

(19)



Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number:

0 279 362
A1

(12)

EUROPEAN PATENT APPLICATION

(21) Application number: 88102046.5

(51) Int. Cl.4: **E02F 3/32**, **E02F 9/22**,
F15B 11/22, **F15B 11/16**,
F15B 13/02

(22) Date of filing: 12.02.88

(30) Priority: 19.02.87 US 16318

(43) Date of publication of application:
24.08.88 Bulletin 88/34

(84) Designated Contracting States:
DE FR IT

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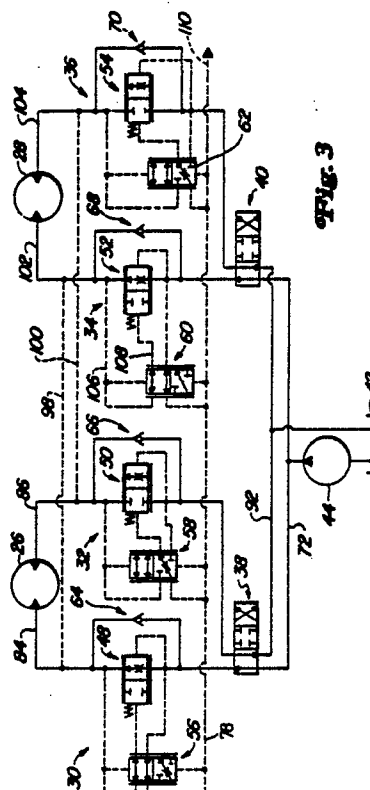
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(54) Hydraulic system.

(57) A crawler loader or other large industrial earth-moving machine has a hydraulic propulsion system comprising at least two hydraulic motors (26, 28) which are powered from a pump (44) to drive a common load, namely its tracks (24). Each motor (26, 28) of the hydraulic propulsion system is provided with two compensating valve assemblies (30, 32 and 34, 36). Each compensating valve assembly has a compensating spool (48, 50, 52, 54) and a shuttle spool (56, 58, 60, 62) to provide accurate control of the hydraulic motors (26, 28). In each pair of compensating valve assemblies (30, 32 and 34, 36), there is a forward compensating valve assembly (30, 34) and a backward valve assembly (32, 36) respectively controlling forward and backward movement of the associated hydraulic motor (26, 28). Between both forward compensating valve assemblies (30, 34) and the respective hydraulic motors (26, 28), the compensating valve assemblies (30, etc.) are fluidically coupled to one another by a small hydraulic communication line (98) that better equalizes hydraulic fluid flow to the motors (26, 28) and prevents domination of one forward compensating valve assembly over the other. Similarly, the backward compensating valve assemblies (32, 36) are provided with an identical small hydraulic com-

munication line (100) accomplishing the same results.



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Hydraulic System

The invention is directed to a hydraulic propulsion system comprising first and second hydraulic motors, a pump supplying pressurised hydraulic fluid to the motors, a first compensating valve assembly between one side of the first motor and the pump, and a second compensating valve assembly between the corresponding one side of the second motor and the pump.

Large industrial or construction machines such as track-laying excavators are often propelled by hydraulic motors. Typically, such machines are provided with internal combustion engines that are used to drive hydraulic pumps. The hydraulic pumps draw hydraulic fluid from a sump and pump the hydraulic fluid into hydraulic lines where it is directed to the propulsion motors for the tracks and to other operating members. Individual three-position directional control valves are used to control the flow of hydraulic fluid to each of the motors, thereby controlling the propulsion motors and other hydraulic motors used for driving the operating members.

In simple hydraulic systems, hydraulic fluid takes the path of least resistance and flows to the area requiring the lowest pressure. This is especially troublesome wherein two hydraulic motors are being used to move a common load, for example two crawler tracks of a crawler excavator, because the low pressure motor will command more hydraulic fluid resulting in an uneven operation of the two motors. To overcome this natural tendency of the hydraulic fluid, compensator valve assemblies are provided to better balance the flow between the two motors by having the high pressure compensator valve assembly meter the low pressure side to even the pressure between the two assemblies.

Although compensator systems work well in most instances, another problem develops when the loads are equal or close to being equal. This situation is noticeable when a crawler operator wants to go in a straight line wherein the tracks need to move equally to accomplish this task. The crawler operator would notice that the crawler would tend to turn to one side or the other as it moves. Therefore, the operator has to continually adjust for this turning movement in the crawler. This situation arises because one of the compensator valve assemblies is dominating the other compensator valve assembly effectively reducing flow through one of the hydraulic motors. This typically happens because the directional control valves are never opened simultaneously and the directional control valve that is opened first creates a dominating compensator valve assembly as it becomes the

high pressure compensator valve. The compensator valve assembly associated with the later opening directional control valve becomes dominated by the earlier opening and now high pressure compensator valve assembly, and tends to reduce flow to the hydraulic motor with which it is associated. Therefore, the hydraulic motor associated with the first opening directional control valve moves faster than the motor associated with the later opening directional control valve resulting in a turning movement by the crawler.

The present invention overcomes or reduces this problem.

According to the present invention the connections between the first and second assemblies and motors are coupled by a first communication hydraulic line.

By providing a small communication hydraulic line between the downstream hydraulic paths of the two compensator valve assemblies domination of one over the other is reduced or avoided. In the case of a crawler an arrangement is as follows. A source of hydraulic fluid supplies hydraulic fluid to two directional control valves each of which direct pressurized hydraulic fluid to a pair of downstream compensator valve assemblies. Each pair of compensator valve assemblies is provided with a forward compensator valve assembly for controlling forward movement of the crawler and a backward compensator valve assembly for controlling the backward movement of the crawler. The position of the directional control valve determines which one of the compensator valve assemblies in each pair of compensator valves the hydraulic fluid is directed to, thereby controlling the movement of the crawler. Two small communication hydraulic lines are provided for transmitting hydraulic fluid between the two forward compensator valve assemblies and between the two backward compensator valve assemblies.

An embodiment of the invention will now be described with reference to the accompanying diagrammatic drawings in which:

Fig. 1 is a side view of a crawler excavator;

Fig. 2 is a schematic of a hydraulic propulsion system for an excavator crawler without the small communication line referred to above; and

Fig. 3 is a schematic of a hydraulic propulsion system for an excavator crawler with the small communication line.

Fig. 1 illustrates an excavator crawler to which the present hydraulic propulsion is particularly well suited. Excavator 10 is provided with a movable boom 12, dipper 14 and bucket 16. The boom, dipper and bucket are controlled by linear hydraulic

motors 18, 20 and 22, respectively. Excavator crawler 10 is a self-propelled excavator being supported on two ground engaging tracks 24 (only one shown) which are used to drive and position the excavator at a work site.

The tracks are independently driven by rotary hydraulic motors 26 and 28 which are coupled through compensator valve assemblies 30, 32, 34 and 36 to directional control valves 38 and 40. Hydraulic fluid is pumped to the directional control valves 38 and 40 from sump 42 by hydraulic pump 44. The hydraulic pump is driven by an internal combustion engine mounted in the excavator. The operator in cab 46 can move or position the excavator by manipulating the directional control valves to propel the excavator forward or backward, or turning the excavator by operating hydraulic motors 26 and 28 in different directions and at different speeds.

It should be noted that although the invention is being described with regard to an excavator crawler propulsion system, the present invention could be utilized in a number of hydraulic applications wherein two independently controlled hydraulic motors drive a common load from a single source of pressurized hydraulic fluid.

Fig. 2 is the hydraulic schematic of the hydraulic propulsion system without the small balancing communication line between the downstream output of the compensator valve assemblies. Each compensator valve assembly is provided with a metering compensator spool 48, 50, 52 and 54, a shuttle spool 56, 58, 60 and 62, and a return flow check valve 64, 66, 68 and 70. For forwardly driving motor 26 hydraulic pump 44 pumps hydraulic fluid into hydraulic pumping line 72 to directional control valve 38. The directional control valve 38 directs the fluid to forward compensator valve assembly 30 and specifically to metering two-position compensator spool 48 having a restricted orifice position and a checked position. Spool 48 is spring biased into a closed position by spring 74 which is overcome by hydraulic pressure in sensing line 76 which pushes the valve into the open position. Hydraulic pressure from line 72 is also directed through hydraulic line 77 to shuttle spool 56 and into compensation communication line 78. Shuttle spool 56 is hydraulically balanced by the hydraulic pressure in line 78 and the pressure downstream of compensator spool 48 as transmitted through line 80. The hydraulic fluid in line 80 is used both for balancing spool 56 and for flowing through spool 56 to line 82 to balance spool 48 by adding to the biasing force of spring 74.

Hydraulic fluid passing through valve 48 into line 84 is directed to motor 26 driving one of the crawler tracks of the excavator. The exhausted hydraulic fluid then passes into line 86 where it is

directed to backward compensator valve assembly 32. As shuttle spool 58 is shifted into the closed position by the hydraulic pressure in compensator communication line 78, and spool 50 is closed by the biasing force of spring 88 and the hydraulic pressure in line 90 which is fluidically coupled to compensator communication line 78 by the closed position of spool 58, the exhausted fluid passes through check valve 66 and into exhaust hydraulic line 92 wherein it is directed into sump 42. Hydraulic fluid does not pass through check valve 64 of compensator valve assembly 30 because of the pressure drop across the restricted orifice of spool 48.

In Fig. 2, both motors are being driven in the same forward direction as determined by directional control valves 38 and 40. However, compensator valve assembly 30 has become dominant, either because it was triggered first by the operator or because of shorter hydraulic line connections when compared with compensator valve assembly 34. Compensator valve assembly 34 works in an identical manner to that of compensator valve assembly 30 except that because of the hydraulic pressure in compensation communication line 78 shuttle spool 60 tends to be biased into a closed position which in turn directs hydraulic pressure from line 78 through shuttle spool 60 and hydraulic line 94 to aid spring 96 in biasing compensator spool 52 closed.

It should be noted that the shuttle and compensating spools are two-position metering spools which are hydraulically balanced. As such, the spools are reciprocated between each of the two positions during operation and they do not normally maintain a fixed position. Therefore, in viewing Fig. 2, it should be noted that dominating compensating spool 48 in compensating valve assembly 30 is opened and transmits more hydraulic fluid because of its higher pressure, if it is the dominating valve assembly, and compensating spool 52, of compensating valve assembly 34 transmits less hydraulic fluid because of its lower hydraulic pressure when compared to dominating compensating valve assembly 30.

As with compensating valve assemblies 30 and 32, hydraulic fluid from pump 44 flows through pumping line 72 to directional control valve 40 where it is transmitted to compensating spool 52. Hydraulic fluid passes through the restricted orifice in compensating spool 52 and is directed to pump 28 from which it is exhausted to compensating valve assembly 36. As with compensating valve assembly 32, hydraulic fluid is prevented from passing through compensating spool 54 and instead passes through check valve 70 and back to sump 42. The balancing hydraulic lines for all of the compensating spools and shuttle spools of

compensating valve assemblies 32, 34 and 36 are identical to those explained with regards to compensating valve assembly 30 and function in the same manner.

If the excavator crawler is to be reversed, directional control valves 38 and 40 are moved to the left to direct pumping fluid to backward compensating valve assemblies 32 and 36. In this situation, the pumps exhaust hydraulic fluid through check valves 64 and 68, respectively. To pivot the machine, one hydraulic motor is operated in the forward direction and the other in a reverse direction. The excavator itself can be pivoted on the tracks which means that since the hydraulic motors are adjacent to the tracks, the hydraulic lines leading from the pump to the motors must pass through a hydraulic line swivel (not shown) which is well known in the art.

Fig. 3 illustrates the small communication hydraulic lines used for overcoming the problem arising in Fig. 2. Hydraulic lines 98 and 100 fluidically couple hydraulic line 84 to line 102, and line 86 to line 104, respectively. When the excavator crawler is moving forward, line 98 tends to equalize the hydraulic pressure between compensating valve assembly 30 and compensating valve assembly 34. As compensating valve assembly 30 tries to dominate valve assembly 34, hydraulic fluid pressure increases in line 84 increasing the pressure in line 98 and line 102 which in turn increases pressure in line 106 causing metering shuttle spool 60 to remain open for transmitting pressure through line 108 to help bias compensating spool 52 open, and better equalizing the hydraulic flow to both motors. During forward movement, exhaust lines 86 and 104 are joined by line 100, but this does not affect the operation of the system because the hydraulic pressure in compensating line 78 serves to maintain compensating valve assemblies 32 and 36 closed except for the normal exhaust flow through check valves 66 and 70.

In reversing the excavator crawler, communication line 100 would prevent either compensating valve assembly 32 or 36 from dominating one another. As with the forward operation, exhaust lines 84 and 102, even though coupled through line 98, would not affect operation of the compensating valve assemblies.

To prevent inexact operations, lines 98 and 100 must be quite small when compared to hydraulic lines 84, 86, 102 and 104 which are used to transfer hydraulic fluid to the motors. For example, lines 84, 86, 102 and 104 can be 0.75 inches in diameter and in accordance therewith communication lines 98 and 100 should be 0.25 inches in diameter. In addition, lines 98 and 100 should be provided with an orifice further restricting flow. This orifice should be 0.004 inches in diameter to reduce further the

cross flow between the pumping lines.

Compensating communication line 78 serves an additional function as indicated by arrow 110 and that is to provide a pressure sensing circuit with a hydraulic feedback to better control the operation of the hydraulic pump.

Claims

1. An hydraulic system comprising first and second hydraulic motors (26, 28), a pump (44) supplying pressurised hydraulic fluid to the motors (26, 28), a first compensating valve assembly (30) between one side of the first motor (26) and the pump (44), and a second compensating valve assembly (34) between the corresponding one side of the second motor (28) and the pump (44), characterised in that the connections (84, 86) between the first and second assemblies (30, 34) and motors (26, 28) are coupled by a first communication hydraulic line (98).

2. A system according to claim 1 in which the system includes a third compensating valve assembly (32) between the other side of the first motor (26) and the pump (44), and a fourth compensating valve assembly (36) between the corresponding other side of the second motor (28) and the pump (44) characterised in that the connections between the third and fourth assemblies (32, 36) and the motors (26, 28) are coupled by a second communication hydraulic line (100).

3. A system according to claim 1 or 2 in which the first, second, third and fourth compensating valve assemblies (30, 34, 32, 36) are provided respectively with first, second, third and fourth bypass hydraulic lines from the associated motors (26, 28) to the pump (44), each line having a check valve (64, 68, 66, 70) therein permitting flow only in the direction of the pump (44).

4. A system according to any preceding claim including first and second three-position control valves (38, 40) between the pump (44) and the first and third (30, 32), and second and fourth, compensating valve assemblies (34, 36).

5. A system according to any preceding claim in which the compensator valve assemblies (30, 32, 34, 36) are fluidically coupled to one another by a compensating hydraulic line (78).

6. A system according to claim 5 in which each compensator valve assembly (30, 32, 34, 36) has a metering two-position compensator spool (48, 50, 52, 54) and a metering two-position shuttle spool (56, 58, 60, 62).

7. A system according to any preceding claim characterised in that the diameter of the first, or first and second, communication hydraulic line or

lines (98, 100) is smaller than the diameter of the connections (84, 102) between the first and second assemblies (30, 34) and motors (26, 28).

8. A system according to claim 7 characterised in that the diameter of the said line or lines (98, 100) is substantially one third of that of the said connections (84, 102).

9. A propulsion unit for an industrial machine characterised in that the unit includes a system according to any preceding claim, the hydraulic motors (26, 28) being drivingly connected to ground-engaging means for moving the machine.

10. A propulsion unit according to claim 9 in which the means for moving the machine are tracks (24).

11. An industrial machine characterised in that it has a propulsion unit according to claim 9 or 10.

12. An industrial machine according to claim 11 in which the machine is an excavator (10).

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Fig. 1

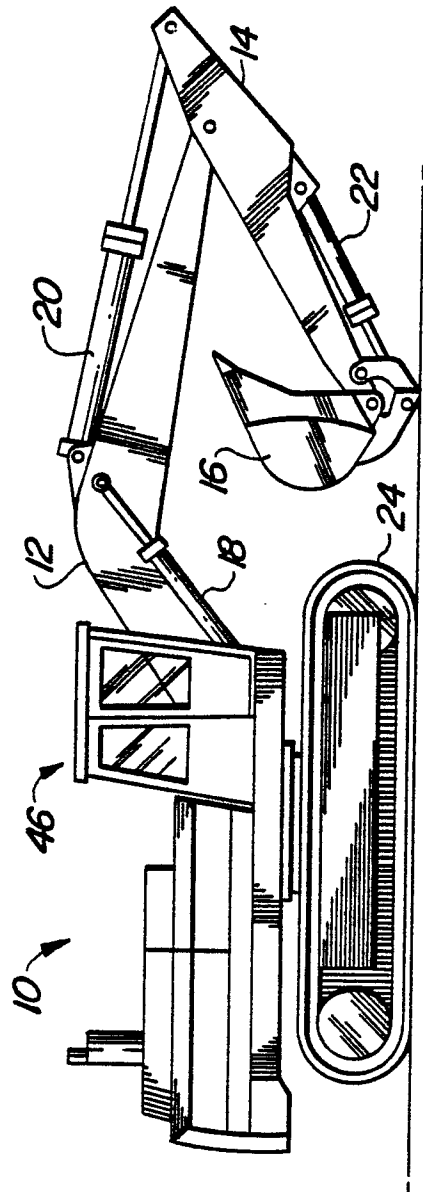
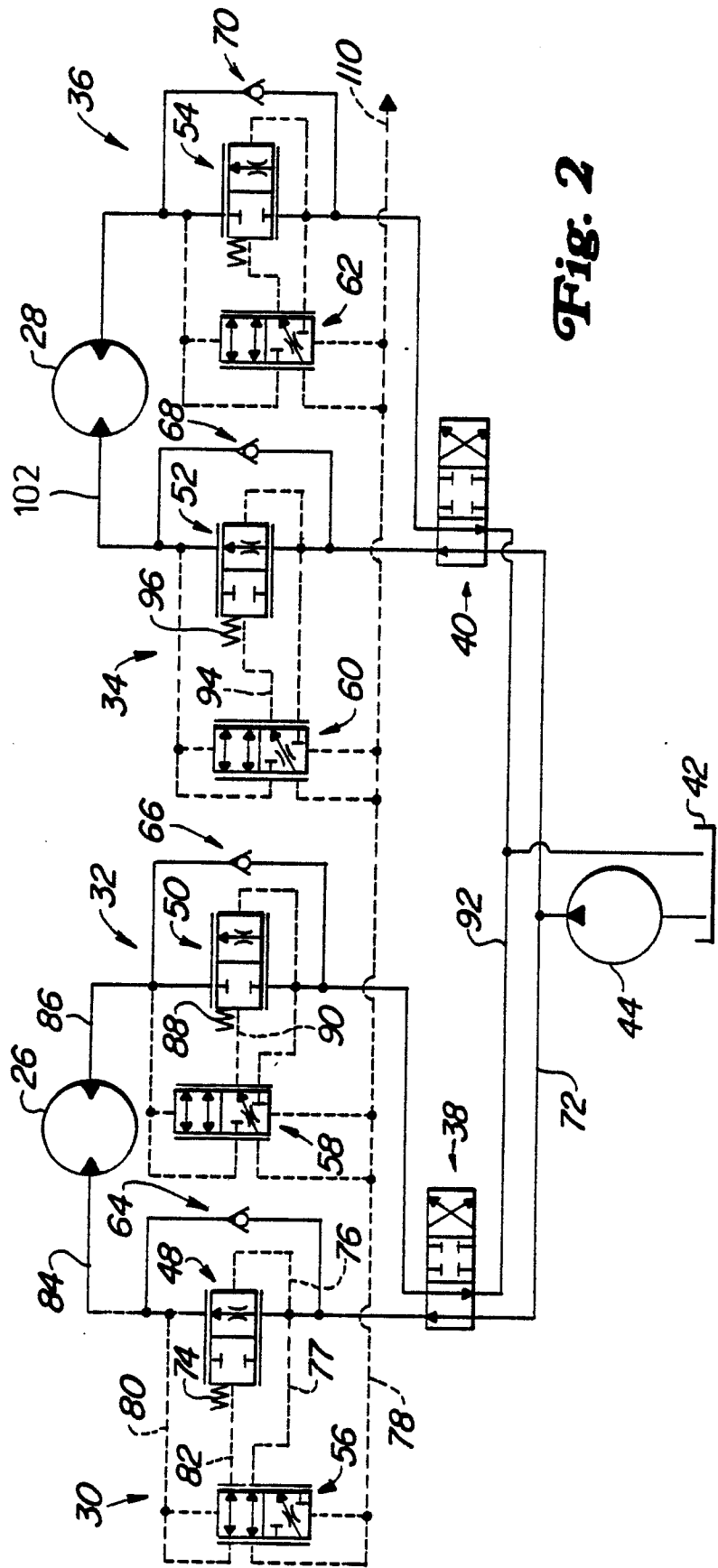


Fig. 2



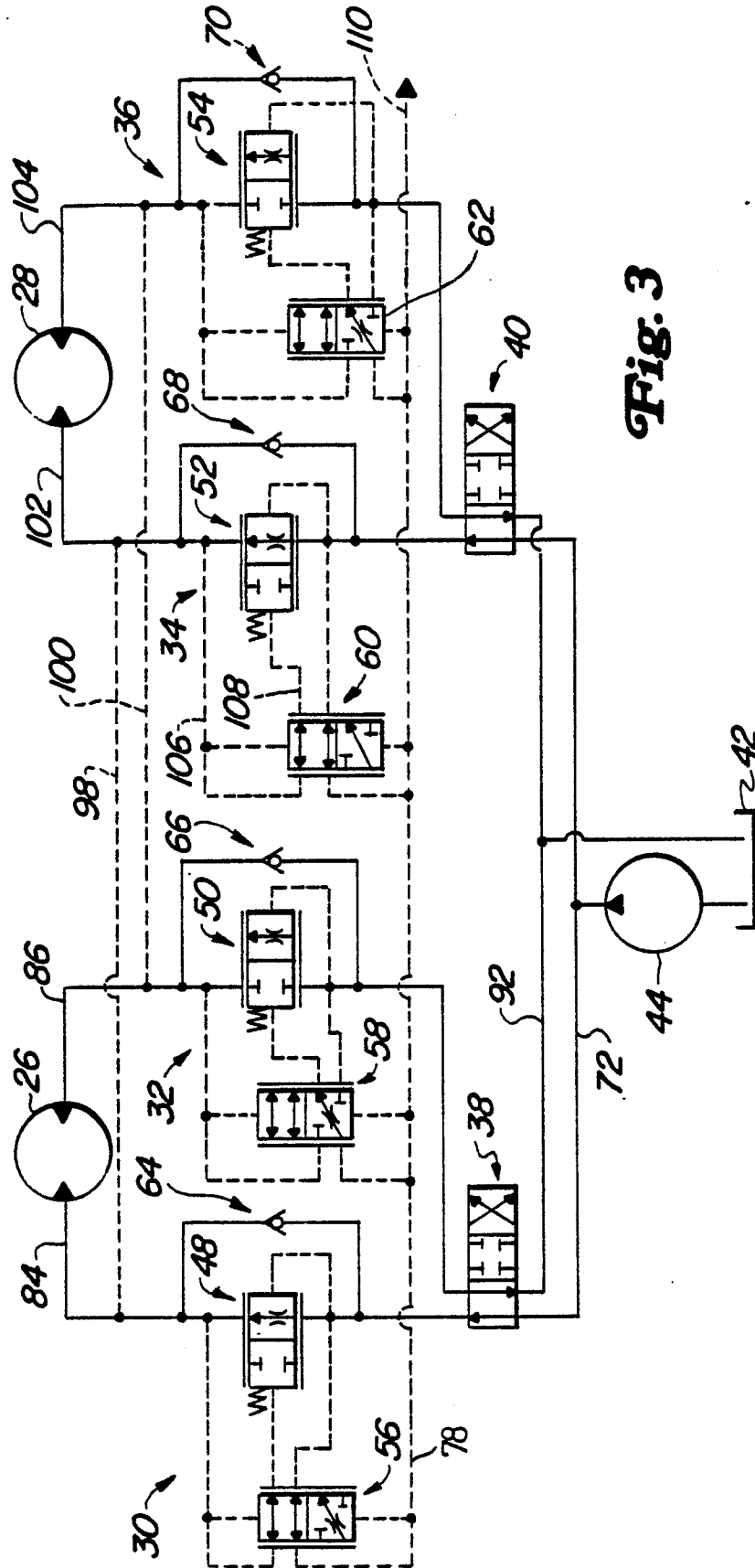


Fig. 3



DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	GB-A-1 131 750 (LINDE AG) * Page 1, lines 9-80; figure * ---	1,9-12	E 02 F 3/32 E 02 F 9/22
X	GB-A-1 035 141 (PRIESTMAN BROTHERS LTD) * Page 3, lines 4-50; figure * ---	1,3,9, 11,12	F 15 B 11/22 F 15 B 11/16 F 15 B 13/02
X	MACHINE DESIGN, vol. 40, no. 13, 6th June 1968, pages 166-170, Columbus, Ohio, US; W. MEISEL: "Hydraulic actuators" * Figure 4 * ---	1,3,5,6	
A	US-A-3 960 284 (CARPENTER) * Abstract; figures 3,4 * ---	1,9-12	
A	DE-A-2 336 157 (KUBOTA) * Figures 1,2 * ---	1,9-12	
A	GB-A-1 044 851 (AUXITRA) * Figures 1,2 * ---	1,9-12	
A	US-A-2 912 131 (B. JUNG et al.) * Column 1, lines 51-70 * ---	1,9-12	
A	DE-A-3 525 823 (W. AENGENEYNDT et al.) * Figure 2 * -----	1	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 31-03-1988	Examiner ANGIUS P.
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	