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(54) **Lubricant separation for compressor**

(57) An integrated system of gas - oil separation of compressed fluid for an oil-lubricated gaseous fluids compressor (1) comprising a motor unit (2), a compression unit (3) and an external cage (13) of the compression unit provided with a chamber for collection of the lubricating oil (17), wherein said gas - oil separation system comprises at least one separation stage consisting in the traversing of said oil collection chamber (17) by the compressed fluid; the invention relates to an oil-lubricated gaseous fluids compressor (1) provided with this system.

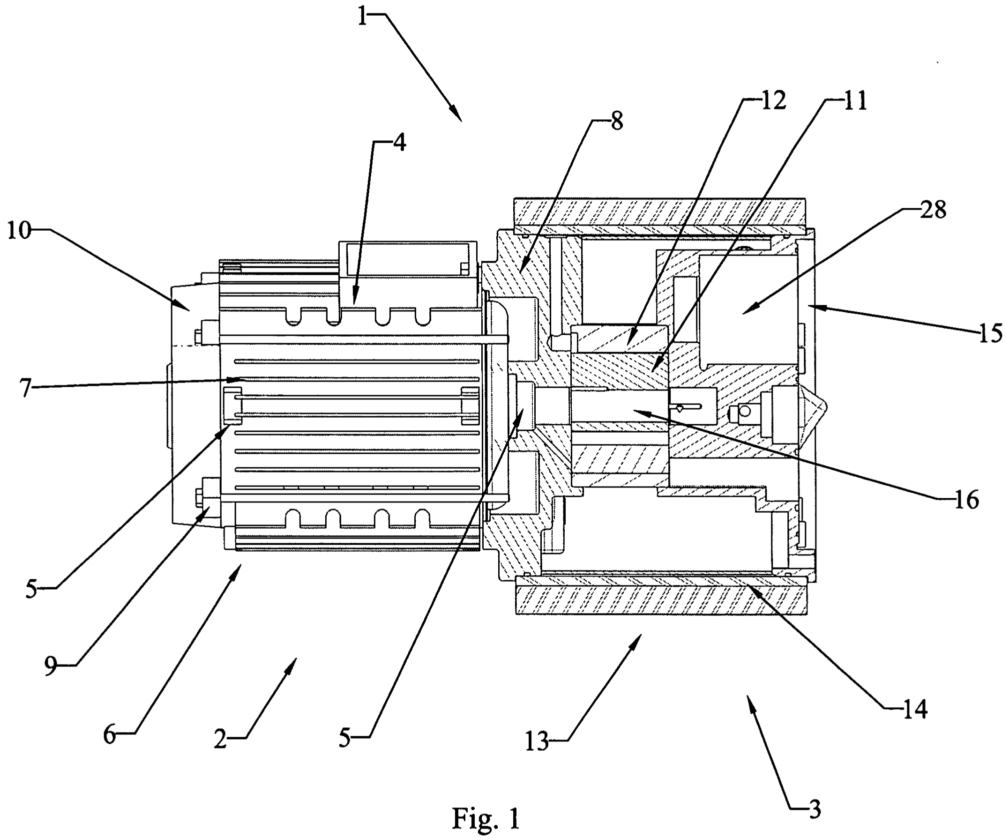

Fig. 1

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Description

[0001] The present invention relates particularly but not exclusively to compressors for elastic fluids with low viscosity such as air or gas, of the type lubricated with oil. More specifically a first aspect of the invention relates to a gas - oil separation system integrated in a compressor and a second aspect of the invention relates to a compressor of gaseous fluids provided with this system.

[0002] Air compressors have numerous applications, for example in industry or building, and the various requirements related to these areas of use have entailed the development of a range of extremely diversified products.

[0003] Rotary blade air compressors of the oil-lubricated type are known to the state of the art. These compressors have a motor unit, provided for example with an electric motor of variable power, which can be powered directly by the mains voltage or by a generator, and a compression unit, comprising a rotor placed inside a stator with whose internal walls it defines at least one chamber of compression for the air. The rotor is notoriously formed by a cylindrical body supported eccentrically inside the hollow stator, provided with angularly equidistant radial grooves inside whereof the same number of blades are mounted loosely. Through the effect of the centrifugal force these blades are pushed into contact with the internal wall of the stator, also generally with a cylindrical shape, thus dividing the at least one compression chamber of the compressor into various channels with progressively decreasing volume. The rotor of the compression unit is generally connected to the shaft of the motor by means for example of a flexible joint. The moving parts do not encounter contact friction thanks to an oil injection circuit which allows the formation and the maintaining of a thin film of oil between the moving parts, which avoids wear of the same and the phenomenon of seizure, at the same time ensuring perfect airtightness. The compression unit also comprises an external cage provided in particular with various channels for the circulation of air, a space for housing the stator and an oil collection chamber which, during operation of the compressor, transfers the oil upstream of the circuit and recovers the oil downstream of the same. At least one radiator, a fan for cooling, at least one part for separation of the air - oil mixture and if necessary a condensate separator are also connected to the compression unit.

[0004] The oil taken from the collection chamber is in fact injected into the compression chamber where it combines with the air, forming a mixture. The oil injection circuit not only allows the formation of said layer of oil between the moving parts but also contributes to cooling the air during compression, which otherwise would take place in a substantially isoentropic manner. The mixture formed in this way must therefore undergo a process of separation of its component air and liquid phases which in the current state of the art is generally carried out through several stages of separation in series. Among the separation systems adopted, that through centrifuging, through gravity decanting and through separation by means of a filter, for example in borosilicate fibres, known colloquially as "candle", are known. These systems however involve additional elements which, placed in series, considerably increase the overall dimensions of the compressor. Separation by centrifuging and that by gravity, moreover, do not allow very high separation factors to be achieved, and it is therefore necessary to finalise this separation by means of the so-called candle, a separation filter which is replaced periodically and which forms a fairly bulky external appendage of the compressor. The oil, once separated from the air, can be cooled by means of a radiator also placed outside of the compressor before being reused.

[0005] English patent application no. 2394007 describes an oil-tight rotary blade compressor which comprises a directly coupled motor unit and a compression unit, the latter oil lubricated. For this purpose in fact the shaft of the electric motor has an extension with such a length as to allow its insertion in the rotor of the compression unit, provided with a suitable central hole, via a flange of the compression unit. The direct coupling of the electric motor with the rotor of the compressor allows elimination of the flexible joint or another equivalent element of coupling, allowing greater compactness of the compressor. The device described is provided with a first oil separator of the centrifugal type and a second annular separator, which occupy a certain volume inside the compression unit.

[0006] European patent no. 0277583, in the name of the same Applicant, describes a rotary blade air compressor provided with means for the separation of the oil that comprise a labyrinth path inside the compressor, bordered by diaphragms and by radial fins placed on alternating planes of the oil chamber. This system of mechanical separation, wherein the pressurised air is demixed from the air through successive impacts against the walls that define said labyrinth, although being very efficient presupposes the presence of a certain volume inside the compressor occupied exclusively by this device, a volume which can only be reduced to the detriment of the factor of demixing or excessive load losses, which limit the effective ratio of compression that can be obtained.

[0007] The primary object of the present invention is that of providing a system for gas - oil separation for a compressor of gaseous fluids integrated in the compression unit, without the provision of internal volumes and outside elements additional thereto.

[0008] Another object of the present invention is that of providing a system for gas - oil separation integrated in a compressor of gaseous fluids with high demixing factor, yet at the same time with reduced overall dimensions thanks to the smaller number of its component parts.

[0009] The object of the present invention is likewise that of providing a system for gas - oil separation integrated in a compressor of gaseous fluids that can be made with a lower production cost in terms of times and raw materials, and at the same time provided with important requirements of quality, reliability and durability.

[0010] All these objects are achieved by the system of gas - oil separation of compressed fluid according to the present invention, for an oil-lubricated compressor of gaseous fluids comprising a motor unit, a compression unit and an external cage of the compression unit provided with a chamber for the collection of the lubricating oil, wherein said system for gas - oil separation of the compressed fluid comprises at least one stage of separation consisting in the traversing of said oil collection chamber by the compressed fluid.

[0011] Advantageously this system for separation of gas - oil of the compressed fluid is fully integrated in the compressor.

[0012] The system for gas - oil separation of the compressed fluid will preferably comprise means for conveying said compressed fluid into the oil collection chamber.

[0013] According to another aspect of the invention, an oil-lubricated compressor of gaseous fluids is provided, equipped with a motor unit and a compression unit which substantially comprises a rotor and a hollow stator whose internal walls define with said rotor at least one compression chamber, and an external cage provided with a chamber for collection of the lubricating oil, provided with an integrated system for gas - oil separation of the compressed fluid as disclosed above.

[0014] Further features and advantages of the present invention will be made clearer on reading the following detailed description of a preferred embodiment, given by way of a non-limiting example, whereto the drawings refer, in which:

Figure 1 is a sectioned side view of an air compressor according to the present invention;

Figure 2 is a sectioned side view of the compression unit of the compressor of Figure 1;

Figure 3a is a sectioned front view of the compression unit of Figure 2, with the detail of the motor side cover; and

Figure 3b is a sectioned front view of the compression unit of Figure 2, with the detail of the cover on the intake side of the body of the external cage.

[0015] Figure 1 is a sectioned side view of an air compressor provided with the system for gas - oil separation of the compressed fluid integrated according to the present invention. The air compressor 1 is of the rotary blade type and lubricated with oil, and is composed of the motor unit 2 coupled directly in a known manner to the compression unit 3.

[0016] The motor unit 2 comprises an electric motor 4 whose shaft, not shown in the drawing, rotates around the bearings or bushings 5. Said electric motor 4 is closed externally by a cylindrical body 6 provided with longitudinal fins 7 suitable for aiding cooling of the stator and rotor apparatuses of the electric motor 4. The cylindrical body 6 is closed at the rear by the cap 10, and at the front by the motor side cover 8 of the compression unit 3. Said cap 10 is screwed directly to the motor side cover 8 of the compression unit 3 by means of the tie-rods 9, so that the cylindrical body 6 remains closed on both the flat sides. A fan, not shown, is mounted in a known manner on an extension of the drive shaft on the side of the cap 10, also not shown, so as to provide adequate convective cooling for both the motor and compression units.

[0017] The compression unit 3, illustrated schematically in Figure 1, comprises in a known manner a rotor 11 and a stator 12, which define an air compression chamber, and an external cage 13. This external cage 13 is formed by a motor side cover 8, to which the aforementioned tie-rods 9 are screwed, by a side cylindrical body 14 integral with said motor side cover 8, these parts being made in a known manner in a single die-cast part, and by an intake side cover 15.

[0018] The rotating shaft of the electric motor 4 also has an extension 16 on the side of the compression unit 3 whereon the rotor 11 is keyed, so that the motor unit 2 and the compression unit 3 function through direct coupling.

[0019] Figure 2 is a sectioned side view of the compression unit 3 of the compressor 1 of Figure 1, wherein the path of the compressed fluid, after exiting the compression chamber, is indicated by means of arrows A, B and C and which we will explain in detail herein below. The compression unit 3 is lubricated with oil and has means for the injection and the collection of the same. In this respect the external cage 13 of the compression unit 3 is provided with a chamber for the collection of the oil 17, formed from an internal volume of said compression unit between the lower portion of the side cylindrical body 14, the space for housing the stator 18 of the intake side cover 15, the lower portion of the stator 12 and the motor side cover 8. This chamber 17 for the collection of the oil must maintain a virtually constant level of oil, which is continuously removed during operation of the compressor thanks to a difference in pressure which is created between the oil collection chamber 17, wherein there can be a working pressure of 10 bars, and the inlet of the compression chamber, not shown in the drawing, wherein the pressure is atmospheric pressure of approximately 1 bar. The oil also succeeds in lubricating the bushing 19 wherein the end portion of the extension 16 of the drive shaft rotates, since it is taken from the base of the chamber 17 by means of a special small tube, not shown, and is discharged through the small channel 20 formed in the intake side cover 15. The oil taken from the oil collection chamber 17 is injected by means of special injectors placed on the intake side cover, not shown, and is mixed in the compression chamber with the air aspirated from the compressor through the conduit and the intake valve, also not shown in the drawing. 6 litres of oil a minute are typically removed in this type of compressor and are mixed with 120 litres per minute of air removed by aspiration, at atmospheric pressure. In the compression chamber the oil creates a thin film which isolates the moving parts one from the other, preventing the phenomenon of seizure and limiting the dissipation of power due to dynamic friction. During compression the oil, due to the centrifugal motion of the rotor 11 and the increase in pressure, is mixed with the air to form a mixture, which exits from the compression chamber through the outlet manifold 21. The flow of compressed mixture rises up the vertical channel 22, formed in the motor side cover 8 through a radial hole, in the direction of arrows A in Figure 1 and, through a series of stages which we will explain herein below, is subjected to a process of separation of the liquid phase, the oil, from the gaseous phase, the air. This separation is necessary as the compressor has to feed user machines which in the majority of cases do not tolerate the presence of oil in the pressurised air. Advantageously the present invention provides a system for gas - oil separation of the compressed fluid fully integrated in the compression unit 3, separation which is organised in three stages whereof one is mechanical and two through coalescence.

[0020] The first stage of separation of the gas from the oil phase takes place through mechanical impact of the oil component of the pressurised mixture following at least one change in direction at a right angle of the out flow from the compression chamber. This change in direction of the mixture takes place at the outlet of the vertical channel 22, when said flow impacts against the internal wall of the upper portion of the side cylindrical body 14. As a result of this impact, most of the oil component present in the mixture adheres to the upper portion of said internal wall involved in the impact, and flows progressively downwards along the internal cylindrical wall until it reaches the collection chamber 17, as will be described in greater detail herein below. The second stage of separation of the air phase from the oil phase, the stage with greatest efficiency of separation, takes place through coalescence of the oil component still largely present in the mixture. The flow of compressed air mixed with oil is in fact divided into at least two opposite and substantially symmetrical flows, not visible in Figure 2, which flow from above downwards in a semicircular trajectory through the cylindrical gap 24 defined by the internal walls of the side cylindrical body 14 and the internal cylindrical shell 25. This gap serves to convey the flows of compressed air mixed with oil to the oil collection chamber 17. The cylindrical shell 25 is a cylindrical body positioned laterally to the external cage 13 and made in thin sheet metal or another suitable material. The cylindrical shell 25 is supported concentrically in relation to the side cylindrical body 14 by means of a circular groove 26 formed in the motor side cover 8, and a ring seal 27 in contact with the intake side cover 15 of the external cage 13. The lower portion of the cylindrical shell 25 also has a series of holes, suitable for allowing the passage of the compressed fluid. Since said lower portion of the cylindrical shell 25 is located below the level of oil in the oil collection chamber 17, when the flows of air move down symmetrical from above downwards through the cylindrical gap 24 to join up in the lower portion of this gap, the compressed fluid traverses the aforementioned holes there and flows into the oil contained in the collection chamber 17. The component of oil still present in the compressed mixture tends to aggregate through affinity with the oil of the collection chamber 17 in the direction of the arrows C in Figure 2, and the air which emerges there, represented by the arrows B, only contains a very low fraction of residual oil. This stage of separation has a very high efficiency and, as mentioned previously, does not entail the provision of any additional separation chamber, although exploiting the volume of the oil separation chamber 17. The cylindrical gap 24 is also formed by means of the insertion of the cylindrical shell 25 and does not entail any oversizing of the circumference of the side cylindrical body 14 of the external cage 13. The third and final stage of separation of the air phase from the oil phase takes place in a known manner through coalescence of the residual particles during the passage of the flow of compressed air through the separation filter 28 of Figure 1, not shown in Figure 2, and contained in the candle space formed in the intake side cover 15 of the external cage 13. Once the second stage of separation has been passed, the flow of air rises from below upwards in the direction of the arrows B in Figure 2 to enter the inlet manifold 29. From here the air traverses the aforementioned separation filter, referred to colloquially as "candle", and leaves the compression unit through the delivery conduit, not shown in Figure 2.

[0021] Figures 3a, 3b show a sectioned front view of the compression unit 3 of Figure 2, wherein the features of the motor side cover 8 and of the intake side cover 15 are shown respectively. In a known manner the compressor according to the present invention is provided with the cylindrical rotor 11 supported eccentrically inside the hollow stator 12, whose internal walls define with said rotor 11 the air compression chamber 30. The rotor 11 is provided with angularly equidistant radial grooves 31 which extend along the whole length of the rotor, wherein the same number of blades 32 are mounted loosely. These blades are pushed into contact with the internal wall of the stator so as to define channels for compression of the air with decreasing volume. The mixture, in the direction of the arrow A, leaves the outlet manifold 21 compressed, enters the vertical channel 22 as indicated by the arrow B and, impacting on the internal wall of the upper portion of the side cylindrical body 14, divides into at least two symmetrical flows after having performed the primary separation explained previously. The forced route of the compressed fluid which, through the cylindrical gap 24, allows said fluid to reach the oil collection chamber 17, is defined by the arrows C, D of Figure 3a. The air - oil separation system described within the sphere of the present invention also integrates within itself a system for cooling of the compressed fluid, as will be explained herein below. In flowing through the cylindrical gap 24, in fact, the two symmetrical flows exchange heat directly with the side cylindrical body 14, whose internal surface is washed from above downwards throughout its development. In order to facilitate this heat exchange and consequent cooling of the fluid, various rows of fins 33 are provided outside of the side cylindrical body 14, wherein the fins are placed parallel one to the other and have their plane parallel to the axis of said cylindrical body 14. These fins are in turn washed by the air moved by the fan placed on the cap 10 of the drive unit, as described previously. The compressed fluid, which is formed by air mixed with oil, is cooled simply and directly, without the provision of any radiator outside of the compressor. Advantageously both the air phase and the oil phase of the compressed fluid exchange heat at the same time, in such a way that by reaching a temperature lower than the oil collection chamber 17 the second stage of separation through coalescence, or secondary separation, takes place more efficiently. The air then rises up in the volume between the internal cylindrical shell 25 and the stator 12, in the direction of the arrows E of Figure 3b, and enters the inlet manifold 29 in the direction of the arrow F where it undergoes the final stage of separation of the air phase from the oil phase by means of the aforementioned candle, and then flows into the delivery conduit of the compressor.

[0022] In relation to Figure 3a, other advantageous features of the air compressor are shown according to the present invention. The direct coupling of the compression unit on the motor unit is achieved by means of the extension 16 of the drive shaft, whereon the rotor 11 is keyed. For this purpose the central hole of the rotor 11 and said extension 16 are provided with a longitudinal groove 34 with semicircular section, in such a way that the two adjacent grooves form a cylindrical space. Inside said cylindrical space a pin 35 is inserted by shape coupling, which makes the rotor 11 integral with the extension 16, preventing its relative sliding. Figure 3a shows raised external circular ribs 36 which define the spaces of the housings of the tie-rods which make the motor side cover 8 integral with the motor unit 2. Internal circular elements 37 can also be seen, suitable for allowing the screwing of other tie-rods, not shown in the drawings, which close the external cage 13 of the compression unit 3. Figure 3b, depicting the intake side cover 15, instead shows the raised internal circular ribs 38 which define the spaces for housings of the heads of said tie-rods which secure the intake side cover 15 integral with the side cylindrical body 14 to the motor side cover of the external cage of the compression unit, and the candle space 39 wherein the candle is housed, or separation filter, for the third separation stage. Advantageously the inlet manifold 29 and the candle space 39 are provided in the upper portion of the intake side cover 15. This technique prevents the foam, which is released from the oil during the phase of disabling of the compressor, from succeeding in invading the candle space 39, consequently wetting the filter.

[0023] It is clear how the gas - oil separation system is fully integrated in the compression unit of the air compressor and considerably simplifies the process of assembly of the compressor and its routine and non-scheduled maintenance. To an even more evident extent the system described allows a considerable reduction in the final volume of the machine. It is understood that the means for conveying the compressed fluid in the oil collection chamber can be different from those provided in the embodiment described. For example the outlet manifold can be positioned in the lower portion of the stator and be connected to a vertical channel flowing directly into the compression chamber, or on the base of the latter. It is also understood that the compressor according to the present invention, described here in detail as of the rotary blade type, could also be of the rotary screw type and also have two or more compression chambers, without the principles of operation described losing the special features claimed herein below.

Claims

1. A system for gas - oil separation of compressed fluid for an oil-lubricated compressor (1) of gaseous fluids comprising a motor unit (2), at least one compression unit (3) and an external cage (13) of the compression unit equipped with a chamber (17) for the collection of the lubricating oil, wherein said system for gas - oil separation of the compressed fluid comprises at least one stage of separation consisting in the traversing of said oil collection chamber (17) by the compressed fluid.

2. A system of gas - oil separation of compressed fluid according to claim 1, **characterised in that** this system is integrated in the compressor (3).

3. A system of gas - oil separation of compressed fluid according to claim 1, **characterised in that** it comprises means for conveying said compressed fluid into the oil collection chamber (17).

4. A system of gas - oil separation of compressed fluid according to the previous claims, **characterised in that** said means for conveying said compressed fluid into the oil collection chamber consist of at least one cylindrical gap (24) bordered by the internal walls of the side cylindrical body (14) of said external cage (13), said gap (24) serving to convey the compressed fluid to the oil collection chamber (17).

5. A system of gas - oil separation of compressed fluid according to the previous claims, **characterised in that** it comprises a stage of gas - oil separation through mechanical impact following at least one change in direction of the flow of compressed fluid,

which impacts for this purpose against the internal wall of the upper portion of the side cylindrical body (14) of the external cage (13).

6. A system of gas - oil separation of compressed fluid according to the previous claims, **characterised in that** in said cylindrical gap (24) the compressed fluid exchanges heat directly with the side cylindrical body (14), whose internal surface is washed from above downwards throughout its development.

7. A system of gas - oil separation of compressed fluid according to the previous claims, **characterised in that** at least one row of fins (33) is provided outside of the side cylindrical body (14) of the external cage (13) of the compressor (3).

8. A system of gas - oil separation of compressed fluid according to the previous claims, **characterised in that** a fan is mounted on said drive unit (2) to cool the motor unit (2) and the compression unit (3).

9. An oil-lubricated compressor of gaseous fluids, provided with a motor unit (2) and a compression unit (3) which substantially comprises a rotor (11) and a hollow stator (12) whose internal walls define with said rotor (11) at least one compression chamber, and an external cage (13) provided with a chamber (17) for collection of the lubricating oil, provided with a system of gas - oil separation of the compressed fluid according to claims 1 to 8.

10. An oil-lubricated compressor of gaseous fluids according to claim 9, **characterised in that** it comprises at least one cylindrical shell (25) positioned inside the external cage (13) and supported concentrically in relation to the side cylindrical body (14) of the external cage (13) of the compressor (3), said cylindrical shell (25) defining with the internal walls of said side cylindrical body (14) the cylindrical gap (24).

11. An oil-lubricated compressor of gaseous fluids according to the previous claims, wherein said lower portion of the cylindrical shell 25 is located below the level of oil in the oil collection chamber (17) and has means for the passage of the compressed fluid.

12. An oil-lubricated compressor of gaseous fluids according to the previous claims, wherein the pressurised fluid, in output from the compression chamber, flows into the vertical channel (22).

13. An oil-lubricated compressor of gaseous fluids according to claim 12, wherein said vertical channel (22) is formed in the motor side cover (8) through a radial hole.

14. An oil-lubricated compressor of gaseous fluids according to the previous claims, wherein the pressurised fluid at the outlet of the vertical channel (22) impacts against the internal wall of the upper portion of the side cylindrical body (14), performing the primary separation.

15. An oil-lubricated compressor of gaseous fluids according to the previous claims, wherein the flow of pressurised fluid at the outlet of the vertical channel (22) is divided into at least two opposite and substantially symmetrical flows which flow from above along a semicircular trajectory through the cylindrical gap (24).

16. An oil-lubricated compressor of gaseous fluids according to the previous claims, wherein said at least two opposite and substantially symmetrical flows of pressurised fluid join up in the lower portion of said gap (24), and there traverse said means for the passage of the compressed fluid, in such a way that said compressed fluid flows into the oil contained in the oil collection chamber (17), performing the secondary separation.

17. An oil-lubricated compressor of gaseous fluids according to the previous claims, **characterised in that** the intake side cover (15) of the external cage (13) is provided with an inlet manifold (29) and a candle space (39), positioned in the upper portion of said intake side cover.

18. An oil-lubricated compressor of gaseous fluids according to the previous claims, **characterised in that** the flow of air rises up from the oil collection chamber (17) in the volume between the cylindrical shell (25) and the stator (12), and enters the inlet manifold (29) for access to the candle space (39), where it undergoes the final stage of separation.

19. An oil-lubricated compressor of gaseous fluids according to the previous claims, **characterised in that** the candle space (39) is provided inside the external cage (13) of the compression unit (3).

20. An oil-lubricated compressor of gaseous fluids according to the previous claims, **characterised in that** the rotor (11) is of the blade type.

21. An oil-lubricated compressor of gaseous fluids according to claims 9 to 20, **characterised in that** the rotor is of the screw type.

22. An oil-lubricated compressor of gaseous fluids according to the previous claims, **characterised in that** the compression unit (3) is coupled directly to the motor unit (2).

23. An oil-lubricated compressor of gaseous fluids according to the previous claims, **characterised in that** said direct coupling of the compression unit (3) on the motor unit (2) is performed by means of the extension (16) of the drive shaft of the motor unit (2), whereon the rotor (11) of the compression unit (3) is keyed.

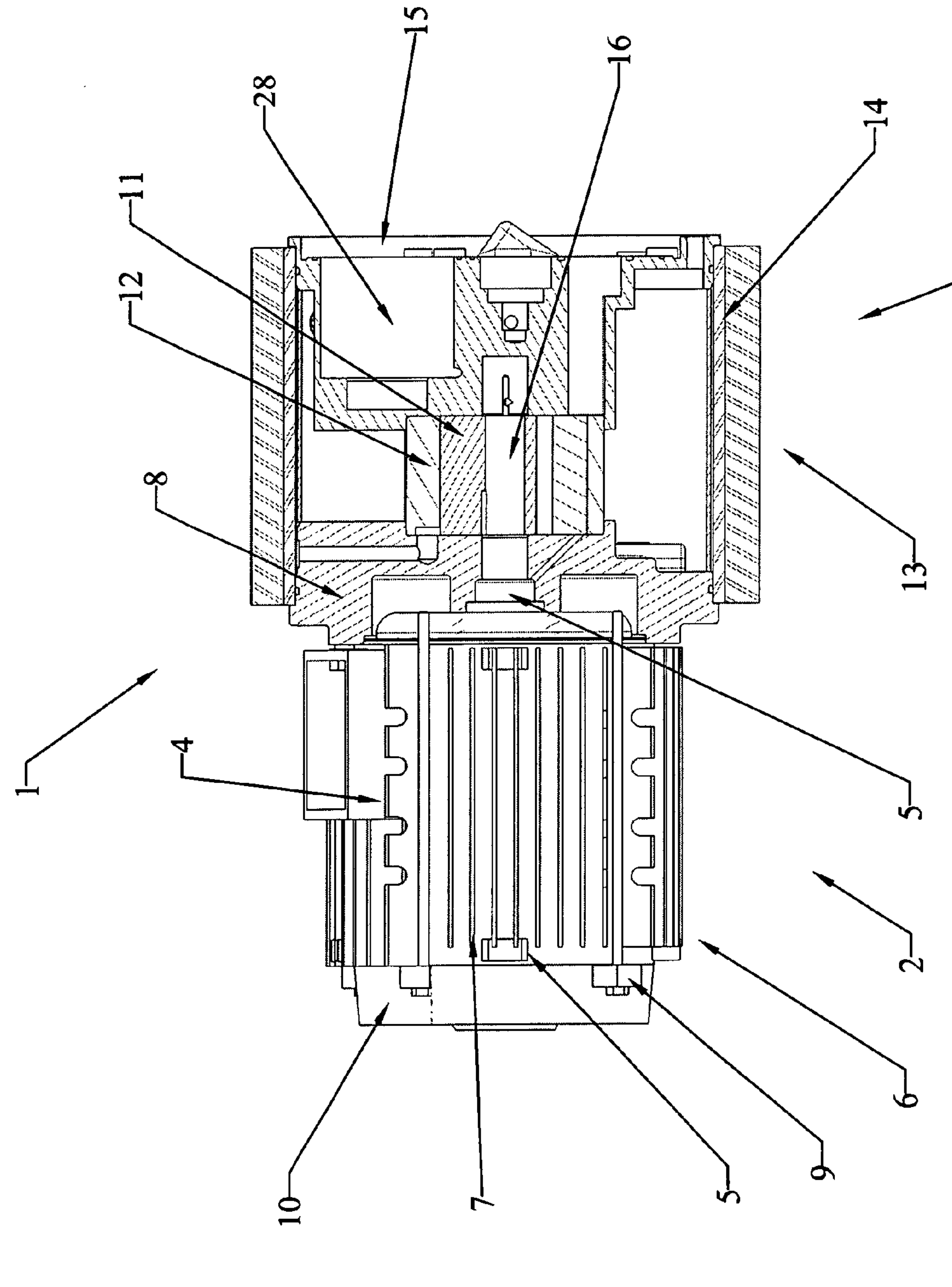

Fig. 1

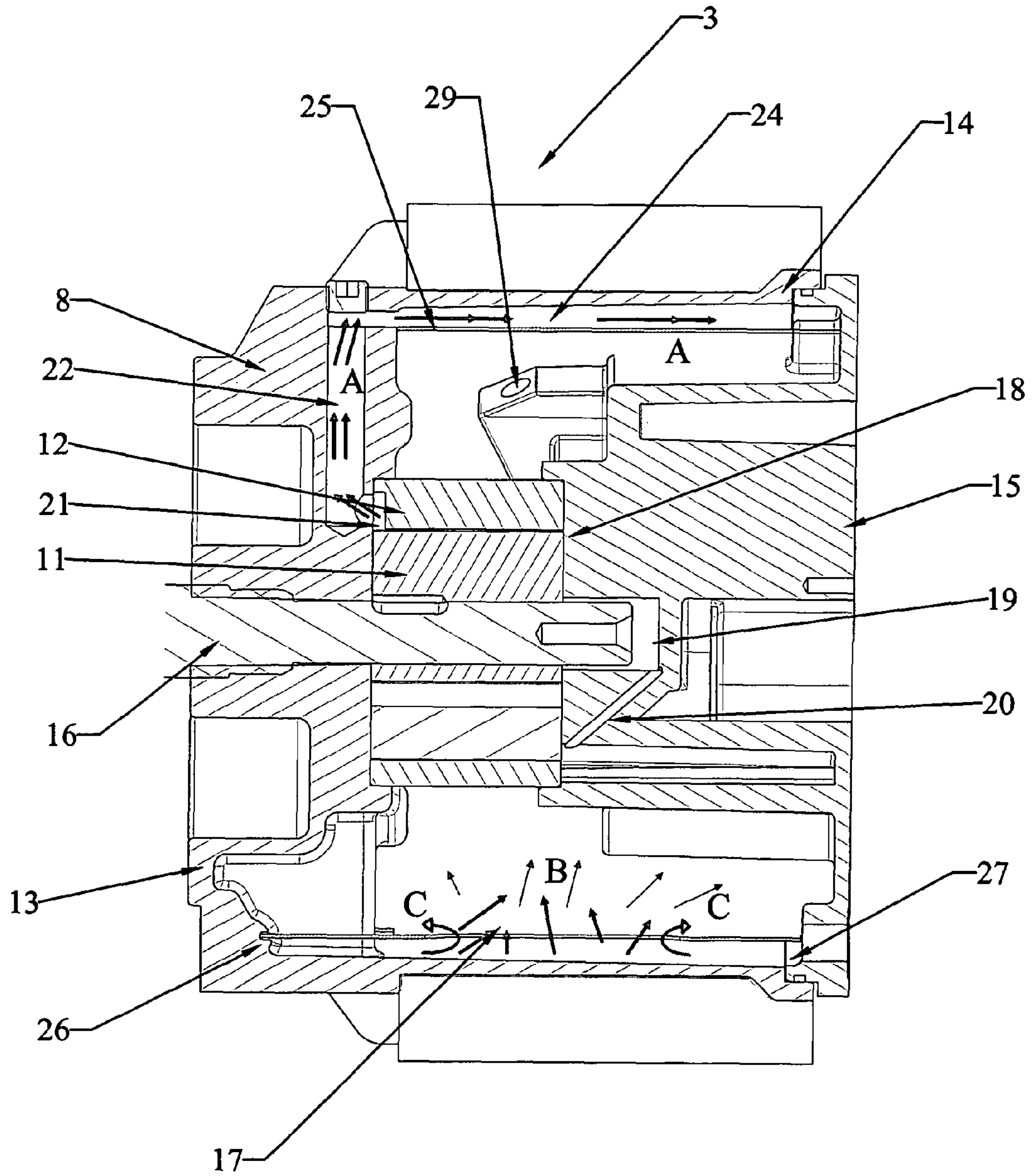

Fig. 2

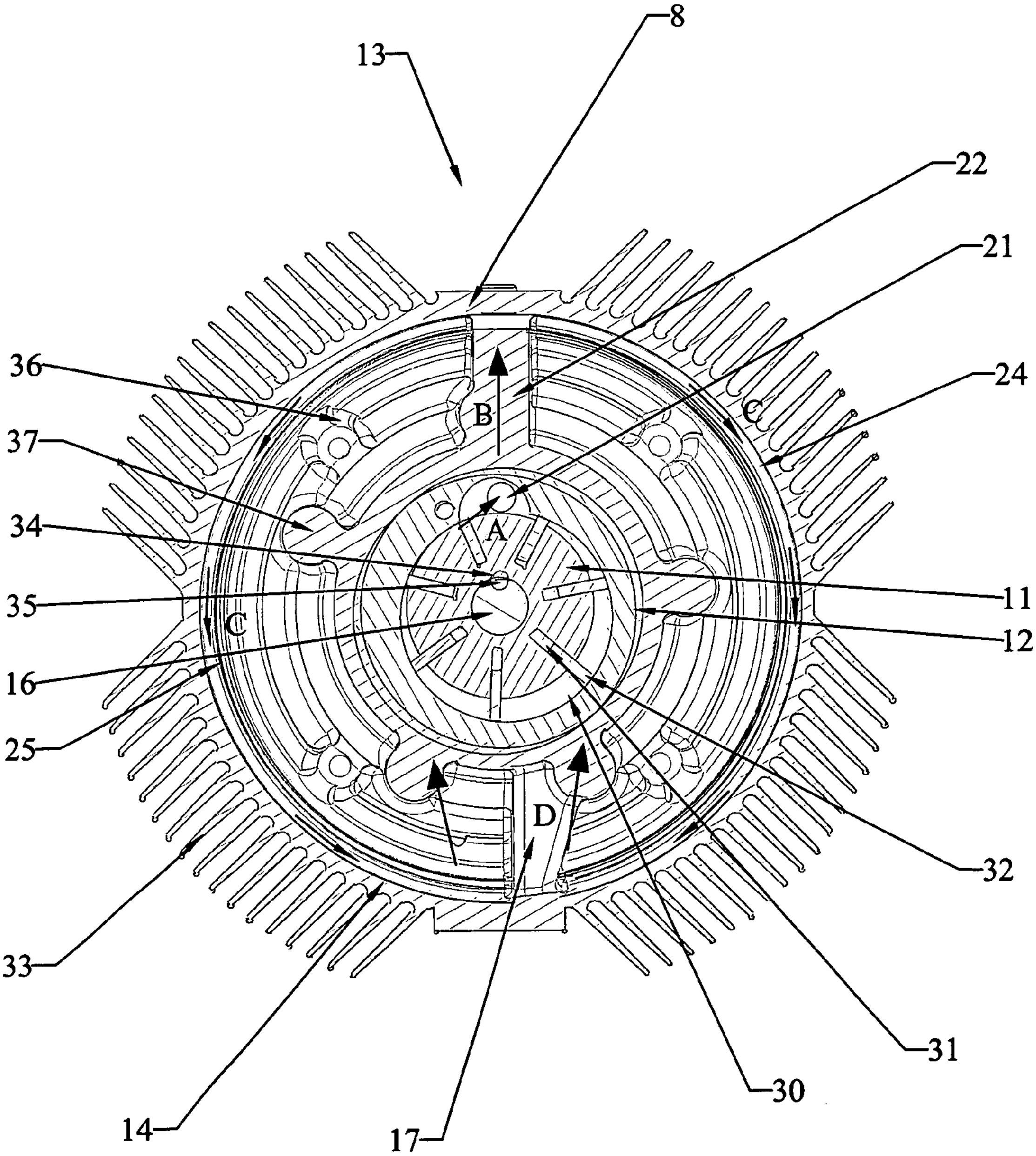

Fig. 3a

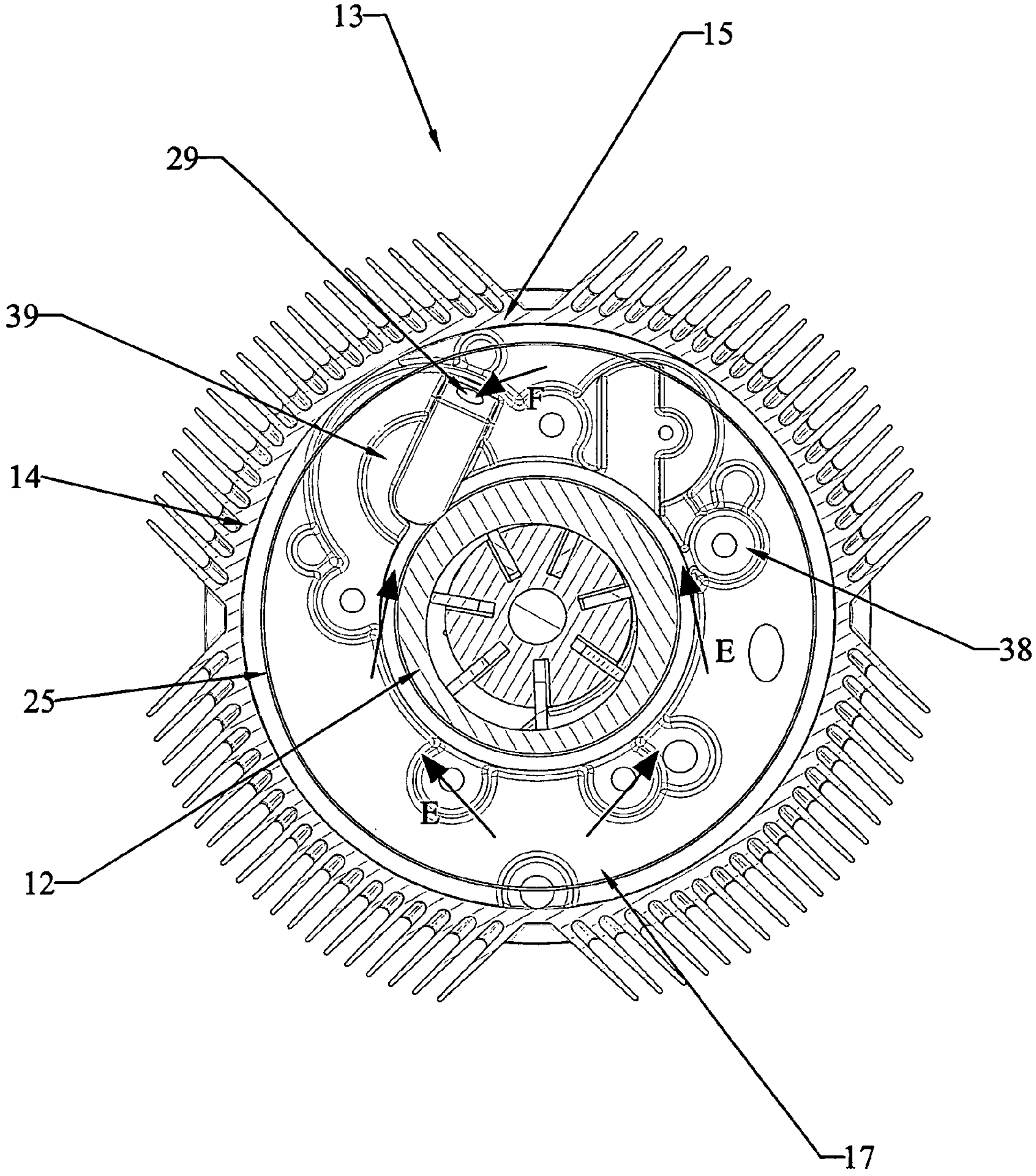

Fig. 3b

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 02 3545

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	GB 2 242 936 A (HYDROVANE COMPRESSOR [GB]) 16 October 1991 (1991-10-16) * the whole document *	1-3, 17-20	INV. F04C29/02
X Y	US 2 476 041 A (REYNOLD HAPPE ET AL) 12 July 1949 (1949-07-12) * figures 1,2,6 * * column 1, lines 5-13 * * column 2, lines 28-47 * * column 3, lines 46-58 *	1-3,7,8, 20,22,23 4-6, 11-16	
X	EP 0 459 116 A (LEYBOLD AG [DE]) 4 December 1991 (1991-12-04) * figures 1,2 * * column 2, lines 1-5 * * column 3, lines 4-10 *	1,2	
X Y	GB 448 167 A (BOSCH ROBERT) 3 June 1936 (1936-06-03) * figure 1 * * page 1, lines 62-68 *	1-3 4-6, 9-16,21	TECHNICAL FIELDS SEARCHED (IPC) F04C
Y A	US 4 091 638 A (MITCH GEORGE CHARLES) 30 May 1978 (1978-05-30) * figures 1,2,5 * * column 1, line 66 - column 2, line 24 * * column 3, lines 44-63 * * column 4, lines 13-19 *	4-6,9, 10,14 7	
Y	US 2 057 381 A (KENNEY MAHLON W ET AL) 13 October 1936 (1936-10-13) * figure 3 *	12,14,16	
Y	US 4 545 742 A (SCHAEFER DONALD D [US]) 8 October 1985 (1985-10-08) * figure 1 *	21	

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	6 March 2007	Biloen, David

3

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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Application Number
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DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	GB 2 081 383 A (HYDROVANE COMPRESSOR THE CO LT) 17 February 1982 (1982-02-17) * figure 1 * * page 1, lines 110-130 * * page 2, lines 30-35 * * page 2, lines 48-56 * -----	4-6, 17-19	

TECHNICAL FIELDS SEARCHED (IPC)

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 06 02 3545

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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06-03-2007

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
GB 2242936	A	16-10-1991	NONE			
US 2476041	A	12-07-1949	NONE			
EP 0459116	A	04-12-1991	DE	4017193	A1	05-12-1991
			JP	4231698	A	20-08-1992
			US	5145335	A	08-09-1992
GB 448167	A	03-06-1936	NONE			
US 4091638	A	30-05-1978	AU	509655	B2	22-05-1980
			AU	3099977	A	28-06-1979
			CA	1062483	A1	18-09-1979
			DE	2754476	A1	15-06-1978
			FR	2373695	A1	07-07-1978
			GB	1560438	A	06-02-1980
			JP	53075513	A	05-07-1978
			MX	145354	A	27-01-1982
US 2057381	A	13-10-1936	NONE			
US 4545742	A	08-10-1985	NONE			
GB 2081383	A	17-02-1982	DE	3162800	D1	26-04-1984
			EP	0057198	A1	11-08-1982
			ES	8205959	A1	01-11-1982
			WO	8200500	A1	18-02-1982
			IT	1142786	B	15-10-1986

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REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- EP 0277583 A **[0006]**