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(52) UK CL (Edition Q)
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(58) Field of Search
UK CL (Edition P) F2L , F2W
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ONLINE: WPI; EDOC.

(54) Abstract Title

A viscous coupling with plate apertures providing uniform moistening of the plates

(57) A viscous coupling comprises a housing 2 with outer plates 4 and a coaxial relatively rotatable hub 3 having inner plates 6. The outer and inner plates 4, 6 are arranged alternatively and have closed apertures 51 which are shaped so that, when the plates 4, 6 rotate relative to each other, a viscous fluid is pressed inward against centrifugal forces towards the couplings axis of rotation, thereby counteracting a separation of the viscous fluid and air. As a result, the plates 4, 6 are moistened uniformly which reduces the amount of wear and increases the service life of the coupling. The apertures 51 have delimiting faces 52, 53 which may be inclined to radius R and are joined by a base face 55 so as to form a drop shape. In other embodiments the apertures may be a different shape, eg see figs 4 and 6. Also the inner or outer plates may comprise slots 56 of differing configurations (eg see fig 5).

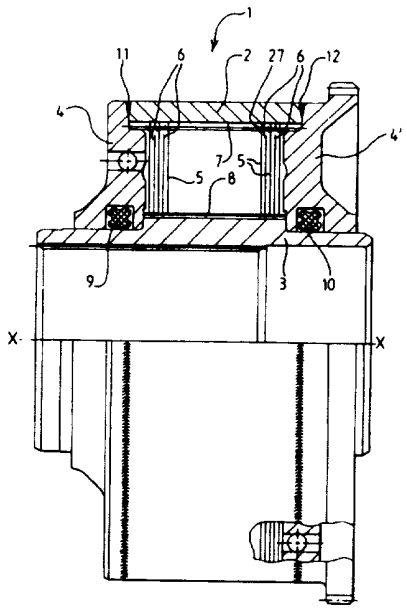

FIG 1

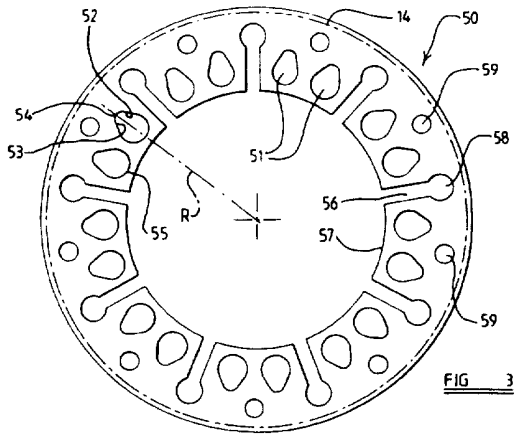

FIG 3

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

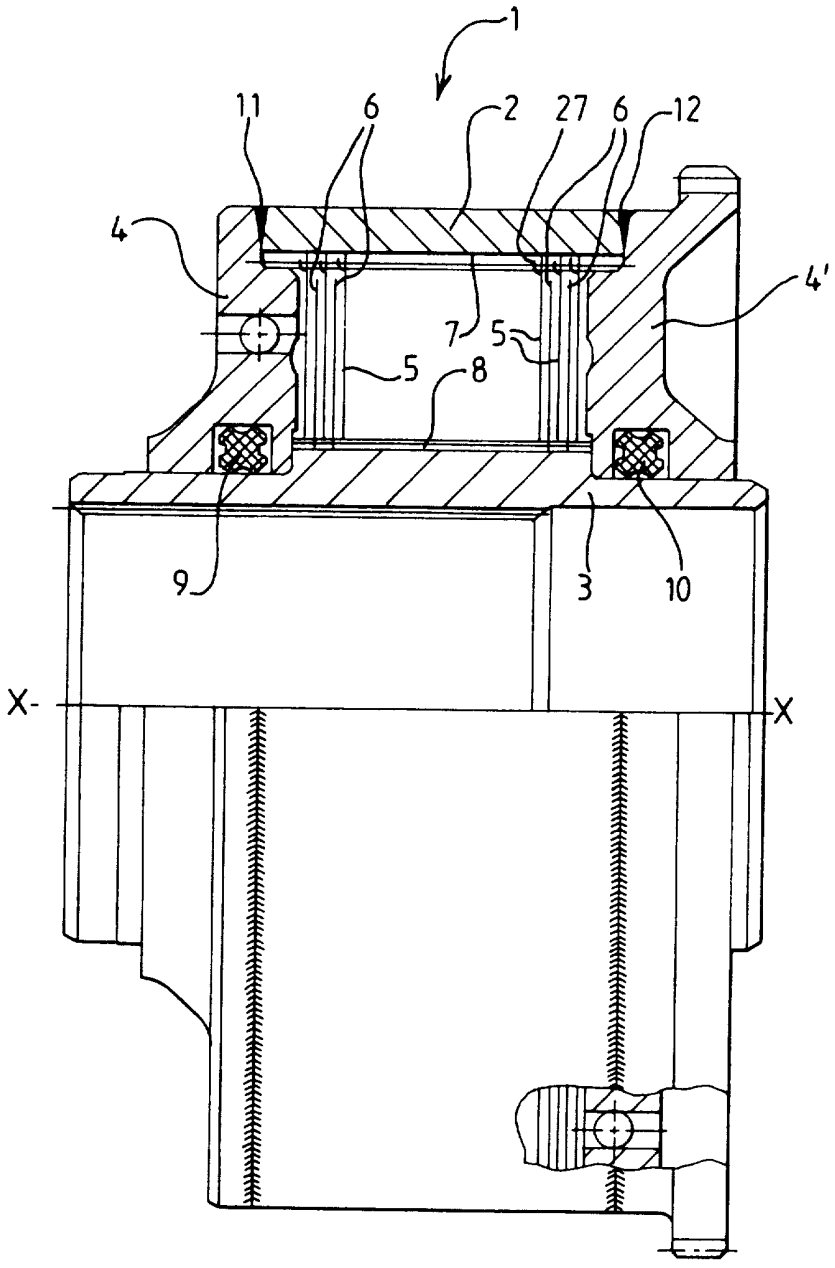

FIG 1

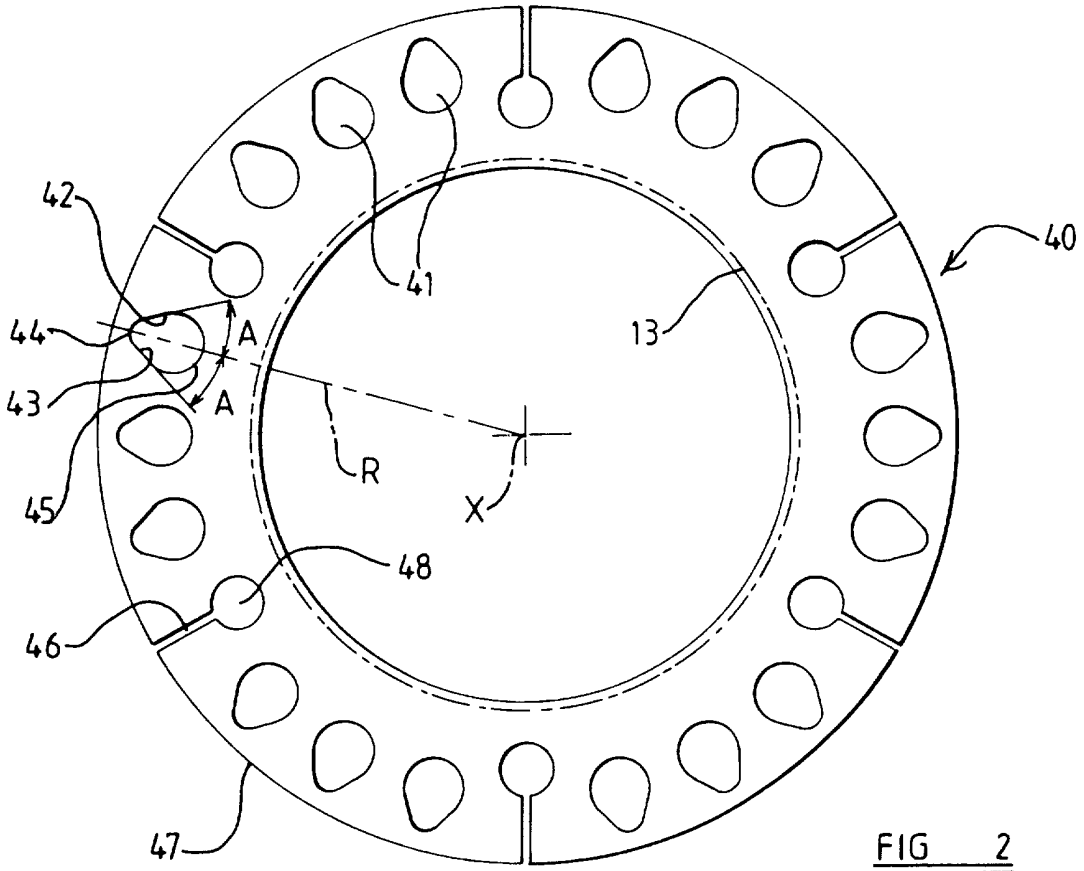

FIG 2

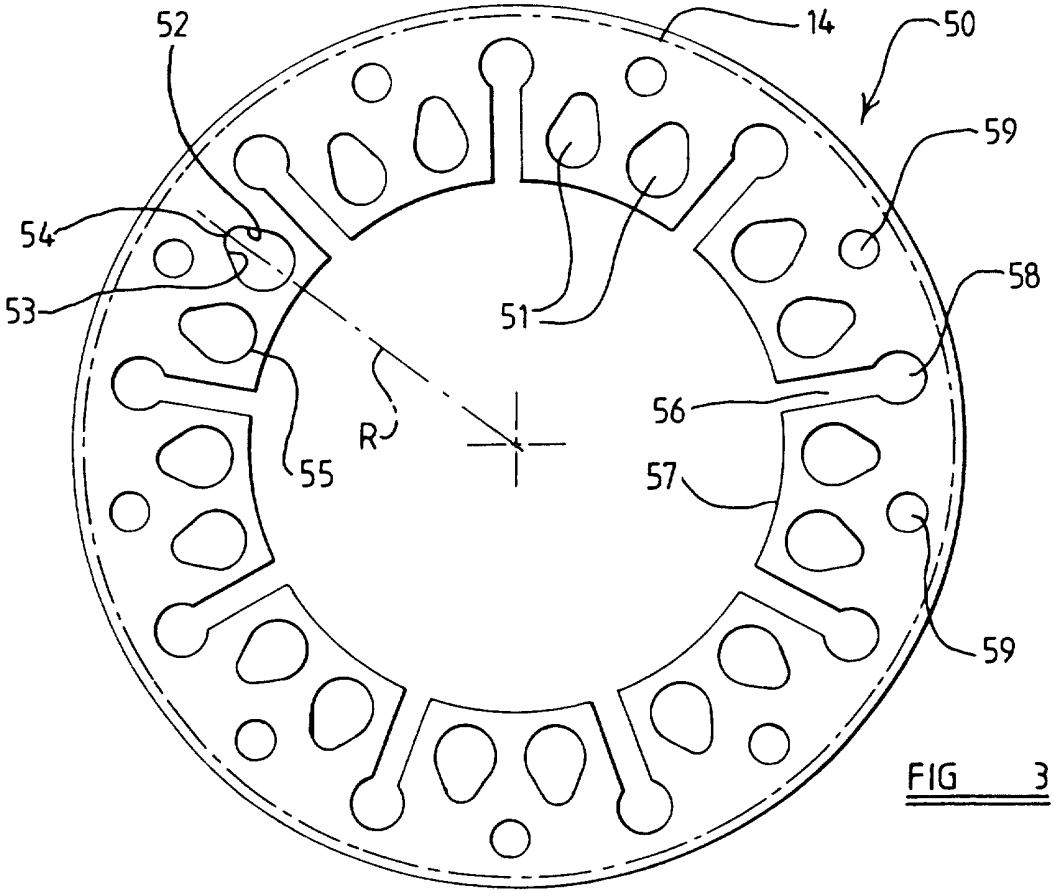

FIG 3

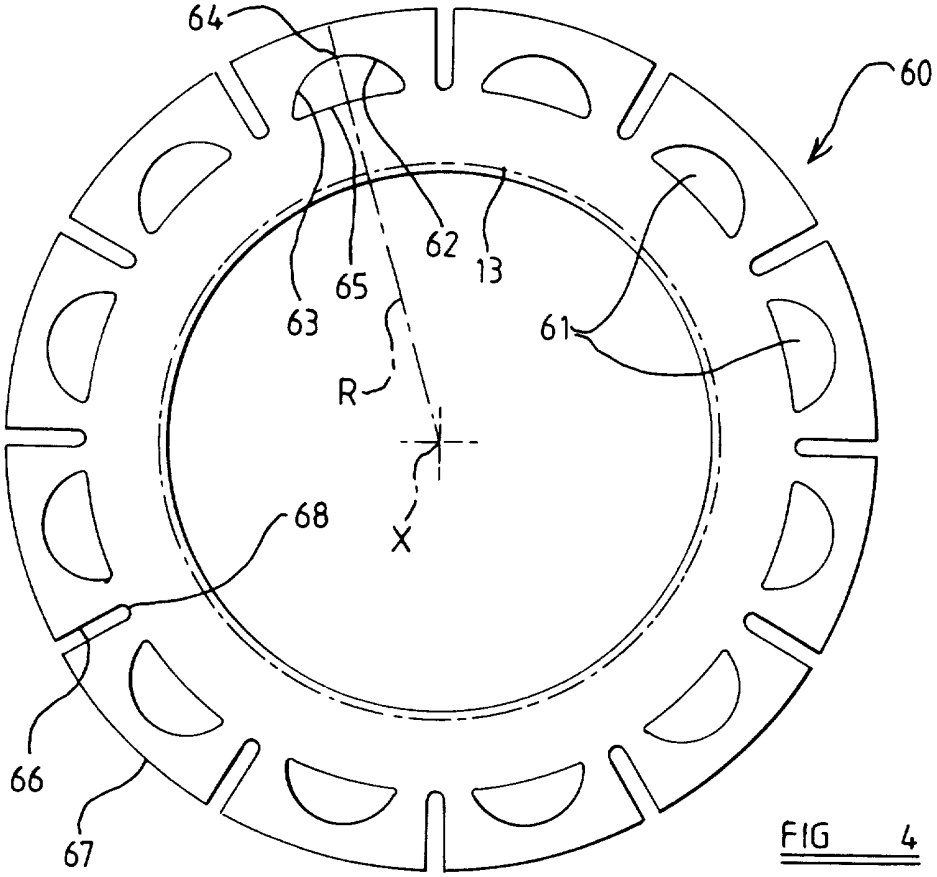

FIG 4

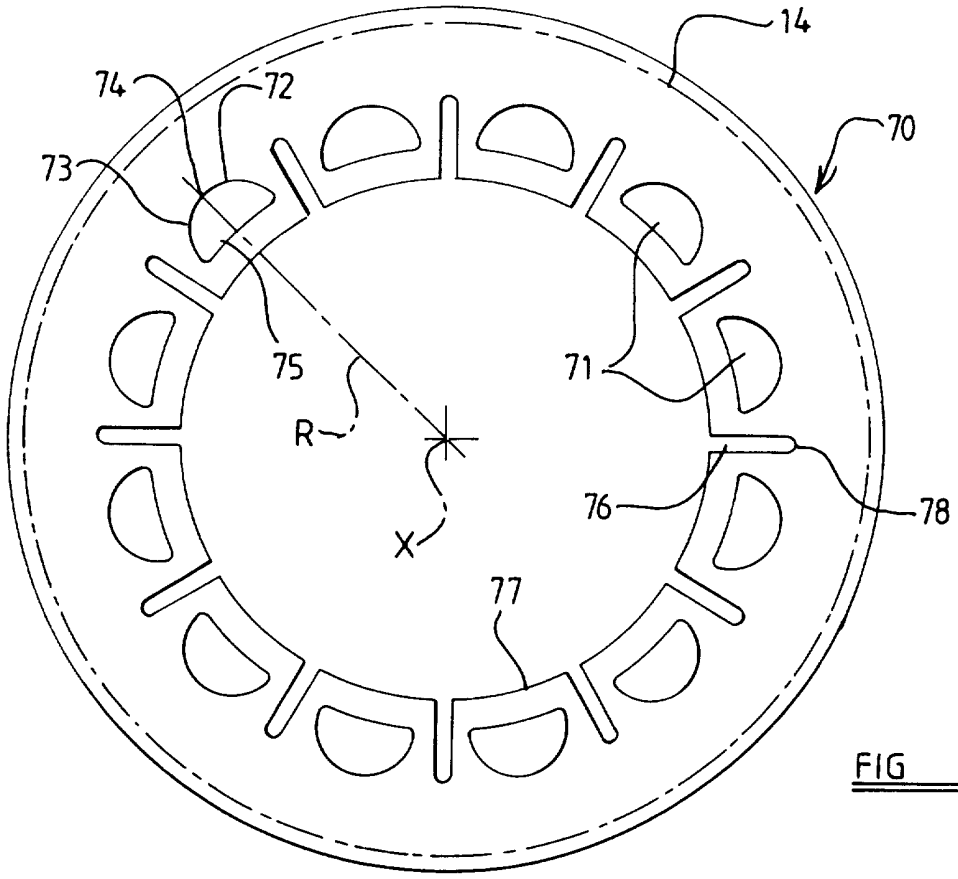

FIG 5

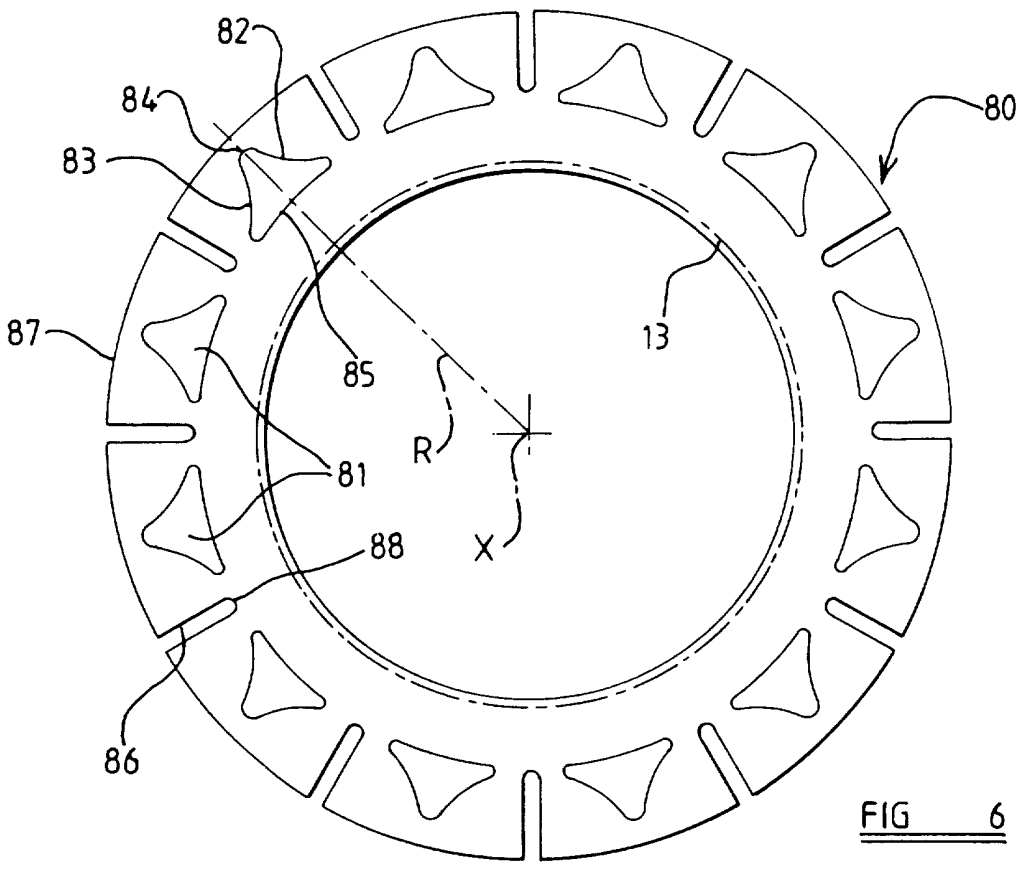

FIG 6

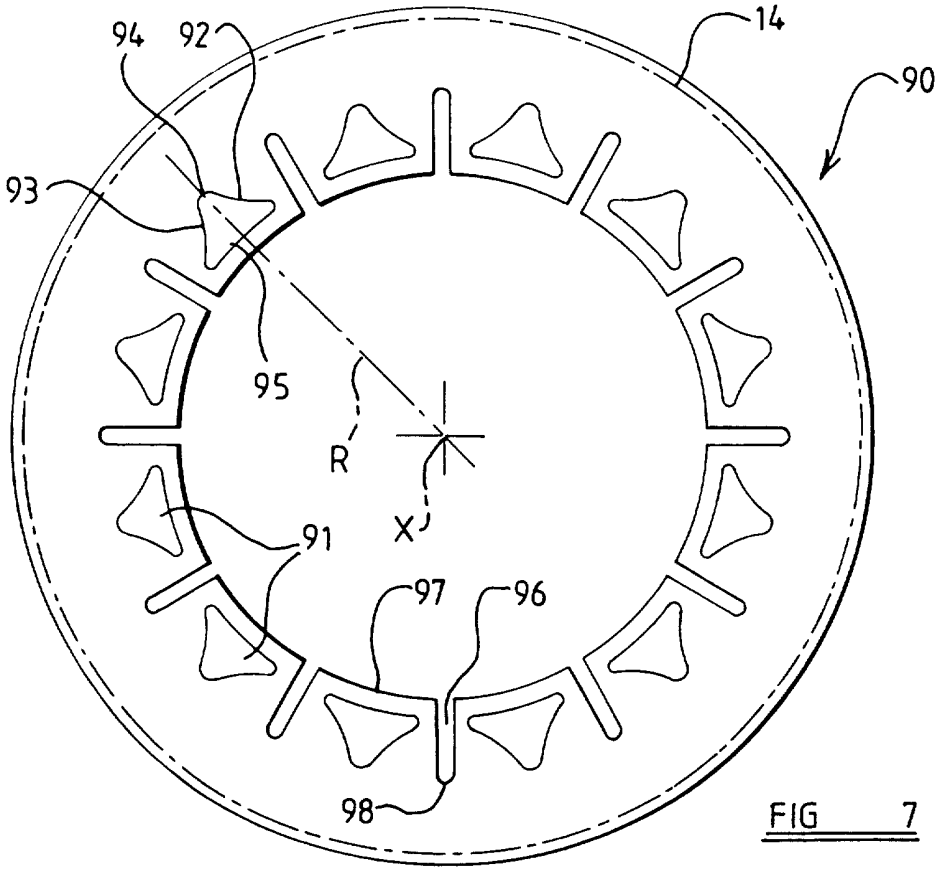

FIG 7

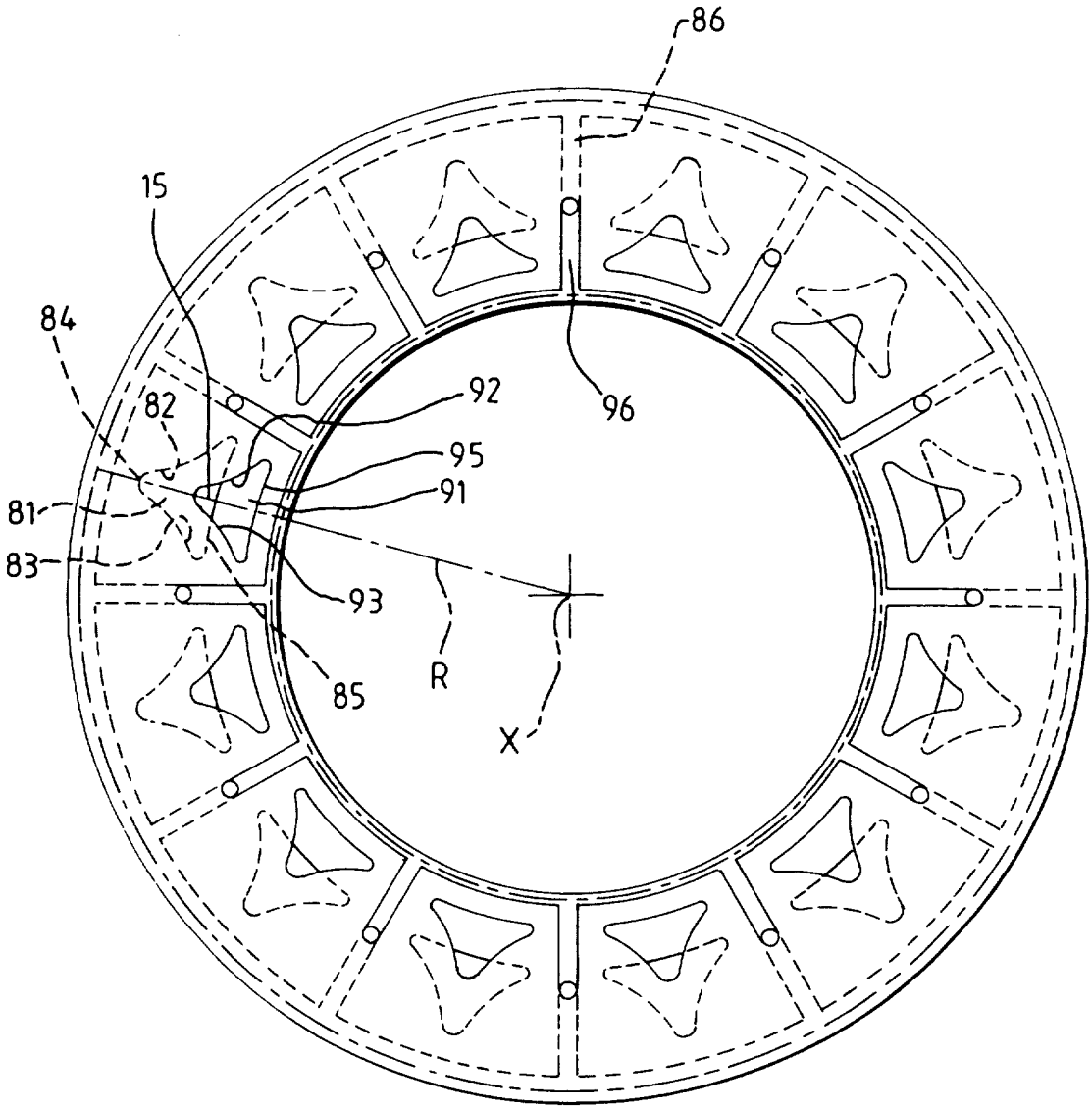

FIG 8

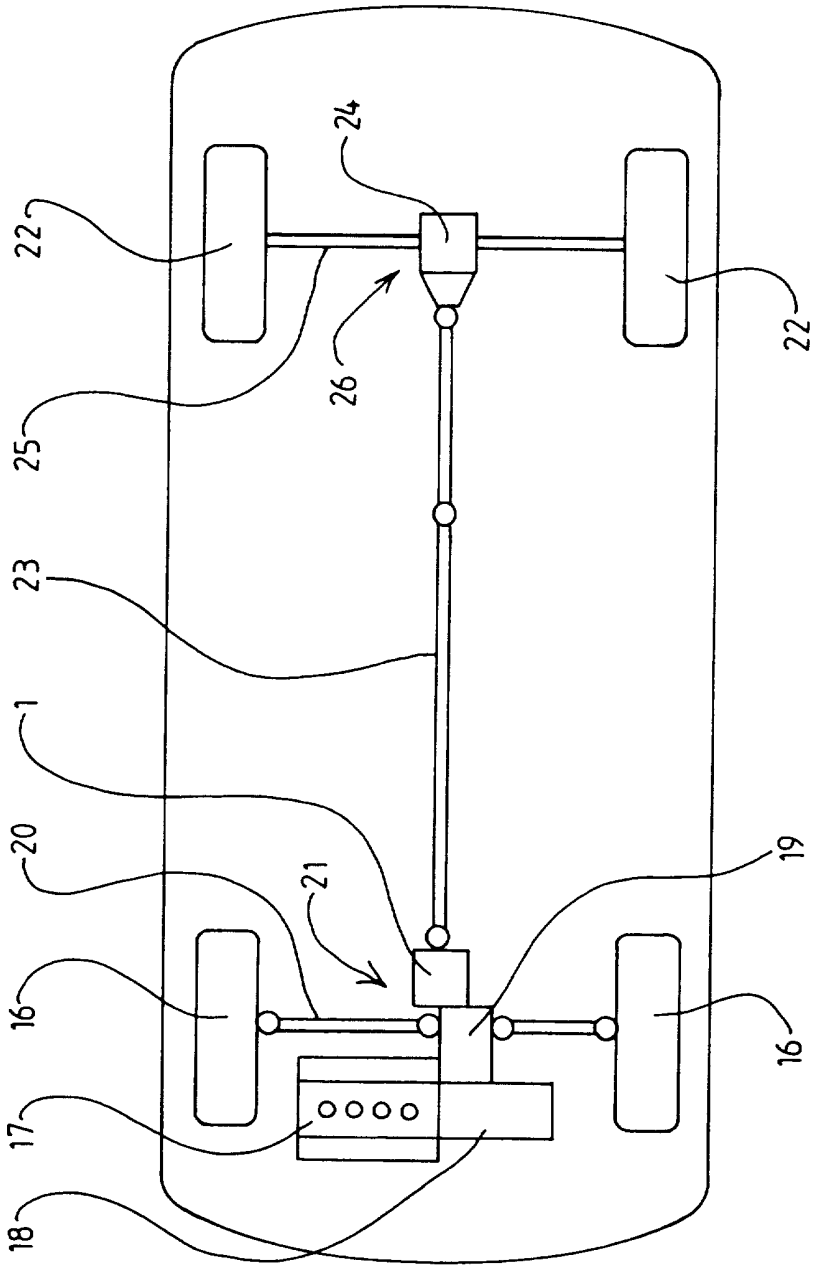

FIG 9

PATENTS ACT 1977

GMD/A9479GB

Title: VISCOUS COUPLING

Description of Invention

This invention relates to a viscous coupling having a housing and a hub which are arranged around an axis of rotation so as to be rotatable relative to one another and which form a closed unit; having a set of inner plates which are rotationally fast with the hub and a set of outer plates which are rotationally fast with the housing, with the plates of at least one set of plates being movable in the direction of the axis of rotation and with the inner plates and the outer plates being alternately arranged in the direction of the axis of rotation in a certain sequence while at least partially radially overlapping one another; the inner plates and/or the outer plates comprising apertures; and a viscous medium which at least partially fills the remaining spaces between the housing, the hub and the plates.

Viscous couplings can be used in the drivelines of motor vehicles. For example, if slip occurs at the front wheels of a front wheel drive vehicle, the rear wheels can be drivingly connected by means of a viscous coupling in a driveline which includes a second gearbox output, the viscous coupling, a propeller shaft, a differential and sideshafts.

From DE-OS-2135791 it is known to provide the plates associated with one set of plates with apertures in the form of bores. The plates of the other set comprise slots. By designing the plates in such a way, it is possible to improve the torque capacity of such couplings. Furthermore, the degree of heat dissipation is increased by improving the circulation of the viscous medium.

At high viscous coupling speeds such as they occur if the viscous coupling is used in the driveline of a motor vehicle and if the vehicle travels at a high speed, centrifugal forces acting on the viscous medium separate the

viscous medium and the air if, as usual, the viscous coupling is only partially filled with the viscous medium. In consequence, the inner regions of the plates, i.e. those regions positioned close to the axis of rotation, are either not moistened by the viscous medium or they are moistened to a lesser extent than the outer regions. As a result, wear symptoms occur at the inner regions at an earlier stage.

DE-3702299-C1 describes a viscous coupling wherein the inner and outer plates are provided with slots, with the slots of the inner plates and those of the outer plates intersecting one another. As a result, in the regions of intersection, there are formed cavities which extend from one plate to the next and which, in the case of a relative rotational movement of the plates relative to one another, move radially inwardly or outwardly, depending on the direction of rotation. This means that viscous medium is transported inwardly or outwardly, the purpose being to provide the coupling with a torque capacity which is dependent on the direction of rotation. However, when the viscous medium is transported outwardly, the separation of viscous medium and air at high coupling speeds is assisted, as a result of which plate wear is intensified.

It is the object of the present invention to provide a viscous coupling which, when the sets of plates rotate relative to one another, and independently of the direction of rotation, ensures a largely uniform distribution of the viscous medium in the region of plate overlap and acts against a separation of viscous medium and air caused by centrifugal forces at high viscous coupling speeds.

In accordance with the invention, the apertures of the plates of at least one set of plates each comprise two delimiting faces whose distance from a respective imaginary radius therebetween referring to the axis of rotation, starting from a vertex positioned on said imaginary radius, increases as the axis of rotation is approached, with the apertures, furthermore, being delimited by a base face which connects the delimiting faces.

Because both delimiting faces enclose an acute angle together with the imaginary radius, a force component acts in the direction of the axis of rotation on the viscous medium; it acts independently of the direction of rotation when the sets of plates rotate relative to one another. This means that the viscous medium flows specifically inwardly towards the axis of rotation. This specific inward flow of the viscous medium acts against the viscous medium flow generated by the centrifugal forces at high viscous coupling speeds and it also effectively acts against the separation of viscous medium and air. Furthermore, the inner regions of the opposed faces of the plates are moistened with viscous medium to a greater extent, as a result of which the plates are subjected to less wear and the service life of the viscous coupling is improved.

According to an advantageous embodiment, the apertures of both the inner plates and of the outer plates are each distributed on at least one imaginary circular line around the axis of rotation, with the apertures of the inner plates being offset relative to the apertures of the outer plates in the radial direction with reference to the axis of rotation in such a way that, when the hub is in a certain rotational position relative to the housing, said apertures overlap in certain regions and thus form through-flow channels between the apertures of the inner plates and the apertures of the outer plates.

This measure ensures that at the point in time when the apertures of adjoining plates partially overlap one another, the viscous medium is conveyed from the aperture of one plate into the aperture of another plate, as a result of which the viscous medium flows inwardly over a longer distance. The advantages of the viscous medium flowing inwardly towards the axis of rotation are thus intensified.

Furthermore, the delimiting faces and the base faces of the apertures can be shaped differently to achieve different flow characteristics as a function of the rotational movement. By changing the angle enclosed by the delimiting faces and the imaginary radius, it is possible to vary the force component

inwardly in the direction of the axis of rotation. As a result, it is possible to achieve different flow intensities of the viscous medium. By providing the delimiting faces and/or the base faces of the apertures with a curved shape, it is possible to achieve different flow conditions inside the apertures, as a result of which it is possible to improve the transport of the viscous medium from the aperture of one plate into the aperture of another plate.

According to a further embodiment it is proposed to achieve a thermal and mechanical stress relief. For this purpose, the plates, in addition to the apertures, are provided with slots which are positioned on respective imaginary radii referring to the axis of rotation and which are open towards a circumferential face.

Preferred embodiments of the invention will be described below with reference to the drawings, wherein:-

Figure 1 is a side view of a viscous coupling which is partially shown in a longitudinal section;

Figures 2, 4 and 6 are views of different embodiments of an inner plate;

Figures 3, 5 and 7 are views of different embodiments of an outer plate;

Figure 8 is a view showing an overlap of an outer plate according to Figure 7 and an inner plate according to Figure 6;

Figure 9 shows the drive concept of a front wheel drive vehicle with one possible application for a viscous coupling.

To the extent that the details of Figures 1 to 9 correspond to one another, they are given the same reference numbers, but increased by the factor 10.

The viscous coupling 1 shown in Figure 1 comprises a housing 2 and a hub 3 coaxially arranged relative to the housing 2, a cover 4, 4', and outer plates 5 and inner plates 6. The housing 2 is cylindrical, and on the inside of the cylindrical face, comprises axially extending toothing 7 with which the outer plates 5 engage in a rotationally fast way, with the outer plates 5, on their circumference, being provided with corresponding toothing. The hub 3 is

provided with a set of axially extending toothing 8 for connecting the internally toothed inner plates 6 in a rotationally fast way.

In this embodiment, the inner plates 6 are axially movable. The outer plates 5 are provided with spacing means 27 arranged between the plates and are axially immovably held by the covers 4, 4' in the housing 2.

The housing 2 is sealed relative to the hub 3 by seals 9 and 10. Furthermore, the cover 4, 4' is securely and sealingly connected to the housing 2 by welds 11, 12. The remaining space between the housing 2, the hub 3, the covers 4, 4' and the plates 5, 6 is at least partially filled with a viscous medium, especially high-viscosity silicone oil. When the hub 3 and the inner plates 6 rotate relative to the housing 2 and the outer plates 5, torque is transmitted. In this context, it is necessary to differentiate between two operating conditions characterised by different torque transmission mechanisms. In one operating condition, the shear effect of the viscous medium in the region of overlap of the plates 5, 6 leads to a transmission of torque. In another operating condition, the so-called condition of hump, the inner plates 6 come into contact with the outer plates 5, as a result of which a torque generated by friction between the plates 5, 6 is transmitted. If the hub 3 and housing 2 rotate at the same speed around the axis of rotation X-X without the hump condition having previously occurred so that the hub 3 does not rotate relative to the housing 2, no torque is transmitted.

Figure 2 shows an inner plate 40 which corresponds to the inner plates 6 in Figure 1. To achieve a rotationally fast, but axially movable connection with the hub 3, the inner plate 40 is provided with a set of toothing 13 of which, however, only the reference diameter is shown. On an imaginary circle around the axis of rotation X-X, there are arranged drop-shaped apertures 41. The distance between the delimiting faces 42, 43 and the imaginary radius R, said distance starting from a vertex or extremity 44, increases in the inward direction for the purpose of avoiding a phase separation. The straight-flanked

portions of the delimiting faces 42, 43 and the radius R enclose an acute angle "A". The base faces 45 in the form of circular cut-outs close the apertures 41. Furthermore, there are provided slots 46 which are distributed on the circumference of the inner plate, which are open towards the outer circumferential face 47 and whose closed ends 48 each form a bore.

The outer plate 50 illustrated in Figure 3 corresponds to the outer plates 5 in Figure 1 and is provided with outer toothing 14 to achieve a rotationally fast arrangement and axial spacing by means of bent teeth in the housing 2, with only the reference diameter of the toothing 4 being shown. The apertures 51 are also drop-shaped, like those of the inner plate 40 in Figure 2. The delimiting faces 52, 53 and the base face 55 of an aperture 51 are designed in the same way as the corresponding delimiting faces 42, 43 and the base face 45 of the inner plate 40. The delimiting faces 52, 53 start from the vertex 54. The slots 56 are open towards the inner face 57 and outwardly closed by means of the end 58 in the form of a bore. Furthermore, circular apertures 59 are arranged on an imaginary circle whose diameter is greater than the diameter of the imaginary circle on which the drop-shaped apertures 51 are positioned.

Figures 4 and 6 show further differently designed inner plates 60, 80 which each are provided with inner toothing 13.

Figures 5 and 7 show correspondingly differently designed outer plates 70, 90 which are each provided with outer toothing 14.

The inner plate 60 according to Figure 4 comprises apertures 61 wherein the distance between the delimiting faces 62, 63 and the imaginary radius R extends degressively, i.e. as each face 62, 63 extends inwardly of the plate, its inclination to the respective imaginary radius R decreases. The apertures 61 alternate with circumferentially distributed slots 66 which are open towards the outer circumferential face 67 and which comprise a closed end 68.

The apertures 71 of the outer plate 70 according to Figure 5 correspond to the apertures 61 of the inner plate 60. The apertures 71 are arranged on an imaginary circle around the axis of rotation X-X which circle has a smaller diameter than the circle on which the apertures of the respective inner plates are positioned.

The embodiment of the inner plate 80 according to Figure 6 largely corresponds to the inner plate 60 of Figure 4, but it is provided with apertures 81 in the case of which the distance between the delimiting faces 82, 83 and the radius R extends progressively, i.e. the inclination of the faces to the radius R increases as they extend inwardly.

The apertures 91 of the outer plate 90 according to Figure 7 correspond to the apertures 81 of the inner plate 80. The apertures 91 are positioned on an imaginary circle around the axis of rotation X-X, which circle has a smaller diameter than the circle on which the apertures of the respective inner plates are positioned.

In Figure 8, the inner plate 80 and the outer plate 90 according to Figures 6 and 7 are shown in overlap. In the relative rotational position as shown, through-flow channels 15 are obtained due to the partial overlap of the apertures 81 and 91. If the inner plate 80 rotates anticlockwise, the viscous medium is pressed by the delimiting faces 82 inwards towards the axis of rotation X-X and at the time of overlap of the apertures 81 and 91 the viscous medium flows through the through-channel 15 from the aperture 81 into the aperture 91 of the outer plate 90 from where it is conveyed further inwardly.

Figure 9 shows the drive concept of a front wheel drive vehicle in which a viscous coupling as above described may be utilised. The front wheels 16 are driven by the engine 17 via the gearbox 18, the differential 19 and the sideshafts 20 of the front axle 21. Under normal driving conditions, the rear wheels 22 only roll along, so that the inner plates and outer plates do not rotate relative to one another in the viscous coupling 1. If the front wheels 16 are

subject to slip due to inadequate adhesive friction relative to the road surface, a rotational movement of the inner plates relative to the outer plates does occur in the viscous coupling 1, so that the rear wheels 22 are driven as well by means of the propeller shaft 23, the differential 24 and the sideshafts 25 of the rear axle 26.

The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, as appropriate, may, separately, or in any combination of such features, be utilised for realising the invention in diverse forms thereof.

CLAIMS

1. A viscous coupling having a housing and a hub which are arranged around an axis of rotation so as to be rotatable relative to one another and which form a closed unit; having a set of inner plates which are rotationally fast with the hub; and a set of outer plates which are rotationally fast with the housing, with the plates of at least one set of plates being movable in the direction of the axis of rotation and with the inner plates and the outer plates being alternately arranged in the direction of the axis of rotation in a certain sequence while at least partially radially overlapping one another; the inner plates and/or the outer plates comprising apertures; and a viscous medium which at least partially fills the remaining spaces between the housing, the hub and the plates; wherein the apertures of the plates of at least one set each comprise two delimiting faces whose distance from a respective imaginary radius therebetween referring to the axis of rotation, starting from a vertex positioned on said imaginary radius, increases as the axis of rotation is approached, and a base face which connects the delimiting faces.

2. A viscous coupling according to Claim 1, wherein the apertures of both the inner plates and of the outer plates are each distributed on at least one imaginary circular line around the axis of rotation, with the apertures of the inner plates being offset relative to the apertures of the outer plates in a radial direction with reference to the axis of rotation in such a way that, when the hub is in a certain rotational position relative to the housing, said apertures overlap in certain regions and thus form through-flow channels between the apertures of the inner plates and the apertures of the outer plates.

3. A viscous coupling according to Claim 1 or Claim 2, wherein the distance between each of the delimiting faces and the imaginary radius extends linearly.

4. A viscous coupling according to Claim 1 or Claim 2, wherein the distance between each of the delimiting faces and the imaginary radius extends progressively.

5. A viscous coupling according to Claim 1 or Claim 2, wherein the distance between each of the delimiting faces and the imaginary radius extends degressively.

6. A viscous coupling according to any one of the preceding claims, wherein each of the base faces of the apertures extends tangentially relative to an imaginary circular line around the axis of rotation.

7. A viscous coupling according to any one of Claims 1 to 5, wherein the base faces of the apertures are curved.

8. A viscous coupling according to any one of the preceding claims, wherein the inner plates and/or the outer plates comprise slots which are positioned on respective imaginary radii referring to the axis of rotation, with slots of the inner plates being open towards an outer circumferential face and slots of the outer plates being open towards an inner face.

9. A viscous coupling substantially as hereinbefore described with reference to Figures 1 to 8 of the accompanying drawings.

10. A motor vehicle having a drive line including a viscous coupling according to any one of the preceding claims.

11. Any novel feature or novel combination of features described herein and/or in the accompanying drawings.

The Patent Office

12

Application No: GB 9814607.9 **Examiner:** Mike McKinney
Claims searched: 1 to 10 **Date of search:** 27 August 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): F2L; F2W.

Int Cl (Ed.6): B60K 17/346, 17/35; F16D 35/00.

Other: ONLINE: WPI; EDOC.

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	GB 2200728 A (UNI-CARDAN)	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.