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(71) Applicant: **DAN GEVA**

27206 Kiryat Bialik (IL)

(72) Inventor: **DAN GEVA**

27206 Kiryat Bialik (IL)

(74) Representative: **Intès, Didier Gérard André et al**

Cabinet Beau de Loménie

158, rue de l'Université

75340 Paris Cedex 07 (FR)

(54) **Insert vacuum pump**

(57) An multi-stage vacuum pump (10) powered by compressed air and comprising:

* at least one central inner body (14) carrying venturi tubes (16,18,20,22) aligned co-axially and separated by spaces (24), said tubes varying in diameter from a smallest tube (16) proximate to an inlet port (12) for compressed air to a largest diameter tube (22) proximate to an air outlet port (26);

* an outer housing carrying said inlet and outlet ports and a vacuum connector port;

* divider walls (41) separating said ports;

* connecting passages between said vacuum connector port and between said spaces;

* one-way valves (34) between each said vacuum connector port and between said space between successive tubes, to allow air to flow only from said vacuum connector port to said spaces; and

a reduced resistance inlet path for air being drawn into the space between the venturi tubes via said one-way valves.

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Description

[0001] The present invention relates to devices for the generation of a vacuum.

More particularly, the invention provides an improved venturi-type vacuum pump

Powered by a compressed gas, usually air, the pump being particularly useful for medical applications.

[0002] Vacuum pumps are used in materials handling equipment, printing machines and in various industrial applications. Medium-large vacuum pumps are usually driven by an electric motor. However where vacuum demand is small, as in medical and other laboratories, and compressed air is available Venturi-type vacuum pumps, sometimes referred to as jet pumps or ejectors can be used.

[0003] Vacuum pumps of this type have been known for about a century, as seen for example in the steam jet disclosed by Dambow in 1916. Pumps may be referred to as a jet pump, charge pump, or as an ejector pump in addition to a vacuum pump, the latter term being used in the current specification. The pump consists of at least one venturi tube to reduce air pressure in a closed volume. However 2-4 venturi tubes arranged in series, each tube interconnecting two vacuum chambers allow for the generation of an improved vacuum. The tubes progressively vary in size from the largest to the smallest. The vacuum pumps may be used for work holding, cleaning, operating fuel cells, medical and pharmaceutical applications. Venturi type vacuum pumps have advantages such as being explosion protected, have no rotating parts and are no more compact and weigh less than the more commonly used motor-driven pump. For moderate vacuum demand these advantages often outweigh the higher efficiency of the electrically driven pump.

The state of the art can be assessed by reference to the following US Patents.

The present inventor has disclosed three previous pumps in 4,554,956, 4,565,499 and 6,171,068.

Further designs are seen in 5,007,803 to DiVito et al., 6,575,705 to Akiyama et al., 6,851,936 to Stimgel et al., 6,877,960 to Presz, Jr. et al., 6,935,845 to Berner et al., 6,955,526 to Yamazaki et al., 7,340,892 to Trimble, and 7,438,535 to Morishima. Venturi type vacuum pumps are also seen in US Patent applications 2004/0197196 by Matheis et al., 2005/0089408 by Solomon, 2010/0209819 by Fukuma et al., 2010/0290925 by Tell and a nozzle inlet in 2010/029024 by Becker et al.

[0004] With regard to multi-stage pumps, the vacuum being generated and used is connected to the last stage of the pump only. It has now been found that this arrangement does not provide the best pump performance.

There are several difficulties with present day vacuum pumps. Vacuum pumps are often used in pharmaceutical laboratories where it has been found that some chemical components in the air thereof attack and distort the rubber used in the one-way valves which are a part of venturi vacuum pumps. The result is poor pump performance,

eventually followed by pump failure.

Where pump valves function using a flat rubber disk which is reasonably accessible for servicing, a replacement disk can be inserted provided personnel responsible are trained to detect and rectify poor pumping performance. However many pump designs, for example US Patent 6,394,760 to Tell rely on complex shapes to seal the one-way valves pertaining to this type of pump and such seal elements have a short life but a high cost of replacement.

[0005] It is therefore one of the objects of the present invention to obviate all the disadvantages of prior art venturi vacuum pumps and to provide a higher performance pump without significant increase in complexity, first and servicing cost, size or weight.

[0006] The present invention achieves the above objects by providing an improved multi-stage vacuum pump powered by compressed air, said pump comprising

- * at least one central inner body carrying a plurality of venturi tubes aligned co-axially and leaving a space between successive tubes, said tubes varying in diameter from the smallest tube proximate to an inlet port for compressed air, and increasing in size so that the largest diameter tube is proximate to an air outlet port;
- * an outer housing carrying an inlet port for compressed air, an air outlet port and a vacuum connector port;
- * divider walls separating said ports; and
- * connecting passages between said vacuum connector port and between said space between successive venturi tubes; and
- * one-way valves between each said vacuum connector port and each said space

between successive tubes, said valves allowing air flow only in direction from said

[0007] vacuum connector port to said space between successive tubes, and preventing flow in the reverse direction; and

a reduced resistance inlet path for air being drawn into the spacer between the venturi tubes via said one-way valves.

[0008] In a preferred embodiment of the present invention there is provided a pump wherein said one-way valve comprises a flat seating and a flexible disk automatically covering air passages from said vacuum connector port to said space between successive tubes when air pressure within the central inner body exceeds air pressure in the volume being evacuated, said valve opening during normal pump operation when said air pressure is higher outside said central inner body than the air pressure as measured near said space between said successive tubes.

[0009] In a further preferred embodiment of the present invention there is provided a pump wherein said flexible disk is made of a chemically-resistant plastic.

[0010] In a further preferred embodiment of the present invention there is provided a pump wherein said flexible disk is made of stainless steel less than 0.2 mm thickness.

[0011] In a further preferred embodiment of the present invention there is provided a vacuum pump wherein a gas accumulating chamber serving as a vacuum accumulator is provided between vacuum connector ports in said central body and said vacuum connector port is disposed in an outer housing.

[0012] In a further preferred embodiment of the present invention there is provided a large capacity vacuum pump, wherein an outer housing carries a plurality of central bodies each of said plurality of gas accumulating chambers being in fluid communication with said vacuum connector ports of each of said central body.

[0013] In yet further preferred embodiment of the present invention there is provided a vacuum Pump being made of stainless steel and allowing sterilization thereof. In another preferred embodiment of the present invention there is provided a vacuum Pump being made of a high temperature engineering plastic.

[0014] It is reasonable to suppose that connecting all the different vacuum chambers the vacuum being generated would degrade the performance of the pump, on the assumption that air would flow from the vacuum chambers holding a early stage vacuum to the Surprisingly it has now been found that connecting all stages of the vacuum pump to the vacuum being generated brings about the very opposite result, a significant improvement in pump performance, as was verified by testing a prototype manufactured according to present invention.

[0015] It will thus be realized that the novel device of the present invention serves to reliably supply moderate quantities of vacuum, while side-by-side installations as seen in FIG.7 can increase vacuum supply as needed. The flat disk used in the one-way valve is more reliable than the complex cylindrical seal element seen in the Tell patent Resistance to distortion of the disk is of much value in laboratories where the air contains chemical to which rubber is susceptible.

[0016] In an embodiment of the present invention, in the vacuum pump, a nozzle is part of the spacer house. The invention will now be described further with reference to the accompanying drawings, which represent by example preferred embodiments of the invention. Structural details are shown only as far as necessary for a fundamental understanding thereof. The described examples, together with the drawings, will make apparent to those skilled in the art how further forms of the invention may be realized.

[0017] In the drawings:

FIG. 1 is a cross-sectional view of preferred embodiment of the vacuum pump according to the invention;

FIG.2 is a fragmented sectional view of a pump hav-

ing improved air flow;

FIG.3 is a perspective view of a plastic washer suitable for use in the pump according to the invention; FIG.4 is the same as FIG.3 illustrating a stainless steel washer;

FIG.5 is an elevational sectional view of further embodiment enclosed in a housing, and

Fig.7 is a sectioned plan view of an embodiment having increased capacity

FIG. 8 is a cross-sectional view of preferred embodiment of the vacuum pump according to the invention with opposite connection of body section to FIG.1

[0018] There is seen in FIG.1 an improved multi-stage vacuum powered by a compressed gas, usually air, which enters the pump through a first inlet port 12.

The pump 10 comprises a central inner body 14 carrying four venturi tubes 16, 18, 20 and 22, all aligned coaxially. A small space 24 remains between adjacent tubes.

The venturi tubes 16, 18, 20 and 22 vary in diameter, the smallest tube 16 being proximate to the first inlet port 12, the tubes increasing in size so that largest tube 22 is proximate to an air outlet 26.

The central body 14 has several passages which serve as further inlet ports 36, 37, 40 to individual sections of the pump, all said passages being in fluid communication with the main inlet port 28. The inlet port 28 withdraws air or other gas from the volume 30 which is to be evacuated.

The central body has an outlet port 26 for discharge of the compressed air. Preferably a silencer section 32 allows gradual expansion of the air before discharge.

One-way valves 34 are seen disposed between the inlet ports 36, 37, 40 and the space 24 between adjacent venturi tubes. The valves 34 allow air flow only in the direction from the inlet port 28 to the spaces 24, and prevent flow in the reverse direction.

The seal element for the valves 34 comprises a flat flexible thin disk 42, which automatically seats against a flat surface 44 when the pump is not actuated. Under pressure of incoming air the disk 42 is reversibly dished while air enters the spaces 24. Divider walls 41 separate the port 28 from both the inlet port 12 the outlet port 26.

Seal elements 46 are deployed as necessary to prevent air leakage.

Where it is necessary to meet the requirement of competitive pricing the main components of the pump are made of an engineering plastic with sufficient heat resistance to withstand sterilization. Suitable polymers include Nylon 6/6 alloy or copolymer. Polyester is a useful alternative. Where extended durability is demanded and some additional cost can be tolerated the pump can be made of stainless steel. With reference to the rest of the figures, similar reference numerals have been used to identify similar parts.

[0019] Referring now to FIG.2 there is seen a detail of pump 50 having a further improved air entry path. The air referred to is the air which is evacuated from the vol-

ume 30. The air enters the central body 52 via the ports 54 and 56, and then the two air streams continue

[0020] on a collision course. The meeting of the two opposed air streams is useful in diverting the flow into the small space 34 between successive venturi tubes 16, 18. The improved air flow increases pump efficiency and so reduces the quantity of compressed air needed for operation of the pump.

[0021] FIG.3 illustrates a flexible valve disk 58 suitable for use of the one-way valves 34 describes with reference to FIG.1. The disk is made of chemically-resistant polymer such as acetate which extends the working life of the pump. The stepped form of the inner diameter 60 reduces the resistance of the disk to being dished. For the same purpose the disk thickness is typically less than 0.4mm.

[0022] Seen in FIG.4 is a further embodiment 62 of the valve disk. The disk is made stainless steel and may have a thickness of 0.2mm or less.

[0023] Referring now to FIG.5, there is depicted a vacuum pump 64 similar to the pump 10 seen in FIG.1. The central body 14 is held in an outer housing 66 which is readily openable by removal of the cover 68 with its gasket 70 if servicing is necessary. A gas accumulating chamber 72 serves as a vacuum accumulator which results in more even pump operation. The chamber 72 is operationally disposed between vacuum connector ports 40 in the central body 14 and the vacuum connector port 28 in the outer housing 66. The plug 74 seen on the right side of the figure is removable to allow assembly/disassembly of the central body 14. Compressed air enters through the port 76 and is discharges through the port 78.

[0024] FIG.6 shows a vacuum pump 80 wherein the one-way valve(s) 81 are disposed in the outer housing 82 leaving a freer access path for air being drawn into the pump 80. Furthermore the valves 81 are readily accessible for servicing, and can be replaced without having to dismantle the central body 14. An intermediate closure plate 84 provides three individual air passages 86 for the three chambers 88 between the venturi tubes.

[0025] FIG.7 illustrates a high-capacity vacuum pump 90, wherein three central bodies 14 are disposed in parallel in the housing 92. The pump 90 has two air inlets 76, 28 and three discharge ports 26. The three central bodies 14 can have different pneumatic properties as is suited to the application.

[0026] The scope of the described invention is intended to include all embodiments coming within the meaning of the following claims. The foregoing examples illustrate useful forms of the invention, but are not to be considered as limiting its scope, as those skilled in the art will be aware that additional variants and modifications of the invention can readily be formulated without departing from the meaning of the following claims.

[0027] There is seen in FIG.8 with opposite connection of body section to FIG.1 an improved multi-stage vacuum powered by a compressed gas, usually air, which enters the pump through a first

inlet port 12.

The pump 10 comprises a central inner body 14 carrying four venturi tubes 16, 18, 20 and 22, all aligned coaxially. A small space 24 remains between adjacent tubes.

5 The venturi tubes 16, 18, 20 and 22 vary in diameter, the smallest tube 16 being proximate to the first inlet port 12, the tubes increasing in size so that largest tube 22 is proximate to an air outlet 26.

10 The central body 14 has several passages which serve as further inlet ports 36, 37, 40 to individual sections of the pump, all said passages being in fluid communication with the main inlet port 28. The inlet port 28 withdraws air or other gas from the volume 30 which is to be evacuated.

15 The central body has an outlet port 26 for discharge of the compressed air. Preferably a silencer section 32 allows gradual expansion of the air before discharge.

One-way valves 34 are seen disposed between the inlet ports 36, 37, 40 and the space 24 between adjacent venturi tubes. The valves 34 allow air flow only in the direction from the inlet port 28 to the spaces 24, and prevent flow in the reverse direction.

20 The seal element for the valves 34 comprises a flat flexible thin disk 42, which automatically seats against a flat surface 44 when the pump is not actuated. Under pressure of incoming air the disk 42 is reversibly dished while air enters the spaces 24. Divider walls 41 separate the port 28 from both the inlet port 12 the outlet port 26.

25 [0028] Seal elements 46 are deployed as necessary to prevent air leakage.

Where it is necessary to meet the requirement of competitive pricing the main components of the pump are made of an engineering plastic with sufficient heat resistance to withstand sterilization. Suitable polymers include 35 Nylon 6/6 alloy or copolymer. Polyester is a useful alternative. Where extended durability is demanded and some additional cost can be tolerated the pump can be made of stainless steel.

40 With reference to the rest of the figures, similar reference numerals have been used to identify similar parts.

Claims

45 1. An improved multi-stage vacuum pump powered by compressed air, said pump comprising

- * at least one central inner body carrying a plurality of venturi tubes aligned co-axially and leaving a space between successive tubes, said tubes varying in diameter from the smallest tube proximate to an inlet port for compressed air, and increasing in size so that the largest diameter tube is proximate to an air outlet port;
- * an outer housing carrying an inlet port for compressed air, an air outlet port and a vacuum connector port;
- * divider walls separating said ports; and

- * connecting passages between said vacuum connector port and between said space between successive venturi tubes; and
 - * one-way valves between each said vacuum connector port and between said space between successive tubes, said valves allowing air flow only in the direction from said vacuum connector port to said space between successive tubes, and preventing flow in the reverse direction; and
 - a reduced resistance inlet path for air being drawn into the spacer between the venturi tubes via said one-way valves.
2. The pump as claimed in claim 1, wherein at least one of said valves one-way comprises a flat seating and a flexible disk automatically covering air passages from said vacuum connector port to said space between successive tubes when air pressure within the central inner body exceeds air pressure in the volume being evacuated, said valve opening during normal pump operation when said air pressure is higher outside said central inner body than the air pressure as measured near said space between said successive tubes. 25
 3. The pump as claimed in claim 2, wherein said flexible disk is made of a chemically-resistant plastic.
 4. The pump as claimed in claim 2, wherein said flexible disk is made of stainless steel less than 0.2mm thickness. 30
 5. The vacuum pump as claimed in any one of claims 1 to 4, wherein a gas accumulating chamber serving as a vacuum accumulator is provided between vacuum connector port in said central body and said vacuum connector port is disposed in outer housing. 35
 6. A large capacity vacuum pump, wherein an outer housing carries a plurality of central bodies as claimed in claim 1, each of said plurality of gas accumulating chambers being in fluid communication with said vacuum connector ports of each central body. 40 45
 7. A large capacity vacuum pump as claimed in claim 5, wherein the outer housing carries a plurality of the central bodies defined in claim 1, each of said plurality of gas accumulating chambers being in fluid communication with said vacuum connector ports of each central bodies. 50
 8. The large capacity vacuum pump as claimed in claim 6 or 7, wherein said outer housing is provided with a sealed cover removable for maintenance and cleaning purposes. 55
 9. The large capacity vacuum pump as claimed in claim 6 or 7, wherein said one-wayvalve(s) are disposed in said housing leaving a freer access path for air being drawn into said pump.
 10. The vacuum pump as claimed in any one of claims 1 to 9, being made of stainless steel and allowing sterilization thereof.
 11. The vacuum pump as claimed in any one of claims 1 to 9, being made of a high temperature engineering plastic. 10
 12. The vacuum pump as claimed in any one of claims 1 to 11, wherein a nozzle is part of the spacer house. 15

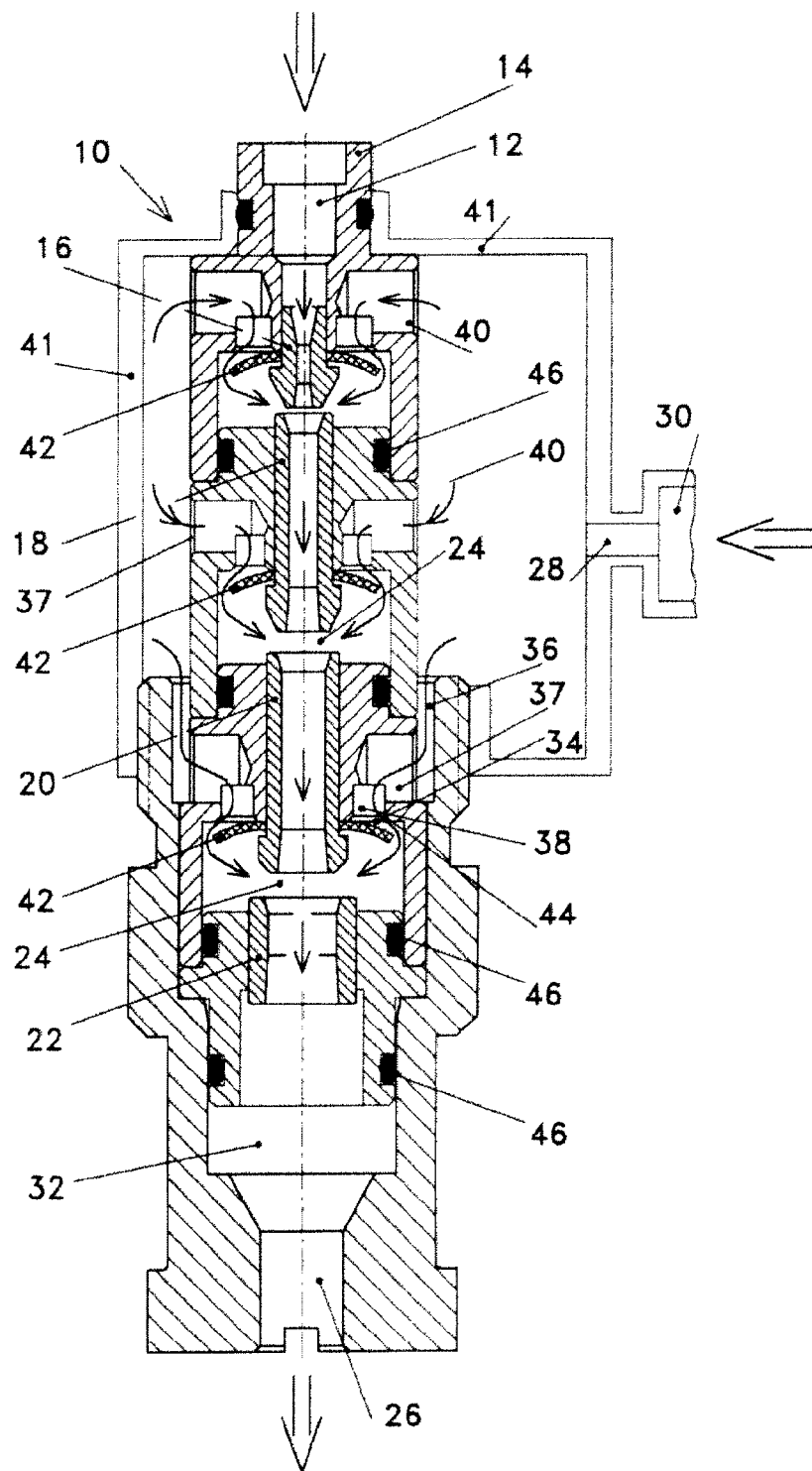
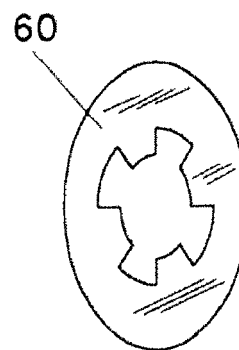
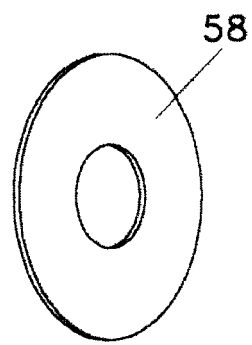
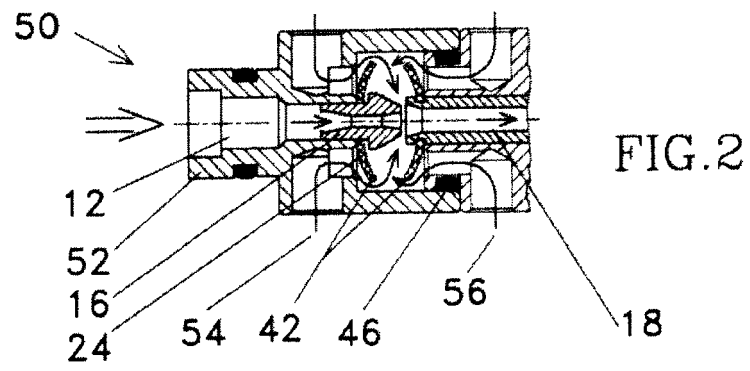


FIG. 1



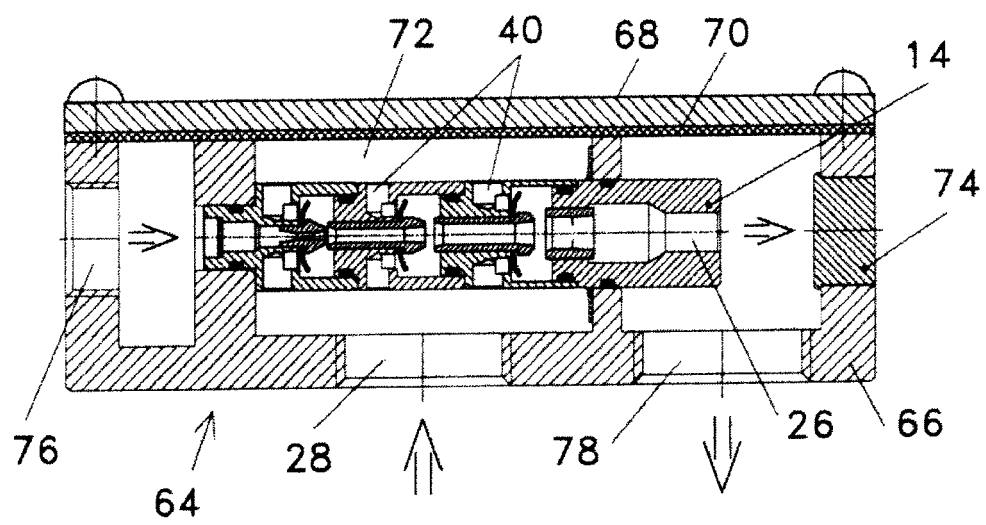


FIG.5

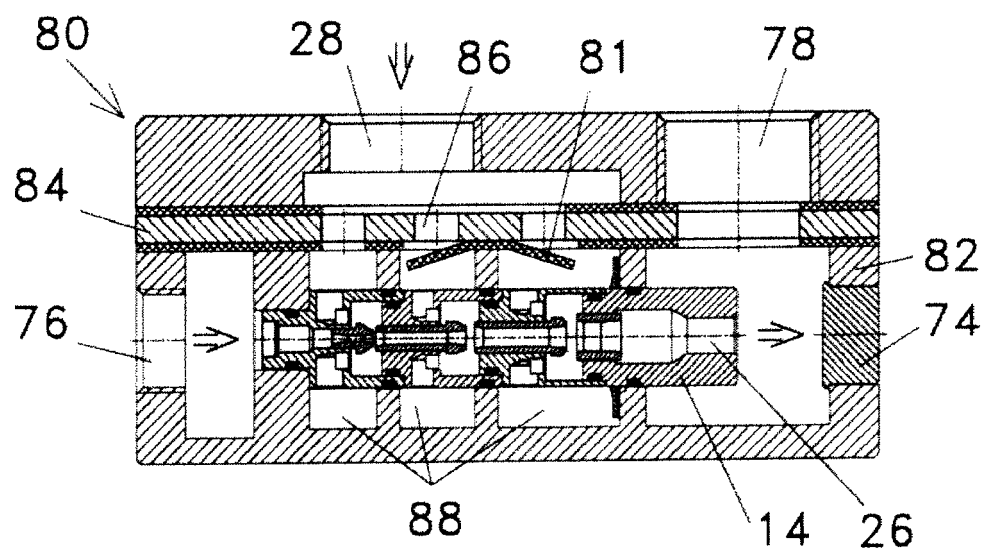


FIG.6

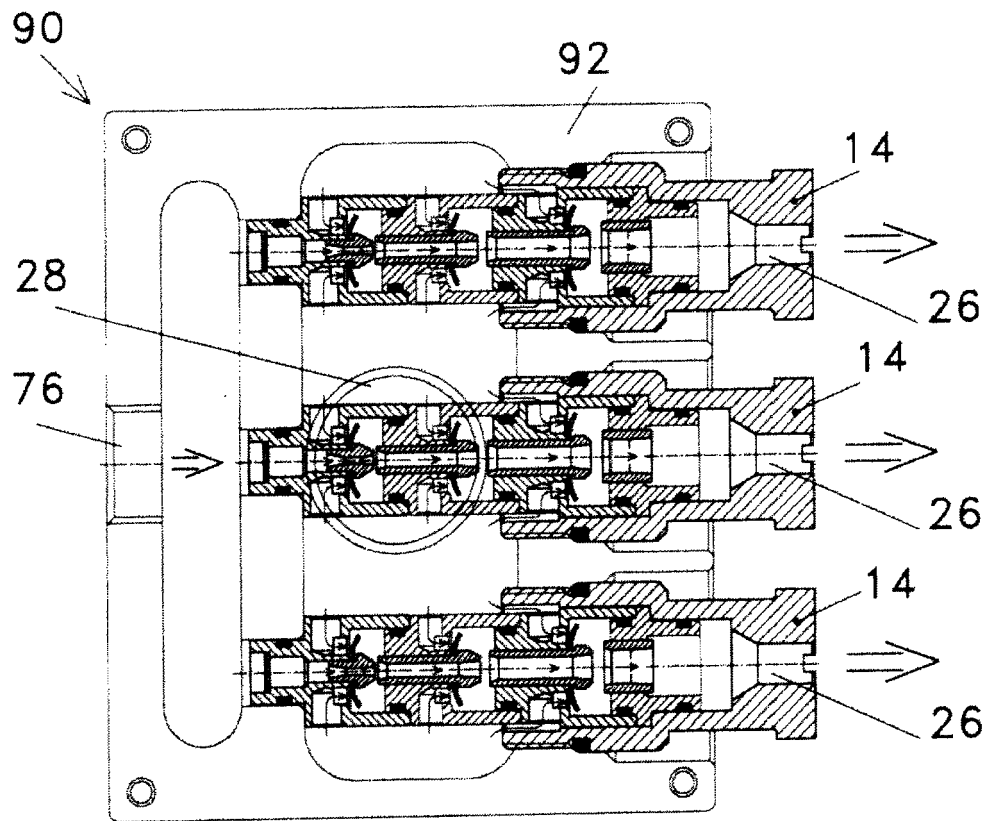


FIG. 7

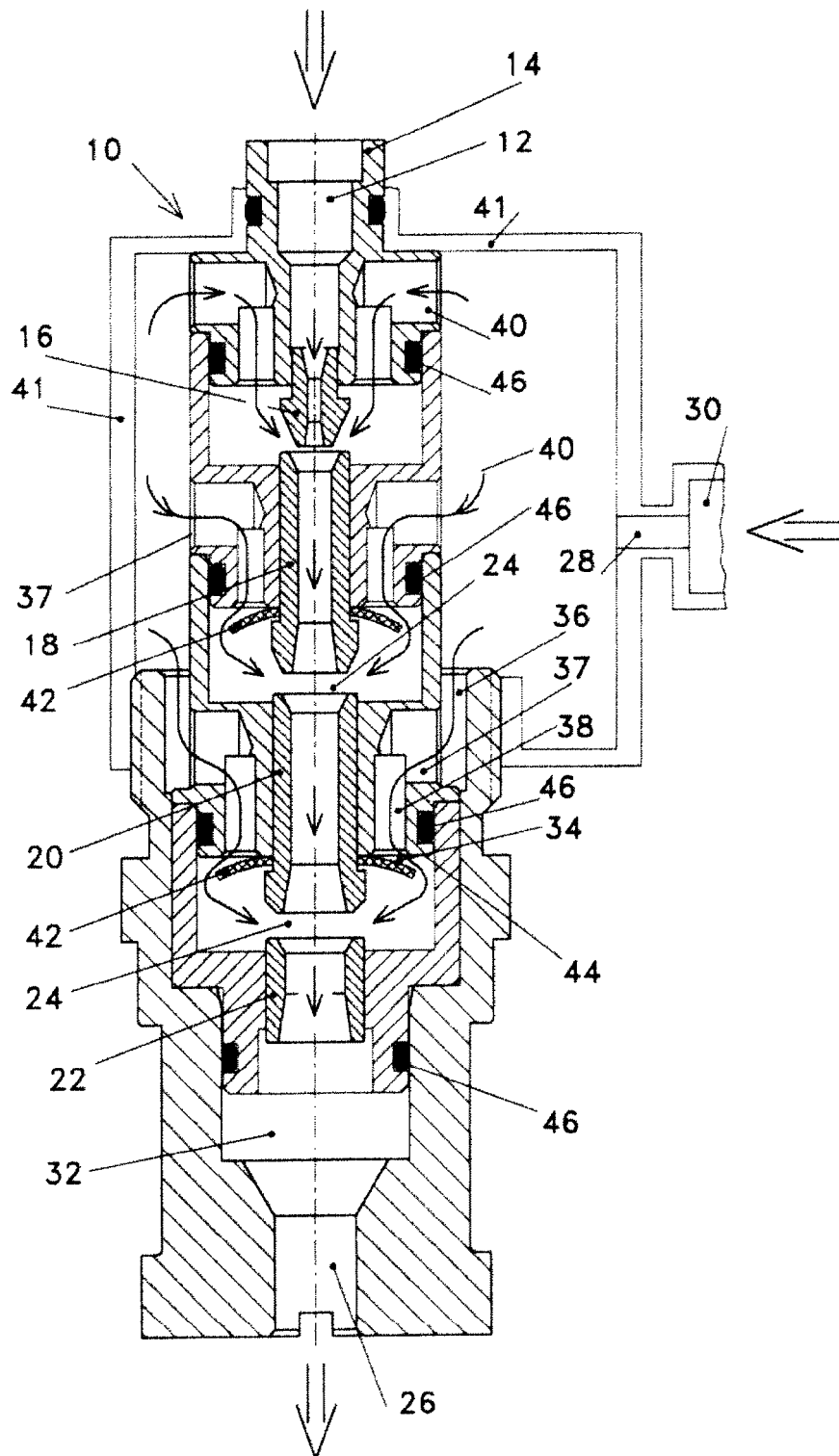


FIG.8



EUROPEAN SEARCH REPORT

Application Number
EP 12 18 5978

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	KR 101 066 212 B1 (KOREA PNEUMATIC SYS CO LTD [KR]) 20 September 2011 (2011-09-20)	1,5,6, 10,11	INV. F04F5/22
Y	* figures 1,2 * * paragraph [0024] - paragraph [0032] * * paragraph [0042] - paragraph [0044] *	2-4,7-9	F04F5/46 F04F5/54
X	WO 2007/050011 A1 (XEREX AB [SE]; TELL PETER [SE]) 3 May 2007 (2007-05-03) * figure 2 * * page 4 - page 7 *	1,6, 10-12	
X	WO 03/093678 A1 (PIAB AB [SE]; TELL PETER [SE]) 13 November 2003 (2003-11-13) * figure 3 * * page 5 - page 9 *	1,6,10, 11	
Y	US 6 682 313 B1 (SULMONE MICHAEL [US]) 27 January 2004 (2004-01-27) * figures 1,2 * * column 2, line 15 - line 18 * * column 3, line 3 - line 37 *	2-4	
Y	WO 01/20170 A1 (PIAB AB [SE]; TELL PETER [SE]) 22 March 2001 (2001-03-22) * figure 1 * * page 1 - page 4 *	7-9	
A	FR 2 375 471 A1 (ZENOU BIHI BERNARD [FR]) 21 July 1978 (1978-07-21) * figure 1 * * page 1 - page 2 *	1,12	
A	JP H02 110300 U ([]) 4 September 1990 (1990-09-04) * the whole document *	1-11	
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 7 February 2013	Examiner Durante, Andrea
CATEGORY OF CITED DOCUMENTS		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	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

 1
EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 12 18 5978

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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07-02-2013

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
KR 101066212 B1	20-09-2011	KR 101066212 B1	20-09-2011
		WO 2012121442 A1	13-09-2012

WO 2007050011 A1	03-05-2007	AT 472683 T	15-07-2010
		BR PI0618015 A2	16-08-2011
		CN 101297122 A	29-10-2008
		EP 1945956 A1	23-07-2008
		JP 4960968 B2	27-06-2012
		JP 2009513874 A	02-04-2009
		KR 20080059387 A	27-06-2008
		SE 528162 C2	19-09-2006
		SE 0502371 A	19-09-2006
		US 2008260544 A1	23-10-2008
		WO 2007050011 A1	03-05-2007

WO 03093678 A1	13-11-2003	AU 2003230499 A1	17-11-2003
		BR 0309677 A	22-02-2005
		DE 60317659 T2	30-10-2008
		EP 1502029 A1	02-02-2005
		ES 2294278 T3	01-04-2008
		JP 4216801 B2	28-01-2009
		JP 2005524796 A	18-08-2005
		SE 519647 C2	25-03-2003
		SE 0201335 A	25-03-2003
		US 2005232783 A1	20-10-2005
		WO 03093678 A1	13-11-2003

US 6682313 B1	27-01-2004	NONE	

WO 0120170 A1	22-03-2001	AT 377712 T	15-11-2007
		AU 7464600 A	17-04-2001
		BR 0012364 A	26-03-2002
		DE 60037031 T2	21-08-2008
		EP 1222401 A1	17-07-2002
		ES 2292470 T3	16-03-2008
		JP 2003509626 A	11-03-2003
		SE 513897 C2	20-11-2000
		SE 9903287 A	20-11-2000
		US 6464262 B1	15-10-2002
		WO 0120170 A1	22-03-2001

FR 2375471 A1	21-07-1978	NONE	

JP H02110300 U	04-09-1990	JP 2559238 Y2	14-01-1998
		JP H02110300 U	04-09-1990

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 4554956 A **[0003]**
- US 4565499 A **[0003]**
- US 6171068 B **[0003]**
- US 5007803 A, DiVito **[0003]**
- US 6575705 B, Akiyama **[0003]**
- US 6851936 B, Stimgel **[0003]**
- US 6877960 B, Presz, Jr. **[0003]**
- US 6935845 B, Berner **[0003]**
- US 6955526 B, Yamazaki **[0003]**
- US 7340892 B, Trimble **[0003]**
- US 7438535 B, Morishima **[0003]**
- US 20040197196 A, Matheis **[0003]**
- US 20050089408 A, Solomon **[0003]**
- US 20100209819 A, Fukuma **[0003]**
- US 20100290925 A, Tell **[0003]**
- US 2010029024 A, Becker **[0003]**
- US 6394760 B, Tell **[0004]**