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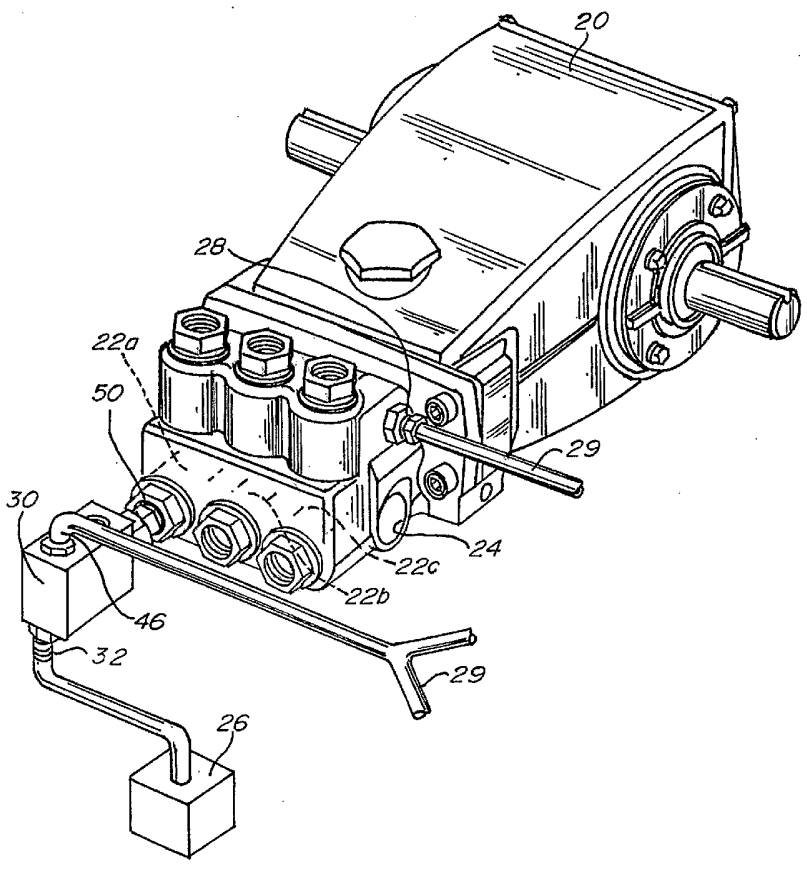
(54) Title: METERED PULSE PUMP



(57) Abstract: A metering pulse pump for metering an additive liquid into a liquid carrier under high pressure includes a rapidly reciprocating piston pump having a number of pumping chambers and having an inlet connectable to a source of liquid and an outlet, and an outlet line carrying liquid from the outlet under high pressure; a source of additive liquid; a differential piston pump having an inlet connectable to the source of additive liquid, an inlet check valve, a pumping chamber, an outlet check valve, and an outlet connected to the outlet line; and a connection from one of the reciprocating pump pumping chambers to the differential piston pump feeding high-pressure liquid to start the pumping stroke of the differential piston pump. In one embodiment, a spring is used to return the differential piston on its intake stroke. In a second embodiment, a connection from another of the reciprocating pump pumping chambers, which is out of phase with the first chamber, is used to return the differential piston on its intake stroke.

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METERED PULSE PUMP

BACKGROUND OF THE INVENTION

Rapidly reciprocating piston pumps are used to pump high-pressure fluid for a variety of purposes. It is also sometimes necessary to insert a chemical additive into the high-pressure fluid stream. However, when such additives are corrosive, they should not be pumped by the primary pump. Instead, a secondary, metering pump is used to pump the additive liquid.

Various devices have been employed for automatically metering small amounts of an additive liquid to the mainstream of a liquid carrier. When the liquid carrier is under high pressure, however, highly sophisticated and hence expensive metering pumps such as gear pumps ordinarily are employed. An inexpensive apparatus which would permit an additive liquid to be metered to a liquid carrier under high pressure is much to be desired.

A Metering Pulse Pump is disclosed in U.S. Patent No. 3,930,756. However, this pulse pump uses a diaphragm pump to pump the additive liquid to the mainstream of the liquid carrier. Such diaphragm pumps are prone to early failure. It also requires a pressure-relief valve to regulate the pressure of the metering pulse pump and the speed of the pump and length of its stroke.

There is a need for an improved metering pulse pump that overcomes the above problems.

SUMMARY OF THE INVENTION

A metering pulse pump for metering an additive liquid into a liquid carrier under high pressure, the pump comprising:

a rapidly reciprocating piston pump having a plurality of pumping chambers and having an inlet connectable to a source of liquid and an outlet, and an outlet line carrying liquid from the outlet under high pressure;

a source of additive liquid;

a differential piston pump having an inlet connectable to the source of additive liquid, an inlet check valve, a pumping chamber, an outlet check valve, and an outlet connected to the outlet line; and

a connection from one of the plurality of reciprocating pump pumping chambers to the differential piston pump feeding high-pressure liquid to start the pumping stroke of the differential piston pump.

A principal object and advantage of the present invention is that the differential piston pump has a longer life than a diaphragm pump used previously.

Another principal object and advantage of the present invention is that it is simpler than earlier metering pulse pumps.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a perspective view of a first embodiment of the metering pulse pump of the present invention.

FIG. 2 is a cross-section taken at approximately the lines 2 of Fig. 1, during the pumping stroke.

FIG. 3 is similar to Fig. 2, taken during the return stroke.

FIG. 4 is a perspective view of a second embodiment of the metering pulse pump of the present invention.

FIG. 5 is a cross-section taken at approximately the lines 5 of Fig. 4, during the pumping stroke.

FIG. 6 is similar to Fig. 5, taken during the return stroke.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The metering pulse pump of the present invention is generally shown in the Figures as reference numeral 10.

The metering pulse pump 10 is used for metering an additive liquid (such as a chemical) into a liquid carrier which is under high pressure.

The metering pulse pump 10 comprises a rapidly reciprocating piston pump 20 having a plurality of pumping chambers 22a, 22b, 22c etc. and also having an inlet 24, a source 26 of additive liquid and an outlet 28, and also comprising an outlet line 29 carrying liquid from the outlet 28 under high pressure. A pump 20 which may be used in the present invention is disclosed in U.S. Patent No. 3,930,756, herein incorporated by reference. However, this earlier pump suffers from the disadvantage of being prone to earlier failure because of its use of a diaphragm pump and also of being complex because of the need for a pressure relief valve to regulate the pressure in the pumping chamber.

The present invention comprises the following changes to the previously described rapidly reciprocating piston pump 20.

A differential piston pump 30 has an inlet 32 connectable to the source 26 of additive liquid. The differential piston pump 30 further comprises a pumping chamber 42. An inlet check valve 40 is inserted between the inlet 32 and the pumping chamber 42. The differential piston pump 30 further comprises an outlet check valve 44, and an outlet 46 connected to the outlet line 29 of the rapidly reciprocating piston pump 20.

A connection 50 is made from one of the plurality of pumping chambers 22a, 22b, 22c, etc. to the differential piston pump so that high-pressure liquid from the rapidly reciprocating piston pump 10 can be used to start the pumping stroke of the differential piston pump 30 as will be further described.

In further detail, the differential piston pump 30 further comprises a differential piston 34, having a first portion 34a and a second portion 34b, the first portion 34a having a larger

surface area than the second portion 34b. The differential piston 34 reciprocates in the pumping chamber 42.

A first embodiment of the present invention is shown in Figs. 1-3.

In the first embodiment, the differential piston pump 30 further comprises a spring 36 biasing the differential piston 34 toward its return stroke. In this embodiment, the pumping chamber 42 may enclose the spring 36, as shown.

Operation of the first embodiment is as follows.

As shown in Fig. 2, during the pumping stroke of one of the plurality of pumping chambers 22a, 22b, 22c etc. of the rapidly reciprocating piston pump, high-pressure fluid is forced against the first portion 34a of the differential piston pump 34. At this same moment, the pumping chamber 42 of the differential piston pump 34 is encountering high-pressure from the fluid in the outlet line of the rapidly reciprocating piston pump. These pressures may be approximately equal. However, high-pressure fluid in the pumping chamber 42 encounters the portion 34b having a smaller surface area than the portion 34a.

The operating principle of a differential piston having an inlet pressure P_i, an outlet pressure P_o, an inlet piston area A_i, and an outlet piston area A_o is that $P_o/P_i = A_i/A_o$.

Under this operating principle, the difference in surface areas between the first portion 34a and the second portion 34b will cause the piston 34 to be biased toward the outlet 46, thus allowing the pressure from the first of the plurality of pumping chambers 22a, 22b, 22c. etc. to force the piston against the spring 36 and the pressure in the outlet 46, thus pumping additive liquid into the outlet line 29.

As shown in Fig. 3, during the return stroke of the differential piston 34, additive liquid is drawn into the pumping chamber 42 by vacuum. Pressure from the pumping chamber of the reciprocating piston pump is low, as that chamber is now filling with liquid. The spring 36 can then force the differential piston 34 away from the pumping chamber 42, thus drawing additive liquid into the pumping chamber 42.

In the second embodiment, shown in Figs. 4-6, rather than having a spring 36 biasing the differential piston 34 toward its return stroke, the differential piston pump 30 further comprises a connection 60 from another of the plurality of reciprocating pump pumping chambers 22a, 22b, 22c., etc. to the differential piston pump 30. It will be clear from a study of U.S. 3,930,756 that the pumping chambers 22a, 22b, 22c., etc. are out of phase from each other. That is, for example, as chamber 22a is pumping high-pressure primary liquid, another chamber 22c will be on its intake stroke. Conversely, as chamber 22a is on its intake stroke, chamber 22c is pumping high-pressure primary liquid.

In the second embodiment, high-pressure liquid from chamber 22a, for example, is fed through the connection 50 to the differential piston pump 34, and high-pressure liquid from chamber 22c, for example, is fed through connection 60 to the differential piston pump 34. As shown in Figs. 5 and 6, high-pressure liquid from the connection 50 engages the first portion 34a of the differential piston 34, while high-pressure liquid from the connection 60 engages the second portion 34b of the differential piston 34.

Operation of the second embodiment is as follows.

As shown in Fig. 5, during the pumping stroke of one of the plurality of pumping chambers 22a, for example, of the rapidly reciprocating piston pump, high-pressure fluid from the connection 50 is forced against the first portion 34a of the differential piston 34. At this same moment, the pumping chamber 42 of the differential piston pump 34 is encountering high-pressure from the fluid in the outlet line of the rapidly reciprocating piston pump. These pressures may be approximately equal. However, high-pressure fluid in the pumping chamber 42 encounters only the difference between the surface areas of the portion 34a and portion 34b. This differential may be made as small as necessary to overcome the pressure in the outlet 46.

This differential will cause the piston 34 to be biased toward the outlet 46, thus allowing the pressure from the first of the plurality of pumping chambers 22a, for example, through the connection 50 to force the piston against the pressure in the outlet 46, thus pumping additive liquid into the outlet line 29. The pressure in connection 60 from chamber 22c, for example, is low.

As shown in Fig. 6, during the return stroke of the differential piston 34, additive liquid is drawn into the pumping chamber 42 by vacuum. Pressure from the pumping chamber 22a of the reciprocating piston pump through the connection 50 is low, as that chamber is now filling with liquid. However, pressure from the pumping chamber 22c through the connection 60 is now high, and forces the differential piston 34 away from the pumping chamber 42, thus drawing additive liquid into the pumping chamber 42.

The operation of the inlet check valve 40 and outlet check valve 44 is as known, to coordinate with the pumping stroke and the return stroke of the differential piston 34.

Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. Although methods and materials similar to or equivalent to those described herein can be used in the practice or testing of the present invention, suitable methods and materials are described below. All publications, patent applications, patents, and other references mentioned herein are incorporated by reference in their entirety to the extent allowed by applicable law and regulations. In case of conflict, the present specification, including definitions, will control.

The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof, and it is therefore desired that the present embodiment be considered in all respects as illustrative and not restrictive, reference being made to the appended claims rather than to the foregoing description to indicate the scope of the invention.

WHAT IS CLAIMED:

1. A metering pulse pump for metering an additive liquid into a liquid carrier under high pressure, the pump comprising:

(a) a rapidly reciprocating piston pump having a plurality of pumping chambers and having an inlet connectable to a source of liquid and an outlet, and an outlet line carrying liquid from the outlet under high pressure;

(b) a source of additive liquid;

(c) a differential piston pump having an inlet connectable to the source of additive liquid, an inlet check valve, a pumping chamber, an outlet check valve, and an outlet connected to the outlet line; and

(d) a connection from one of the plurality of reciprocating pump pumping chambers to the differential piston pump feeding high-pressure liquid to start the pumping stroke of the differential piston pump.

2. The apparatus of claim 1, wherein the differential piston pump further comprises a differential piston having a first portion and a second portion, the differential piston reciprocating in a chamber, the first portion having a larger surface area than the second portion.

3. The apparatus of claim 2, further comprising a spring biasing the differential piston pump toward its return stroke.

4. The apparatus of claim 3, wherein high-pressure liquid from one of the plurality of reciprocating pump pumping chambers engages the first portion and wherein high-pressure liquid in the outlet line engages the second portion, the difference in surface areas between the first portion and the second portion biasing the differential piston to pump the additive liquid into the outlet line.

5. The apparatus of claim 1, further comprising a connection from another of the plurality of reciprocating pump pumping chambers to the differential piston pump feeding high-pressure liquid to start the return stroke of the differential piston pump.

6. The apparatus of claim 5, wherein the first portion is engaged by liquid from one of the plurality of reciprocating pump pumping chambers, the second portion engages liquid from another of the plurality of reciprocating pump pumping chambers, and wherein liquid pressures in each of the reciprocating pump pumping chambers vary inversely.

7. The apparatus of claim 4, wherein the first portion directly contacts high-pressure liquid from one of the plurality of reciprocating pump pumping chambers.

8. The apparatus of claim 7, wherein the second portion directly contacts high-pressure liquid in the outlet line.

9. In a rapidly reciprocating piston pump having a plurality of pumping chambers and having an inlet connectable to a source of liquid and an outlet, and an outlet line carrying liquid from the outlet under high pressure, the improvement comprising:

(a) a source of additive liquid;

(b) a differential piston pump having an inlet connectable to the source of additive liquid, an inlet check valve, a pumping chamber, an outlet check valve, and an outlet connected to the outlet line; and

(c) a connection from one of the plurality of reciprocating pump pumping chambers to the differential piston pump feeding high-pressure liquid to start the pumping stroke of the differential piston pump.

10. The apparatus of claim 9, wherein the differential piston pump further comprises a differential piston having a first portion and a second portion, the differential piston reciprocating in a chamber, the first portion having a larger surface area than the second portion.

11. The apparatus of claim 10, further comprising a spring biasing the differential piston pump toward its return stroke.

12. The apparatus of claim 11, wherein high-pressure liquid from one of the plurality of reciprocating pump pumping chambers engages the first portion and wherein high-pressure liquid in the outlet line engages the second portion, the difference in surface areas between the first portion and the second portion biasing the differential piston to pump the additive liquid into the outlet line.

13. The apparatus of claim 10, further comprising a connection from another of the plurality of reciprocating pump pumping chambers to the differential piston pump feeding high-pressure liquid to start the return stroke of the differential piston pump.

14. The apparatus of claim 13, wherein the first portion is engaged by high-pressure liquid from one of the plurality of reciprocating pump pumping chambers, the second portion engages high-pressure liquid from another of the plurality of reciprocating pump pumping chambers, and wherein liquid pressures in each of the reciprocating pump pumping chambers vary inversely.

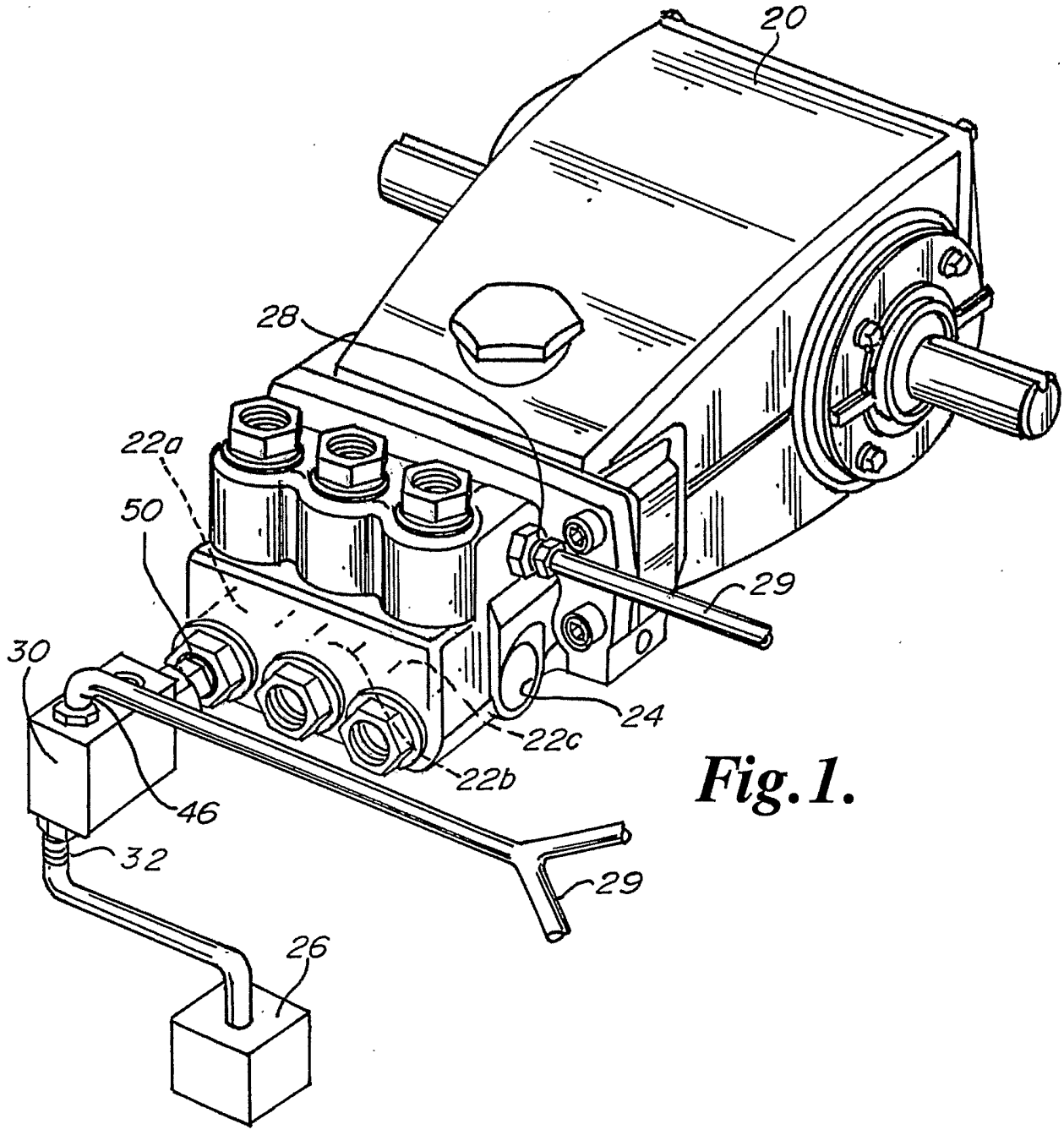

Fig. 1.

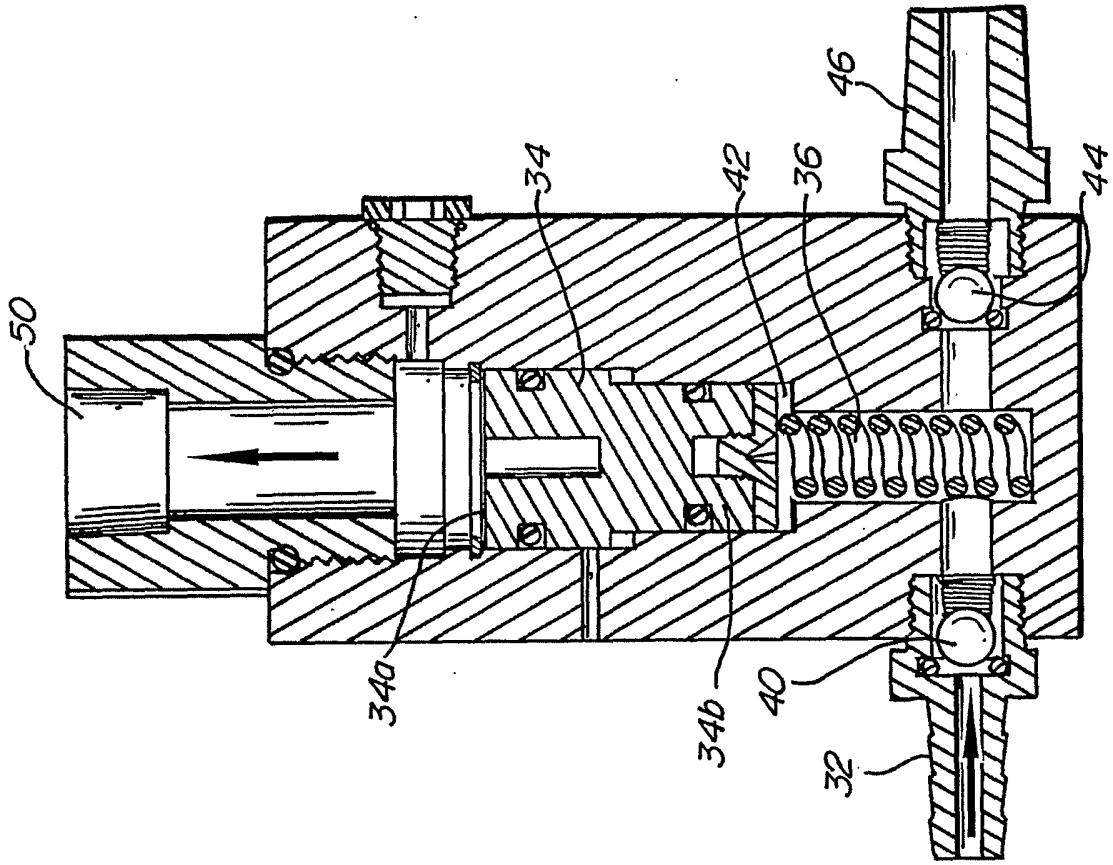

Fig.3.

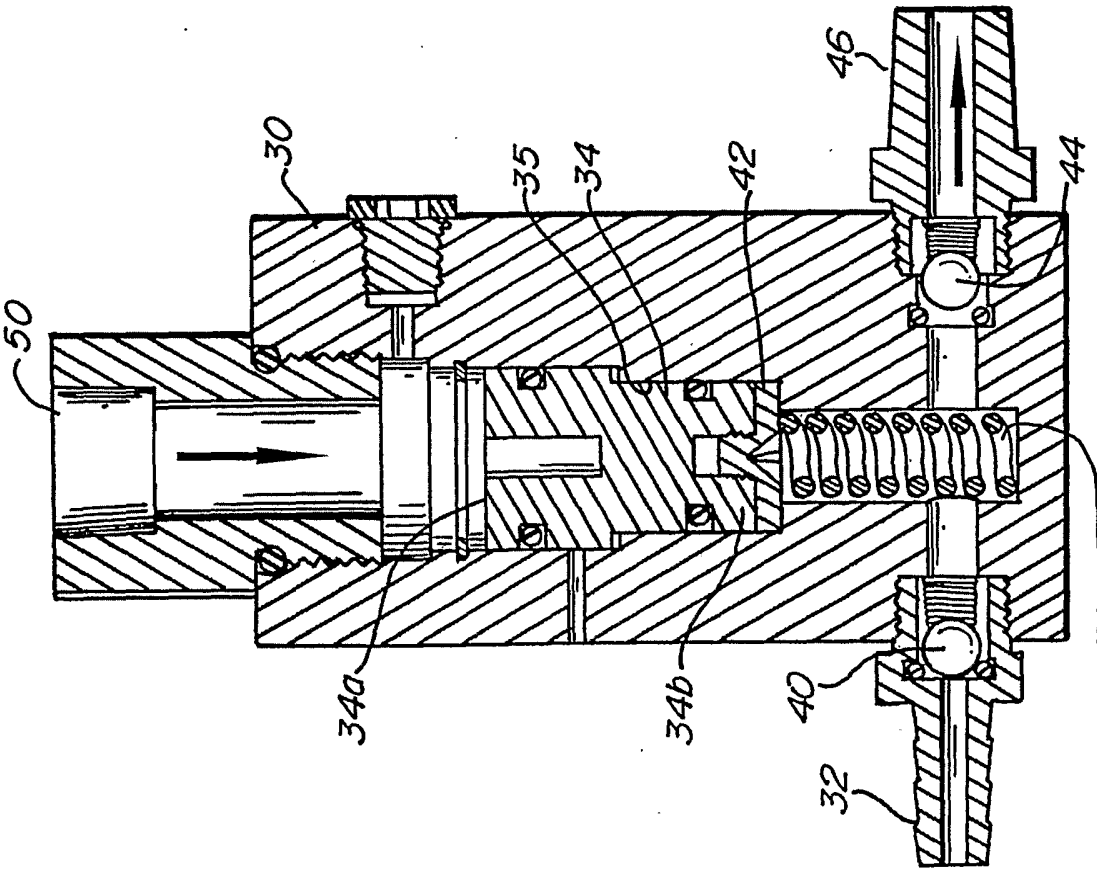

Fig.2.

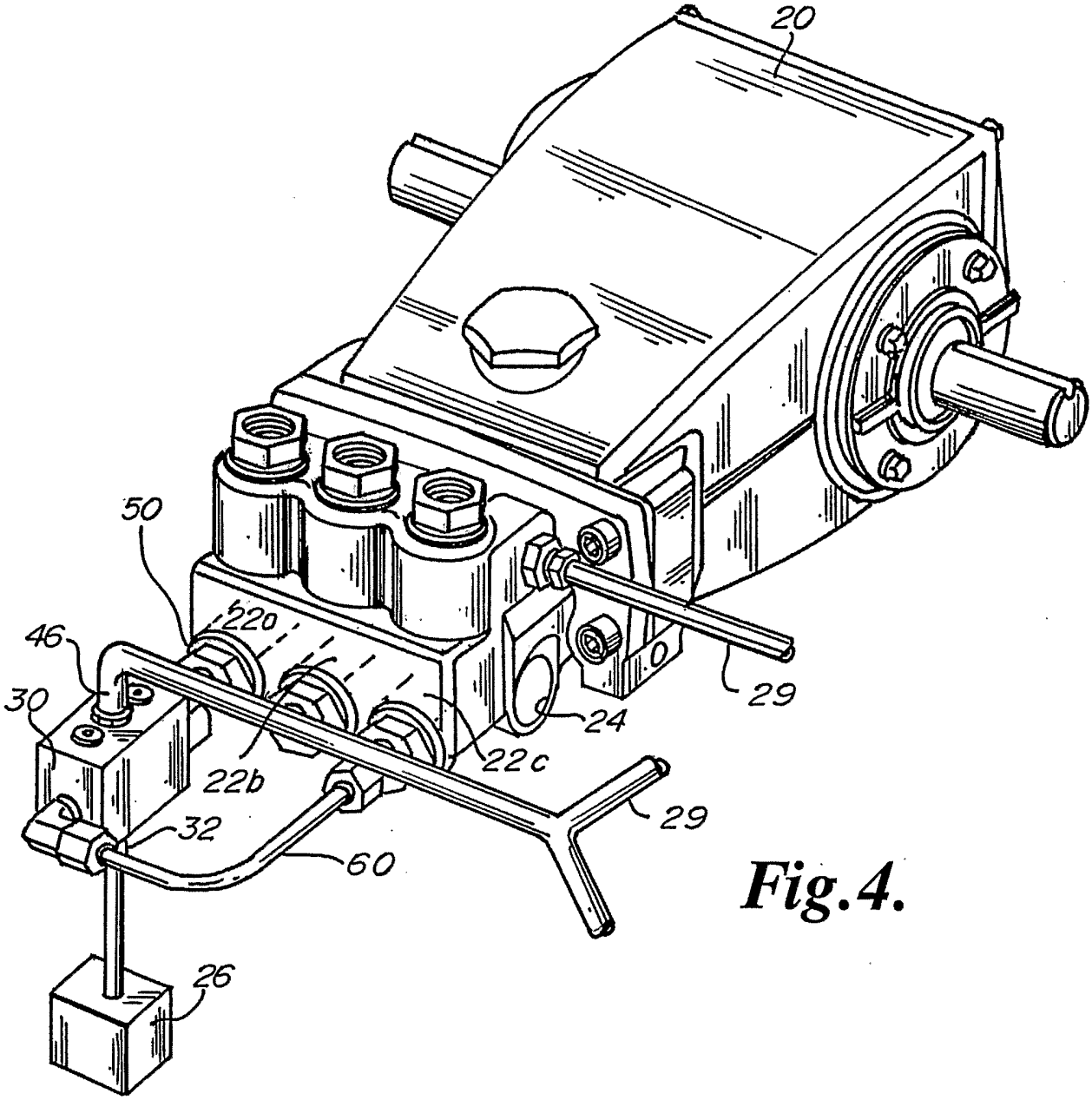

Fig.4.

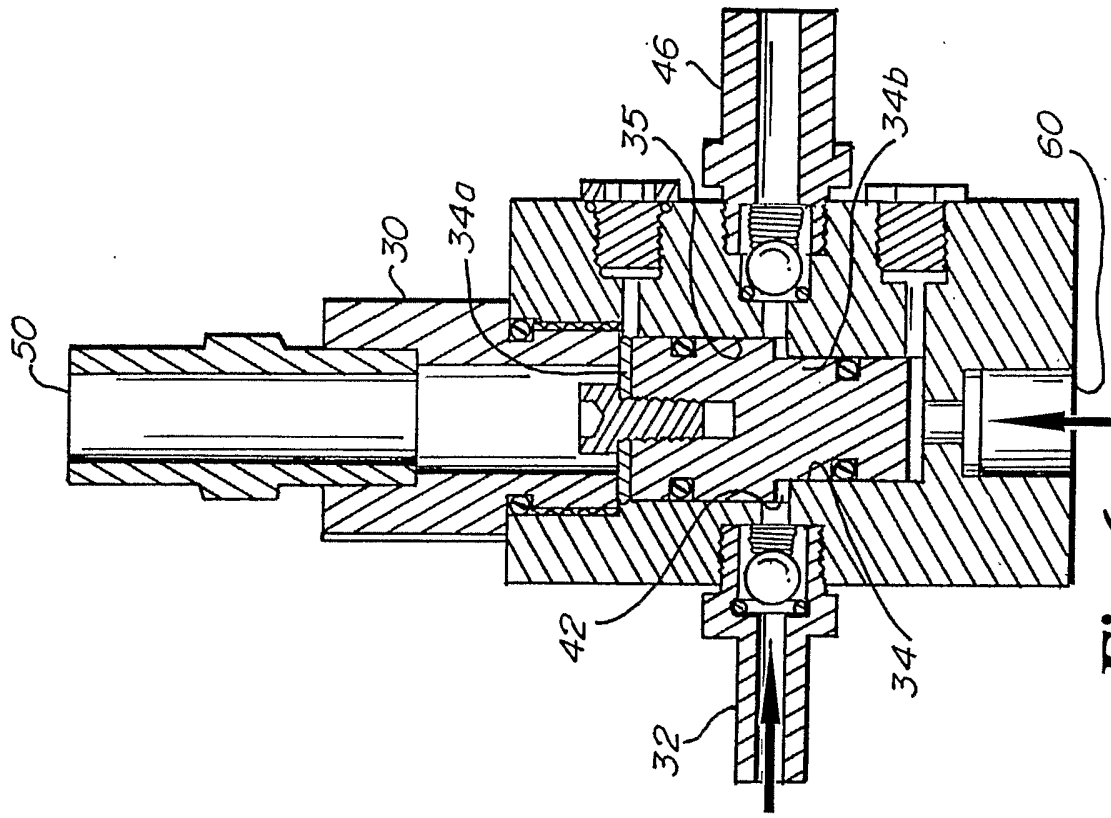

Fig.6.

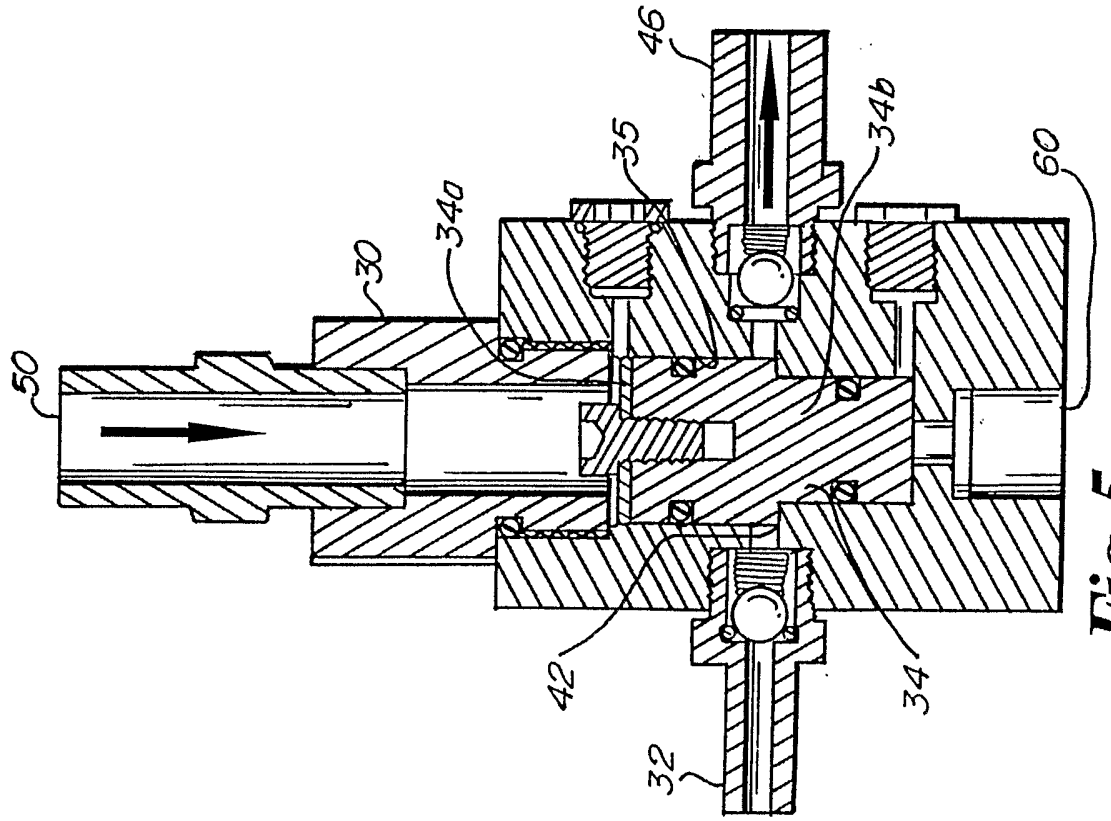

Fig.5.

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2006/008431

A. CLASSIFICATION OF SUBJECT MATTER
INV. F04B13/02 F04B23/06 F04B9/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 450 053 A (DOYLE W. MCCULLOCH) 17 June 1969 (1969-06-17) the whole document	1-14
Y	US 3 930 756 A (BRUGGEMAN ET AL) 6 January 1976 (1976-01-06) cited in the application the whole document	1-14
Y	DE 15 28 633 A1 (ZOELLER GEB. KEHL; SCHULZ-ZOELLER GEB. ZOELLER) 31 July 1969 (1969-07-31) the whole document	1-14
A	DE 25 49 008 A1 (OBERDORFER,GUIDO; OBERDORFER, GUIDO, 7919 BELLENBERG, DE) 5 May 1977 (1977-05-05) the whole document	1-14

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 June 2006	03/07/2006

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2006/008431

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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