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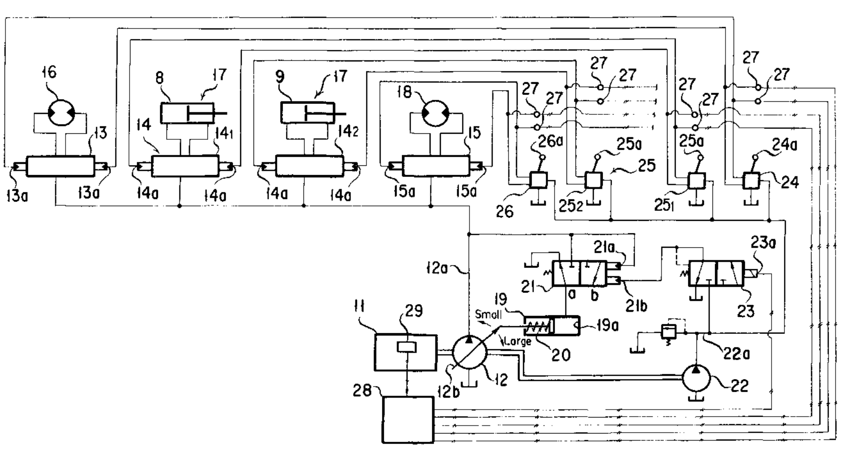
(54) **Work vehicle with turning upper structure**

(57) The pump discharge volumetric flow of a variable delivery oil pressure pump (12) is rapidly increased when the vehicle's working machine starts working to improve the machine's action efficiency and is slowly increased when the vehicle starts traveling to diminish the shock thereto. An arrangement is thus provided including a torque control valve (21) for controlling the pump discharge volumetric flow of the pump (12), an electromagnetic proportional pressure reducing valve (23) for applying a pilot pressure to the torque control valve (21) and a controller (28) for controlling the current to energize the solenoid (23a) of the electromagnetic proportional pressure reducing valve (23). When a machine control valve (14) is exclusively operated, the controller (28) rapidly changes the current to the solenoid (23a) of the electromagnetic proportional control valve (23) to rapidly increase the pump discharge volumetric flow. And, when the vehicle traveling morion control valve (13) is operated, it slowly changes the energizing current to slowly increase the pump discharge volumetric flow.

FIG. 2



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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to an upper structure turning work vehicle such as an oil hydraulic shovel and, more particularly, to an arrangement for controlling the operations of actuators therein such as a vehicle traveling motion oil hydraulic motor and vehicle working motion oil hydraulic cylinders with discharge pressure oil supplied from a variable delivery oil pressure pump.

Description of the Prior Art

[0002] In an oil hydraulic shovel, its upper vehicle body is mounted turnably on its lower vehicle body provided with a traveling body (moving mechanism), and a working machine provided with a boom, arm and bucket is mounted on the upper vehicle body to make them capable of swinging vertically. In operation, the traveling body is driven to move by a traveling motion oil hydraulic motor, and the upper vehicle body is driven to turn horizontally by a turning motion oil hydraulic motor. The boom, arm and bucket are driven to swing vertically by a boom, an arm and a bucket cylinder, respectively.

[0003] Each of the oil hydraulic motors and cylinders are supplied with discharge pressure oil from an engine driven, variable delivery oil pressure pump via respective motion control valves. The pump discharge volumetric flow (amount of pressure oil discharged per revolution) of the variable delivery oil pressure pump into a given motion control valve is controlled in response to its discharge pressure and the position taken by the control valve in its outlet paths.

[0004] It has then been the practice to control the pump discharge volumetric flow, for example, so as to maintain its absorbable torque or torque absorption: (pump discharge volumetric flow) x (pump discharge pressure) constant. More specifically, the pump discharge volumetric flow is controlled so as to become small and large when the pump discharge pressure is high and low, respectively. The torque absorption or absorbable torque of this oil pressure pump is set up in accordance output state of the engine (i. e., if it is the full power or a partial output).

[0005] So doing makes it possible to prevent the variable delivery oil pressure pump from halting when the engine driving it is overloaded.

[0006] The discharge volumetric flow of the variable delivery oil pressure pump is also controlled so as to become small and large when the control valve is in its neutral position (at which the oil hydraulic motor/cylinder is not to be supplied with pressure oil) and in its feed position (at which it is to be supplied with pressure oil), respectively.

[0007] Controlling the pump discharge volumetric flow of the variable delivery oil pressure pump in this manner makes it possible to reduce the horse power consumption of the engine for rotationally driving the variable delivery oil pressure pump since the pump discharge volumetric flow of the variable delivery oil pressure pump is made small when the oil hydraulic motor or the cylinder need not be supplied with pressure oil.

[0008] Engaged for the most part with an excavation and scarcely traveled in operation, a general oil hydraulic shovel has a variable delivery oil pressure pump typically designed so that its pump discharge volumetric flow is rapidly increased when the control valve is switched over from the neutral position to the feed position to immediately operate the boom, arm and bucket cylinders and thereby to permit initiating a given excavating operation therewith efficiently, and that the same is rapidly decreased when the control valve is returned from the feed position to the neutral position to reduce the horse power consumed by the engine.

[0009] As a result, however, when the control valve for shovel's traveling motion is switched from its neutral position to its feed position to cause the shovel to start traveling, pressure oil is abruptly fed into the traveling motion oil hydraulic motor, thereby bringing about a large shock to the shovel when set to start traveling.

[0010] Further, with the pump discharge volumetric flow of the variable delivery oil pressure pump increased and decreased at an identical rate, it is noted that a hunching in traveling motion may develop in a way as follows: Setting the traveling motion control valve to its feed position to feed the traveling motion oil hydraulic motor with pressure oil of the variable delivery oil pressure pump causes the traveling body to be driven and thus the oil hydraulic shovel to start traveling. While the shovel is traveling, the torque absorption of the variable delivery oil pressure pump may exceed its preset value depending on how the engine's output is. For example, when flat traveling is followed by uphill traveling, a traveling load on the shovel is increased and then the increase in traveling load entails an increase in the pump discharge pressure of the variable delivery oil pressure pump, thus making its torque absorption = (minimum pump discharge volumetric flow) x (pump discharge pressure) greater than the preset value.

[0011] Then, a load on the engine is increased and the engine has its number of revolutions (engine speed) lowered, eventually coming to cease revolving. To meet with this problem, an alternative control has been adopted in the prior art, in which the pump discharge volumetric flow is reduced and thus the torque absorption of the variable delivery oil pressure pump is reduced to less than its present value so that the engine's speed or number of revolutions may then become a prescribed value. Quickly reducing the pump discharge volumetric flow of the variable delivery oil pressure pump permits the engine's speed of rotation to be restored instantly to the prescribed value. However, the quickness of the rate at which the pump discharge volumetric flow of the variable delivery oil pressure pump is reduced (or its deceleration) tends to excessively reduce the same and thus the torque absorption of the variable delivery oil pressure pump is excessively reduced to less than its present value so that the engine may be revolved more quickly than at its prescribed number of revolutions. Then, if an attempt is made to increase again the pump discharge volumetric flow to slow the engine's revolution, the quickness of the rate at which the pump discharge volumetric flow is increased (or its acceleration) tends to make the torque absorption of the pump again greater than its preset value so that the engine may be revolved more slowly than at its prescribed number of revolutions.

[0012] The engine repeating the cycle of revolving too slowly and too rapidly a number of times causes the variable delivery oil pressure pump to repeat the cycle of revolving too slowly and too rapidly such a number of times. This in turn causes the traveling motion oil hydraulic motor to repeat the cycle of revolving too slowly and too rapidly such a number of times . As a result, the oil hydraulic shovel has fluctuations in the speed of travel and suffers from a hunching in travel, and hence is uncomfortable to drive for the operator.

[0013] Moreover, the development of such a hunching in travel with the operator holding the travel control lever in its hand to drive will cause the chassis to rock back and forth, following which the traveling control lever will be jolted, thereby causing the opening (meter-in opening) area of the traveling motion control valve to increase and decrease. This results in a further repetition of increase and decrease in the amount of pressure oil fed into the traveling motion oil hydraulic motor, thus merely promoting the hunting in shovel travel.

BRIEF SUMMARY OF THE INVENTION

[0014] It is accordingly an object of the present invention to provide an improved upper structure turning work vehicle incorporating an arrangement or a pressure oil feed control system that can reduce the shock to the body of the vehicle when set to start traveling and also prevents the development of the hunting in vehicle's travel.

[0015] In order to achieve the object mentioned above there is provided in accordance with the present invention (with reference to the accompanying drawing figures) an upper structure turning work vehicle which comprises:

a variable delivery oil pressure pump (12) adapted to be driven by an engine (11), the variable delivery oil pressure pump having its pump discharge volumetric flow controllable;
a torque control valve (21) for controlling the pump discharge volumetric flow of the variable delivery pressure pump (12) in accordance with a pump discharge pressure thereof so that a torque absorption of the variable delivery oil pressure pump (12) becomes a preset value;
an electromagnetic proportional pressure reducing valve (23) for providing a pilot pressure and imparting it to the torque control valve (21) to cause the latter to change its torque control position;
a controller (28) for acting on the electromagnetic proportional pressure reducing valve (23) to control the pilot pressure;
a vehicle traveling motion oil hydraulic motor (16) ;
a vehicle traveling motion control valve (13) for feeding the vehicle traveling motion oil hydraulic motor (16) with discharge pressure oil from the variable delivery oil pressure valve (12);
a vehicle working machine actuator (17);
a vehicle working motion control valve (14) for feeding the vehicle working machine actuator (17) with discharge pressure oil from the variable delivery oil pressure pump (12); and
motion control valve operation sensing means (27) for sensing respective switching operations of the vehicle traveling motion control valve (13) and the vehicle working motion control valve (14) to provide signals indicative thereof for the controller (28), the signals including a vehicle traveling motion start signal and a vehicle working motion start signal derived from the switching operations of the vehicle traveling motion and working motion control valves (13 and 14), respectively, wherein:

in response to the vehicle working motion start signal from the motion control valve operation sensing means (27) for the vehicle working control valve (14), the controller (28) is adapted to furnish the electromagnetic proportional pressure reducing valve (23) with a first electromagnetic proportional pressure reducing valve control signal for producing the pilot pressure in the form of a rapidly decreasing pressure to cause the torque control valve (21) to be rapidly displaced to take the pump discharge volumetric flow increasing position whereby the pump discharge volumetric flow from the pump (12) into the vehicle working motion control valve (14) is rapidly increased, and
in response to the vehicle traveling motion start signal from the motion control valve operation sensing means (27) for the vehicle traveling motion control valve (13), the controller (28) is adapted to furnish the electromagnetic proportional pressure reducing valve (23) with a second electromagnetic proportional pressure reducing valve control signal for producing the pilot pressure in the form of a slowly decreasing pressure to cause the torque control valve (21) to be slowly displaced to take the pump discharge volumetric flow increasing position

whereby the pump discharge volumetric flow from the pump (12) into the vehicle traveling motion control valve (13) is slowly increased.

whereby the pump discharge volumetric flow of the variable delivery oil pressure pump (12) is rapidly increased and slowly increased, selectively when the work vehicle is set to start traveling or the work vehicle is set to start working, respectively.

[0016] Making up the work vehicle as mentioned above allows the pump discharge volumetric flow to be quickly increased when the working motion control valve 14 is set to start operating. Therefore, setting the working motion control valve (14) to start operating permits the working machine on the vehicle to start working immediately. Hence, the operator is allowed to work efficiently. Also, when the traveling motion control valve (13) is exclusively set to start operating, the pump discharge volumetric flow is permitted to increase slowly. Hence, the shock to the work vehicle when set to start traveling is diminished.

[0017] The present invention also provides an upper structure turning work vehicle which in addition to the makeup mentioned above comprises: an engine speed sensor (29) for sensing an engine speed of the engine (11) and providing the controller (28) with an engine speed signal indicative thereof, wherein;

in response to such an engine speed signal indicating that the engine speed comes down below a preset engine speed while the vehicle is traveling and/or the working machine is working, the controller (28) is adapted to furnish the electromagnetic proportional pressure reducing valve (23) with a third electromagnetic proportional pressure reducing signal for producing the pilot pressure in the form of a rapidly increasing pressure to cause the torque control valve (21) to be rapidly displaced to take a pump discharge volumetric flow decreasing position whereby the pump discharge volumetric flow from the pump (12) is rapidly decreased, and

in response to such an engine speed signal indicating that the engine speed comes up above such a preset engine speed, the controller (28) is adapted to furnish the electromagnetic proportional pressure reducing valve (23) with a fourth electromagnetic proportional pressure reducing signal for producing the pilot pressure in the form of a slowly increasing pressure to cause the torque control valve (21) to be slowly displaced to take the pump discharge volumetric flow increasing position whereby the pump discharge volumetric flow from the pump (12) is slowly decreased

whereby a change of the engine speed from a preset engine speed while the work vehicle is traveling and/or working causes the pump discharge volumetric flow of the variable delivery oil pressure pump (12) to be rapidly decreased or slowly increased, selectively according to the direction in which that change occurs.

[0018] According to the makeup of the work vehicle mentioned above, a rise of the torque absorption of the variable delivery oil pressure pump above its preset value, thus reducing the engine speed, causes the pump's discharge volumetric flow to decrease rapidly. A drop of the pump discharge volumetric flow to the extent that the torque absorption falls below its preset value, thus raising the engine speed, causes the pump discharge volumetric flow to increase slowly. In consequence, the torque absorption if raised above the preset value can be restored quickly to the preset value; hence a repetition of the cycle of the torque absorption becoming too small and too large a number of times is effectively avoided.

[0019] Thus, with a hunching in travel prevented if the torque absorption rises above its preset value, a work vehicle is realized that is much more comfortable to ride in to the operator than the existing work vehicles.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] These and other objects, features and advantages of the present invention will be more readily apparent, and the invention itself will also be better understood, from the following detailed description taken with reference to the drawings attached hereto showing a certain illustrative form of embodiment of the present invention. In the drawings:

Fig. 1 is a side view illustrating an oil hydraulic shovel that represents one form of embodiment of the upper structure turning work vehicle according to the present invention;

Fig. 2 is an explanatory diagram illustrating a pressure oil feed control system according to the present invention that can be used in the form of embodiment shown in Fig. 1;

Fig. 3 is a flow chart illustrating how the pump discharge volumetric flow is controlled differently according to vehicle motion control modes in this pressure oil feed control system;

Fig, 4 is a graph illustrating changes in the electric current applied to the electromagnetic proportional pressure reducing valve in this pressure oil feed control system;

Fig. 5 is a graph illustrating changes in the pump's discharge volumetric flow which occur according to the changes in the electric current applied to the electromagnetic proportional pressure reducing valve as shown in Fig. 4;

Fig. 6 is a graph illustrating another change in the electric current applied to the electromagnetic proportional pressure reducing valve in this pressure oil feed control system;

Fig. 7 is a graph illustrating a change in the pump's discharge volumetric flow which occurs according to the change in the electric current applied to the electromagnetic proportional pressure reducing valve as shown in Fig. 6; and

Fig. 8 is a graph illustrating a relationship between the engine's output torque and the toque absorption.

DETAILED DESCRIPTION

[0021] Referring now to Fig. 1, there is shown an upper structure turning work vehicle, e. g., an oil hydraulic shovel, in which its upper vehicle body 3 is mounted turnably on its lower vehicle body 2 provided with a traveling body (moving mechanism) 1, and a working machine 4 is mounted on the upper vehicle body 3. The working machine 4 is provided with a boom 5, an arm 6 and a bucket 7, which in operation are driven to swing vertically by a boom cylinder 8, an arm cylinder 9 and a bucket cylinder 10, respectively.

[0022] Referring to Fig. 2 showing the pressure oil feed control system for the oil hydraulic shovel, an engine 11 is shown as driving a variable delivery oil pressure pump 12 having its pressure oil discharge passage 12a connected to a plurality of actuators via a like plurality of vehicle's motion control valves. Thus, the discharge passage 12a as shown is provided with a vehicle traveling motion control valve 13, working machine motion control valves 14 (14_1 and 14_2) and an upper vehicle body turning motion control valve 15. The traveling motion control valve 13 which controls feeding a vehicle traveling motion oil hydraulic motor 16 with pressure oil, is held at its neutral position by spring forces, and can be switched to take its two oil feed positions alternatively when its two pressure receiving areas 13a are fed alternatively with pilot pressure oil, respectively. The working machine motion control valves 14 are shown to include a boom and an arm motion control valve 14_1 and 14_2 for feeding working machine actuators 17, that is, the boom and arm cylinders 8 and 9 with pressure oil, respectively, each of which valves is held at its neutral position by spring forces and can be switched to take its two oil feed positions alternatively when its two pressure receiving areas 14a alternatively are fed with pilot pressure oil, respectively. The upper vehicle body turning control valve 15 which controls feeding a turning motion control oil hydraulic motor 18 with pressure oil, is held at its neutral position by spring forces, and can be switched to take its two oil feed positions 15a alternatively when its two pressure receiving areas 13a alternatively are fed with pilot pressure oil, respectively. Each of these motion control valves is a conventional three-way directional switching valve whose further detailed illustration is therefore omitted here as deemed unnecessary.

[0023] The variable delivery oil pressure pump 12 has its swash plate 12b adapted to be obliquely rotated bidirectionally by a volumetric flow control cylinder 19 which is included to control the discharge volumetric flow of this oil pressure pump. The volumetric flow control cylinder 19 when operated under the force of a spring 20 to have its piston retracted acts to increase the pump volumetric flow and when operated to have its piston advanced by supplying its chamber 19a with pressure oil acts to decrease the pump volumetric flow. This chamber 19a is supplied with discharge pressure oil from the variable delivery oil pressure pump 12 via a torque control valve 21, which acts to control the amount of the discharge pressure oil supplied.

[0024] The torque control valve 21 is displaced by a spring force to take its drain position (pump discharge volumetric flow increasing position) **a** and is displaced by a pump discharge pressure acting on a first pressure receiving area 21a and by a pilot pressure applied to a second pressure receiving area 21b to take its oil feed position (pump discharge volumetric flow decreasing position) **b.**

[0025] An oil pressure pump for control 22 is also rotationally driven by the engine 11. The control oil pressure pump 22 has its discharge passage 22a connected to an electromagnetic proportional pressure reducing valve 23 at its inlet. The discharge passage 22a of the control oil pressure pump 22 is also connected to a vehicle traveling motion control pilot valve 24, working machine motion control pilot valves 25, here a boom motion and an arm motion control pilot valve 25_1 and 25_2, and a turning motion control pilot valve 26 at their inlets, respectively. The electromagnetic proportional pressure reducing valve 23 provides pressure oil under an output pressure proportional in amount to an electric current applied as a control signal to energize its solenoid 23a. The output pressure of the electromagnetic proportional pressure reducing valve 23 is used as a pilot pressure applied to the second pressure receiving area 21b of the torque control valve 21.

[0026] The pilot valves 24, 25_1, 25_2 and 26 are here included to supply the traveling motion control valve 13, the working machine motion control valves 14 and the turning motion control valve 15 at their pressure receiving areas 13a, 14a and 15a with pressure oil under pressures which are proportional to strokes operated by operating levers 24a, 25a and 26a, respectively. Supplying a pilot pressure oil switching signal towards each of the pressure receiving areas 13a, 14a and 15a actuates each of pressure switches 27 provided associated with its own oil inlet path upon sensing a change in pressure therein, respectively, which in turn furnishes a controller 28 with a sensing signal indicating a switching operation caused for the traveling motion control valve 13, each of the machine motion control valves 14 or the turning motion control valve 15. Hence, the pressure switches 27 may represent a motion control valve operation sensing means in accordance with the present invention, a term used in the appended claims.

[0027] The controller 28 is also furnished with a signal indicating the engine speed (rpm) of the engine 11 sensed by an engine speed sensor 29 and then furnishes the electromagnetic proportional pressure reducing valve 23 with an electromagnetic proportional valve control signal, that is, a signal for controlling the amount of electric current applied to energize its solenoid 23a.

[0028] The torque control valve 21 acts to control the pump discharge volumetric flow of the variable delivery oil pressure pump 12 in accordance with the pump's discharge pressure so that the pump 12 has a preset torque absorption value. Further, the electromagnetic proportional pressure reducing valve 23 and the controller 28 together make up a pump discharge volumetric flow increasing and decreasing control means for changing the pump discharge volumetric flow acceleration and deceleration here.

[0029] Mention is next made of how the torque control valve 21 functions and operates. It is assumed then that acting on the second pressure receiving area 21b, the output pressure of the electromagnetic proportional pressure reducing valve 23 is fixed. A rise in the pump discharge pressure of the oil pressure pump 12 causes the torque control valve 21 to be displaced to take the feed position **b** for feeding the chamber 19a of the volumetric flow control cylinder 19 with the pump discharge pressure oil to decrease the pump volumetric flow. A fall in the pump discharge pressure of the oil pressure pump 12 causes the torque control valve 21 to be displaced to take the drain position **a** at which the pressure oil is discharged from the chamber 19a of the cylinder 19 into a reservoir to increase the pump discharge volumetric flow. Consequently, the pump discharge volumetric flow of the oil pressure pump 12 is controlled so as to maintain the torque absorption (= [pump discharge volumetric flow] x [pump discharge pressure] constant at a preset value.

[0030] The torque absorption is preset with the output pressure of the electromagnetic proportional pressure reducing valve 23 (pilot pressure). For instance, under a fixed pump discharge pressure, increasing the electric current passed through the solenoid 23a of the electromagnetic proportional pressure reducing valve 23 to raise its output pressure raises the pilot pressure acting on the second pressure receiving area 21b of the torque control valve 21. This results in an increase in the force that displaces the torque control valve 21 to take its feed position b, at which it feeds discharge pressure oil from the pump 12 into the chamber 19a of the volumetric flow control cylinder 19, and hence a decrease in the pump discharge volumetric flow. Consequently, the torque absorption of the variable delivery oil pressure pump 12 is decreased.

[0031] The rate at which the pump discharge volumetric flow is decreased, namely the pump discharge volumetric flow deceleration, is proportional to the increase per unit time of the electric current applied to the solenoid 23a of the electromagnetic proportional pressure reducing valve 23, and hence can be controlled by changing the same.

[0032] In contrast, decreasing the electric current applied to the solenoid 23a of the electromagnetic proportional pressure reducing valve 23 under a fixed pump discharge pressure to reduce its output pressure reduces the pilot pressure acting on the second pressure receiving area 21b of the torque control valve 21. Since the force by which the torque control valve 21 is displaced to take its feed position b is then reduced, it follows that the pump discharge volumetric flow of the variable delivery oil pressure pump 12 is increased as opposed to the case mentioned above, thus making the torque absorption greater than its preset value.

[0033] The rate at which the pump discharge volumetric flow is increased, namely the pump discharge volumetric flow acceleration, is proportional to the decrease per unit time of the electric current applied to the solenoid 23a of the electromagnetic proportional pressure reducing valve 23, and hence can be controlled by changing the same.

[0034] The controller 28 has a pump discharge volumetric flow acceleration and a pump discharge volumetric flow deceleration preset therein which are optimum for each of the operating actuators. These parameters are preset, for example, in terms of optimum current output time periods predetermined of the current applied to the solenoid 23a of the electromagnetic proportional pressure reducing valve 23 for operating each working machine component, and those for turning the upper vehicle body and those for driving the work vehicle, respectively. Those current output time periods include a time period in which the solenoid 23a is supplied with the current at a magnitude I_0 and a time period in which the current supplied at the magnitude I_0 to the solenoid 23a is reduced to I_1 (where $I_0 > I_1$).

[0035] Specifically, the controller 28 in response to a sensing signal furnished from a pressure switch 27 determines which particular actuator is operating and to be acted on and controls the current output to the solenoid 23a of the electromagnetic proportional pressure reducing valve 23 by the current output time period preset for that particular actuator.

[0036] For example, referring to Fig. 3, upon receipt of the traveling motion start signal $TRVL_{MSS}$ (the sensing signal from the pressure switch 27 associated with the traveling pilot valve 24) alone, the controller 28 determines that the traveling motion TRVL is intended and to be controlled exclusively. Upon receipt of the boom motion start signal BM_{MSS} (the sensing signal from the pressure switch 27 associated with the boom motion pilot valve 25_1) alone, the controller 28 determines that the boom motion BOOM is intended and to be controlled exclusively. Upon receipt of the turning motion start signal TRN_{MSS} (the sensing signal from the pressure switch 27 associated with the turning motion pilot valve 26) alone, the controller 28 determines that the turning motion TRN is intended and to be controlled exclusively. Upon receipt of both the boom and turning motion start signals BM_{MSS} and TRN_{MSS}, it determines that both the turning and boom motions BOOM and TRN are intended and to be controlled. Upon receipt of any other combination of the motion signals, it can determine that those motions in combination are intended and to be controlled.

[0037] Mention is next made of how the pump discharge volumetric flow Q_v is here controlled when each motion is started. When a motion control valve is at its neutral position, the pressure switch 27 associated therewith is inoperative and no motion start sensing signal is received by the controller 28. This allows the controller 28 to determine that each motion control valve is at its neutral position and to permit the solenoid 23a of the electromagnetic proportional pressure reducing valve 23 to be supplied with the current at a predetermined magnitude I_0 (mA) continuing as shown in Fig. 4. With the solenoid 23a so energized, a rise in pressure at the output of the electromagnetic control valve 23 causes the torque control valve 21 to be displaced to take its feed position **b,** which in turn causes the control cylinder 19 to set or reduce the discharge volumetric flow of the pump 12 at or to a minimum as shown in Fig. 5.

[0038] Now, assume first that the traveling motion control valve 13 is intended and to be exclusively controlled as the sole pressure oil feed site for the vehicle that starts traveling. Then, the controller 28 judging this to be the case as mentioned above provides a signal that causes the current applied to the solenoid 23a of the electromagnetic proportional pressure reducing valve (EMPPRV) 23 to be reduced, as indicated by the solid line in Fig. 4., to the level I_1 slowly, e. g., taking a time period τ of 3.0 seconds. This switches the pilot pressure PILOTp at the output of the electromagnetic proportional pressure reducing valve 23 from the constant to a gradually reduced pressure form. As a result, the torque control position of the torque control valve 21 is slowly changed to its drain position **a,** thereby causing the pump discharge volumetric flow Q_V as indicated by the solid line in Fig. 5 to be increased slowly, or with a slowed pump discharge volumetric flow acceleration or at a slowed rate of the increase of the pump discharge volumetric flow Q_v. Thus, slowly increasing the rate of flow of pressure oil fed into the traveling motion oil hydraulic motor 16 diminishes the shock to the vehicle that starts traveling.

[0039] Assume next that the turning motion control valve 15 is intended and to be controlled exclusively as the sole pressure oil feed site for the upper vehicle body that starts to be turned, or that both the turning motion control valve 15 and the boom motion control valve 14_1 are to be controlled as joint pressure oil feed sites for the upper vehicle body that starts to be turned. Then, the controller 28 judging this to be the case as mentioned above provides a signal that causes the current applied to the solenoid 23a of the electromagnetic proportional pressure reducing valve (EMPPRV) 23 to be reduced, as indicated by the alternate long and short dash line in Fig. 4., to the level I_1 relatively rapidly (or at a moderate rate) , e. g., taking a time period τ of 2.0 seconds. This switches the pilot pressure PILOTp at the output of the electromagnetic proportional pressure reducing valve 23 from the constant to a relatively rapidly (or moderately) declined pressure form. As a result, the torque control position of the torque control valve 21 is changed relatively rapidly to its drain position **a,** thereby causing the pump discharge volumetric flow Q_V as indicated by the alternate long and short dash line in Fig. 5 to be increased at a moderate rate, or with a moderately slowed or quickened pump discharge volumetric flow acceleration or at a moderately slowed or quickened rate of the increase of the pump discharge volumetric flow Q_V. Thus, moderately or relatively rapidly increasing the rate of flow of pressure oil fed into the turning motion oil hydraulic motor 18 or each of the turning motion oil hydraulic motor 18 and the boom cylinder 8 diminishes to some extent the shock to the vehicle that starts traveling and also improves the action efficiency of the actuators.

[0040] Assume next that the boom motion control valve 14_1 is intended and to be exclusively controlled as the sole pressure oil feed site for the boom that starts to be swung. Then, the controller 28 judging this to be the case as mentioned above provides a signal that causes the current applied to the solenoid 23a of the electromagnetic proportional pressure reducing valve (EMPPRV) 23 to be reduced, as indicated by the alternate long and two short dashes line in Fig. 4., to the level I_1 rapidly, e. g., taking a time period τ of 0.1 second. This switches the pilot pressure at the output of the electromagnetic proportional pressure reducing valve (EMPPRV) 23 from the constant to a sharply declined pressure form. As a result, the torque control position of the torque control valve 21 is changed rapidly to its drain position **a,** thereby causing the pump discharge volumetric flow Q_v as indicated by the alternate long and two short dashes line in Fig. 5 to be increased rapidly, or with a quickened pump discharge volumetric flow acceleration or at a quickened rate of the increase of the pump discharge volumetric flow Q_v. Thus, rapidly increasing the rate of flow of pressure oil fed into the boom cylinder 8 improves the action efficiency of the boom actuator.

[0041] If a actuator other than those mentioned actuator, e.g., the arm cylinder 9, is to be controlled in its starting action, then the controller 28 effects therefor the same control as mentioned above for the exclusive boom motion control. In Fig. 3, AM_{MSS} is the sensing signal from the pressure switch associated with the arm motion pilot valve 252.

[0042] Now, in response to the disappearance of the sensing signal that has been received from the pressure sensor 27, the controller 28 judges the motion to have come to a halt and provides a signal that causes the current applied to the solenoid 23a of the electromagnetic proportional pressure reducing valve (EMPPRV) 23 to be increased, as indicated by the alternate long and two short dashes line in Fig. 6., to the level I_0 rapidly, e. g., taking a time period T of 0.1 second. This causes the pilot pressure at the output of the electromagnetic proportional pressure reducing valve 23 to rise rapidly to a high pressure, and in turn the pump discharge volumetric flow Q_v to be reduced rapidly as indicated by the alternate long and two short dashes line in Fig. 7. Alternatively, the controller 28 may provide a signal that causes the current applied to the solenoid 23a of the electromagnetic proportional pressure reducing valve (EMPPRV) 23 to be increased to the level I_0 slowly, e. g., taking a time period τ of 3.0 seconds, and in turn the pump discharge volumetric flow Q_v to be reduced slowly.

[0043] The discharge volumetric flow of the variable delivery oil pressure pump may also be controlled in response to a change in the engine speed, of which mention is made next. As mentioned previously, the torque control valve 21 acts to control the pump discharge volumetric flow of the variable delivery oil pressure pump 12 in accordance with the pump's discharge pressure so that the pump 12 has a preset torque absorption value which is set up in accordance with output state of the engine 11. Then, for example, the torque absorption as shown in Fig. 8 is preset for a rated torque B on the torque curve A of an engine 11 driving in the full power, and the engine speed at the rated torque B is sensed by an engine speed sensor 29 and stored in the controller 28 as a preset engine speed or number of revolutions N_1. A rapid increase in the load on the traveling motion oil hydraulic motor 16, a working machine actuator 17 or the turning motion oil hydraulic motor 18 brings about a rise in the discharge pressure of the pump 12, which in turn makes the actual torque absorption in excess of the preset torque absorption or rated torque. Then, the engine speed of the engine 11 drops to a number of revolutions N_2 corresponding to the torque absorption C then increased.

[0044] The engine speed sensor 29 senses the N_2 and provides a DOWN (engine speed down) signal for the controller 28, which upon judging a drop of the engine speed below the preset value to have occurred, provides a signal for increasing the current to energize the solenoid 23a, thereby turning the pilot pressure at the output of the electromagnetic proportional pressure reducing valve 23 to an elevated pressure. This results in a decrease in the discharge volumetric flow of the pump 12, which in turn reduces the torque absorption and makes it smaller successively towards the rated torque B. With this, the engine speed of the engine 11 rises successively.

[0045] As shown in Fig. 8, the torque absorption may drop to D below that corresponding to the rated torque B. Then, the engine speed rises to N_3 greater than its preset value N_1. In receipt of an UP (engine speed up) signal from the engine speed sensor 29 indicating that the preset engine speed N_2 is exceeded, the controller 28 judges this to be the case as mentioned above and provides a signal for decreasing the current to energize the solenoid 23a, thereby turning the pilot pressure at the output of the electromagnetic proportional pressure reducing valve 23 to a reduced pressure. Consequently, the pump discharge volumetric flow of the pump 12 is increased and the torque absorption is increased as opposed to the case mentioned above. In this way, the engine speed is controlled so as to be maintained constant at N_1.

[0046] The way of increasing the current to energize the solenoid 23a as mentioned above is to increase the amount of its addition per unit time, namely to increase the current rapidly. For example, the amount of the current added per unit time may here be 1000 mA/sec. This permits the pilot pressure from the electromagnetic proportional pressure reducing valve 23 to be rapidly increased, the torque control valve 21 to be rapidly displaced to take its feed position **b**, the pump discharge volumetric flow of the pump 12 to rapidly decrease and the rate of decrease of the pump discharge volumetric flow to be fast and hence the toque absorption to rapidly drop. Also, the way of decreasing the current to energize the solenoid 23a as mentioned above is to decrease the amount of its reduction per unit time, namely to decrease the current slowly. For example, the amount of the current reduced per unit time may here be 100 mA/sec. This permits the pilot pressure from the electromagnetic proportional pressure reducing valve 23 to be slowly decreased, the torque control valve 21 to be slowly displaced to take its drain position **a**, the pump discharge volumetric flow of the pump 12 to slowly increase and the rate of increase of the pump discharge volumetric flow to be slow and hence the toque absorption to slowly rise. These ways of changing the current may prevent the torque absorption from repetitively increasing and decreasing a number of times and thus from hunting, about the preset value, and permit returning the former to the latter quickly.

[0047] It follows, therefore, that when the work vehicle is traveling with the traveling motion control valve 13 set to be controllable as the sole pressure oil feed site, the torque absorption of the variable delivery oil pressure pump 12 if it becomes greater than a preset value set up in accordance with output state of the engine 11 is effectively prevented from repetitively increasing and decreasing a number of times about such a preset value, namely from hunting.

[0048] Accordingly, since the engine speed is also prevented from hunting about its prescribed value, the speed of revolutions of the variable delivery oil pressure pump 12 is likewise prevented from hunting. And, since the speed of revolutions of the traveling motion oil hydraulic motor 16 is prevented from hunting, the speed of travel of the oil hydraulic shovel (work vehicle) is likewise prevented from hunting.

Claims

1. An upper structure turning work vehicle comprising:

a variable delivery oil pressure pump (12) adapted to be driven by an engine (11), said variable delivery oil pressure pump having its pump discharge volumetric flow controllable;
a torque control valve (21) for controlling the pump discharge volumetric flow of said variable delivery pressure pump (12) in accordance with a pump discharge pressure thereof so that a torque absorption of said variable delivery oil pressure pump (12) becomes a preset value;
an electromagnetic proportional pressure reducing valve (23) for providing a pilot pressure and imparting it to said torque control valve (21) to cause the latter to change its torque control position;
a controller (28) for acting on said electromagnetic proportional pressure reducing valve (23) to control said pilot pressure;
a vehicle traveling motion oil hydraulic motor (16) ;
a vehicle traveling motion control valve (13) for feeding said vehicle traveling motion oil hydraulic motor (16) with discharge pressure oil from said variable delivery oil pressure pump (12);
a vehicle working machine actuator (17);
a vehicle working motion control valve (14) for feeding said vehicle working machine actuator (17) with discharge pressure oil from said variable delivery oil pressure pump (12); and
motion control valve operation sensing means (27) for sensing respective switching operations of said vehicle traveling motion control valve (13) and said vehicle working motion control valve (14) to provide signals indicative thereof for said controller (28), said signals including a vehicle traveling motion start signal and a vehicle working motion start signal derived from the switching operations of said vehicle traveling motion and working motion control valves (13 and 14), respectively, wherein:

in response to said vehicle working motion start signal from said motion control valve operation sensing means (27) for said vehicle working control valve (14), said controller (28) is adapted to furnish said electromagnetic proportional pressure reducing valve (23) with a first electromagnetic proportional pressure reducing valve control signal for producing said pilot pressure in the form of a rapidly decreasing pressure to cause said torque control valve (21) to be rapidly displaced to take the pump discharge volumetric flow increasing position whereby the pump discharge volumetric flow from said pump (12) into said vehicle working motion control valve (14) is rapidly increased, and
in response to said vehicle traveling motion start signal from said motion control valve operation sensing means (27) for said vehicle traveling motion control valve (13), said controller (28) is adapted to furnish said electromagnetic proportional pressure reducing valve (23) with a second electromagnetic proportional pressure reducing valve control signal for producing said pilot pressure in the form of a slowly decreasing pressure to cause said torque control valve (21) to be slowly displaced to take said pump discharge volumetric flow increasing position whereby the pump discharge volumetric flow from said pump (12) into said vehicle traveling motion control valve (13) is slowly increased,

whereby the pump discharge volumetric flow of said variable delivery oil pressure pump (12) is rapidly increased and slowly increased, selectively when the work vehicle is set to start traveling or the work vehicle is set to start working, respectively.

2. An upper structure turning work vehicle as set forth in claim 1, further comprising an engine speed sensor (29) for sensing an engine speed of said engine (11) and providing said controller (28) with an engine signal indicative thereof, wherein;

in response to such an engine speed signal indicating that the engine speed comes down below a preset engine speed while the vehicle is traveling and/or the working machine is actuated, said controller (28) is adapted to furnish said electromagnetic proportional pressure reducing valve (23) with a third electromagnetic proportional pressure reducing signal for producing said pilot pressure in the form of a rapidly increasing pressure to cause said torque control valve (21) to be rapidly displaced to take a pump discharge volumetric flow decreasing position whereby the pump discharge volumetric flow from said pump (12) is rapidly decreased, and
in response to such an engine speed signal indicating that the engine speed comes up above such a preset engine speed, the controller (28) is adapted to furnish said electromagnetic proportional pressure reducing valve (23) with a fourth electromagnetic proportional pressure reducing signal for producing said pilot pressure in the form of a slowly increasing pressure to cause said torque control valve (21) to be slowly displaced to take the pump discharge volumetric flow increasing position whereby the pump discharge volumetric flow from said pump (12) is slowly decreased

whereby a change of the engine speed from a preset engine speed while the work vehicle is traveling and/or working causes the pump discharge volumetric flow of said variable delivery oil pressure pump (12) to be rapidly decreased or slowly increased, selectively according to the direction in which that change occurs.

FIG. 1

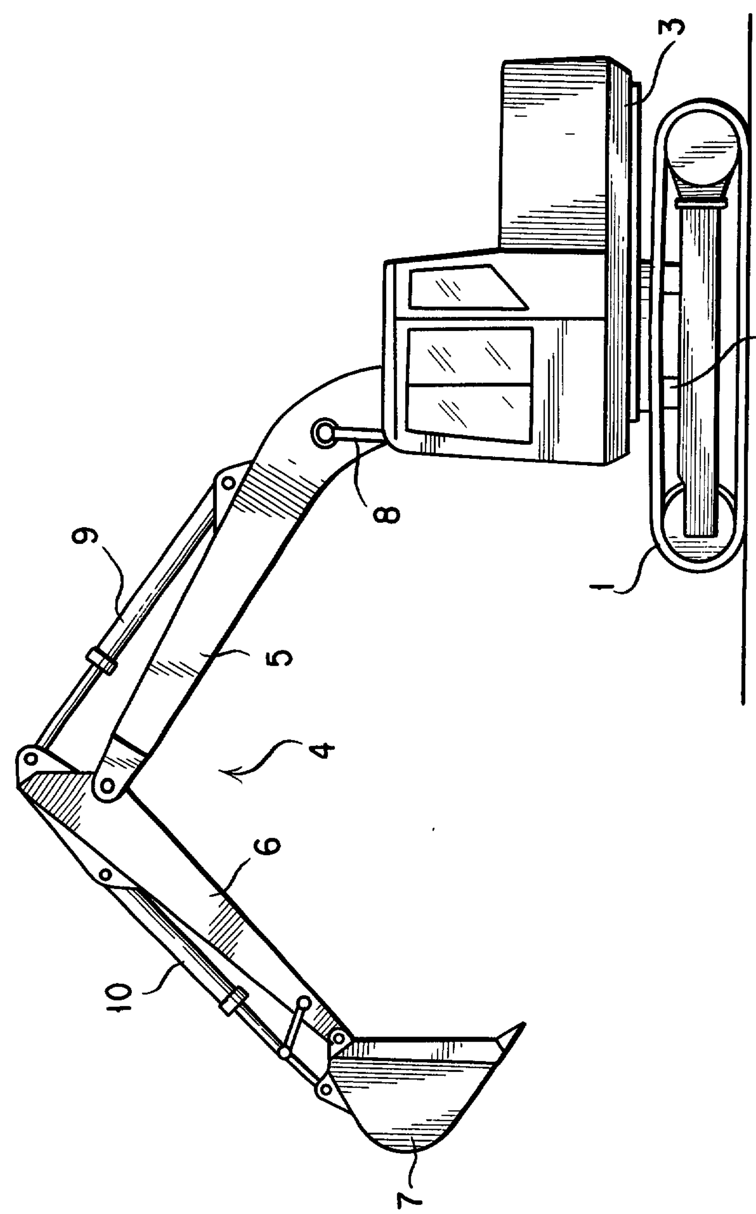


FIG. 2

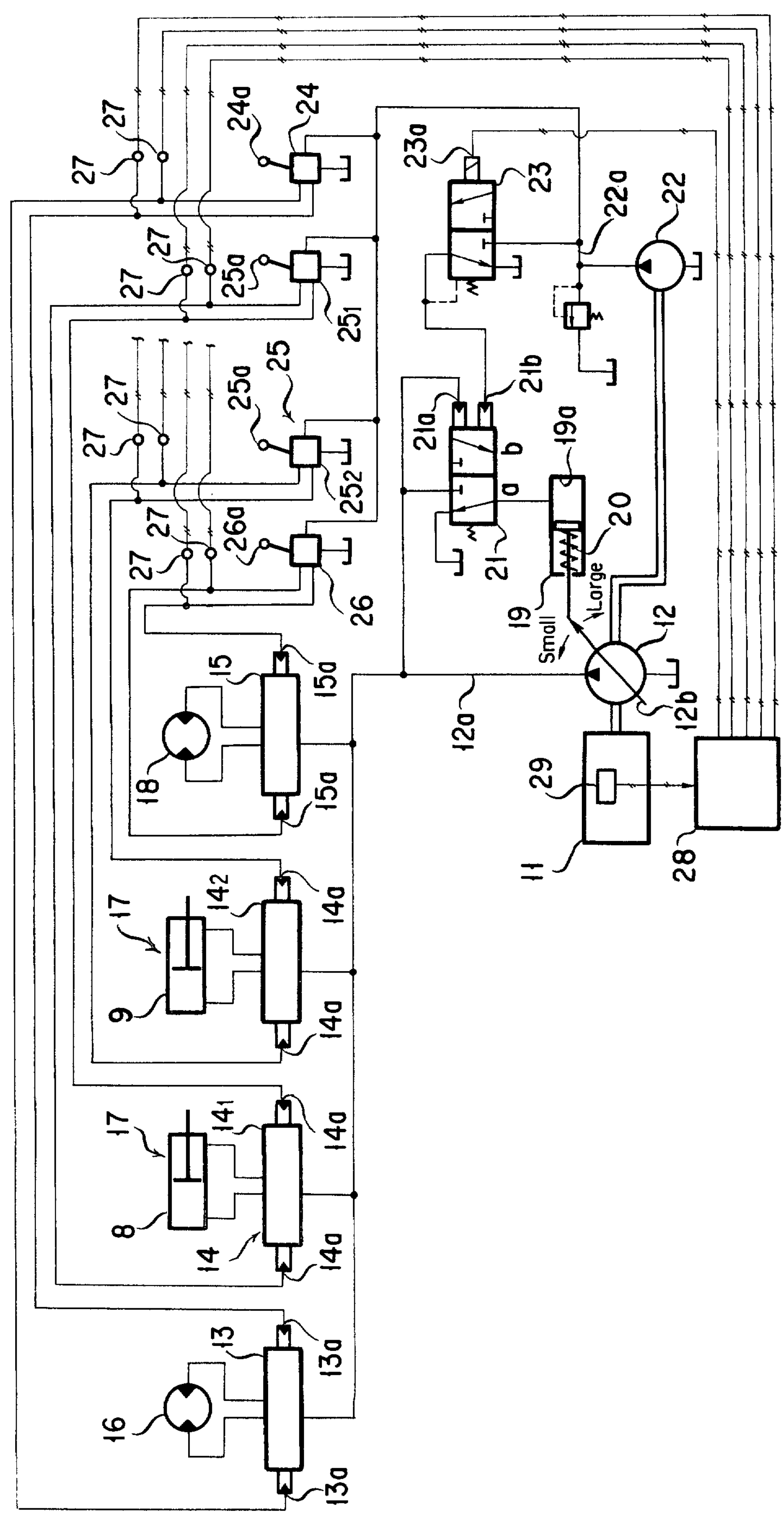


FIG. 3

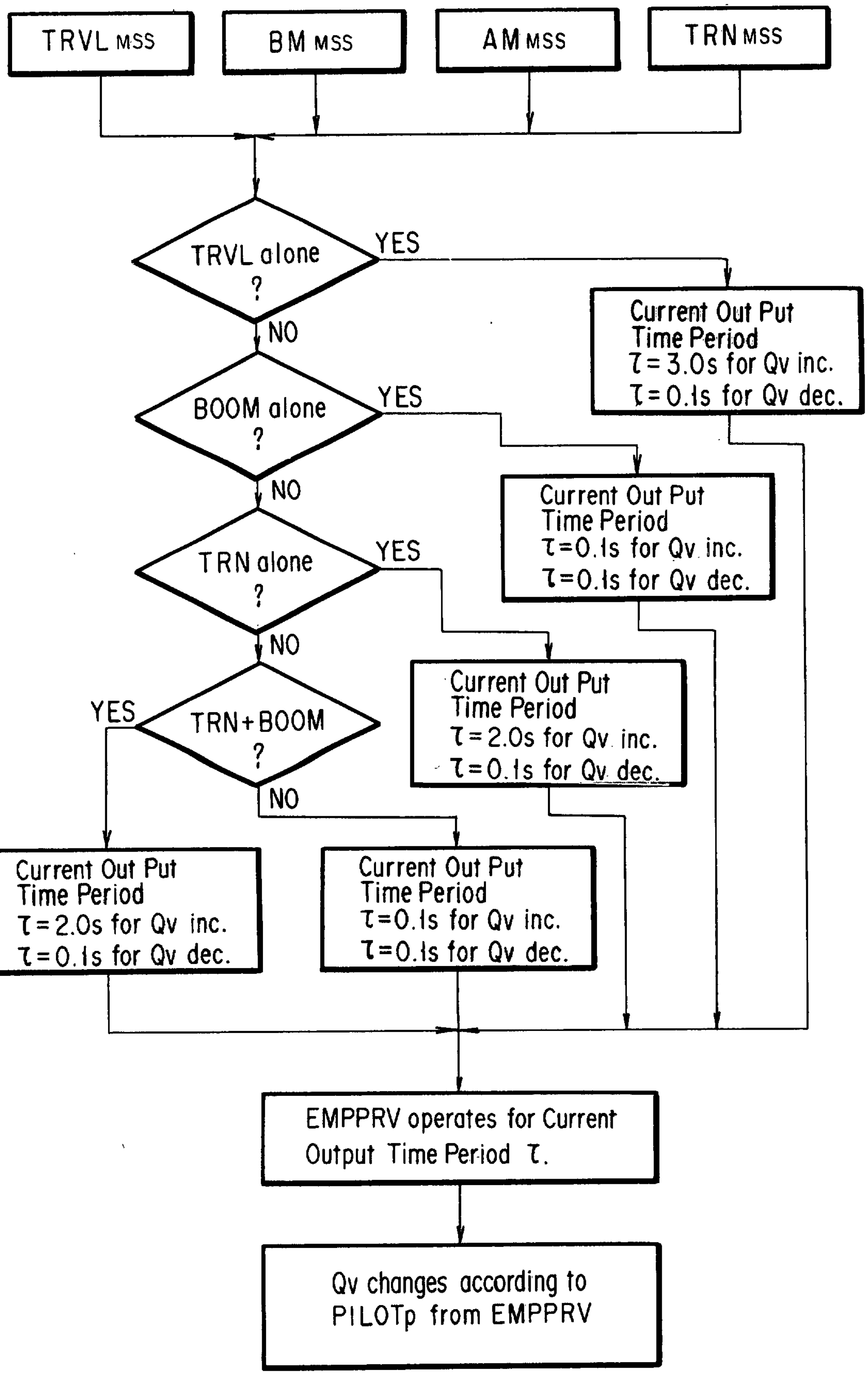

TRVL MSS
BM MSS
AM MSS
TRN MSS
TRVL alone ?
YES
NO
Current Out Put Time Period τ = 3.0s for Qv inc. τ = 0.1s for Qv dec.
BOOM alone ?
YES
NO
Current Out Put Time Period τ=0.1s for Qv inc. τ=0.1s for Qv dec.
TRN alone ?
YES
NO
Current Out Put Time Period τ = 2.0s for Qv inc. τ = 0.1s for Qv dec.
TRN+BOOM ?
YES
NO
Current Out Put Time Period τ = 2.0s for Qv inc. τ = 0.1s for Qv dec.
Current Out Put Time Period τ=0.1s for Qv inc. τ=0.1s for Qv dec.
EMPPRV operates for Current Output Time Period τ.
Qv changes according to PILOTp from EMPPRV

FIG. 4

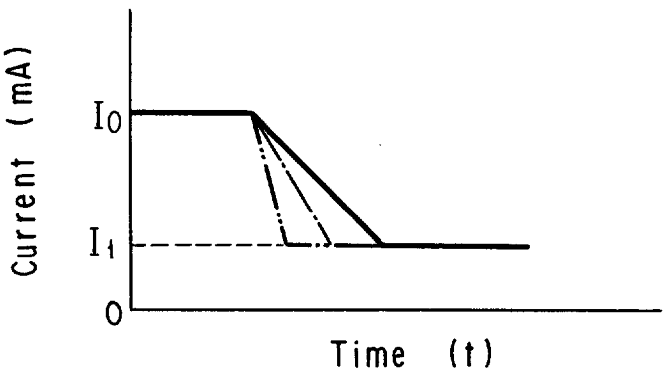

Current (mA)
I_0
I_1
0
Time (t)

FIG. 5

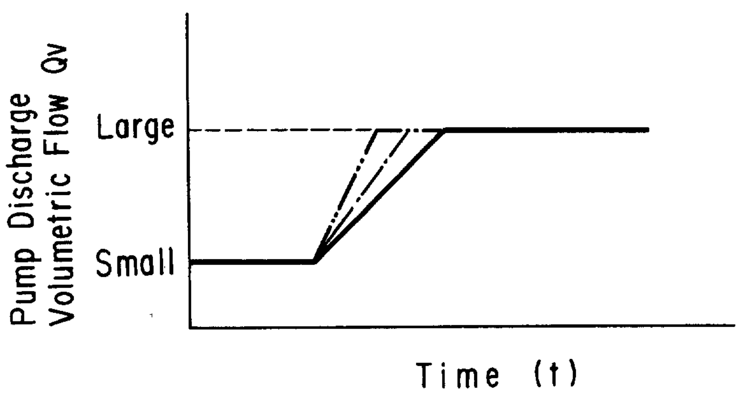

Pump Discharge
Volumetric Flow Qv
Large
Small
Time (t)

FIG. 6

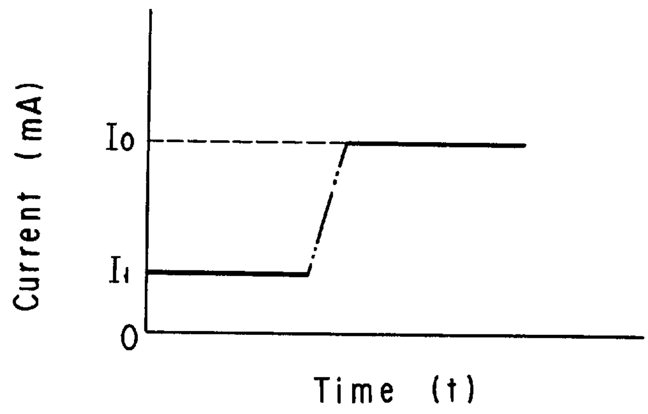

Current (mA)
I0
I1
0
Time (t)

FIG. 7

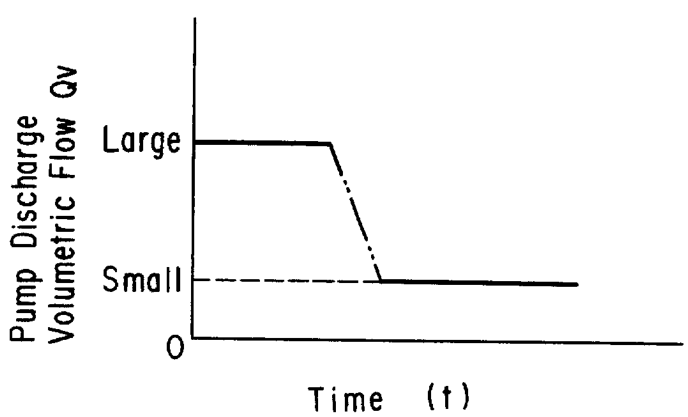
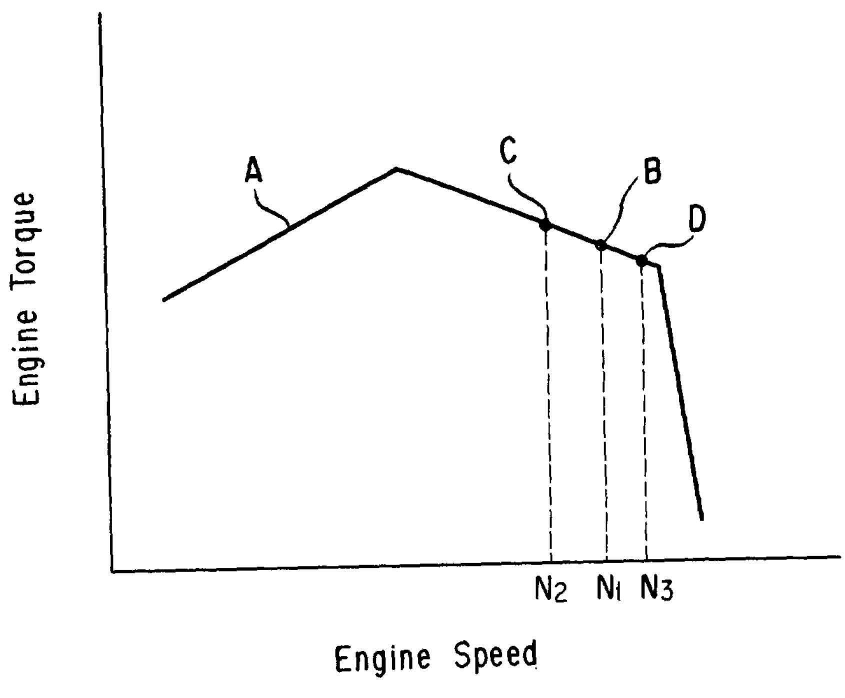

Pump Discharge
Volumetric Flow Qv
Large
Small
0
Time (t)

FIG. 8



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EUROPEAN SEARCH REPORT

Application Number
EP 02 02 7168

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	US 5 996 341 A (TOHJI YUTAKA) 7 December 1999 (1999-12-07) * abstract * * figures 1,6,7 * * column 4, line 27 - line 38 * * column 5, line 34 - column 6, line 17 * ---	1,2	E02F9/22
A	EP 0 644 335 A (HITACHI CONSTRUCTION MACHINERY) 22 March 1995 (1995-03-22) * figure 10 * * second embodiment * ---	1,2	
A	US 6 308 516 B1 (KAMADA SEIJI) 30 October 2001 (2001-10-30) * figures 1,11A,13E,14A,21A * ---	1,2	
A	US 6 209 322 B1 (ENDO HIROSHI ET AL) 3 April 2001 (2001-04-03) * figures 5,8 * ---	1,2	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	10 February 2003	Guthmuller, J

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