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Ikeda

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[54] HYDRAULIC CIRCUIT OF HYDRAULICALLY DRIVEN VEHICLE

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

[58] **Field of Search**.....60/DIG. 5, 53 R; 92/1

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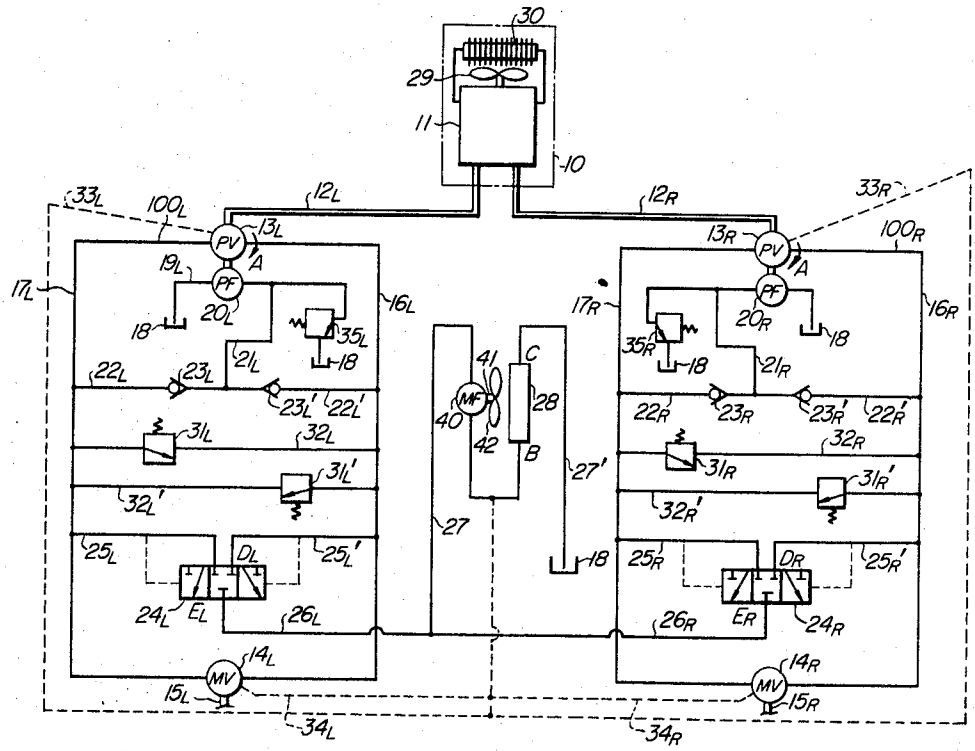
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[57] **ABSTRACT**

A hydraulic pump driven by an engine and a hydraulic motor to drive running wheels are connected with each other by a conduit to form a closed circuit for the circulation of hydraulic oil therethrough, and the hydraulic oil is supplied into said closed circuit from an oil tank through a hydraulic oil supply circuit including a booster pump and excess oil in said closed circuit is discharged through a hydraulic oil discharge circuit. An auxiliary hydraulic motor having a fan on the drive shaft thereof is provided at one point of either the hydraulic oil supply circuit or the hydraulic oil discharge circuit, so as to be driven by the hydraulic oil passing therethrough. Further, a hydraulic oil cooling radiator is provided in the hydraulic oil discharge circuit in opposed relation to said fan to be cooled by the latter. Therefore, the position of the hydraulic oil cooling radiator can be freely selected and a sufficient cooling capacity can be obtained.

12 Claims, 3 Drawing Figures

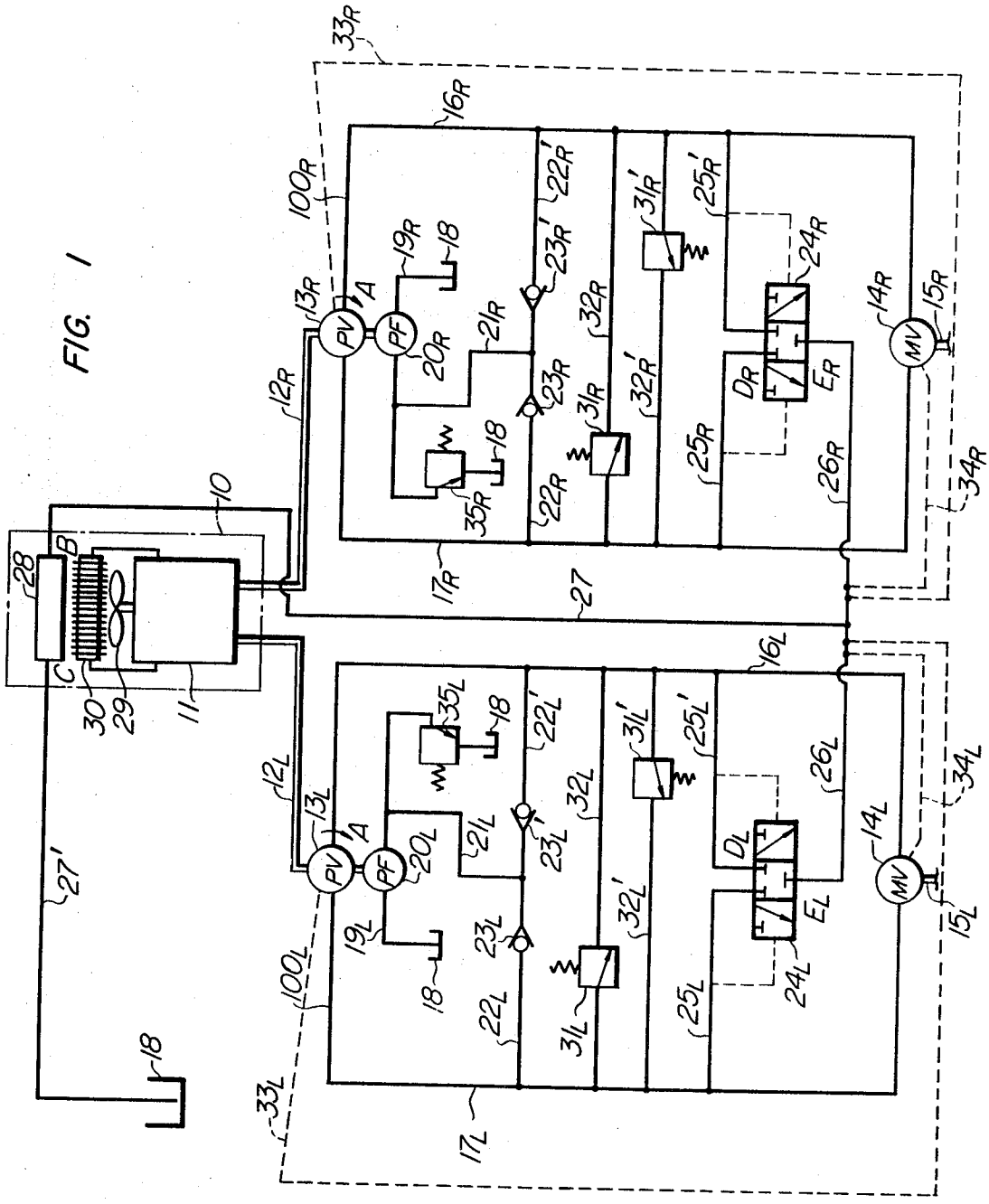


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SHEET 1 OF 3

FIG. 1



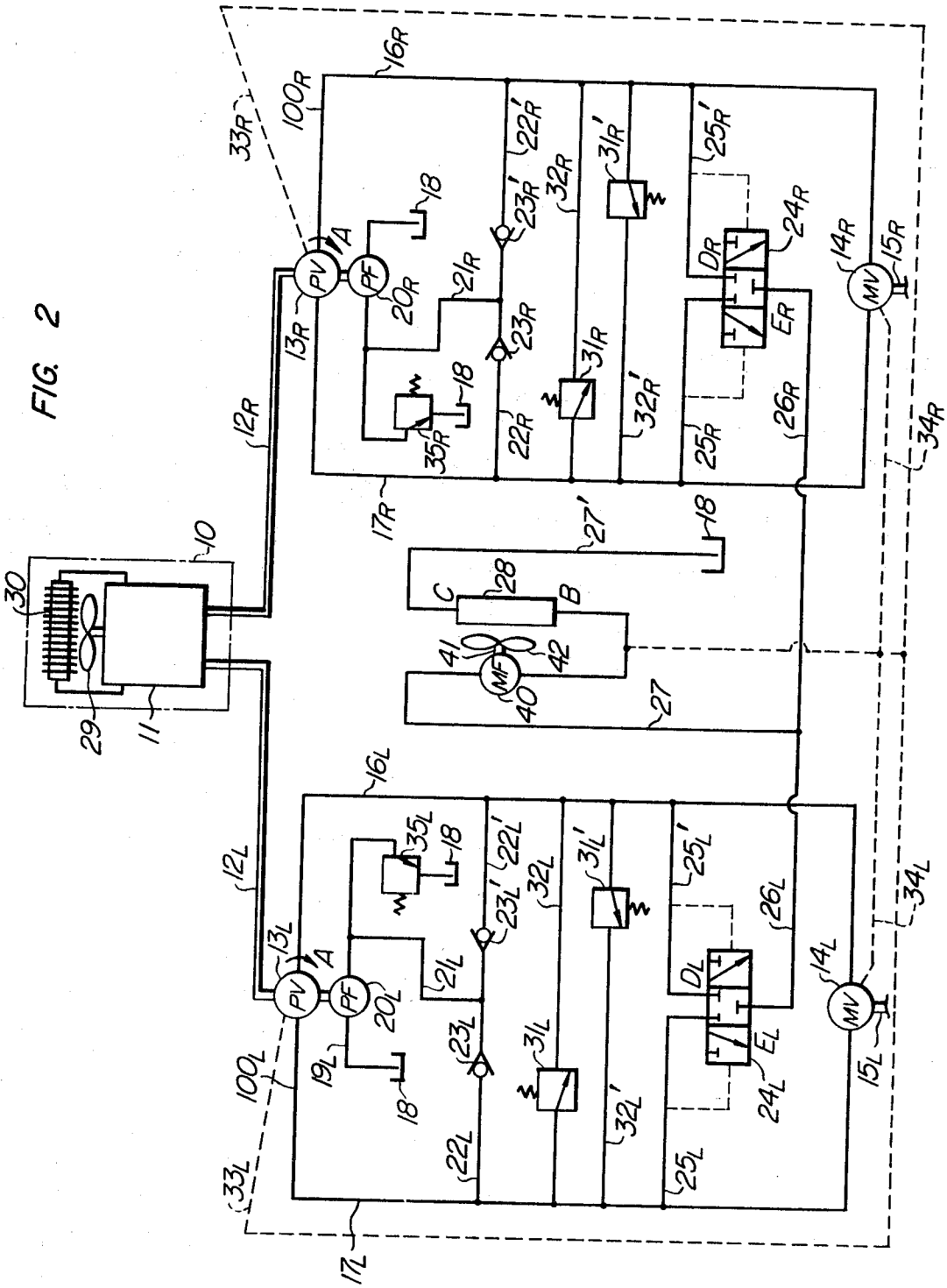
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FIG. 2



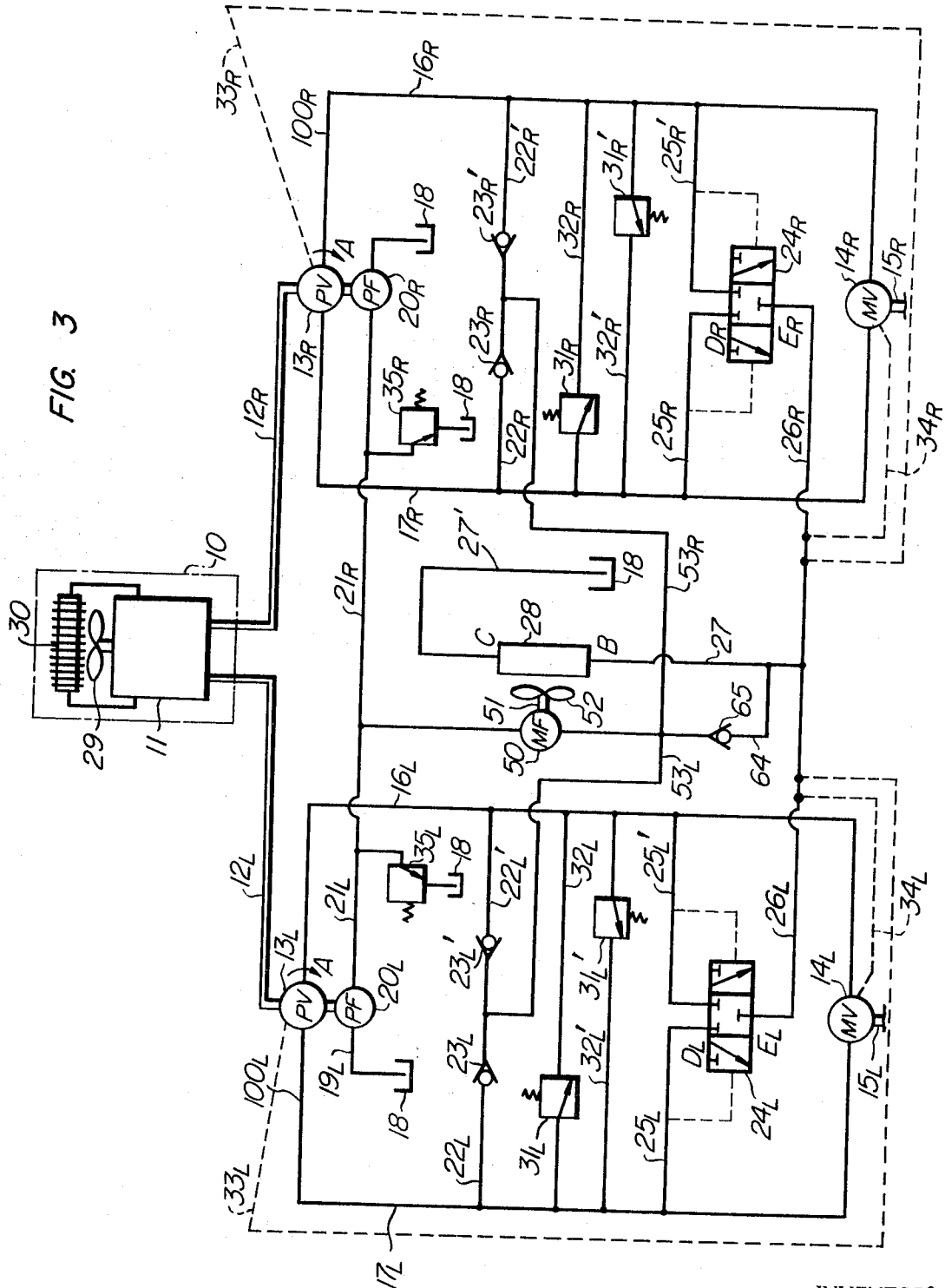
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FIG. 3



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HYDRAULIC CIRCUIT OF HYDRAULICALLY DRIVEN VEHICLE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a hydraulic circuit in a vehicle of the type wherein running elements such as drive wheels are driven by hydraulic pressure, and more specifically to a hydraulic circuit comprising improved hydraulic oil cooling mechanism.

2. Description of the Prior Art

Hydraulic pressure is utilized in construction machinery such, for example, as tractors by reason of the facts that it can transmit a large amount of energy easily and that the moving direction thereof can be controlled easily.

Hydraulically driven vehicles of the type described generally comprise a hydraulic pump which is driven by a driving source (e.g. an engine) and a hydraulic motor which is driven by the hydraulic oil discharged from said hydraulic pump. In case, for example, of a tractor, crawlers are engaged around driving wheels and said driving wheels are driven by the hydraulic motor, whereby the tractor is advanced.

In a hydraulic circuit, as is well known, a large quantity of hydraulic oil flowing through a pump, a motor, a large number of relief valves and a long conduit is heated by the heat of friction with said respective elements during passage therethrough and leakage at various portions thereof. Heating of the hydraulic oil aggravates the oil leakage at the various elements mentioned above, occasionally making it impossible to obtain the intended function of the hydraulic system comprising said elements. Thus, it becomes necessary to sufficiently cool the hydraulic oil in the hydraulic circuit.

A hydraulic circuit of the type described above which includes a hydraulic pump to be driven by an engine mounted on a vehicle as driving source and a hydraulic motor to be driven by said hydraulic pump, is generally so constructed that the hydraulic pump and hydraulic motor are connected with each other by a conduit to form a closed circuit and a circuit which is composed of an oil source, a booster pump to such the hydraulic oil from said oil source and supply it to said closed circuit at a predetermined pressure and a predetermined flow rate, valve means to exhaust excess oil in said closed circuit therefrom and an oil discharge conduit (hereinafter referred to as booster circuit), is connected to said closed circuit.

The hydraulic oil of a conventional hydraulically driven vehicle having the above-described hydraulic circuit has heretofore been cooled by a radiator which is positioned in the oil discharge conduit in front of an engine of the vehicle and which is cooled by a radiator fan (engine fan) for cooling the cooling water of the engine.

In the conventional vehicle described above, however, since the engine fan is used for cooling both the radiator for cooling the cooling water of engine and the hydraulic oil cooling radiator, the cooling effect of the hydraulic oil cooling radiator in particular, which is cooled by the engine fan through the cooling water radiator, is insufficient. In order to obtain a sufficient cooling effect, it may be considered to enlarge the hydraulic oil cooling radiator to the size of the confronting engine fan, but to this end, the engine room must be expanded in the transverse direction. This will necessitate, for example, the gauge of a vehicle to be increased and hence present a considerable difficulty in the design work.

SUMMARY OF THE INVENTION

The first object of the present invention is to provide a hydraulic circuit of a hydraulically driven vehicle, which does not utilize an engine fan of the vehicle for cooling the hydraulic oil passing therethrough but is provided with an independent fan for cooling said hydraulic oil and an auxiliary hydraulic motor for driving said fan.

The second object of the invention is to provide a hydraulic circuit of a hydraulically driven vehicle, which enables

hydraulic oil cooling radiator to be provided, not only in the engine room of the vehicle but also at an optional location of the vehicle.

In order to achieve the foregoing objects, according to the present invention an independent fan is provided solely for the forced-air cooling of a hydraulic oil cooling radiator and further a hydraulic motor is provided solely for driving said fan, said hydraulic motor being driven by the hydraulic oil passing through the booster circuit described previously.

Further, the hydraulic motor and the hydraulic oil cooling radiator are located at an optional position of the vehicle in confronting relation to each other.

The other objects, features and advantages of the present invention will be fully understood from the following detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a conventional hydraulic circuit and

FIGS. 2–3 are block diagrams of hydraulic circuits according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is of course applicable to any and all hydraulically driven vehicles of the type wherein running elements are driven by hydraulic pressure, but will be described with reference to a hydraulically driven tractor for the sake of simplicity.

Referring to FIG. 1 there is shown a conventional hydraulic circuit, having a hydraulic oil cooling radiator, of a tractor.

As will be seen from FIG. 1, the tractor usually comprises two sets of hydraulic circuits including a hydraulic pump and a hydraulic motor. The hydraulic circuit on the left side of the Figure is for driving the running wheel on the left side of the tractor and the hydraulic circuit on the right side of the Figure is for driving the running wheel on the right side of the same. These two hydraulic circuits are identical in construction, and hence same elements are indicated by same reference numerals. The character "R" suffixed to the reference numeral means that the element is of the right side hydraulic circuit and "L" suffixed to the reference numeral means that the element is of the left side hydraulic circuit. The elements which are common for both the left side and right side hydraulic circuits are indicated by reference numeral only, with no character suffixed thereto. For the sake of simplicity, the following description will be given mainly on the left side hydraulic circuit.

Reference numeral **10** designates an engine room of the tractor, **11** an engine mounted within the engine room, **13L** a variable delivery hydraulic pump driven from the engine **11** through a transmission shaft **12L**, and **14L** a variable delivery hydraulic motor. Reference numeral **15L** designates the drive shaft of the hydraulic motor **14L** connected to the left side driving wheel. Reference numerals **16L**, **17L** designate hydraulic oil conduits respectively. The hydraulic oil conduit **16L** has one end connected to the discharge side of the hydraulic pump **13L**, with the other end connected to the inlet side of the hydraulic motor **14L**. The hydraulic oil conduit **17L** has one end connected to the suction side of the hydraulic pump **13L**, with the other end connected to the discharge side of the hydraulic motor **14L**. The hydraulic pump **13L** and the hydraulic motor **14L** form a closed circuit **100L**, with the hydraulic oil conduits **16L**, **17L**. The operation of the closed circuit **100L** will be described later. The hydraulic pressure in the conduits **16L**, **17L** is relatively shifted from high pressure to low pressure, depending upon the rotational direction of the hydraulic pump **13L**.

Reference numeral **18** designates an oil tank and **20L** designates a booster pump connected to the hydraulic pump **13L** and driven from the engine **11**. This booster pump is generally driven from the engine as stated above but a driving

source for the booster pump is not restricted only to the engine. The motor and any other suitable driving source may be used for driving the booster pump. The capacity of the booster pump **20L** is selected to be smaller than the capacity of the hydraulic pump **13L**, and is generally 20–30 percent of the latter.

Reference numeral **19L** designates a first hydraulic oil supply conduit which has one end open into the oil tank **18**, with the other end communicated with the suction side of the booster pump **20L**. Reference numeral **21L** designates a second hydraulic oil supply conduit which has one end connected to the discharge side of the booster pump **20L**, with the other end connected to conduits **22L**, **22L'**. The conduits **22L**, **22L'** have one end connected to the second hydraulic oil supply conduit **21L** respectively, and the other end of the conduit **22L** is connected to the hydraulic oil conduit **17L** and the other end of the conduit **22L'** to the hydraulic oil conduit **16L**.

Reference numerals **23L**, **23L'** designate check valves provided in the conduits **22L**, **22L'** respectively, which prevent the hydraulic oil, passing through the high pressure side conduit of the closed circuit, from flowing into the discharge side of the booster pump. Reference numeral **24L** designates valve means having an inlet port DL and an outlet port EL, said inlet port being controlled by the pilot pressure of the closed circuit to control the discharge of excess oil in said closed circuit. In practice, this valve means is a shuttle valve. Reference numerals **25L**, **25L'** designate first hydraulic oil discharge conduits which have one end connected to the conduits **16L**, **17L**, with the other end opening into the inlet port DL of the valve means **24L** respectively. Reference numeral **26L** designates a second hydraulic oil discharge conduit having one end connected to the outlet port EL of the valve means **24L**, with the other end connected to one end of a first main hydraulic oil discharge conduit **27**.

The other end of the first main hydraulic oil discharge conduit **27** is connected to an inlet B of a hydraulic oil cooling radiator **28**. Reference numeral **27'** designates a second main hydraulic oil discharge conduit having one end connected to an outlet of the hydraulic oil cooling radiator **28**, with the other end opening into the oil tank **18**.

The hydraulic oil cooling radiator **28** is located within the engine room **10**.

Reference numeral **29** designates an engine fan connected directly to the engine **11** within the engine room **10** to be driven thereby, in confronting relation to the hydraulic oil cooling radiator **28**. Reference numeral **30** designates a radiator for cooling the cooling water of the engine **11**, which is generally interposed between the engine fan **29** and the hydraulic oil cooling radiator **28** within the engine room. Reference numeral **35L** designates a low pressure relief valve which is provided to protect the pump and the circuit from unusual high pressure.

Reference numerals **31L**, **31L'** designate high pressure relief valves provided in conduits **32L**, **32L'** respectively, which conduits connect the conduits **16L**, **17L** with each other, bypassing the hydraulic motor **14L**. These high pressure relief valves **31L**, **31L'** serve to release the hydraulic oil into the suction side of the hydraulic pump **13L** through said conduits **32L**, **32L'** respectively without passing it through the hydraulic motor **14L**, in the event that said hydraulic motor **14L** is stopped due to an excessively large load imposed on the running element for some reason. Reference numerals **33L**, **34R** designate discharge conduits for discharging the oil leaking from the hydraulic pump **13L** and the hydraulic motor **14L**. These discharge conduits **33L**, **34R** have one end connected to the hydraulic motor and the hydraulic pump, with the other end connected to the second hydraulic oil discharge conduit **26L**, respectively.

Now, the closed circuit **100L** will be described hereunder: Hydraulic pressure transmitting means are basically classified into an open circuit and a closed circuit. In the open circuit, the hydraulic oil discharged from a hydraulic pump rotates a hydraulic motor and is returned to an oil tank, whereas in the closed circuit the hydraulic oil, after rotating the hydraulic motor, is directly led to the suction side of the hydraulic pump. This is the significant difference between the open circuit and the closed circuit, and the closed circuit has the following advantages over the open circuit:

1. The hydraulic system is compact in size.
2. Normal and reverse rotations are easy.
3. A braking effect for the load is produced.

However, if, in the closed circuit, the hydraulic pump **13L** and the hydraulic motor **14L** are completely sealed by the conduits **16L**, **17L** as stated above, a shortage of oil occurs in the closed circuit due to a leakage of oil at said hydraulic pump and/or hydraulic motor and a cavitation occurs at the suction side of the hydraulic pump. Thus, it becomes necessary to replenish oil into the return passage of the closed circuit. In addition, since the hydraulic oil becomes deteriorated during circulation in the closed circuit, it is necessary to constantly supply fresh oil into the closed circuit and concurrently to remove excess oil therefrom. It is for this purpose that the booster circuit composed of the elements **18**, **19L**, **20L**, **21L**, **22L**, **23L**, **25L**, **26L**, **27** and **27'** is connected to the closed circuit **100L** as stated previously.

In the hydraulic circuit of the construction as described above, the hydraulic oil flows as follows: for simplicity, an explanation will be given with reference to the case wherein the hydraulic pump **13L** is driven in the direction of the arrow A, and the hydraulic oil conduit **16L** is a high pressure side conduit and the hydraulic oil conduit **17L** a low pressure side conduit.

The hydraulic oil in the closed circuit is pressurized by the hydraulic pump **13L** and the pressurized oil discharged from said hydraulic pump enters the hydraulic motor **14L** to rotate said motor, whereby the driving wheel (not shown) is driven. The oil discharged from the hydraulic motor **14L** is led to the suction side of the hydraulic pump **13L**. Thus, the hydraulic oil in the closed circuit is circulated therein as long as the hydraulic motor is in operation.

On the other hand, the hydraulic oil pressurized by the booster pump **20L** flows from **18** to **19L**, **20L**, **21L**, **23L** and thence to **22L** and enters the suction side of the closed circuit, and thereafter is circulated in said closed circuit with the hydraulic oil in said closed circuit. Excess oil flows from **25L** to **26L** and thence to **27** and enters the inlet B of the hydraulic oil cooling radiator **28**. In the hydraulic oil cooling radiator **28**, the oil is cooled by the engine fan **29** and then flows into the oil tank **18** through the outlet C of said cooling radiator and the second main hydraulic oil discharge conduit **27'**.

As stated above, the hydraulic oil in the conventional hydraulic circuit of the tractor is cooled by the hydraulic oil cooling radiator which is located within the engine room **10** and forcibly cooled by the engine fan **29**. However, there occurs many difficulties in providing the cooling radiator in the engine room.

Further, what is to be noted here is that, while the pressurized oil discharged from the booster pump has the effect of preventing the formation of cavitation at the suction side of the hydraulic pump **13L**, it can also be used as a driving source for the other elements.

With this in mind, the present invention has made it possible to locate the hydraulic oil cooling radiator, not only within the engine room of the vehicle but also at an optional position, by making use of the pressurized oil discharged from the booster pump, and the characteristic feature of the invention resides in this point. Namely, the present invention is characterized by the fact that an auxiliary hydraulic motor having a fan is provided in at least one of a first conduit starting from the discharge side of the booster pump and terminating in the low pressure side conduit of the closed circuit and a second conduit starting from said low pressure side conduit of the closed circuit and terminating in the oil tank, to be driven by the pressurized oil passing therethrough and further a hydraulic oil cooling radiator is provided in said second conduit which is cooled by said fan.

FIGS. 2 and 3 show embodiments of the present invention so constructed as described above. In these embodiments, the same reference numerals as in FIG. 1 indicate the same elements.

The embodiments of the invention shown in FIGS. 2 and 3 will be described in detail hereunder individually:

First of all, in the embodiment of FIG. 2 an auxiliary hydraulic motor **40** is provided in the first main hydraulic oil discharge conduit **27** at a location upstream of the hydraulic oil cooling radiator **28** and a fan **42** is mounted on the drive shaft **41** of said motor so as to cool said hydraulic oil cooling radiator. In this case, the radiating surface of the hydraulic oil cooling radiator is located adjacent said fan **42** in opposed relation thereto. The auxiliary hydraulic motor **40** is driven by the pressurized oil passing through the valve means **24L, 24R**.

The hydraulic circuit constructed as described above operates in the following manner:

As in the embodiment of FIG. 1, when the hydraulic pump **13L** is driven in the direction of the arrow A, the hydraulic oil passing through the valve means **24L** from the conduit **17L** flows in the second hydraulic oil discharge conduit **26L** and the first main hydraulic oil discharge conduit **27** and enters the auxiliary hydraulic motor **40** to drive the same and, therefore, the fan **42**. Thereafter, the hydraulic oil flows into the hydraulic oil cooling radiator **28** from the hydraulic motor through the first main hydraulic oil discharge conduit, wherein it is sufficiently cooled, and is discharged into the oil tank **18**.

As described above, in this embodiment of the hydraulic circuit the auxiliary hydraulic motor and the hydraulic oil cooling radiator to cool the hydraulic oil discharged from said hydraulic motor are provided in the first main hydraulic oil discharge conduit. Therefore, the location of the hydraulic oil cooling radiator can be selected freely.

In the FIG. 2 embodiment, however, since the auxiliary hydraulic motor for the hydraulic oil cooling radiator is driven by the pressurized oil discharged from the valve means, the flow rate of the pressurized oil emerging from the valve means is variable as a result of the amount of oil leakage at the hydraulic pump **13L**, the hydraulic motor **14L** and the other elements being varied due to fluctuation of the load on the tractor. Consequently, the rotational speed of the hydraulic motor **40** becomes instable, affecting the cooling effect of the hydraulic oil cooling radiator.

A hydraulic circuit in which improvements are made to overcome such problem is shown in FIG. 3. In the embodiment of FIG. 3, reference numeral **50** designates an auxiliary hydraulic motor having its inlet connected to the other end of the second hydraulic oil supply conduit **21R**. The auxiliary hydraulic motor **50** has a drive shaft **51** and a fan **52** mounted on said drive shaft. Reference numeral **53L** designates a third hydraulic oil supply conduit having one end connected to an outlet of the hydraulic motor **50** and the other end to one end of the conduit **22L**. In this case, the hydraulic oil cooling radiator is provided with its inlet connected to the other end of the first main hydraulic oil discharge conduit and with its outlet connected to the second main hydraulic oil discharge conduit, and the cooling surface thereof is located adjacent the fan **52**. The auxiliary hydraulic motor **50** is driven by the pressurized oil discharge from the booster pump.

The hydraulic circuit of FIG. 3 operates in the following manner: namely, when the hydraulic pump **13L** is driven in the direction of the arrow A as in FIG. 1, the hydraulic oil in the motor exhaust circuit flows through the valve means **24L** since it has moved to its leftmost position, the line **26L**, the first main hydraulic oil discharge conduit **27**, the hydraulic oil cooling radiator **28** and the second main hydraulic oil discharge conduit **27'** from the conduit **17L**, and is discharged into the oil tank **18**. On the other hand, the pressurized oil discharged from the booster pump **20L** flows into the auxiliary hydraulic motor **50** through the second hydraulic oil supply conduit **21L**, to drive said motor and, therefore, the fan **52**. Thus, the used hydraulic oil successively flowing into the hydraulic oil cooling radiator **28** is discharged into the oil tank **18** after having been cooled by the fan **52**.

The hydraulic oil leaving the hydraulic motor **50** flows into the closed circuit through the third hydraulic oil supply conduit **53L**, a check valve **23L** and the third hydraulic oil supply conduit **22L**.

As described above, in this embodiment of the hydraulic circuit the auxiliary hydraulic motor **50** is provided at the other ends of the respective second hydraulic oil supply conduits and the hydraulic oil cooling radiator **28** is provided between the first and second hydraulic oil discharge conduits. Therefore, the hydraulic oil cooling radiator is of course not located within the engine room as in the conventional tractor, and in addition, since the pressurized oil is supplied to the hydraulic motor always under a constant pressure and at a constant rate, the rotational speed of said motor does not fluctuate and hence the hydraulic oil can be highly efficiently cooled by the cooling radiator.

However, where no load acts on the respective closed circuit in the embodiment described above, the respective valve means are held in their neutral position even when the respective booster pumps are in operation, so that the hydraulic oil in the respective closed circuit is not discharged therefrom and the pressurized oil discharged from the respective booster pumps is discharged into the oil tank **18** through the low pressure relief valve **35L**, without rotating the auxiliary hydraulic motor. The result is that the temperature of the hydraulic oil rises, because the oil in the oil tank is obviously heated by the ambient temperature in summer or in the other high temperature environments, and also because the respective booster pumps are rotating continuously. Thus, it becomes necessary to positively cool the hydraulic oil even when the respective valve means **24L, 24R** are in the neutral position.

To this end, in the embodiment of FIG. 3 a by-pass conduit **64** is provided, with one end connected to the third hydraulic oil supply conduits **63L, 63R** and the other end to the first main hydraulic oil discharge conduit **27**, and a check valve **65** is provided in said by-pass conduit **64**.

When the oil pressure in the third hydraulic oil supply conduits rises to a level higher than a preset value, the check valve **65** is opened, whereby the hydraulic oil discharged from the auxiliary hydraulic motor **50** flows into the hydraulic oil cooling radiator through the by-pass conduit **64** and the first main hydraulic oil discharge conduit **27**, to be sufficiently cooled therein by the fan **52**, and is then discharged into the oil tank **18**.

By constructing the hydraulic circuit as described above, it becomes possible, not only to provide the hydraulic oil cooling radiator at an optional position of the tractor but also to keep the auxiliary hydraulic motor running as long as the booster pump is driven, which is of great advantage.

In the foregoing description, the present invention has been described in detail as applied to a tractor and, hence one of the fan driving motors and one of the hydraulic oil cooling means are provided for both the left and right hydraulic circuits for driving the left and right driving wheels, in each embodiment of the invention described and illustrated herein. However, it should be understood that the present invention is not restricted to those embodiment and it is obviously possible as required to provide the fan driving motor and the hydraulic oil cooling radiator for each of the hydraulic circuits for driving the respective driving wheels.

In this case, the second hydraulic oil discharge conduit **26L** (**26R**) in each embodiment includes the first main hydraulic oil discharge conduit **27** and accordingly the second main hydraulic oil discharge conduit **27'** takes the place of the third hydraulic oil discharge conduit.

I claim:

1. A hydraulic circuit of a hydraulically driven vehicle, comprising:

a driving source;

a closed circuit which comprises

a hydraulic pump driven by said driving source,

a hydraulic motor driven by pressurized oil supplied by said hydraulic pump,

a high pressure side oil conduit connecting a discharge side of said hydraulic pump to an input side of said hydraulic motor, and

a low pressure side oil conduit connecting a suction side of said hydraulic pump to an output side of said hydraulic motor;

a booster pump;

means for driving said booster pump;

an oil source;

a first hydraulic oil supply conduit having one end opening into said oil source and the other end connected to a suction side of said booster pump;

a second hydraulic oil supply conduit having one end connected to a discharge side of said booster pump and the other end to said low pressure side oil conduit;

valve means having an inlet port and an outlet port for discharging excess oil in said low pressure side oil conduit;

a hydraulic oil cooling radiator having an inlet and an outlet;

a first hydraulic oil discharge conduit having one end connected to said low pressure side oil conduit and the other end connected to the inlet port of said valve means;

a second hydraulic oil discharge conduit having one end connected to the outlet port of said valve means and the other end connected to the inlet of said hydraulic oil cooling radiator; and

a third hydraulic oil discharge conduit having one end connected to the outlet of said hydraulic oil cooling radiator and the other end opening into said oil source, wherein an improvement comprises an auxiliary hydraulic motor which is driven by the pressurized oil discharged from said booster pump and a fan rotated by said auxiliary hydraulic motor for cooling said hydraulic oil cooling radiator.

2. A hydraulic circuit as defined in claim **1**, wherein said auxiliary hydraulic motor is interposed in said second hydraulic oil supply conduit.

3. A hydraulic circuit as defined in claim **1**, wherein said auxiliary hydraulic motor is interposed between the other end of said second hydraulic oil supply conduit and said low pressure side oil conduit.

4. A hydraulic circuit as defined in claim **3**, which further comprises a third hydraulic oil supply conduit connecting the outlet of said auxiliary hydraulic motor with said low pressure side oil conduit, a bypass conduit having one end connected to said second hydraulic oil discharge conduit and the other end to said third hydraulic oil supply conduit, and second valve means adapted in said by-pass conduit to prevent the pressurized oil from flowing from said first valve means in said by-pass conduit and to communicate said by-pass conduit with said second hydraulic oil discharge conduit when the oil pressure in said third hydraulic oil supply conduit becomes higher than a preset value.

5. A hydraulic circuit as defined in claim **1**, wherein said auxiliary hydraulic motor is interposed between the other end of said second hydraulic oil discharge conduit and the inlet of said hydraulic oil cooling radiator.

6. A hydraulic circuit as defined in claim **1**, wherein said auxiliary hydraulic motor is interposed between the other end of said third hydraulic oil discharge conduit and said oil tank.

7. A hydraulic circuit of a hydraulically driven vehicle, comprising

a driving source;

an oil source;

at least two closed circuits each of which comprises

a hydraulic pump driven by said driving source,

a hydraulic motor driven by pressurized oil supplied from said hydraulic pump,

a high pressure side oil conduit connecting a discharge side of said hydraulic pump to an input side of said hydraulic motor, and

a low pressure side oil conduit connecting a suction side of said hydraulic pump with the output side of said hydraulic motor;

at least two devices each provided in correspondence to each of said closed circuits and comprising

a booster pump,

means for driving said booster pump, a first hydraulic oil supply conduit having one end opening into said oil source and the other end connected to a suction side of said booster pump,

a second hydraulic oil supply conduit having one end connected to the discharge side of said booster pump and the other end to said low pressure side oil conduit, valve means having an inlet port and an outlet port for discharging excess oil in said low pressure side oil conduit, and a first hydraulic oil discharge conduit having one end connected to said low pressure side oil conduit and the other end to the inlet port of said valve means;

a hydraulic oil cooling radiator having an inlet and an outlet;

a first main hydraulic pressure discharge conduit having one end connected to the outlet ports of the respective valve means and the other end connected to the outlet of said hydraulic oil cooling radiator; and

a second main hydraulic oil discharge conduit having one end connected to the outlet of said hydraulic oil cooling radiator and the other end opening into said oil source,

wherein an improvement comprises an auxiliary hydraulic motor driven by the pressurized oil discharged from each of said booster pumps and a fan driven by said booster pump for cooling said hydraulic oil cooling radiator.

8. A hydraulic circuit as defined in claim **6**, wherein said auxiliary hydraulic motor has an inlet port and an outlet port for hydraulic oil and said inlet port is opened into the other end of said second hydraulic oil supply conduit in each of said closed circuits, while said outlet port is connected to said low pressure side oil conduit in each of said closed circuit.

9. A hydraulic circuit as defined in claim **7**, which further comprises a third hydraulic oil supply conduit connecting the outlet port of said auxiliary hydraulic motor with the low pressure side oil conduit in each of said closed circuits, a by-pass conduit having one end connected to said first main hydraulic oil discharge conduit and the other end to each of said third hydraulic oil supply conduits, and second valve means adapted to block the hydraulic oil flowing from each of said first valve means into said by-pass conduit and to communicate said by-pass conduit with said first main hydraulic oil discharge conduit when the oil pressure in each of said third hydraulic oil supply conduits becomes higher than a preset value.

10. A hydraulic circuit as defined in claim **6**, wherein said auxiliary hydraulic motor is interposed between the other end of said first main hydraulic oil discharge conduit and the inlet of said hydraulic oil cooling radiator.

11. A hydraulic circuit as defined in claim **6**, wherein said auxiliary hydraulic motor is interposed between the other end of said second main hydraulic oil discharge conduit and said oil source.

12. A hydraulic circuit of a hydraulically driven vehicle, comprising

a hydraulic pump having a suction port and a discharge port, which pump sucks a predetermined quantity of oil from the suction port and discharges the same from the discharge port;

a hydraulic motor having an input side and output side;

a first pressurized oil conduit for connecting the discharge port of said hydraulic pump and the input side of said hydraulic motor;

a second pressurized oil conduit for connecting the output side of said hydraulic motor to the suction port of said hydraulic pump, so that said hydraulic motor is driven by the pressurized oil discharged from said pump;

an oil tank;

a first conduit starting from said oil tank and terminating at a point in said second pressurized oil conduit;

a second conduit starting from a point upstream from the terminating point of said first conduit in said second pressurized oil conduit and terminating at said oil tank;

an auxiliary pump provided in said first conduit for constantly supplying from said oil tank to the suction port of said pump a predetermined quantity of oil smaller than that sucked by said hydraulic pump;

a radiator provided in said second conduit for cooling the oil passing therethrough;

an auxiliary motor provided in at least one of said first and second conduits so as to be driven by the oil passing therethrough; and a fan driven by said auxiliary motor for cooling said radiator.

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