(19) IPOS INTELLECTUAL PROPERTY OFFICE OF SINGAPORE

(11) Publication number: **SG 190045 A1**
(43) Publication date: **28.06.2013**
(51) Int. Cl: **F15B 3/00;**

(12) Patent Application

(21) Application number: **2013032495**
(22) Date of filing: **31.10.2011**
(30) Priority: **EP 10189641.3 02.11.2010**

(71) Applicant: **VETCO GRAY CONTROLS LIMITED 2, HIGH STREET NAILSEA BRISTOL BS48 1BS GB**
(72) Inventor: **ROBERTS, TIMOTHY JAMES 12 RIVERSIDE PARK, SEVERN BEACH SOUTH GLOUCESTERSHIRE BS35 4PN (GB) GB**

(54) **Title:**
HIGH PRESSURE INTENSIFIERS

(57) **Abstract:**
A hydraulic intensifier (1) comprises a reciprocating differential piston arrangement (3, 4, 4') and control means for controlling the supply of low pressure hydraulic fluid to the intensifier, said control means comprising at least one solenoid operated pilot valve (10, 10') and electronic means (25) for operating the pilot valve.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
10 May 2012 (10.05.2012)

PCT

(10) International Publication Number
WO 2012/059478 A1

(51) International Patent Classification:
F15B 3/00 (2006.01)

(21) International Application Number:
PCT/EP2011/069172

(22) International Filing Date:
31 October 2011 (31.10.2011)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
10189641.3 2 November 2010 (02.11.2010) EP

(71) Applicant *(for all designated States except US)*: **VETCO GRAY CONTROLS LIMITED** [GB/GB]; 2, High Street, Nailsea, Bristol BS48 1BS (GB).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **ROBERTS, Timothy James** [GB/GB]; 12 Riverside Park, Severn Beach South Gloucestershire BS35 4PN (GB).

(74) Agent: **ILLINGWORTH-LAW, William**; GE International Inc., Global Patent Operation - Europe, 15 John Adam Street, London WC2N 6LU (GB).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) **Title**: HIGH PRESSURE INTENSIFIERS

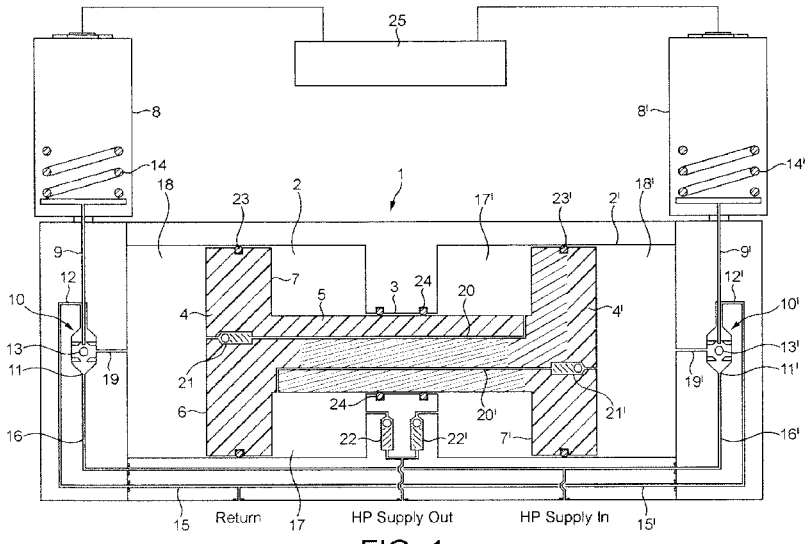

FIG. 1

(57) **Abstract**: A hydraulic intensifier (1) comprises a reciprocating differential piston arrangement (3, 4, 4') and control means for controlling the supply of low pressure hydraulic fluid to the intensifier, said control means comprising at least one solenoid operated pilot valve (10, 10') and electronic means (25) for operating the pilot valve.

WO 2012/059478 A1

HIGH PRESSURE INTENSIFIERS

Field of the Invention

The present invention relates to high pressure intensifiers.

Background of the Invention

Within the subsea oil industry, subsea trees require few high pressure valve functions. For most wells, often only one high pressure valve, typically the subsea safety valve (SSSV), is required on each well head tree. This valve requires a source of high pressure hydraulic fluid at the seabed. The cost of an additional high pressure line in an umbilical from a surface platform to a well is very expensive, so subsea pressure intensification, local to the well tree, is sometimes used. This is particularly cost-effective when a number of wells are strung out as offsets fed from a primary manifold, especially as the offsets are increasingly further away from the manifold. Where subsea pressure intensification is used, a high pressure accumulator is designed into the system and, since the SSSV is operated extremely infrequently, the intensifier is only required to top up the accumulator.

Current subsea intensifiers are highly engineered, and can be expensive and unreliable. Typically, they are self-governing, twin-acting, intensifiers that rely on a piston reaching the end of its stroke to trigger a change-over valve, to send the piston back in the opposite direction. When the high pressure fluid demand is almost zero, i.e. when the SSSV is not being actuated and only fluid leakage is 'consuming' pressure, the piston can stall at the end of the stroke with the change-over valve in a half-moved position. In this condition, these devices leak from a low pressure supply, to a return. This can compromise the function of the field and the change-over valve concerned can only be unstuck by actuating the SSSV to 'consume' some high pressure fluid. The SSSV is functionally critical to the oil well and can not easily be replaced if it wears out. This invention enables an improvement, which is more reliable, cheaper and more error tolerant in engineering.

GB-A-2 461 061 describes an intensifier using directional control valves (DCVs). Other forms of hydraulic intensifier are described in GB-A-2 275 969, EP-A-0 654 330, GB-A-2 198 081, GB-A-1 450 473 and EP-A-1 138 872.

Summary of the Invention

According to the present invention from one aspect, there is provided a hydraulic intensifier comprising a reciprocating differential piston arrangement and control means for controlling

the supply of low pressure hydraulic fluid to the intensifier, said control means comprising at least one solenoid operated pilot valve and electronic means for operating the pilot valve.

Such an intensifier could comprise:

a piston which has a first face at a low pressure side and a second, opposite face at a high pressure side, the first face having a greater surface area than the second face;

an input for supplying low pressure hydraulic fluid to said low pressure side; and

an output for high pressure hydraulic fluid from said high pressure side, said control means being arranged for controlling the supply of low pressure hydraulic fluid to the input.

Such an intensifier could include:

first and second such pistons, each of which has such a first face at a respective low pressure side and each of which has such a second face, at a respective high pressure side, wherein:

there is a respective such input at each of the low pressure sides;

the output is coupled with each of said high pressure sides;

the pistons are joined by a cylindrical member which defines the second face of each of the pistons; and

the control means comprises a respective such solenoid operated pilot valve for each input operable alternately by said electronic means.

Typically each of said pistons is reciprocable in a respective cylinder.

According to the present invention from another aspect, there is provided a hydraulic intensifier comprising:

a first piston which is reciprocable in a first cylinder;

a second piston which is reciprocable in a second cylinder;

a cylindrical member joining the pistons so that each of them has a first face which has a greater surface area than its second, opposite face as a result of said cylindrical member, the first face of each of the pistons being at a respective low pressure side and the second face of each of the pistons being at a respective high pressure side;

first and second inputs for supplying low pressure hydraulic fluid to respective ones of the low pressure sides;

an output for high pressure hydraulic fluid from the high pressure sides;

first and second solenoid operated pilot valves for controlling the supply of low pressure hydraulic fluid to respective ones of the inputs; and

electronic means arranged for operating the pilot valves for supplying low pressure hydraulic fluid alternately to the inputs.

There could be coupling means whereby, if low pressure fluid is applied to one of said low pressure sides, such fluid is also applied to the high pressure side of the other of the pistons.

Such coupling means could comprise a first passageway, between the low pressure side of such a first piston and the high pressure side of such a second piston, and a second passageway, between the low pressure side of the second piston and the high pressure side of the first piston, each of the passageways being provided with a respective non-return valve for permitting flow from the low pressure side to the high pressure side.

Said electronic means could be provided by a subsea electronics module of a subsea well control system.

According to the present invention from a further aspect, there is provided a method of producing high pressure hydraulic fluid, comprising providing a hydraulic intensifier comprising a reciprocating differential piston arrangement and controlling the supply of low pressure hydraulic fluid to the intensifier, using at least one solenoid operated pilot valve and electronic means which operate the pilot valve.

The intensifier could comprise:

a piston which has a first face at a low pressure side and a second, opposite face at a high pressure side, the first face having a greater surface area than the second face;

an input for supplying low pressure hydraulic fluid to said low pressure side; and

an output for high pressure hydraulic fluid from said high pressure side, said control means controlling the supply of low pressure hydraulic fluid to the input.

In such a method, the intensifier could include first and second such pistons, each of which has such a first face at a respective low pressure side and each of which has such a second face, at a respective high pressure side, wherein:

there is a respective such input at each of the low pressure sides;

the output is coupled with each of said high pressure sides;

the pistons are joined by a cylindrical member which defines the second face of each of the pistons; and

the control means comprises a respective such solenoid operated pilot valve for each input operated alternately by said electronic means.

Typically, each of said pistons is reciprocable in a respective cylinder.

According to the present invention from yet a further aspect, there is provided a method of producing high pressure hydraulic fluid comprising providing a hydraulic intensifier comprising:

a first piston which is reciprocable in a first cylinder;

a second piston which is reciprocable in a second cylinder;

a cylindrical member joining the pistons so that each of them has a first face which has a greater surface area than its second, opposite face as a result of said cylindrical member, the first face of each of the pistons being at a respective low pressure side and the second face of each of the pistons being at a respective high pressure side;

first and second inputs for supplying low pressure hydraulic fluid to respective ones of the low pressure sides; and

an output for high pressure hydraulic fluid from the high pressure sides;

there being first and second solenoid operated pilot valves which control the supply of said low pressure hydraulic fluid to respective ones of the inputs; and

electronic means which operate the pilot valves to supply low pressure hydraulic fluid alternately to the inputs.

The method could be such that, if low pressure fluid is applied to one of said low pressure sides, coupling means applies such fluid to the high pressure side of the other of the pistons.

Such coupling means could comprise a first passageway, between the low pressure side of such a first piston and the high pressure side of such a second piston, and a second passageway, between the low pressure side of the second piston and the high pressure side of the first piston, each of the passageways being provided with a respective non-return valve for permitting flow from the low pressure side to the high pressure side.

In a method according to the present invention, said electronic means could be provided by a subsea electronics module of a subsea well control system.

An embodiment of this invention is a pressure intensifier that uses commercially available pilot valves to operate a double-acting pair of pistons as a pressure intensifier that operates in a manner that eliminates complex and expensive DCVs and does not suffer from the problem of hydraulic fluid leakage experienced with current designs.

Brief Description of the Drawings

Fig. 1 shows a first embodiment of this invention; and

Fig. 2 shows a second embodiment of this invention.

Description of Embodiments of the Invention

Referring to Fig. 1, a double-acting hydraulic intensifier 1 comprises first and second cylinders 2 and 2' joined by a narrower cylinder section 3. Reciprocally slidable in cylinder 2 is a piston 4 and reciprocally slidable in cylinder 2' is a piston 4', pistons 4 and 4' being joined by a cylindrical member 5 extending through and slidable in cylinder section 3. By virtue of member 5, piston 4 has a first face 6, on the left-hand side in the figure, which has a greater surface area than its second, opposite face 7 and piston 4' has a first face 6', on the right-hand side in the figure, which has a greater surface area than its second, opposite face 7'.

On each side of the intensifier there is a solenoid operated pilot valve. More particularly, on each side there is: a solenoid 8 or 8' which operates a push rod 9 or 9'; and a hydraulic pilot valve 10 or 10' that has two ports 11 and 12 or 11' and 12' that can be closed by a small ball bearing 13 or 13' that is loose between them. In each case, when the solenoid is de-energised, the rod 9 or 9' presses down on the ball bearing 13 or 13' by the action of a spring 14 or 14' of the solenoid to close the port 11 or 11' but allow trapped hydraulic fluid to vent to a return via port 12 or 12' and a passageway 15 or 15'. When the solenoid 8 or 8' is energised, the rod 9 or 9' is moved upwards against the action of spring 14 or 14' to allow ball bearing 13 or 13' to cover the return port 12 or 12'.

A supply of low pressure (LP) hydraulic fluid is in communication with valves 10 and 10' via passageways 16 and 16' respectively. On the side of pistons 4 and 4' with smaller area faces (the high pressure sides), there are chambers 17 and 17' respectively, on the opposite (low pressure) sides there being chambers 18 and 18'. The valves 10 and 10' are linked with chambers 18 and 18' via input passageway 19 and 19' respectively.

Chamber 18 is in communication with chamber 17' via a passageway 20 through member 3 and a non-return valve 21; and chamber 18' is in communication with chamber 17 via a passageway 20' through member 3 and a non-return valve 21'. Chambers 17 and 17' are in communication with a high pressure (HP) supply output via non-return valves 22 and 22' respectively.

Reference numerals 23 and 23' denote seals via which pistons 4 and 4' slide in cylinders 2 and 2' respectively and reference numerals 24 denote seals against which member 5 slides in section 3.

Reference numeral 25 denotes electronic operating means for alternately energising and de-energising the solenoids 8 and 8', one after the other. The electronic means 25 could be

provided by a multivibrator module attached to or located close to the intensifier for other than subsea well usage. Alternatively, for example, in the case of use of the intensifier in connection with a subsea well, the function of electronic means 25 could be provided by a subsea electronics module (SEM) of the well control system.

When the solenoid 8 is energised by electronic means 25, low pressure hydraulic fluid is 'switched' by the pilot valve 10 into the chamber 18, whereby the pressure of the fluid acts on the face 6 of the piston 4, causing the latter to move to the right in Fig. 1 and force the fluid in the chamber 17, through the non-return valve 22 as a high pressure output. This output is at a higher pressure than the low pressure input because the surface area of the piston face 7 is less than the surface area of the piston face 6. The non-return valve 21 allows fluid transfer into the chamber 17', fluid in chamber 18' passing via passageway 19' and port 11' of pilot valve 10' to be vented to the return since solenoid 8' is de-energised. It is to be noted that, because of passageway 20 and non-return valve 21, when low pressure hydraulic fluid is applied to face 6 of piston 4, the pressure of that fluid will also be present at the face 7' of piston 4', thereby increasing the sum of areas exposed to low pressure fluid. Thereafter, de-energising of solenoid 8 and energising of solenoid 8' by electronic means 25 causes the piston 4 to return to the left, with the same form of pumping action as described above to the high pressure output via valve 22' being effected as a result of the action of piston 4'. Thus, the arrangement of pistons 4 and 4' is double-acting, providing a continuous pumping action.

Fig. 2 shows an alternative form of intensifier to that of Fig. 1 in that, for the sake of ease of manufacture, passageway 20 and valve 21 and passageway 20' and valve 21' are external of pistons 4 and 4' and cylinder member 3. Otherwise, its arrangement and manner of operation are identical to the intensifier of Fig. 1.

Advantages of using the Invention

The pressure intensifier of this invention is more reliable, cheaper to manufacture and does not have the fluid leakage problems of current designs.

CLAIMS:

1. A hydraulic intensifier comprising a reciprocating differential piston arrangement and control means for controlling the supply of low pressure hydraulic fluid to the intensifier, said control means comprising at least one solenoid operated pilot valve and electronic means for operating the pilot valve.

2. A hydraulic intensifier according to claim 1, comprising:

a piston which has a first face at a low pressure side and a second, opposite face at a high pressure side, the first face having a greater surface area than the second face;

an input for supplying low pressure hydraulic fluid to said low pressure side; and

an output for high pressure hydraulic fluid from said high pressure side, said control means being arranged for controlling the supply of low pressure hydraulic fluid to the input.

3. An intensifier according to claim 2, including:

first and second such pistons, each of which has such a first face at a respective low pressure side and each of which has such a second face, at a respective high pressure side, wherein:

there is a respective such input at each of the low pressure sides;

the output is coupled with each of said high pressure sides;

the pistons are joined by a cylindrical member which defines the second face of each of the pistons; and

the control means comprises a respective such solenoid operated pilot valve for each input operable alternately by said electronic means.

4. An intensifier according to claim 3, wherein each of said pistons is reciprocable in a respective cylinder.

5. A hydraulic intensifier comprising:

a first piston which is reciprocable in a first cylinder;

a second piston which is reciprocable in a second cylinder;

a cylindrical member joining the pistons so that each of them has a first face which has a greater surface area than its second, opposite face as a result of said cylindrical member, the first face of each of the pistons being at a respective low pressure side and the second face of each of the pistons being at a respective high pressure side;

first and second inputs for supplying low pressure hydraulic fluid to respective ones of the low pressure sides;

an output for high pressure hydraulic fluid from the high pressure sides;

first and second solenoid operated pilot valves for controlling the supply of low pressure hydraulic fluid to respective ones of the inputs; and

electronic means arranged for operating the pilot valves for supplying low pressure hydraulic fluid alternately to the inputs.

6. An intensifier according to any of claims 3 to 5, including coupling means whereby, if low pressure fluid is applied to one of said low pressure sides, such fluid is also applied to the high pressure side of the other of the pistons.

7. An intensifier according to claim 6, wherein said coupling means comprises a first passageway, between the low pressure side of the first piston and the high pressure side of the second piston, and a second passageway, between the low pressure side of the second piston and the high pressure side of the first piston, each of the passageways being provided with a respective non-return valve for permitting flow from the low pressure side to the high pressure side.

8. An intensifier according to any preceding claim, wherein said electronic means is provided by a subsea electronics module of a subsea well control system.

9. A method of producing high pressure hydraulic fluid comprising providing a hydraulic intensifier comprising a reciprocating differential piston arrangement and controlling the supply of low pressure hydraulic fluid to the intensifier, using at least one solenoid operated pilot valve and electronic means which operate the pilot valve.

10. A method according to claim 9, wherein the intensifier comprises:

a piston which has a first face at a low pressure side and a second, opposite face at a high pressure side, the first face having a greater surface area than the second face;

an input for supplying low pressure hydraulic fluid to said low pressure side; and

an output for high pressure hydraulic fluid from said high pressure side, said control means controlling the supply of low pressure hydraulic fluid to the input.

11. A method according to claim 10, wherein the intensifier includes first and second such pistons, each of which has such a first face at a respective low pressure side and each of which has such a second face, at a respective high pressure side, wherein:

there is a respective such input at each of the low pressure sides;

the output is coupled with each of said high pressure sides;

the pistons are joined by a cylindrical member which defines the second face of each of the pistons; and

the control means comprises a respective such solenoid operated pilot valve for each input operated alternately by said electronic means.

12. A method according to claim 11, wherein each of said pistons is reciprocable in a respective cylinder.

13. A method of producing high pressure hydraulic fluid comprising providing a hydraulic intensifier comprising:

a first piston which is reciprocable in a first cylinder;

a second piston which is reciprocable in a second cylinder;

a cylindrical member joining the pistons so that each of them has a first face which has a greater surface area than its second, opposite face as a result of said cylindrical member, the first face of each of the pistons being at a respective low pressure side and the second face of each of the pistons being at a respective high pressure side;

first and second inputs for supplying low pressure hydraulic fluid to respective ones of the low pressure sides; and

an output for high pressure hydraulic fluid from the high pressure sides;

there being first and second solenoid operated pilot valves which control the supply of said low pressure hydraulic fluid to respective ones of the inputs; and

electronic means which operate the pilot valves to supply low pressure hydraulic fluid alternately to the inputs.

14. A method according to any of claims 11 to 13, wherein, if low pressure fluid is applied to one of said low pressure sides, coupling means applies such fluid to the high pressure side of the other of the pistons.

15. A method according to claim 14, wherein said coupling means comprises a first passageway, between the low pressure side of the first piston and the high pressure side of the second piston, and a second passageway, between the low pressure side of the second piston and the high pressure side of the first piston, each of the passageways being provided with a respective non-return valve for permitting flow from the low pressure side to the high pressure side.

16. A method according to any of claims 11 to 15, wherein said electronic means is provided by a subsea electronics module of a subsea well control system.