(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number : **0 644 151 A1**

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number : **94306806.4**

(51) Int. Cl.[6] : **B66F 9/22**

(22) Date of filing : **16.09.94**

(30) Priority : **17.09.93 GB 9319315**

(43) Date of publication of application :
22.03.95 Bulletin 95/12

(84) Designated Contracting States :
DE ES FR GB IT NL SE

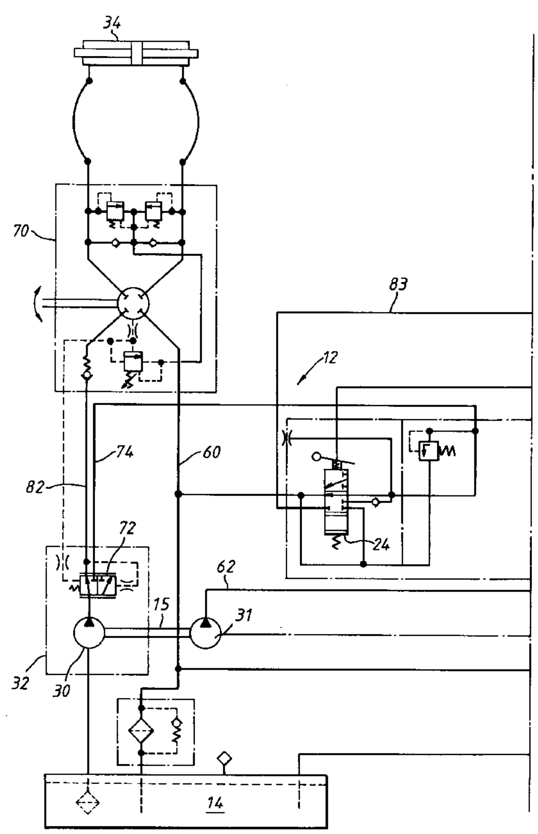
(71) Applicant : **BOSS GROUP LIMITED**
Grovebury Road
Leighton Buzzard, Bedfordshire LU7 8SR (GB)

(72) Inventor : **Bowman Shaw, Neville**
Toddington Manor
Toddington Bedfordshire (GB)
Inventor : **Turner, Murray**
173 Mead End
Biggleswade Bedfordshire (GB)

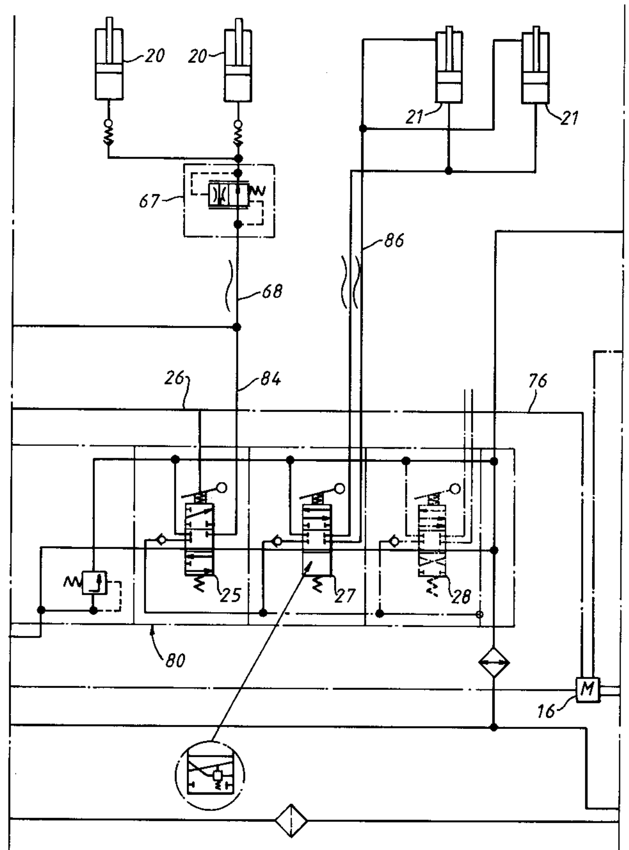
(74) Representative : **Richards, David John et al**
PAGE, WHITE & FARRER
54 Doughty Street
London WC1N 2LS (GB)

(54) **Hydraulic control circuit for self-propelled lift truck.**

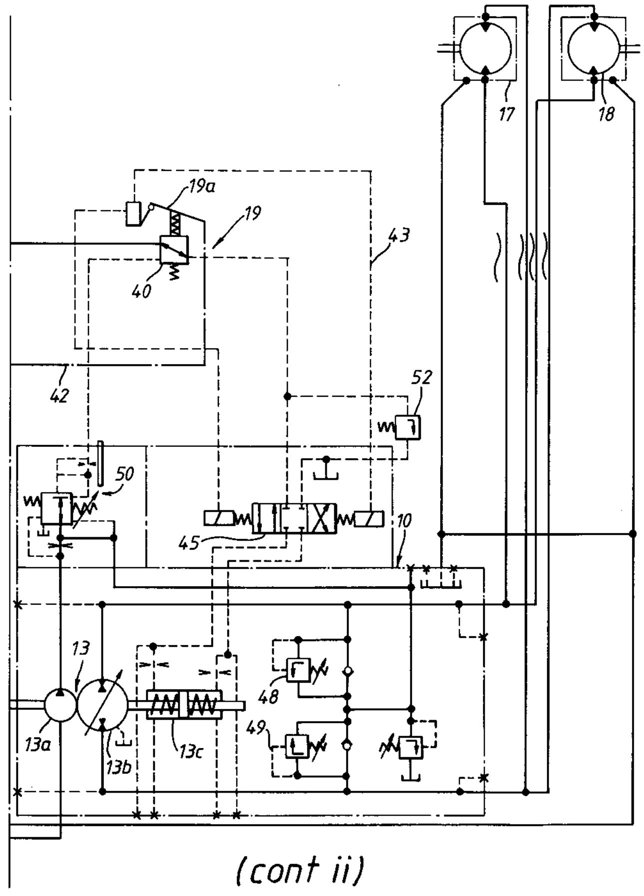
(57) The invention concerns a hydraulic control circuit for a self-propelled lift truck having a hydrostatic transmission, a hydraulic lift cylinder (20) for lifting and lowering a load with an associated hydraulic lift supply circuit (68), and at least one auxiliary hydraulic cylinder (21) for controlling an auxiliary function of the truck with an associated auxiliary hydraulic supply circuit (86). Hydraulic valve means (24,25,27) are operable to control fluid supply to said lift and auxiliary supply circuits from an associated hydraulic pump (15). According to the invention, the hydraulic valve means directs flow from the hydraulic pump into the lift supply circuit through at least two separate supply conduits (84,83). While means are provided responsive to operation of the lifting cylinder to increase the speed of the drive means thereby to increase the output from the hydraulic pump, the auxiliary hydraulic cylinder and its associated supply circuit are operable by the output from the hydraulic pump substantially at the idle speed of the engine driving the pump. By splitting the input to the lift supply circuit into at least two separate flows, the sizes of all the valves can be reduced. Auxiliary functions are powered by reduced pump flow which is matched more accurately to the requirements of the circuit and the auxiliary cylinder or cylinders therein. This means that there is sufficient power to operate auxiliary functions at an engine speed below drive engagement speed without any danger of stalling the engine.



EP 0 644 151 A1



(cont i)



(cont ii)

This invention relates to self-propelled lift trucks of the kind which are powered by a hydrostatic transmission incorporating one or more wheel motors; and more particularly to a hydraulic control circuit for such a truck.

Lift trucks such as fork lift trucks which are powered by hydrostatic transmissions usually comprise a diesel or gas engine driving a hydraulic transmission pump which supplies hydraulic fluid under pressure to one or more wheel motors. The same engine is used to drive a second hydraulic pump which supplies pressure to hydraulic cylinders which control other functions of the truck, such as steering and lifting.

Hydrostatic transmissions effectively operate as stepless automatic transmissions, and can be controlled by the driver through a conventional speed control pedal with a direction lever for forward and reverse drive, or through a cross-linked twin foot pedal arrangement which provides proportional drive speed in forward or reverse direction in response to the depression of the respective pedal by the driver's right or left foot. This latter arrangement means that the truck does not need a separate direction lever, thus leaving the drivers' hands free to steer and operate other functions of the truck.

Since maximum drive speed of the hydrostatic transmission is achieved at full pump delivery, a mechanical or electrical linkage is provided between the pedal and a speed controller on the engine which increases engine speed proportional to pedal depression. A similar engine speed controller is needed to boost delivery of the second hydraulic pump to the lifting circuit which controls the operation of the lift cylinder or cylinders. Maximum hoist speed requires maximum output from the pump, and a mechanism is provided which automatically speeds up the engine to meet the hydraulic demand in the lifting circuit when full speed lift is called for. Since any speeding up of the engine will increase the outputs from both transmission and lifting pumps, a pressure control valve is provided in the transmission circuit operable to prevent any pressure increase in the transmission circuit during a full rate lifting operation.

Since lifting performance is a crucial factor in truck operation, the size of the hydraulic pump supplying the lifting and auxiliary circuits is usually determined by the need to obtain the highest possible lift speed available from the engine. This in turn determines the size and nature of the associated valves and controls which operate the lifting and auxiliary circuits.

Unlike the cylinder or cylinders dedicated to lifting a load, the cylinders controlling auxiliary services such as mast tilt and carriage side shift require relatively small levels of pressure and displacement to operate them, and do not need any substantial increase in engine speed and pump output when they are operated. However, since these cylinders share the same hydraulic pump as the lift cylinders, their controls and supply circuits are usually configured to match the same pump delivery characteristics; for example they must be capable of operating under conditions of full pump delivery. One consequence of this mis-matching of controls to requirements is that when these auxiliary cylinders are operated, their control circuits rapidly reach relief pressure, and if the auxiliary cylinders are operated at engine idle speed, the engine will often stall as soon as relief pressure is reached, since the engine is not powerful enough at low speed to maintain pump operation. On a truck with a conventional transmission, this problem is overcome by pressing the accelerator to increase engine revs whilst operating the auxiliary function, but this is not possible with a hydraulic transmission since if this is done, the truck would drive away. The supply circuits for the auxiliary functions thus have to be provided with similar mechanisms to those provided in the supply circuits to the lift cylinders, to provide an automatic increase in engine speed when these functions are operated to avoid stalling the engine at low revs. It may not be possible to overcome this by reducing the size of these valves and other components since for economic reasons it is usually desirable to use valves of the same size for controlling all functions of the truck under manual control.

The present invention provides a hydraulic control circuit for a self-propelled lift truck which enables the various valves and controls to be more closely configured to the operating characteristics of the cylinders which they control; which permits the use of control valves of the same size; and which avoids the neccessity for complicated and expensive mechanical and/or electrical interlocks operable to increase engine speed when an auxiliary function is operated. This provides a substantial cost saving, enables more precise control over the auxiliary functions, and generates less noise and heat from the engine, pumps and valves.

According to the present invention, there is provided a hydraulic control circuit for a self-propelled lift truck of the kind having a hydrostatic transmission operable to drive the truck through one or more wheel motors; at least one hydraulic lift cylinder for lifting and lowering a load; a hydraulic lift supply circuit connected to the lift cylinder; at least one auxiliary hydraulic cylinder for controlling an auxiliary function of the truck; an auxiliary hydraulic supply circuit connected to the auxiliary cylinder; hydraulic valve means operable to control fluid supply to the lift and auxiliary supply circuits; a first hydraulic pump operable to supply the hydrostatic transmission; a second hydraulic pump operable to supply the lift and auxiliary supply circuits via the valve means; and variable-speed drive means adapted to drive the first and second hydraulic pumps; the circuit being characterised in that the hydraulic valve means is adapted to direct flow from the second hydraulic pump into the lift supply circuit through at least two separate supply conduits, and means are provided responsive to operation of the lifting cylinder to increase the speed of the drive means thereby to increase the output from the second hydraulic pump; and whereby the auxiliary hydraulic cylinder and its associated supply circuit are operable by the output from the second hydraulic pump substantially at the idle speed of the drive means.

By splitting the input to the lift supply circuit into at least two separate flows, the sizes of all the valves can be reduced, and the full pump flow supplied at maximum engine power is only required for lifting a load. Auxiliary functions are powered by reduced pump flow which is matched more accurately to the requirements of the circuit and the auxiliary cylinder or cylinders therein. This means that there is sufficient power to operate auxiliary functions at engine idle speed or slightly above (below drive engagement speed) without any danger of stalling the engine, thus saving on linkage, circuitry and operating costs.

Preferably, the hydraulic valve means comprises first and second hydraulic control valves each connected to a respective one of the supply conduits, and an auxiliary hydraulic control valve operable to direct fluid flow from the second hydraulic pump into the auxiliary supply circuit.

Preferably, the hydraulic control valves are spool valves disposed in a common housing and are operated manually, e.g. by means of a joystick control.

The second hydraulic pump is suitably operable to supply the first and second hydraulic control valves through first and second pump supply circuits. In the preferred embodiment, the pump comprises a two-chamber pump having first and second chambers, and the first and second pump supply circuits are connected respectively to the first and second pump chambers.

In one particular embodiment of the invention, the hydraulic control circuit further comprises a power steering hydraulic cylinder and a power steering hydraulic cylinder control circuit; and said first pump supply circuit is connected both to the power steering hydraulic cylinder control circuit and the first hydraulic control valve. In this arrangement, preferably the second pump supply circuit is connected both to the second hydraulic control valve and the auxiliary hydraulic control valve.

The auxiliary hydraulic cylinder may comprise, for example, a tilt cylinder or a side-shift cylinder, and more than one such auxiliary cylinder may be included. In one such arrangement, a second auxiliary hydraulic cylinder is served by a second auxiliary supply circuit, and the hydraulic valve means comprises a second auxiliary hydraulic control valve operable to direct fluid flow from the second hydraulic pump into the second auxiliary supply circuit. In this construction the first and second auxiliary hydraulic control valves may share a common supply from the second hydraulic pump.

Suitably, linkage means interconnect the first and second hydraulic control valves and are connected to the speed controller of the drive means, e.g. by an electrical or mechanical connection. These linkage means also enable the first and second hydraulic control valves to be operated in sequence, thereby permitting finer control over the operation of the lift cylinder.

In order that the invention may be more fully understood, an embodiment in accordance therewith will now be described by way of example with reference to the accompanying drawing, which shows a hydraulic control circuit for a self-propelled lift truck.

Referring to the drawing, this shows a hydraulic control circuit for a masted fork lift truck fitted with a hydrostatic transmission. As will be described, the lift truck is of conventional design, having lift cylinders for raising and lowering a fork carriage along a mast, tilt cylinders for tilting the mast, a power steering cylinder, and hydraulic drive motors.

The main elements of the hydraulic circuit are a traction control circuit 10, and a load-handling and steering control circuit 12. Traction control circuit 10 is pressurised by hydraulic traction pump 13, while circuit 12 is supplied by hydraulic pump 15. Both pumps 13 and 15 are driven by the same drive means 16 which in this case comprises a diesel or gas engine. The circuits share a common supply and return tank 14.

The traction control circuit 10 is of generally conventional design. Traction pump 13, which comprises a primary pump 13a, a secondary pump 13b, and control system 13c, supplies hydraulic fluid under pressure to wheel motors 17, 18 as required by pedal control device 19. This consists of linked twin pedals 19a which operate pump control valve 40 to provide proportional drive speed in forward or reverse direction in response to depression of the pedals by the left or right foot of the driver. A servo connection 42 which in this case is electrical but which may be mechanical or hydraulic is provided between the pedal control device 19 and the speed control of engine 16 operable to speed up the engine when this is called for by depression of the pedals. A further servo connection 43, which in this case operates an electrical solenoid valve, is also provided for forward and reverse control valve 45 to enable forward or reverse drive to be selected.

Traction control circuit 10 is further provided with relief valves 48, 49 to prevent excess pressure due to overrun of the drive motors; hydraulic smoothing unit 50; and power brake cylinder 52. All these components are conventional and need not be described in further detail here.

Hydraulic circuit 12 is adapted to supply and control fluid flow to the operating functions of the truck, which in this case comprise a double-acting power steering cylinder 34, a pair of lift cylinders 20, and a pair of auxiliary mast tilt cylinders 21. All these cylinders are supplied by hydraulic pump 15 which comprises twin chambers 30 and 31. Fluid supply from pump 15 to lift cylinders 20 and auxiliary cylinders 21 is controlled by a manually operated valve unit generally indicated at 80 which in this case incorporates three juxtaposed hydraulic spool valves 24, 25 and 27. A further valve 28 may be provided to operate an additional auxiliary function of the truck (such as a carriage side-shift cylinder) which is not illustrated in the drawing.

Fluid flow to power steering cylinder 34 is controlled by a conventional hand steer pump 70 connected to the steering column of the vehicle. Hand steer pump 70 is supplied by pump chamber 30 via flow divider 32 which incorporates diverter valve 72, and supply line 82. Diverter valve 72 is also operable to direct fluid through line 74 to valve unit 80. Valve unit 80 is also supplied by chamber 31 of pump 15 via line 62, as will be described.

Valve unit 80 is adapted to direct flow from hydraulic pump 15 into lifting cylinders supply circuit 68 through two separate supply conduits 83, 84. Conduit 83 is connected to spool valve 24 which receives fluid supply from chamber 30 of pump 15 via line 74. Conduit 84 receives fluid supply from spool valve 25 which is supplied by line 62 from pump chamber 31. Line 62 is also connected to valve 27 which supplies tilt cylinders 21 via line 86, and may also supply spool valve 28 if an additional auxiliary function is fitted to the truck.

Since pump chamber 30 supplies both steering cylinder 34 and lift cylinders 20, flow divider 32 is operable to divert fluid flow to steering cylinder 34 whenever steering power is required. When there is no steering demand, delivery from chamber 30 is automatically directed by valve 72 through line 74 to spool valve 24.

Spool valves 24 and 25 supplying conduits 83 and 84 of lifting cylinder supply circuit 68 are mechanically connected by linkage 26 to provide simultaneous control over fluid supply to cylinders 20. Linkage 26 is also connected to the speed control of engine 16 by connection 76 and operates to speed up engine 16 so as to increase delivery of pump 15 when required for a full rate lifting operation.

It will be appreciated that conventionally, pump 15 would be connected to lift cylinders 20 through a single circuit and a single spool valve. Since the tilt cylinders 21 share the same valve housing and the same circuitry, valves of similar configuration would normally be needed to control these functions. By splitting the supply to the cylinders 80 into two parts, and controlling the lift cylinders with two valves each handling only half the pump output, smaller valves and fittings can be used throughout valve unit 20 which are more closely matched to the output of the pump 15 at engine idle speed. This avoids the necessity of speeding up engine 16 during operation of the tilt cylinders 21 and any other auxiliary functions, thus saving on linkage, costs and fuel, and generating less noise and heat.

The use of twin pump chambers 30 and 31 to provide two separate outputs (and two separate supplies to valve unit 80) further enables the delivery of pump 15 to be matched to the operating requirements of the hydraulic cylinders it supplies. However, it will be appreciated that the pump 15 could be a single-chamber pump, and could supply valve unit 80 via a single supply line.

The use of two separate spool valves 24 and 25 for controlling lift cylinders 20 gives rise to the possibility of phased operation of these valves in order to achieve finer control over the lifting operation. This can be done by appropriate adjustment of the mechanical linkage 26.

Claims

1. A hydraulic control circuit for a self-propelled lift truck of the kind having a hydrostatic transmission operable to drive the truck through one or more wheel motors (17, 18), at least one hydraulic lift cylinder (20) for lifting and lowering a load, a hydraulic lift supply circuit (68) connected to said lift cylinder; at least one auxiliary hydraulic cylinder (21) for controlling an auxiliary function of the truck; an auxiliary hydraulic supply circuit (86) connected to said auxiliary cylinder; hydraulic valve means (24, 25, 27) operable to control fluid supply to said lift and auxiliary supply circuits; a first hydraulic pump (13) operable to supply said hydrostatic transmission; a second hydraulic pump (15) operable to supply said lift and auxiliary supply circuits via said valve means; and variable-speed drive means (16) adapted to drive said first and second hydraulic pumps; characterised in that said hydraulic valve means is adapted to direct flow from said second hydraulic pump (15) into said lift supply circuit (68) through at least two separate supply conduits (83, 84) and means (16, 26, 76) are provided responsive to operation of said lifting cylinder to increase the speed of the drive means thereby to increase the output from said second hydraulic pump; and whereby said auxiliary hydraulic cylinder and its associated supply circuit are operable by the output from said second hydraulic pump substantially at idle speed of said drive means.

2. A hydraulic circuit as claimed in Claim 1, wherein said hydraulic valve means comprises first and

second hydraulic control valves (24, 25) each connected to a respective one of said supply conduits (83, 84), and an auxiliary hydraulic control valve (27) operable to direct fluid flow from said second hydraulic pump into said auxiliary supply circuit (86).

3. A hydraulic control circuit as claimed in Claim 2, wherein said second hydraulic pump (15) is operable to supply said first and second hydraulic control valves through first and second pump supply circuits (74, 62).

4. A hydraulic control circuit as claimed in Claim 3, wherein said second hydraulic pump (15) comprises a two chamber-pump having first and second chambers (30, 31), and said first and second pump supply circuits (74, 62) are connected respectively to said first and second pump chambers.

5. A hydraulic control circuit as claimed in Claim 4, further comprising a power steering hydraulic cylinder (34) and a power steering hydraulic cylinder control circuit (82); and said first pump supply circuit (74) is connected both to said power steering hydraulic cylinder control circuit and said first hydraulic control valve (24).

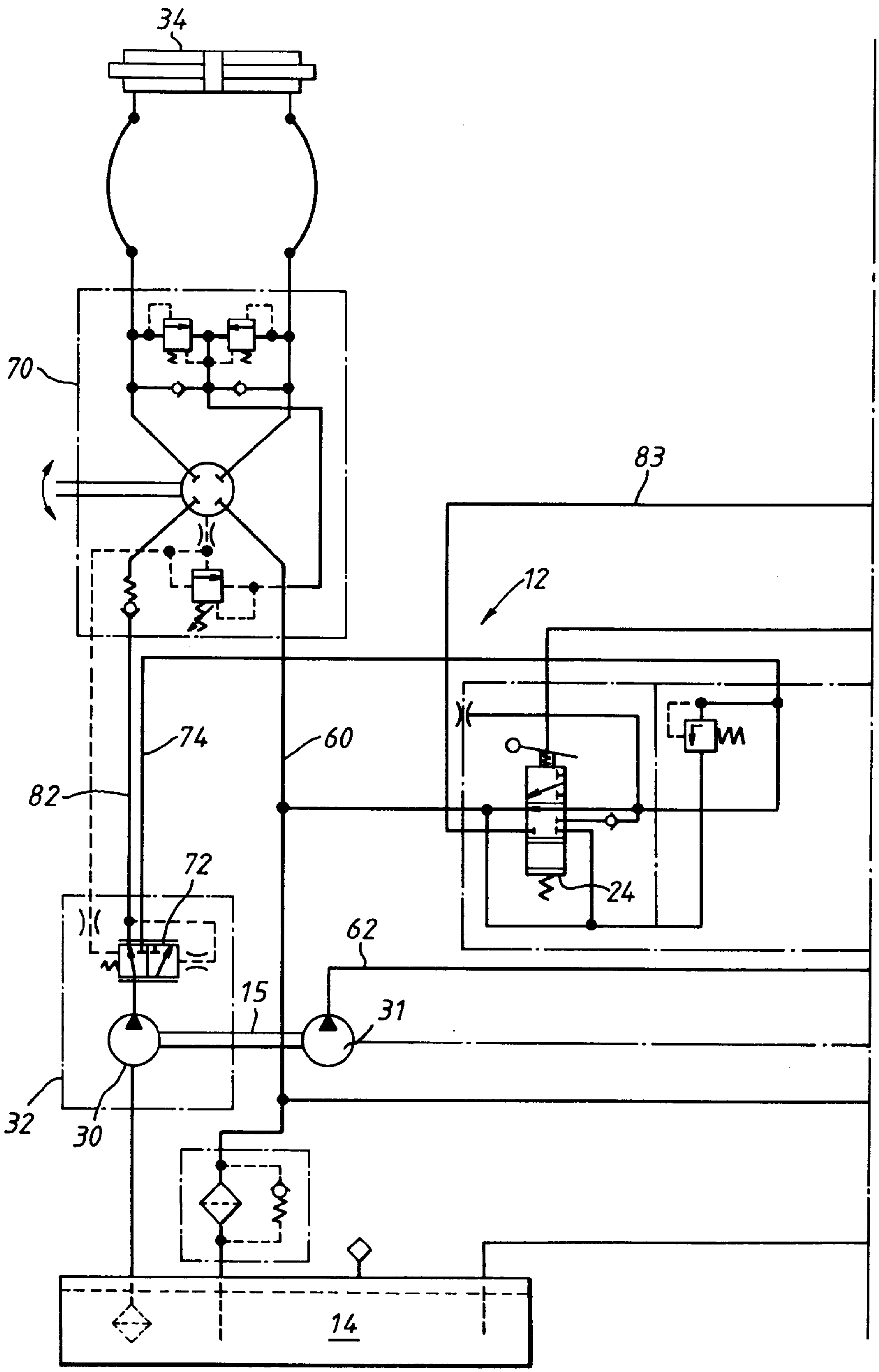
6. A hydraulic control circuit as claimed in any one of Claims 3 to 5, wherein said second pump supply circuit is connected both to said second hydraulic control valve (25) and said auxiliary hydraulic control valve (27).

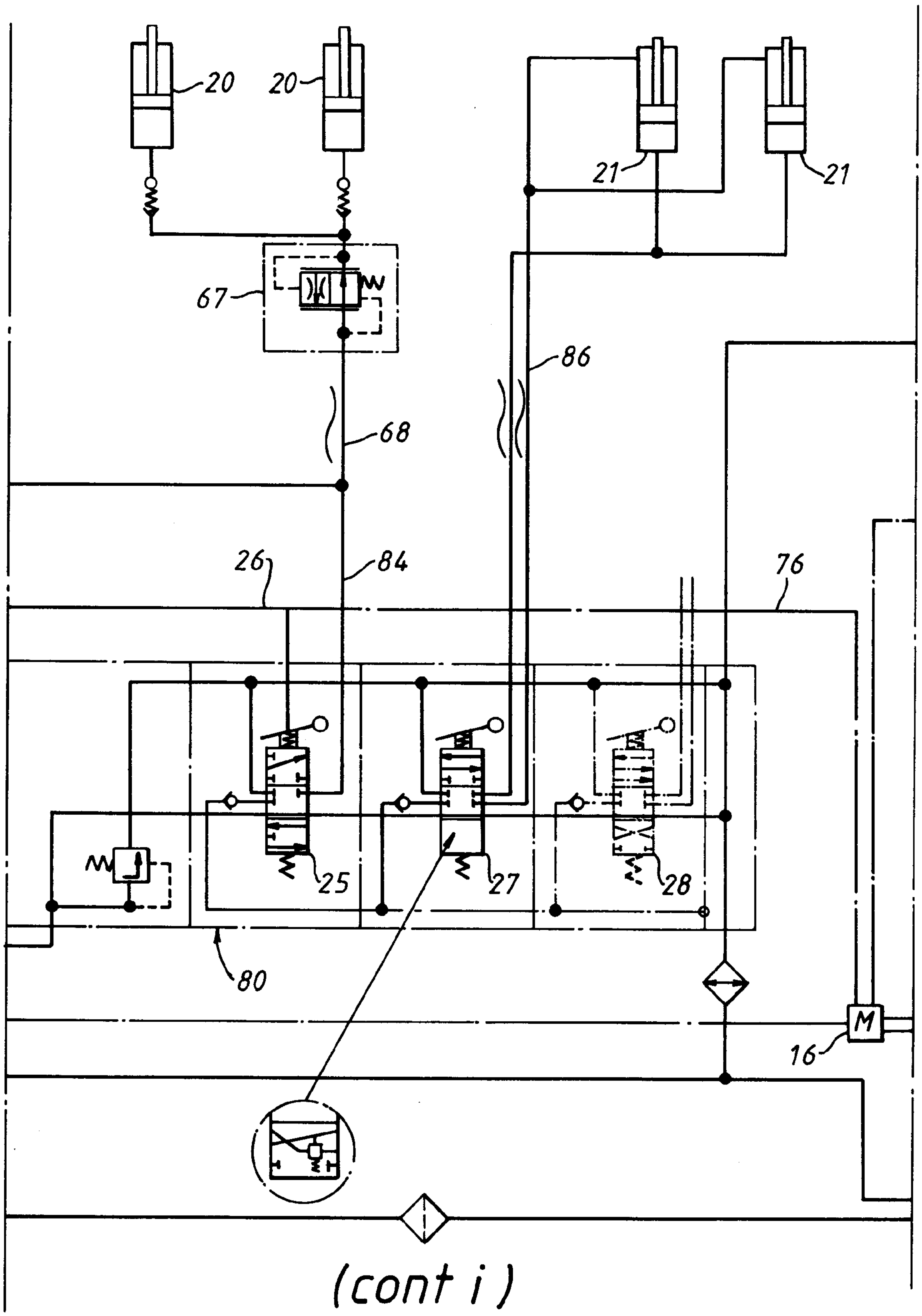
7. A hydraulic control circuit as claimed in any of Claims 2 to 6, further comprising a second auxiliary hydraulic cylinder and a second auxiliary supply circuit, and wherein said hydraulic valve means comprises a second auxiliary hydraulic control valve (28) operable to direct fluid flow from said second hydraulic pump (15) into said second auxiliary supply circuit.

8. A hydraulic control circuit as claimed in Claim 7, wherein said first and second auxiliary hydraulic control valves share a common supply (62) from said second hydraulic pump (15).

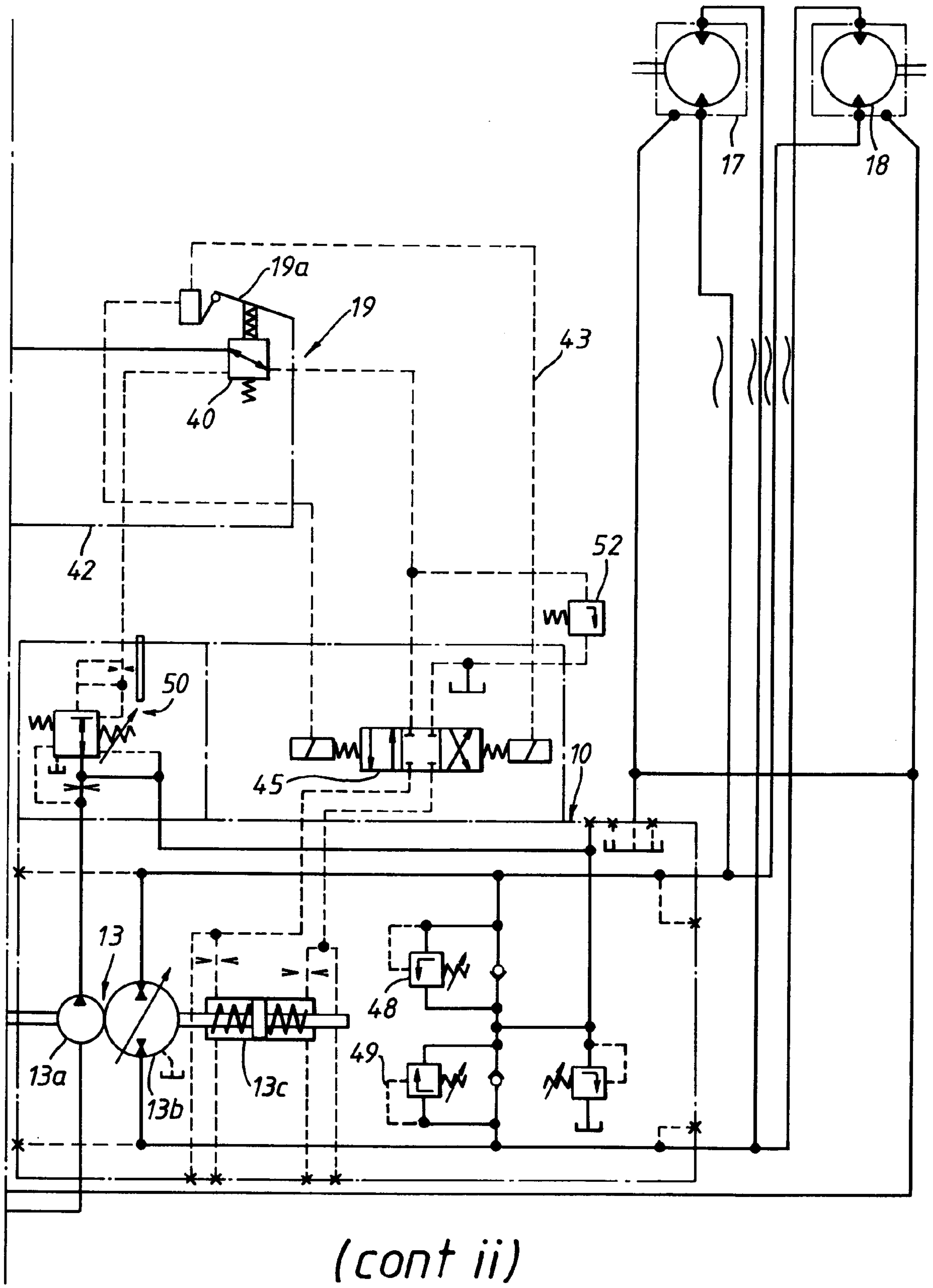
9. A hydraulic control circuit as claimed in any one of Claims 2 to 8, further comprising linkage means (26) interconnecting said first and second hydraulic control valves (24, 25) and being connected to said means (76) operable to increase the speed of said drive means.

10. A hydraulic control circuit as claimed in Claim 9, wherein said first and said second hydraulic control valves are operable in sequence.


34
70
83
12
74
60
82
72
24
62
15
31
32
30
14



(cont i)



(cont ii)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 30 6806

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
P,A	EP-A-0 592 235 (BOSS TRUCKS LTD.) * column 3, line 11 - line 15 * * column 3, line 25 - line 28 * * column 3, line 36 - column 4, line 2 * * figure 1 * ---	1,2	B66F9/22
A	GB-A-2 200 889 (NISSAN MOTOR COMPANY LTD.) * figures 5,8 * * page 11, line 9 - line 12 * * page 11, line 26 - page 12, line 11 * * page 12, line 24 - line 30 * ---	1	
A	US-A-4 467 894 (SINCLAIR) * figures * * column 3, line 39 - line 56 * * column 3, line 67 - column 4, line 10 * ---	1	
A	EP-A-0 251 290 (STILL G.M.B.H.) -----		

TECHNICAL FIELDS SEARCHED (Int.Cl.6)
B66F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	16 November 1994	Guthmuller, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)