes are flexible. Rigid tube sections 51, 52 and 63 could help confine motion of pattern members 42, 45 and 48 respectively to movements parallel to their respective mimic member movements. In any given swing position, pattern members 42, 45 and 48 would be in essentially the same vertical plane.

Swing pattern finger 73 actuates swing pilot valve 49 by means of its spring extended plunger 85, or actuates valve 50 by means of its plunger 84. In a similar manner crowd pilot valves 58 or 57 are actuated by crowd pattern member 42 by means of plunger 94, which is visible in FIG. 3 or plunger 95 respectively of valve 57, which is not visible. Dipper arm pattern member 45 actuates dipper arm pilot valve 600 by means of its plunger 114, or valve 59 by means of its plunger 115 not visible. Also dipper rotational pattern member 48 actuates valve 62 by means of its plunger 124, or valve 61 by means of its plunger 125 not visible.

All pairs of valves as mentioned for the swing, crowd, dipper arm, and dipper movement signal output have spring extended plungers, as related, which force their entrapped related pattern member to a spring centered neutral position when the operator is exerting no overriding pattern force on control knob 71.

FIG. No. 1 shows the small sized mimic members only — on which the pilot valves are mounted. Pattern members 44, 42, 45 and 48 are omitted from FIG. No. 1 for clarity.

Vertical support tubes 14 in FIG. 1 become horizontal support tubes 79 and 80 as shown in FIG. 3.

Mimic crowd member 16 is strengthened and made more rigid by parallel crowd mimic member 83.

I claim as my Invention:

1. A controller for a hydraulically driven back hoe; the back hoe utilizing the following present day commercially, available, items:

1. An engine prime mover.
2. Main hydraulic pump or pumps.
3. Hydraulic linear or rotary actuators used to drive the digging members.
4. Main digging members including: (a) a dipper, (b) a dipper arm (c) a crowd arm, (d) rotational (swing) base for members a, b, and c,
5. Hydraulic, pneumatic or electric reversible, stepless signal devices, of standard commercial types, that are used to provide the pilot signals to hydraulic pneumatic or electric actuated main hydraulic valves that control the flow of hydraulic fluid to the main actuators that in turn control the movement of the dipper, dipper arm, crowd arm, and swing support members;

and the following novel assemblies:

- A. means for continuously transmitting the dipper angle, dipper arm angle, the crowd arm angle, and the swing base position angle-with significant force-greater than the operator's strength to resist that transmitting effort,
- B. a means for representing and mimicing the exact angular position of the main digging members (dipper, dipper arm, crowd arm, and rotary or swing base) by small scale equivalent members,
- C. means for mounting the signal devices, on the mimic or main members and which signal devices actuate the means for continuously driving the main and mimic members to follow pattern elements, and
- D. pattern control elements that represent the dipper, dipper arm, crowd arm, and swing base, in the same small scale as the mimic members, and located with respect to the mimic members so that the pattern members break down the operator's hand movement into the proper vector signals of direction and speed for each of the four sets of

main and mimic members required to make the four main digging and mimic elements actuate the signal devices and follow the exact relative sequence of positions as set up by the positions of the pattern elements wherein said positions of the pattern members comprise direction and speed vectors.

2. Controller as described in claim 1 whose sensing devices are mounted on the small scale mimic members, and have spring positioned stems so that the operator controlled pattern members have to move against the spring centering effort exerted by the four sets of signal devices; the resistive effort of the signal devices against the dipper, dipper arm crowd arm, and swing base pattern members increases as the pattern members are moved from slightly off neutral in one direction before hitting mechanical stops; the amount of signal device displacement is proportionate to the force exerted by the dipper in breaking through earth and rock and thus the operator has an indication of the digging effort of the back hoe.

3. A controller for a back hoe as recited in claim 1 where the required relative positions of the dipper to the dipper arm; dipper arm to the crowd arm; and crowd arm to the swing base are continuously coordinated by the signals from the pattern members to the signal devices on the mimic members so that the dipper can follow exactly, step-by-step, the locus of points set up by the operator's hand in small scale.

4. A controller as recited in claim 1 for a back hoe whose main and mimic members follow within an approximate equivalent range of angular positions signaled by the pattern members; the control knob having a direction and speed vector which is substantially equivalent to the sum of the speed and direction vectors of the pattern members so that the dipper can follow a relative sequence of positions associated with the control knob.

5. A controller whose assembly of control elements as described in claim 1 above causes any motion in progress to be self cancelling when the control knob is brought to a stationary position.

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