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LUCCHI

(54) **AIR COMPRESSOR UNIT**

(71) Applicant: **F.I.A.C. S.p.A.**, Sasso Marconi (Bologna) (IT)

(72) Inventor: **Fabio LUCCHI**, Fr. Pontecchio - Sasso Marconi (Bologna) (IT)

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(57) **ABSTRACT**

A volumetric reciprocating compressor comprises an air compressing unit equipped with a plurality of cylinders adapted to receive reciprocating pistons, a motor for driving the compressing unit and having a shaft which rotates about a respective axis of rotation, a cooling unit comprising a fan assembly driven by the rotating shaft to produce an air flow for cooling the compressed air in the unit, the cylinders being located inside an axisymmetric housing casing and being angularly spaced from each other.

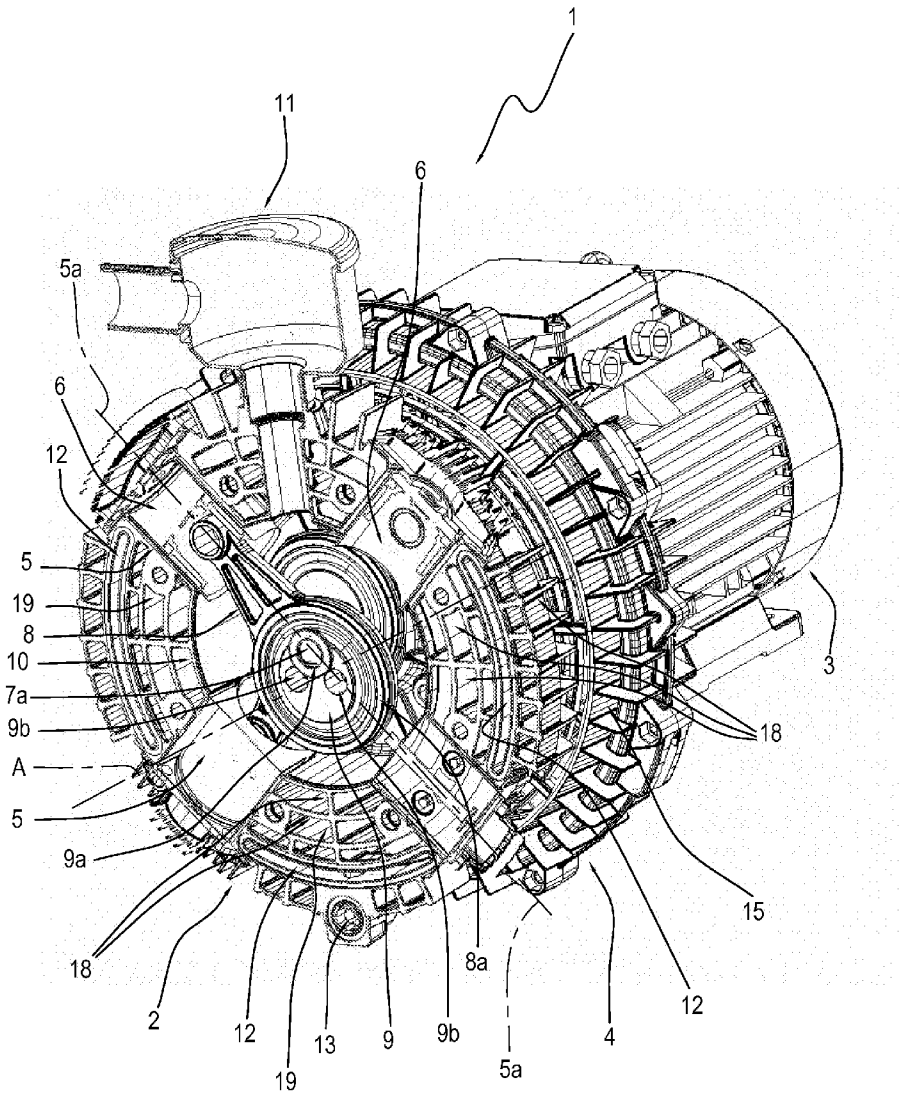


FIG.1

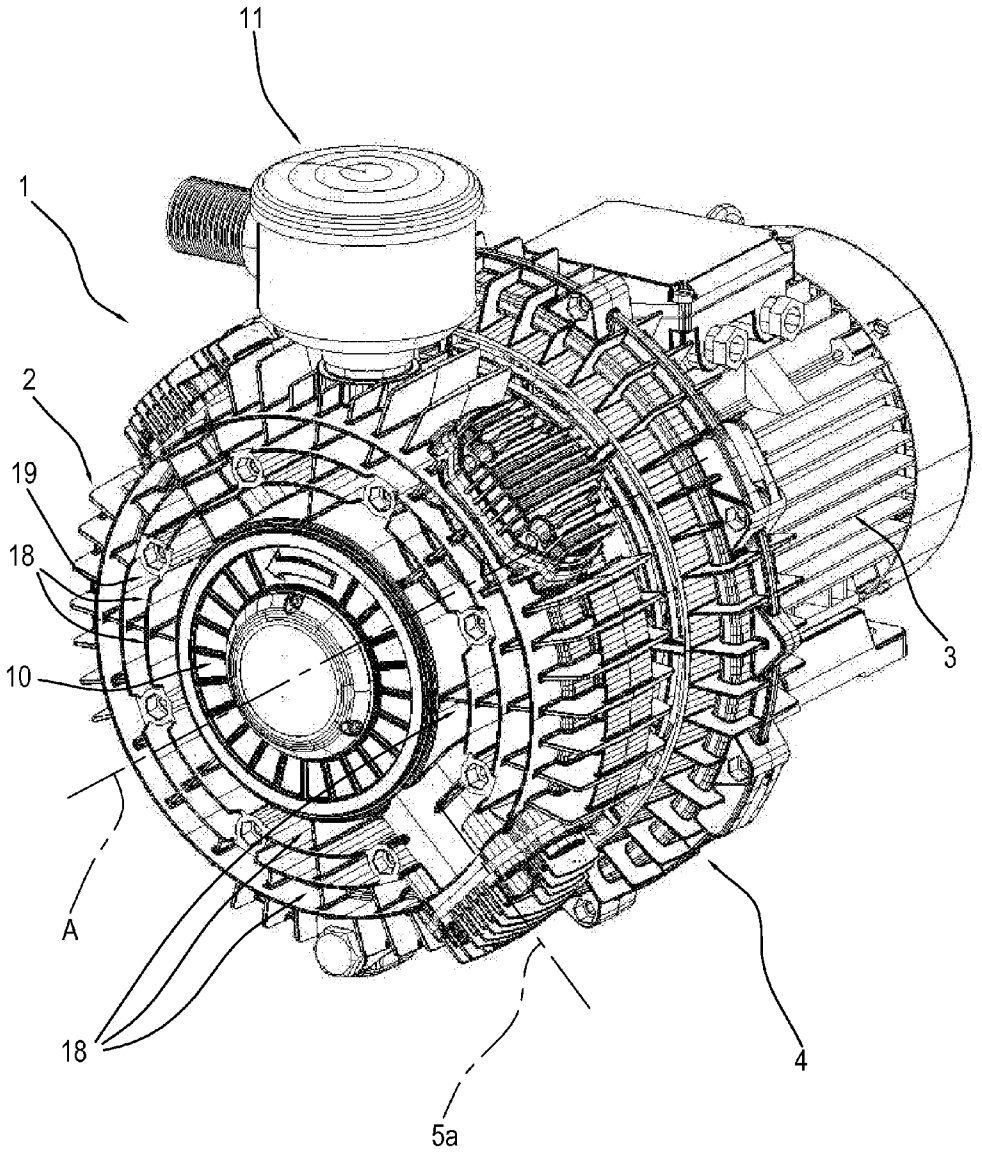


FIG.2

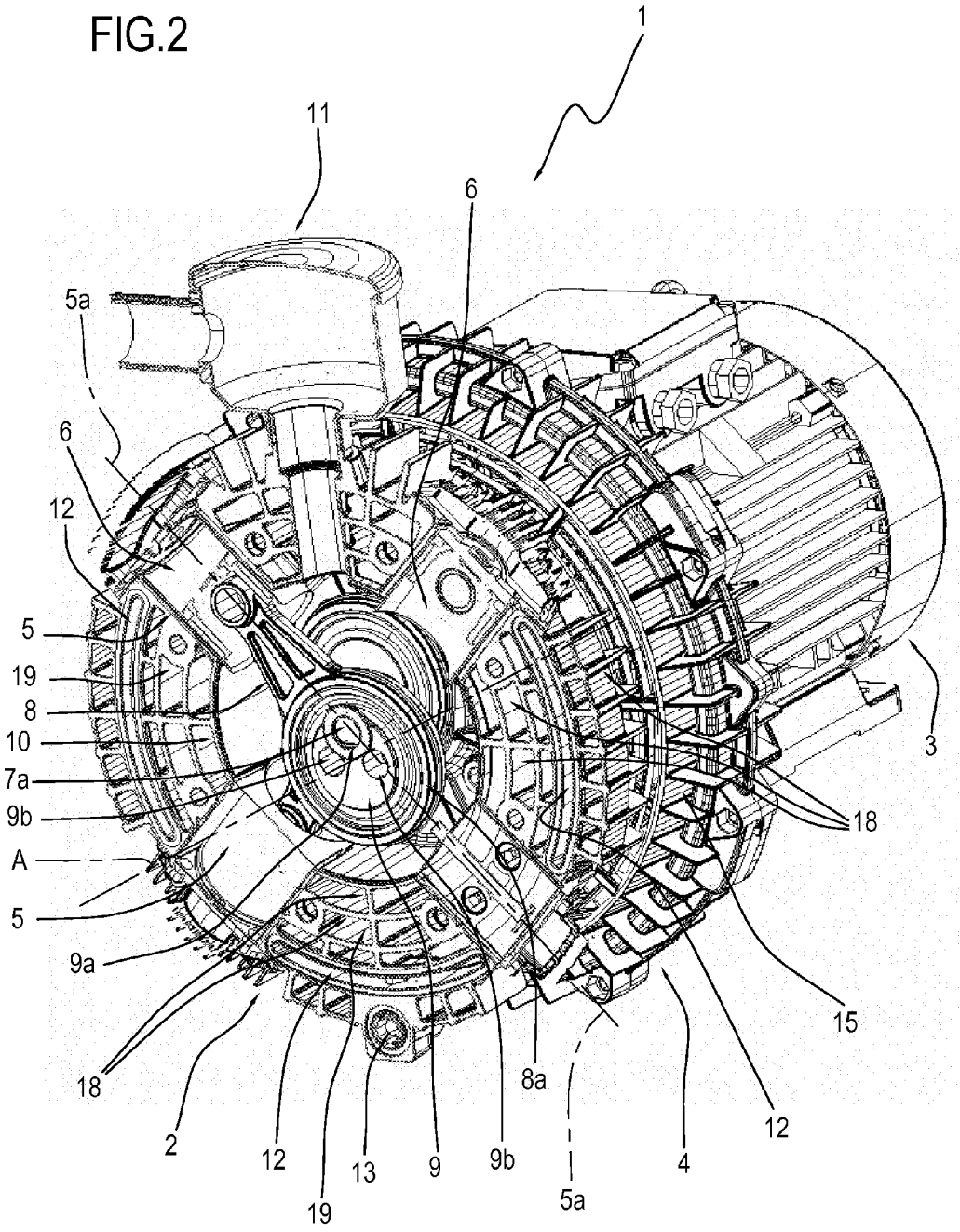


FIG.3

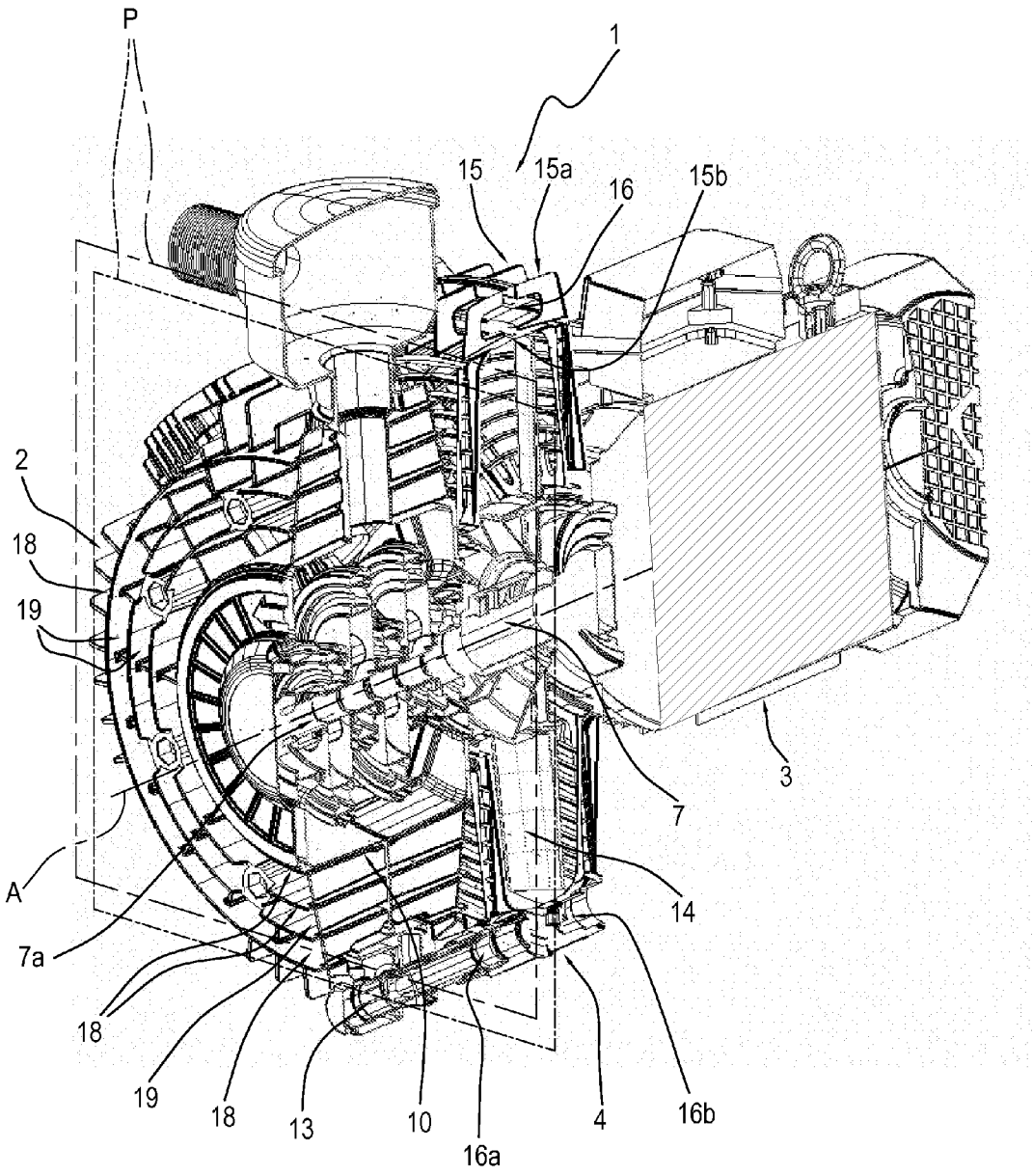
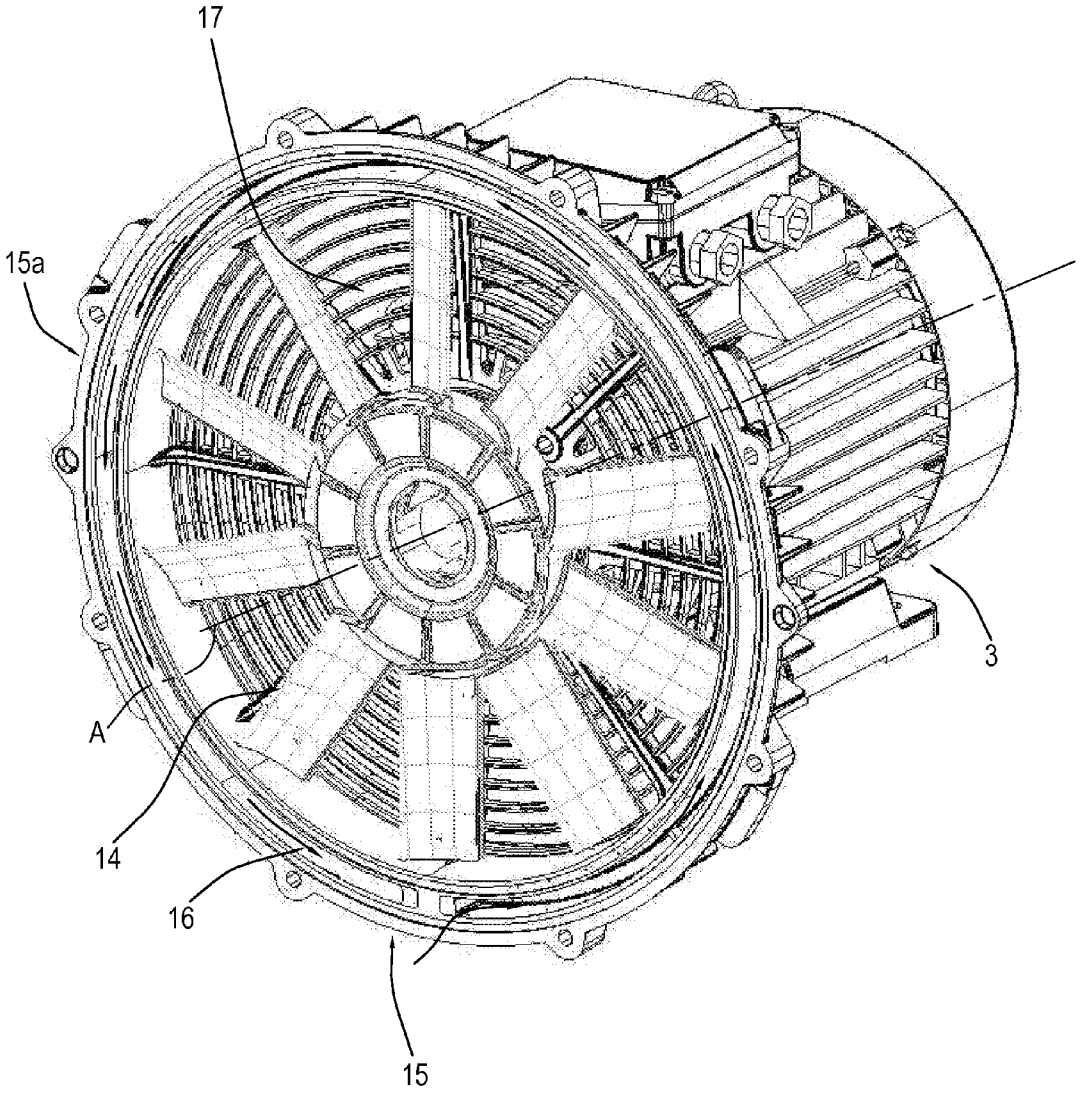


FIG.4



AIR COMPRESSOR UNIT

[0001] This application claims priority to Italian Patent Application BO2012A000308 filed Jun. 5, 2012, the entirety of which is incorporated by reference herein.

BACKGROUND OF THE INVENTION

[0002] This invention relates to an air compressor unit.

[0003] More specifically, the invention relates to a volumetric reciprocating air compressor.

[0004] The air compressor unit of the invention can be used in any situation where a supply of compressed air is required.

[0005] in many technical activities, pneumatic tools are used because they are very practical and robust. Such activities include, for example, the application of rivets in metal sheeting and nails in wood, and the loosening and tightening of vehicle wheel bolts.

[0006] Especially in professional applications, tools of his kind are required to attain higher and higher performance levels.

[0007] Obviously, increasing the performance level normally corresponds to an increase in the overall dimensions of the tools and of the compressor units which drive them.

[0008] In this regard, in recent years, the design of volumetric compressors has more and more regarded the development of multi-cylinder configurations which, as the term implies, involve a plurality of cylinders whose purpose is normally that of increasing the total cylinder capacity of the compressor unit but which might also be that of obtaining high pressure values (multi-stage compressors).

[0009] The development of multi-cylinder configurations essentially translates as production of compressors which are somewhat cumbersome and which have complex parts for coordinating the operation of the multiple cylinders.

[0010] Known in the prior art, for example, are "star" type solutions comprising a main con rod (also known as master con rod) and a plurality of secondary con rods for driving the other cylinders and pivoted to the main con rod.

[0011] Compressors of this kind are considerably complicated in construction and require high precision machining and assembling of components, with extremely tight tolerances.

[0012] Moreover, the increased number of cylinders has given rise to problems, as yet unsolved, in cooling the cylinders and the air supplied by them.

[0013] In other words, the main drawbacks of prior art multi-cylinder compressors are due to their constructional complexity and the size and weight of their mechanical components. This complexity involves high production costs which constitute a further drawback of the prior art compressors.

SUMMARY OF THE INVENTION

[0014] This invention therefore has for an aim to overcome the above mentioned drawbacks by providing a compact, high-efficiency multi-cylinder air compressor unit.

[0015] A further aim of the invention is to provide an air compressor unit which is easy to make and practical to maintain.

[0016] A further aim of the invention is to provide a compressor unit with an effective system for cooling the compressed air supplied to the tank and/or to the users.

[0017] The technical features of the invention, with reference to the above aims, can be easily inferred from the appended claims, in particular claim **1**, and preferably any of the claims that depend, either directly or indirectly, on claim **1**.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] Further, the advantages of the invention will become more apparent from the detailed description which follows, with reference to the accompanying drawings which illustrate a preferred, non-limiting example embodiment of it and in which:

[0019] FIG. **1** is a perspective view from above, with some parts cut away for clarity, of a preferred embodiment of the compressor unit according to the invention;

[0020] FIG. **2** is a perspective view from above of the compressor unit of FIG. **1**, with some parts cut away for clarity and others in cross section through a plane perpendicular to the axis of rotation of the motor which drives the compressor unit itself;

[0021] FIG. **3** is a perspective view from above of the compressor unit of the preceding figures, with some parts cut away for clarity and others in cross section through a plane at right angles to the section plane of FIG. **2** and parallel to the axis of rotation of the motor which drives the compressor unit itself;

[0022] FIG. **4** illustrates a detail of the compressor unit of FIGS. **1** and **2**, with some parts in cross section through a plane parallel to the section plane of FIG. **2**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0023] In the accompanying drawings, the reference numeral **1** denotes a volumetric reciprocating compressor for compressing air for use preferably by pneumatic tools.

[0024] As clearly illustrated in FIGS. **1** and **2**, the compressor **1** comprises an air compressing unit **2**, a motor **3** for driving the compressing unit **2** and a cooling unit **4** by which the compressed air from the unit **2** is cooled.

[0025] As illustrated in FIGS. **2** and **3**, the air compressing unit **2** comprises a plurality of cylinders **5** (four in the embodiment illustrated), within which respective reciprocating pistons **6** are received.

[0026] The motor **3**, which is advantageously an electric motor, has a shaft **7** which rotates about a respective axis of rotation A.

[0027] As described in detail below, the rotating shaft **7** protruding from the motor **3** drives both the cooling unit **4** and the compressing unit **2**.

[0028] Each piston **6** is kinematically connected to the shaft **7** by a respective con rod **8** and a crank lever member **9**.

[0029] The crank lever member **9** is circular in shape and is housed freely rotatably in an annular portion **8***a* of the con rod **8** defining the small end of the con rod itself.

[0030] The crank lever member **9** has a hole **9***a* which is shaped to match a flattened portion **7***a* of the shaft **7** in order to define, together with the shaft **7** itself, a shape fit for transmitting a torque moment from the motor **3** to the compressing unit **2**.

[0031] In other words, the shape fit between each crank lever member **9** and the rotating shaft **7** allows the crank lever member **9** itself to rotate as one with the shaft **7**.

[0032] The hole **9***a* is eccentric relative to the crank lever member so that a complete rotation of the shaft **7** causes the piston **6** to perform a complete intake-compression cycle.

[0033] In other words, the eccentricity of the hole **9***a* relative to the centre of the circle defined by the crank lever member **9** determines the stroke of the piston **6**, that is to say, the distance between its top dead centre and its bottom dead centre.

[0034] Advantageously, the crank lever member **9** has other holes **9***b* in it, in order to lighten it.

[0035] As illustrated in FIGS. **1** to **3**, the cylinders **5** are mounted inside a housing casing **10** which is axisymmetric in shape and whose axis coincides with the axis of rotation A of the motor.

[0036] The cylinders **5** are angularly spaced from each other, relative to an observer positioned along the axis of rotation A of the rotating shaft **7**.

[0037] Advantageously, the cylinders **5** are angularly equispaced from each other.

[0038] The cylinders **5** have respective central axes **5***a* which lie in respective planes P which are parallel to each other and perpendicular to the axis of rotation A of the rotating shaft **7**.

[0039] Advantageously, the fact that the cylinders **5** are distributed both along the axis A and radially means that the casing **10** can be made compact in order to save space.

[0040] As illustrated in the accompanying drawings, a housing container **11** extends from the periphery of the casing **10**, the container **11** housing a filter (not illustrated) and also defining an inlet opening for allowing air into the compressing unit **2**.

[0041] In alternative variant embodiments of the compressor according to the invention which are not illustrated, the container **11** is mounted in a central position relative to the casing **10**, substantially concentrically with the axis of rotation A of the shaft **7**.

[0042] Each cylinder **5** and its respective piston **6** also comprise valve means, of known type and not further described, designed to allow air intake into the cylinder **5**, to compress the air and to discharge it from the cylinder.

[0043] Also formed in the casing **10** is a plurality of ducts **12**, partly visible in FIG. **2** and designed to allow the air fed into the unit **2** to pass from the cylinders **5** towards a common discharge manifold **13**.

[0044] The discharge manifold **13** is formed in the casing **10** and communicates with the air cooling unit **4** to transfer to the unit **4** the air which has been compressed in the unit **2**.

[0045] The cooling unit **4** defines, for the compressor **1**, respective means for cooling the air which has been compressed in the compressing unit **2**.

[0046] In effect, during compression, the air undergoes heating and before it can be used safely and effectively, must normally be cooled to a temperature as near as possible to ambient temperature.

[0047] As illustrated in FIGS. **3** and **4**, the cooling unit **4** comprises a fan assembly **14** such as the fan illustrated in these drawings.

[0048] The fan assembly **14** is keyed to the shaft **7** which drives it o ion order to produce an air flow directed towards the air compressing unit **2**.

[0049] The cooling unit **4** also comprises an element **15** for containing the fan assembly **14**, the element **15** having an axisymmetrical configuration and extending coaxially with the axis of rotation A of the motor **3**.

[0050] The cooling unit **4** and, in particular, the containing element **15**, is interposed between the air compressing unit **2** and the drive motor **3**.

[0051] This configuration advantageously enables a compact, efficient compressor to be obtained.

[0052] As illustrated in FIG. **3**, formed in the containing element **15** there is a duct **1** for cooling the compressed air discharged from the air compressing unit **2**.

[0053] Advantageously, in the preferred embodiment illustrated in the accompanying drawings, the containing element **15** is made in two halves **15***a*, **15***b* coupled to each other. More specifically, formed on the periphery of each of the two halves **15***a*, **15***b* there is an annular cavity (labelled **16** in FIG. **4**) and, when the two halves are coupled to each other, the two cavities face each other in such a way as to define the cooling duct **16**.

[0054] The cooling duct **16** is substantially annular in shape, extends along, the periphery of the containing element and has an inlet opening **16***a* and an outlet opening **16***b*.

[0055] This arrangement along the periphery advantageously allows the airflow path within the compressor **1** to be maximized without necessitating external cooling pipes,

[0056] With reference to FIG. **4** which, however, shows only one **15***a* of the two halves **15***a*, **15***b* of the containing element **15**, each of the halves **15***a*, **15***b* has a respective wall **17** transversal to the axis A and substantially reticulated, that is to say, having a plurality of openings.

[0057] These openings are designed to allow the passage of the air flow produced by the fan assembly **14** and used, for cooling both the compressed air and the compressing unit **2**.

[0058] The two transversal walls **17** are located on opposite sides of the fan assembly **14**.

[0059] As illustrated in the FIGS. **1** to **3**, the casing **10** containing the cylinders has a plurality of cooling fins **18** defining multiple channels **19** through which the cooling air flow produced by the fan assembly **14** passes.

[0060] In practice, the channels **19** essentially extend between the cylinders **5**, parallel to the axis A, and allow the air flow produced by the assembly **14** to flow into them, the flow being suitably divided between the multiplicity of channels and by coming into contact with the fins **18** provide the required cooling effect on the unit **2**.

[0061] In use, during a normal operating cycle of the compressor **1**, for example to supply compressed air to one or more pneumatic tools, not illustrated, the compressing unit **2**, driven by the electric motor **3**, compresses the air inside its cylinders **5**.

[0062] The air is taken into the casing **10** through the container **1** of he filter (not illustrated) and from here is distributed between all the cylinders **5**.

[0063] More specifically, the air is taken into a central zone of the casing **10** and, by means of respective valves (not illustrated) advantageously mounted on the piston head **6**, flows into the compression chamber of the cylinder **5**.

[0064] Air flow into the compression chamber occurs during the downstroke of the piston **6**, that is, during the intake stroke.

[0065] The air is then compressed, discharged from the head of the cylinder **5** through further valve means of known type and not illustrated, and flows into the ducts **12** formed in the casing **10**.

[0066] In other words, the reciprocating movement of the pistons **6** compresses the air in known manner in the cylinders **5** and, through valve devices also of known type and not described further, the compressed air is discharged from the cylinders **5** and channelled into the manifold **13** by way of the ducts **12**.

[0067] From the manifold **13**, the compressed air flows through the inlet opening **16***a* into the cooling duct **16**, travels the full length of the duct and flows out through the outlet opening **16***b*, directed towards the users or the tank if any, neither of which is illustrated.

[0068] By means of its rotating shaft **7**, the electric motor **3** not only drives the pistons **6** in their reciprocating motion but also simultaneously sets the fan assembly **14** in rotation.

[0069] The fan assembly **14** thus generates a cooling air flow which passes through the transversal walls **17** of the containing element **15** and cools the element **15** itself by convection.

[0070] Cooling the containing element **15** involves cooling the walls of the duct **16** through which the air previously compressed in the compressing unit **2** flows and, consequently, cools this air as it flows through the selfsame duct **16**.

[0071] In other words, the compressed air, which is heated during compression, is cooled as it flows through the duct **16** and is channelled towards the users or to the tank, at a temperature closer to ambient temperature.

[0072] Even as it flows along the ducts **12** inside the casing **10**, the compressed air undergoes a first cooling stage because the walls of the ducts **12** are themselves cooled by the passage of the airflow which is produced by the fan assembly **14** and which, after being channelled into the channels **19**, comes into contact with the fins **18**, thereby not only cooling the cylinders **5**, but also the ducts **12** and the compressed air flowing therein.

[0073] In the example embodiment illustrated in the accompanying drawings, the compressing unit **2** is a single-stage unit and comprises four cylinders **5** which are angularly spaced round the circular form of the casing **10**.

[0074] In other words, the four cylinders **5** are spaced at 90° from each other, an arrangement which can effectively balance the forces involved.

[0075] The four cylinders **5** have respective central axes **5***a* which are substantially incident upon the axis of rotation of the shaft **7**.

[0076] In alternative embodiments, not illustrated, of the invention, the compressor is a two-stage unit, that is to say, one in which one or more cylinders are used for a first air compressor stage and one or more cylinders are used for a second air compressor stage.

[0077] Advantageously, although the cylinders used for the two compressor stages are equal to each other in number, the cylinder capacity of those used for the second stage is smaller than that of the cylinders used for the first stage.

[0078] This difference in cylinder capacity is advantageously obtained by using different (smaller) bores and/or different (smaller) strokes in the cylinders of the first stage compared to those of the second stage.

[0079] Advantageously, the volumetric compressor according to the invention lends itself to wide-ranging, versatile applications thanks to the modularity of the multi-cylinder system: by reducing the number of pistons, it is possible to obtain compressors with a different cylinder capacity using the same casing.

[0080] Advantageously, making the ducts **12** internally of the casing **10** and the duct **16** internally of the containing element **15** of the fan assembly **14** makes it possible to eliminate the need for external piping for conveying the compressed air and thereby allow the overall dimensions of the compressor to be reduced.

[0081] Advantageously, the radial arrangement of the cylinders allows a particularly compact compressor to be made. This compactness is achieved also thanks to the particular cooling system used in the compressing unit according to the invention.

[0082] A further notable advantage of the compact multi-cylinder compressor according to the invention is that it delivers a large quantity of air in very little space.

[0083] Advantageously, as mentioned above, the distribution of the cylinders both along the axis A and radially means that a compact and space-saving casing **10** can be made. In effect, the angular distribution of the cylinders, compared to an inline arrangement, makes it possible for the cylinder axes to be drawn much closer together, whilst the distribution in the axial direction, compared to a star configuration, allows the crank mechanisms to be greatly simplified.

[0084] The invention described above is susceptible of industrial application and may be modified and adapted in several ways without thereby departing from the scope of the inventive concept. Moreover, all the details of the invention may be substituted by technically equivalent elements.

What is claimed is:

1. A volumetric reciprocating compressor comprising

an air compressing unit, said unit comprising a plurality of cylinders adapted to receive reciprocating pistons,

a motor for driving the compressing unit and having a shaft which rotates about a respective axis of rotation,

cooling means comprising at least one fan assembly driven by the rotating shaft to produce an air flow for cooling the compressed air in the unit, characterized in that the cylinders are located inside an axisymmetrically shaped housing casing and are angularly spaced from each other, and in that they have respective central axes which lie in respective planes which are parallel to each other and perpendicular to the axis of rotation of the rotating shaft.

2. The compressor according to claim **1**, characterized in that it comprises, for each of the pistons, a respective con rod and a crank lever member which is rotatably connected to the con rod at the respective small end and which is eccentrically connected to the rotating shaft.

3. The compressor according to claim **2**, characterized in that the crank lever member is connected to the shaft by a shape fit which allows it to rotate as one with the shaft.

4. The compressor according to claim **1**, characterized in that the cooling means comprise an element for containing the fan assembly, the containing element having an axisymmetrical configuration and comprising a duct for cooling the compressed air discharged from the air compressing unit.

5. The compressor according to claim **4**, characterized in that the cooling duct is at least partly annular in shape and extends along the periphery of the containing element.

6. The compressor according to claim **4**, characterized in that the containing element is interposed between the air compressing unit and the drive motor.

7. The compressor according to claim **4**, where the containing element for the fan assembly has at least one wall which is transversal to the axis of rotation of the motor, characterized in that the wall has a plurality of openings designed to allow the passage of the air flow produced by the fan assembly.

8. The compressor according to claim **7**, characterized in that the containing element for the fan assembly has two walls which are transversal to the axis of rotation of the motor and

which are located on opposite sides of the fan assembly, both of the walls having a plurality of openings designed to allow the passage of the air flow produced by the fan assembly.

9. The compressor according to claim **1**, characterized in that the casing housing the cylinders has, between the cylinders, a plurality of cooling fins defining multiple channels through which the cooling air flow produced by the fan assembly passes.

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