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Huffman

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[54] **MULTIPLE SPEED HYDRAULIC DRIVE CIRCUIT**

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[51] **Int. Cl.** **F15b 15/18**

[58] **Field of Search** .... 60/52 R, 52 HE; 91/6

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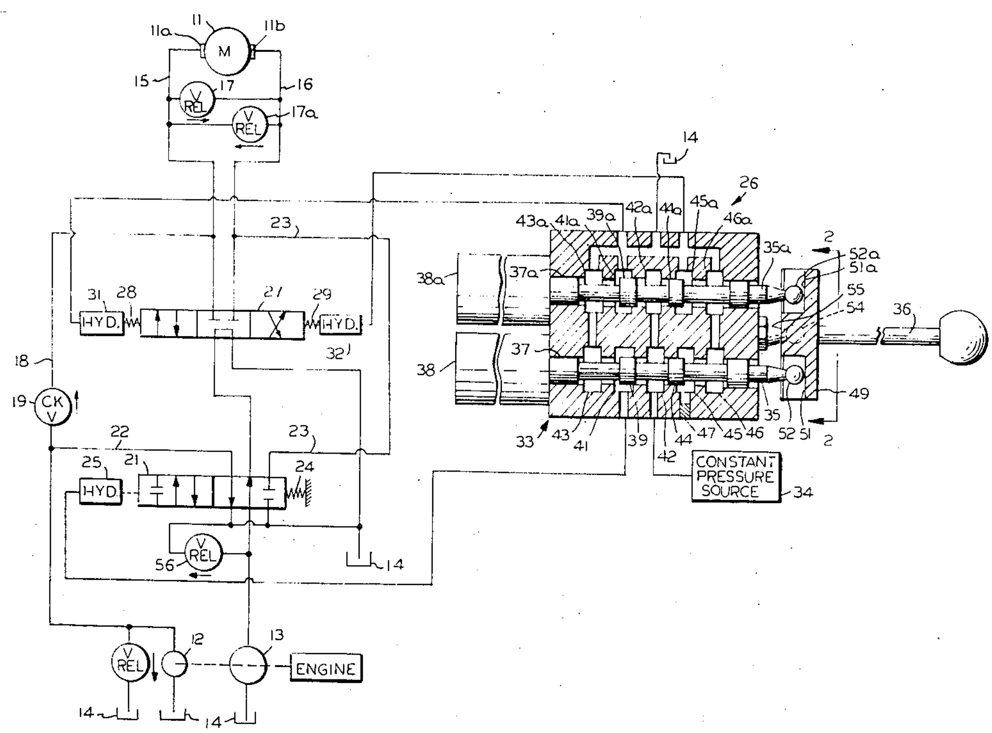
[57] **ABSTRACT**

The disclosure concerns a hydraulic power circuit particularly suited for use in driving the elevator of an earth-moving scraper, and which affords three driving speeds in the forward direction and one driving speed in reverse. The circuit preferably employs two fixed displacement pumps of different capacities, and a pair of pilot operated control valves which selectively cause the output of either or both pumps to be delivered to the drive motor. The control valves are so arranged that they may be incorporated in a single, conventional valve body, and that neither has to be sized to handle the combined outputs of both pumps.

10 Claims, 4 Drawing Figures



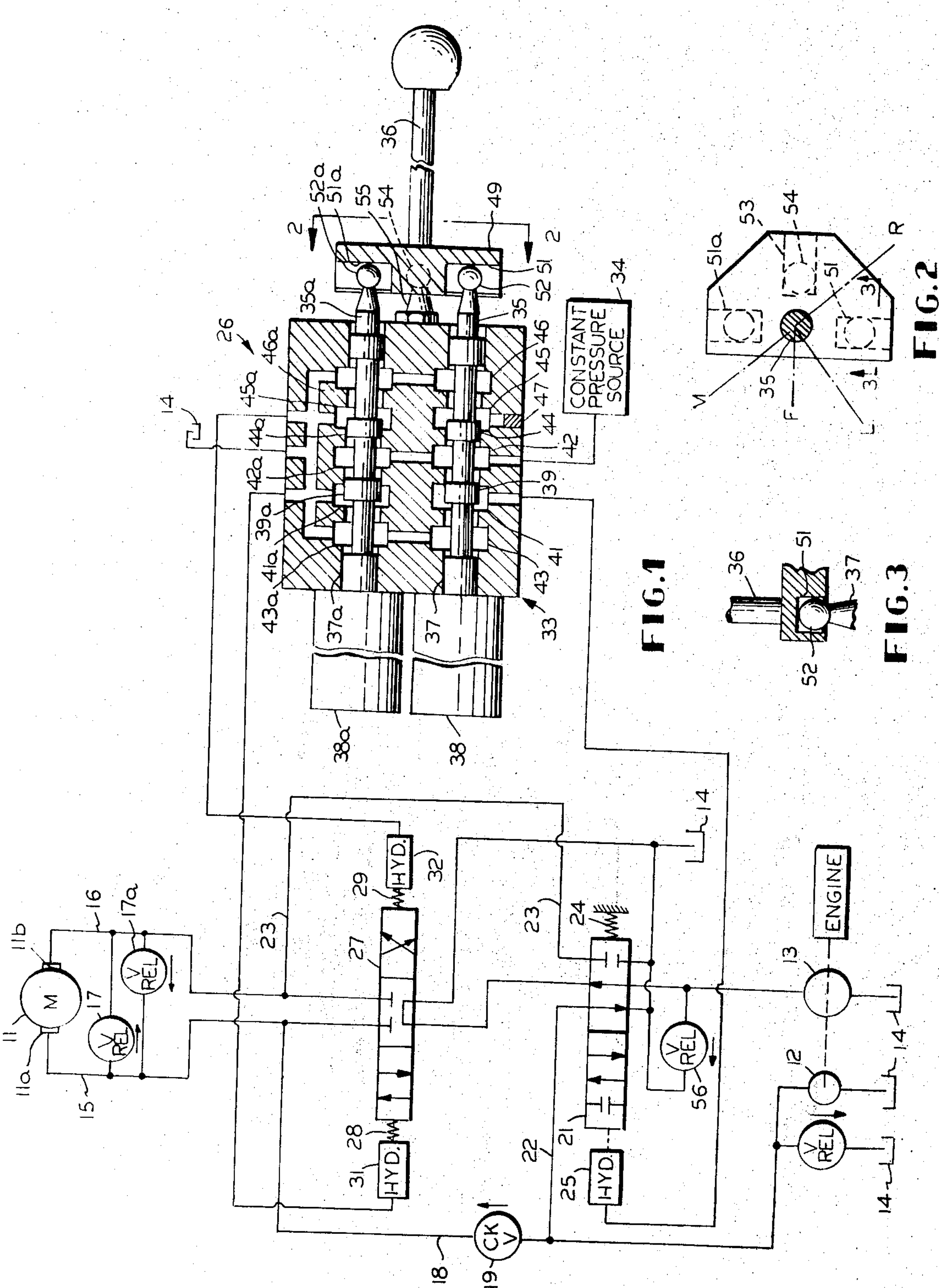

CONSTANT PRESSURE SOURCE
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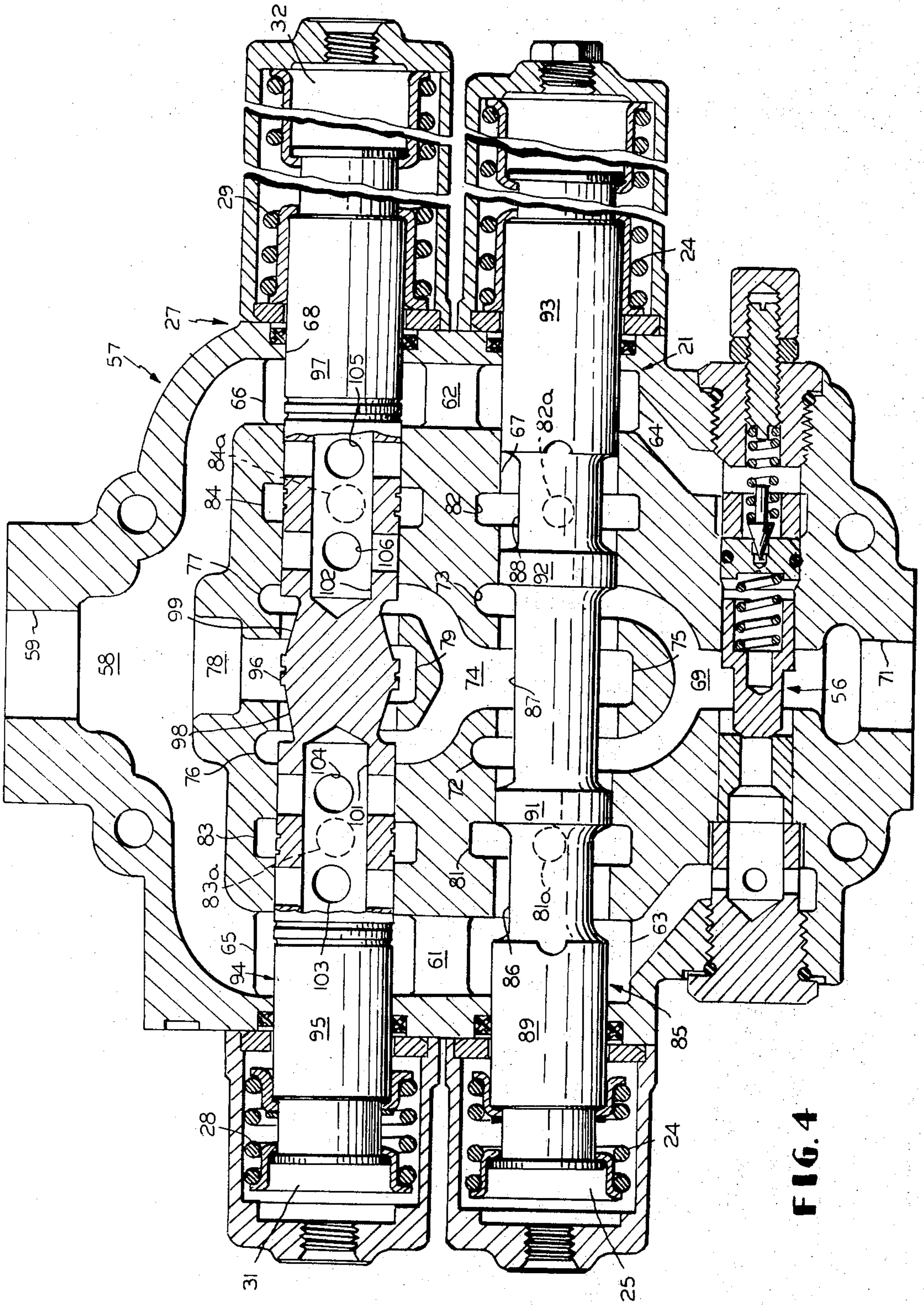
FIG.1
FIG.2
FIG.3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82a
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83a
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81a
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FIG.4

MULTIPLE SPEED HYDRAULIC DRIVE CIRCUIT

BACKGROUND AND SUMMARY OF THE INVENTION

Although it is common practice to use a hydraulic drive for the elevator of a self-loading, earth-moving scraper, each of the prior drive circuit proposals of which I am aware has disadvantages which limit its utility. The simplest circuit includes a single fixed displacement pump, and a two-position selector valve which either unloads the pump or delivers its output to the drive motor. This arrangement affords only a single driving speed; therefore, the elevator operates efficiently only in a very limited range of vehicle speeds. Moreover, since the driving direction cannot be reversed, dislodgment of objects caught in the elevator can be difficult. These disadvantages have given rise to several proposals for improving the performance of the basic circuit. One of these involves the addition of a directional control valve which allows reversal of the direction of flow through the motor. Another consists in the addition of a second fixed displacement pump which is selectively unloaded or connected in parallel with the main pump by a selector valve. This auxiliary pump may serve only the drive circuit, in which case its output always is available for driving purposes, or it may be an implement pump whose output is conveyed to the drive circuit through a high pressure carry-over in the implement control valve, and thus is available only when the implements are idle. While these proposals provide an effective solution of the dislodgment problem and do increase the range of vehicle speeds in which efficient elevator operation can be achieved, they do not accommodate the wide range of ground speeds which are encountered in some applications. Moreover, if the two-pump drive incorporates a directional control valve, that valve must be sized to handle the combined outputs of both pumps. This increases the cost of the circuit.

Another prior drive circuit, and probably the best in certain applications, consists of a hydrostatic transmission using a fixed displacement piston motor and a variable displacement, overcenter piston pump. This proposal affords reversing capability as well as infinitely variable drive speed, and thus constitutes a very attractive solution to the drive problem in applications where its cost is comparable to that of the dual pump-reversing valve scheme. Unfortunately, at the present time, transmission pumps and motors are mass produced, and thus readily available on the commercial market, only in capacities up to about 6 cubic inches per revolution, which is the size required to satisfy the power requirements of the elevator on a 9 cubic yard scraper. Since the cost of larger transmission components increases at a rate far exceeding that normally attributable to the change in power rating, this type of drive is impractical for large scrapers, particularly those in the 20–40 cubic yard class.

The object of this invention is to provide an improved hydraulic drive circuit which accommodates a wider range of ground speeds than the prior proposals which employ fixed displacement pumps, and which is more economical than the hydrostatic tansmission proposal in the sizes required for high power applications. According to the invention, the new circuit includes a drive motor which is selectively supplied with the output of either or both of a pair of fixed displacement pumps depending upon the positions of a pair of control valves. The pumps have different capacities, so the circuit affords a choice of three driving speeds. One of the pumps is connected with the motor through a check valve and is selectively loaded and unloaded by one of the control valves, which also is arranged to selectively open and close a return path leading from the motor. The second valve, on the other hand, controls a supply path from the other pump to the motor as well as an additional return path from the motor to a fluid reservoir. With this arrangement, neither control valve is required to handle the combined outputs of the two pumps, and both valves can be incorporated in a conventional tandem (i.e., series-parallel circuit) valve body having the usual Y-shaped coring for the open center path. These features contribute to the relatively low cost of the circuit.

In its preferred form, the drive motor is reversible, and the second control valve takes the form of a conventional three-position directional control valve which is adapted to reverse the direction of flow through the motor. Moreover, in this version of the invention, both control valves are of the pilot operated type and are operated by a remote control system having a single actuating lever which determines the positions of both control valves. This embodiment, therefore, facilitates dislodgment of objects stuck in the elevator, reduces operator effort, and allows considerable freedom in locating and arranging circuit components.

BRIEF DESCRIPTION OF THE DRAWINGS

The preferred embodiment of the invention is described herein with reference to the accompanying drawings in which:

FIG. 1 is a schematic diagram of the improved drive circuit.

FIG. 2 is a sectional view taken on line 2—2 of FIG. 1.

FIG. 3 is a sectional view taken on line 3—3 of FIG. 2.

FIG. 4 is a cross sectional view of the control valve assembly used in the FIG. 1 circuit.

DESCRIPTION OF ILLUSTRATED EMBODIMENT

As shown in FIG. 1, the drive circuit includes a reversible, rotary hydraulic motor **11** which drives the elevator (not shown), a pair of engine-driven, fixed displacement pumps **12** and **13** of unequal capacities, and a fluid reservoir or tank **14**. Motor **11** is provided with a pair of ports **11***a* and **11***b*, either of which may serve as the supply port while the other serves as the return port, and which are connected to the service lines **15** and **16**, respectively. These lines are equipped with criss cross relief valves **17** and **17***a* which serve to prevent cavitation and reduce shocks when motor **11** is stopped or reversed.

The smaller supply pump **12** is connected with service line **15** through a conduit **18** containing a check valve **19**, and is selectively loaded and unloaded by a two-position control valve **21** which is connected with conduit **18** at a point upstream of the check valve via branch conduit **22**. In addition to its unloading function, valve **21** also controls a motor return path leading from service line **16** to tank **14** through conduit **23**. Valve **21** is biased by spring **24** to the illustrated position, in which it unloads pump **12** and closes conduit **23**, and is shifted to the second position, in which it loads pump **12** and opens conduit **23**, by a piloted pressure motor **25** which is actuated by a remote control system **26**.

The larger supply pump **13** is selectively unloaded, or loaded and connected with one or the other of the service lines **15** and **16**, by a three-position control valve **27** which also is adapted to establish a return path from the remaining service line to tank **14**. Valve **27** is biased to the illustrated neutral position by a pair of centering springs **28** and **29** and is shifted to one or the other of two motor-actuating positions by a pair of opposed piloted pressure motors **31** and **32** under the control of system **26**. In its neutral position, valve **27** unloads pump **13** to tank **14** and isolates the service lines **15** and **16** from both of these components and from each other, whereas in each of the actuating positions the unloading path is closed, one service line is connected to pump **13**, and the other service line is connected to tank **14**.

It should be noted here that, while valve **27** is connected with pump **13** through control valve **21**, this path is continuously open. Therefore, the functions of valve **27** are not affected by actuation of valve **21**.

The remote control system **26** comprises a pilot valve **33** which is supplied with hydraulic fluid at a relatively low, constant pressure on the order of 250 p.s.i. by a source **34**, such as the power steering circuit of the vehicle, and which contains a pair of valving units **35** and **35*a*** which serve to pressurize and vent the piloted pressure motors of control valves **21** and **27**, respectively, in accordance with the position of a common actuating lever **36**. Valve unit **35** includes a spool **37** which is equipped with a conventional centering spring and detent assembly **38**, and which is formed with a land **39** which controls communication between an outlet chamber **41**, which is joined to piloted motor **25**, and supply and exhaust chambers **42** and **43**, respectively. When spool **37** is in the illustrated neutral position, toward which it is biased by the centering spring, land **39** blocks communication between chambers **41** and **42**, and the outlet chamber is in free communication with exhaust chamber **43**. On the other hand, when spool **37** is shifted to the left to the detented actuating position, land **39** blocks communication between chambers **41** and **43**, and the outlet chamber is connected with supply chamber **42**. Valve unit **35** is a double-acting unit, so spool **37** includes another land **44** which controls communication between a second outlet chamber **45** and the supply and exhaust chambers **42** and **46**. However, since control valve **21** incorporates only a single actuating motor, this added capability of unit **35** is not needed, and the outlet port of chamber **45** is sealed by a plug **47**.

Valve unit **35*a*** is identical to unit **35**, but its full double-acting capability is needed. Therefore, outlet chamber **41*a*** is connected with piloted motor **31**, outlet chamber **45*a*** is connected with opposed motor **32**, and the second detented actuating position of spool **37*a*** (i.e., the position of the right of neutral) is utilized.

The spools **37** and **37*a*** of the two pilot valve units are shifted by the common actuating lever **36** which includes a plate **49** containing a pair of aligned slots **51** and **51*a*** in which the spherical heads **52** and **52*a*** of the spools are held captive. Plate **49** also is provided with a third slot **53** in which is retained the spherical head **54** of a fixed pivot **55**. Lever **36** is biased to the illustrated neutral position, in which it is parallel with spools **37** and **37*a***, by the centering springs associated with those spools, and can be tilted about fixed pivot head **54** to one of the following four actuating positions labeled in FIG. 2:

a. Low Speed Position L in which it shifts spool **37** to its actuating position, to thereby pressurize chamber **41**, but keeps spool **37*a*** in neutral position.

b. Medium Speed Position M in which it shifts spool **37*a*** to its first actuating position, to thereby pressurize chamber **41*a*** and vent chamber **45*a***, but keeps spool **37** in neutral position.

c. Fast Speed Position F in which it shifts both of the spools **37** and **37*a*** to the actuating positions just mentioned.

d. Reverse Position R in which it shifts spool **37*a*** to its second actuating position, to thereby pressurize chamber **45*a*** and vent chamber **41*a***, but keeps spool **37** in neutral position.

When the illustrated circuit is in service and lever **36** is in the neutral position, the outlet chambers **41**, **41*a*** and **45*a*** of the pilot valve **33** are in free communication with tank **14** through the associated exhaust chambers **43**, **43*a*** and **46*a***. Therefore, the three piloted motors **25**, **31** and **32** are vented, and the springs **24**, **28** and **29** hold the control valves **21** and **27** in their neutral positions. As a result, both of the pumps **12** and **13** are unloaded to tank **14**, and drive motor **11** is hydraulically locked.

In order to drive the elevator in the forward direction at the lowest of the three available speeds, lever **36** is tilted to position L. This action raises the pressure in pilot valve outlet chamber **41** and in the connected piloted motor **25**, so the latter now shifts control valve **21** to its second position to thereby load the small pump **12** and open a return path for motor port **11*b***. The output of pump **12** is now delivered to motor **11** via conduit **18**, check valve **19**, service line **15** and port **11*a***, and the fluid exhausting from port **11*b*** is returned to tank **14** via service line **16** and return conduit **23**. Therefore, motor **11** will now drive the elevator at a low speed proportional to the delivery rate of pump **12**.

If lever **36** is tilted to position M, pilot spool **37** will return to the illustrated neutral position under the action of its centering spring to thereby again vent piloted motor **25** and allow spring **24** to return control valve **21** to its neutral position. This action unloads pump **12** and closes return conduit **23**. Simultaneously, pilot spool **37*a*** is shifted to its first actuating position, so outlet chamber **41*a*** and piloted motor **31** are pressurized by source **34**, and chamber **45*a*** and motor **32** remain vented. Therefore, motor **31** will shift control valve **27** to the actuating position in which it connects pump **13** with service line **15**, and opens a return path from service line **16** to tank **14**. Since the check valve **19** prevents the escape of oil from line **15** through the unloading path established by valve **21**, the full output of large pump **13** will be delivered to motor **11**, and the latter will now drive the elevator at a higher speed.

The highest output speed of motor **11** is developed by shifting lever **36** to position F. In this mode of operation, the pilot valve outlet chambers **41** and **41*a*** are pressurized, so piloted motors **25** and **31** set both of the control valves **21** and **27**, respectively, to their second positions. As a result, both of the pumps **12** and **13** are loaded, and their combined outputs are delivered to motor **11**. In contrast to the previous modes of operation, the return flow from motor **11** is delivered to tank **14** along two parallel paths; one leading through conduit **23** and control valve **21**, and the other leading through control valve **27**. Inasmuch as the flow rate through motor **11** now equals the sum of the outputs of the two pumps, the driving speed will equal the sum of the low and medium speeds.

In the event it becomes necessary to reverse the elevator, lever **36** is shifted to position R. This movement of the actuator allows spool **37** to return to its neutral position, thereby causing control valve **21** to unload pump **12** and block return conduit **23**, and simultaneously shifts spool **37***a* to the right to the second actuating position in which it isolates outlet chamber **45***a* from exhaust chamber **46***a* and opens communication between the outlet chamber and supply chamber **42***a*. Since piloted motors **31** and **32** are now vented and pressurized, respectively, control valve **27** is moved to the left to the position in which large pump **13** is connected with service line **16**, and service line **15** is connected with tank **14**. Inasmuch as these connections reverse the direction of flow through motor **11**, the motor now drives the elevator in reverse. Its speed, of course, is proportional to the output of pump **13**, and thus is the same as during forward operation at medium speed.

In the preferred form of the invention, the two control valves **21** and **27** take the form of sliding plunger valves, and, together with the relief valve **56** for large pump **13**, they are incorporated in the conventional tandem circuit valve body **57** shown in FIG. **4**. The body **57** is cored to provide a C-shaped exhaust manifold **58**, which communicates with an exhaust port **59** and has legs **61** and **62** which interconnect the annular chambers **63–66** located at opposite ends of the plunger bores **67** and **68**. The body also is cored to provide a central unloading path which includes a y-shaped section **69** leading from inlet port **71** to the annular chambers **72** and **73** encircling bore **67**, a second y-shaped section **74** connecting the central annular chamber **75** of bore **67** with the annular chambers **76** and **77** encircling bore **68**, and a downstream portion **78** leading from the central chamber **79** of bore **68** to the exhaust manifold. Each valve bore is also provided with a pair of annular outlet chambers **81, 82** or **83, 84** which communicate with service ports **81***a*, **82***a*, **83***a* and **84***a*, respectively; the ports **81***a* and **82***a* being connected to branch conduit **22** and return conduit **23**, respectively, and the ports **83***a* and **84***a* being connected with service lines **15** and **16**, respectively.

The control valve **21** of FIG. **4** includes a solid valve plunger **85** formed with three axially spaced peripheral grooves **86–88** which define four valve lands **89, 91, 92** and **93**, and is biased by a pair of springs **24** to the illustrated neutral position in which groove **86** interconnects chambers **63** and **81**, and lands **92** and **93** isolate outlet chamber **82**. Plunger **85** is moved to its second or actuating position by the piloted motor **25**, which includes the left end of the plunger, and in this position lands **89** and **91** isolate outlet chamber **81**, and groove **88** interconnects chambers **64** and **82**. In both positions of valve **21**, groove **87** interconnects chambers **72, 73** and **75**, so control valve **27** always is able to receive oil from pump **13** via inlet port **71** and the open center path regardless of the position of valve plunger **85**.

The preferred control valve **27**, on the other hand, includes a conventional three-position hollow valve plunger **94** formed with three lands **95, 96** and **97** which are separated by a pair of peripheral grooves or necks **98** and **99**. The plunger contains two axial bores **101** and **102**, each of which is intersected by a pair of axially spaced radial passages **103** and **104** or **105** and **106**. The arrangement of the parts is such that

a. in the illustrated neutral position, lands **95** and **97** isolate outlet chambers **83** and **84**, and plunger necks **98** and **99** connect chamber **79** with chambers **76** and **77**, respectively, and thereby complete the open center unloading path;

b. in the second position, to which the plunger is moved by motor **31**, lands **95** and **96** close the open center path, radial passages **103** and **104** register, respectively, with chambers **83** and **76**, and radial passages **105** and **106** register, respectively, with chambers **66** and **84**; and

c. in the third position, to which the plunger is moved by motor **32**, lands **96** and **97** close the open center unloading path, radial passages **103** and **104** register, respectively, with chambers **65** and **83**, and radial passages **105** and **106** register, respectively, with chambers **84** and **77**.

I claim

1. A hydraulic drive circuit comprising
- a. a hydraulic motor (**11**) having first and second ports (**11***a*, **11***b*);
- b. a fluid reservoir (**14**);
- c. a pair of pumps (**12, 13**) connected to draw fluid from the reservoir and discharge same under pressure;
- d. conduit means (**18**) connecting the first pump (**12**) with the first motor port (**11***a*);
- e. means preventing reverse flow from the first port (**11***a*) through the conduit means;
- f. a first control valve (**21**) connected with the first pump (**12**), the second motor port (**11***a*) and the reservoir (**14**) and having a neutral position in which it unloads the first pump to the reservoir and isolates the second motor port from both of these components, and a second position in which it closes the unloading path and connects the second motor port with the reservoir; and
- g. a second control valve (**27**) connected with the second pump (**13**), the reservoir (**14**) and the motor ports (**11***a*, **11***b*) and having a neutral position in which it unloads the second pump to the reservoir and isolates the motor ports from both of these components, and a second position in which it closes the unloading path and connects the first (**11***a*) and second (**11***b*) motor ports with the second pump and reservoir, respectively.

2. A drive circuit as defined in claim **1** in which
- a. the pumps (**12, 13**) are fixed displacement pumps having different capacities; and
- b. the means for preventing reverse flow through the conduit means (**18**) is a check valve (**19**).

3. A drive circuit as defined in claim **2** in which
- a. the motor (**11**) is reversible; and
- b. the second control valve (**27**) has a third position in which it closes the unloading path for the second pump and connects the first and second motor ports (**11***a*, **11***b*) with the reservoir (**14**) and the second pump (**13**), respectively.

4. A drive circuit as defined in claim **2** in which the second pump (**13**) is connected with the second control valve (**27**) via a passage in the first control valve

(**21**) which is open in both of said positions of the first valve.

5. A drive circuit as defined in claim **4** in which the two control valves (**21, 27**) are sliding plunger units incorporated in a common valve body (**57**) having Y-shaped coring (**64, 78, 79**) which defines an open center unloading path for the second pump (**13**) when both valves are in neutral position.

6. A drive circuit as defined in claim **5** in which the second pump (**13**) has the greater capacity.

7. A drive circuit as defined in claim **2** in which both control valves (**21, 27**) are operated by mechanism employing a common actuating lever (**36**), the lever having

a. a first position in which it sets both valves to neutral position,

b. a second position (L) in which it sets the first valve (**21**) to second position and the second valve (**27**) to neutral position,

c. a third position (M) in which it sets the first valve (**21**) to neutral position and the second valve (**27**) to second position, and

d. a fourth position (F) in which it sets both valves to second position.

8. A drive circuit as defined in claim **3** in which both control valves are operated by mechanism employing a common actuating lever (**36**), the lever having

a. a first position in which it sets both valves to neutral position,

b. a second position (L) in which it sets the first valve (**21**) to second position and the second valve (**27**) to neutral position,

c. a third position (M) in which it sets the first valve (**21**) to neutral position and the second valve (**27**) to second position,

d. a fourth position (F) in which it sets both valves to second position, and

e. a fifth position (R) in which it sets the first valve (**21**) to neutral position and the second valve (**27**) to third position.

9. A drive circuit as defined in claim **7** in which

a. the control valves (**21, 27**) are operated by piloted pressure motors (**25** and **31, 32**); and

b. the common lever (**36**) positions a pair of pilot valves (**35, 35***a*) which selectively pressurize and vent the piloted pressure motors of the first and second control valves (**21, 27**), respectively.

10. A drive circuit as defined in claim **8** in which

a. the control valves (**21, 27**) are operated by piloted pressure motors (**25** and **31, 32**) and

b. the common lever (**36**) positions a pair of pilot valves (**35, 35***a*) which selectively pressurize and vent the piloted pressure motors of the first and second control valves (**21, 27**), respectively.

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