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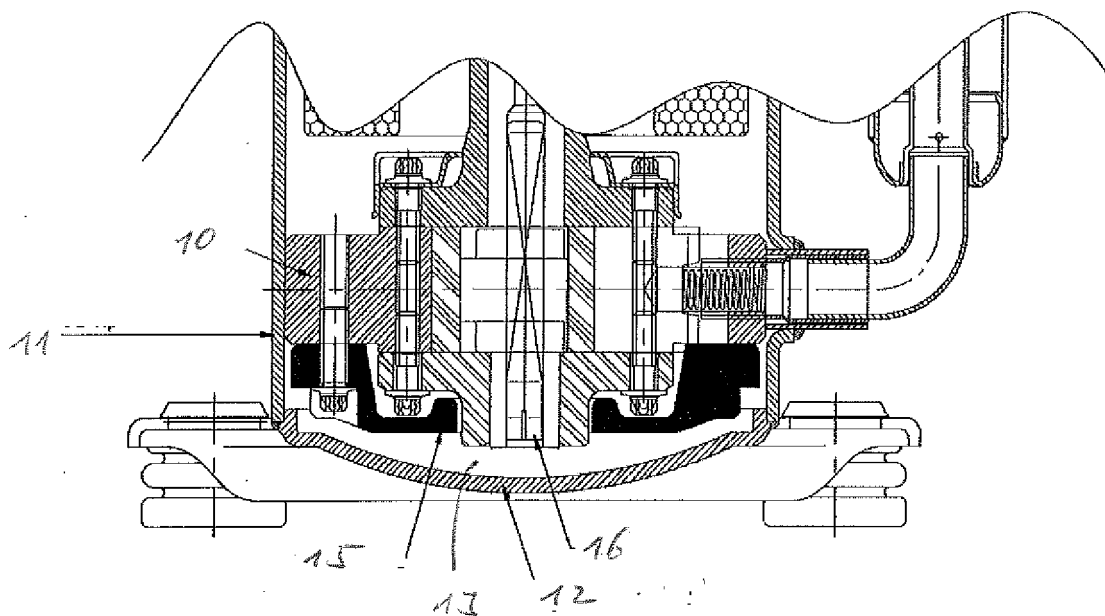
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(54) COMPRESSOR, AND HEAT PUMP INCLUDING SUCH COMPRESSOR

(57) Compressor (9) for compressing a refrigerant, comprising a housing (11) for containing said refrigerant, a refrigerant pump (10), said pump (10) disposed within said housing (11), and a sump (13) for containing an amount of lubricating oil to a predetermined level (14) is defined within said housing (11) separate from said re-

frigerant pump (10). Said housing (11) includes means (15, 12) for reducing the amount of lubricating oil contained in said sump (13) while maintaining said level (14). The invention also relates to a heat pump (5, 6, 7, 8, 9) including such compressor (9), the heat pump (5, 6, 7, 8, 9) preferably being contained in a laundry dryer (1).

**Fig. 2****EP 3 421 804 A1**

Description

[0001] The invention relates to a compressor for compressing a refrigerant, comprising a housing for containing said refrigerant, a refrigerant pump, said pump disposed within said housing, and a sump for containing an amount of lubricating oil to a predetermined level is defined within said housing separate from said refrigerant pump.

[0002] The invention also relates to a heat pump including such compressor, and to a laundry dryer including such heat pump.

[0003] The publication WO 2016/024009 A1 discloses such compressor and also such heat pump. The disclosed compressor is a rotary compressor having a displacement between 5 cm³ and 10 cm³. It may contain a lubricating oil of a type selected from PAG and POE type oils at an amount between 150 cm³ and 210 cm³, and may be dedicated for compressing the refrigerant commonly known as R290 or propane. The compressor may be included in a heat pump comprising in addition a refrigerant condenser for condensing the refrigerant as compressed by the compressor, thereby releasing heat, a restrictor, particularly a capillary, for reducing an internal pressure of the liquid refrigerant, thereby converting it to a two-phase fluid including both liquid and gas, an evaporator for fully evaporating the refrigerant, thereby absorbing heat. The refrigerant is guided through all of these components as detailed in a closed circuit. On purpose of conforming to the standard IEC 60335-2-11 the amount of refrigerant contained in the heat pump may be restricted to 150 g. As an alternative to R290, the refrigerant commonly known as R1270 or propylene may be used. The heat pump may be comprised in a laundry dryer.

[0004] A compressor as typically dedicated to use in a laundry dryer heat pump uses refrigerant oil in an amount of 120 cm³ to 350 cm³, depending on the displacement of the pump for compressing the refrigerant in the compressor, this displacement being typically from 2 cm³ to 25 cm³. A compressor with a displacement of 5,5 cm³ may require some 120 cm³ of oil, and a compressor with a displacement of 12,4 cm³ may require an amount of 210 cm³.

[0005] In the case of a flammable refrigerant like R290 and R1270 which are hydrocarbons and R32 which is difluoromethane, the IEC 60335-2-11 regulation limits the amount of refrigerant to be loaded into a heat pump of a household appliance as a laundry dryer to 150 g for compliance with safety standards. In designing a heat pump in accordance with such regulation it has to be taken into account that refrigerants like R290 and R1270 have considerable solubilities into usual lubrication oils. First, a proper relation between the amount of refrigerant and the amount of oil must be retained; a minimum amount of oil being defined by providing oil at a weight which is around 20 % of the sum of the weights of the oil and the refrigerants at least. For 150 g of refrigerant this

calls for a minimum amount of oil at some 40 g. Second, the lower portion of a closed compressor housing that defines a sump for containing the lubrication oil must be filled to an appropriate level, for ascertaining proper lubrication of the pump in operation. This however increases the amount of lubricating oil in the compressor much above the specified minimum level, to 120 g or even more (assuming a specific weight of usual oil at or near 1 g/cm³, as with conventional PAG-100S oil).

[0006] In addition to the two criteria specified previously it must also be considered that a considerable amount of refrigerant will be dissolved in the lubricating oil, in particular to some 30 % of the mass of the oil. Such amount of dissolved refrigerant is no more available for circulation through the heat pump. With the data presented above, this may be a quantity from 40 g of refrigerant at 120 g of oil to even 60 g of refrigerant at 200 g of oil. It follows that under limitation of the total amount of refrigerant to 150 g, operational conditions for the heat pump will be considerably affected by dissolution of refrigerant into the lubricating oil.

[0007] Accordingly it is an object of the invention to overcome the disadvantages of the prior art as detailed above, and provide a compressor and a heat pump with improved requirements for lubricating oil, in particular for applications which require the use of a flammable refrigerant like R290 and R1270 in a limited amount.

[0008] According to the invention this object is achieved by a compressor and a heat pump in accordance with the respective independent claim attached. Preferred yet facultative embodiments of the invention are defined in the dependent claims or the subsequent description and exhibited in the drawing attached. Preferred embodiments of the compressor imply preferred embodiments of the heat pump and vice versa, even if not shown or described herein in detail.

[0009] According to the invention the object is therefore achieved by a compressor for compressing a refrigerant, comprising a housing for containing said refrigerant, a refrigerant pump, said pump disposed within said housing, and a sump for containing an amount of lubricating oil to a predetermined level is defined within said housing separate from said refrigerant pump, wherein said housing includes means for reducing the amount of lubricating oil contained in said sump while maintaining said level.

[0010] In accordance with the invention attention is given to properties of the compressor which influence the amount of lubricating oil necessary for ascertaining proper lubrication. Special care is applied to effectively reduce the amount of oil that needs to be present for the purpose, in order to limit the amount of refrigerant dissolved in the oil and enable use of a maximum amount of refrigerant for the heat pump operation intended.

[0011] In the present context the pump is understood to comprise, besides the machine for accomplishing the gas compression process for compressing the refrigerant, a motor, in particular an electric motor that drives that machine.

[0012] According to a preferred embodiment of the invention said means include a solid insert placed within the sump below the level, thereby filling up a considerable portion of the volume defined by the sump and reducing the necessity to use oil in excess of the minimum amount required for mere filling the sump. Thereby the mass of oil that could dissolve the refrigerant instead of allowing it to circulate through the heat pump is reduced, thus allowing an increased portion of the total for operating the heat pump. Such insert may be manufactured from any material suitable for being retained in the compressor at the given operating conditions and appropriate for mass production, for example by die-casting. Such material may be a cheap metal like an appropriately selected aluminum alloy or even plastic, and may be added to the compressor within a just slightly modified mass production process.

[0013] As to manufacturing the insert, alternative methods for die-casting include, depending on the material selected, injection molding, and compression molding, both with using plastic material, and powder metallurgy, forging, and sheet-metal forming, these three with using metal material. It is also noted that the insert may be composed of several components which are put together prior to or upon manufacturing the compressor.

[0014] According to more preferred embodiments of the invention the said insert is fixed to the pump, or alternatively to the housing, and more specifically to a lower cap of the housing and closing the housing at a bottom side. Such lower cap may have a semi-spherical or semi-ellipsoidal shape. Even more preferred, such fixing may be accomplished by one of a rivet, a clamp, and a weld.

[0015] The insert may be dipping into the sump particularly by being attached to the pump, with also the pump extending below the predetermined level. This may assist for transferring lubricant oil into the pump, and avoid special lubricating means separate from the pump for providing proper lubrication to the pump.

[0016] Applying the insert also allows keeping essentially all other components of the compressor without changes in shape, thus possibly retaining an original and approved design. In particular the insert may be applied with a lower cap of the housing that defines the sump at least to a major extent, and that is being left with a shape according to its original design.

[0017] According to another preferred embodiment of the invention said insert has a volume of more than 50 % of a volume of said sump. As an example, an insert may be used in a compressor with a diameter of 106 mm, and a sump below a suction tube of the pump extending to 27 mm down from the tube to a spherical cap of the housing, the original sump volume of about 130 cm³ could be filled with some 70 cm³ by an insert, leaving a volume of just 60 cm³ to be filled with lubricating oil.

[0018] As an alternative to providing means as an insert, a further preferred embodiment of the invention provides that said means include a cap that closes said housing around said sump, and said cap is shaped conformant

to components placed within said housing and located above said sump. Accordingly departure is made from shaping such lower cap of a housing simply spherical as may appear to be expedient in view of mechanical strain by the pressure difference across the housing, and a shape is provided that conforms to the components located proximate to the cap within the housing, thus ascertaining a specifically low free volume for containing a liquid as lubricating oil.

[0019] The modified cap may feature the shape adapted in accordance with the invention on its inside only, thereby retaining its external spherical shape and replacing an insert made separately, or it may feature the shape adapted also on its outside. Thereby the manufacturing process may be retained with a minimum of modifications if any.

[0020] In addition to adapting the shape of the cap as described above it may be contemplated to apply modifications to internal components of the compressor also, to obtain a further reduction of sump volume for containing lubricating oil.

[0021] In accordance with yet another preferred embodiment of the invention the lubricating oil is selected from the group consisting of PAG oil, mineral oil, POE oil, and PVE oil. Particularly preferred may be the oil denoted as PAG-100S.

[0022] In accordance with yet a further preferred embodiment of the invention the pump has a displacement between 2 cm³ and 25 cm³.

[0023] In accordance with still another preferred embodiment of the invention the amount of lubricating oil is between 30 cm³ and 120 cm³.

[0024] According to the invention the object is also achieved by a heat pump including a refrigerant evaporator, a compressor, a refrigerant condenser, and a refrigerant restrictor, all connected in series within a closed loop containing a refrigerant for circulation, wherein said compressor is in accordance with the invention or its preferred embodiments as described hereinabove.

[0025] In accordance with a preferred embodiment of the invention the refrigerant is R290. Alternatives to R290 may be R1270 and R32.

[0026] In accordance with another preferred embodiment of the invention the refrigerant is contained in an amount not exceeding 150 g. This embodiment makes specific use of the advantage obtained by reducing the amount of refrigerant dissolved in the lubricating oil, thus retaining a particularly large amount of the refrigerant for operating the heat pump process.

[0027] In accordance with a further preferred embodiment of the invention the heat pump according to the invention or a preferred embodiment thereof as described hereinabove is comprised in a laundry dryer. Such laundry dryer may be dedicated to being used in a private household as a household appliance, by drying an amount of wet laundry of some 5 kg to 12 kg during a process time interval of 2 hours to 3 hours. As in a laundry dryer the invention may also be applied to a va-

riety of other household appliances including, but not limited to, dishwashers and air conditioners for household use.

[0028] Preferred embodiments of the invention will now be described with reference to the Figures of the drawing attached. In the drawing:

- Fig. 1 shows schematically a laundry dryer including a heat pump with a compressor;
- Fig. 2 a first embodiment of a compressor;
- Fig. 3 a second embodiment of a compressor;
- Fig. 4 a third embodiment of a compressor;
- Fig. 5 a fourth embodiment of a compressor;
- Fig. 6 a fifth embodiment of a compressor;
- Fig. 7 a sixth embodiment of a compressor;
- Fig. 8 a seventh embodiment of a compressor;
- Fig. 9 an eighth embodiment of a compressor;
- Fig. 10 a ninth embodiment of a compressor; and
- Fig. 11 a tenth embodiment of a compressor.

[0029] Fig. 1 shows a schematic representation of a laundry dryer 1, the laundry dryer 1 to be understood also as a representative of any household appliance. This dryer 1 comprises a rotatable drum 2 for holding laundry 3 to be dried by process air that is conveyed by a process air guide 4 by some blower means not shown for clarity. The dryer 1 as shown by Fig. 1 is a tumble dryer 1 specifically dedicated to drying wet laundry 3. Yet the dryer may also be understood to be a combination machine dedicated both to washing laundry 3 and drying laundry 3. In such case the drum 2 may be permeable by washing suds or rinsing suds, and held in a closed tub which in its turn contains such suds. Of course means for entering and removing suds have to be present, as means for allowing the drum 2 to rotate very fast in order to extract suds from the laundry by centrifugation. All of these means are known as such, and are not displayed in Fig. 1 for clarity.

[0030] The process air guide 4 is essentially closed in itself for circulating a flow of process air, thus defining a condensation-type dryer 1 which relies on extracting humidity from the laundry 3 to be dried by heated process air, and cooling process air after saturation with humidity for extracting the humidity by condensation. Subsequently the process air is heated again and recirculated to the laundry 3. As an alternative an open process air guide 4 may also be considered. Such open process air guide 4 would have to include some heating means, but would

not necessarily include cooling means for extracting humidity from the process air. Rather the saturated process air could simply be vented from the dryer 1. This would define a vented-type dryer 1. The innovation to be described subsequently imposes not necessarily a requirement for a specific type of dryer 1. Thus the following description will focus on a condensation-type dryer 1 as a model without any intent or implication to define a limitation.

[0031] The dryer 1 includes a heat pump 5, 6, 7, 8, 9 of the compressor type and implementing a reverse Rankine process to provide cyclic heating and cooling of process air circulating. A heat exchanger or heat source and also termed condenser 5 serves to heat process air flowing through by liquefying a circulating refrigerant which is R290 (alternatively R1270 or R32) and present in a total amount of 150 g in accordance with the IEC 60335-2-11 regulation, and another heat exchanger or heat sink and also termed evaporator 6 serves to cool process air flowing through by evaporating the circulating refrigerant. The refrigerant circulates within a refrigerant circuit closed in itself. The refrigerant enters the evaporator 5 from a restrictor 8 embodied as a capillary or valve and dedicated to reduce the internal pressure of the refrigerant in its liquid phase, thereby creating a dual-phase mixture of liquid and gas, and is fully evaporated in the evaporator 5 by absorbing heat from the process air. Subsequently the gaseous refrigerant passes to the compressor 9 for being compressed to an increased internal pressure, thereby being also heated adiabatically. The compressed gaseous refrigerant then passes to the condenser 6, and is liquefied by releasing heat to the process air. From the condenser 6 the refrigerant returns to the restrictor 8, thereby closing its cycle.

[0032] The compressor 9 now comprises a pump 10 which serves to compressing the refrigerant and includes an electric motor for driving the pump 10 and not shown for clarity, and a housing which encloses all functional components of the compressor 9 and is hermetically sealed. The pump 10 may be a rotary pump, and have a displacement between 2 cm³ and 25 cm³. A lower bound of the housing 11 is given by a lower cap 12. Above the lower cap 12 there is located a sump 13 containing a lubricating oil, in particular an oil of type PAG-100S, applied for lubricating the pump 10 by means not shown in detail for clarity. Within the sump 13 the lubricating oil is contained to a predetermined level 14. In a concrete embodiment the pump 10 may be partially immersed in the lubricating oil, or some means for sucking lubricating oil from the sump 13 may dip into the sump 13.

[0033] As elaborated hereinabove the amount of lubricating oil to be provided in a compressor 9 depends on multiple conditions, some of them being geometric realities like the position of the predetermined level 14 and the geometry of the housing 11 including its lower cap 12 and defining the sump 13, and another being a requirement of providing at least a minimum amount of lubricating oil in relation to the amount of refrigerant in the

refrigerant circuit 7. Defining this minimum amount at 20 % to 22 % of the amount of refrigerant which is 150 g, the minimum amount would be 38 g to 42 g, equating for PAG-100S type oil 38 cm³ to 42 cm³.

[0034] In usual practice of designing compressors 9 however the specified minimum amount will be grossly exceeded, by requiring lubricating oil in amounts of 130 cm³ or even 250 cm³. Taking now into account that a considerable amount of refrigerant will be dissolved in the lubricating oil, in particular to some 30 % of the amount of the oil, it follows that a heat pump 5, 6, 7, 8, 9 including such compressor 9 may face a problem in view of the limited total amount of refrigerant. With the data presented above, this may be a quantity from 40 g of refrigerant at 120 g of oil to even 60 g of refrigerant at 200 g of oil. It follows that under limitation of the total amount of refrigerant to 150 g, operational conditions for the heat pump 5, 6, 7, 8, 9 will be considerably affected by dissolution of refrigerant into the lubricating oil, and no option available for increasing the total amount of refrigerant in the heat pump 5, 6, 7, 8, 9.

[0035] Accordingly the present innovation provides for reducing dissolution of refrigerant into lubricating oil by reducing the amount of oil to be provided in a compressor 9. According exemplary solutions are shown in Figures 2 to 11.

[0036] Fig. 2 shows a lower part of a compressor 9 including the pump 10 placed in the housing 11. The housing 11 is essentially cylindrical and terminates in a lower cap 12 inserted into and fixed to the housing's 11 cylindrical portion. The lower cap 12 bulges outside slightly in order to accommodate the operational pressure difference between the inside and the outside of the housing 11. In order to reduce free space above the lower cap 12, the compressor 9 also includes an insert 15 made of die-cast material and fixed, in this case bolted, to the pump 10. With the pump 10 this insert 15 will dip into the sump 13 formed in the lower part of the housing 11, and thus allow for providing a much lower amount of lubricating oil in the sump 13 for reaching a predetermined level 14. The insert 15 has a volume of more than 50 % of a volume of said sump 13, as may be inferred from Fig 2 easily. The insert 15 is used in a compressor 9 with a diameter of 106 mm, and a sump 13 below a suction tube 16 of the pump 10 extending to 27 mm down from the tube to the lower cap 12. Thereby the original sump volume of about 130 cm³ may even be filled with some 70 cm³ by the insert 15, leaving a volume of just 60 cm³ to be filled with lubricating oil.

[0037] As to manufacturing the insert 15, alternative methods for die-casting include, depending on the material selected, injection molding, and compression molding, both with using plastic material, and powder metallurgy, forging, and sheet-metal forming, these three with using metal material. It is also noted that the insert 15 may be composed of several components which are put together prior to or upon manufacturing the compressor 9.

[0038] The configuration of Fig. 3 is much similar to the configuration of Fig. 2 except for the insert 15 being riveted to the lower cap 12 by rivets 19.

[0039] Also the configuration of Fig. 4 is much similar to the configuration of Fig. 2 except for the insert 15 being press-fitted to the cylindrical portion of the housing 11 below the pump 10.

[0040] According to Fig. 5, the insert 15 is fitted to the lower cap 12 which in its turn is fixed to the cylindrical portion of the housing 11 by a circumferential weld 18. A rim portion of the lower cap 12 is bent inwards somewhat for forming a clamp 21 that fixes the insert 15 to the lower cap 12.

[0041] According to Fig. 6 the insert 15 has a spring element 17 which fixes it to the lower cap 12. In its own turn the lower cap 12 is again fixed to the cylindrical portion of the housing 11 by a weld 18.

[0042] According to Fig. 7 the insert 15 is made from metal that can be welded, and is fixed to the circumference of the lower cap 12 by a weld 18.

[0043] According to Fig. 8 the insert 15 is fixed to the lower cap 12 by rivets 19.

[0044] According to Fig 9 the insert 15 is made by molding from a suitable plastic material. In order to provide for fixing the insert 15 is molded around a metal ring 20, which in its turn is fixed to the lower cap 12 by a circumferential weld 18.

[0045] According to Fig. 10 the insert 15 is formed directly within the lower cap 12, and concurrently bonded to the lower cap 12, by molding. It is noted that by providing the insert 15 directly on its inside the lower cap 12 features the shape adapted in accordance with the invention on its inside only, thereby retaining its external spherical shape. Thereby the functional features of the cap as regards resistance to operational pressure differences and manufacturing process are retained with a minimum of modifications.

[0046] As a general feature of all embodiments shown the combination of the lower cap 12 and the insert 15 is shaped towards the inside of the housing 11 conformant to components including the pump 10 and the suction pipe 16 placed within the housing 11, and located above the sump 13.

[0047] According to Fig. 11 this feature is implemented in a different manner by replacing the original spherical lower cap 12 by a novel lower cap 12a which may be manufactured from sheet stock as the lower cap 12 in the embodiments described hereinabove but which is shaped in its entirety conformant to the components including in the present case a lower flange 22 surrounding the suction tube 16 and a shaft 23 placed within the housing 12 and located above the sump 13.

[0048] A general advantage of all embodiments is the reduction of amount of refrigerant dissolved in the lubricating oil, thus saving considerable amounts of refrigerant for performing the heat pump process. This provides for an increased mass flow through the heat pump 5, 6, 7, 8, 9 (see Fig. 1), and thus for improved performance.

In a practical case of a heat pump using R290 as the refrigerant in an amount of 150 g, the amount of refrigerant dissolved in the lubricating oil of type PAG-100S be reduced to 24 g, in comparison to a dissolved amount of 63 g in a heat pump of equal construction and dimensions except for replacing the innovative compressor 9 by a conventional one. The reason is that by using an insert 15 as disclosed herein the total amount of lubricating oil to be provided in the compressor 9 could be reduced from 210 g to 80 g.

[0049] Accordingly the invention provides for a compressor, and a heat pump including such compressor, and a laundry dryer including such heat pump, wherein a particularly high fraction of the total amount of the refrigerant is available for performing the heat pump process. This is of particular importance to a flammable refrigerant like R290, R1270, and R32, and used in a heat pump of a household appliance wherein the total amount of refrigerant is limited due to pertinent regulation, such as 150 g of refrigerant as allowed by the IEC 60335-2-11 regulation.

Reference Numerals

[0050]

1	Dryer	
2	Drum	
3	Laundry	
4	Process air guide	
5	Condenser	
6	Evaporator	
7	Refrigerant circuit	
8	Restrictor	
9	Compressor	
10	Pump	
11	Housing	
12	Lower cap	
12a	Lower cap, modified	
13	Sump	
14	Level	
15	Insert	
16	Suction tube	
17	Spring element	
18	Weld	
19	Rivet	
20	Metal ring	
21	Clamp	
22	Lower flange	
23	Shaft	

Claims

1. A compressor (9) for compressing a refrigerant, comprising a housing (11) for containing said refrigerant, a refrigerant pump (10), said pump (10) disposed within said housing (11), and a sump (13) for con-

taining an amount of lubricating oil to a predetermined level (14) is defined within said housing (11) separate from said refrigerant pump (10), **characterized in that** said housing (11) includes means (15, 12a) for reducing the amount of lubricating oil contained in said sump (13) while maintaining said level (14).

2. The compressor (9) according to claim 1, wherein said means (15, 12a) include a solid insert (15) placed within said sump (13) below said level (14).

3. The compressor (9) according to claim 2, wherein said insert (15) is fixed to said pump (10).

4. The compressor (9) according to claim 2, wherein said insert (15) is fixed to said housing (11).

5. The compressor (9) according to claim 4, wherein said insert (15) is fixed to a lower cap (12) of said housing (11).

6. The compressor (9) according to any of claims 2 to 5, wherein said insert (15) is fixed by one of a rivet (19), a clamp (21), and a weld (18).

7. The compressor (9) according to any of claims 2 to 6, wherein said insert (15) has a volume of more than 50 % of a volume of said sump (13).

8. The compressor (9) according to any preceding claim, wherein said means (15, 12a) include a cap (12a) that closes said housing (11) around said sump (13), and said cap (12a) is shaped conformant to components (10, 16) placed within said housing (11) and located above said sump (13).

9. The compressor (9) according to any preceding claim, wherein said lubricating oil is selected from the group consisting of PAG oil, mineral oil, POE oil, and PVE oil.

10. The compressor (9) according to any preceding claim, wherein the pump (10) has a displacement between 2 cm³ and 25 cm³.

11. The compressor (9) according to claim 10, wherein the amount of lubricating oil is between 30 cm³ and 120 cm³.

12. A heat pump (5, 6, 7, 8, 9) including a refrigerant evaporator (6), a compressor (9), a refrigerant condenser (5), and a refrigerant restrictor (8), all connected in series within a closed loop (7) containing a refrigerant for circulation, wherein said compressor (9) accords to one of the preceding claims.

13. The heat pump (5, 6, 7, 8, 9) according to claim 12,

wherein said refrigerant is a compound selected from the group consisting of R290, R1270, and R32.

14. The heat pump (5, 6, 7, 8, 9) according to claim 13, wherein said refrigerant is contained in an amount not exceeding 150 g. 5
15. The heat pump (5, 6, 7, 8, 9) according to one of claims 12 to 14, which is comprised in a laundry dryer (1). 10

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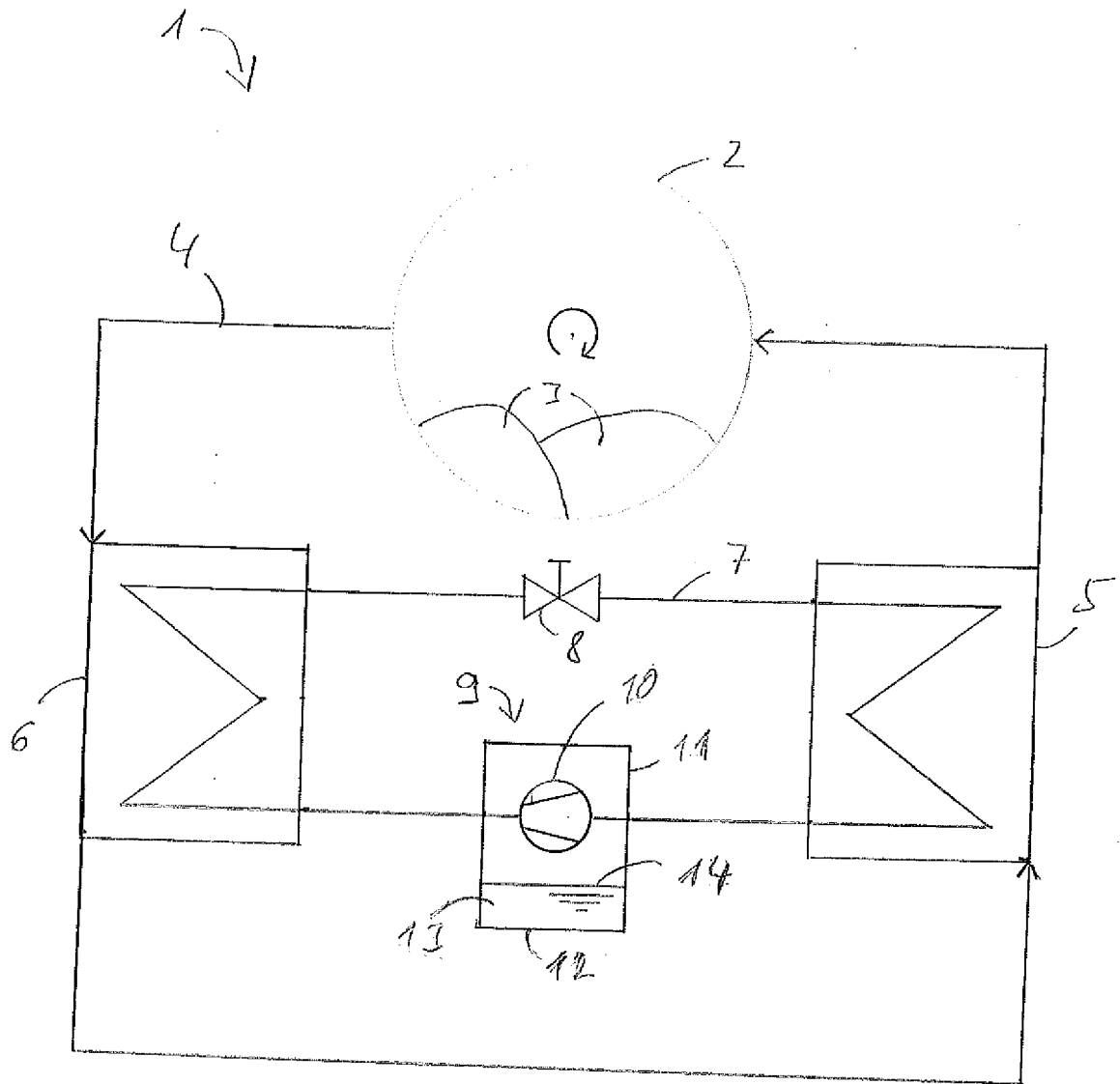
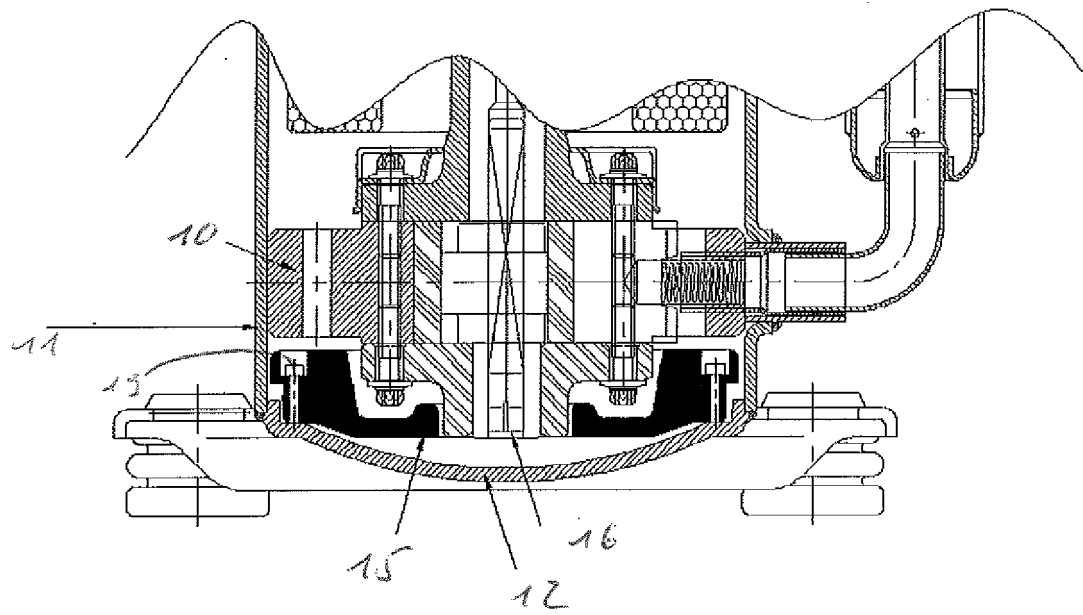
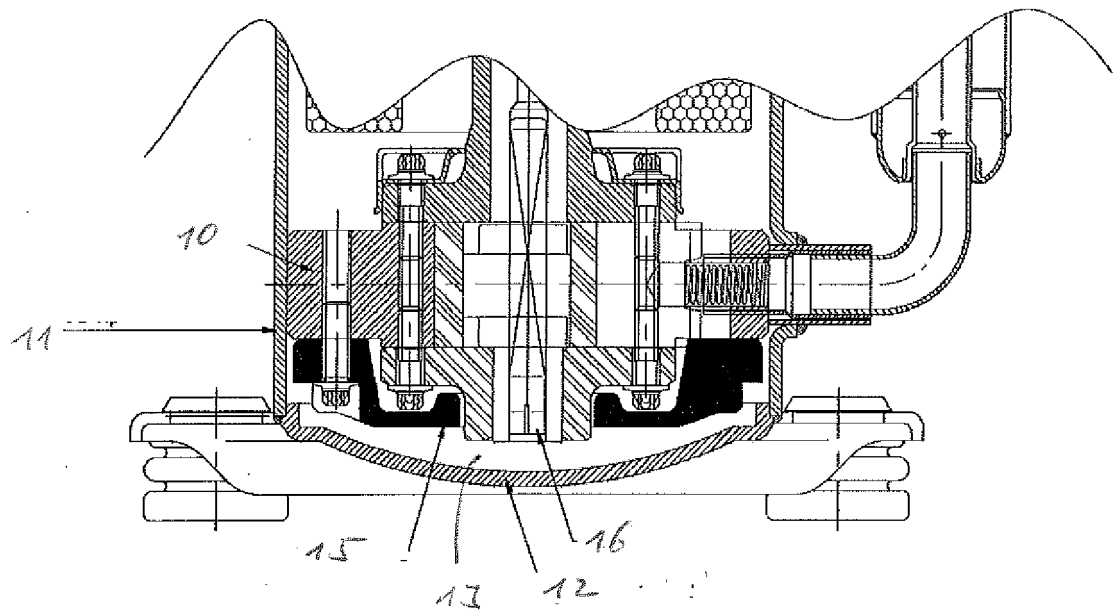
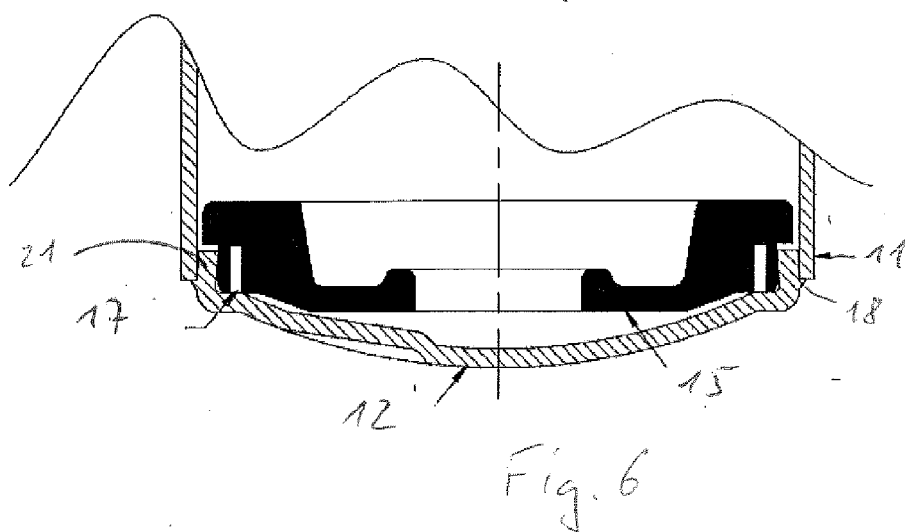
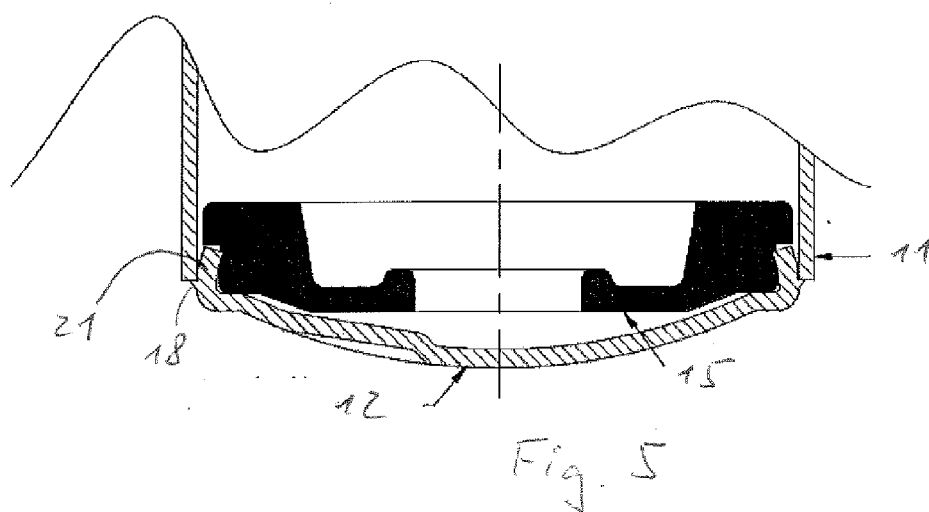
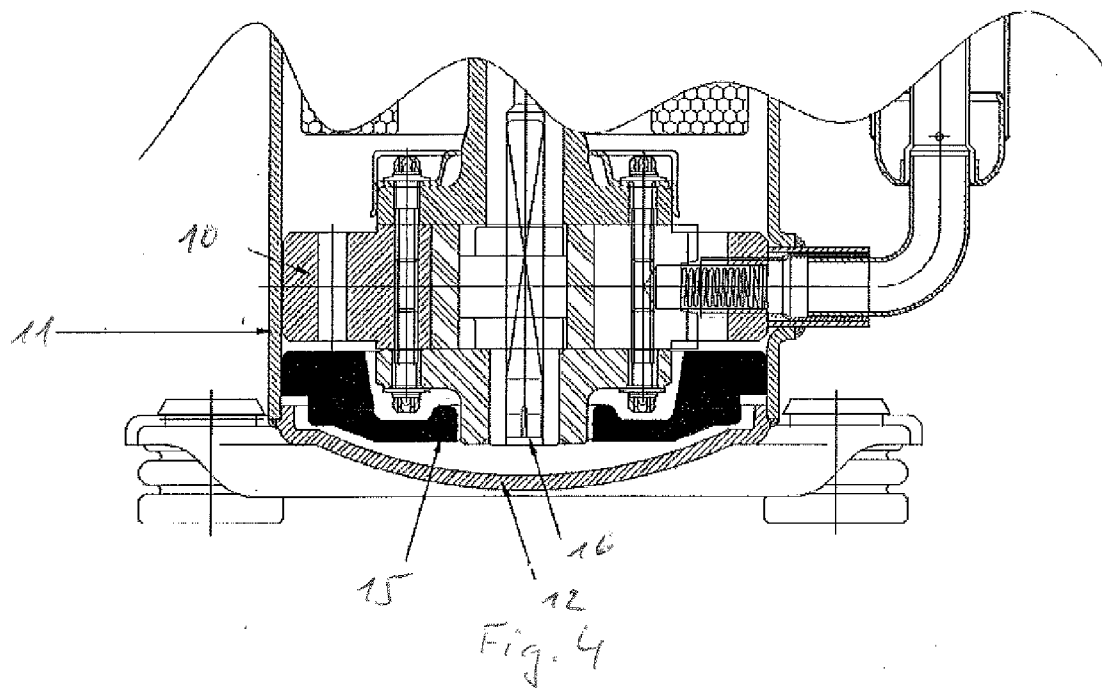
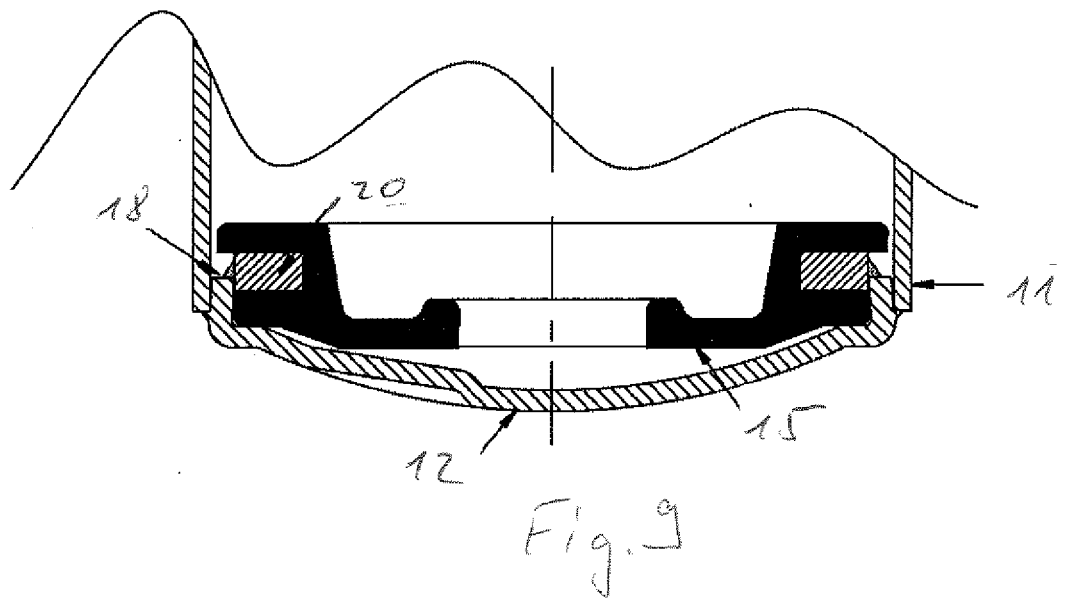
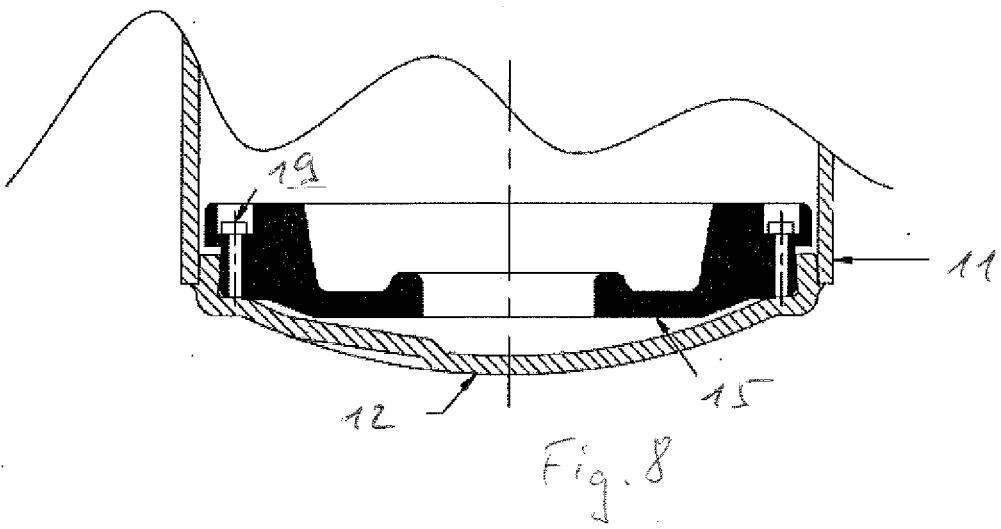
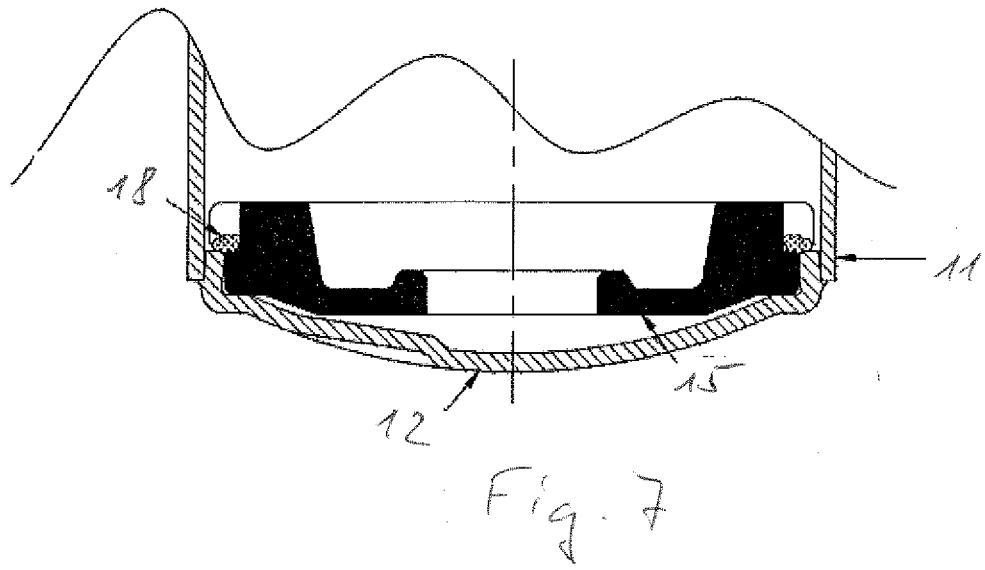


Fig. 1







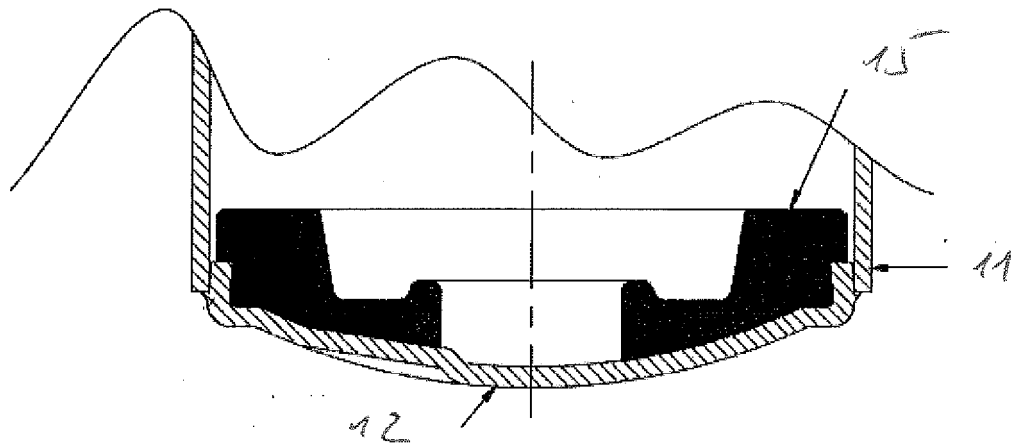


Fig. 10

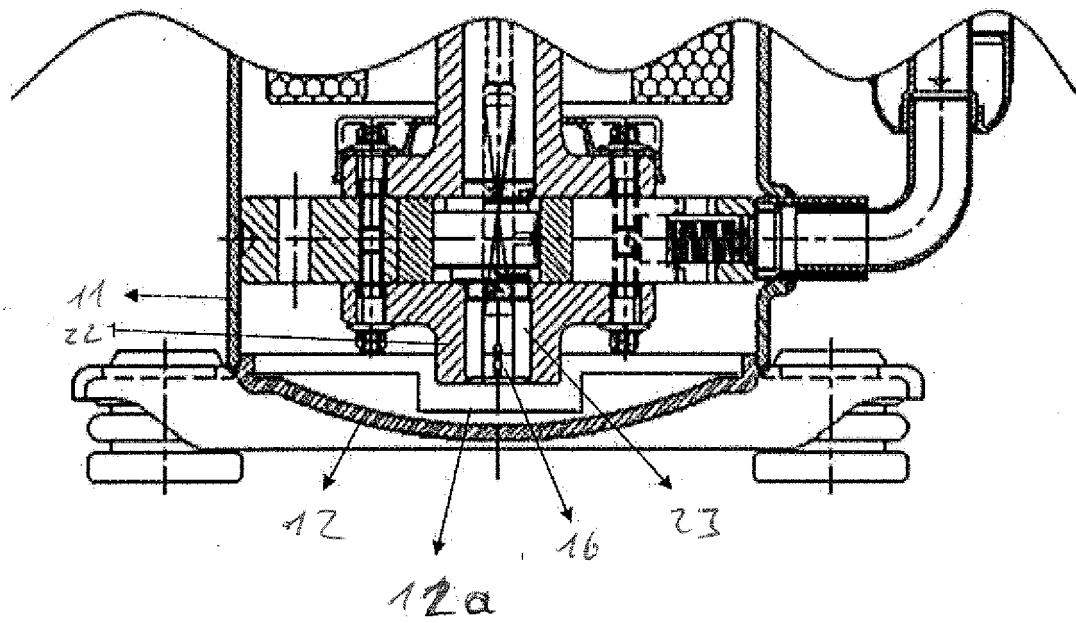


Fig. 11



EUROPEAN SEARCH REPORT

 Application Number
 EP 17 17 7913

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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)
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