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(54) Title of the Invention: **A Hydraulic Valve Manifold**
Abstract Title: **A hydraulic valve manifold**

(57) A hydraulic valve manifold 3000 for a hydraulic actuator 120 is provided. The hydraulic valve manifold 3000 comprises: a hydraulic fluid input line 701; a hydraulic fluid return line 702; a pressurisation line 703, 704 for connection to the hydraulic actuator; a command input line 707 for receiving pressurised hydraulic fluid from a command manifold for the hydraulic actuator; and a positioner valve 3100 with a first isolation position, a second actuator pressurisation position and a third command position. The invention also provides an aircraft landing gear drive system, a method of operating a hydraulic valve manifold and a method of operating an aircraft landing gear drive system.

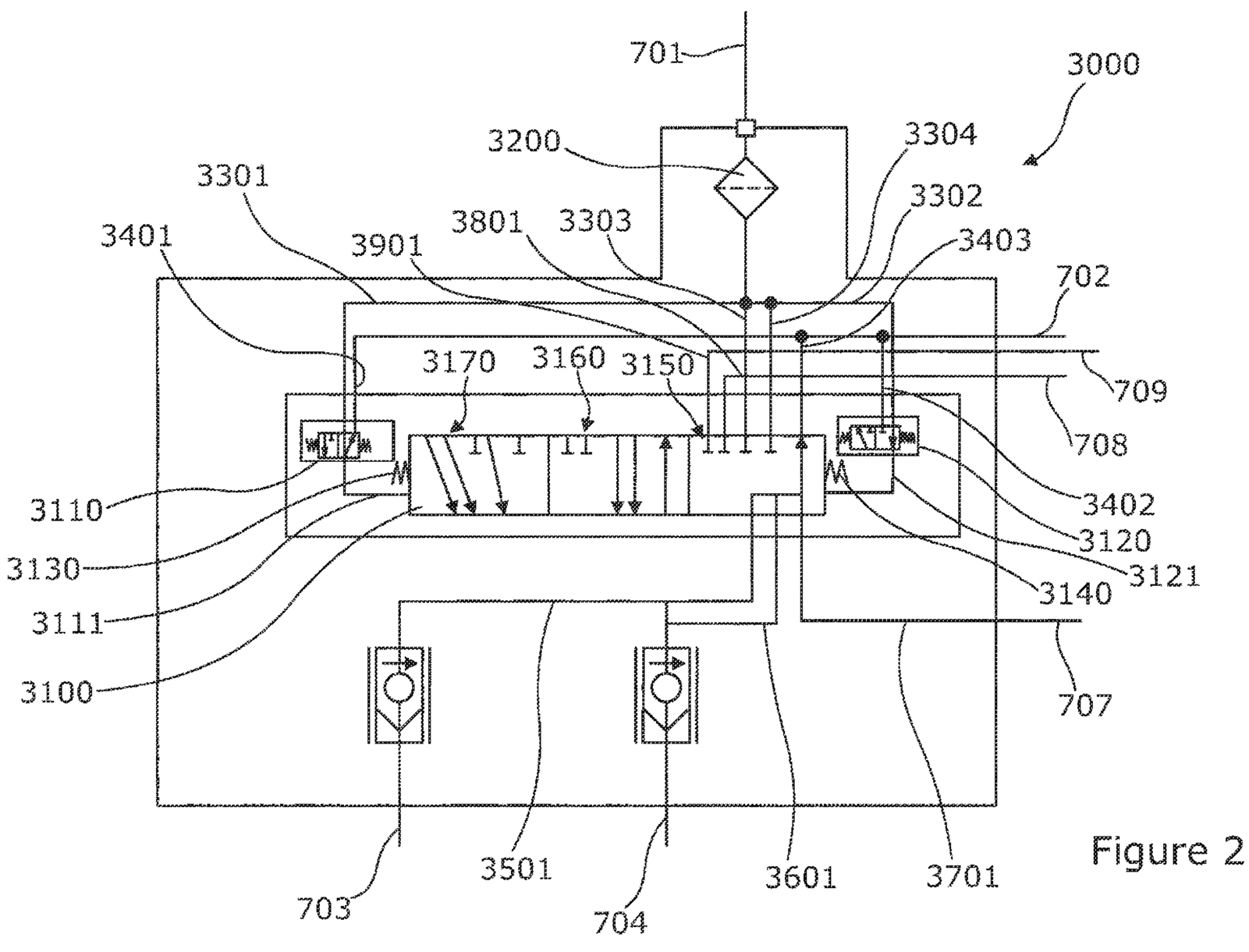

Figure 2

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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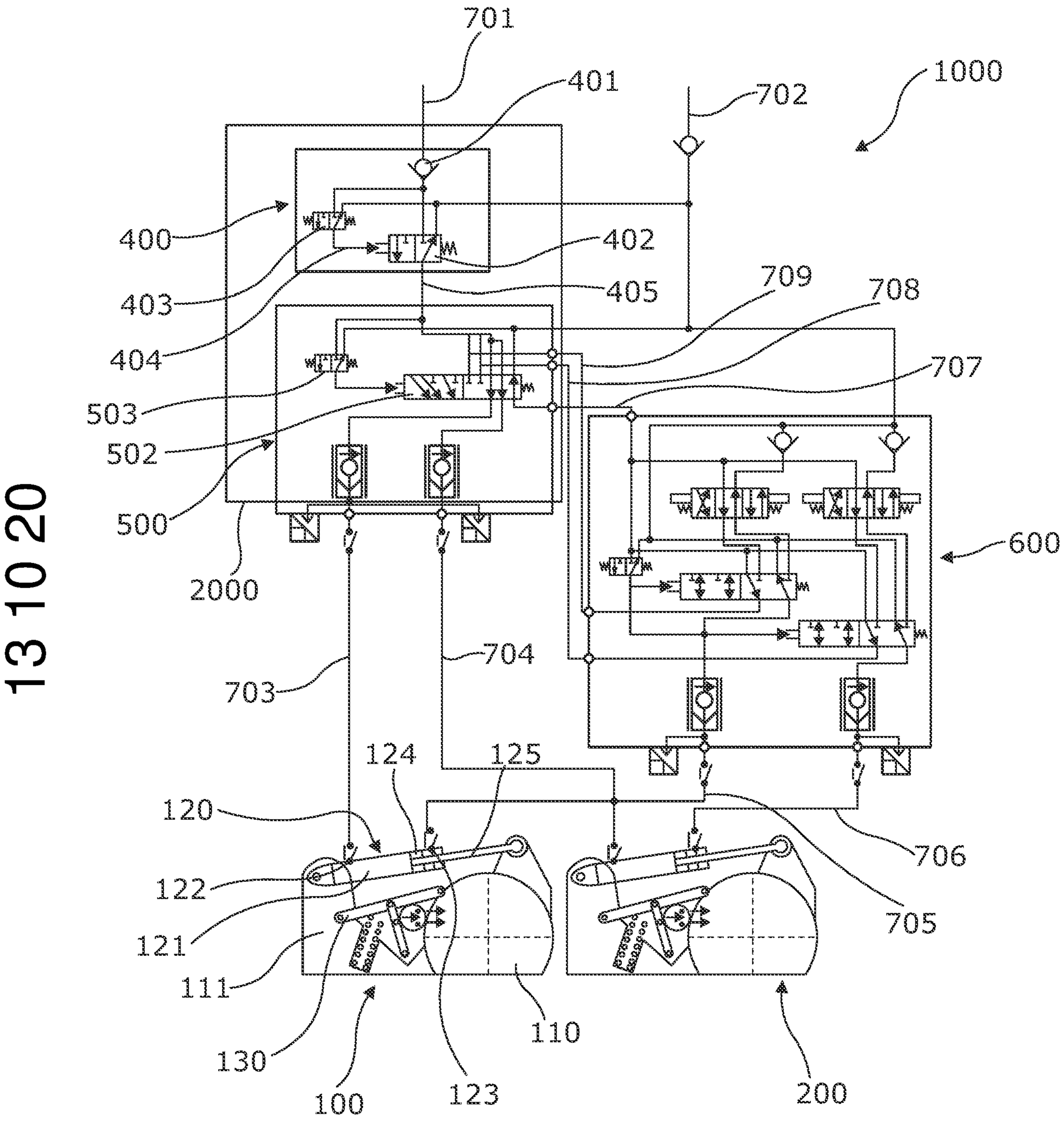
1000
701
401
702
400
402
403
405
709
708
404
707
503
502
500
600
2000
704
703
124
125
120
706
122
705
121
111
110
130
100
123
200

Figure 1

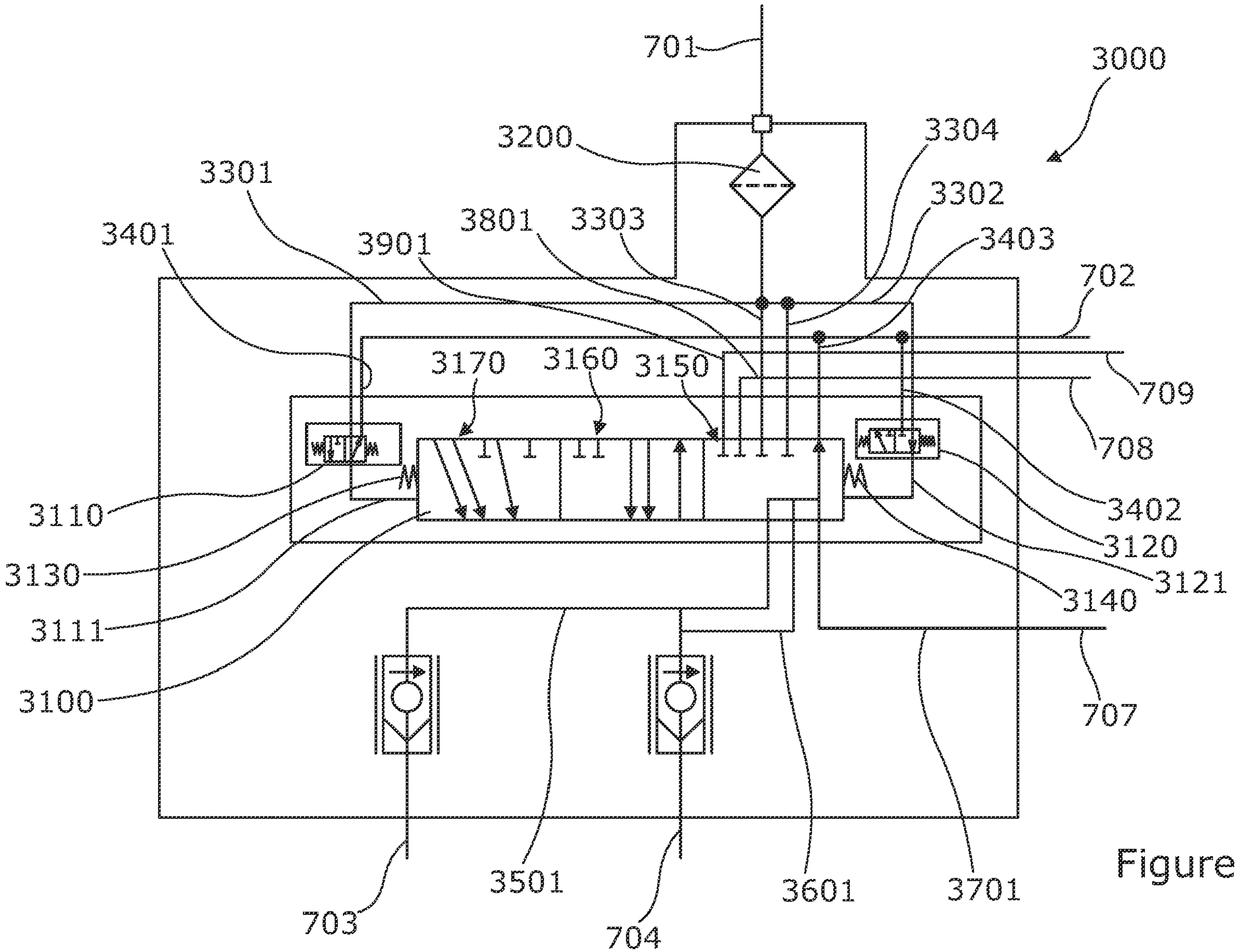
701
3000
3200
3304
3301
3302
3801
3303
3403
3401
3901
702
3170
3160
3150
709
708
3110
3402
3120
3130
3121
3140
3111
3100
707
703
3501
3601
3701
704

Figure 2

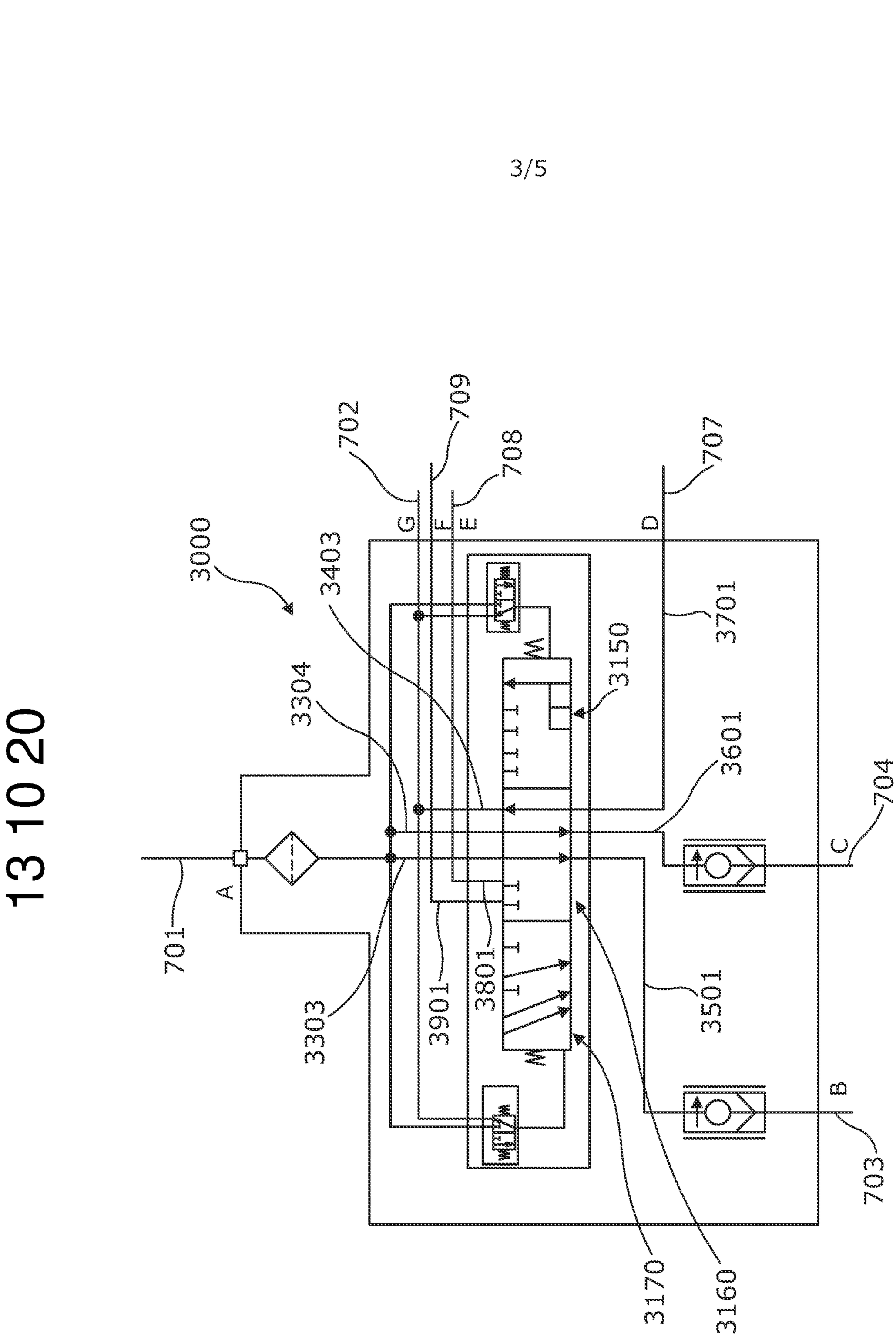
3000
3403
3304
3303
3301
3801
3501
3150
3701
3601
3170
3160
701
702
703
704
707
708
A
B
C
D
E
F
G
W

Figure 3

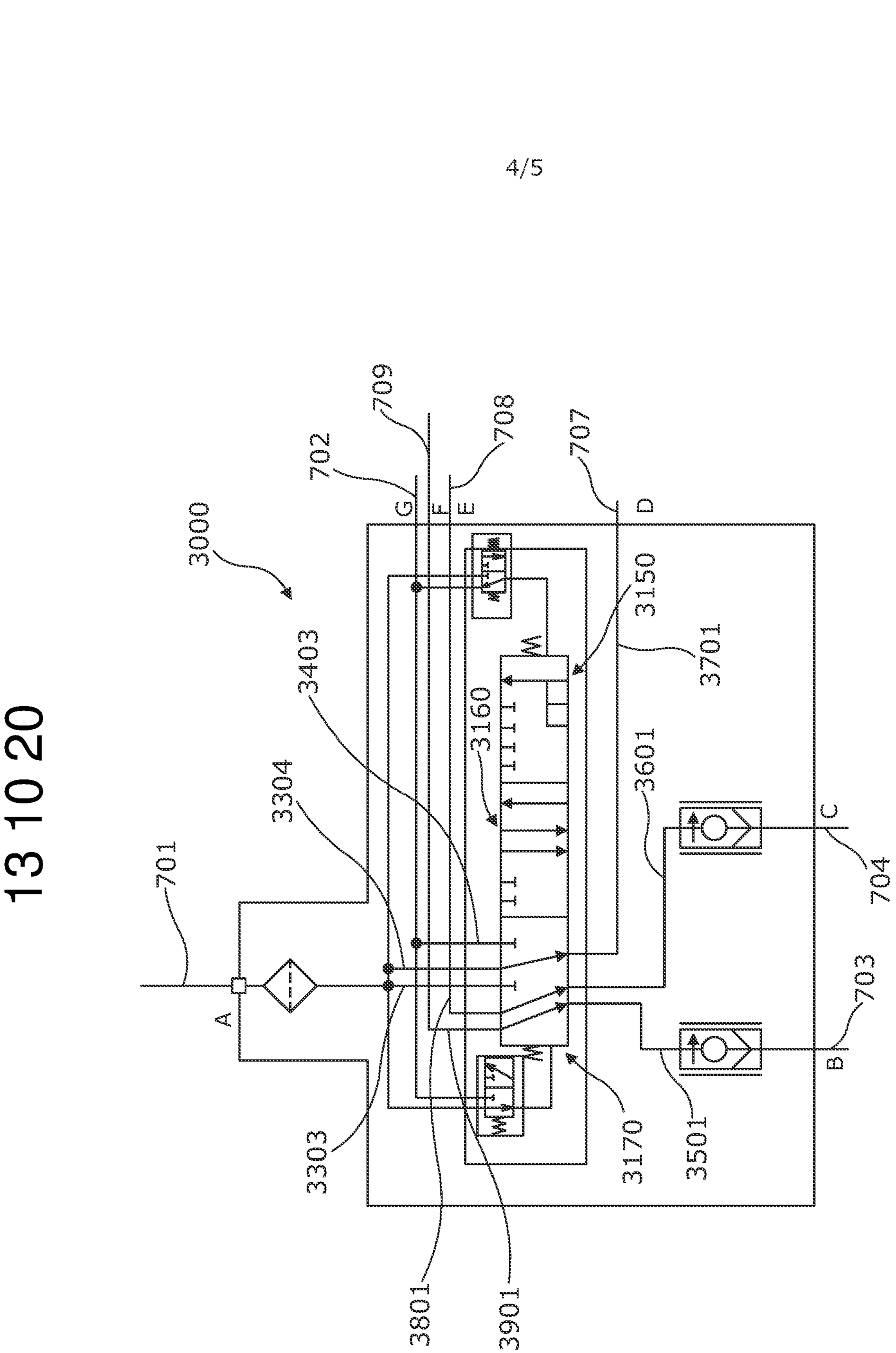
1320
1310
3000
3403
3304
3303
3160
3170
3150
3701
3601
3501
3801
3901
701
702
703
704
707
708
A
B
C
D
E
F
G
W

Figure 4

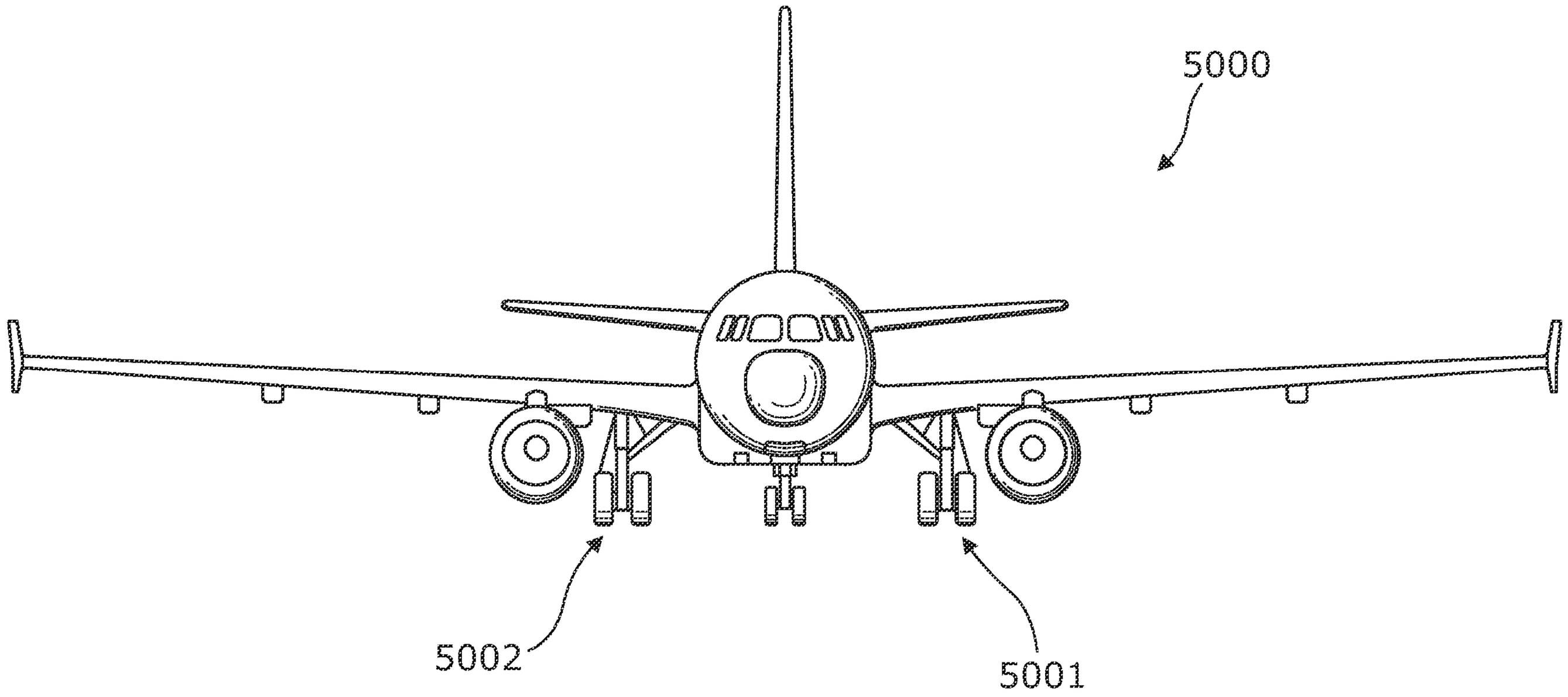

Figure 5

A HYDRAULIC VALVE MANIFOLD

BACKGROUND OF THE INVENTION

[0001] The present disclosure relates to a hydraulic valve manifold.

[0002] The present invention concerns hydraulic valve manifolds. More particularly, but not exclusively, this invention concerns a hydraulic valve manifold for a hydraulic actuator, perhaps for use on an aircraft, and perhaps for use to move a landing gear drive system pinion, the hydraulic valve manifold comprising a hydraulic fluid input line, for receiving pressurised hydraulic fluid from a hydraulic fluid supply, a hydraulic fluid return line for returning hydraulic fluid to a hydraulic fluid return, at least one pressurisation line for connection to the hydraulic actuator, and at least one command input line for receiving pressurised hydraulic fluid from a command manifold for the hydraulic actuator. The invention also concerns provides an aircraft landing gear drive system, a method of operating a hydraulic valve manifold and a method of operating an aircraft landing gear drive system.

[0003] Figure 1, which will be described in detail later, is an illustration of a prior example of a hydraulic system for use with a hydraulic actuator. The hydraulic system comprises a number of different manifolds; an isolation manifold, a pressurisation manifold and a command manifold. Each of the manifolds adds a complexity to the hydraulic system and increases the weight of the system.

[0004] The present invention seeks to mitigate the above-mentioned problems. Alternatively or additionally, the present invention seeks to provide an improved hydraulic valve manifold.

SUMMARY OF THE INVENTION

[0005] The present invention provides, according to a first aspect, a hydraulic valve manifold for a hydraulic actuator, the hydraulic valve manifold comprising a hydraulic

fluid input line, for receiving pressurised hydraulic fluid from a hydraulic fluid supply, a hydraulic fluid return line for returning hydraulic fluid to a hydraulic fluid return, at least one pressurisation line for connection to the hydraulic actuator, and at least one command input line for receiving pressurised hydraulic fluid from a command manifold for the hydraulic actuator, wherein the hydraulic valve manifold further comprises a positioner valve with three positions: a first isolation position, in which the at least one pressurisation line is connected through the positioner valve to the hydraulic fluid return line, such that the at least one pressurisation line is in a low pressure state, a second actuator pressurisation position, in which the hydraulic fluid input line is connected through the positioner valve to the at least one pressurisation line, such that that at least one pressurisation line is in a high pressure state, and a third command position, in which the at least one command input line is connected through the positioner valve to the at least one pressurisation line, such that the pressure state of the at least one pressurisation line is controlled by the command manifold.

[0006] The low pressure state is a state where there is little or no pressure from hydraulic fluid in the pressurisation line. The high pressure state is a state where there is a high pressure from hydraulic fluid in the pressurisation line. Of course, a skilled person knows a low pressure state occurs where there is no supply of pressurised hydraulic fluid and the high pressure state occurs where there is.

[0007] Such a manifold is able to control a hydraulic system and provide three different control functions or modes, with a single manifold. This provides a significant weight saving over the arrangement of Figure 1, where two separate manifolds are provided to achieve the same three control functions or modes. In addition, this manifold comprises less moving parts than the arrangement of Figure 1, meaning that maintenance and repair, as well as reliability, are improved.

[0008] The at least one pressurisation line may be for connection to one end of the hydraulic actuator. The at least one pressurisation line may act to provide pressurisation to the actuator to move it to an actuator first position. An additional pressurisation line may be connected to an opposite end of the hydraulic actuator. The additional pressurisation line may act to provide pressurisation to the actuator to move it to an

actuator second position. The actuator first position may be an actuator extended position. The actuator second position may be an actuator retracted position. The additional pressurization line may be connected to the command manifold.

[0009] The hydraulic manifold may be a unitary object. In other words, there is a single valve providing the three different control functions or modes.

[0010] Preferably, the hydraulic valve manifold further comprises a command pressurisation line connected to the positioner valve and for connection to the command manifold for the hydraulic actuator. Hence, the hydraulic valve manifold can isolate the command manifold, so the command manifold is not provided with pressurised hydraulic fluid.

[0011] More preferably, when the positioner valve is in the first isolation position, the command pressurisation line is connected through the positioner valve to the hydraulic fluid return line, such that the command pressurisation line is in a low pressure state.

[0012] Preferably, when the positioner valve is in the second actuator pressurisation position, the command pressurisation line is connected through the positioner valve to the hydraulic fluid return line, such that the command pressurisation line is in a low pressure state.

[0013] Preferably, when the positioner valve is in the third command position, the command pressurisation line is connected through the positioner valve to the hydraulic fluid input line, such that the command pressurisation line is in a high pressure state. Hence, the command manifold is able to use that pressurised hydraulic fluid to command movement of the hydraulic actuator.

[0014] Preferably, the hydraulic valve manifold has two pressurisation lines connected to the positioner valve; a first pressurisation line for connection to a first hydraulic actuator and a second pressurisation line for connection to a second hydraulic actuator.

[0015] More preferably, the hydraulic valve manifold has two command input lines; a first command input line for receiving from the command manifold a command pressure for the first actuator and connected to a first command input of the positioner

valve and a second command input line for receiving from the command manifold a command pressure for the second actuator and connected to a second command input of the positioner valve.

[0016] Preferably, the hydraulic fluid input line comprises two positioner valve branch lines; a first positioner valve branch line connected to a first fluid input of the positioner valve and a second positioner valve branch line connected to a second fluid input of the positioner valve.

[0017] More preferably, when the positioner valve is in the second actuator pressurisation position, the first positioner valve branch line is connected through the positioner valve to the first pressurisation line and the second positioner valve branch line is connected through the positioner valve to the second pressurisation line.

[0018] Preferably, when the positioner valve is in the third command position, the command pressurisation line is connected through the positioner valve to only one of the first and second positioner valve branch lines.

[0019] Preferably, the hydraulic valve manifold further comprises two pilot valves; a first pilot valve capable of urging the positioner valve in a first direction and a second pilot valve capable of urging the positioner valve in a second, opposite direction. Thus, the pilot valves are able to facilitate movement of the positioner valve into the desired position (out of the three).

[0020] The hydraulic fluid input line may comprise two pilot valve input branch lines; a first pilot valve input branch line connected to the first pilot valve and a second pilot valve input branch line connected to the second pilot valve. The hydraulic fluid return line may comprise two pilot valve return branch lines; a first pilot valve return branch line connected to the first pilot valve and a second pilot valve return branch line connected to the second pilot valve. Each pilot valve may be moveable between two positions; a pilot valve first position in which the relevant pilot valve input branch line provides pressurised hydraulic fluid and causes movement of the positioner valve in the relevant direction, and a pilot valve second position in which the relevant pilot valve return branch line removes pressurised hydraulic fluid and does not cause movement of the positioner valve in the relevant direction.

[0021] Preferably, the positioner valve is biased by at least one biasing element into one of the three positions. For example, this position may be the second pressurisation position. Alternatively, it may be the first isolation position. It is possible, but unlikely, to be the third command position, as it is preferred to have the default position as one in which the hydraulic actuator(s) cannot be commanded.

[0022] Preferably, wherein the hydraulic actuator is for moving a landing gear drive pinion into and out of engagement with a landing gear driven gear. In the third command position, the command manifold controls the pressure state of the at least one pressurisation line, and so controls engagement/disengagement of drive pinion.

[0023] There may be first and second hydraulic actuators to control engagement/disengagement of first and second drive pinions, associated with first and second driven gears on first and second aircraft wheels, respectively.

[0024] The actuator first position may be an actuator extended position. In this position, the drive pinion may be disengaged from the driven gear (i.e. locked out of engagement). The second position may be an actuator retracted position. In this position, the drive pinion may be engaged with the driven gear.

[0025] Preferably, the positioner valve has five ports: a hydraulic fluid input port, for receiving pressurised hydraulic fluid from a hydraulic fluid supply, a hydraulic fluid return port, for returning hydraulic fluid to a hydraulic fluid return, a pressurisation port for connection to the hydraulic actuator, a command input port for receiving pressurised hydraulic fluid from a command manifold for the hydraulic actuator, and a command pressurisation port for connection to the command manifold for the hydraulic actuator.

[0026] More preferably, the positioner valve has a further three ports: a second hydraulic fluid input port, for receiving pressurised hydraulic fluid from a hydraulic fluid supply, a second pressurisation port for connection to a second hydraulic actuator, and a second command input port for receiving pressurised hydraulic fluid from a command manifold for the second hydraulic actuator.

[0027] According to a second aspect of the invention there is also provided an aircraft landing gear drive system comprising a driven gear for mounting to an aircraft wheel, a drive pinion moveable in relation to the driven gear between an engaged position

and a disengaged position, a hydraulic actuator for moving the drive pinion between the engaged and disengaged positions, a command manifold to command movement of the hydraulic actuator, and a hydraulic valve manifold as described above.

[0028] The at least one pressurisation line may be for connection to one end of the hydraulic actuator. The pressurisation line may act to provide pressurisation to the actuator to move it to an actuator first position. An additional pressurisation line may be connected to opposite end of the hydraulic actuator. The additional pressurisation line may act to provide pressurisation to the actuator to move it to an actuator second position. The actuator first position may be an actuator extended position. The second position may be an actuator retracted position. The additional pressurization line may be connected to the command manifold.

[0029] The aircraft landing gear drive system may comprise two sets of drive pinion, driven gear and hydraulic actuator. The hydraulic valve manifold may have two pressurisation lines connected to the positioner valve; a first pressurisation line for connection to a first hydraulic actuator and a second pressurisation line for connection to a second hydraulic actuator.

[0030] According to a third aspect of the invention there is also provided a method of operating a hydraulic valve manifold, the method comprising the steps of having a positioner valve of the hydraulic valve manifold in a first isolation position, in which a hydraulic actuator is connected to a hydraulic fluid return, having the positioner valve in a second actuator pressurisation position, in which the hydraulic actuator is connected to a pressurised hydraulic fluid supply, and having the positioner valve in a third command position, in which a command input is connected to the hydraulic actuator.

[0031] In the second step, the pressurised hydraulic fluid supply provides pressurisation to the actuator to move it to an actuator first position. An additional pressurisation line may be connected to an opposite end of the hydraulic actuator. The additional pressurisation line may be capable of acting to provide pressurisation to the actuator to move it to an actuator second position. The actuator first position may be an actuator extended position. The second position may be an actuator retracted position. The additional pressurization line may be connected to the command manifold.

[0032] The method steps may occur in the above order, or they may occur in reverse order.

[0033] According to a fourth aspect of the invention there is also provided a method of operating an aircraft landing gear drive system, the method comprising the steps of having a positioner valve of a hydraulic valve manifold in a first isolation position, in which a hydraulic actuator, that controls engagement of a drive pinion with a driven gear, is connected to a hydraulic fluid return, having the positioner valve in a second actuator pressurisation position, in which the hydraulic actuator is connected to a pressurised hydraulic fluid supply, and having the positioner valve in a third command position, in which a command input is connected to the hydraulic actuator.

[0034] In the second step, the pressurised hydraulic fluid supply provides pressurisation to the actuator to move it to an actuator first position. An additional pressurisation line may be connected to an opposite end of the hydraulic actuator. The additional pressurisation line may be capable of acting to provide pressurisation to the actuator to move it to an actuator second position. The actuator first position may be an actuator extended position. The second position may be an actuator retracted position. The additional pressurization line may be connected to the command manifold.

[0035] The method steps may occur in the above order, or they may occur in reverse order.

[0036] It will of course be appreciated that features described in relation to one aspect of the present invention may be incorporated into other aspects of the present invention. For example, the method of the invention may incorporate any of the features described with reference to the apparatus of the invention and vice versa.

DESCRIPTION OF THE DRAWINGS

[0037] Embodiments of the present invention will now be described by way of example only with reference to the accompanying schematic drawings of which:

[0038] Figure 1 shows a schematic view of an example of a landing gear drive system;

[0039] Figure 2 shows a schematic view of a hydraulic valve manifold according to a first embodiment of the invention, the hydraulic valve manifold being in first isolation position;

[0040] Figure 3 shows a schematic view of the hydraulic valve manifold of Figure 2, the hydraulic valve manifold being in second pressurisation position; and

[0041] Figure 4 shows a schematic view of the hydraulic valve manifold of Figures 2 and 3, the hydraulic valve manifold being in third command position; and

[0042] Figure 5 shows a front view of an aircraft, having a landing gear and a landing gear drive system including the hydraulic valve manifold of Figures 2, 3 and 4.

DETAILED DESCRIPTION

[0043] Figure 1 shows a schematic view of an example of a landing gear drive system 1000. As can be seen, the system comprises a left hand landing gear 100 and a similar right hand landing gear 200. The system also comprises an isolation manifold 400, a pressurisation manifold 500 and a command manifold 600. The system also comprises various hydraulic lines within and between the different manifolds and the landing gear.

[0044] First of all, the left hand landing gear 100 will be described. The right hand landing gear 200 is similar and will not be described separately. The left hand landing gear comprises a roller gear drive pinion 110 which is pivotally mounted to a landing gear structure 111 (including a wheel provided with a driven sprocket gear that has sprocket teeth corresponding to the rollers of the roller gear drive pinion, not shown). The drive pinion 110 is moveable in and out of meshing with the sprocket by a hydraulic actuator 120. The actuator 120 comprises a hydraulic cylinder 121. The cylinder has a piston 124 within the cylinder, connected to a piston rod 125 extending out of the cylinder. The far end of the piston rod 125 is connected to the drive pinion 110. Within the hydraulic cylinder 121 is a first end port 122 located on one side of the piston 124 (furthest away from the piston rod 125). On the other side of the piston 124 there is a

second end port 123 (nearer the piston rod 125). The landing gear also comprises a lock link arrangement 130 designed to retain the drive pinion 110 in the non-meshing position.

[0045] The isolation manifold 400 will now be described. The isolation manifold 400 comprises an input 701 from a hydraulic fluid supply. This input 701 is passed through an inlet filter 401 and then provided to an isolation valve 402 and an isolation pilot valve 403. There is also an output 702 to a hydraulic fluid return. This output 702 is also connected to the isolation valve 402 and isolation pilot valve 403. There is a pilot pressurisation line 404 between the pilot valve 403 and the isolation valve 402. There is also an isolation manifold output line 405.

[0046] The pilot valve 403 has two positions. In a first isolation position (as shown), the input 701 is blocked from the pilot pressurisation line 404 and the output 702 is connected to the pilot pressurisation line 404. In this position, the pilot pressurisation line 404 only exerts a low pressure on the isolation valve 402 and so the isolation valve 402 remains, under spring pressure, in the isolation positon shown.

[0047] When the pilot valve 403 is moved to a second pressurisation position, the input 701 is connected to the pilot pressurisation line 404. Also, the output 702 is blocked from the pilot pressurisation line 404. In this position, the pilot pressurisation line 404 exerts a high pressure on the isolation valve 402 and so the isolation valve 402 would move to a second pressurisation position.

[0048] In the first isolation position of the isolation valve 402, the input 701 is blocked and the output 702 is connected to the isolation manifold output line 405. Hence, in this position, the isolation manifold output line 405 only provides low-pressure hydraulic fluid. In other words, everything down stream of the isolation manifold 400 is isolated from the hydraulic fluid supply 701.

[0049] In the second pressurisation position of the isolation valve 402, the input 701 is connected to the isolation manifold output line 405 and access to the output 702 from the isolation valve 402 is blocked. Hence, in this position, the isolation manifold output line 405 provides high-pressure hydraulic fluid.

[0050] The isolation manifold output line 405 is connected to the pressurisation manifold 500, which will now be described. The pressurisation manifold 500 is also

connected to the hydraulic fluid return 702. It also has further connections to connection lines, as follows:

- a left hand actuator first end command line 703, which connects to the first end port 122 of the left hand landing gear actuator 120,
- a right hand actuator first end command line 704, which connects to the first end port of the right hand landing gear actuator,
- a command manifold pressurisation line 707, which connects to the command manifold 600,
- a command receiving line for the left hand actuator first end 709, which connects to the command manifold 600, and
- a command receiving line for the right hand actuator first end 708, which connects to the command manifold 600.

[0051] In a similar way to the isolation manifold 400, the pressurisation manifold comprises a valve (pressurisation valve 502) controlled by a pilot valve 503.

[0052] In a first position of the pilot valve 503 and hence, a first position of a pressurisation valve 502, (as shown), both the lines 708, 709 are blocked off. The line 707 is connected to the return line 702 and the line 405 is connected to both lines 703 and 704. Hence, in the position shown, any pressure in the isolation manifold output line 405 is provided to the first end ports 122 of the two landing gear actuators 120. This means that hydraulic pressure for locking the actuators 120 in the drive pinion 110 non-meshing position may be provided. In addition, as the command manifold pressurisation line 707 is connected to the return 702, the command manifold is only provided with low-pressure hydraulic fluid (i.e. the command manifold 600 is isolated).

[0053] In a second position of the pilot valve 503 and hence, a second position of a pressurisation valve 502, (not as shown), the line 708 is connected to line 704 and line 709 is connected to line 703. The line 707 is connected to the line 405. Hence, in the position shown, if the isolation valve 402 is in the second position, the command manifold 600 is provided with high-pressure hydraulic fluid. Also, command pressure provided from the command manifold 600 in lines 709, 708 is provided to the first end port 122 of the left and right hand landing gear actuators, respectively.

[0054] The command manifold 600, in addition to the connection lines described above, has two further connection lines, as follows:

- a left hand actuator second end command line 705, which connects to the second end port 123 of the left hand landing gear actuator 120, and
- a right hand actuator second end command line 706, which connects to the second end port of the right hand landing gear actuator.

[0055] Hence, when the isolation valve 402 is in the second positon and when the pressurisation valve is in the second position, the command manifold 600 is able to command pressure in the first and second end ports 122, 123 of the landing gear actuators 120. In particular, if low-pressure is provided to the first end ports 122 and high pressure is provided to the second end ports 123, the pistons 124 are pushed towards the first end ports of the cylinder 121 and so the drive pinions 110 are pivoted towards the landing gear structures 111 to mesh with the sprockets (not shown).

[0056] Figure 2 shows a schematic view of a hydraulic valve manifold 3000 according to a first embodiment of the invention, the hydraulic valve manifold being in first isolation position.

[0057] The hydraulic valve manifold 3000 is used to replace the elements shown in box 2000 in Figure 1. Hence, the manifold 3000 is connected to the following lines:

- 701 hydraulic fluid supply,
- 702 hydraulic fluid return,
- 703 left hand actuator first end command line,
- 704 right hand actuator first end command line,
- 707 command manifold pressurisation line,
- 708 command receiving line for the right hand actuator first end, and
- 709 command receiving line for the left hand actuator first end.

[0058] The hydraulic valve manifold 3000 comprises a hydraulic valve 3100 controlled by a first pilot valve 3110 and a second pilot valve 3120. All three valves are connected to the hydraulic fluid supply 701 and hydraulic fluid return 702.

[0059] In particular, the hydraulic fluid supply line 701 is connected, through an inlet filter 3200, to the following branch lines:

- a first pilot valve input branch line 3301, which is connected to the first pilot valve 3110,
- a second pilot valve input branch line 3302, which is connected to the second pilot valve 3120,
- a hydraulic valve first input branch line 3303, which is connected to a first input to the hydraulic valve 3100, and
- a hydraulic valve second input branch line 3304, which is connected to a second input to the hydraulic valve 3100.

[0060] Also, the hydraulic fluid return 702 is connected to the following branch lines:

- a first pilot valve return branch line 3401, which is connected to the first pilot valve 3110,
- a second pilot valve return branch line 3402, which is connected to the second pilot valve 3120, and
- a hydraulic valve return branch line 3403, which is connected to the hydraulic valve 3100.

[0061] In addition, the hydraulic valve 3100 is connected to the left hand actuator first end command line 703 by an internal left hand actuator first end command line 3501, and to the right hand actuator first end command line 704 by an internal right hand actuator first end command line 3601. There is also an internal command manifold pressurisation line 3701, which connects the hydraulic valve 3100 to the command manifold pressurisation line 707.

[0062] Further, there is an internal command receiving line for the right hand actuator first end 3801, which is connected to the command receiving line for the right hand actuator first end 708 and an internal command receiving line for the left hand actuator first end 3901, which is connected to the command receiving line for the left hand actuator first end 709.

[0063] The hydraulic valve 3100 has three sections; a first isolation section 3150, a second pressurisation section 3160 and a third command section 3170. The position of

the valve 3100 is determined by which section of the valve 3100 is lined up with the various lines of the valve.

[0064] Figure 2 shows the valve 3100 in a first isolation position, in which the isolation section 3150 is lined up with the various lines 3303, 3304, 3403, 3501, 3601, 3701, 3801, 3901.

[0065] Here, the lines 3303 and 3304 are blocked off. In addition, lines 3801 and 3901 are also blocked off. In this positon, lines 3501, 3601 and 3701 are all connected to line 3403.

[0066] Hence, in this first isolation position, no high-pressure hydraulic fluid is supplied to the command manifold or to the left or right hand actuators 120. Hence, the system can be considered to be isolated, in the same way as the system of Figure 1 with the isolation valve 402 in the first isolation position.

[0067] Figure 3 shows the valve 3100 in second pressurisation position, in which the pressurisation section 3160 is lined up with the various lines 3303, 3304, 3403, 3501, 3601, 3701, 3801, 3901.

[0068] Here, the lines 3801 and 3901 are blocked off. In this positon, lines 3303 and 3304 are connected to the lines 3501 and 3601, respectively. Finally, line 3701 is connected to line 3403.

[0069] Hence, in this second pressurisation position, no high-pressure hydraulic fluid is supplied to the command manifold. However, high-pressure hydraulic fluid is provided to the first end ports of the left and right hand actuators 120. Hence, the system can be considered to be pressurised, in the same way as the system of Figure 1 with the isolation valve 402 in the second pressurisation position.

[0070] Figure 4 shows the valve 3100 in a third command position, in which the command section 3170 is lined up with the various lines 3303, 3304, 3403, 3501, 3601, 3701, 3801, 3901.

[0071] Here, the lines 3801 and 3901 are connected to lines 3601, 3501, respectively. In this positon, line 3303 is blocked off but line 3304 is connected to line 3701. Finally, line 3403 is blocked off.

[0072] Hence, in this third command position, high-pressure hydraulic fluid is supplied to the command manifold. In addition, the pressure commanded by the command manifold (in lines 709, 708 respectively) is provided to the first end ports 122 of the left and right hand actuators, respectively. This is done via lines 3901, 3501 and 3801, 3601, respectively. Hence, the system can be considered to be commanded, in the same way as the system of Figure 1 with the isolation valve 402 in the second pressurisation position and the pressurisation valve 502 in the second position.

[0073] The hydraulic valve 3100 can be moved between its three positions using the two pilot valves 3110, 3120 to urge the hydraulic valve against the biasing action of springs 3130, 3140 located at either end of the hydraulic valve 3100. The spring s 3130, 3140 bias the valve 3100 to the second pressurisation position (i.e. where the middle (pressurisation) section 3160 of the valve is lined up with the various lines).

[0074] In particular, the first pilot valve 3110 is provided with high-pressure hydraulic fluid from the hydraulic fluid supply 701 via first pilot valve input branch line 3301 and provided with access to the hydraulic return line 702 via first pilot valve return branch line 3401. The second pilot valve 3120 is provided with high-pressure hydraulic fluid from the hydraulic fluid supply 701 via second pilot valve input branch line 3302 and provided with access to the hydraulic return line 702 via second pilot valve return branch line 3402.

[0075] The first pilot valve 3110 has a first pilot valve command line 3111 connected to the hydraulic valve 3100. This command line 3111 can either receive high-pressure hydraulic fluid or low-pressure hydraulic fluid, depending on the positon of the first pilot valve. Similarly, the second pilot valve 3120 has a second pilot valve command line 3121 connected to the hydraulic valve 3100. This command line 3121 can either receive high-pressure hydraulic fluid or low-pressure hydraulic fluid, depending on the positon of the second pilot valve.

[0076] To achieve the first isolation position of Figure 2, the first pilot valve command line 3111 is provided with low-pressure hydraulic fluid and the second pilot valve command line 3121 is provided with high-pressure hydraulic fluid. Hence, the hydraulic valve 3100 is urged against the biasing action of the springs 3130, 3140 to the

isolation position (i.e. where the right (isolation) section 3150 of the valve is lined up with the various lines).

[0077] To achieve the second pressurisation position of Figure 3, the first pilot valve command line 3111 is provided with low-pressure hydraulic fluid and the second pilot valve command line 3121 is provided with low-pressure hydraulic fluid. Hence, the biasing action of the springs 3130, 3140 biases the hydraulic valve to its default pressurisation position (i.e. where the middle (pressurisation) section 3160 of the valve is lined up with the various lines).

[0078] To achieve the third command position of Figure 4, the first pilot valve command line 3111 is provided with high-pressure hydraulic fluid and the second pilot valve command line 3121 is provided with low-pressure hydraulic fluid. Hence, the hydraulic valve 3100 is urged against the biasing action of the springs 3130, 3140 to the command position (i.e. where the left (command) section 3170 of the valve is lined up with the various lines).

[0079] Figure 5 shows a front view of an aircraft 5000, having a left landing gear 5001 and a right landing gear 5002. The aircraft 5000 also comprises (not shown) the hydraulic valve manifold 3000 of Figures 2, 3 and 4.

[0080] Whilst the present invention has been described and illustrated with reference to particular embodiments, it will be appreciated by those of ordinary skill in the art that the invention lends itself to many different variations not specifically illustrated herein. By way of example only, certain possible variations will now be described.

[0081] In the above example, the hydraulic valve 3100 is biased towards the pressurisation position by the springs 3130, 3140. It could also be biased to a different position, for example, the isolation position.

[0082] Various fuses and valves etc. have not been described where their functionality does not affect the elements described. However, any suitable number of other valves and/or filters and/or fuses may be used.

[0083] Where in the foregoing description, integers or elements are mentioned which have known, obvious or foreseeable equivalents, then such equivalents are herein incorporated as if individually set forth. Reference should be made to the claims for

determining the true scope of the present invention, which should be construed so as to encompass any such equivalents. It will also be appreciated by the reader that integers or features of the invention that are described as preferable, advantageous, convenient or the like are optional and do not limit the scope of the independent claims. Moreover, it is to be understood that such optional integers or features, whilst of possible benefit in some embodiments of the invention, may not be desirable, and may therefore be absent, in other embodiments.

[0084] It should be noted that throughout this specification, "or" should be interpreted as "and/or".

CLAIMS

1. A hydraulic valve manifold for a hydraulic actuator, the hydraulic valve manifold comprising:

i) a hydraulic fluid input line, for receiving pressurised hydraulic fluid from a hydraulic fluid supply,

ii) a hydraulic fluid return line for returning hydraulic fluid to a hydraulic fluid return,

iii) at least one pressurisation line for connection to the hydraulic actuator, and

iv) at least one command input line for receiving pressurised hydraulic fluid from a command manifold for the hydraulic actuator,

wherein the hydraulic valve manifold further comprises;

v) a positioner valve with three positions:

a) a first isolation position, in which the at least one pressurisation line is connected through the positioner valve to the hydraulic fluid return line, such that the at least one pressurisation line is in a low pressure state,

b) a second actuator pressurisation position, in which the hydraulic fluid input line is connected through the positioner valve to the at least one pressurisation line, such that that at least one pressurisation line is in a high pressure state, and

c) a third command position, in which the at least one command input line is connected through the positioner valve to the at least one pressurisation line, such that the pressure state of the at least one pressurisation line is controlled by the command manifold.

2. A hydraulic valve manifold as claimed in claim 1, wherein the hydraulic valve manifold further comprises a command pressurisation line connected to the positioner valve and for connection to the command manifold for the hydraulic actuator.

3. A hydraulic valve manifold as claimed in claim 2, wherein, when the positioner valve is in the first isolation position, the command pressurisation line is connected through the positioner valve to the hydraulic fluid return line, such that the command pressurisation line is in a low pressure state.

4. A hydraulic valve manifold as claimed in claim 2 or claim 3, wherein, when the positioner valve is in the second actuator pressurisation position, the command pressurisation line is connected through the positioner valve to the hydraulic fluid return line, such that the command pressurisation line is in a low pressure state.

5. A hydraulic valve manifold as claimed in claim 2, claim 3 or claim 4, wherein, when the positioner valve is in the third command position, the command pressurisation line is connected through the positioner valve to the hydraulic fluid input line, such that the command pressurisation line is in a high pressure state.

6. A hydraulic valve manifold as claimed in any preceding claim, wherein the hydraulic valve manifold has two pressurisation lines connected to the positioner valve; a first pressurisation line for connection to a first hydraulic actuator and a second pressurisation line for connection to a second hydraulic actuator.

7. A hydraulic valve manifold as claimed in claim 6, wherein the hydraulic valve manifold has two command input lines; a first command input line for receiving from the command manifold a command pressure for the first actuator and connected to a first command input of the positioner valve and a second command input line for receiving from the command manifold a command pressure for the second actuator and connected to a second command input of the positioner valve.

8. A hydraulic valve manifold as claimed in any preceding claim, wherein the hydraulic fluid input line comprises two positioner valve branch lines; a first positioner valve branch line connected to a first fluid input of the positioner valve and a second positioner valve branch line connected to a second fluid input of the positioner valve.

9. A hydraulic valve manifold as claimed in claim 8 when dependent on claim 6, wherein, when the positioner valve is in the second actuator pressurisation position, the first positioner valve branch line is connected through the positioner valve to the first pressurisation line and the second positioner valve branch line is connected through the positioner valve to the second pressurisation line.

10. A hydraulic valve manifold as claimed in claim 8 or claim 9, when dependent on claim 5, wherein, when the positioner valve is in the third command position, the command pressurisation line is connected through the positioner valve to only one of the first and second positioner valve branch lines.

11. A hydraulic valve manifold as claimed in any preceding claim, wherein the hydraulic valve manifold further comprises two pilot valves; a first pilot valve capable of urging the positioner valve in a first direction and a second pilot valve capable of urging the positioner valve in a second, opposite direction.

12. A hydraulic valve manifold as claimed in any preceding claim, wherein the positioner valve is biased by at least one biasing element into one of the three positions.

13. A hydraulic valve manifold as claimed in any preceding claim, wherein the hydraulic actuator is for moving a landing gear drive pinion into and out of engagement with a landing gear driven gear.

14. A hydraulic valve manifold as claimed in any preceding claim, wherein the positioner valve has five ports:

- a hydraulic fluid input port, for receiving pressurised hydraulic fluid from a hydraulic fluid supply,

- a hydraulic fluid return port, for returning hydraulic fluid to a hydraulic fluid return,

- a pressurisation port for connection to the hydraulic actuator,

- a command input port for receiving pressurised hydraulic fluid from a command manifold for the hydraulic actuator, and

- a command pressurisation port for connection to the command manifold for the hydraulic actuator.

15. A hydraulic valve manifold as claimed in claim 14, wherein the positioner valve has a further three ports:

- a second hydraulic fluid input port, for receiving pressurised hydraulic fluid from a hydraulic fluid supply,

- a second pressurisation port for connection to a second hydraulic actuator, and

- a second command input port for receiving pressurised hydraulic fluid from a command manifold for the second hydraulic actuator.

16. An aircraft landing gear drive system comprising:

i) a driven gear for mounting to an aircraft wheel,

ii) a drive pinion moveable in relation to the driven gear between an engaged position and a disengaged position,

iii) a hydraulic actuator for moving the drive pinion between the engaged and disengaged positions,

iv) a command manifold to command movement of the hydraulic actuator, and

v) a hydraulic valve manifold as claimed in any preceding claim.

17. A method of operating a hydraulic valve manifold, the method comprising the steps of:

i) having a positioner valve of the hydraulic valve manifold in a first isolation position, in which a hydraulic actuator is connected to a hydraulic fluid return,

ii) having the positioner valve in a second actuator pressurisation position, in which the hydraulic actuator is connected to a pressurised hydraulic fluid supply, and

iii) having the positioner valve in a third command position, in which a command input is connected to the hydraulic actuator.

18. A method of operating an aircraft landing gear drive system, the method comprising the steps of:

i) having a positioner valve of a hydraulic valve manifold in a first isolation position, in which a hydraulic actuator, that controls engagement of a drive pinion with a driven gear, is connected to a hydraulic fluid return,

ii) having the positioner valve in a second actuator pressurisation position, in which the hydraulic actuator is connected to a pressurised hydraulic fluid supply, and

iii) having the positioner valve in a third command position, in which a command input is connected to the hydraulic actuator.

Intellectual Property Office

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Claims searched:	1 to 18	**Date of search:**	20 December 2019

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A	-	US 2013/0318838 A1 (WALIMAA et al.) See especially the Abstract; and Figures 2 & 3.
A	-	WO 2015/137177 A1 (KAYABA INDUSTRY) See especially the Abstract; and all Figures.
A	-	US 2018/0112686 A1 (ROBERTI) See especially the Abstract; and all Figures.

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B64C; F15B

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WPI, EPODOC

International Classification:

Subclass	Subgroup	Valid From
F15B	0013/08	01/01/2006
B64C	0025/18	01/01/2006
B64C	0025/26	01/01/2006