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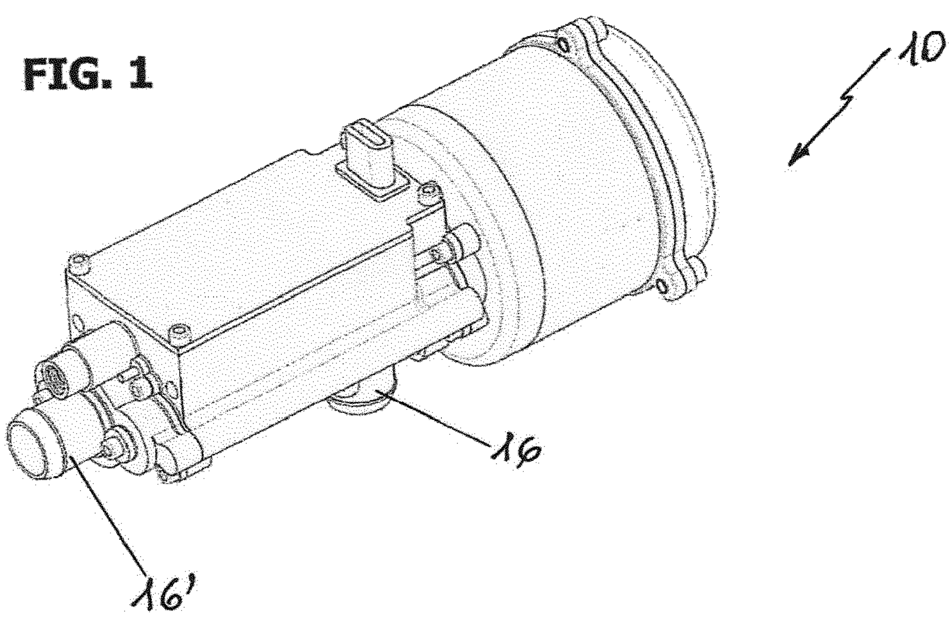
(54) MULTISCREW PUMP FOR COOLING CIRCUITS

(57) A multi-screw pump (10) (14, 14') for cooling circuits, especially suitable for engine and auxiliary cooling circuits installed on vehicles with internal combustion engines, comprises a pump body (12) housing a plurality of rotors having a typically helical thread, and wherein the screw (14) or drive screw of a rotor is actuated by an electric or other motor (18), housed in a cover container body (18') so that the rotational motion is transferred to the other screws or driven screws (14'); said pump is provided with a dynamic seal, preferably a front mechanical seal (20) with sliding rings, and with possible static seals (24) for containing the processed fluid.

FIG. 1



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Description

[0001] The present invention relates to a multi-screw pump for cooling circuits.

[0002] More particularly, the present invention relates to a multi-screw, rotary, positive displacement pump for engine and auxiliary cooling circuits installed on vehicles with internal combustion, electric or hybrid engines.

[0003] As is known, the circulation of coolant fluid in reciprocating internal combustion engines, known as MCIs, is currently accomplished by means of centrifugal pumps of the dynamic type, mechanically connected to the rotation shaft of the engine. This connection means that said pumps are driven at different speeds, depending on the speed of the drive shaft. It is also known that in centrifugal technology dynamic circulation pumps, performance is strongly influenced by the rotation speed, as well as by the flow rate and head produced; as a result, when the rotation speed varies, they operate with average lower performance than envisaged in the design conditions, usually referring to the operating point of the motor at which maximum power is expressed.

[0004] Considering that vehicle type-approval cycles regard engine operating conditions characterised by medium/low performance in terms of rotation speed and power produced, and that CO2 emissions in relation to the maximum admissible are assessed on these cycles, it can be seen how the pumps usually used have high mechanical consumption which in turn influences fuel consumption and, ultimately, CO2 emissions. It would instead be desirable for pump performance to be as independent as possible of its rotation speed and operating conditions.

[0005] The known pumps currently on the market, designed mainly for light industrial use in the hydraulics sector, do not meet these requirements; pumps in which the pumped fluid is conveyed between the threads of one or more rotors, in which the liquid is positioned in a direction generally parallel to the axis of rotation of the rotor or each rotor, are known and are generally referred to as screw pumps. An example of this can be found in US 2,693,763. It is possible to increase the maximum pressure of the fluid in output from such a pump by increasing the length of the screw, but this does not result in a compact product suitable for automotive applications where installation space in the engine bay is limited. US 6,443,711 relates to the lubrication and refrigeration system of a compressor, carried out through a portion of the engine cooling and suction flow.

[0006] In WO 2017 189022, a modular rotor assembly for a screw pump is described suitable for handling high pressure, low viscosity fluids without requiring costly and complex counterbalance structures. US 2015/369241 discloses the solution of a screw pump in which the dynamic seal is applied to the pump shaft itself, and in US 2002 081226 the area of the end of a screw rotor driven by the discharge pressure is reduced by separating the suction and discharge pressures by means of a labyrinth seal. EP 1 475 537 discloses a pump equipped with at least three rotors, arranged in a shared housing, in which the rotation of the drive screw causes the rotation of the driven screws and the pressurised fluid is used to drive an actuator; the drive screw is supported by a radial ball bearing, while the driven screws are hydro-dynamically supported. Pumps of this type cannot be used for cooling circuits of engines and auxiliaries installed on vehicles with internal combustion engines.

[0007] The purpose of the present invention is to overcome the drawbacks complained of above.

[0008] More particularly, the aim of the present invention is to provide a circulation pump capable of ensuring performance substantially independent of its rotation speed and of the operating conditions. A further and consequent aim of the invention is to provide a circulation pump capable of allowing an appreciable saving of the mechanical energy needed to drive it, therefore a reduction of CO2 emissions.

[0009] A further, no less important purpose of the invention is to provide a pump in which friction and wear phenomena that could degrade its performance over time are minimized.

[0010] A further purpose of the invention is to make available to users a multi-screw pump for cooling circuits suitable to ensure a high level of resistance and reliability over time, in addition such as to be easily and economically made.

[0011] These and other purposes are achieved by the multi-screw pump for cooling circuits of the present invention according to the main claim.

[0012] The construction and functional characteristics of the multi-screw pump for cooling circuits of the present invention will be more clearly comprehensible from the detailed description below in which reference is made to the appended drawings which show a preferred and non-limiting embodiment and wherein:

figure 1 schematically represents an axonometric view of the multi-screw pump for cooling circuits of the present invention;
figure 2 schematically represents the same pump in longitudinal cross-section;
figure 3 schematically represents the same pump in longitudinal cross-section, rotated by 90° with respect to the previous view; figure 4 schematically represents a partially sectioned axonometric view of one of the rotors of the pump of the present invention.

[0013] With reference to the aforesaid figures, the multi-screw pump for cooling circuits of the present invention, denoted by reference numeral 10 in Figure 1 in which it is shown in its entirety, comprises a pump body 12 in which a plurality of rotors are housed, preferably with hollow screws to lighten the weight of said pump. The rotors are at least three in number and each is provided with a typically and non-critically helical thread; said pump is advantageously predisposed for use in cooling circuits of vehicle engines and/or related auxiliary systems; at least one of the rotors indicated by reference numeral 14 is activated by an electric or other type of motor 18, so that the rotational motion is transferred to the other driven rotors 14'. The motor 18 is housed in a cover container body 18'. In practice, rotating compartments are created which favour the movement of the fluid towards the delivery section or duct, near which the pressurisation of the fluid feeds one or more delivery circuits-(16).

[0014] The pump 10 is preferably provided with a front mechanical seal 20 with sliding rings, one integral with the pump itself and the other with the rotation shaft 22 of the motor 18, kept in connection by elastic force or by a lip seal to delimit the area lapped by the processed fluid; however, the use of static seals 24, with the same purpose of containing the processed fluid, may also be envisaged. The driven screws are advantageously supported by bearings, sliding bearings, rolling bearings or a combination thereof, so as to avoid seizing and minimize wear phenomena and dissipation due to friction, as well as vibrations and noise; the particular arrangement of the axial constraints, referable to the shoulder 28 (figure 4) of the drive shaft 22 and to the bushings 32 (figure 2), allows the assembly composed of the drive screw or rotor 14 and the driven screws 14' (figures 2 and 4) to be axially floating, which on the one hand, facilitates assembly operations and, on the other, avoids seizures due to thermal expansion.

[0015] The drive screw 14 is unilaterally constrained towards the drive shaft 22 and the torque transmission is realized by key means 26, while the coaxiality of said drive shaft 22 with respect to the drive screw 14 is realized by means of a cylindrical coupling, as per Figure 4.

[0016] The end stop in this position is determined by the contact between the drive screw 14 and the shoulder 28 on the drive shaft 22. The driven screws 14' are also constrained in such direction, given that once inserted in the housing in the presence of the drive screw, their sliding has as end-stroke the contact established between the threads, in particular between the grooves of said driven screws 14' and the corresponding ridges of the drive screw 14. In the same direction, the driven screws 14' do not require axial restraint and the bearings, whether sliding or rolling, are attributable to a carriage restraint. In the specific case represented, the carriage constraint comprises at least one non-flanged bushing 30 (fig. 2). The stop to the axial sliding in the opposite direction is realized on the driven screws 14' by a generic bearing or equivalent abutment means; in the specific case represented in figure 2, the carriage constraint is constituted by a flanged bushing 32.

[0017] According to a further advantageous feature of the pump 10 according to the invention, the same cover container body 18' is used both to create a seat for at least one bearing 34 of the drive shaft 22, and for the seat of the dynamic seal and bushings 30; this makes it possible to minimize alignment errors between these components. In the preferred, non-limiting embodiment shown in the figures, the dynamic seal comprises a front mechanical seal with sliding rings 20, although said dynamic seal may also be of another type, for example formed by a lip seal or the like.

[0018] As mentioned, the drive screw 14 and the driven screws 14' are preferably hollow (Fig. 4), in order to reduce the weights and inertias of the system. If the cavity of the drive screw is a through cavity and connects the two ends of the screw axially, it is possible to create a fluid passage between the suction chamber and the chamber near the seal indicated by reference numeral 39 in figure 3; this way it is possible to balance the pressure acting on the dynamic seal, preserving its functionality over time. In addition, a screw with a through cavity allows the passage of electrical cables, if necessary, for example to be used for one or more sensors interacting with the electronic control unit on board the vehicle or dedicated.

[0019] The pump 10 of the invention can be provided with a device for conveying the fluid in suction from the relative duct 16' so as to avoid or reduce the impact on the drive screw 14 and consequently improve the fluid-dynamic performance; this device can be integral with the rotating element or ogive 36 (fig. 4) or the fixed element 41 (fig. 2). The same pump may include two or more delivery points 16 at different pressure levels, which can be achieved by means of one or more intermediate tappings; this type of solution is particularly useful when a single pump is used to supply two circuits having two different purposes; an example in this regard concerns the case of auxiliary services for the first outlet and engine cooling services for the second.

[0020] The control and power electronics, schematised by reference numeral 38 in figure 3, are arranged as an on-board circuit on the pump body or, possibly, on or near the electric motor 18, and are advantageously cooled by the processed fluid so as to preserve their operational and functional characteristics. Similarly, the pump 10 may comprise an on-board overpressure control system, schematically indicated by reference numeral 40 in Figure 3.

[0021] A number of more than three rotating elements achieves higher processed flows than only three rotating elements at the same speed of rotation; in fact, for the same screw diameter there is a larger cross-section of fluid, so that to obtain the same flow rates at the same number of revolutions a shorter length of the screws is sufficient. The pump of the present invention preferably processes fluids such as solutions of water or glycol in various concentrations, specific fluids for cooling the motor or auxiliary components functional for the thermal requirements of the vehicle, as well as for cooling electrical/electronic components functional for electric, hybrid propulsion or battery energy storage.

[0022] As may be seen from the above, the advantages which the invention achieves are evident.

[0023] The multi-screw pump for cooling circuits of the present invention has high performance as the rotation speed and operating conditions vary, thus resulting operationally superior to the dynamic pumps traditionally used in the automotive industry for the circulation of fluids and achieving the result of a lower absorption of mechanical energy; in fact, centrifugal pumps over-accelerate the fluid, the losses increase and, in order to provide the same hydraulic performance, they require more mechanical energy, since the energy losses increase as the speed of the fluid increases. The fact that the seats of the supports of the rotating elements, referred to the bearing 34 of the shaft 22 and to the front mechanical seal 20, are obtained directly on the body 18' of the electric motor 18, in order to avoid/minimize possible positioning errors, is particularly advantageous. Additionally, the positioning of the drive screw 14 and the driven screws 14' is ensured by positioning their respective axes through the bushings 30, 32 and the bearing 34.

[0024] Despite the invention having been described above with particular reference to one of its preferred embodiments, given solely by way of a non-limiting example, numerous modifications and variants will appear evident to a person skilled in the art in the light of the above description. The present invention therefore sets out to embrace all the modifications and variants which fall within the sphere and scope of the following claims.

Claims

1. A multi-screw (14, 14') pump (10) for cooling circuits, suitable for cooling circuits of engines and auxiliaries installed on vehicles with internal combustion engines, comprising a pump body (12) housing a plurality of rotors having helical threads and wherein the screw (14) or drive screw of a rotor is actuated by an electric or other motor (18), the rotation shaft (22) of which comprises a shoulder (28), housed in a cover container body (18') so that the rotation motion is transferred to the other screws or driven screws (14'), **characterised in that** it is provided with a front mechanical dynamic seal (20) with sliding rings, and with possible static seals (24) for containing the processed fluid, wherein one of the sliding rings is integral with the pump itself, while the other is integral with the rotation shaft (22) of the motor (18), the arrangement of the axial constraints, referable to the shoulder (28) of the drive shaft (22) and to the bushings (32) making the assembly composed of the drive screw or rotor (14) and the driven screws (14') axially floating, facilitating assembly operations and avoiding seizures due to possible thermal expansion.

2. The multi-screw pump according to claim 1, **characterized in that** the drive screw (14) is unilaterally constrained towards the drive shaft (22) and the torque transmission is realized by key means (26), the end stroke in such position being determined by the contact between said drive screw (14) and the shoulder (28) made on said shaft.

3. The multi-screw pump according to claim 1, **characterized in that** the sliding of said driven screws (14') positioned in the pump body (12) has as end-stroke the contact established between the grooves of said driven screws and the corresponding ridges of the drive screw (14), and the axial constraint of said driven screws (14') is constituted by a non-flanged bushing (30), the stop to the axial sliding in the opposite direction being realized on said driven screws (14') by a bearing or equivalent means, with a carriage constraint constituted by a flanged bushing (32).

4. The multi-screw pump according to claim 1, **characterized in that** the cover container body (18') integrates both the seat for at least one bearing (34) of the drive shaft (22), and the seat of the dynamic seal (20) and the bushings (30) and/or (32), so as to minimize alignment errors between said elements.

5. The multi-screw pump according to one or more of the preceding claims, **characterized in that** it comprises on the pump body (12) two or more delivery points (16) at different pressure levels, realizable by means of one or more intermediate tappings.

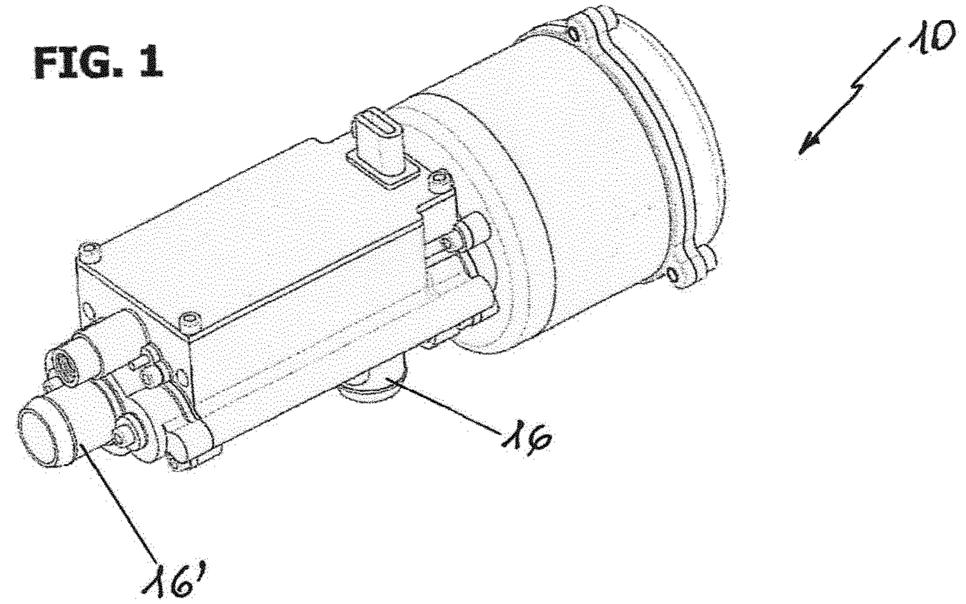
6. The multi-screw pump according to claim 3, **characterized in that** said drive screws (14) and/or driven screws (14') and/or in combination with each other, are hollow.

7. The multi-screw pump according to claim 6, **characterized in that** the cavity of the drive screw is a through cavity and places in communication the two ends in the axial direction of said screw, to realize a fluid passage between the suction chamber and the chamber near the dynamic seal (39).

8. The multi-screw pump according to claim 1, **characterized in that** it comprises a conveying device of the fluid in suction integral with the rotating element or ogive (36) of the screw (14) or the fixed element (41).

9. The multi-screw pump according to claim 1, **characterized in that** it comprises an electronic control and power circuit (38) arranged on-board on or near the pump body or the electric motor (18), cooled by the processed fluid so as to preserve its operational and functional characteristics.

FIG. 1



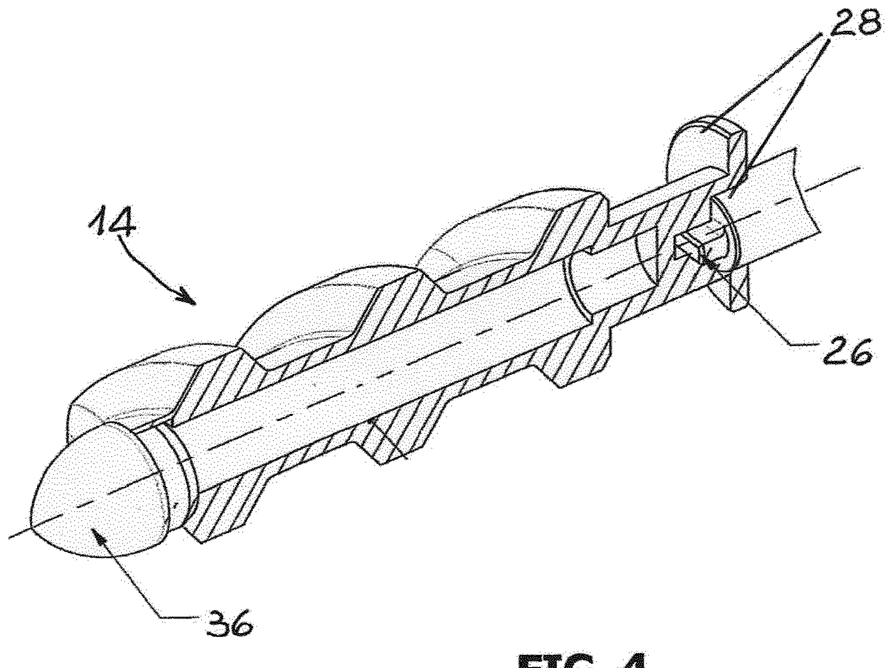


FIG. 4

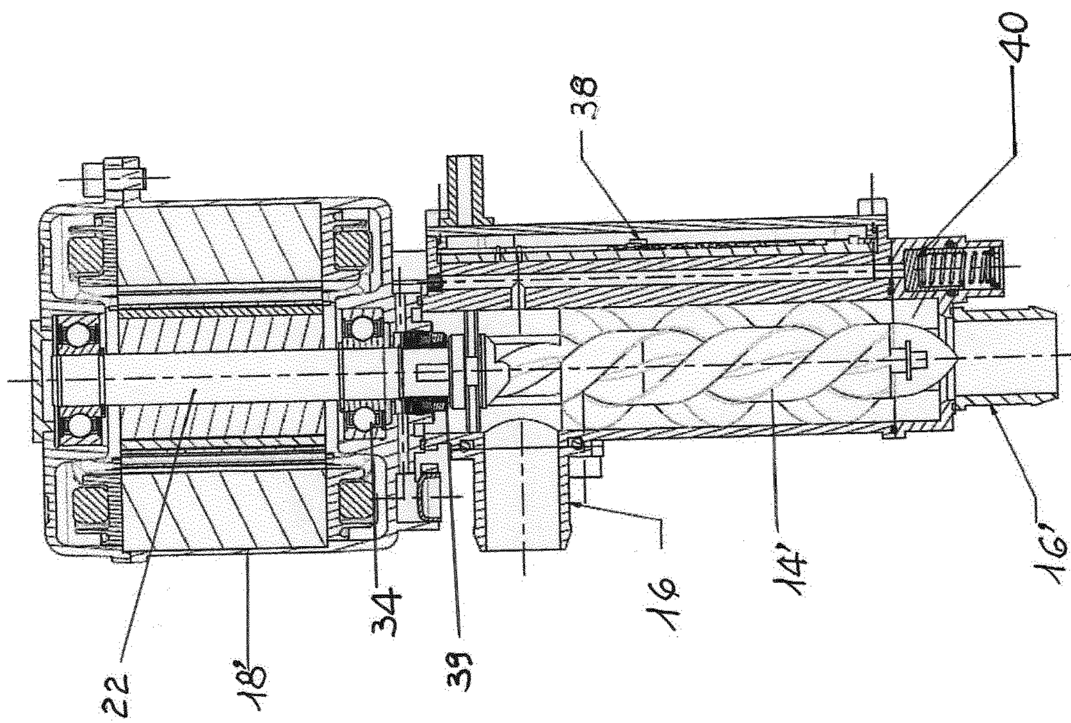


FIG. 3

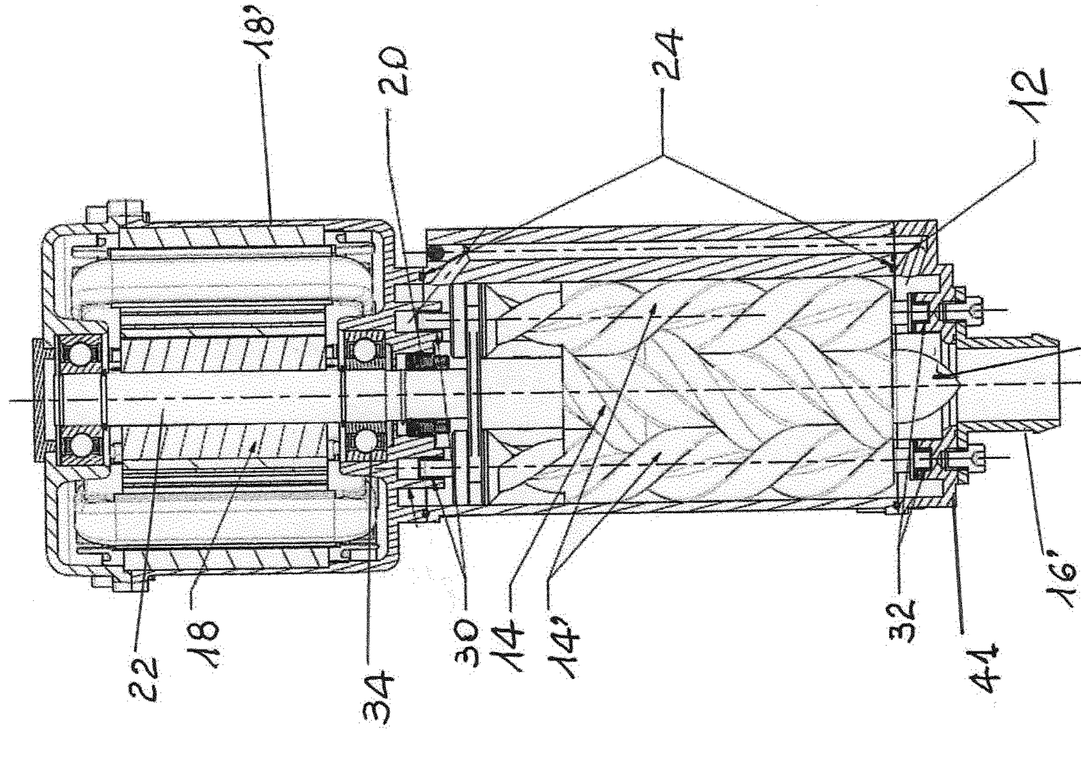


FIG. 2

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EUROPEAN SEARCH REPORT

Application Number
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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	13 October 2021	Durante, Andrea

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Place of search	Date of completion of the search	Examiner
Munich	13 October 2021	Durante, Andrea

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