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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
19 May 2005 (19.05.2005)

PCT

(10) International Publication Number
WO 2005/045249 A1

(51) International Patent Classification[7]: F04C 18/02, F01C 17/00, F04C 29/00, 27/00

(21) International Application Number: PCT/GB2004/004213

(22) International Filing Date: 4 October 2004 (04.10.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0325006.5 27 October 2003 (27.10.2003) GB

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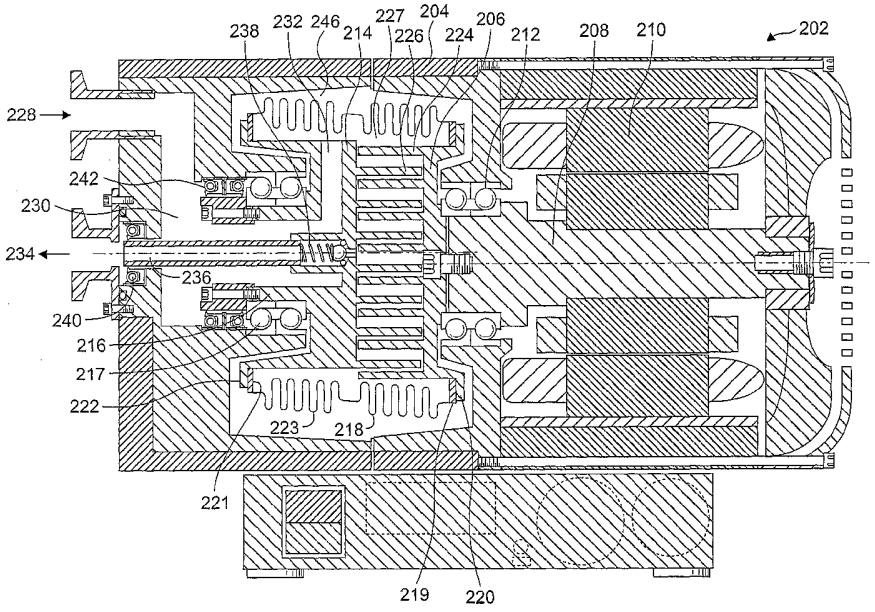
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR,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

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

Published:
— *with international search report*

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

(54) Title: SCROLL-TYPE VACUUM PUMP



(57) Abstract: Scroll-type pumping apparatus comprises a housing (204), a driving scroll member (206) having an end plate with a first spiral wrap (224) extending therefrom, a driven scroll member (214) having an end plate with a second spiral wrap (226) extending therefrom to intermesh with the first spiral wrap, and a bellows (218), attached at one end thereof to the driving scroll member and at the other end thereof to the driven scroll member, to drive the driven scroll member. The bellows further serves to separate a vacuum space (227) in the apparatus from ambient atmosphere (246).

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SCROLL-TYPE VACUUM PUMP

The present invention relates to scroll-type apparatus and, more particularly, to scroll-type apparatus for use in vacuum pumps.

Scroll-type apparatus is known for operating compressors or vacuum pumps. In both cases the apparatus comprises two scroll members each comprising a flat end plate on which are upstanding strips defining a spiral (or scroll) type structure which interact by placing the scroll members together with the respective spiral type structures inter-engaging and allowing one scroll member to "orbit" relative to the other. In this way it is possible to trap a volume of gas between the scroll members thereby to urge the gas from one end of the respective spirals to the other. In a vacuum pump in particular the gas enters via a pump inlet at the periphery of the scroll members and exits via a pump outlet at the centre of the scroll members.

Traditionally, one of the scroll members remains stationary, whilst the other scroll member is caused to "orbit" relative to the stationary member. For example, Figure 1 illustrates one known arrangement of such scroll-type apparatus in the form of a vacuum pump 2 which includes a housing 4 to which is mounted a fixed scroll member 6. Complimenting the fixed scroll member 6 and intermeshing therewith in a manner known per se is an orbital scroll member 8. The orbital member 8 is mounted on bearings 10, which are supported on a crank end 12 of a drive shaft 14 which extends from a motor 16. Bearings 17 serve to support the drive shaft 14 relative to the housing 4. Each scroll member 6, 8 includes an end plate to which is attached and from which extends outwardly therefrom a spiral wrap 18, 20. The height of each wrap 18, 20 is substantially the same as the distance between the opposed end plates so that the free edge of each wrap 18, 20 forms a seal against the face of the complimentary scroll member end plate. To assist in the sealing process, tip seals (not shown) may be provided at the free edge of each wrap 18, 20. In use, a pumped gas is drawn into the pump 2 from inlet 22 and exits via outlet 24 and non-return valve 25. In order to seal the

vacuum space in the housing 4 from ambient atmosphere and the pump drive system, a metal bellows 26 is disposed substantially co-axially with the drive shaft 14. The metal bellows is attached at one end by bolts 28 to the orbital scroll member 8 and at its opposite end to a stationary part 30 of the pump by bolts 32. O-rings 29, 31 serve to seal the attachment of the metal bellows 26. By virtue of the torsional stiffness of the metal bellows 26, the bellows 26 also serves to limit undesirable travel in the circular translation of the orbital scroll member 26 and thus maintain the correct angular position between the fixed scroll member 6 and the orbital scroll member 8. However, the use of such axial bellows restricts the design of any vacuum pump incorporating such bellows to the dimensions of adequately sized axial bellows having the required torsional stiffness and sufficient radial freedom for required crank throw to achieve in practice an infinite life.

It is one aim of the present invention to provide a scroll-type apparatus, which provides more freedom in the design of, for example, a pump incorporating such apparatus.

In a first aspect, the present invention provides apparatus, such as a scroll-type vacuum pump, comprising a housing, a fixed scroll member having an end plate with a first spiral wrap extending therefrom, an orbital scroll member having an end plate with a second spiral wrap extending therefrom to intermesh with the first spiral wrap, a shaft for driving the orbital scroll member, and a flexible annulus mounted to separate a vacuum space in the housing from ambient atmosphere and to prevent rotation of the orbital scroll member.

Preferably, the annulus is attached at one end thereof to the orbiting scroll and at the other end thereof to the housing.

Preferably, the annulus comprises a plurality of convolutions extending between the inner periphery and the outer periphery thereof. Preferably, each convolution is curved, and may follow a respective involute path.

The use of a flexible annulus rather than a metal bellows both to separate a vacuum space in the housing from ambient atmosphere and to prevent rotation of the orbital scroll member can allow for many design modifications of, for example, a vacuum pump incorporating the scroll-type apparatus in view of the substantial reduction in pump length in comparison to a similar type of pump incorporating axial bellows.

In the traditional scroll-type apparatus having a fixed scroll member and an orbiting scroll member illustrated in Figure 1, to achieve efficient performance and reduce back leakages in the pump clearances are minimised and speeds are maximised. As the speed of the pump increases, the inertia load on the orbiting scroll bearing 10 increases in proportion to the square of the pump speed, and so operation at high speeds requires the use of large and costly bearings. In order to avoid high inertia loads, another known form of scroll-type apparatus replaces the fixed scroll member and orbiting scroll member with two co-rotating scrolls synchronised to each other by means of an Oldham coupling. However, there are a number of problems associated with the use of Oldham couplings. For example, such couplings are prone to wear, and vibration thereof during use of the apparatus can generate undesirable noise. With severe wear, synchronisation between the scrolls can be lost.

In a second aspect, the present invention provides scroll-type pumping apparatus comprising a housing, a driving scroll member having an end plate with a first spiral wrap extending therefrom, a driven scroll member having an end plate with a second spiral wrap extending therefrom to intermesh with the first spiral wrap, and a flexible member connected between the driving scroll member and the driven scroll member to separate a vacuum space in the housing from ambient atmosphere and to drive the driven scroll member.

Preferably, the flexible member is attached at one end thereof to the driving scroll member and at the other end thereof to the driven scroll member.

Preferably, the flexible member is attached directly to the driving scroll member and the driven scroll member. For example, the flexible member may be attached to a first radial flange of the driving scroll member and to a second radial flange of the driven scroll member. Preferably, the flexible member comprises a bellows surrounding the first and second spiral wraps.

The apparatus preferably comprises a drive shaft for rotating the driving scroll member, the driven scroll member being mounted on a driven scroll member shaft axially offset from the drive shaft. The flexible member is preferably arranged to separate the vacuum space from the drive shaft.

Preferably, the driven scroll member shaft includes means in fluid communication with the vacuum space for discharging fluid therefrom. For example, the means for discharging fluid from the vacuum space may comprise a conduit substantially co-axial with the driven scroll member shaft.

Preferably, the driven scroll member includes means in fluid communication with the vacuum space for introducing fluid thereto. For example, the means for introducing fluid to the vacuum space may comprise a radially extending conduit passing through the driven scroll member.

In a third aspect the present invention provides scroll-type pumping apparatus comprising a driving scroll member having an end plate with a first spiral wrap extending therefrom, a driven scroll member having an end plate with a second spiral wrap extending therefrom to intermesh with the first spiral wrap, and a bellows, attached at one end thereof to the driving scroll member and at the other end thereof to the driven scroll member, to drive the driven scroll member.

In a fourth aspect the present invention provides use of a bellows in a scroll-type apparatus having a driving scroll member and a driven scroll member, to drive the driven scroll member.

The use of a flexible member such as a bellows connected between the scroll members to drive the driven scroll member can avoid the problems associated with the wear of an Oldham coupling whilst also serving to separate a vacuum space from ambient atmosphere. This can enable the number of shaft seals in the pumping mechanism to be reduced in comparison to pumps using Oldham couplings.

Preferred features of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a cross-section through a known scroll-type vacuum pump;

Figure 2 is a cross-section through a first embodiment of a scroll-type vacuum pump;

Figure 3 is an isometric view of a flexible annulus of the pump of Figure 2; and

Figure 4 is a cross-section through a second embodiment of a scroll-type vacuum pump.

With reference to Figure 2, a first embodiment of a scroll-type apparatus is in the form of a vacuum pump 102 which includes a housing 104 to which is mounted a fixed scroll member 106. Complimenting the fixed scroll member 106 and intermeshing therewith in a manner known per se is an orbital scroll member 108. The orbital member 108 is attached to a drive shaft 112, which extends from a motor 114. Bearings 116 serve to support the drive shaft 112 relative to the housing 104. Each scroll member 106, 108 includes an end plate to which is attached and from which extends outwardly therefrom a spiral wrap 118, 120. The height of each wrap 118, 120 is substantially the same as the distance between the opposed end plates so that the free edge of each wrap 118, 120 forms a seal against the face of the complimentary scroll member end plate. To assist in the sealing process, tip seals (not shown) may be provided at the free edge of each

wrap 118, 120. In use, a pumped gas is drawn into the pump 102 from inlet 122 at the periphery of the scroll members 106, 108. A volume of gas is trapped between the scroll members 106, 108 and is urged from the outer end of the wraps 118, 120 to the inner end for discharge via pump outlet 124. Non-return valve 125 prevents gas entering the pump via the outlet 124. In order to seal the vacuum space 126 in the housing 104 from ambient atmosphere and the pump drive system, in particular from the motor 114 and bearings 116, a flexible annulus 128 is provided. The annulus 128 is attached at one end to the orbiting scroll 108, and at the other end to the housing 104 by any suitable attachment means. For example, as shown in Figure 2 the annulus 128 may be provided with inner and outer flanges 130, 132 for securing between respective parts of the orbiting scroll 108 and the housing 104.

As shown in Figure 3, the annulus 128 is in the form of a substantially flat disc with curved convolutions 134 following an involute or similar profile radiating from the inner flange 130 to the outer flange 132. This form of convolutions 134 allow radial movement of the inner flange 130 relative to the outer flange 132 with circular translational movement of the orbiting scroll 108. The annulus 128 may be formed from any suitable material, such as metallic or plastics material, having a sufficient torsional stiffness so as to maintain the correct angular position between the scroll members 106, 108.

In comparison to the prior scroll-type apparatus illustrated in Figure 1, this embodiment of scroll-type apparatus can allow for many design modifications of, for example, a vacuum pump incorporating the apparatus in view of the substantial reduction in pump length in comparison to the prior apparatus. In particular, the shorter structural distance between the end plate of scroll member 108 and bearings 116 in Figure 2 in comparison to the distance between the end plate of the scroll member 8 and bearings 17 in Figure 1 can give rise to improvements in manufacturing and assembly alignment tolerance stack. This reduction in structural distance can also reduce operating deflections, thereby improving scroll alignment. The reduced length of the pump housing 104 and drive shaft length

can also substantially reduce pump weight and reduce costs. Furthermore, improved cooling of the bearings 116 is afforded by virtue of the annulus 128 being positioned between the orbiting scroll 108 and bearings 116.

Turning now to Figure 4, a second embodiment of a scroll-type apparatus is in the form of a vacuum pump 202 which includes a housing 204 to which is mounted a driving scroll member 206. The driving scroll member 206 is attached to a drive shaft 208, which extends from a motor 210. Bearings 212 serve to support the drive shaft 208 relative to the housing 204. Complimenting the driving scroll member 206 and intermeshing therewith in a manner known per se is a driven scroll member 214. A driven scroll member shaft 216 is axially offset from the drive shaft 208. Bearings 217 support the driven scroll member shaft 216 relative to the housing 204; placing the bearings 217 proximate the driven scroll member 214 assists in the accurate alignment of the scroll members 206, 214.

The driven scroll member 214 is connected to and driven by the driving scroll member 206 by a flexible member such as, as shown in Figure 4, a bellows 218. One end 219 of the bellows 218 is attached to a radial flange 220 of the driving scroll member 206 and the other end 221 of the bellows 218 is attached to a radial flange 222 of the driven scroll member 214. The bellows 218 may be attached to the scroll members by any suitable means, for example, by means of the attachment, using adhesive or fixings, of flanges formed on the ends 219, 221 of the bellows 218 to the radial flanges 220, 222. The bellows 218 comprises a plurality of convolutions 223 to permit eccentric movement of the driven scroll member 214 relative to the drive scroll member 206. The bellows 218 may be formed from any suitable material, such as metallic or plastics material, having a sufficient torsional stiffness so as to maintain synchronicity between the scroll members.

Each scroll member 206, 214 includes an end plate to which is attached and from which extends outwardly therefrom a spiral wrap 224, 226. The height of each wrap 224, 226 is substantially the same as the distance between the opposed end

plates so that the free edge of each wrap 224, 226 forms a seal against the face of the complimentary scroll member end plate. To assist in the sealing process, tip seals (not shown) may be provided at the free edge of each wrap. The wraps 224, 226 are surrounded by the bellows 218, which thus serves to separate a vacuum space 227 in the housing 204 from ambient atmosphere, in particular from the drive mechanism for the drive scroll member 206 and bearings 217.

In use, the driving scroll member 206 is rotated by the motor 210. In turn, the driven scroll member 214 is driven by bellows 218 to rotate synchronously with the driving scroll member. A pumped gas is drawn into the pump 202 from inlet 228. The drawn gas flows through a sealed conduit 230 in the housing 204 to the scroll members 206, 214 via a radially extending conduit 232 passing through the driven scroll member 214. A volume of gas is trapped between the scroll members and is urged from the outer end of the wraps 224, 226 to the inner end for discharge via pump outlet 234 in fluid communication with a discharge conduit 236 located inside the driven shaft 216. Non-return valve 238 prevents gas entering the pump via the outlet 234. Seal 240 prevents leakage of compressed gas into the conduit 230, whilst seal 242 seals the conduit 230 from the bearings 217. Any heat generated in the rotating scroll members 206, 214 is dissipated via the bellows into the ambient atmosphere 246 surrounding the bellows 218.

In summary, scroll-type pumping apparatus comprises a housing, a driving scroll member having an end plate with a first spiral wrap extending therefrom, a driven scroll member having an end plate with a second spiral wrap extending therefrom to intermesh with the first spiral wrap, and a bellows, attached at one end thereof to the driving scroll member and at the other end thereof to the driven scroll member, to drive the driven scroll member. The bellows further serves to separate a vacuum space in the apparatus from ambient atmosphere.

CLAIMS

1. Scroll-type pumping apparatus comprising a housing, a driving scroll member having an end plate with a first spiral wrap extending therefrom, a driven scroll member having an end plate with a second spiral wrap extending therefrom to intermesh with the first spiral wrap, and a flexible member connected between the driving scroll member and the driven scroll member to separate a vacuum space in the housing from ambient atmosphere and to drive the driven scroll member.

2. Apparatus according to Claim 1, wherein the flexible member is attached at one end thereof to the driving scroll member and at the other end thereof to the driven scroll member.

3. Apparatus according to Claim 2, wherein the flexible member is attached directly to the driving scroll member and the driven scroll member.

4. Apparatus according to Claim 3, wherein the flexible member is attached to a first radial flange of the driving scroll member and to a second radial flange of the driven scroll member.

5. Apparatus according to any preceding claim, wherein the flexible member comprises a bellows surrounding the first and second spiral wraps.

6. Apparatus according to any preceding claim, comprising a drive shaft for rotating the driving scroll member, the driven scroll member being mounted on a driven scroll member shaft axially offset from the drive shaft.

7. Apparatus according to Claim 6, wherein the flexible member is arranged to separate the vacuum space from the drive shaft.

8. Apparatus according to Claim 6 or 7, wherein the driven scroll member shaft includes means in fluid communication with the vacuum space for discharging fluid therefrom.

9. Apparatus according to Claim 8, wherein said means for discharging fluid from the vacuum space comprises a conduit substantially co-axial with the driven scroll member shaft.

10. Apparatus according to any preceding claim, wherein the driven scroll member includes means in fluid communication with the vacuum space for introducing fluid thereto.

11. Apparatus according to Claim 10, wherein said means for introducing fluid to the vacuum space comprises a radially extending conduit passing through the driven scroll member.

12. Scroll-type pumping apparatus comprising a driving scroll member having an end plate with a first spiral wrap extending therefrom, a driven scroll member having an end plate with a second spiral wrap extending therefrom to intermesh with the first spiral wrap, and a bellows, attached at one end thereof to the driving scroll member and at the other end thereof to the driven scroll member, to drive the driven scroll member.

13. Use of a bellows in a scroll-type apparatus having a driving scroll member and a driven scroll member, to drive the driven scroll member.

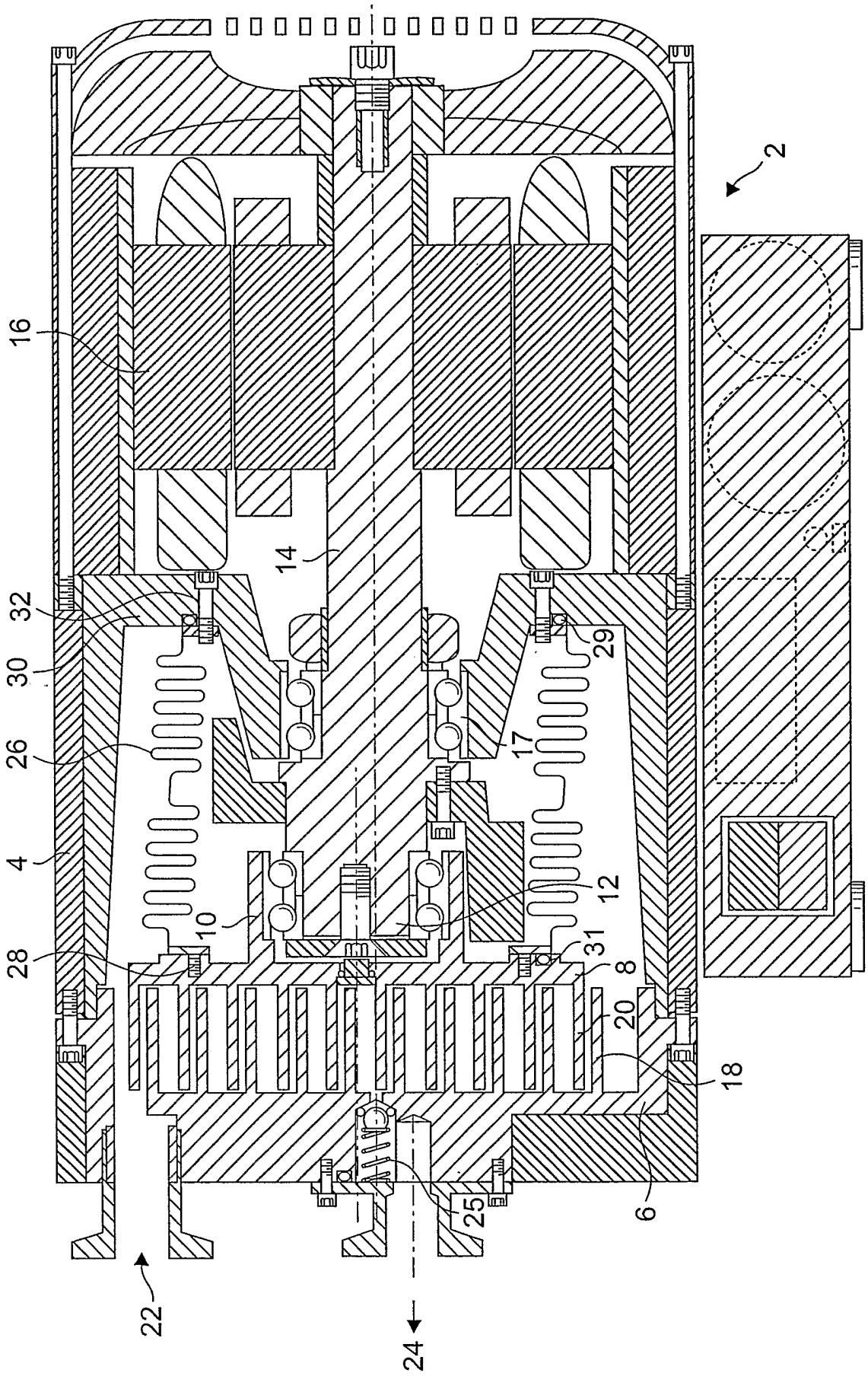

FIG. 1 (PRIOR ART)

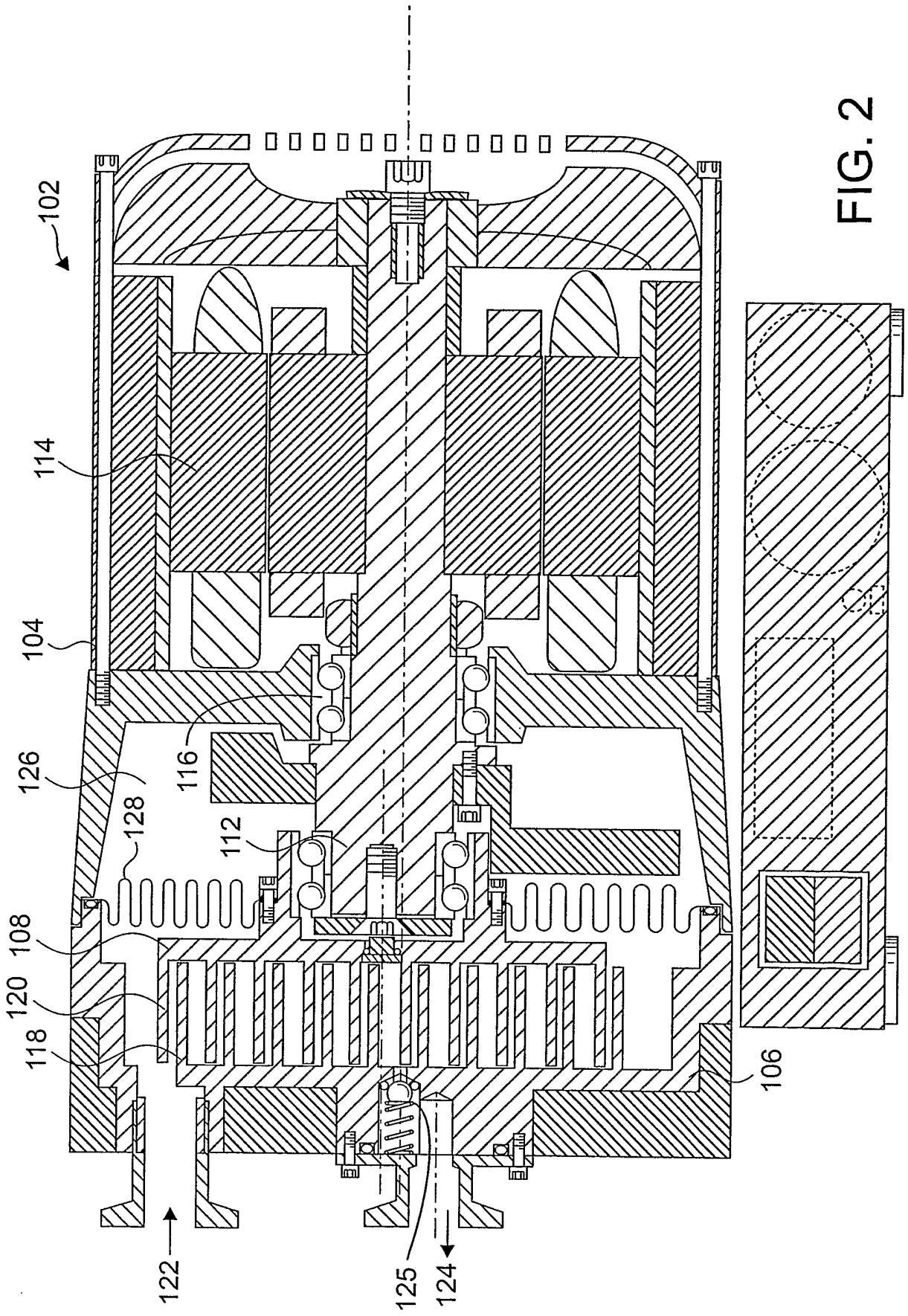

FIG. 2

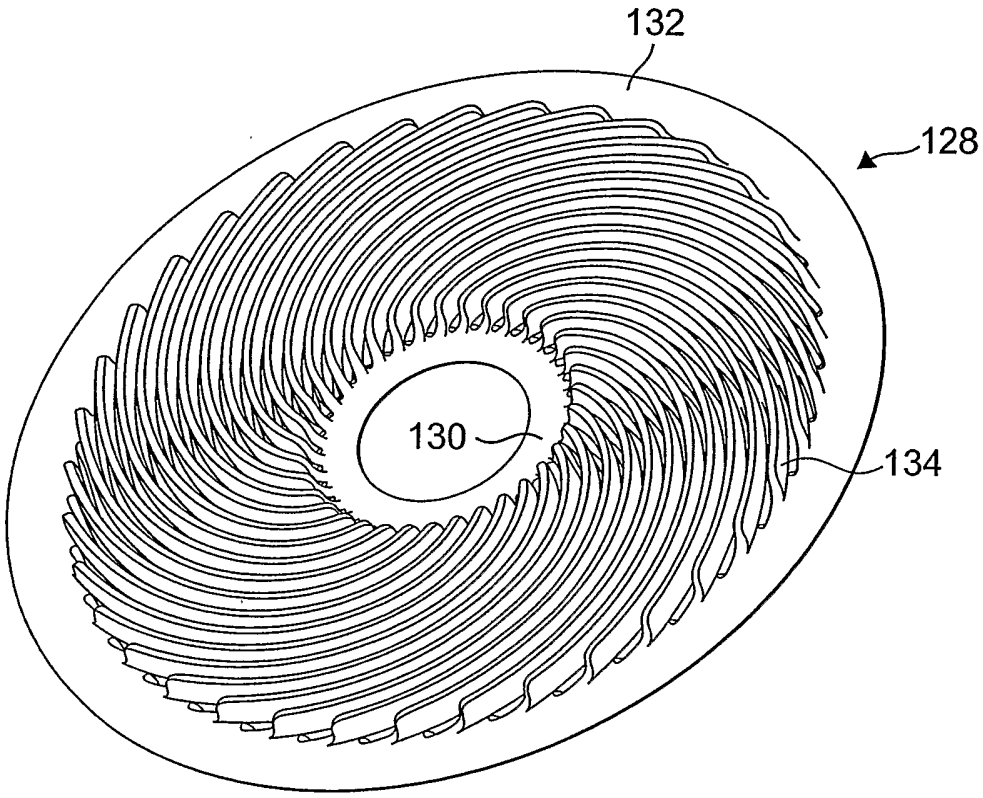

FIG. 3

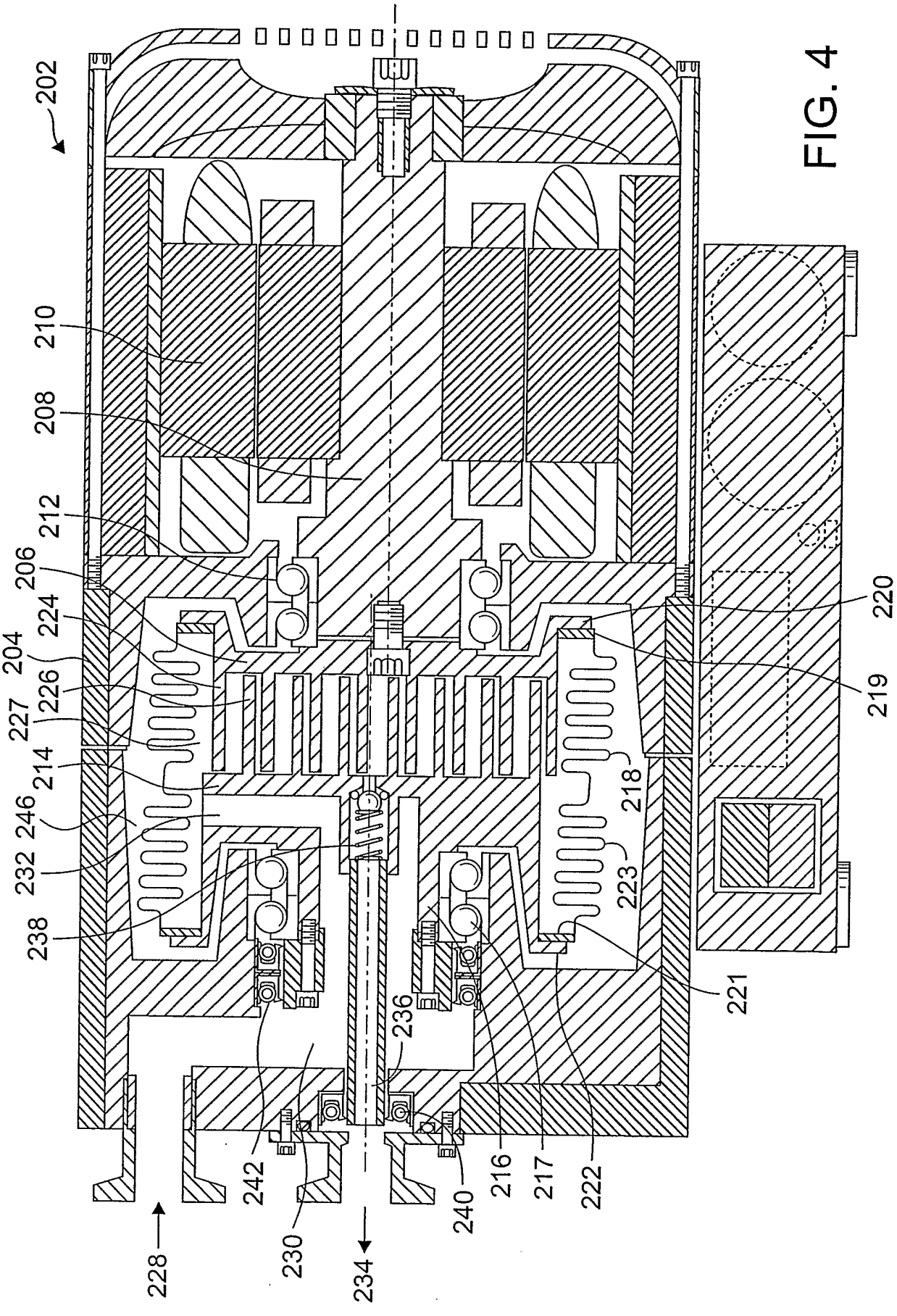
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FIG. 4

INTERNATIONAL SEARCH REPORT

tional Application No
PCT/GB2004/004213

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F04C18/02 F01C17/00 F04C29/00 F04C27/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F04C F01C

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	figures 1,2 column 2, line 13 - line 21 column 3, line 4 - line 37 claims 2,3	12,13
X	US 5 199 280 A (RIFFE DELMAR R ET AL) 6 April 1993 (1993-04-06) figures 2,3,8 column 2, line 56 - line 62 column 5, line 9 - column 6, line 12	12,13

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
8 December 2004	21/12/2004

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

Ir tional Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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