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(54) **METHOD AND SYSTEM FOR FEEDING A COOLING FLUID DURING MACHINING OF A WORKPIECE BY MEANS OF A CUP GRINDING WHEEL, AND CUP GRINDING WHEEL USED THEREIN**

(57) During machining of a workpiece (L) by means of a cup grinding wheel (8) controlled by a rotating spindle (3), coolant is fed into the area of contact between the annular front surface (91) of the cup grinding wheel (8) and the workpiece (L) being machined, by means of passages (81) formed in the body of the cup grinding wheel (8) and leading to said annular front surface (91). These passages (81) receive coolant fed by one or more coolant dispensers (10) arranged in fixed positions on the outside of the spindle (3) and configured to direct jets of coolant inside the cup grinding wheel body and through the aforesaid passageways leading to the annular front surface (91) of the cup grinding wheel (8). In the annular front surface (91) of the cup grinding wheel (8), at least one circumferential continuous groove (T) is formed that follows a wavy path, in order to cover a predominant portion of the radial extension of the aforesaid annular front surface (91) of the cup grinding wheel (8).

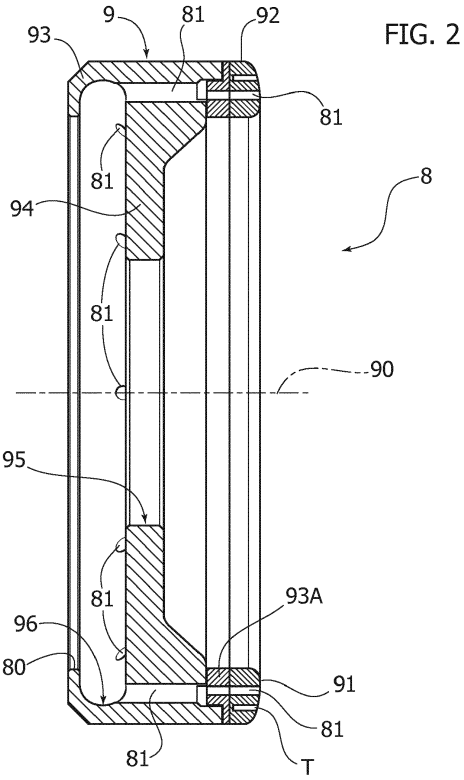

FIG. 2

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Description

Field of the invention

[0001] The present invention relates to a method and a system for feeding a coolant during machining of a workpiece by means of a cup grinding wheel, and a cup grinding wheel used therein.

Prior art

[0002] Cup grinding wheels are tools used for abrasion processes, comprising a cup-shaped body, with an annular front machining surface, typically incorporating diamond particles or other very hard materials. The cup grinding wheel is mounted on a rotating spindle and brought into contact with the surface to be machined in order to perform the required machining. Examples of machining by means of a cup grinding wheel are the machining of the edges of glass sheets or of natural or synthetic stone material, in so-called "bilateral" machines, in which the sheet to be machined is advanced horizontally along a longitudinal direction, while a pair of grinding wheels arranged on both sides of the sheet simultaneously perform the machining of the two side edges of the sheet parallel to the advancing direction. Cup grinding wheels are also used in other types of glass sheet or stone slab machining machines, for example, in work centers with numerical control of three or more axes, where a working head moves relative to a sheet kept in a fixed horizontal position on a work plane.

[0003] Whatever type of machine or type of machining in which it is used, the cup grinding wheel requires the feeding of coolant into the machining area. This is typically achieved by providing external nozzles held in a position adjacent to the grinding wheel and configured to send one or more jets of coolant adjacent to the surface portion of the workpiece with which the cup grinding wheel is in contact. To facilitate the distribution of the coolant, it is also known to form one or more grooves on the annular front surface of the cup grinding wheel, for example, circumferential circular grooves concentric with the grinding wheel body, or straight grooves in order to transversely cut the annular front surface, separating it into multiple sectors.

[0004] As an alternative to the distribution of coolant through nozzles, it has also been proposed to let the coolant flow into an inner passage of the rotating spindle on which the cup grinding wheel is mounted. However, this solution is complicated and costly, as it requires the provision of passages for the coolant through the electric motor driving the spindle, and the consequent provision of connection joints for feeding the coolant through the electric motor, arranged in such a way to ensure that the fluid does not contaminate the electric coiling or the mechanical parts of the electric motor.

[0005] On the other hand, the most conventional solutions do not allow optimum cooling because they are not able to feed the coolant exactly into the machining area, that it, in the area of contact between the cup grinding wheel and the workpiece. As a result, known systems lead to an excessively rapid consumption of the cup grinding wheel, over-heating of the workpiece in the machining area, and a non-constant finishing of the workpieces in a production line.

[0006] The invention relates in particular to a method according to the preamble of claim 1, a cup grinding wheel according to the preamble of claim 5 and a system according to the preamble of claim 8. A method and a system of this type, as well as a cup grinding wheel of this type, are illustrated in EP 0 483 561 A1.

[0007] From the document DE 24 25 179 A1, a cup grinding wheel is known with an annular front surface having a plurality of separated and spaced apart grooves for distributing coolant on the front surface of the cup grinding wheel. Each of these grooves extends from a radially inner edge up to a radially outer edge of the front surface of the cup grinding wheel, so that the coolant is distributed over the entire radial extension of the annular front surface of the cup grinding wheel. However, this result is obtained at the cost of a more complex and expensive manufacture of the grinding wheel.

Object of the invention

[0008] The object of the present invention is to overcome the disadvantages of the known solutions, ensuring optimum cooling in the area of contact between the cup grinding wheel and the workpiece, without having an excessively complicated construction or an excessive manufacturing cost of the cup grinding wheel.

Summary of the invention

[0009] In view of achieving the aforesaid objects, the invention relates to a method according to claim 1, a cup grinding wheel according to claim 5 and a system according to claim 8.

[0010] According to the invention, at least one continuous circumferential groove is formed in the said annular front surface of the cup grinding wheel, which preferably intercepts the outlet ports of the said passages leading to the annular front surface of the cup grinding wheel, and which extends in a wavy path, or with zig-zag-shaped segments, so as to distribute the coolant, covering a predominant portion of the radial extension of the annular front surface of the cup grinding wheel.

[0011] Thanks to this additional characteristic, the cooling of the workpiece is improved further since the coolant is injected directly above the workpiece surface in contact with the cup grinding wheel for a predominant portion of the radial extension of the front surface of the cup grinding wheel.

[0012] At the same time, manufacture of the cup grinding wheel is simple and quick, since the aforesaid continuous groove can be formed with a single mechanical

operation while the grinding wheel is rotated.

[0013] In the method according to the invention, the coolant (which is simply water) is fed to the said passages formed in the body of the cup grinding wheel by one or more coolant dispensers, arranged in fixed positions outside the drive spindle of the cup grinding wheel. The body of the cup grinding wheel has a rear portion, opposite the annular front machining surface, having a circumferential inner channel acting as a coolant supply manifold, configured to receive coolant from said one or more dispensers and to feed it to said passages leading to the front surface of the cup grinding wheel, which are in communication with said circumferential channel.

[0014] During operation, the jets of coolant are directed by said nozzles against the wall of the inner circumference channel of the cup grinding wheel. The coolant is pushed by centrifugal force along the entire circumferential extension of the channel and from this through the aforesaid passages formed in the body of the cup grinding wheel, leading to the annular front surface of the cup grinding wheel. In this way, the coolant is applied exactly to the area of contact between the annular front surface of the cup grinding wheel and the workpiece.

[0015] Thanks to all of the above characteristics, the invention allows improved cooling in the machining area of the cup grinding wheel, which results in a lower wear of the cup grinding wheel, resulting in greater uniformity of the degree of finishing of the workpieces in a production line and, overall, a better quality and increased production efficiency. At the same time, the construction of the cup grinding wheel is relatively simple and economical.

Detailed description of a preferred embodiment

[0016] The present invention will now be described with reference to the attached drawings, provided purely by way of non-limiting example, wherein:

- Figure 1 is a schematic perspective view of a spindle assembly carrying a cup grinding wheel according to the invention in a system conforming to the disclosures of the present invention,
- Figure 2 is a cross-sectional view of a preferred embodiment of the cup grinding wheel according to the invention, in a plane containing the axis of the cup grinding wheel,
- Figure 3 is a cross-sectional view of a preferred embodiment of the system according to the invention, and
- Figure 4 is a front view of a cup grinding wheel according to the preferred embodiment of the invention.

[0017] In Figures 1 and 3 of the attached drawings, reference numeral 1 indicates, in its entirety, an electrospindle assembly comprising a support body 2 within which a spindle 3 is rotatably supported around an axis 4, by means of roller bearings 5. The spindle 3 is driven by an electric motor M, partially visible in Figure 1. On the end of the spindle 3 opposite to the electric motor M, a circular disk flange 7 is attached by means of screws 6, for attaching a cup grinding wheel 8.

[0018] Of course, the constructive details of the electro-spindle assembly and the type of mounting of the cup grinding wheel 8 on the spindle 3, which are shown in Figure 3 of the attached drawings, are hereby provided purely by way of non-limiting example. These details can be widely varied, as known to those skilled in the art, depending on the specific characteristics of the machine on which the electro-spindle assembly is provided and depending on the specific machining needs.

[0019] Similarly, in a typical application, a plurality of electro-spindle assemblies of the type illustrated in Figures 1 and 3 can be provided in a bilateral machine for simultaneously working the opposite edges of a glass sheet or stone material that is made to advance through the machine. As stated above, however, the present invention is of general application, not being limited to the specific embodiment that is illustrated in the attached drawings purely by way of example and, instead, being usable on any type of machine and for any type of machining where a cup grinding wheel is used.

[0020] With reference in particular to Figures 2 and 3, the cup grinding wheel 8 comprises a cylindrical cup-shaped body, indicated in its entirety by 9, having an axis 90 and an annular front surface 91, which constitutes the abrasive machining surface of the grinding wheel. The annular front surface 91 typically incorporates particles of a very hard material, such as diamond particles, according to a conventional technique in this field.

[0021] Again, with reference to the specific example illustrated, and therefore without any limiting value, the body 9 is constituted in this case by three elements welded together or otherwise rigidly connected. The abrasive front surface 91 forms part of a separate annular element 92, which is joined to an annular body 93 defining the rear portion of the body 9 by means of interposing an additional ring 93A. Of course, the body of the cup grinding wheel could, however, also be produced in one piece or in a different number of pieces. The specific configuration described herein has been chosen since it facilitates the manufacture of the grinding wheel and obtainment of the passages that are formed through the grinding wheel body and which are described below.

[0022] The body 9 of the cup grinding wheel 8 comprises a central disc 94 (which in the illustrated example forms part of the annular body 93 defining the rear portion of the body of the grinding wheel) having a central hole 95.

[0023] As can be seen in Figure 3, in the assembled condition, the disc 94 of the cup grinding wheel 8 body is centered over the attachment flange 7, as a cylindrical portion 70 protruding from the front face of the flange 7 is received within the hole 95 of the disc 94. The rear surface of the disc 94 of the body of the grinding wheel 8, i.e. the surface facing to the left in Figure 2, rests- in the mounted condition- against the front face of the at-

tachment flange 7 and is held against it by means of screws 71, by means of which the central disc 94 of the grinding wheel is clamped between the front face of flange 7 and a front clamp plate 72.

[0024] Still with reference to the embodiment shown here, the transverse half-cross section of the body of the cup grinding wheel 8, in a plane containing the axis 90, is essentially T-shaped, with a peripheral cylindrical wall extending axially from the disc 94 both forwards, to define the abrasive annular front surface 91, and in the opposite direction, with a wall portion 93, which protrudes axially from the rear face of the central disc 94.

[0025] The cylindrical wall portion 93 ends with a border defining a circular aperture 80 concentric with the axis 90 of the body of the cup grinding wheel. The inner surface of the cylindrical portion 93 defines an inner circumferential channel 96, with a circular profile, designed to define a feed manifold for a coolant to be fed into the area of contact between the abrasive annular front surface 91 of the cup grinding wheel 8 and the workpiece.

[0026] As visible in the attached drawings, the inner circumferential channel 96 communicates with a plurality of axial passages 81 formed in the body of the cup grinding wheel and having outlet ports leading to the abrasive annular front surface 91 of the cup grinding wheel 8.

[0027] In the specific example illustrated, in which the body of the cup grinding wheel 9 is formed of several elements 92, 93, 93A connected to each other, the axial passages 81 have respective portions formed within said elements and in communication with each other.

[0028] Referring now to Figures 1 and 3, the system according to the invention comprises a coolant supply system, including one or more coolant dispensers 10. In the illustrated example, two dispensers 10 are provided that are diametrically opposed to each other, but it is evident that it is also possible to provide a single coolant dispenser 10, or any other number of dispensers 10 spaced apart angularly from each other. Each dispenser 10 comprises a body 101 supported in a fixed position by the support structure 2. The body 101 of each dispenser 10 is arranged on the outside of the spindle assembly 2 adjacent to the end of the spindle carrying the cup grinding wheel 8. Each body 101 has a distal portion protruding axially within the body of the cup grinding wheel through the rear circular opening 80 adjacent to the rear face of the central disc 94 of the grinding wheel body.

[0029] Within the body 101 of each coolant dispenser 10, one or more passages 102 are formed for the coolant, which receive the coolant from a manifold channel 103 (Figure 3). The manifold channel 103 formed in the body of each dispenser 10 receives, in turn, the coolant through a connection R (see Figure 1) intended to be connected to a feed pipe (not shown in Figure 1) that receives pressurized coolant from a feed pump (not shown in the drawings) or network water, according to a conventional technique.

[0030] The details of the coolant supply circuit for the part arranged upstream of the inlet connections R of the dispenser devices 10 are not described or illustrated here, as they can be produced in any known way and as they are, taken alone, not within the scope of the present invention.

[0031] The passages 102 formed in the body 101 of each dispenser 10 have outlet ports 104 facing radially outwards and facing the wall of the inner circumferential channel 96 of the cup grinding wheel 8.

[0032] During operation, the spindle 3 is rotated by the electric motor M and the electro-spindle assembly is made to advance in the direction of the axis 4 to carry the abrasive annular front surface 91 of the cup grinding wheel 8 in contact with the surface of the workpiece to be machined, for example, a lateral edge of a sheet L of glass or of stone material advancing in an orthogonal direction with respect to the axis 4 (Figure 1).

[0033] During machining, the pressurized coolant is fed from the coolant supply system to the inlet connections R of the dispensers 10. The coolant enters through the connections R into the manifold channels 103 and then flows into the passages 102. The jets of coolant leaving the ports 104 of the dispensers 10 are directed against the wall of the inner circumferential channel 96 formed in the rear cylindrical portion of the cup grinding wheel 8. The coolant is forced by centrifugal force to distribute along the entire circumference of the circumferential channel 96 and to flow through the axial passages 81 leading to the abrasive annular front surface 91.

[0034] Therefore, in the system according to the invention, the coolant is directed exactly into the area of contact between the abrasive annular front surface of the cup grinding wheel and the surface of the workpiece being machined. This allows optimal cooling, which reduces the wear of the grinding wheel, avoids excessive heating of the machining area and allows the maintenance of an essentially uniform degree of finishing of the workpieces in a production line.

[0035] Of course, the construction details of the cup grinding wheel and the coolant supply dispensers, which have been illustrated here, are provided purely by way of example. The most general principle underlying the present invention is to form passages in the body of the cup grinding wheel, which lead to the abrasive annular front surface of the cup grinding wheel configured for being supplied with coolant to feed said fluid directly into the area of contact between the abrasive annular front surface and the workpiece being machined. The conformation and arrangement of said passages formed in the body of the cup grinding wheel can vary widely, depending on the needs of each specific application. Likewise, the provision of an inner circumferential channel in the rear portion of the body of the cup grinding wheel, to create the function of supply manifold of the coolant, is hereby provided by way of example only. The shape of the grinding wheel, and in particular, the manner in which the coolant is carried to the passages leading to the abrasive annular front surface of the grinding wheel may vary

widely, depending on the specific application requirements. As mentioned above, the same applies to the structure and configuration of the coolant dispensers 10.

[0036] In a particularly preferred embodiment, the distribution of the coolant into the area of contact between the cup grinding wheel and the workpiece being machined is further improved since at least one circumferential groove T is formed on the annular front surface of the cup grinding wheel 8, which extends along a wavy path, in order to distribute the coolant on a predominant part of the radial extension of the annular front surface of the grinding wheel. Still preferably, this circumferential groove T is arranged in such a way as to intercept the outlet ports of the passages 81 leading to the annular front surface 91 of the cup grinding wheel 8 (see Figure 4).

[0037] As is visible in Figure 4, in the preferred embodiment, the aforesaid circumferential groove T follows a sinusoidal path. However, the path followed by the groove T could be any shape. For example, it would be possible to provide a star-shaped groove T, defined by a plurality of zig-zag segments, or a Greek fret conformation. It would also be possible to provide more grooves T concentric to each other and having a conformation of the type described herein.

[0038] Finally, it should be noted that the provision of at least one circumferential continuous groove on the abrasive annular front surface of the cup grinding wheel, according to a wavy or zig-zag pathway, which covers a predominant portion of the radial extension of the aforesaid annular front surface, is however advantageous in a conventional-type cup grinding wheel as well, i.e. not provided with aforesaid passages for the coolant, and designed to cooperate with conventional nozzles for supplying the coolant. A cup grinding wheel is therefore also part of the present invention that is not provided with the coolant supply system described herein but which is, however, provided on its annular front surface with at least one continuous and wavy circumferential groove, of the type described herein.

[0039] Still with reference to the coolant supply system, the embodiment illustrated here utilizes axial passages 81 leading to the abrasive annular front surface 91 of the cup grinding wheel 8 in a direction orthogonal to the plane of the surface 91. However, the passages 81 can also be formed in such a way as to direct the jets of coolant along directions non-orthogonal to the plane of the front surface of the cup grinding wheel 8.

[0040] Of course, without prejudice to the principle of the invention, the details of construction and the embodiments may vary widely with respect to those described and illustrated purely by way of example, without departing from the scope of the present invention.

Claims

1. A method for feeding a coolant during machining of a workpiece (L) by means of a cup grinding wheel (8) driven by a rotating spindle (3) and having a cup-shaped body (9) with an annular front machining surface (91), wherein the coolant is fed into the area of contact between said annular front surface (91) of the cup grinding wheel (8) and the workpiece (L) being machined, by means of passages (81) for the coolant formed in the body (9) of the cup grinding wheel (8) and leading to said annular front machining surface (91),
said method being **characterized in that** the coolant fed from said passages (81) leading to the annular front surface (91) of the cup grinding wheel (8) is distributed onto a predominant portion of the radial extension of said annular front surface (91) by making it flow through a continuous circumferential groove (T) formed in said annular front surface (91) of the cup grinding wheel (8), and extending with a wavy or zig-zag path that intercepts the outlet ports of said passages (81) on said annular front surface (91).

2. A method according to claim 1, **characterized in that** the coolant is fed to said passages (91) formed in the body (9) of the cup grinding wheel (8) from one or more coolant dispensers (10) arranged in fixed positions outside the spindle (3)

3. A method according to claim 2, **characterized in that** the body (9) of the cup grinding wheel (8) has a rear portion (93) with an inner circumferential channel (96) acting as a coolant supply manifold, configured to receive coolant from said one or more coolant dispensers (10) and to feed it to said passages (81) leading to the annular front surface (91) of said coolant of the cup grinding wheel (8).

4. A method according to any one of the preceding claims, **characterized in that** the coolant is water.

5. A cup grinding wheel, comprising a cup-shaped body (9) with an annular front machining surface (91) wherein passages (81) are formed in the cup-shaped body (9), leading to the annular front surface (91) of the cup grinding wheel, which can be used to feed coolant into the area of contact between said annular front surface (91) of the cup grinding wheel (8) and the workpiece (L) being machined,
said grinding wheel being **characterized in that** at least one circumferential continuous groove (T) is formed in said annular front surface (91) of the cup grinding wheel (8), extending with a wavy or zig-zag path, so as to be suitable for distributing coolant covering a predominant portion of the radial extension of the aforesaid annular front surface (91) of the cup grinding wheel (8).

6. A cup grinding wheel according to claim 5, **characterized in that** the body (9) of the cup grinding wheel

(8) defines on its rear side, opposite to said annular front surface (91), an inner circumferential channel (96) acting as a coolant supply manifold for receiving coolant from one or more coolant supply dispensers (10) and feeding it to said passages (81) leading to the front surface of the cup grinding wheel (8), said passages (81) being in communication with said inner circumferential channel (96).

7. A cup grinding wheel according to claim 5, **characterized in that** said at least one continuous circumferential groove (T) formed on the annular front surface (91) of the cup grinding wheel (8) is arranged so as to intercept outlet ports of the aforesaid passages (81) leading to the annular front surface (91) of the cup grinding wheel (8).

8. A system for feeding a coolant during machining of a workpiece (L) by means of a cup grinding wheel driven by a rotating spindle (3) and having a cup-shaped body (9) with an annular front machining surface (91), wherein passages (81) are formed in the body (9) of the cup grinding wheel (8) leading to said annular front surface (91) and wherein said system comprises one or more coolant dispensers (10) arranged outside the spindle (3) for supplying coolant to said passages (81) leading to said annular front surface (91) of the cup grinding wheel (8) in order to feed coolant into the area of contact between said annular front surface (91) of the cup grinding wheel (8) and the workpiece (L) being machined,
said system being **characterized in that** at least one circumferential continuous groove (T) is formed in said annular front surface (91) of the cup grinding wheel (8), extending with a wavy or zig-zag path, in order to be suitable for distributing coolant covering a predominant portion of the radial extension of the aforesaid annular front surface (91) of the cup grinding wheel (8).

9. A system according to claim 9, **characterized in that** the body (9) of the cup grinding wheel (8) has a rear portion opposite to said annular front surface (91) having a circumferential inner groove (96) acting as a coolant supply manifold, said one or more coolant dispensers (10) having passages for the coolant (102) with outlet ports (104) arranged to supply coolant within said circumferential inner groove (96) of the cup grinding wheel body, in such a way that the coolant thus supplied is distributed by the effect of the centrifugal force **in that** said circumferential groove and flows therefrom through aforesaid passages leading to the annular front surface (91) in the area of contact between said annular front surface (91) of the cup grinding wheel (8) and the workpiece being machined.

FIG. 1

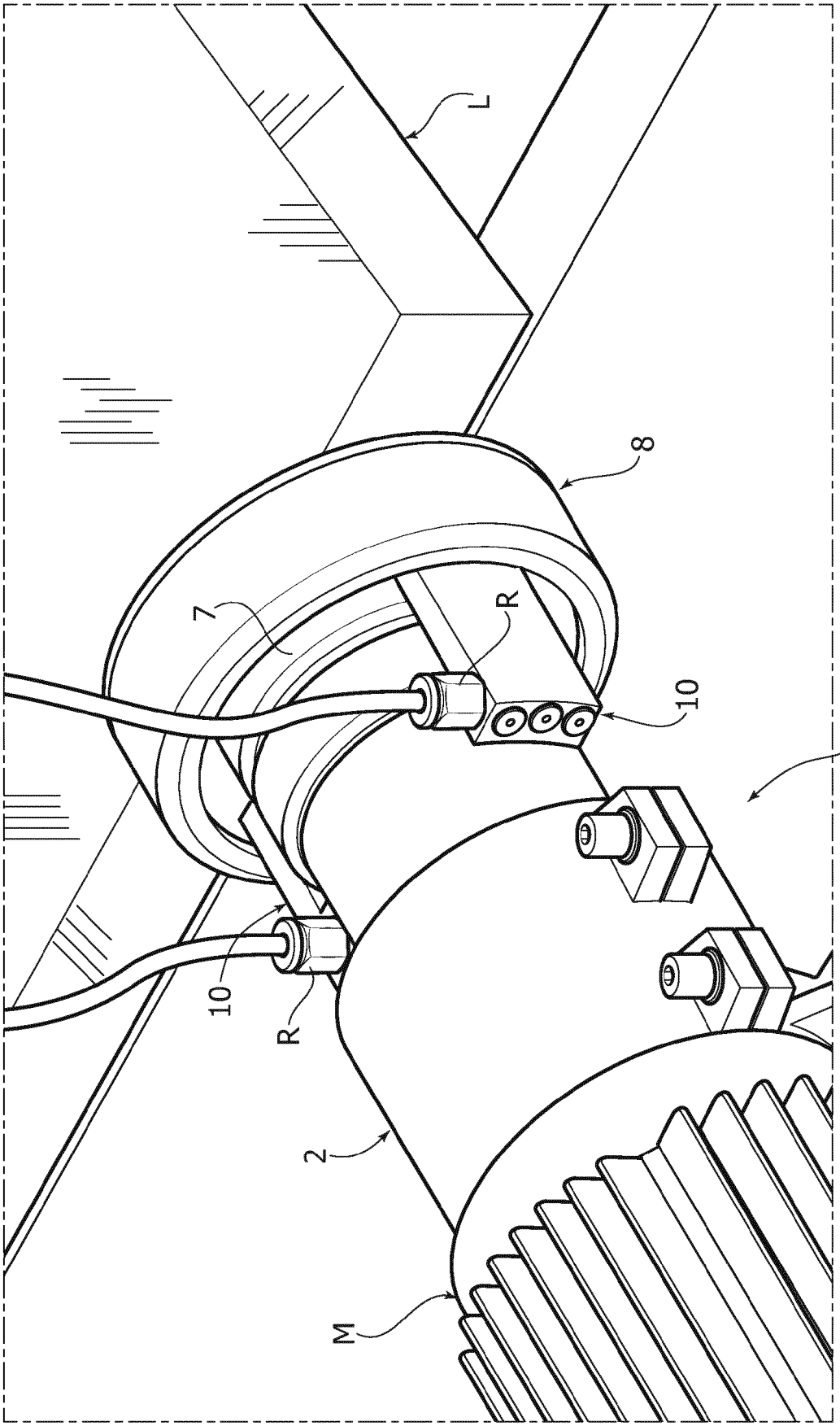

FIG. 2

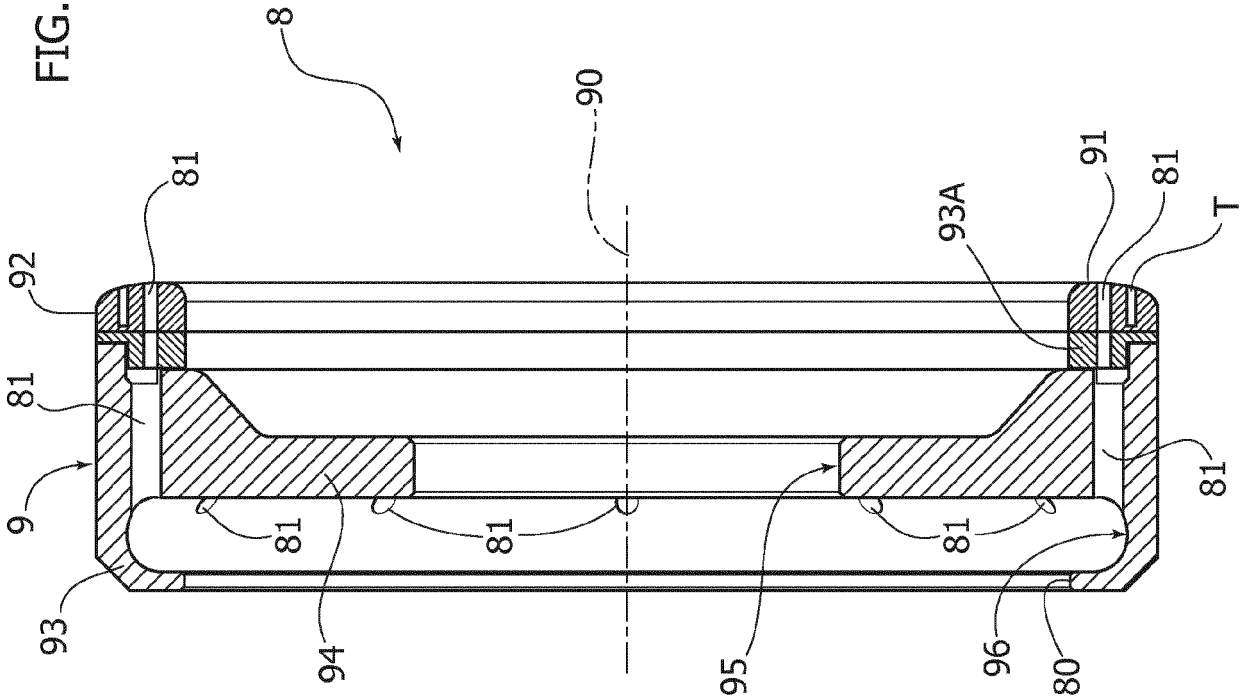

FIG. 3

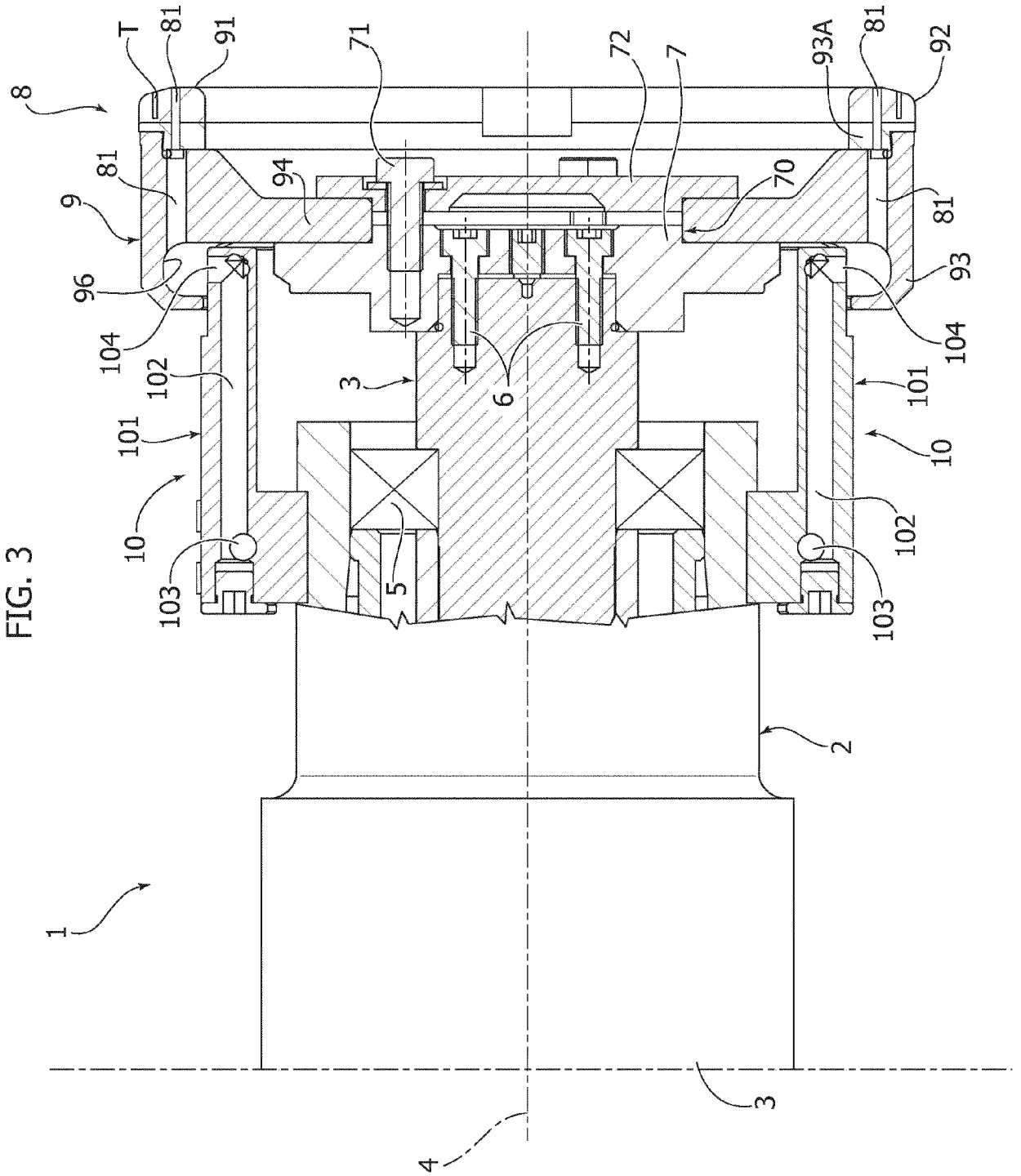
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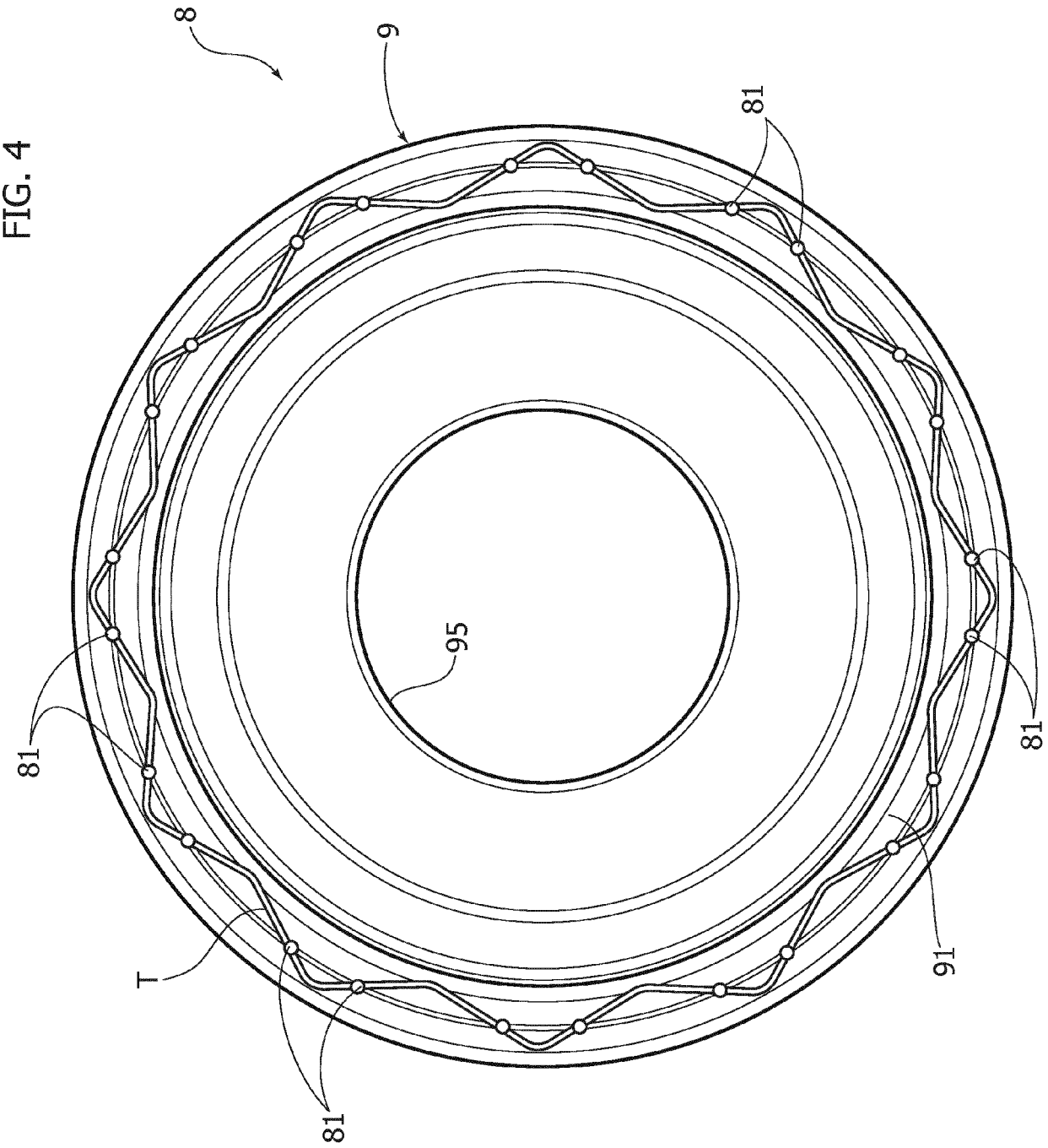
FIG. 4



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- DE 2425179 A1 **[0007]**