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(54) Earth moving machine

(57) An earth moving apparatus (10) having a base (11) including a ground engaging propulsion means (12,13) whereby the apparatus (10) may move over the ground, first hydraulic actuator means (60,61) to drive the ground engaging propulsion means (12,13), a body (15) carried on the base (11), second hydraulic actuator means (65) for moving the body (15) relative to the base (11) about a first generally upright axis (A), a working arm (21) connected at or towards one end (25) thereof to the body (15), third actuator means (26) for moving the working arm (21) relative to the body (15) about a second generally upright axis (B) and fourth hydraulic actuator means (28) for moving the working arm (21) relative to the body (15) about a first generally horizontal axis (C), and the working arm (21) carrying at or towards a second outer end (29) thereof, an earth working implement (30), fifth hydraulic actuator means (31) to move the working implement (30) about a second generally horizontal axis (D), characterised in that the first, second, third, fourth and fifth hydraulic actuator means are in use, provided with pressurised hydraulic fluid by a single variable displacement pump (43).

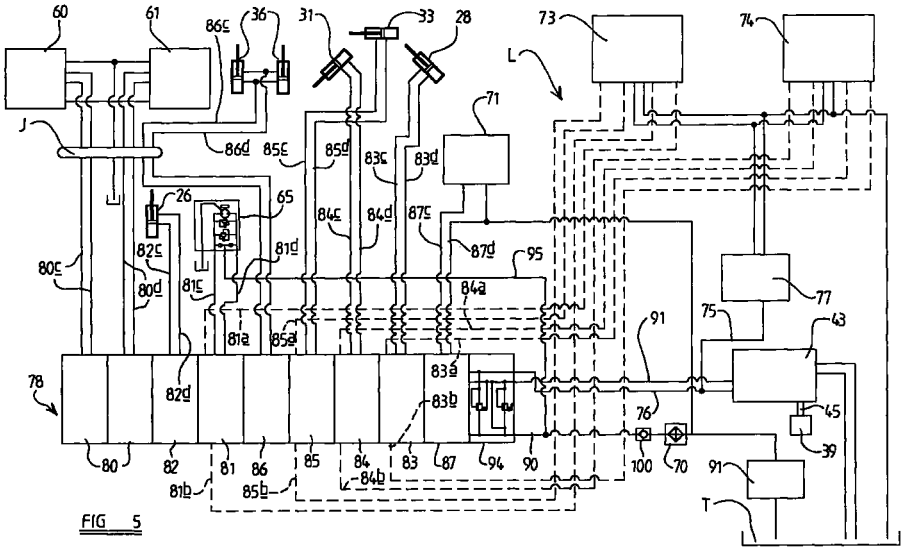


FIG 5

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Description

[0001] This invention relates to an earth moving apparatus and more particularly to such an apparatus of the kind adapted to move over the ground, and having a working arm with an earth working implement. Such apparatus are well known.

[0002] One particular type of such apparatus is known as a "mini-excavator" because of its relatively small size and the ability of the working arm to be used for excavating e.g. in relatively confined conditions. Such an apparatus typically has a body mounted for pivotal slewing movement on a base, the base having wheels, tracks or other ground engaging propulsion means, and the working arm being carried on the body for swinging movement about a generally upright axis, e.g. on a king post. The body typically mounts an operator's cab, from which cab an operator may drive the apparatus over the ground, and control the operating functions of the working arm and other services.

[0003] The working arm typically is mounted at a front end of the body and an engine of the apparatus, which powers the apparatus, is usually mounted at or towards a rear end of the body, to act as a counterweight to the working arm. An additional counterweight may be provided at the rear end if desired.

[0004] Such apparatus are often required to work in relatively confined conditions. In many known apparatus of the kind with which the invention is concerned, slewing movement of the body about the pivot axis relative to the base requires a clearance adequate to accommodate the rear of the swinging body.

[0005] So called "zero swing" apparatus are known in which the body may be pivoted relative to the base without any body part extending outwardly of the base. However necessarily such apparatus have a small (short) operator's cab which in many case do not comply with European standards at least. In order to accommodate the engine in such zero swing machines, it is known to arrange the engine at a rear corner of the body.

[0006] In another arrangement, the engine could be positioned more centrally of the apparatus, but this would require the operator's cab to be raised up to accommodate the engine beneath, but this is undesirable because there would then be a height restriction detrimental to the usefulness of the apparatus, and the operator may be too high efficiently to operate the working arm.

[0007] Another requirement for a small excavator which is intended to work in confined conditions, is that there is adequate visibility for the operator. It is particularly desirable for the operator to be able to see the extremities of the body, at least to the front of the operator. Where the engine is mounted at the rear of the body, any body part to the side of the operator's cab can be shaped to allow such visibility.

[0008] Thus it will be appreciated that in designing an earth moving apparatus, compact and efficient positioning of the components thereof is an essential design consideration.

[0009] An earth moving apparatus of the kind with which the invention is concerned typically has other hydraulically operated services too, such as for examples a dipper arm at the outer end of which there is provided the excavating bucket or other tool which may also be hydraulically operated, an earth moving or "dozer" blade which is extendible/retractable and/or raisable and lowerable, for pushing earth or other ground material, and other auxiliary services too.

[0010] The fluid pressure and volume requirements for a fluid operated actuator designed to move e.g. a working arm relative to a body of an earth moving apparatus about an upright axis for example, are substantially different to the requirements of a fluid operated transmission for powering a ground engaging propulsion means. Hithertofore, it has been common practice for a variable displacement fluid pump to be provided for providing pressurised fluid for a first set of the hydraulic actuating means, such as for driving the ground engaging propulsion means, operating the working implement at an outer end of the working arm, for moving the working arm relative to the body about a generally horizontal axis, and for moving a dipper of the working arm relative to a boom of the working arm, about another generally horizontal axis, but for there to be a separate pump, such as a gear pump driven from an output shaft of the engine, to provide pressurised fluid for another, second set of, services such as the actuator or actuators of an earth moving blade, actuator means for moving the working arm relative to the base about an upright axis, and actuator means for moving the body relative to the base about an upright axis.

[0011] Thus the first set of services for which hydraulic fluid is provided from the variable displacement pump may be operated without affecting the supply of hydraulic fluid to the second set of services to which hydraulic fluid is provided from the auxiliary pump.

[0012] However, two such separate pumps each require space. Where the separate pump is driven from the engine output shaft, from which the variable displacement pump too is driven, a substantial longitudinally extending space would be required to accommodate the variable displacement and auxiliary pumps. Such space may not readily be available in the case of a small excavator, and particularly but not exclusively so in the case of an apparatus in accordance with which the present invention is concerned.

[0013] According to a first aspect of the invention we provide an earth moving apparatus having a base including a ground engaging propulsion means whereby the apparatus may move over the ground, first hydraulic actuator means to drive the ground engaging propulsion means, a body carried on the base, second hydraulic actuator means for moving the body relative to

the base about a first generally upright axis, a working arm connected at or towards one end thereof to the body, third actuator means for moving the working arm relative to the body about a second generally upright axis and fourth hydraulic actuator means for moving the working arm relative to the body about a generally horizontal axis, and the working arm carrying at or towards a second outer end thereof, an earth working implement, fifth hydraulic actuator means to move the working implement about a second generally horizontal axis, characterised in that the first, second, third, fourth and fifth hydraulic actuator means are provided with pressurised hydraulic fluid by a single variable displacement pump.

[0014] Thus no separate pump is required to provide pressurised fluid for driving the second or third hydraulic actuating means, although a hydraulic fluid control means will be required for controlling the delivery of pressurised fluid to the various actuator means when required from the variable displacement pump, which ensures that there is no or minimal interference with the operation of any one of the actuator means when another of the actuator means is operated.

[0015] The hydraulic pump to provide pressurised hydraulic fluid is preferably mounted in an engine compartment of the apparatus, preferably between the engine and a first end of the body, so as to be drivable directly from the engine.

[0016] The body may be movable relative to the base about the first generally upright axis, through substantially 360°, through a datum position in which the first end of the body is at a front end of the base.

[0017] The ground engaging means of the apparatus preferably includes a pair of tracks, each track of the pair being positioned at a side of the base, whereby edges of the tracks define the width of the base and hence of the apparatus at least when the body is in its datum position.

[0018] The working arm may include a boom mounted on the body, and a dipper which is adapted to carry the working implement, the dipper being movable relative to the boom about a third generally horizontal axis, by sixth hydraulic actuator means to which pressurised hydraulic fluid may be provided from the variable displacement pump, via the fluid control means.

[0019] The apparatus may further include an earth moving blade which is mounted on the base, and there is a seventh hydraulic actuator means for causing up and down movement of the blade about a fourth generally horizontal axis, in which case, to avoid providing a separate pump, the seventh actuator means may be provided with pressurised hydraulic fluid for operation, from the variable displacement pump, via the hydraulic fluid control means.

[0020] By virtue of a single variable displacement pump being used to provide hydraulic fluid for all of the services, greater flexibility in the design of the apparatus is thus possible, facilitating the positioning of the engine in the compartment at or towards the side of the body.

[0021] In a preferred embodiment the variable displacement pump is arranged to supply a stand-by flow of pressurised fluid when all of the hydraulic actuator means are de-activated. Where the pump is a swashplate pump a stop means may conveniently be provided to prevent the swashplate moving to a fully unloaded position.

[0022] In each case, unloading valve means may be provided to permit the stand-by flow to be communicated to a fluid return line of the fluid control means and to prevent the flow of fluid to the fluid return line when a fluid actuating means is operated.

[0023] To prevent such stand-by flow simply being dumped to tank, means may be provided to maintain the fluid pressure in the fluid return line above a minimum pressure.

[0024] Where the first actuator means includes a hydraulic motor, the stand-by flow may be communicated to the hydraulic motor to assist in braking the momentum of the rotating body when the first actuator means is de-activated.

[0025] Preferably means are provided to prevent the variable displacement pump from providing fluid at its maximum operating pressure in the event that the first and/or second actuator means is operated in combination with at least one of the third, fourth and fifth actuator means.

[0026] The invention will now be described with reference to the accompanying drawings in which:-

FIGURE 1 is a side view of an earth moving apparatus in accordance with the invention, showing a body thereof in a datum position relative to a base;
FIGURE 2 is an opposite side view of the apparatus of figure 1;
FIGURE 3 is a side view of the apparatus of figures 1 and 2 but with the body moved with respect to the base so as to present a rear view of the body;
FIGURE 4 is a front view of the apparatus of figures 1 to 3, with the body in the same position relative to the base as in figure 3;
FIGURE 5 is a diagram of a hydraulic circuit which may be provided in the apparatus of the previous figures;
FIGURE 5a shows part of the diagram of figure 5 but to an enlarged scale;
FIGURE 6 is a simplified diagrammatic illustration for help in understanding principles of operation of the diagram of figures 5 and 5a.

[0027] Referring to the drawings an earth moving apparatus 10 of the kind generally known as a "mini" excavator is shown. By "mini" we mean an excavator having a weight of between 1 and 6 tons. However the invention may be applied to a so called "micro" excavator, which typically has a weight of up to one ton, and to

a so called "midi" excavator which typically has a weight of between 6 and up to about 10 tons.

[0028] The apparatus 10 shown in the drawings comprises a base 11 having a ground engaging propulsion means, which in this example includes a pair of tracks 12,13, one positioned at each side of the base 11. The tracks 12,13 are driven by through a transmission by first hydraulic fluid operated actuator means, such as a pair of hydraulic motors 60,61 for example. On the base 11 there is a body 15, which is mounted so as to be slewable, in this example fully rotatable, about a first generally upright axis A with respect to the base 11, about 360°, by means of a second hydraulic actuator means, e.g. a further hydraulic motor 65 or other hydraulic motive means.

[0029] The body 15 further comprises a full size operator's cab 18, by which we mean a cab 18 which complies with European standards for size. From the cab 18, an operator, when seated on a seat 16 therein, may control the apparatus 10 by operating controls.

[0030] In figures 1 and 2, the body 15 is shown in a datum position relative to the base 11, i.e. with the body 15 facing forwardly of the direction of travel of the apparatus using the tracks 12,13, and with an operator in the cab 18 facing forwardly.

[0031] At a first, front, end 20 of the body 15, there is mounted a working arm 21, which in this example comprises a boom 22 and a dipper 24. As is usual with so called "micro", "mini" and "midi" excavators, the boom 22 is mounted at one end 25 thereof to the body 15 in a manner to permit of swinging movement of the arm 21 about a second generally upright axis B, e.g. by virtue of a king post 17 mounting, as well as lifting and lowering movement of the arm 21 about a first generally horizontal axis C.

[0032] Standard excavators, i.e. excavators having a weight above about 10 tons which are designed for heavier duty excavating work, usually have a working arm which is liftable and lowerable, but not swingable as is the working arm of a "micro", "mini" or "midi" excavator, as is it not so essential that a standard excavator is capable of working in such a versatile manner in confined conditions.

[0033] Referring again to the drawings, swinging movement of the arm 21 about the second generally upright axis B is achieved by third hydraulic actuator means which in this example is one or a pair of hydraulic fluid operated linear actuators 26, and lifting and lowering of the arm 21 about axis C is achieved by a fourth hydraulic actuator means which in this example is a single hydraulic fluid operated linear actuator 28, the actuators 26, 28 acting between the body 15 and the arm 21.

[0034] At a free end 29 of the dipper 24, there is provided a working implement comprising in this example an excavating bucket 30, but in another example may be a hammer or drill attachment which is hydraulically operated. The bucket 30 is movable with respect to the dipper 24 about a second generally horizontal axis D, by means of a fifth hydraulic actuator means which in this example is a linear actuator 31. The dipper 24 and boom 22 are pivotally connected for movement about a third generally horizontal axis E, by means of a sixth hydraulic actuator means which in this example is yet another hydraulic fluid operated linear actuator 33.

[0035] The apparatus 10 further comprises a dozer blade 35 mounted on the base 11 which blade 35 is movable up and down about a fourth generally horizontal axis F by means of seventh hydraulic actuator means which in this example again comprises a pair of linear actuators 36.

[0036] It can be seen from figure 3 that the operator's cab 18 is provided at one side S1 of the body 15. At an opposite side S2 of the body 15 there is provided an engine compartment 38 which houses an engine 39, the position of which is indicated in figures 2 and 4. The engine 39 has a length dimension L and is arranged generally longitudinally so that the engine 39 occupies a minimum width of the body 15. By arranging the operator's cab 18 to one side S1 of the body 15 rather than centrally as is typically the case with smaller excavators, and with the engine 39 arranged generally longitudinally, the overall width W of the body 15 can be maintained at a minimum. Preferably with the body 15 in the datum position shown in figures 1 and 2, no part of the body 15 extends widthways beyond the base 11, so that edges of the tracks 12,13 of the base 11 define the full width of the apparatus 10.

[0037] Because the engine 39 is mounted to the side of the cab 18, the overall length of the body 15 can be minimised without compromising the body length space available for the operator's cab 18. It is desirable though for the cab 18 not to be positioned too far rearwardly of the body 15, or else this can leave the cab 18 vulnerable to damage in the event that the body 15 is slewed about axis A too close to an obstacle, as the cab 18 rather than a rear body part could strike the obstacle. Also, accommodation is still required for other operating parts of the apparatus 10

[0038] Accordingly in the apparatus of the invention, behind the operator's cab 18 and engine 39, at a rear end 41 of the body 15, there is provided a compartment 40 which is of small capacity compared to the capacity of engine compartment 38. The rear compartment 40 is used to house hydraulic equipment for which there is insufficient room in the engine compartment 38. For example, the rear compartment 40 may have within it a hydraulic fluid cooling pack 70, including a radiator for cooling the fluid, and other hydraulic equipment. However a hydraulic pump 43 is provided in the engine compartment 38 as described hereinafter in more detail.

[0039] The rear compartment 40 is provided by bodywork and thus in the event that the body 15 is slewed about axis A too close to an obstacle, the bodywork rather than the cab 18 will strike the obstacle, thus

providing some protection for the cab 18.

[0040] It will be appreciated that conventionally, the engine 39 of the apparatus, where mounted at the rear 41 of the body 15 will provide some counterweighting for the working arm 21, but by providing the engine 39 to the side of the cab 18, this counterweighting is reduced. In the apparatus 10 shown, a part of a rear bodywork wall 42 of the rear compartment 40 is provided by a counterweight 44 which is shaped to a desired body contour and thus is an integral part of the body 15. The counterweight 44 extends across the rear end 41 of the body 15 and around the sides S1, S2 in this example. The counterweight 44 is typically of cast iron or similar heavy material, and counterbalances the working arm 21 and any load imposed on the working arm 21 in use, as well as providing a tough primary surface to strike an obstacle in the event that the body 15 is slewed about axis A too close to the obstacle..

[0041] In a conventional small excavating machine, i.e. a machine smaller than a standard machine, a hydraulic pump, usually a variable capacity hydraulic pump such as a swashplate pump, is used to provide a source of pressurised hydraulic fluid for some of the services of the machine, such as the first actuating means which drives the ground engaging propulsion means, the fourth actuating means i.e. actuator 28, the fifth actuator means i.e. actuator 31, and the sixth actuator means i.e. the dipper actuator 33. In the apparatus 10 of the invention, a single variable displacement pump hydraulic pump 43 is provided which is driven directly from an output shaft 45 of the engine 39.

[0042] Conventionally, other services i.e. the second hydraulic actuator means 65 which slews the body 15 relative to the base 11, and the third actuator means i.e. actuators 26 which swing the working arm 21 relative to the body 15 about upright axis B, and the seventh actuator means i.e. actuators 36 which lift and lower the dozer blade 35 would be driven by a separate pump, such as a fixed displacement gear pump, again driven from the output shaft 45 of the engine 39. This separate pump would be typically located in line with the variable displacement pump 43, with the variable displacement pump 43 between the engine 39 and the auxiliary pump.

[0043] This is required because the various hydraulic actuator means each have different requirements as regards hydraulic fluid pressure and flow volume such that the operation of one of the hydraulic services can interfere with the proper simultaneous operation of others of the hydraulic services.

[0044] It will be appreciated from figure 2 of the drawings though, that because of the restricted space available within the engine compartment 38, there is inadequate room for such a separate pump to be provided at the end of the main variable displacement pump 43 at least without moving other components such as the battery, which is most conveniently situated there. Particularly, if an additional pump was provided in line with the engine 39, the overall engine 39, variable displacement pump 43 and auxiliary pump length would be so long that the compartment 38 would have to extend substantially forwardly thereby compromising the visibility of the operator in the cab 18, particularly of the front corner 46 which it is important for the operator to be able to see, for example during an excavating operation close to the base 11.

[0045] Thus in the present arrangement, the use of a separate pump is dispensed with, and the variable displacement hydraulic pump indicated at 43 is used to provide pressurised hydraulic fluid for each of the first to seventh actuator means.

[0046] To avoid interference with the operation of one service when another is operated a fluid control valve means is required which will retain the required pressure and/or flow to one or more selected actuator means in the event that another of the actuator means is operated or is stopped from operating.

[0047] To enable bodywork of the engine compartment 38 to be shaped as shown, so as to curve downwardly from a maximum height at a position 47 to the side of the operator when seated in seat 16 of the cab 18, towards the front corner position 46 of the body 15, the engine 39 is oriented with the output shaft 45 and thus variable displacement pump 43 extending forwardly. Thus an engine cooling apparatus 48 which typically comprises a bulky radiator 49 and a fan 50 to move cooling air over fins of the radiator 49, is positioned rearwardly of the engine 39 where the height required for this will not obstruct an operator's forward or side visibility. As indicated, the radiator 49 may extend rearwardly towards or even partially within the rear compartment 40.

[0048] Obviously if the engine 39 and cooling apparatus 48 were more rearwardly located than shown, the space available in the rear compartment 40 for housing other operating equipment would be compromised.

[0049] Referring again to the drawings, and in particular figure 3, preferably no part of the body 15 extends outwardly beyond the width W or length of the base 11 when the body 15 is in the datum position. Even when the body 15 is rotated about the first generally upright axis A from the datum position, preferably no part of the body 15 extends substantially outwardly of the base 11. The counterweight 44 is shaped to be rounded to maximise the clearance between the rear 41 of the body 15 and an adjacent obstacle during such movement.

[0050] Referring now to figures 5, 5a and 6, there is shown a hydraulic circuit which is adapted to enable a single variable displacement hydraulic pump 43 to be used to provide hydraulic fluid to each of the various hydraulic actuator means.

[0051] Within the operator's cab 18, operator controls may be provided for operating the hydraulic actuators. In this example, a pair of joystick type operator controls 73, 74 are mounted, one on each arm of the operator's seat 16, the operator controls 73,74 being

operable to operate various of the hydraulic actuator means described above via hydraulic control lines. Further manual controls (not shown) are provided for the first actuator means (track 12,13 drive motors 60,61) and for controlling boom 22 swing about upright axis B, and for lifting and lowering the dozer blade 35 and for providing auxiliary hydraulic flow as indicated at 71.

[0052] A hydraulic fluid control line 75 extends from a main pressure line 76 from the pump 43 via a pressure reducing valve means 77 to provide pressurised hydraulic fluid to each of the controls 73, 74, and depending on the positioning of the joystick controls 73, 74, hydraulic signals are sent via hydraulic control lines indicated generally at L, to a valve block 78 which includes a part 80 to 87 with a chamber containing a spool or spools for each control function. Those spools which are not hydraulically moveable as a result of the operation of controls 73, 74 are manually moveable.

[0053] The main pressure line 76 is connected to each of the valve block parts 80 to 87 within the valve block 78 in a circuit (not shown) whereby pressurised hydraulic fluid is fed to the respective spool-containing chambers of the valve block parts 80 to 87, which depending on the position of the spool or spools therein, may direct the fluid to a respective actuator means 60,61;65;26;28;31;33; and 36. Within the valve block 78 there is also a fluid return or neutral line 90 by means of which hydraulic fluid from the various actuators 60,61;65;26;28;31;33; and 36 or pumped fluid not required, is returned to tank T via the hydraulic fluid cooler 70, and a filter 91.

[0054] A foot and/or hand operated manual control not shown is provided in the operator's cab 18 which is separate from the joystick controls 73, 74, for controlling the first actuator means i.e. the track motors 60, 61 which may be adapted to operate either in high speed or low speed mode.

[0055] From the track motor control there are cables or the like mechanical couplings for moving the spool or spools within the valve block part 80 by means of which the right and left track motor 60,61 of the ground engaging tracks 12,13 can be controlled. Hydraulic fluid under pressure to drive the track motors 60, 61 is provided from the first part 80 of the valve block 78, when the control manually is appropriately operated, to the motors 60,61 through a rotary joint J, there being two pairs of operating lines 80c and 80d from the first part 80 of the valve block 78, one pair 80c, 80d for each track motor 60, 61.

[0056] The control lines L from the joystick controls 73, 74 are also arranged in pairs as will now more specifically be described. A pair 81a and 81b from the left control 73 are connected to an associated part 81 of the valve block 78 which contains a spool or spools for directing pressurised fluid from the main pressure line 76 to the second actuator means 65 i.e. the slew motor, depending on the position of the control 73. V/here a hydraulic signal is sent along line 81a to the valve block part 81 the spool/spools therein respond by allowing operating fluid from the main pressure line 76 from the pump 43 to be sent to the slew motor 65 along an operating line 81c to move the slew motor 65 in one direction of rotation, whereas a hydraulic signal sent along the line 81b to the valve block part 81 results in an operating fluid from the main pressure line 76 being sent to the slew motor 65 along another operating line 81d to move the slew motor 65 in an opposite direction of rotation. Operation of the slew motor will be described in more detail below.

[0057] A further manual control is provided in cab 18 by means of which an operator may control swing ram 26. Within a third part 82 of the valve block 78 a spool or spools may be moved therein by the manual control to direct operating fluid from the main pressure line 76 from the pump 43 to one or other of a pair of third fluid lines 82c, 82d to operate the second hydraulic actuator means or swing ram 26 to swing the boom 22 about second upright axis B under manual control.

[0058] A second pair of control lines 83a and 83b from the right joystick control 74 may send control hydraulic signals from the control 74 to a fourth part 83 of the valve block 78, to move a spool or spools therein to direct operating fluid from the main pressure line 76 to one or other of a pair of fourth fluid lines 83c, 83d to operate the fourth hydraulic actuator means or boom ram 28.

[0059] A third pair of control lines 84a and 84b from the right joystick control 74 may send control hydraulic signals from the control 74 to a fifth part 84 of the valve block 78 to move a spool or spools therein to direct operating fluid from the main pressure line 76 from the pump 43 to one or other of a pair of fifth operating fluid lines 84c, 84d to operate the fifth hydraulic actuator means or bucket/crowd ram 31 to operate the excavating implement 30.

[0060] A fourth pair of control lines 85a and 85b from the left joystick control 73 may send control hydraulic signals from the control 73 to a sixth part 85 of the valve block 78 to move a spool or spools therein to direct operating fluid from the main pressure line 76 from the pump 43 to one or other of a pair of sixth operating fluid lines 85c, 85d to operate the sixth hydraulic actuator means or dipper ram 33 to move the dipper 24 about axis D relative to the boom 22.

[0061] A yet further manual control may be provided in the cab 18 connected to a seventh part 86 of the valve block 78 to move a spool or spools therein to direct operating fluid from the main pressure line 76 from the pump 43 to one of a pair of seventh operating fluid lines 86c, 86d to operate the seventh hydraulic actuating means or dozer rams 36 to operate to earth moving shovel 35. The dozer rams 36, being provided on base 11 are fed with operating fluid via the rotating joint J.

[0062] In this example, in the event that the joysticks 73, 74 and other controls are moved or allowed to

move to an inoperative position such that each of the actuator means is de-activated, the pump 43 is arranged to respond by reducing the flow of fluid produced thereby and vice versa. For example in the case of a swashplate type variable displacement pump, the pump 43 senses a pressure in a load sensing line 91 and changes the angle of the swashplate accordingly to provide a pressure/flow to match the pressure/flow requirements of the fluid operating means as a whole. Where all the actuator means are de-activated i.e. at rest, usually, no flow results. As the pressure and flow requirement increases, for example as one or other of the hydraulic services is operated, the swashplate angle is changed to produce the desired flow/pressure for that or those services.

[0063] However a conventional slew motor of the kind shown at 65 requires a supply of hydraulic pressure when the motor 65 is de-activated, in order to brake the momentum of the rotating body 15. Otherwise, the slew motor 65 could well cavitate causing premature motor wear and presenting possible danger. In a conventional earth moving apparatus 10 where the slew motor 65, and conventionally the swing ram 26 and dozer rams 36 are driven from a fixed displacement pump, a supply of pressurised hydraulic fluid will always be available. Where a single variable displacement pump 43 is provided as in the present invention, provision needs to be made to provide a supply of pressurised fluid to feed the slew motor 65 to brake the momentum of the rotating body 15, particular where no other service is calling for hydraulic fluid, so that the swashplate angle moves towards an unloaded position e.g. as follows.

[0064] In accordance with the invention the variable displacement pump 43 is adapted always to provide a supply of pressurised fluid even when no hydraulic service is calling for such fluid (i.e. the various controls are all in a rest condition). In the case of a swashplate pump 43, this may simply be achieved by providing a stop to prevent the swashplate assuming a fully unloaded position, or zero angle. The pressurised fluid thus produced in main supply line 76 is fed via an unloading valve 94 into the neutral line 90 from where the pressurised fluid is transmitted back via neutral or return line 95 from the slew motor 65, to the slew motor 65. Such supply may feed anti-cavitation valves 96, 97 associated with the slew motor 65 to prevent cavitation and to enable the momentum of the rotating body 15 to be braked.

[0065] To prevent the pressurised fluid thus communicated to the neutral line 90 simply being dumped to tank T, in the return line 90, upstream of the hydraulic fluid cooler 70 there is provided a check valve 100 which is set to maintain a fluid pressure in the return or neutral line 90 greater than the minimum required to supply the slew motor 65.

[0066] The unloader valve 94 is sensitive to the pressure in the load sensing line 91 and only opens to permit fluid from the main pressure line 76 to pass into the neutral line 90 when or as the swashplate of the pump 43 is moved to or at least close to its unloaded minimum (stopped) flow position, as a result of sensing a minimum or zero pressure in load sensing line 91.

[0067] Supplying pressurised fluid to the neutral line 90 as described not only prevents cavitation of the slew motor 65 and permits the momentum of the body 15 to be braked, but also provides other benefits. For example, when the engine 39 of the apparatus 10 is started and the pump 43 is initially operated, a "stand-by" flow of fluid from the neutral line 90, assists in de-aerating and filtering of the hydraulic fluid. Also, in stand-by when there is a flow of hydraulic fluid through the hydraulic fluid cooler 70, the fluid will continue to be cooled.

[0068] It will be appreciated that when using a service such as the slew motor 65 and/or the track motors 60, 61 which demand high pressure and fluid flow volume, if another service in operation is stalled, such as for example the fifth hydraulic actuating means i.e. the bucket ram 31, such as when the ram reaches the end of its travel or when digging stubborn matter, a relief valve may be caused suddenly to relieve the fluid pressure to prevent damage to the fluid control system and/or stalling of the engine 39. This relief is sensed in load sensing line 91 and as a result the swashplate angle in the pump 43 will be decreased suddenly. This will affect the speed of slewing or tracking. This can be disconcerting for an operator where such slowing down occurs rapidly.

[0069] Accordingly, the fluid control means has a compensating means, preferably associated with parts 80 and 81 of the valve block 78, to limit the maximum pressure available when combining slewing or track driving with other services so that there is less likelihood of the relief valve operating.

[0070] Various modifications may be made without departing from the scope of the invention. For example, an apparatus 10 with an alternative working arm to that shown at 21 may be provided in which case all of the actuators 26, 28, 33 need not be required or indeed more actuators may be required.. An alternative working implement to the bucket 30 shown may be used.

[0071] Alternative/additional services may be provided on the apparatus 10 to those described. For example, the base 11 may have lowerable stabilisers, actuated by auxiliary actuators as indicated at 71, which may be operated by pressurised hydraulic fluid from the single variable displacement hydraulic pump 43 via yet another part 87 of the valve block 78, under manual or hydraulic control.

[0072] The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, as appropriate, may, separately, or in any combination of such features, be utilised for realising the invention in diverse forms thereof.

Claims

1. An earth moving apparatus (10) having a base (11) including a ground engaging propulsion means (12,13) whereby the apparatus (10) may move over the ground, first hydraulic actuator means (60,61) to drive the ground engaging propulsion means (12,13), a body (15) carried on the base(11), second hydraulic actuator means (65) for moving the body (15) relative to the base (11) about a first generally upright axis (A), a working arm (21) connected at or towards one end (25) thereof to the body (15), third actuator means (26) for moving the working arm (21) relative to the body (15) about a second generally upright axis (b) and fourth hydraulic actuator means (28) for moving the working arm (21) relative to the body (15) about a first generally horizontal axis (C), and the working arm (21) carrying at or towards a second outer end (29) thereof, an earth working implement (30), fifth hydraulic actuator means (31) to move the working implement (30) about a second generally horizontal axis (D), characterised in that the first, second, third, fourth and fifth hydraulic actuator means are in use, provided with pressurised hydraulic fluid by a single variable displacement pump (43).

2. An apparatus according to claim 1 characterised in that a hydraulic fluid control means (73,74,78) is provided for controlling the delivery of pressurised fluid to the various actuator means when required from the single variable displacement pump (43).

3. An apparatus according to claim 1 or claim 2 characterised in that the single variable displacement pump (43) is mounted in an engine compartment (38) and is driven directly from the engine (39).

4. An apparatus according to claim 1 or claim 2 or claim 3 characterised in that the body (15) is movable relative to the base (11) about the first generally upright axis (A), though substantially 360°, though a datum position in which the first end of the body (15) is at a front end of the base (11).

5. An apparatus according to claim 4 characterised in that the ground engaging means (12,13) includes a pair of tracks, each track of the pair being positioned at a side of the base (11), whereby edges of the tracks (60,61) define the width of the base (11) and hence of the apparatus (10) at least when the body (15) is in its datum position.

6. An apparatus according to any one of the preceding claims characterised in that the working arm (21) of the apparatus (10) includes a boom (23) mounted on the body (15), and a dipper (24) which is adapted to carry the working implement (30), the dipper (24) being movable relative to the boom (22) about a third generally horizontal axis (E), by sixth hydraulic actuator means (33) to which pressurised hydraulic fluid may be provided from the single variable displacement pump (43).

7. An apparatus according to any one of the preceding claims characterised in that the apparatus (10) further includes an earth moving blade (35) which is mounted on the base (11), and there is a seventh hydraulic actuator means (36) for causing up and down movement of the blade (11) about a fourth (F) generally horizontal axis, the seventh actuator means (36) being provided with pressurised hydraulic fluid for operation, from the single variable displacement pump (43).

8. An apparatus according to any one of the preceding claims characterised in that the single variable displacement pump (43) is arranged to supply a stand-by flow of pressurised fluid when all of the hydraulic actuator means are de-activated.

9. An apparatus according to claim 8 characterised in that the pump (43) is a swashplate pump and stop means are provided to prevent the swashplate moving to a fully unloaded position.

10. An apparatus according to claim 8 or claim 9 characterised in that unloading valve means (94) are provided to permit the stand-by flow to be communicated to a fluid return line (90) of the fluid control means (73,74,78) and to prevent the flow of fluid to the fluid return line (90) when a fluid actuator means is operated.

11. An apparatus according to claim 10 characterised in that means (100) are provided to maintain the fluid pressure in the fluid return line (90) above a minimum pressure.

12. An apparatus according to any one of claims 8 to 11 characterised in that second actuator means (65) includes a hydraulic motor, the stand-by flow being communicated to the hydraulic motor (65) to assist in braking the momentum of the rotating body (15) when the second actuator means (65) is de-activated.

13. An apparatus according to any one of the preceding claims characterised in that means are provided to prevent the single variable displacement pump (43) from providing fluid at its maximum operating pressure in the event that the first and/or second actuator means (60,61; 65) is operated in combination with at least one of the third, fourth and fifth actuator means.

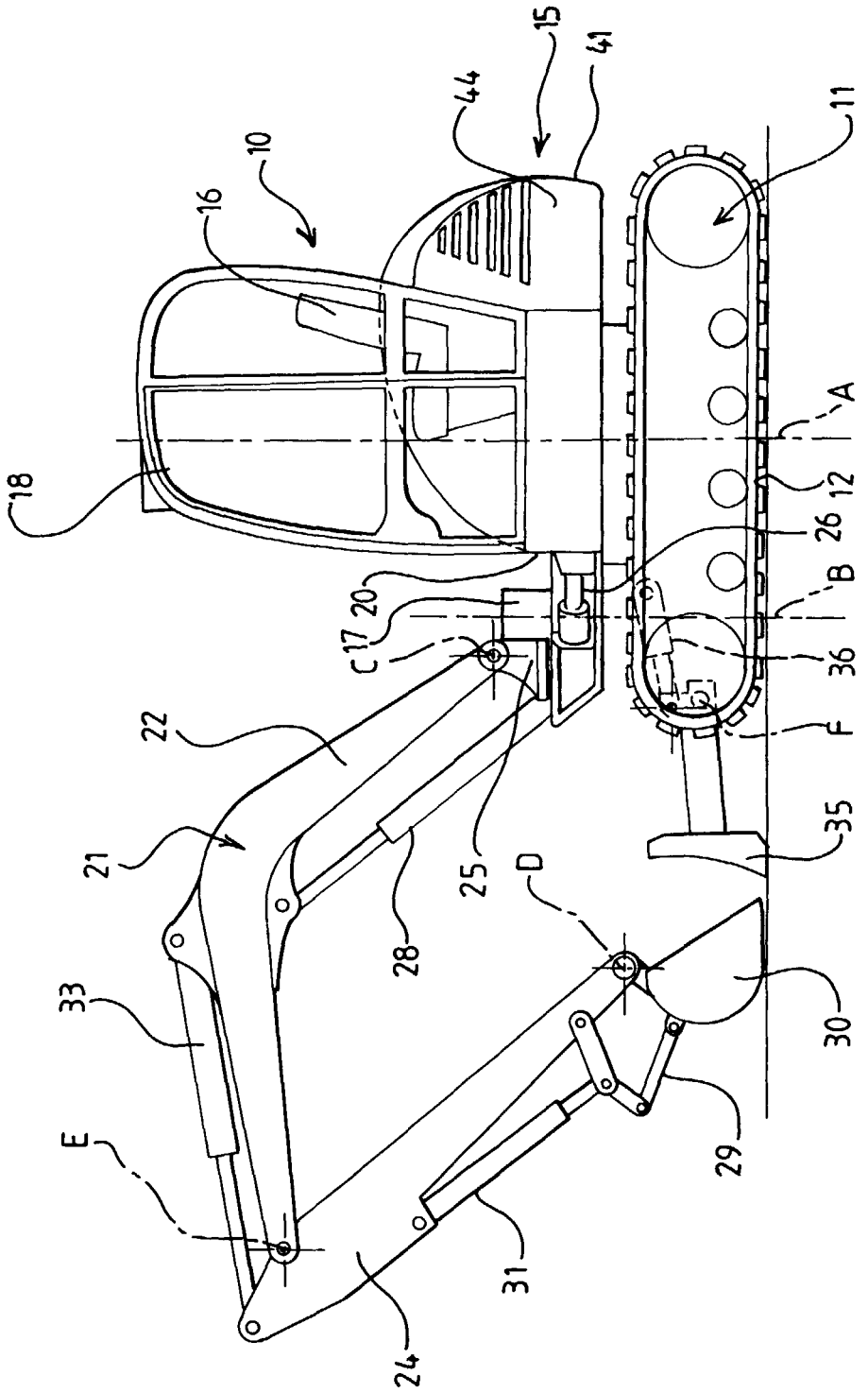

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FIG 1

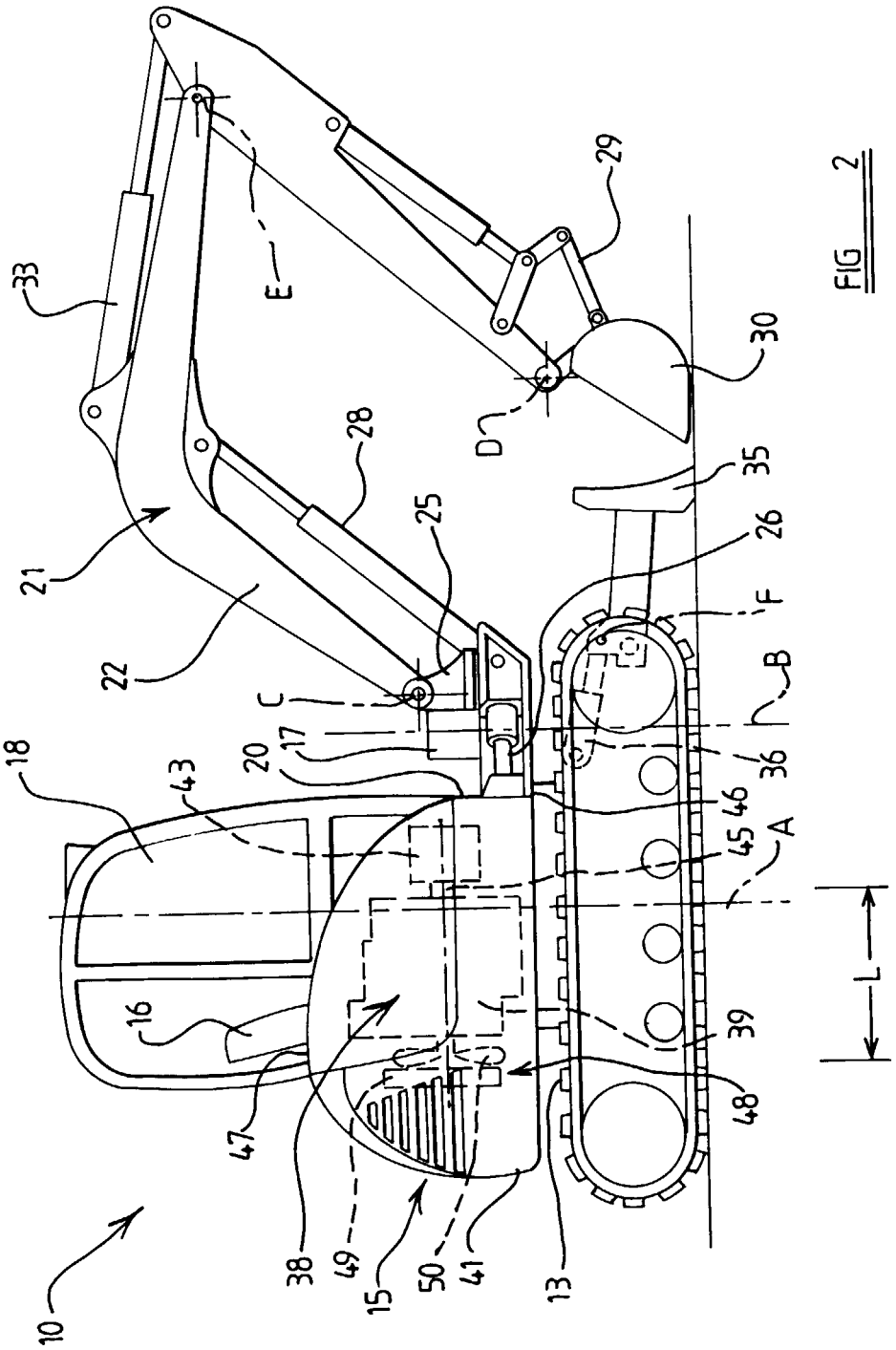

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FIG 2

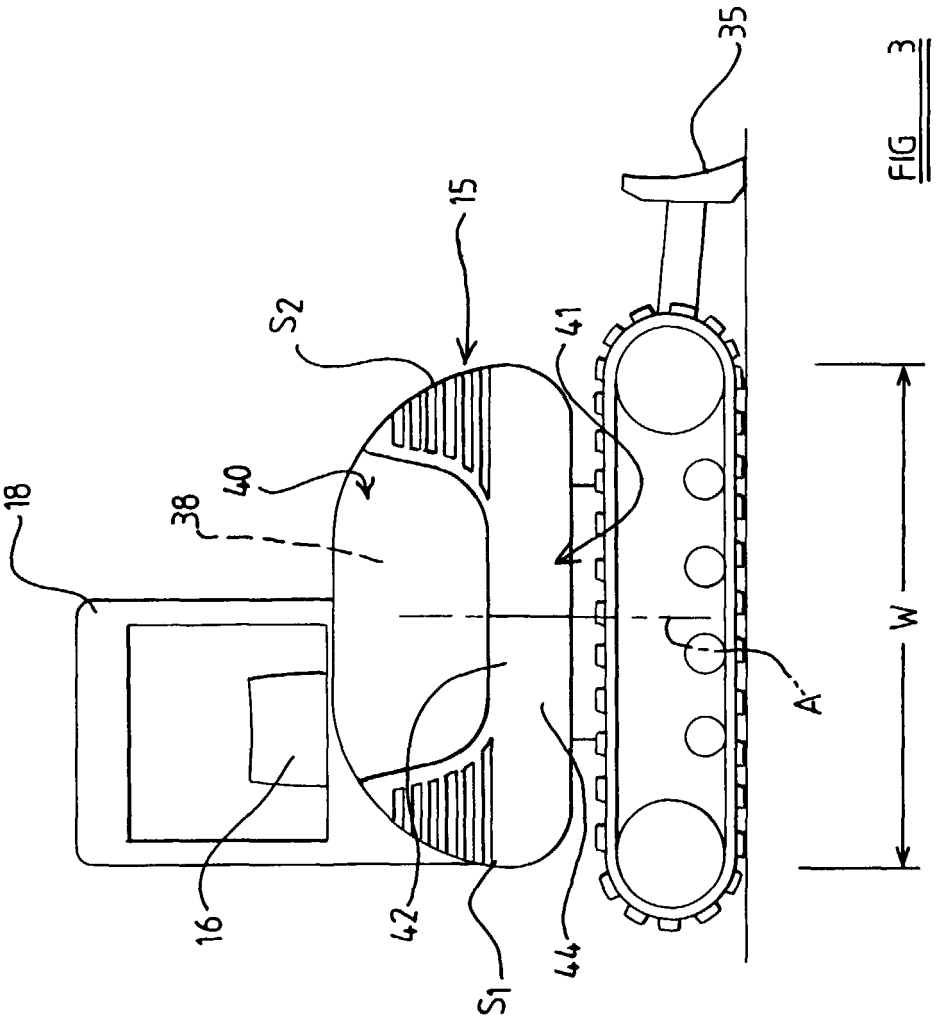


FIG 3

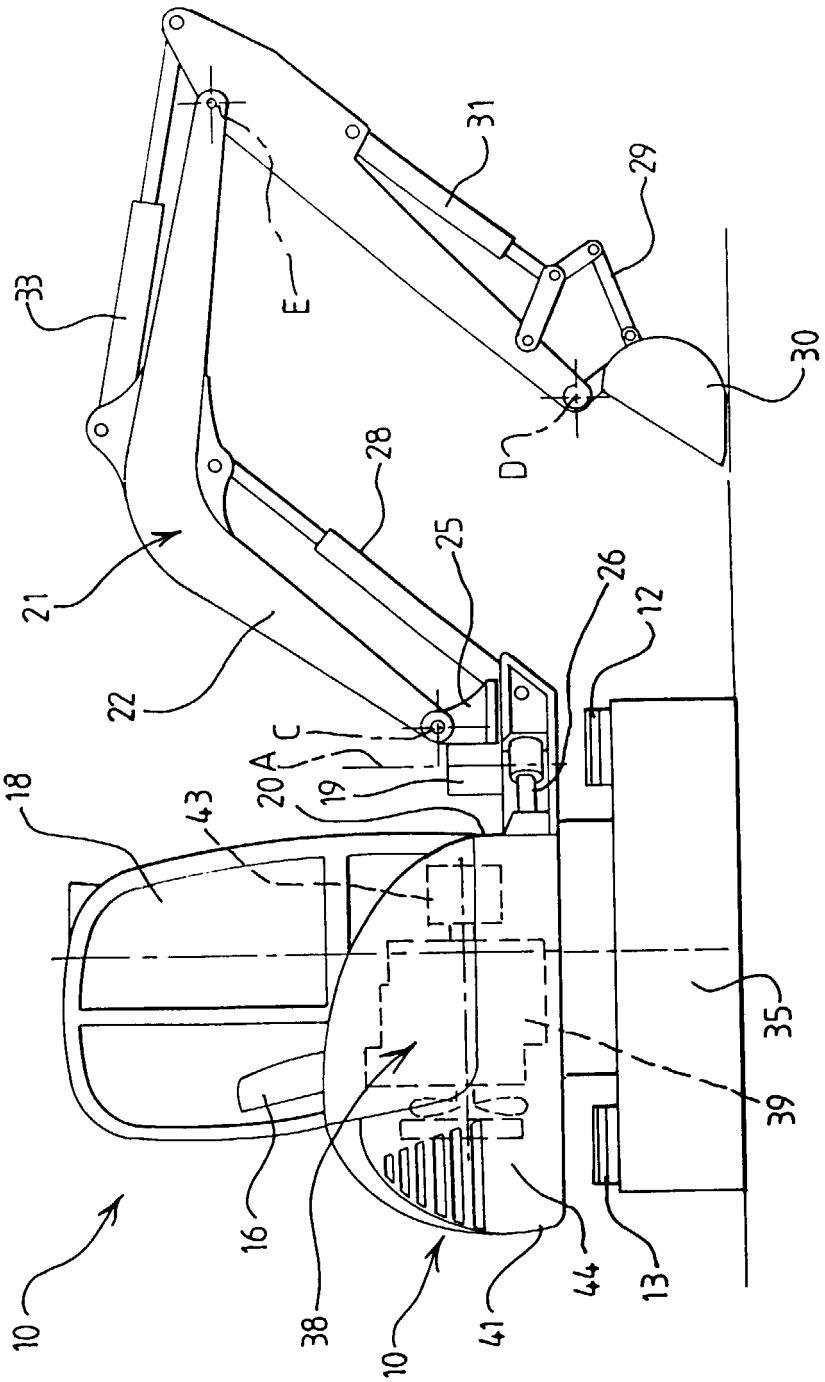

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FIG 4

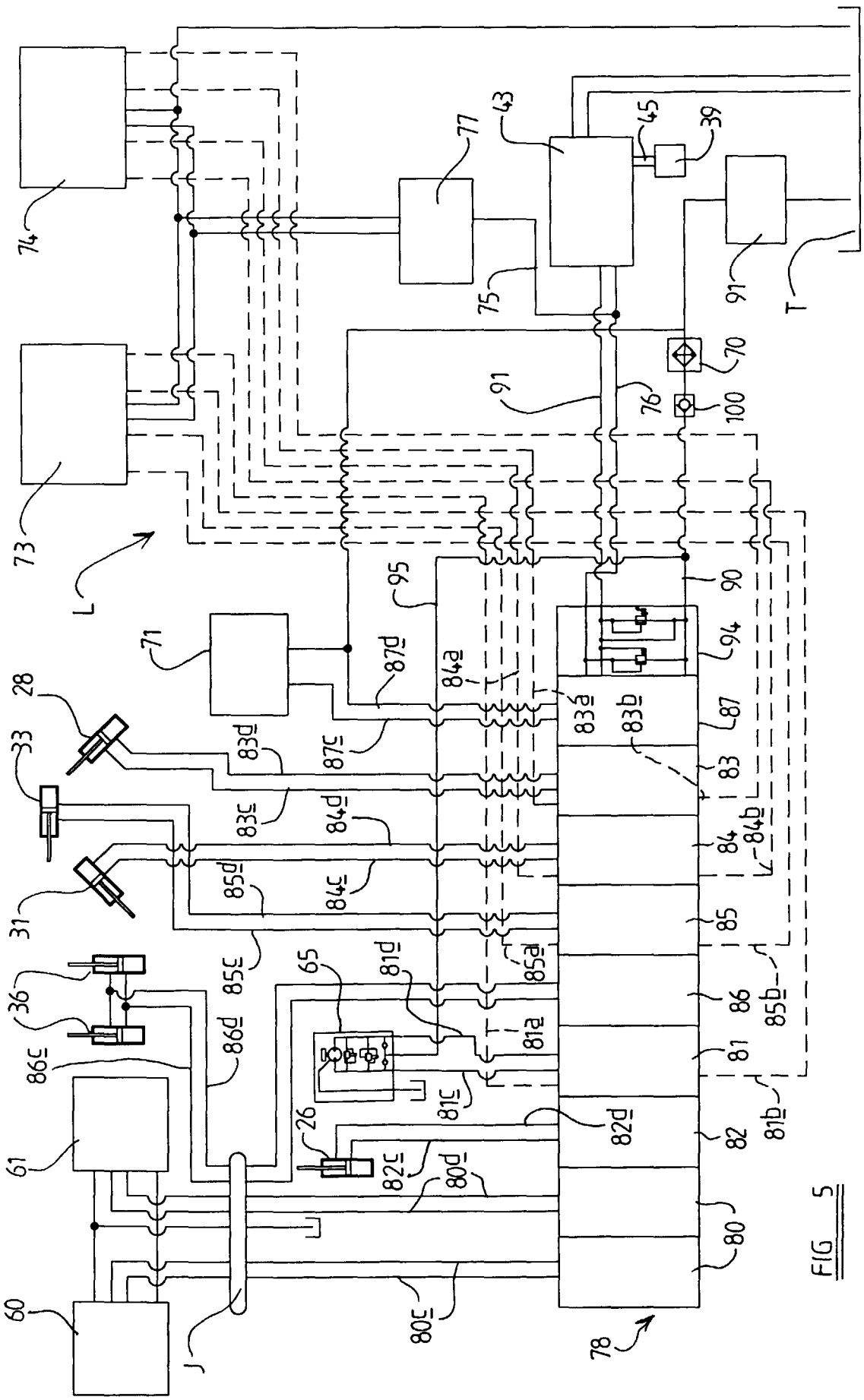
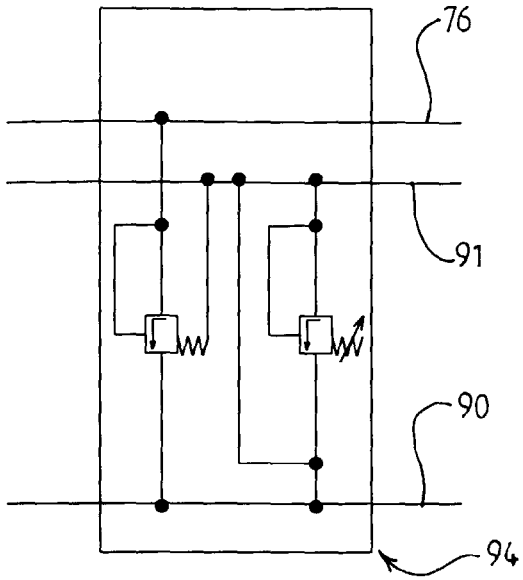

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FIG 5

FIG 5a



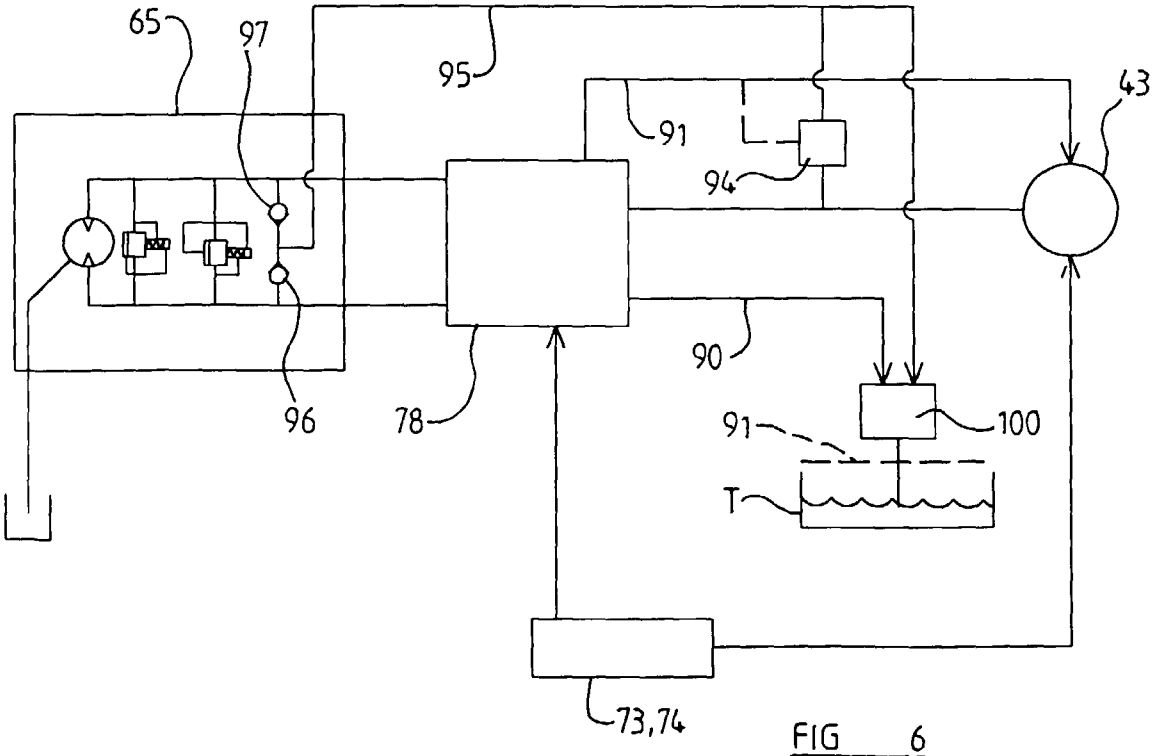


FIG 6