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

(11) Publication number: **0 435 196 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **90125101.7**

(51) Int. Cl.5: **F15B 3/00**

(22) Date of filing: **21.12.90**

(30) Priority: **26.12.89 JP 151331/89 U**

(43) Date of publication of application:
03.07.91 Bulletin 91/27

(84) Designated Contracting States:
CH DE FR GB LI NL SE

(71) Applicant: **SEIHO KIKO CO., LTD.**
12-2, Futamatase, Higashi-ku
Fukuoka-shi(JP)

(72) Inventor: **Saeki, Kunito**
10-15, Minami-Katae 3-chome
Jonan-ku, Fukuoka-shi(JP)

(74) Representative: **Henkel, Feiler, Hänzel & Partner**
Möhlstrasse 37
W-8000 München 80(DE)

(54) Pressure converting device.

(57) This pressure converting device comprises a primary cylinder (1); a secondary cylinder (2) disposed in line with and joined to the primary cylinder (1), a low-pressure-side piston (7) reciprocably fitted in the primary cylinder (1), a high-pressure-side piston (9) reciprocably fitted in the secondary cylinder (2), a piston rod (8) coaxially mounting the low-pressure-side piston and the high-pressure-side piston, a pilot-operated directional control valve (6) provided on a rear cover to supply the working fluid alternately to the front and rear chambers (A,B) of the primary cylinder (1), a pilot valve (5) for operating the directional control valve (6), and a shifting rod (11) for operating the pilot valve (5) which is connected to the rear piston rod (10) extending rearwardly from the low-pressure-side piston (7) and is concentrically accommodated in the pilot valve (5). Due to such construction, the diameter and the length of the primary cylinder (1) can be minimized thus making the pressure converting device extremely compact.

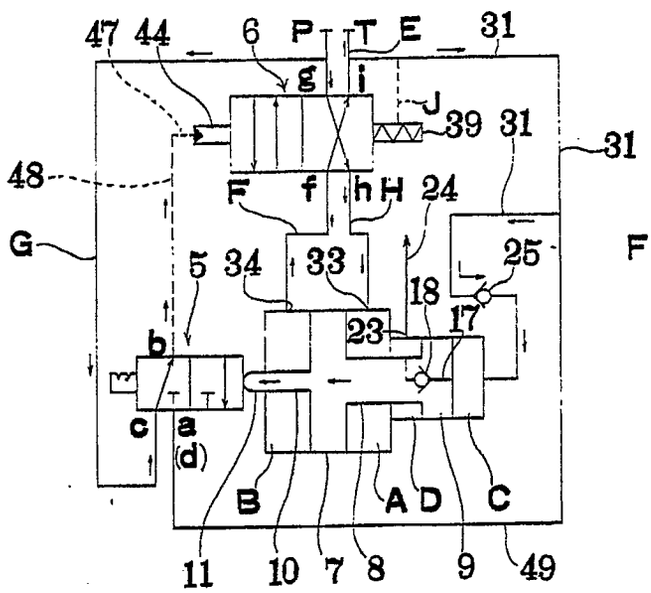


FIG. 5

EP 0 435 196 A1

PRESSURE CONVERTING DEVICE

BACKGROUND OF INVENTION

The present invention relates to a pressure converting device or a booster for increasing the pressure of working fluid supplied thereto to discharge the same at a higher pressure.

A conventional pressure converting device for increasing the pressure of working fluid supplied thereto to discharge the same at a higher pressure is disclosed in, for example, Japanese Patent Publication (Kokoku) No. 62-21994.

This known pressure converting device substantially comprises a low-pressure-side cylinder, a high-pressure-side cylinder disposed in line with and joined to the low-pressure-side cylinder, a low-pressure-side piston reciprocably fitted in the low-pressure-side cylinder, a high-pressure-side piston reciprocably fitted in the high-pressure cylinder, a pilot-operated directional control valve provided on a rear cover to supply the working fluid alternately to the front and rear chambers of the low-pressure-side cylinder, a pilot valve for operating the directional control valve and a limiter provided within a space formed in a piston rod to operate the pilot valve. The low-pressure-side piston and the high-pressure-side piston are mounted on the piston rod.

In the above construction, since the limiter for operating the pilot valve is accommodated in the piston rod, the diameter of the piston rod becomes large and eventually the diameter of the low-pressure-side cylinder and the high-pressure-side cylinder which reciprocably accommodates the piston rod also become large. Therefore, this pressure converting device becomes considerably large in size.

The relatively large pressure converting device is subject to restrictions on the manner of installation and requires a large space for its installation.

Furthermore, provided with reciprocating plungers respectively on the opposite sides of the directional control valve which is operated by the pilot valve, this pressure converting device, in some cases, is unable to be started when the pressure of the working fluid acts on both plungers.

Accordingly, it is an object of the present device to provide a pressure converting device which can overcome these drawbacks of the conventional pressure converting devices.

SUMMARY OF INVENTION

In summary, the present invention discloses the pressure converting device which comprises a primary cylinder, a secondary cylinder disposed in line with and joined to the primary cylinder, a low-pressure-side piston reciprocably fitted in the primary cylinder, a high-pressure-side piston reciprocably fitted in the secondary cylinder, a piston rod coaxially mounting the low-pressure-side piston and the high-pressure-side piston, a pilot-operated directional control valve provided on a rear cover to supply the working fluid alternately to the front and rear chambers of the primary cylinder, a pilot valve for operating the directional control valve, and a shifting rod for operating the pilot valve which is connected to the rear piston rod extending rearwardly from the low-pressure-side piston and is concentrically accommodated in the pilot valve.

The pressure converting device of this invention is also characterized in that a spring is provided on one side of the slide spool of the directional control valve to bias the slide spool in one direction, and a plunger is provided on the other side of the slide spool so as to press the slide spool in the opposite direction when the pressurized working fluid is supplied.

BRIEF EXPLANATION OF THE DRAWINGS

Figures 1 and 2 are sectional views of a pressure converting device of the preferred embodiment in different operating modes according to the present invention;

Figure 3 is a plan view of an essential portion of the pressure converting device of Figs. 1 and 2 taken along line I-I of Fig. 1;

Figure 4 is a transverse sectional view taken on line II-II in Fig. 3.

Figures 5 and 6 are explanatory views of the hydraulic circuits for operating the pressure converting device in different operating modes.

DETAILED DESCRIPTION OF THE PREFFERED EMBODIMENT

(Construction)

A pressure converting device in a preferred embodiment according to the present invention will be described hereinafter with reference to the accompanying drawings.

As shown in Fig. 1 and Fig. 2, a secondary cylinder (a high-pressure-side cylinder) 2 is coaxially connected to a primary cylinder (a low-pressure-side cylinder) 1 by way of a partition wall 3. The inside diameter of the secondary cylinder 2 is designed to be smaller than that of a primary cylinder 1. The rear end of the primary cylinder 1 is closed by a rear wall 4.

A pilot valve 5 is provided within the rear wall 4 on the rear extension of the primary cylinder 1, and

a pilot-operated directional control valve 6 which is controlled by the pilot valve 5 is mounted on the upper surface of the rear wall 4.

A low-pressure-side piston 7 is fitted in the primary cylinder 1 for reciprocation so as to define a front chamber A and a rear chamber B in the primary cylinder 1. A piston rod 8 is formed integrally with the low-pressure-side piston 7 so as to extend frontwardly. A high-pressure-side piston 9 is fitted in the secondary cylinder 2 for reciprocation and is mounted on the front piston rod 8.

The interior of the secondary cylinder 2 is partitioned into a front chamber C and a rear chamber D by the high-pressure-side piston 9.

A rear piston rod 10 is formed integrally with the low-pressure-side piston 7 so as to extend rearward from the low-pressure-side piston 7. A shifting rod 11 is screwed in the rear end of the rear piston rod 10 coaxially with the same.

A flange 12 is formed on the rear end of the shifting rod 11. A mechanical spool 13 is mounted on the shifting rod 11 so as to be axially movable with an inner flange 13-1 thereof in contact with the rear end surface 10-1 of the rear piston rod 10 or the flange 12 of the shifting rod 12. A spool case 14 receiving the mechanical spool 13 therein has valve chambers a, b, c and d.

The shifting rod 11, the mechanical spool 13 and the spool case 14 are the components of the pilot valve 5.

The mechanical spool 13 is provided with an annular groove 15 in its outer circumference. The rear end of the pilot valve 5 is closed with a rear plug 16.

The high-pressure-side piston 9 is provided with a high-pressure-side passage 17 along its axis. A check valve 20 consisting of a ball 18 and a spring 19 is provided at the rear end of the high-pressure-side passage 17.

Shown also in Fig. 1 are a ball stopper 21 for stopping the ball 18 of the check valve 20, a connecting passage 22 connecting the rear chamber D of the secondary cylinder 2 to the high-pressure-side passage 17, a high-pressure-side discharge passage 23 connecting the rear chamber D to a high-pressure-side discharge port 24 to discharge the high-pressure working fluid from the rear chamber D through the high-pressure-side discharge port 24, a check valve 25 provided within the upper wall of the secondary cylinder 2, and a passage 26 extended under the check valve 25 to supply the working fluid to the front chamber C of the secondary cylinder 2.

The check vlave 25 has a ball 27, a spring 28, a valve seat 29 and a cap 30.

A supply passage 31 is formed through the circumferential wall of the secondary cylinder 2, the partition wall 3 and the circumferential wall of the primary cylinder 1 and in the rear wall 4 to connect the check valve 25 to a discharge passage 32 formed in the rear wall 4.

A front supply passage 33 is formed through the partition wall 3 and the circumferential wall of the primary cylinder 1 to connect the front chamber A of the primary cylinder 1 to the directional control valve 6. A rear supply passage 34 is formed through the rear wall 4 to connect the rear chamber B of the primary cylinder 1 to the directional control valve 6.

The directional control valve 6 has a slide spool 35 integrally provided with lands 36 and 37.

The slide spool 35 is fitted in a spool case 38 having valve chambers e, f, g, h and i arranged in that order from left to right. A spring 39 is placed in the right-hand end of the spool case 38 to bias the slide spool 35 continuously to the left. Indicated at 40 is a spring seat, and at 41 is a plug.

A plunger 42 is provided on the left side of the slide spool 35. The working fluid acts on the plunger 42 to push the slide spool 35 to the right. Indicated at 43 is a plunger support cylinder, at 44 is a plunger operating chamber, at 45 is a plunger case, and at 46 is a plug. The valve chamber e of the directional control valve 6 is connected to the discharge passage 32 by a passage E.

The valve chamber e opens into a discharge port T. The valve chamber f is connected to the rear supply passage 34 by a passage F. The valve chamber g is connected to the valve chamber c of the pilot valve 5 by a passage G and also to an inlet port P for receive the working fluid.

As shown in Figs. 1,3 and 4, the valve chamber h is connected to the front supply passage 33 by a passage H. The valve chamber i is connected to the supply passage 31 by a passage J. The plunger operating chamber 44 is connected through a passage 47 and a passage 48 to the valve chamber b of the pilot valve 5. The valve chamber a of the pilot valve 5 is connected through a passage 49 and the passage E to the discharge port T.

As shown in Figs 1 and 2, the mechanical spool 13 is provided with a through hole 50. Packings 51,52,53 and 54 are fitted respectively in an annular groove formed in the circumference of the low-pressure-side piston 7, an annular groove formed in the inner circumference of the partition wall 3, an annular groove formed in the circumference of the rear end of the partition wall 3, and an annular groove formed in the outer circumference of the high-pressure-side piston 9.

A tubular valve seat 55 is fitted in the bore of the high-pressure-side piston 9.

(Manner of Operation)

The manner in which the pressure converting

device of the present invention is operated is hereinafter explained in conjunction with Fig. 5 and Fig. 6 which shows the hydraulic circuit of the pressure converting device as well as Fig. 1 and Fig. 2.

When the low-pressure-side piston 7 and the high-pressure-side piston 9 connected to the low-pressure-side piston 7 are shifted rearward (to the left as viewed in Figs. 1 and 2) as shown in Fig. 2 and Fig. 5, the rear end 10-1 of the rear piston rod 10 comes into contact with the inner flange 13-1 of the mechanical spool 13 to move the mechanical spool 13 rearward.

Consequently, the valve chambers b and c of the pilot valve 5 are disconnected from each other to take a position shown in Fig. 6.

In this state, the working fluid supplied through the inlet port P into the directional control valve 6 is unable to flow beyond the valve chamber c, and the slide spool 35 is pushed rearward by the spring 39 as shown in Fig. 1 and Fig. 6.

Then, the working fluid supplied through the inlet port P flows through the valve chambers g and f, the passage F and the rear supply passage 34 into the rear chamber B of the primary cylinder 1.

Consequently, the low-pressure-side piston 7 Is pushed frontward (to the right as viewed in Figs. 1 and 2) by the working fluid. The axial force W_1 that acts frontward on the low-pressure-side piston P is expressed by:

$$W_1 = (Q_1 - Q_2 \times P_1$$

where Q_1 is the sectional area of the low-pressure-side piston 7, Q_2 is the sectional area of the rear piston rod 10, and P_1 is the pressure of the working fluid.

Thus, the high-pressure-side piston 9 is shifted frontward in the secondary cylinder 2 to exert a pressure on the working fluid filling the front chamber C by the axial force W_1 and, consequently, the pressure of the working fluid is increased. The discharge pressure P_2 of the working fluid discharged from the secondary cylinder 2 is expressed by:

$$P_2 = W_1 / Q_4$$

where Q_4 s the sectional area of the high-pressure-side piston 9.

The high-pressure working fluid flows through the high-pressure-side passage 17, the check valve 20, the rear chamber D and the high-pressure-side discharge passage 23 and is discharged from the high-pressure-side discharge port 24.

As the low-pressure-side piston 7 is shifted frontward, the shifting rod 11 connected to the rear piston rod 10 is shifted gradually frontward, shifting the mechanical spool 13 frontward with the flange 12 of the control rod 11 engaging the rear end 13-2 of the inner flange 13-1.

Consequently, the condition of the pilot valve 5 is changed over to take a position shown in Fig. 5 to allow the valve chambers b and c to communicate with each other.

Then, the working fluid flows through the passage G, the pilot valve 5 and the passage 48 into the plunger operating chamber 44.

Then, the working fluid pushes the plunger 42 to the right against the resilience of the spring 39 to shift the slide spool 35 to the right, so that the directional control valve 6 is set in a state as shown in Fig. 2. Then, the working fluid flows through the front supply passage 33 into the front chamber A of the primary cylinder 1, so taht the low-pressure-side piston 7 is shifted rearward.

Consequently, the working fluid filling the rear chamber B of the primary cylinder 1 is returned through the rear supply passage 34 and the valve chamber f of the diretional control valve 6 to the valve chamber c.

Meanwhile, in the secondary cylinder 2, the working fluid forces the check valve 25 to open and flows into the front chamber C and, consequently, the working fluid in the rear chamber D is pressed by the high-pressure-side piston 9. Force W_2 that urges the high-pressure-side piston 9 rearwardly is expressed by:

$$W_2 = (Q_1 - Q_3) \times P_1$$

where Q_1 is the sectional area of the low-pressure-side piston 7, Q_3 is the sectional area of the front piston rod 8, and P_1 is the pressure of the working fluid.

Thus, the high-pressure-side piston 9 is shifted rearward in the secondary cylinder 2 by the force W_2 to exert pressure by the high-pressure-side piston 9 on the working fluid in the rear chamber D. The discharge pressure P_3 of the working fluid discharged from the secondary cylinder 2 is expressed by:

$$P_3 = W_2 / (Q_4 - Q_3)$$

where Q_4 is the sectional area of the high-pressure-side piston 9, Q_3 is the sectional area of the front piston rod 8, and W_2 is the force urging the high-pressure-side piston 9 rearwardly.

The high-pressure working fluid flows through the high-pressure-side discharge passage 23 and is discharged through the high-pressure-side discharge port 24.

Thus, the low-pressure-side piston 7 and the high-pressure-side piston 9, which are connected

integrally, repeat reciprocation respectively in the primary cylinder 1 and the secondary cylinder 2 to discharge the high-pressure working fluid continuously through the high-pressure-side discharge port 24.

As has been described heretofore, the pressure converting device of this invention has following advantages.

(a) In the pressure converting device of this invention, as described above, the shifting rod for operating the pilot valve is concentrically accommodated in the pilot valve. Due to such construction, the rear piston rod may be formed in a small diameter, hence each of the primary cylinder and the secondary cylinder can be formed in a small size and, consequently, the pressure converting device can be constructed in a small size. Accordingly, the relatively small pressure converting device facilitates the selection of place for the installation thereof and simplifies the installation thereof.

(b) Furthermore, since the slide spool of the directional control valve is biased continuously in one direction by the spring provided on one side of the slide spool and the plunger is provided on the other side of the slide spool, the directional control valve can be controlled, by supplying the working fluid only to control the plunger, which simplifies the construction of the directional control valve and machining operation for forming the passages in the directional control valve, facilitates the control of the directional control valve, and ensures the reliable operation of the directional control valve.

(c) Still further, the spring provided on one side of the slide spool of the directional control valve returns the slide spool to its initial position when the pressure converting device is stopped so that the pressure converting device is able to be started smoothly.

Claims

1. A pressure converting device comprising:
   a) a primary cylinder (1);
   b) a secondary cylinder (2) disposed in line with said primary cylinder (1) and having an inside diameter smaller than that of said primary cylinder (1);
   c) a low-pressure-side piston (7) having a front piston rod (8) and a rear piston rod (10), said piston (7) axially reciprocalbly disposed in said primary cylinder (1) so as to partition the interior of said primary cylinder (1) into a front chamber (A) and a rear chamber (B);
   d) a high-pressure-side piston (9) mounted on the front end of said front piston rod (8) and axially reciprocably disposed in said secondary cylinder (2) together with said low-pressure-side piston (7) so as, to partition the interior of said secondary cylinder (2) into a front chamber (C) and a rear chamber (D), said rear chamber (D) communicating with a high-pressure discharge port (24);
   e) a directional control valve (6) provided on the rear wall (4) of the primary cylinder (1) to connect an inlet port (P) alternately to said front chamber (A) and said rear chamber (B) of said primary cylinder (1) so that the pressurized working fluid is supplied alternately to said front chamber (A) and said rear chamber (B);
   f) a pilot valve (5) provided in said rear wall (4) for operating said directional control valve (6), said pilot valve (5) concentrically accommodating a shifting rod (11) which is connected to a rear end of said rear piston rod (10), said shifting rod (11) being capable of operating said pilot valve (5) corresponding to the reciprocating movement of said rear piston rod (10) extending behind the low-pressure-side piston (7);
   g) a check valve (25) provided in a supply passage (31) for supplying part of the working fluid discharged from said directional control valve (6) to said front chamber (C) of said secondary cylinder (2); and
   h) a check valve (20) provided in a high-pressure-side passage (17) interconnecting said front chamber (C) and said rear chamber (D) of said secondary cylinder (2).

2. A pressure converting device according to Claim 1, wherein said shifting rod (11) forms an integral part of said rear piston rod (10).

3. A pressure converting device according to Claim 1, wherein said directional control valve (6) has a slide spool (35), a spring (29) provided on one side of said slide spool (35) to bias said slide spool (35) in one direction, and a plunger (42) provided on the other side of said pilot spool (35) to push said pilot spool (35) in the opposite direction when the pressurized working fluid is supplied.

4. A pressure converting device according to Claim 1, wherein said directional control valve (6) is separably mounted on said rear

FIG. 1

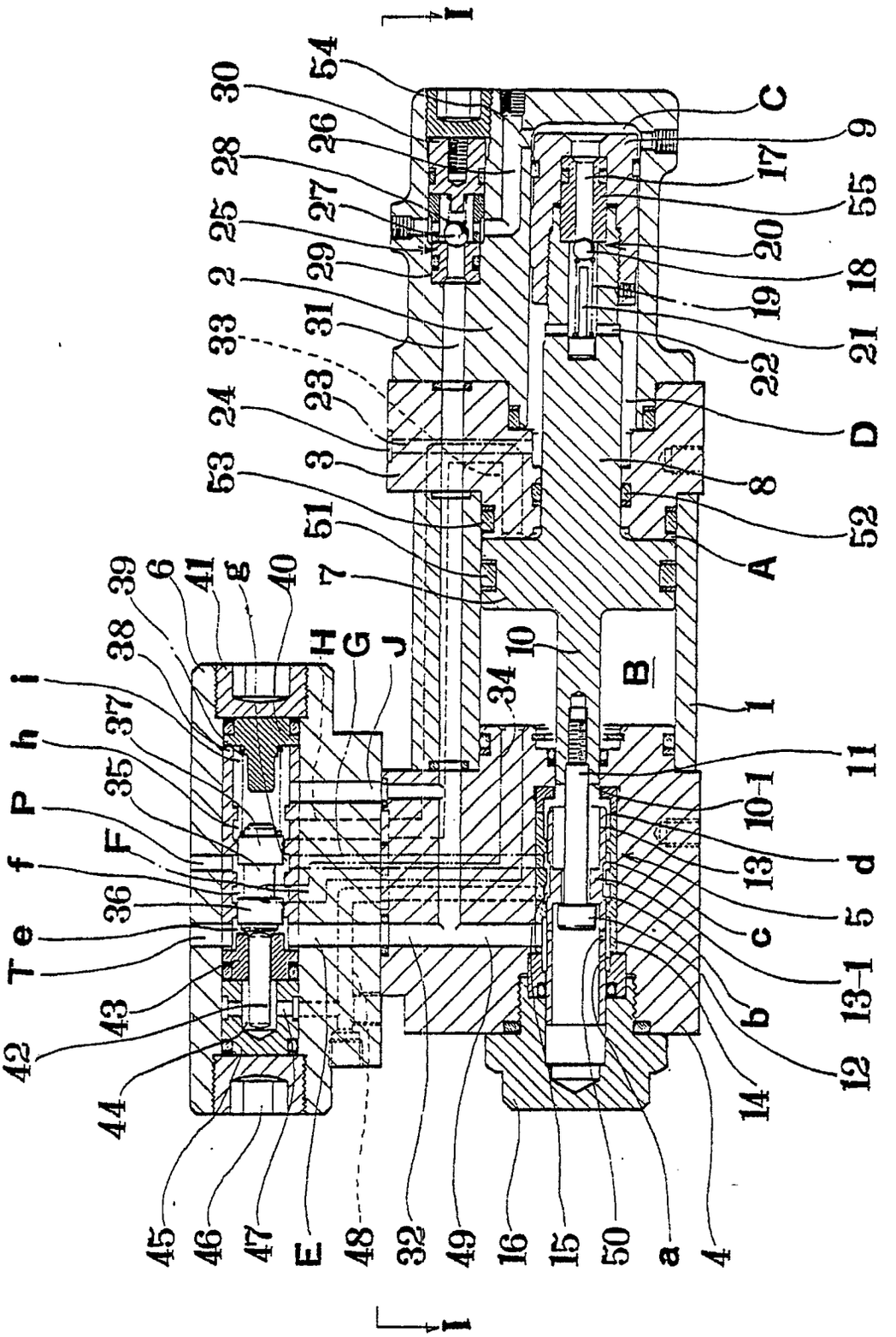

I
I
54
30
26
28
27
25
29
2
31
33
23
24
3
53
51
7
39
6
41
g
40
38
H
G
J
10
34
B
1
A
52
8
D
21
22
18
19
20
55
17
9
C
11
10-1
13
d
5
c
13-1
b
12
14
i
h
37
35
P
F
f
36
e
T
43
42
44
45
46
47
E
48
32
49
16
15
50
a
4

FIG. 2

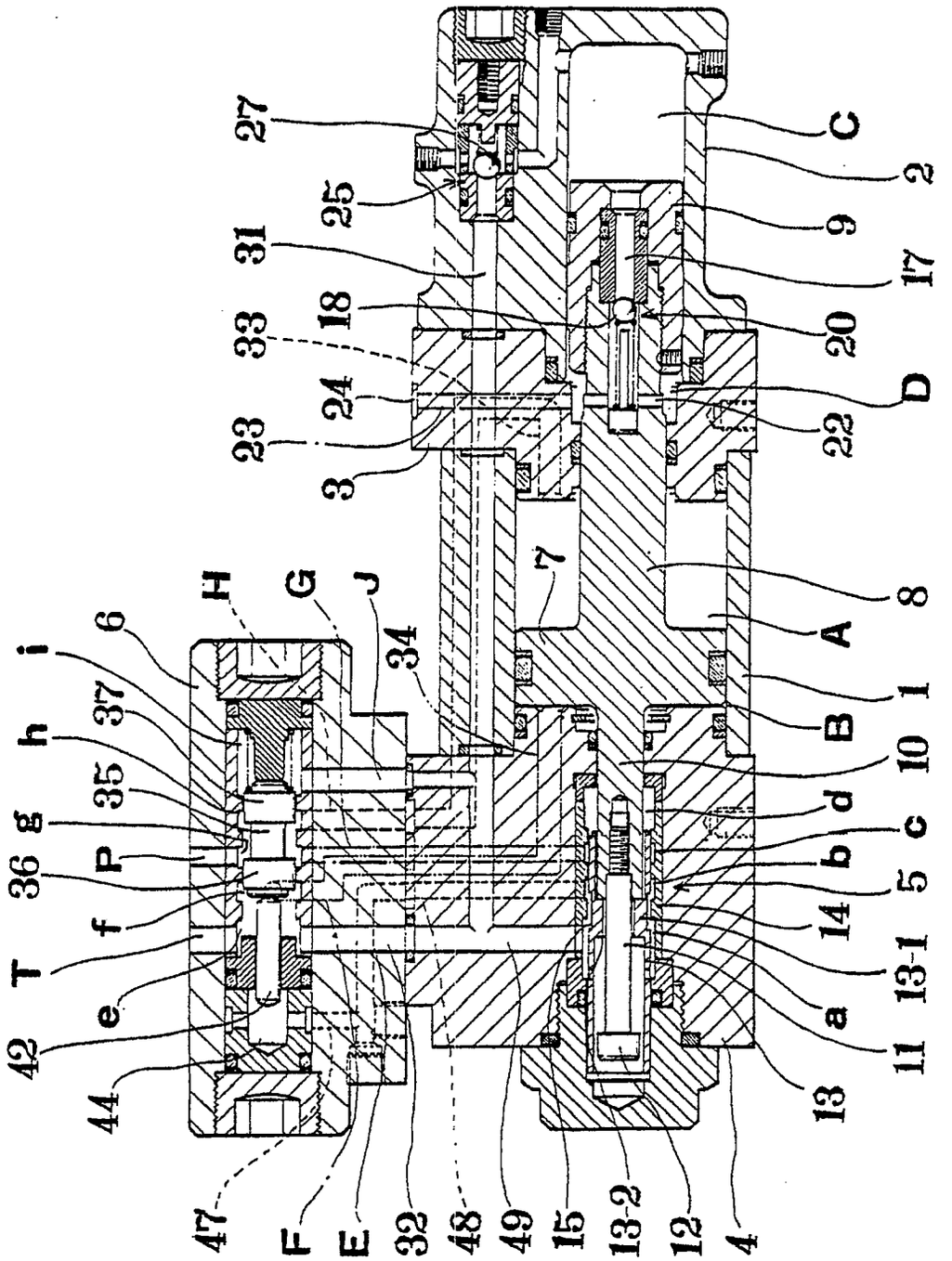

27
25
31
33
23
3
18
24
C
2
9
17
20
D
22
7
8
A
1
B
10
d
c
b
5
14
13-1
a
11
13
6
i
37
h
35
g
36
P
f
T
e
42
44
H
G
J
34
47
F
E
32
48
49
15
13-2
12
4

FIG. 3

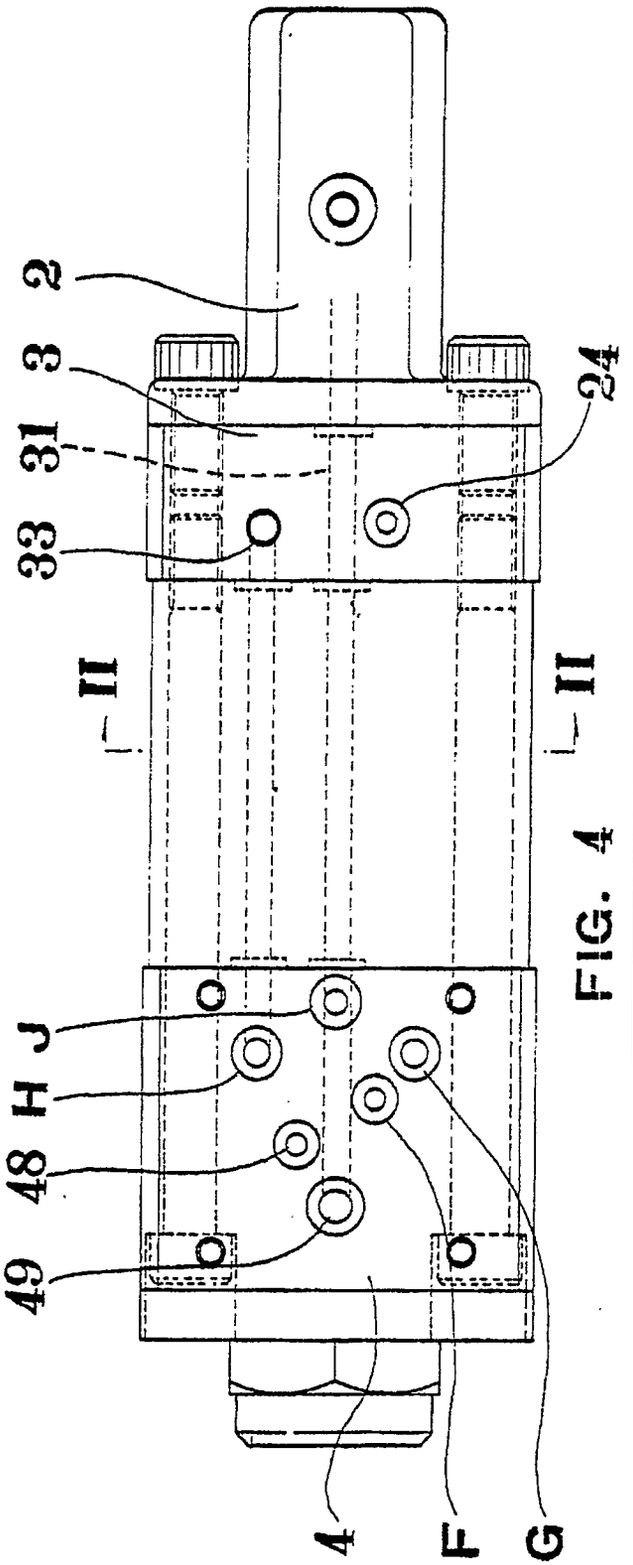
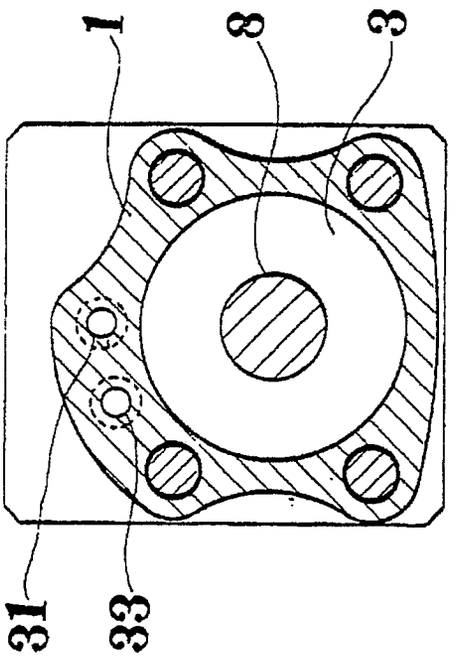


FIG. 4



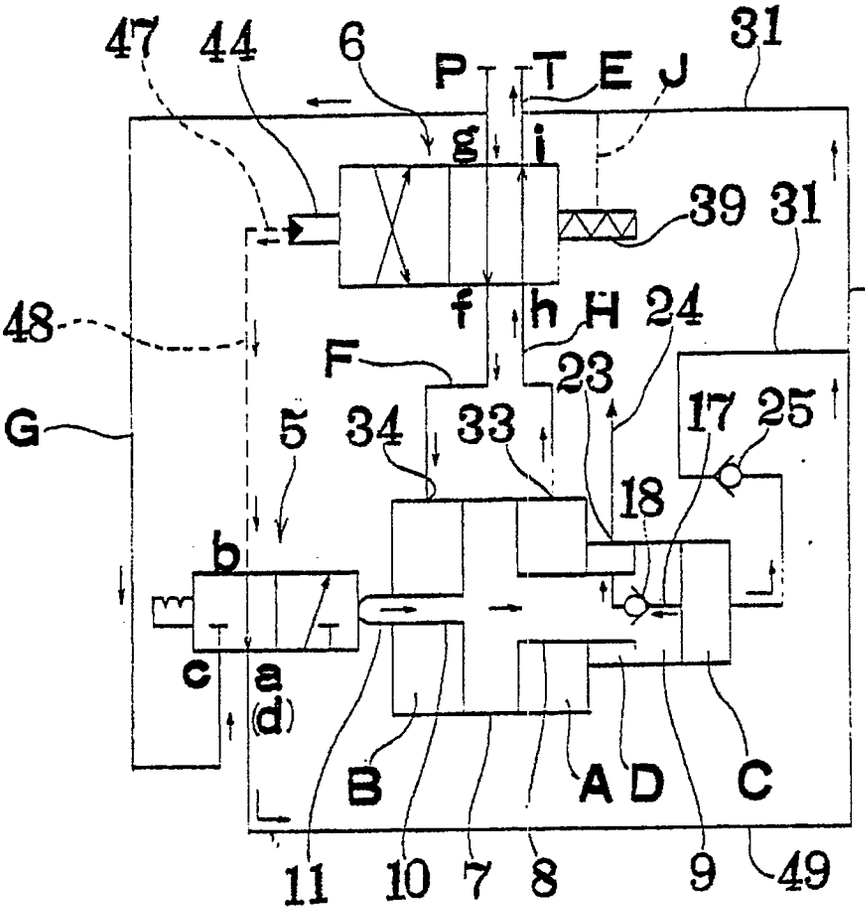

47
44
6
P
T
E
J
31
g
i
39
31
48
f
h
H
24
31
F
23
G
5
34
33
17
25
18
b
c
a
(d)
B
A
D
C
11
10
7
8
9
49

FIG. 6

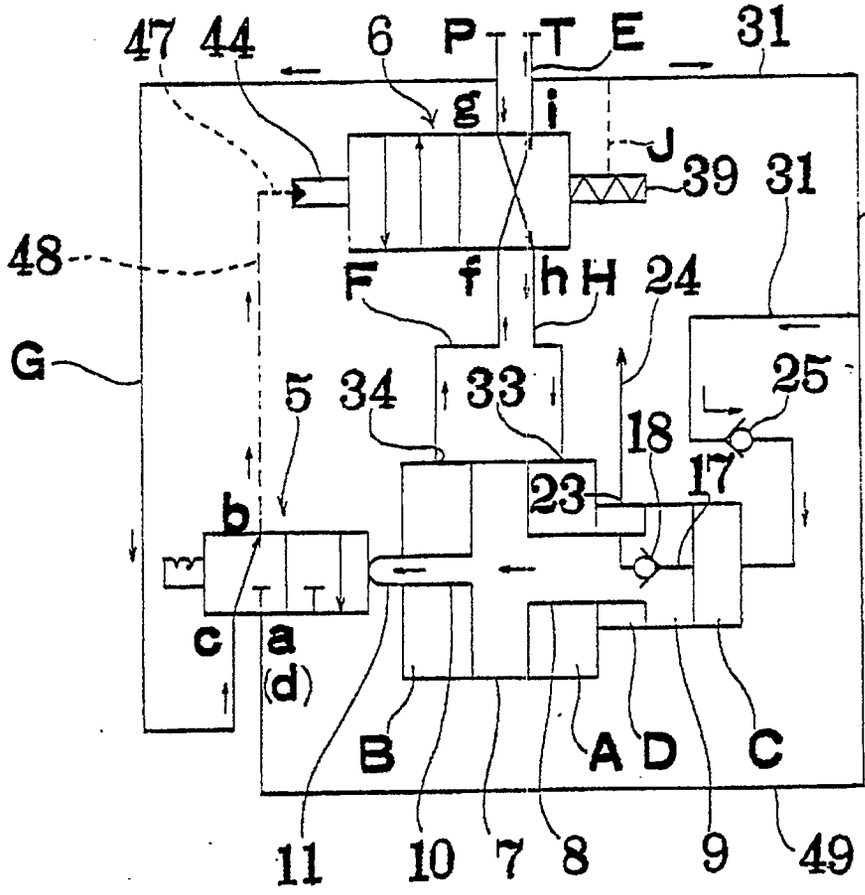

47
44
6
P
T
E
31
g
i
J
39
31
31
48
F
f
h
H
24
G
5
34
33
25
18
17
23
b
c
a
(d)
B
A
D
C
11
10
7
8
9
49

FIG. 5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 12 5101

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.5)
P,Y	SOVIET INVENTIONS ILLUSTRATED Section Mechanical, Week 9001, 14 February 1990, abstract no. 90-005711/01 Q/57, Derwent Publications Ltd., London, GB; & SU - A - 1488586 (SARYCHEV) 23.06.1989	1	F 15 B 3/00
Y	US-A-3 632 230 (ATSUMI UEDA) * figures 1-4; claims 1-3 *	1	
A	DE-C-3 323 902 (H. HEMSCHEIDT) * figures 1-3; claim 1 *		
A	DE-C-9 048 58 (REPPEL)		
A	DE-A-2 221 388 (THE BENDIX CORP.)		

TECHNICAL FIELDS SEARCHED (Int. Cl.5)
F 15 B

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
Berlin	02 April 91	THOMAS C L

CATEGORY OF CITED DOCUMENTS

X: particularly relevant if taken alone
Y: particularly relevant if combined with another document of the same catagory
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