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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
27 January 2005 (27.01.2005)

PCT

(10) International Publication Number
WO 2005/007308 A1

(51) International Patent Classification[7]: B08B 9/04, F16L 55/40

(21) International Application Number: PCT/NO2004/000219

(22) International Filing Date: 15 July 2004 (15.07.2004)

(25) Filing Language: Norwegian

(26) Publication Language: English

(30) Priority Data:
20033233 17 July 2003 (17.07.2003) NO

(71) Applicant and
(72) Inventor: **JEMNE, Rolf, G.** [NO/NO]; Frue Terrasse 4, N-4012 Stavanger (NO).

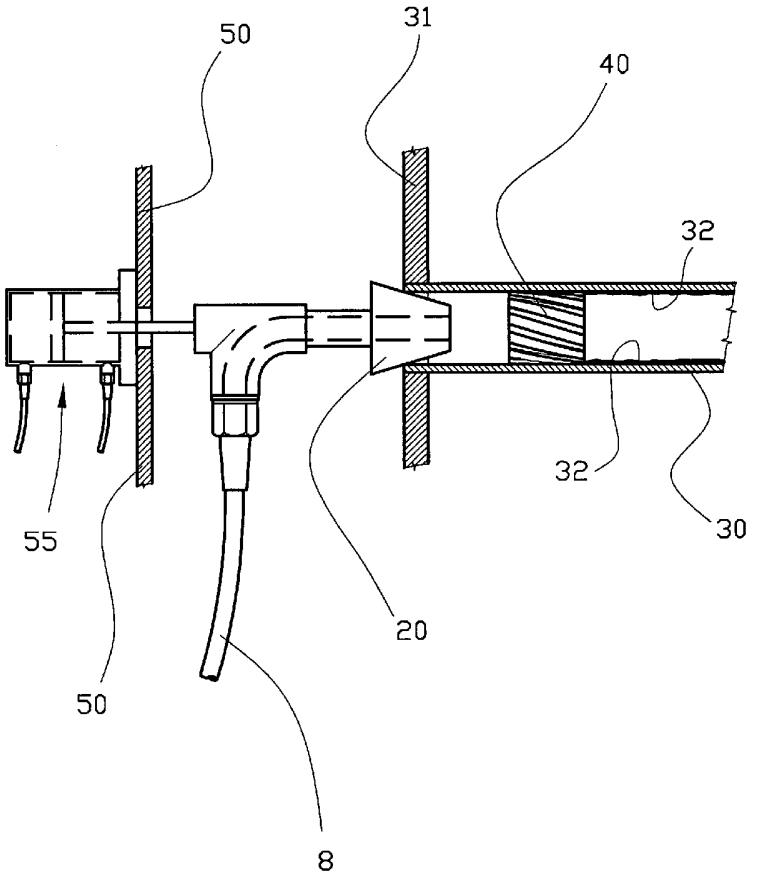
(74) Agent: **HÅMSØ PATENTBYRÅ ANS**; P.O. Box 171, N-4302 Sandnes (NO).

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

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: APPARATUS AND METHOD FOR INTERNAL CLEANING OF PIPES AND TUBES



(57) Abstract: A pipe pig (40) for internal cleaning of deposits in a tube (30), wherein the pipe pig (40) which is provided with at least one axial helical groove (44) shaped in the pipe pig's (40) surface facing the internal surface of the tube (30), is shot by means of fluid at high pressure which is quickly released by means of a valve arrangement, through the tube which is to be cleaned.

WO 2005/007308 A1

Published:

— *with international search report*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

APPARATUS AND METHOD FOR INTERNAL CLEANING OF PIPES AND TUBES.

The invention relates to an apparatus for cleaning off deposits internally in pipes and tubes by the use of a pipe scraper or "pig", which is shot through the pipe at high velocity. The invention also relates to a method of use of the invention.

The purpose of the invention is to provide an apparatus which enables a quick, efficient and safe internal cleaning of tubulars, for example in a heat exchanger, by the use of a pipe scraper which is shot through a tube at high velocity by means of a fluid, preferably so that cavitation and turbulence are created between the pipe scraper and the pipe wall, sufficient to debond deposits on the tube's internal surface.

In the process industry heat exchangers frequently form part of the process equipment . In use different forms of deposits or scale develop on the inside of the individual tubulars of the heat exchanger, which has primarily an insulating effect for the fluid flowing through the individual tubular, so that the effect of the heat exchanger will be considerably reduced, or the deposits on the inside of the pipes and tubes may become so thick that thethrough-flow is obstructed. As individual elements, for instance a heat exchanger, in a process traincannot normally be isolated from the rest of the

process train that they form parts of whilst the process train is in operation, maintenance of the individual pieces of processing equipment has to be performed in connection with periodical shutdowns of the entire, or essential parts of, the process train, so-called maintenance stoppages or "shutdowns". For financial reasons it is desirable to have the maintenance shutdowns as seldom as possible and of as short duration as possible.

In a process train in, for example, the oil, gas, petrochemical and wood processing industries, there may be a relatively large number of tubes or heat exchangers, in which regular cleaning of the internal surface of the individual tubular may be necessary. As the deposits or scale can be very hard and/or firmly stuck, or in other ways hard to remove, cleaning the tubes is a very time-consuming task. Due to the limited time often allowed for maintenance shutdowns, only the equipment having the poorest through-put is often given priority so that equipment with reduced capacity is left until a later maintenance shutdown.

Several different types of apparatus are known, which are used for internal cleaning of tubes or tubulars forming parts of, for example, heat exchangers. At present it is common to carry out cleaning of, for example, heat exchangers by means of "lancing", i.e. high pressure water jetting and/or use of brushing scrapers, rotating mechanical equipment and the use of chemicals. The American patent US 5,423,917 discloses an apparatus and a method for cleaning of tubes for example in a heat exchanger, wherein a pig is placed in the tube which is to be cleaned, and a water column is established, propagating standing waves, vibrations and resonance generated by a valve system formed by 3 or more valves used to create shock waves

in the water column . The pig is driven forward through the pipe by the shock waves bringing about the cleaning of the pipe. By adding chemicals and gas bubbles, in the form of oxygen implosion and explosion, to the water column the cleaning effect is enhanced.

There are several disadvantages related to the above-mentioned solution. The disadvantages relate primarily to the relatively time-consuming operation and to the equipment required being relatively complicated, where there may be a requirement for both gas and chemicals to be added in addition to a relatively extensive control system. Additionally, the use of chemicals represents an environmental problem.

The American patent US 4,724,007 discloses an apparatus and a method for cleaning of tubes of for instance heat exchangers, where a pig is driven by means of a launching device through the tube at great velocity, creating a water hammer which together with the pig brings about the cleaning of the tube.

Even though US 4,724,007 represents great improvements with respect to the time for the cleaning itself, US 4,724,007 represents the same disadvantages as US 5,423,917 described above.

There is also known a pipe scraper or "pig" , which is provided with grooves or rails which are to generate rotation of the plug as it is driven through the pipe which is to be cleaned. US 4,122,575, US 4,474,479, US 4,538,531, US 3,879,790, US 3,204,274 and US 3,605,159 disclose different pipe pigs equipped with helical axial elevations or grooves of different purposes such as conducting water to the front of the pig in order to "lubricate" the interface between the pipe pig and the contamination on the pipe wall, or to provide

rotation of the pig, so that in the advance movement approximately equal wear and tear is achieved on the pig. The pipe pigs are driven sealed against the pipe wall, which is achieved because the pipe pigs are made of a soft compressible material with a diameter larger than the internal area of the pipe. By applying water at low pressure to one side of the pipe pigs, they are moved through the pipe at a velocity of 0.3 to 1 m/s, whilst scraping, brushing, grinding and/or polishing the pipe. The patents US 4,720,884 and US 5.384.929 disclose pipe pigs equipped with brushing and scraping devices which are disposed as helical axial elevations. In opposition to the above-mentioned patents, it is a condition that the pigs described in US 4,720,884 and US 5,384,929 do not rotate, but scrape loose the contaminants in the pipe and carry them towards the back of the pig. For the rest the pigs have the same properties as the pigs of the above-mentioned patents.

There are also several disadvantages related to pipe pigs of the type described in the prior art mentioned above.

The main disadvantages are related to the fact that the above-mentioned pipe pigs are travelling at relatively low velocity. Due to the softness of the material, there are, in addition, essential limitations to the pressure that may be applied to pigs to obtain propulsion. The pigs are essentially made for cleaning larger pipe lines having contaminants like paraffin, wax and similar, and are not very suitable for removing contaminants in, for example, heat exchangers where the contaminants are mainly hard deposits like scale, calcium carbonate, silicon carbonate, lye and similar.

The object of the invention is to remedy the disadvantages of the prior art.

The object is achieved in accordance with the invention by the features specified in the description below and in the following Claims.

The present invention includes a specially designed pipe scraper for cleaning of tubes, for example, but not limited to, tubes in heat exchangers. By means of fluid which is quickly released under high pressure through a nozzle or "shotgun" against one end surface of the pipe scraper, the pipe scraper is carried through the tube at high velocity. In one embodiment the pipe scraper is provided with at least one, but preferably multiple helical axial grooves or rails placed on the external circumferential surface of the pipe scraper, facing the internal surface of the tube wall to be cleaned. The pipe scraper has preferably an outside diameter which is smaller than the tube's internal diameter. When the pig is "shot" through the tube, at very high velocity, several hundred metres per second, by means of fluid, for example water, the fluid will, among other things, be forced through the axial helical grooves and cause a high rotational velocity of the pipe scraper. Together with the high axial velocity the high rotational velocity will create turbulence and cavitation to such a magnitude against the internal contamination of the tube that the contamination will debond from the tube wall.

A sufficient propulsive and rotational velocity of the pipe pig is provided by the generation of a dynamic fluid pressure blow against one end portion of the pipe pig after it has been inserted into the tube which is to be cleaned. By utilising an

apparatus according to the invention which is formed preferably by two fast-acting valves of a type known in itself, and a high-pressure pump of a type known in itself, a fluid pressure is built up, adjusted to the capacity of the tube material to be cleaned. By quickly releasing the fluid under pressure, which is preferably water, this is carried at great velocity against an end portion of the pipe pig placed in the tube. The energy and the inertia of the fluid will instigate a quick movement of of the pipe pig through the tube. When the pipe pig is provided with at least one, but preferably multiple, axial helical grooves, the fluid will generate fast rotation of the pig together with a high axial velocity. As the pig rotates, the at least one groove or elevation will create cavitation and turbulence causing debonding of the contamination.

In those cases where a tube is totally or almost totally blocked by contaminants, the rotational effect of a pipe pig according to the invention could not be fully utilised inasmuch as the rotation brought upon the pig by release of the pressurised fluid will quickly be stopped because of the frictional forces of the considerable amounts of contaminants. In such situations it will be practical to make use of pigs of types known in themselves, which are driven through the totally blocked or almost totally blocked tube by the application of repeated pressure blows on the pig of a type known in itself, by utilising the set of apparatus used for "shooting" the pipe pig according to the invention through a tube. When driving a pipe pig through a totally or almost totally blocked tube, the pressurised fluid preferentially applied in blows against an end surface of the pig, will cause advancement of the pig. Due to the differential pressure between the tube in front of and behind the pig, the fluid

which may be water, for example, will be forced between the pig and the contamination and between the contamination and the tube wall, causing contamination to debond from the tube wall.

In what follows is described a non-limiting example of a preferred embodiment, which is visualised in attached drawings, in which:

Figure 1 shows a diagrammatic overview of the fluid supply arrangement according to the invention.

Figure 2 shows a view of an arrangement according to the invention, in which a nozzle shaped like the frustum of a cone is placed in an essentially sealed connection with a tube which is to be cleaned, and a pipe pig according to the invention has been inserted into the tube.

Figure 3 shows a pipe pig according to the invention, in which the pipe pig is formed by a solid, cylindrical element which is provided with twelve u-shaped axial, helical recesses in its outer surface.

Figure 4 shows a vertical projection of the pipe pig of Figure 3, seen from one of the end surfaces.

Figure 5 shows a section A-A of the pipe pig of Figure 4.

Figure 6 shows a pipe pig according to the invention, in which the pipe pig is formed by a cylindrical element which is provided, in a portion, with a bore and, on the external surface, is provided with twelve essentially rectangularly shaped axial, helical recesses.

Figure 7 shows a vertical projection of the pipe pig of Figure 6 seen from the end surface that is furnished with the bore.

Figure 8 shows a section C-C of the pipe pig of Figure 7.

In the drawings the reference number 1 denotes the tube-cleaning device according to the invention comprising a valve arrangement 3, a valve control unit 10, a nozzle device 20 which is brought to bear in an essentially sealing manner against one end portion of a tube 30 which is to be cleaned, and a pipe pig 40 which is carried through said tube 30 by means of differential pressure between the two end surfaces of the pipe pig 40. In the drawings corresponding details of the different embodiments of the pipe pig are identified by the same reference numbers.

Figure 1 shows a diagrammatic overview of the valve arrangement 3 which is provided with fluid from a high-pressure pump (not shown) of a type known in itself, through a supply line 2, where the valve arrangement 3 is formed by a first fast-acting valve 4 and a second fast-acting valve 6, both of a type known in itself, which are controlled by two valve control units 12, 14, of a type known in itself, the valve control unit 12 controlling said first fast-acting valve 4 and the valve control unit 14 controlling the second fast-acting valve 6. The valve control units 12, 14 can be, for example, but not limited to, pneumatically or electrically controlled, electricity or pneumatics being supplied to the valve control unit by a control supply line 16. From the valve arrangement 3 a fluid line 8 extends to at least one nozzle 20 and to a pressure relief line 5. In order to compensate for a possible pressure drop by sudden opening of valve 4, an

accumulator 7 is installed on the supply line 2 between the high-pressure pump and the valve 4.

Figure 2 shows a nozzle 20 shaped like the frustum of a cone which is connected at its one end portion to a fluid line 8 which connects the nozzle 20 to the valve arrangement 3 (Figure 1), and which is inserted by its other end portion into the pipe 30 which is to be cleaned of internal contamination 32. The end portion of the tube 30 is placed in a hole of a tube sheet 31

A pipe pig 40 according to the invention is placed inside the tube adjacent to the outlet portion of the nozzle 20. The nozzle 20 is kept in the desired position by means of a counter-device 50, and is moved in the axial direction of the tube 30 by means of a hydraulic device 55 of a type known in itself, associated with the counter-arrangement 50.

Figures 3 to 8 show two different pipe pigs 40 formed by a pig body 42 provided with axial, helical grooves 44.

In one embodiment, as shown in Figure 3, the pipe pig 40 is formed by a solid cylindrically shaped, essentially incompressible material which is provided with u-shaped grooves 44. In another embodiment, as shown in Figure 6, the pipe pig 40 is formed by a cylindrically shaped, essentially incompressible material which is provided externally with essentially rectangularly shaped grooves and which is provided, from one end surface, with a bore 46 in a portion of the pig body 42. As appears clearly from Figure 8, the bore 46 does not extend through the pig body 42. In the figures 6 to 8 the bore 46 is shown as a centre bore. In the figures the pipe pig 40 is shown with an essentially square transition between the end faces and the cylinder surface which is

furnished with grooves. However, one or both transitions may be inclined or chamfered (not shown).

In an alternative embodiment (not shown) the pipe pig is formed by a polygonal body, where the edges between the pipe pig's surfaces facing the tube's internal surface form a sloping angle relative to the axial direction of the body (and the pipe). The edges will define inclined flow channels which are formed between the surfaces and the tube's internal surface, which channels will cause rotation of the pipe pig as a mass of fluid flows through the channels.

A method of use of the pipe-cleaning device includes:

a) A pipe pig 40 is adapted to the range of use with respect to the metallurgical integrity, pressure rating and the configuration of the passage of the tube 30 to be cleaned. The pipe pig 40 is preferably produced of a material which is softer than the tube 30 and the pipe pig's 40 outside diameter is preferably under-dimensioned relative to the internal diameter of the tube 30.

b) The pipe pig 40 is placed in an end portion of the tube 30 which is to be cleaned,

c) the nozzle 20 is placed, essentially in a sealing position, in the end portion of the tube 30, where the pipe pig 40 is placed and held in position by a counter-device 50, 55,

d) the supply line 2 is connected to a high-pressure pump (not shown) and the pressure is adjusted to the capacity of the tube, for example to 50-75 % of the yield of the pipe material,

e) the fluid line 8 in fluid communication with the fast-acting valves 4, 6 is connected to the nozzle 20 associated with the tube 30, and an outlet portion of the pressure relief line 9 in fluid communication with the fast- acting valve 6 is routed to a desired discharge point, for example a water reservoir,

f) the fast-acting valve 4 is opened,

g) the fast-acting valve 6 is closed,

h) the fluid line 8 and tube 30 up to the pipe pig 40 is filled with fluid, for example, but not limited to, water,

i) the fast-acting valve 4 is closed by means of the valve control unit 12,

j) the valve 6 is opened by means of the valve control unit 14 and the fluid in the fluid line 8 up to the pipe pig 40 is pressure-relieved,

k) the valve 6 is closed by means of the valve control unit 14,

l) the fast-acting valve 4 is opened and the pipe pig 40 in the tube 30 is exposed to a pressure blow and driven forward through the tube, and

m) if the pipe pig 40 is not driven through the tube by the pressure blow, the sequence j) - l) is repeated.

In situ tests show that the method is suitable both by use of the pipe pig 40 in accordance with the invention and by use of pipe pigs of a type known in itself. The pipe pig 40 in accordance with the invention is best suited for removing a small to moderate thickness of contamination deposits in the

tube 30. For typical tubes in for instance a heat exchanger this can be in the order of up to approximately 1.5 mm. By using the pipe pig 40 according to the invention the fluid supplied as under item l) above, will pass through the axial helical grooves 44 and cause a high rotational velocity of the pig, which in addition to a high axial velocity will create turbulence and cavitation to such a degree against the contamination on the inside of the pipe wall that the contamination will be debonded from the tube wall. By the use of the pipe pig 40 according to the invention it is thus the turbulence and cavitation which bring about the cleaning of the tube 30, and the pipe pig 40 is thus dependent on receiving fluid pressure blows generated by the pipe-cleaning device according to the present invention.

In the cases where the contamination on the tube's 30 inside is so thick that the rotational effect of the pipe pig 40 according to the invention will be limited, a pipe pig of a type known in itself can be utilised to remove the contamination from the tube's 30 inside. The pipe pig known in itself is supplied with pressurized fluid "in blows"against its one end surface according to the method described in the items a) - m) above, and a "hammer effect" is achieved so that the pipe pig is driven through the tube. Because of the differential pressure between the pipe in front of and behind the pig the fluid, which could for example be water, will be forced between the pig and the contamination and between the contamination and tube wall, which causes debonding of contamination from the tube wall.

C l a i m s

1. A pipe pig (40) for cleaning off deposits internally in a tube (30), characterized in that the pipe pig (40) is produced of a material incompressible in the situation of use and with an outside diameter which is smaller than the internal diameter of the tube (30) which is to be cleaned by the pipe pig (40).

2. A pipe pig (40) according to claim 1, characterized in that the pipe pig (40) is provided with at least one axial helical groove (44) formed in the surface of the pipe pig (40) facing the tube's (30) internal surface.

3. A pipe pig (40) according to claim 1, characterized in that the pipe pig (40) is provided with at least one blind bore (46) to reduce the pipe pig's (40) mass .

4. A pipe pig (40) according to claim 3, characterized in that the at least one blind bore (46) forms a centre bore.

5. A pipe pig (40) according to claim 3, characterized in that the at least one blind bore (46) has a centre line positioned to the side of the centre line of the pipe pig (40).

6. A method for internal cleaning of tubes (30) by the use of a pipe pig (40) in accordance with claim 1, characterized in that the method includes the following steps:

The pipe pig (40) is placed at an end portion of the tube (30) which is to be cleaned;

a dynamic fluid pressure blow is directed against an end portion of the pipe pig (40),

whereby the pipe pig (40) is driven through the tube (30) at high axial velocity while at the same time the pipe pig (40) is put into fast rotation by fluid which is forced through the at least one helical groove (44), so that the fast rotation of the pipe pig (40) generates cavitation between the internal surface of the tube (30) and the pipe pig (40), and the great axial velocity generates turbulence behind an end portion of the pipe pig (40), which cavitation and turbulence will cause debonding and extraction of at least parts of the deposit (32) on the internal surface of the tube (30).

7. A method according to claim 6, characterized in that the dynamic fluid pressure blow is provided by an amount of fluid being pressurised by a high-pressure pump and quickly released by an arrangement of fast-acting valves (4, 6).

8. A method according to claim 6, characterized in that the dynamic fluid pressure blow is transferred to the tube (30) and against the pipe pig's (40) end portion by the use of a nozzle (20) which is placed in an essentially sealing position in the end portion of the tube (30) where the pipe pig (40) is inserted.

9. A method according to claim 6, characterized in that if the pipe pig (40) is not driven through the entire tube (30) by the application of one single fluid pressure blow, further fluid pressure blows are applied until the pipe pig (40) exits the tube (30) in the opposite end portion to where the pipe pig (40) was inserted.

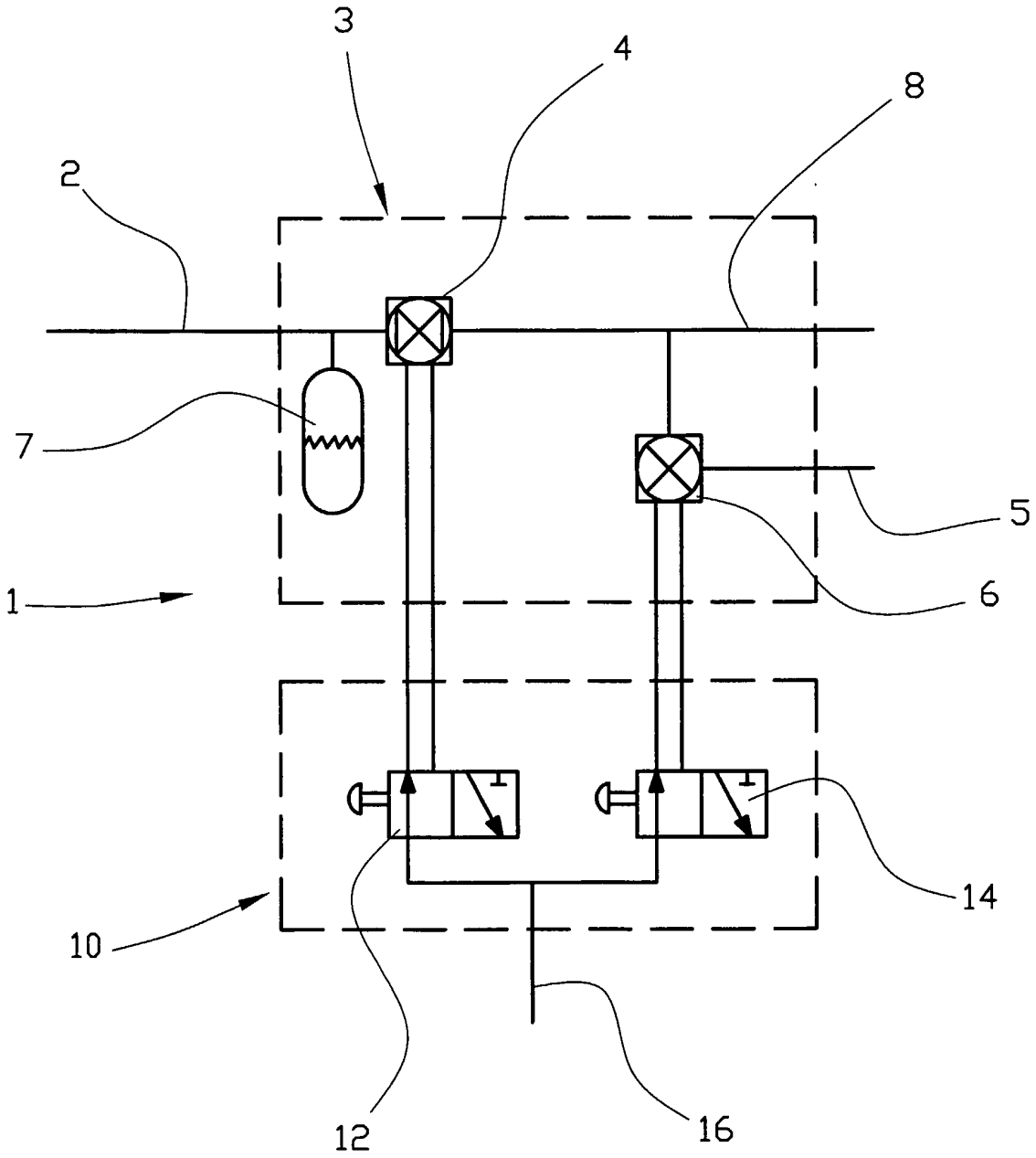


Fig. 1

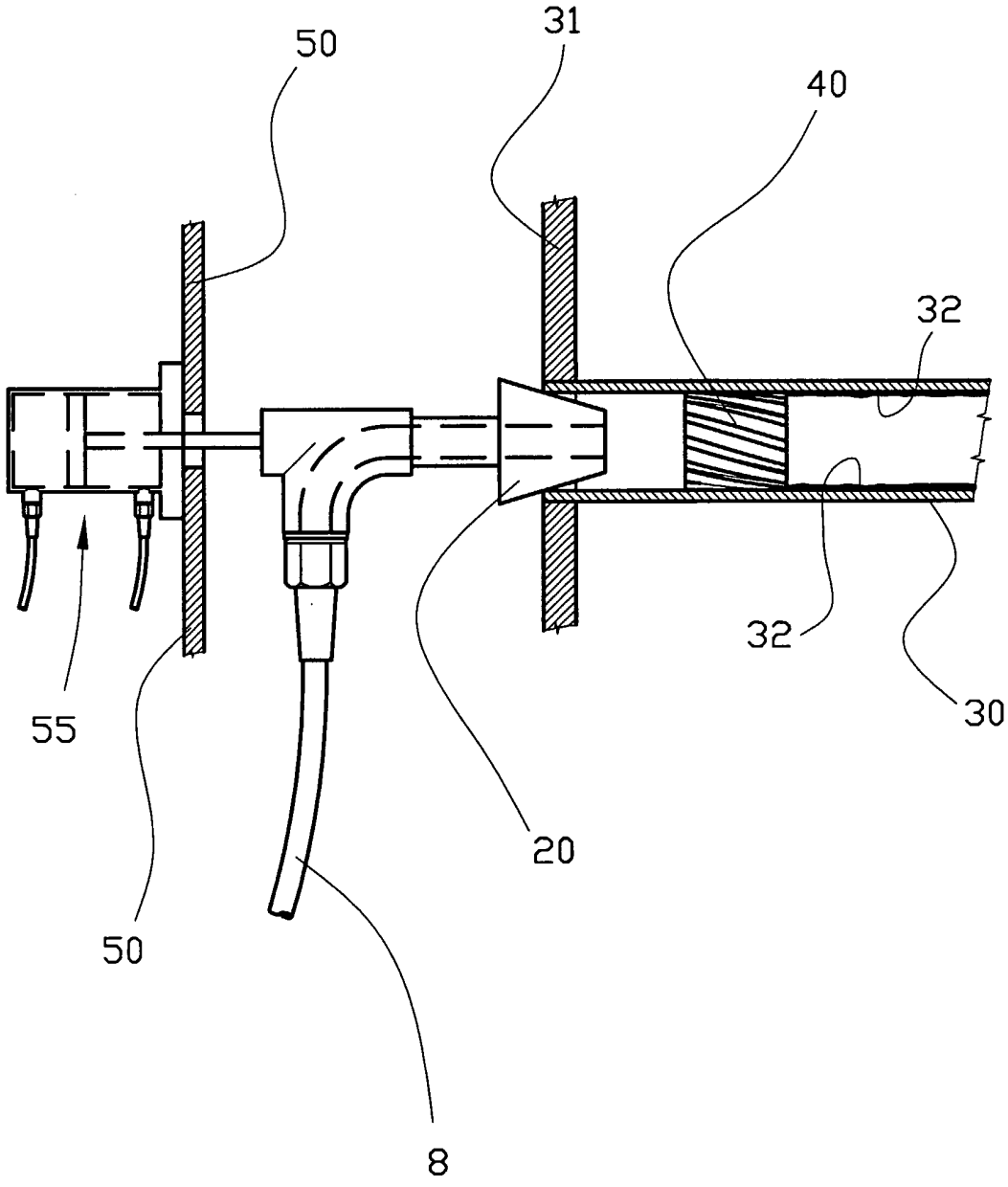


Fig. 2

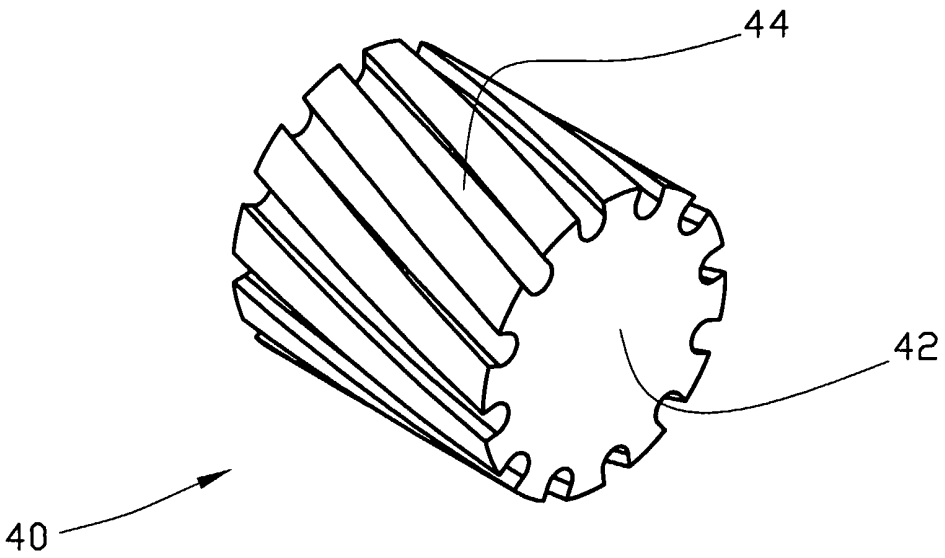


Fig. 3

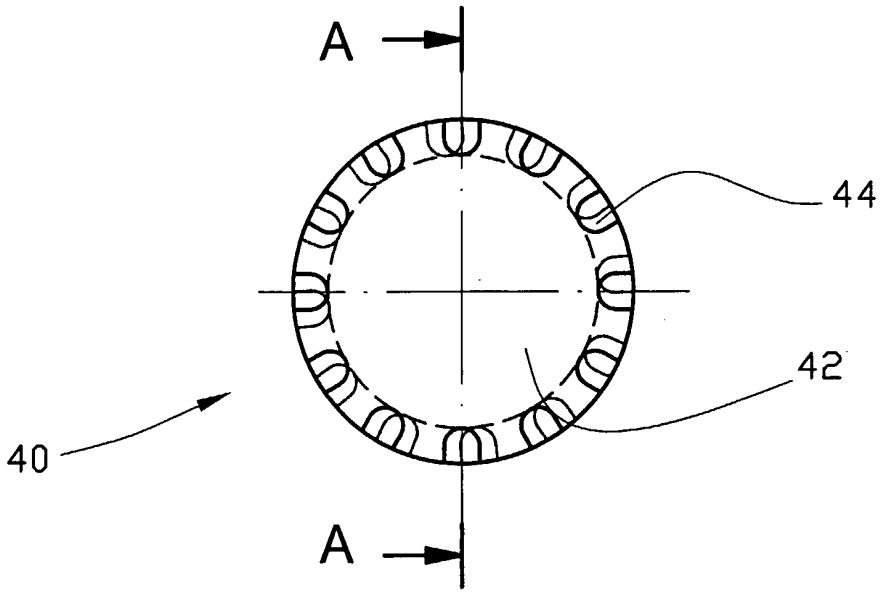


Fig. 4

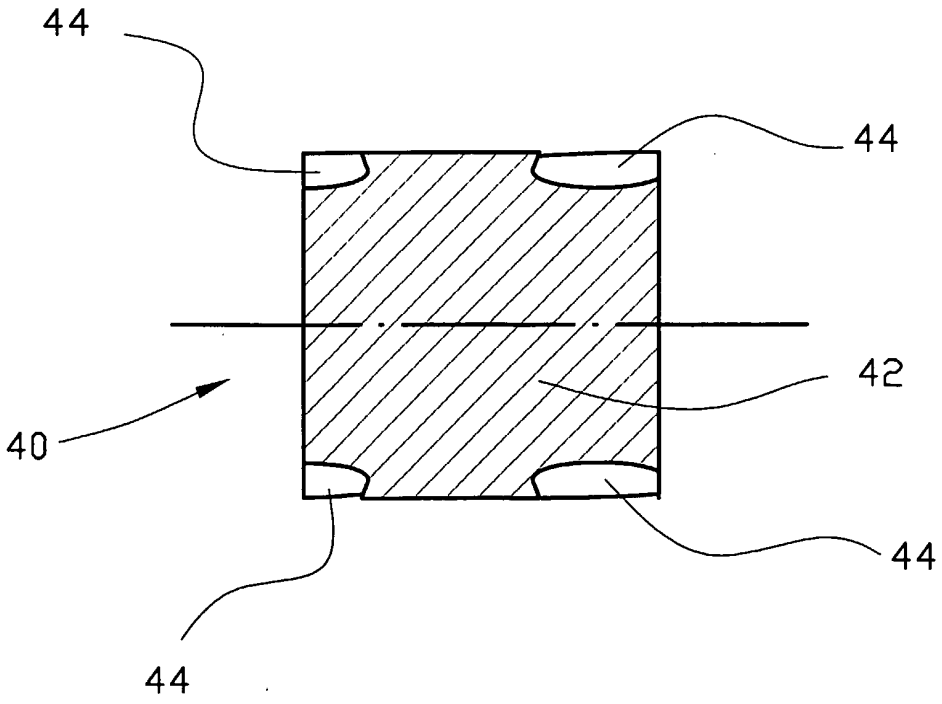


Fig. 5

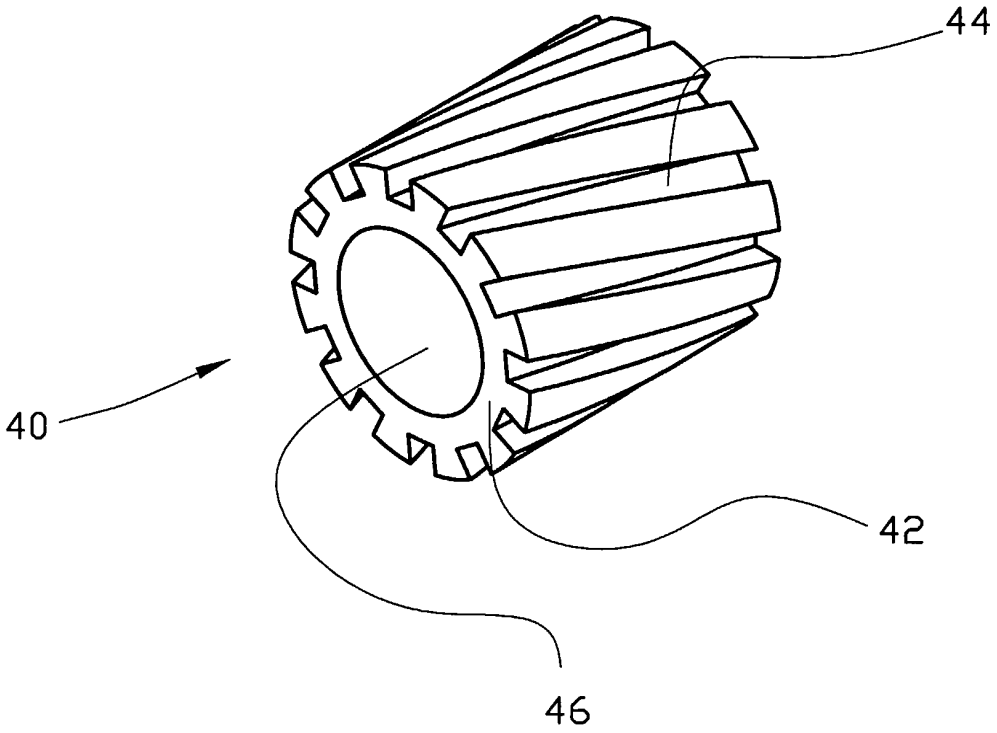


Fig. 6

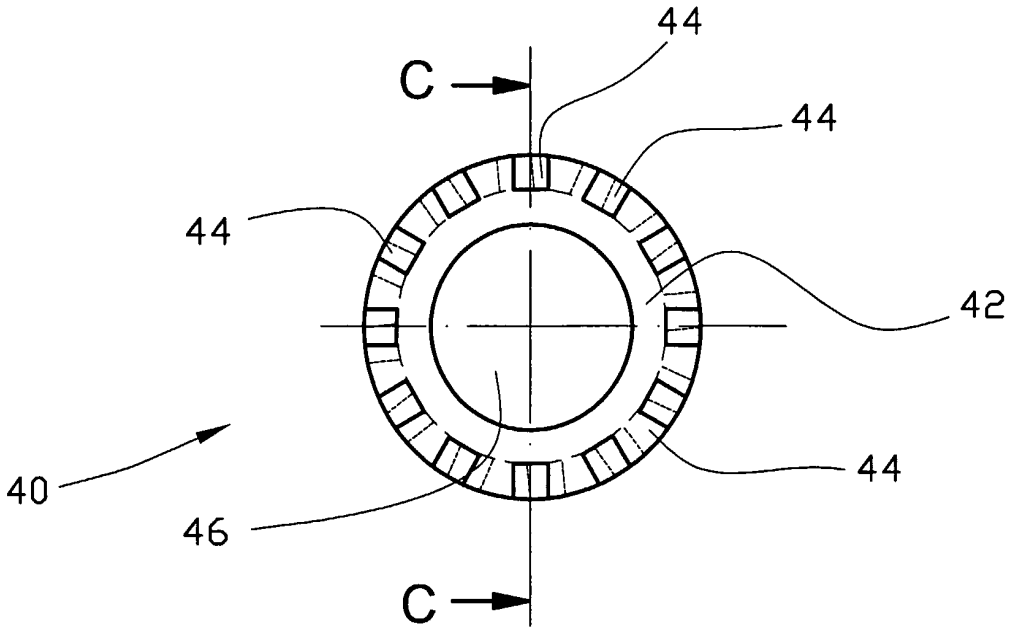


Fig. 7

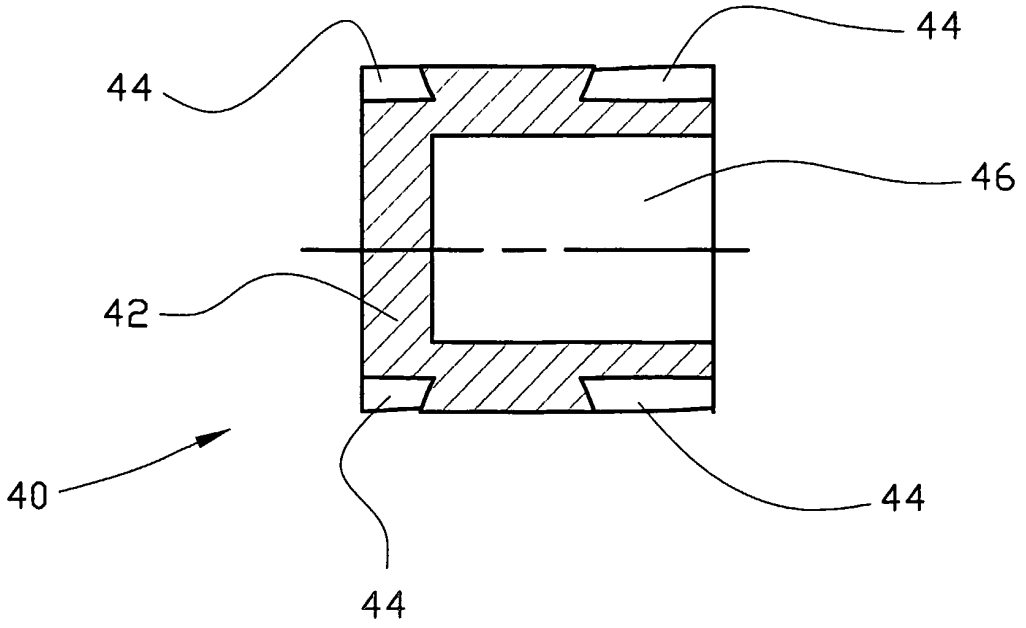


Fig. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 2004/000219

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: B08B 9/04, F16L 55/40
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)

IPC7: B08B, F28G, F16L

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

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 864544 A (PAUL KESSLER), 27 August 1907 (27.08.1907), page 1, column 2, line 103 - page 2, column 1, line 6, figure 1	1-2
	--	
X	US 4898197 A (BARRY ET AL), 6 February 1990 (06.02.1990), column 1, line 55 - line 60; column 3, line 39 - column 4, line 27, figure 3	1
A		6-9
	--	
X	US 4716611 A (BARRY), 5 January 1988 (05.01.1988), column 3, line 1 - line 29	1
	--	

☐ 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
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 December 2004	30 -12- 2004
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Anna Rapp / MRo Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (January 2004)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 2004/000219

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

As claim 1 is considered previously known, the application comprises two different inventions.
Invention I: Claims 2, 6-9
Pipe pig with helical grooves and method for cleaning with said pipe pig by means of cavitation.
Invention II: Claims 3-5
Pipe pig with at least one blind bore to reduce the pigs mass.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: 1-2, 6-9

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

US	864544	A	27/08/1907	NONE			
US	4898197	A	06/02/1990	AU	571845	B	28/04/1988
				AU	572181	B	05/05/1988
				AU	591031	A,B	23/11/1989
				AU	1816583	A	21/02/1985
				AU	3218784	A	29/03/1985
				BR	8407026	A	30/07/1985
				CA	1247310	A	27/12/1988
				DE	3477891	D	00/00/0000
				EP	0152439	A,B	28/08/1985
				SE	0152439	T3	
				JP	5057034	B	23/08/1993
				JP	61500060	T	16/01/1986
				KR	9208005	B	21/09/1992
				SU	1618277	A	30/12/1990
				US	4724007	A	09/02/1988
				WO	8500997	A	14/03/1985
US	4716611	A	05/01/1988	CA	1214004	A	18/11/1986