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(54) Title: LOAD SENSE HYDRAULIC PUMP ALIGNMENT

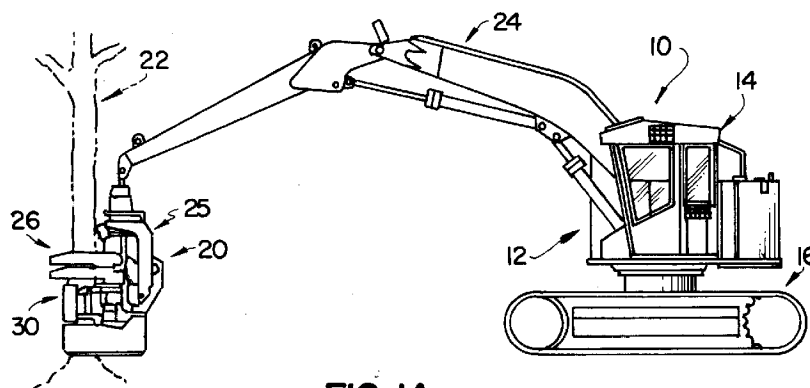


FIG. 1A

(57) Abstract: A tree harvester is disclosed that includes first and second hydraulic pumps for powering a harvesting head of the tree harvester.

LOAD SENSE HYDRAULIC PUMP ALIGNMENT

5

FIELD OF THE INVENTION

The present disclosure relates to forestry equipment. More particularly, the present disclosure relates to a system for managing pumps used to power hydraulic units on forestry equipment.

BACKGROUND OF THE INVENTION

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Forestry equipment is used to fell trees during harvesting. One type of forestry equipment is a tracked harvester that includes a harvesting head the grasps a tree to be felled, downs the tree with a chain saw, and cuts the felled tree trunks to length with the chain saw. The hydraulic components of the harvesting head are powered by one or more hydraulic pumps.

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SUMMARY

According to one embodiment of the present invention, a tree harvester is provided that includes a chassis; at least one ground engaging mechanism configured to propel the chassis over the ground; a harvesting head including a saw configured to cut trees; a plurality of hydraulic units including a hydraulic motor to power the saw; and a hydraulic control system. The hydraulic control system includes a first hydraulic pump providing pressurized hydraulic fluid; a plurality of valves controlling the supply of hydraulic fluids from the first hydraulic pump to the plurality of hydraulic units; a load sense system that detects the load pressure requirements of the plurality of hydraulic units and provides instruction to the first hydraulic pump to produce pressure sufficient to satisfy the requirements of a highest of the load pressure requirements of the plurality of hydraulic units; and a second hydraulic pump providing hydraulic fluid to the harvesting head, the hydraulic motor providing a load sense signal to the load sense system to control operation of the first hydraulic pump

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and a load sense signal to the second hydraulic pump to control operation of the second hydraulic pump.

According to another aspect of the present invention, a method of harvesting trees including the steps of providing a tree harvester including a chassis, traction
5 devices configured to propel the chassis, a plurality of hydraulic units, a harvester head having a saw and hydraulic motor configured to power the saw, and a hydraulic system configured to operate the plurality of hydraulic units and the hydraulic motor; sensing the maximum load pressure required of the plurality of hydraulic units and the
10 harvester head; controlling a first hydraulic pump based on the sensed maximum load pressure; sensing the load pressure required by the harvester head; controlling a second hydraulic pump based on the sensed load pressure required by the harvester head; combining the output of the first and second hydraulic pumps to power the
harvester head; and harvesting a tree using the saw.

15 BRIEF DESCRIPTION OF THE DRAWINGS

The above-mentioned and other features and advantages of this disclosure, and the manner of attaining them, will become more apparent and the disclosure itself will be better understood by reference to the following description of embodiments of the invention taken in conjunction with the accompanying drawings, wherein:

20 Figure 1A is an elevational view of a tracked tree harvester showing the harvester including a chassis, a pair of tracks propelling the chassis, a boom, and a harvesting head supported by the boom,

Figure 1B is an enlarged, front elevational view of the harvesting head of Figure 1A;

25 Figure 2 is a schematic diagram illustrating an hydraulic system of the tracked harvester of Fig. 1,

Figure 3 is a schematic diagram illustrating an alternative embodiment hydraulic system for use with the tracked harvester of Fig. 1,

Figure 4 is a schematic diagram illustrating another alternative embodiment hydraulic system for use with the tracked harvester of Fig. 1, and

Figure 5 is a schematic diagram illustrating another alternative embodiment hydraulic system for use with the tracked harvester of Fig. 1.

5 Corresponding reference characters indicate corresponding parts throughout the several views. The exemplifications set out herein illustrate exemplary embodiments of the invention and such exemplifications are not to be construed as limiting the scope of the invention in any manner.

10 DETAILED DESCRIPTION

Referring to Fig. 1, a tracked tree harvester 10 of the present embodiment illustratively includes a chassis 12 having a cab portion 14, a plurality of tracks 16 for supporting chassis 12 above the ground, an engine 18 for powering tracks 16 to propel chassis 12, and a harvesting head 20 for harvesting trees. Tracked harvester 10 also
15 includes a linkage assembly or boom 24 that allows harvesting head 20 to be raised, lowered, and tilted to position harvesting head 20 at a desired position relative to a tree 22 to be felled. Although a tracked harvester is shown and described herein using tracks 16 as propulsion devices, harvesting head 20 may be provided on other types of tree harvesters, such as wheeled tree harvesters that use tracks as propulsion devices.
20 Additional details of harvesters are provided in U.S. Patent No. 4,412,569 and U.S. Patent Publication No. 2008/0289724, the entire disclosures of which are expressly incorporated by reference herein.

As shown in Figs. 1A and 1B, harvesting head 20 includes a support frame 25 supported by boom 24, arms 26, and chain saw 28 powered by a hydraulic motor 32. Arms 26 grasp tree 22 while saw blade 28 cuts through tree 22. Harvesting head 20
25 further includes advancing wheels 30 that move cut tree 22 relative to head 20 to position chain saw 28 at locations to cut tree 22 into segments. Once tree 22 is segmented, arms 26 open to release the remaining portion of tree 22 still held by head 20. Chain saw 28 and wheels 30 are powered by hydraulic motors, such as motor 32,

and arms 26 are powered by hydraulic cylinders (not shown). Additional details of suitable harvesting heads are provided in U.S. Patent Nos. 4,881,582; 6,516,841; 6,691,751; 6,962,178; and 7,296,602, the entire disclosures of which are expressly incorporated by reference herein.

5 The hydraulic motors, such as motor 32, and hydraulic cylinders of harvesting head 20 and the other hydraulic units 56 of tracked harvester 10 are powered by a first hydraulic pump 50 as part of a hydraulic system 52. Harvesting head 20 is also powered by a second hydraulic pump 54 as part of hydraulic system 52. Hydraulic system 52 coordinates the supply of hydraulic fluid to harvesting head from first
10 pump 50 and second pump 54 based on the load pressure requirements of harvesting head 20. All of the hydraulic fluid of second hydraulic pump 54 is provided to harvesting head 20. Whereas, the hydraulic fluid of first hydraulic pump 50 is split between harvesting head 20 and the other hydraulic components of tracked harvester 10.

15 Hydraulic system 52 is a load sense system that detects the highest pressure required by hydraulic system 52 and controls pump 50 to provide an output pressure sufficient to satisfy this highest required pressure. Hydraulic system 52 receives the load pressure requirement of each of a series of hydraulic units 56, such as a hydraulic cylinder used to power linkage assembly 24, and passes the highest pressure through
20 main load sense line 57 to a pump control 58 for first pump 50. In response, pump 50 provides hydraulic fluid at a pressure sufficient to satisfy the highest pressure required. Similarly, hydraulic system 52 includes a pump control 60 for second pump 54 that controls the operation of second pump 54. Pump control 60 reacts to the load requirements of harvesting head 20 to provide hydraulic fluid to harvesting head 20
25 based on the needs of harvesting head 20.

 Hydraulic system 52 further includes a series or stack of valve assemblies 61 that control the supply of hydraulic fluid to the respective hydraulic units 56. Each valve assembly 60 includes a selection valve 62 that controls the flow of fluid to a hydraulic unit 56 and a pressure compensator 64 to compensate for the high pressure
30 output of pump 50 resulting from the input of load sense system 53. When a particular hydraulic unit 56 does not require the highest pressure provided by first

pump 50, pressure compensator 62 reduces the supply pressure to the particular hydraulic unit 56. Additional details of a suitable load sense system are provided in U.S. Patent No. 7,415,822, titled "Load Sense Boost Device," filed July 21, 2005, to Harber et al. Although hydraulic units 56 are shown as hydraulic cylinders in Fig. 2, 5 hydraulic units 56 may be other hydraulic units, such as hydraulic motors to drive tracks 16, and other hydraulically powered devices.

As shown in Fig. 2, one of the valve assemblies, valve assembly 61a, controls the flow of hydraulic fluid from first pump 50 to harvesting head 20. Hydraulic system 52 also includes a saw on/off valve 65 that controls the flow of fluid through 10 harvesting head 20 to start and stop chain saw 28 rotating for example. On/off valve 65 controls exhausting of hydraulic fluid from harvesting head 20 and the supply of hydraulic fluid from second pump 54. On/off valve 65 is a solenoid valve that receives an electronic signal to open when an operator decides to activate chain saw 28 by moving switch 67 to an on position. When open, valve 65 allows hydraulic 15 fluid to exhaust from harvesting head 20 to tank 66. When closed, valve 65 blocks hydraulic fluid from exhausting to tank 66. As a result, no fluid flows through harvesting head 20 to rotate the blade of chain saw 28. Therefore, valve assembly 61a and on/off valve 65 cooperate to control harvesting head 20. Harvesting head 20 preferably includes one or more valves (not shown) that controls the operation of the 20 hydraulic features, such as retraction and extension of arms 26, rotate of the chair bar of chain saw 28, and the other hydraulic features of head 20. According to an alternative embodiment of the present disclosure, the features of valve assembly 61a and on/off valve 65 may combined in a single valve or other device or otherwise divided among multiple valves or other devices.

25 The demand of harvesting head 20 is communicated to pump control 58 for first pump 50 and pump control 60 for second pump 54. As shown in Fig. 2, a pressure sensor 68 is provided on harvesting head 20 to detect the load sense pressure of harvesting head 20. This load sense pressure is then used to control the output of pumps 50, 54 to power harvesting head 20 and power rotation of the chain of chain 30 saw 28 and the other hydraulic features of harvesting head 20.

As shown in Fig. 2, pressure sensor 68 is coupled to a proportional relief valve 70 that controls exhausting of fluid from hydraulic line network 72 to control the output of pumps 50, 54. Network 72 includes a primary line 74. Primary line 74 is coupled to saw valve assembly 61a at valve port 76 that continuously provides hydraulic fluid to primary line 74 whether or not instructions are provided to power harvesting head 20 and chain saw 28. When pressure sensor 68 detects no load or demand from harvesting head 20, it sends a low electrical current signal to proportional relief valve 70. In response, proportional relief valve 70 allows the hydraulic fluid provided to primary line 74 by valve assembly 61a to exhaust to tank 66. As a result, little or no pressure builds up in primary line 74.

When pressure sensor 68 detects some load or demand from harvesting head 20, it provides a higher electrical current to proportional relief valve 70. In response, proportional relief valve 70 restricts the flow of hydraulic fluid provided to primary line 74 by valve assembly 61a from exhausting to tank 66. As a result, pressure builds in primary line 74. As pressure sensor 68 detects a greater load or demand from harvesting head 20, proportional relief valve 70 further restricts the flow of hydraulic fluid to tank 66 and the pressure builds further. As pressure builds in primary line 74, pressure also builds at valve port 76 of valve assembly 61a. This pressure is fed into load sense system 53 of hydraulic system 52. If the load pressure of harvesting head 20 exceeds the load pressure of the other hydraulic units 56, this pressure is passed onto pump control 58 to control the output pressure of pump 50 at a level sufficient to satisfy the demand of harvesting head 20.

On occasion, pump 50 may require more power from engine 18 than engine 18 can provide in a satisfactory manner, which will cause engine 18 to stall. To avoid engine stall when harvesting head 20 is demanding more pressure than engine 18, through pump 50, can provide, network 72 includes a power feedback line 79 that provide direct feedback to pump control 58 that limits the torque requirements of pump 50 to avoid engine stall.

Network 72 further includes secondary line 78 coupled to output line 80 from second pump 54. Second pump 54 continuously provides hydraulic fluid at a load sense pressure to output line 80 whether or not instructions are provided to power

harvesting head 20 and chain saw 28. Secondary line 78 includes first branch 82 that extends to proportional relief valve 70 and includes a check valve 84 blocking back flow of fluid from primary line 74. Secondary line 78 further includes a second branch 86 that extends to pump control 60 for second pump 54. As stated above, 5 when pressure sensor 68 detects no load or demand from harvesting head 20, it sends a low electrical current signal to proportional relief valve 70. In response, proportional relief valve 70 allows the hydraulic fluid in first branch 82 of secondary line 78 to exhaust to tank 66. As a result, little or no pressure builds up in second branch 86 of secondary line 78 and little or no pressure is provided to pump control 10 60 so that pump 54 does not increase its output pressure above the load sense pressure mentioned above.

When pressure sensor 68 detects some load or demand from harvesting head 20, it provides a higher electrical current to proportional relief valve 70. In response, proportional relief valve 70 restricts the flow of hydraulic fluid from first branch 82 of 15 secondary line 78 to tank 66. As a result, pressure builds in secondary line 78, including first and second branches 82, 86. As pressure sensor 68 detects a greater load or demand from harvesting head 20, proportional relief valve 70 further restricts the flow of hydraulic fluid to tank 66 from secondary line 78 and the pressure builds further. As pressure builds in second branch 86 of secondary line 78, pressure also 20 builds at pump control 60 so that pump 54 increases its output pressure.

As pump 54 increases its output pressure, secondary line 78 communicates this pressure to pump control 60 through second branch 82 resulting in even greater pressure output from pump 54. Eventually, pump 54 either reaches its maximum output pressure or proportional relief valve 70 bleeds sufficiency pressure from 25 secondary line 78 to maintain the output of pump 54 at the desired pressure as determined by the output of pressure sensor 68.

To avoid rapid fluctuations in inputs to pump control 60, an orifice or flow restriction 88 is placed in secondary line 78. During initial ramp up of the output pressure of pump 54, orifice 88 provides a pressure drop to dampen the influence of 30 the change in output pressure from pump 54.

According to an alternative embodiment of the present disclosure shown in Fig. 3, proportional relief valve 70 for controlling pump 50 is replaced by a piloted sequence valve 90 and pressure sensor 68 for controlling pump 50 is replaced with a hydraulic line 92 extending from harvesting head 20 to piloted sequence valve 90.

- 5 Primary line 74 provides continuous load sense pressure to piloted sequence valve 90 and load pressure from harvesting head 20 controls exhausting of this pressure to tank 66. As load pressure from harvesting head 20 increases, less pressure is exhausted to tank 66, which causes pressure in primary line 74 to increase. As discussed above, this pressure is fed into load sense system 53 of and potentially back to pump control
- 10 58 of pump 50 if the load pressure of harvesting head 20 is greater than the other load inputs to the load sense system. A similar piloted sequence valve arrangement can be provided to control the input to pump control 60 of pump 54 when pressure sensor 68 is not provided.

- As shown in Fig. 4, according to another alternative embodiment, proportional
- 15 relief valve 70 is provided to control second pump 54 as described above with the exception that a programmable logic controller (PLC) 94 is positioned between load sense pressure sensor 68 and proportional relief valve 70. Preferably, the output from PLC 94 to proportional relief valve 70 is proportional to the input to PLC 94 from pressure sensor 68. As shown in Fig. 4, PLC 94 also provides input to pressure relief
- 20 valve 96 to controls exhausting of load sense pressure from valve assembly 61a to tank 66. Thus, rather than one proportional relief valve 70 controlling the input to pump 50, 54, two pressure relief valves 70, 96 are used to control the respective pumps 54, 50. With this configuration, pumps 54, 50 can be controlled independently through the logic of PLC 94. Power feedback line 79 provides feedback to pump
- 25 control 58 that limits the torque requirements of pump 50 to avoid engine stall. An alternative power feedback line 79' may also be provided.

- Another alternative embodiment control arrangement is provided in Fig. 5. Compared to the embodiment of Fig. 4, valve assembly 61a is directly controlled with an electronic signal from PLC 94 and a supply pressure sensor 98 is provided. The
- 30 output from PLC 94 to proportional relief valve 70 remains proportional to the load sense output from pressure sensor 68. The output from PLC 94 is proportional to the

supply pressure provided by pressure sensor 98 less the load sense pressure provided by pressure sensor 68.

- While this invention has been described as having preferred designs, the present invention can be further modified within the spirit and scope of this
- 5 disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the disclosure using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains and which fall within the limits of the appended claims.

CLAIMS

1. A tree harvester including:
 - a chassis;
 - at least one ground engaging mechanism configured to propel the chassis over
 - 5 the ground;
 - a harvesting head including a saw configured to cut trees;
 - a plurality of hydraulic units including a hydraulic motor to power the saw;
 - and
 - a hydraulic control system including
 - 10 a first hydraulic pump providing pressurized hydraulic fluid;
 - a plurality of valves controlling the supply of hydraulic fluids from the
 - first hydraulic pump to the plurality of hydraulic units;
 - a load sense system that detects the load pressure requirements of the
 - plurality of hydraulic units and provides instruction to the first hydraulic pump to
 - 15 produce pressure sufficient to satisfy the requirements of a highest of the load
 - pressure requirements of the plurality of hydraulic units; and
 - a second hydraulic pump providing hydraulic fluid to the harvesting
 - head, the hydraulic motor providing a load sense signal to the load sense system to
 - control operation of the first hydraulic pump and a load sense signal to the second
 - 20 hydraulic pump to control operation of the second hydraulic pump.
2. The tree harvester of claim 1, wherein the hydraulic control system includes a relief valve exhausting pressurized fluid from a first of the plurality of valves in proportion to the load sense signal from the harvester head.
3. The tree harvester of claim 2, wherein the first valve continuously provides
- 25 pressurized fluid to the relief valve independent of the load sense signal from the harvester head.
4. The tree harvester of claim 3, wherein the exhausting of the pressurized fluid by the relief valve decreases as the load sense signal from the harvester head increases.
- 30 5. The tree harvester of claim 1, wherein the hydraulic control system includes a relief valve exhausting pressurized fluid from the second hydraulic pump in proportion to the load sense signal from the harvester head.

6. The tree harvester of claim 5, wherein the relief valve exhausts pressurized fluid from at least one of the plurality of valves in proportion to the load sense signal from the harvester head.
7. The tree harvester of claim 5, wherein the hydraulic control system further includes a pump control controlling operation of the second hydraulic pump and the second hydraulic pump provides pressurized fluid to the pump control.
8. The tree harvester of claim 7, wherein the hydraulic control system further includes a flow restriction positioned between the second hydraulic pump and the pump control to dampen fluctuations in the pressure of the pressurized fluid provided by the second hydraulic pump to the pump control.
9. The tree harvester of claim 5, wherein the hydraulic control system further includes a check valve blocking the flow of fluid from the relief valve toward the second hydraulic pump.
10. The tree harvester of claim 1, wherein the operation of the second hydraulic pump is independent of the load sense system.
11. A method of harvesting trees including the steps of:
providing a tree harvester including a chassis, traction devices configured to propel the chassis, a plurality of hydraulic units, a harvester head having a saw and hydraulic motor configured to power the saw, and a hydraulic system configured to operate the plurality of hydraulic units and the hydraulic motor;
sensing the maximum load pressure required of the plurality of hydraulic units and the harvester head;
controlling a first hydraulic pump based on the sensed maximum load pressure;
sensing the load pressure required by the harvester head;
controlling a second hydraulic pump based on the sensed load pressure required by the harvester head;
combining the output of the first and second hydraulic pumps to power the harvester head; and
harvesting a tree using the saw.
12. The method of claim 11, wherein the hydraulic system further includes a plurality of valves controlling the supply of hydraulic fluids from the first hydraulic pump to the plurality of hydraulic units, further comprising the step of exhausting

pressurized fluid from a first of the plurality of valves based on the sensed load pressure required by the harvesting head.

13. The method of claim 12, wherein the exhausting decreases as the sensed load pressure required by the harvesting head increases.

5 14. The method of claim 11, wherein the step of controlling the first hydraulic pump includes restricting the flow of fluid from a valve that controls the first hydraulic pump in response to the harvesting head requesting increased pressure from the first hydraulic pump.

10 15. The method of claim 11, wherein the step of controlling the second hydraulic pump includes restricting the flow of fluid from the second hydraulic pump to a tank in response to the harvesting head requesting increased pressure from the second hydraulic pump.

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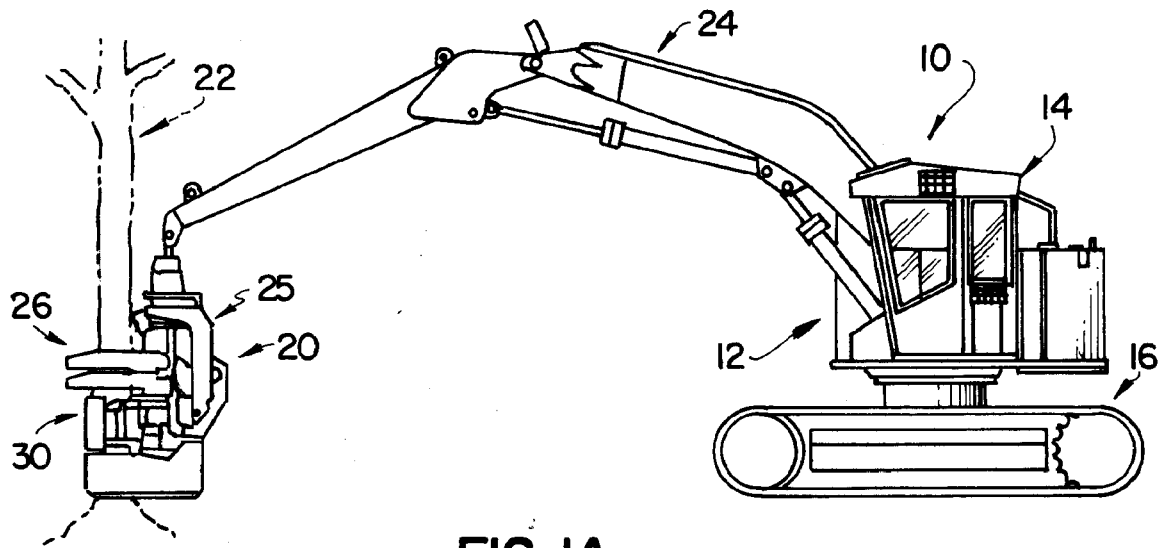


FIG. 1A

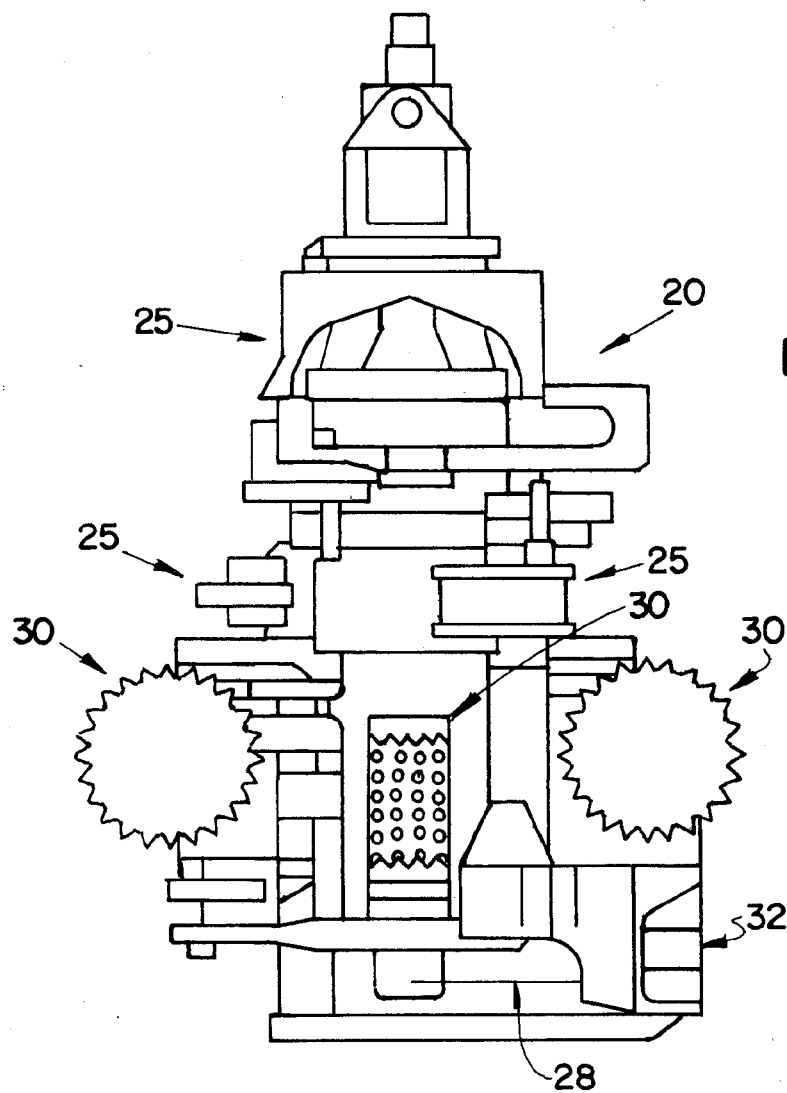


FIG. 1B

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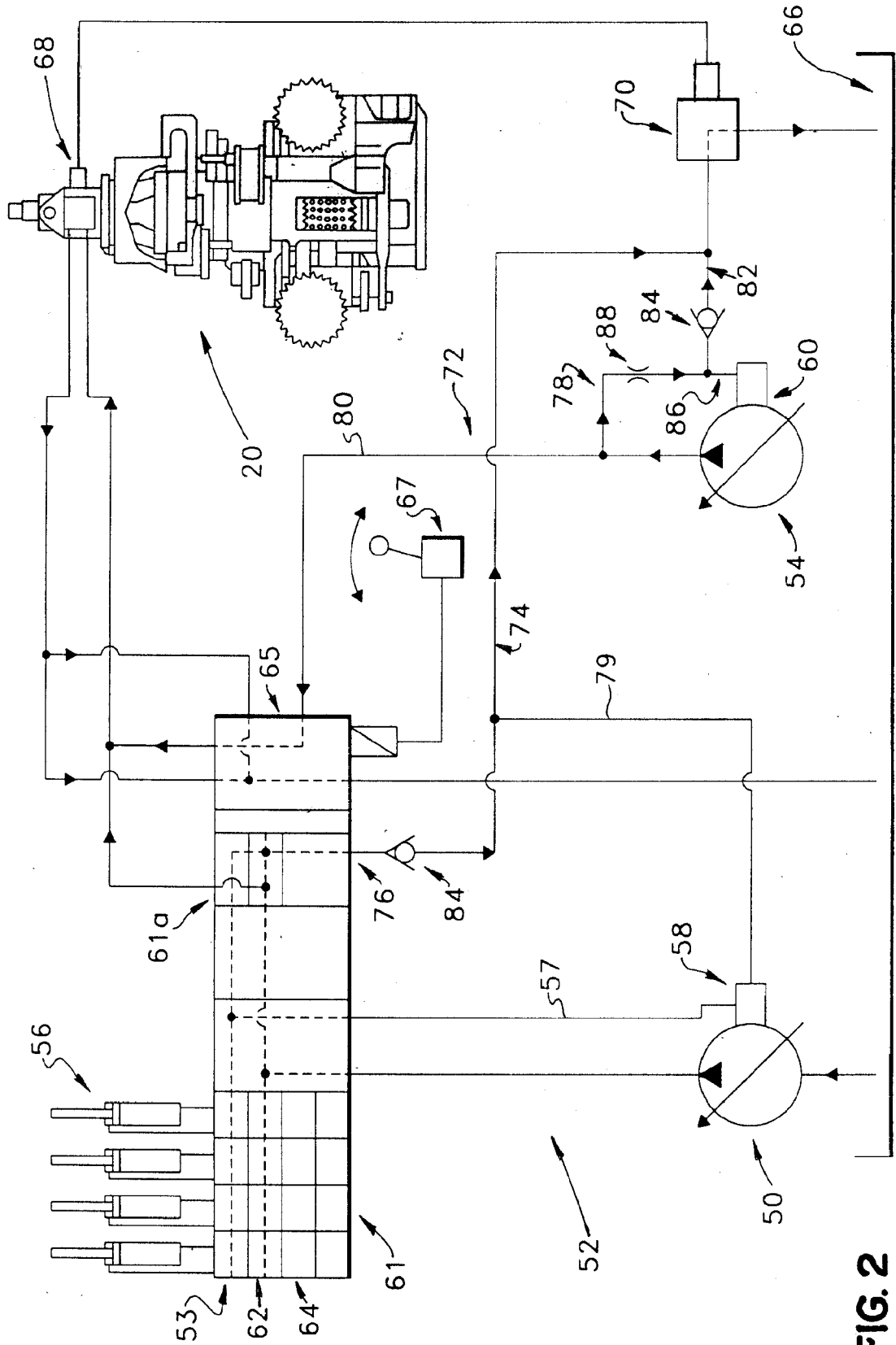


FIG. 2

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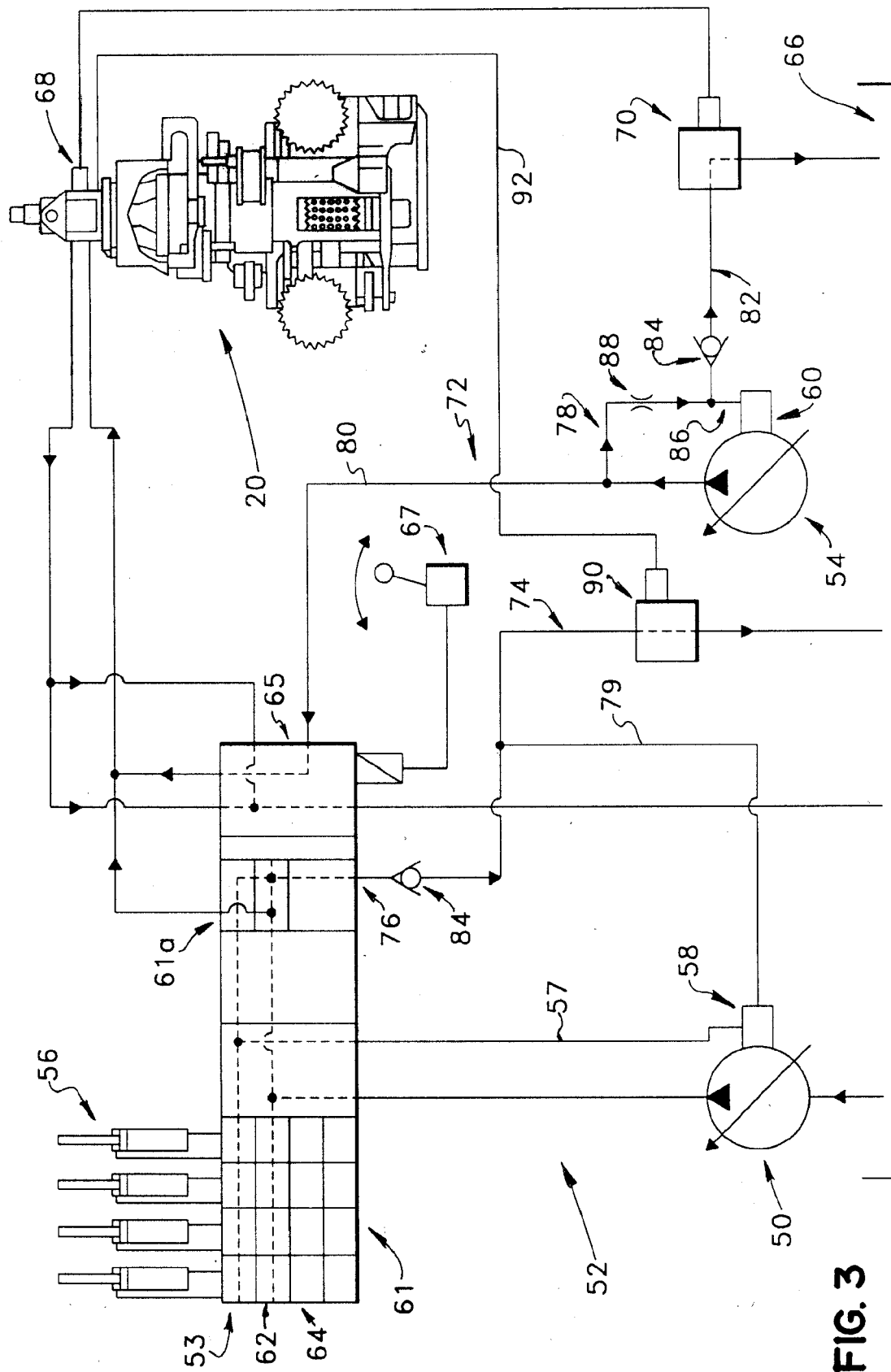


FIG. 3

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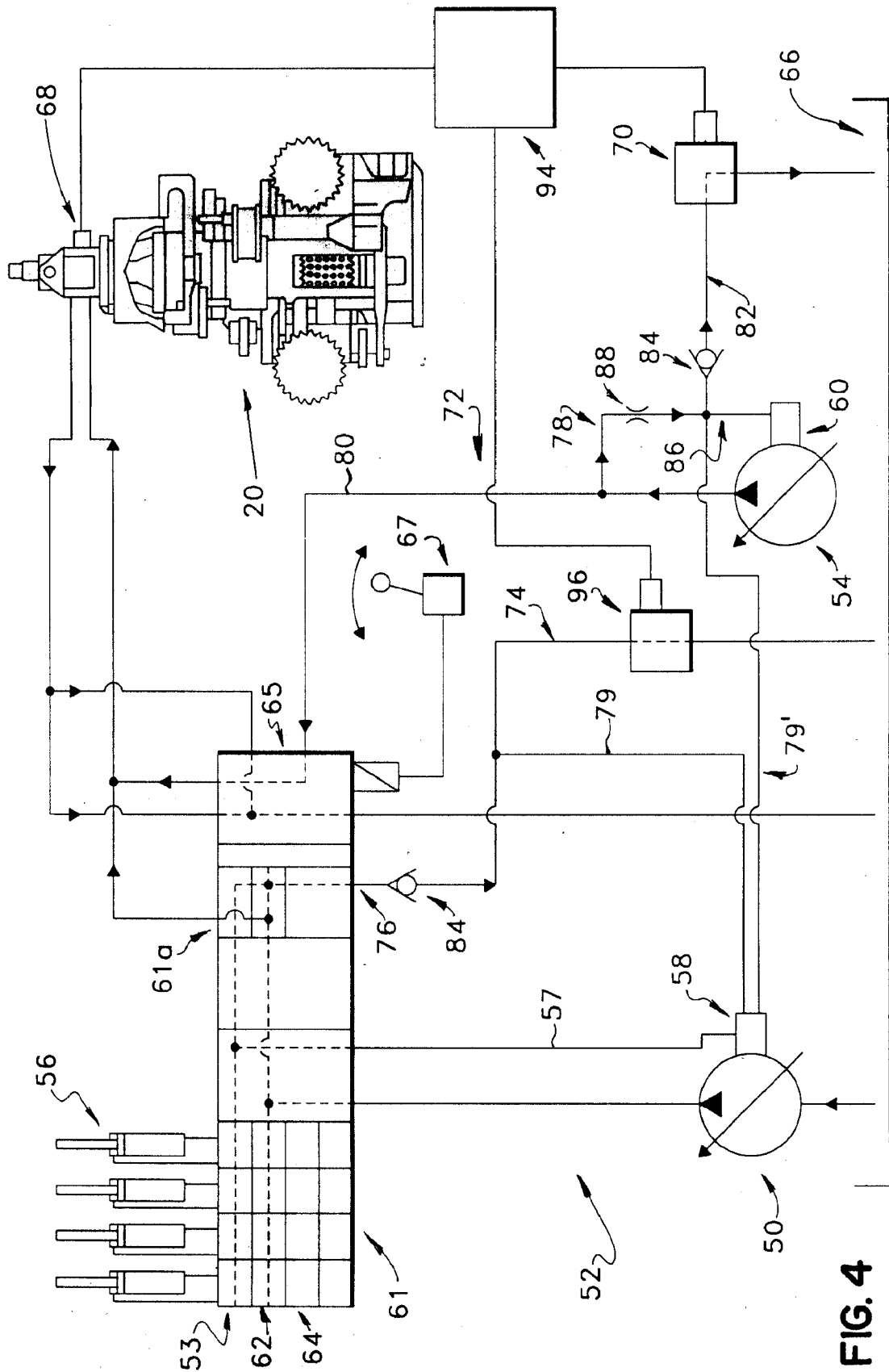


FIG. 4

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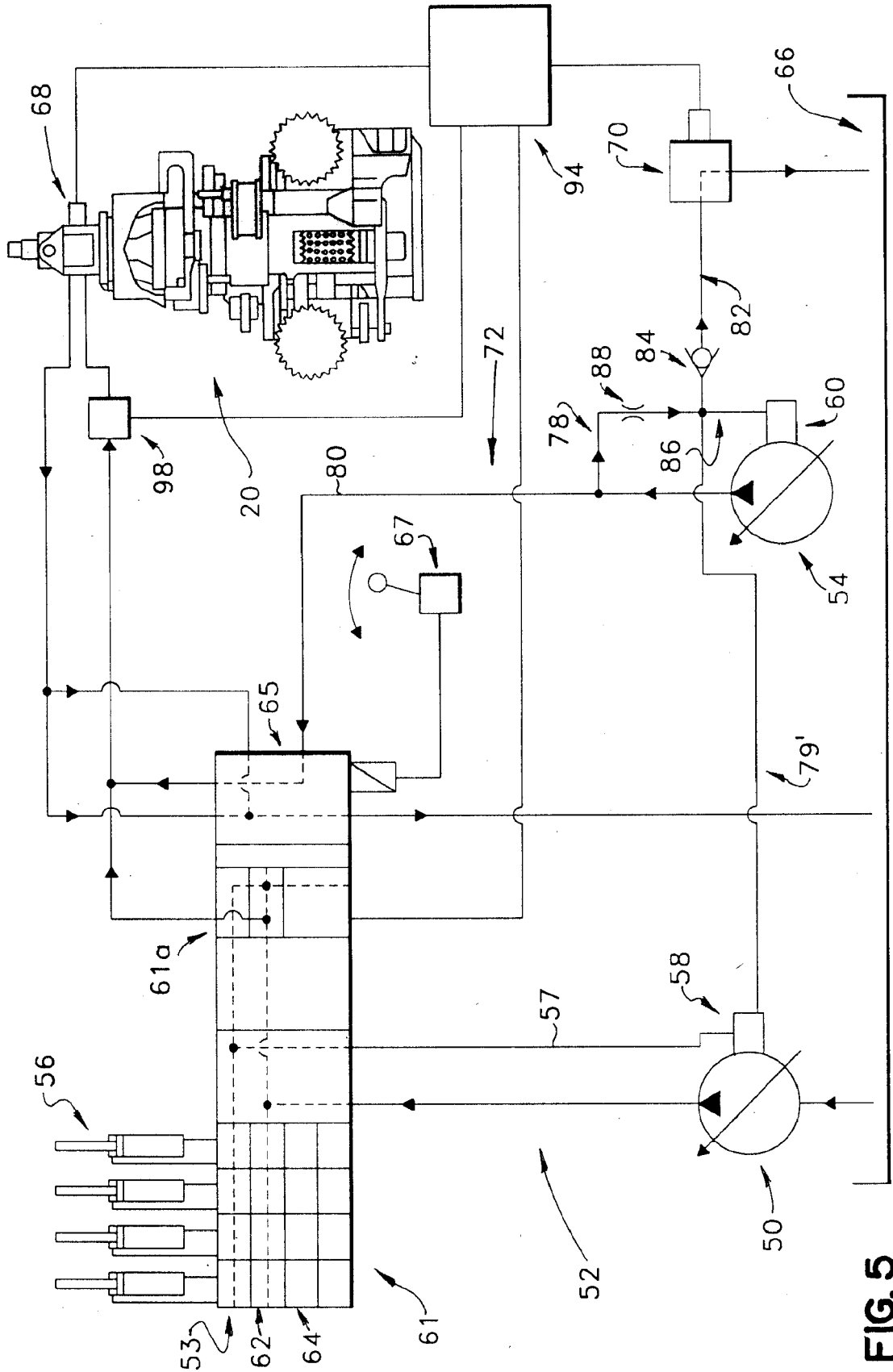


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2009/060346

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - A01G 23/08 (2009.01)

USPC - 144/34.1

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) - A01G 23/08; F15B 11/20 (2009.01)

USPC - 144/34.1,336; 60/368,420,421,422; 91/6,28,29,517; 417/216,287

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

USPTO EAST System (US, USPG-PUB, EPO, DERWENT)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,811,561 A (EDWARDS et al) 14 March 1989 (14.03.1989) entire document	1-15
Y	US 4,039,010 A (TUCEK) 02 August 1977 (02.08.1977) entire document	1-15
Y	US 4,029,439 A (ADAMS) 14 June 1977 (14.06.1977) entire document	10

☐ Further documents are listed in the continuation of Box C.

* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search

29 November 2009

Date of mailing of the international search report

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