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(54) **AN INHERENTLY BALANCED SPINDLE FOR TOOL HEADS USED IN CALIBRATING,
SMOOTHING OR POLISHING NATURAL STONE SLABS AND/OR CERAMIC TILES**

EINE INHÄRENT AUSGEGLICHENE SPINDEL FÜR WERKZEUGKÖPFE ZUM EICHEN, GLÄTTEN
ODER POLIEREN VON STEINPLATTEN UND/ODER VON KERAMIKFLIESEN

BROCHE EQUILIBREE DE MANIERE INHERENTE POUR DES TETES D'OUTIL UTILISEES POUR
LE CALIBRAGE, LE LISSAGE OU LE POLISSAGE DE DALLES EN PIERRE NATURELLE ET/OU
DE CARREAUX DE CERAMIQUE

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Description

[0001] The invention relates to a spindle for tool heads used in calibrating, smoothing or polishing natural stone slabs and/or ceramic tiles, as per the preamble of claim 1. An example of such a spindle is disclosed by GB 2 226 783 A.

[0002] Known in the art are spindles adapted to hold a variety of rotary tool heads with their pivot axis normal to a work surface. The spindle is rotated through a belt drive, which means that an electric motor must be mounted with its centerline parallel to the rotation axis of the spindle. Thus, the center of gravity of the assembly comprised of the spindle, motor and rotary head, operated for rotational and feed movements relative to the work surface, has to be placed far from the spindle axis. This results in the assembly becoming susceptible to vibrations transmitted by abrasive tools to said head and finally supported by the supporting structure to which said spindle is fixed.

[0003] Said vibrations and the eccentricity of said center of gravity amplify the efforts undergone by said supporting structure being thus considerably stressed. A direct consequence and first problem is the difficulty in eliminating the effect of said vibrations, when they are not absorbed by said supporting structure, causing material working defects. Not least, the misaligned motor position allows traditional electric motors to be used and the cooling water leader for the abrasive tools of said head to pass through the holed spindle shaft.

[0004] A second problem occurs in known prior art spindles when mounting the spindle on said supporting structure. Said structure is made of conveniently bent and welded sheet and it has said spindle lock slot to be fitted with the correct position required by the material working; it is thus necessary to correctly position said spindle on said supporting structure and it is known in the art to side-shim the locking flange of said spindle tubular pan to said structure, so as to adjust small construction differences or errors of said metal supporting structure. Said operation is difficult and it requires a considerable testing with following attempts to achieve the correct lie and position required by the spindle axis.

[0005] Another problem is the setting of the head, motor and spindle assembly along the spindle axis relative to the work surface. All conventional spindle axial setting devices use air- or oil-operated cylinder actuators mounted on one side of the spindle for setting the tooling when held fixed, as during the calibrating operation, and when urged downwards, as during the smoothing and polishing operations. The line of action of such actuators is offset from the spindle axis, thus straining both the supporting structure and the spindle. The spindle mass is offset from the line of action of the cylinder actuator. Also in the prior art, the mass of the electric motor is unrelated to the feed motion of the spindle to/from the work surface and the spindle shaft is driven through a belt drive. As a result, a relatively small mass is shifted by said cylinder actuator when the working pressure of the rotary head that holds the abrasive tooling is adjusted, the motor's own mass having no part in it. The small overall mass impairs self-dressing of the tools, and these develop a marked tendency to become fouled with filings and grit and to lose abrasive power.

[0006] The state of the art is open to considerable improvement as far as overcoming the above drawbacks.

[0007] The underlying technical problem of this invention is to provide a spindle assembly for abrasive machining, wherein the spindle, motor and tool head combination is inherently balanced and the spindle/tool head axis can be readily set relative to the work surface in a reliable manner.

[0008] The problem is solved according to the invention by a spindle for tool heads used in calibrating, smoothing or polishing natural stone slabs and/or ceramic tiles, having the features of claim 1.

[0009] In a preferred embodiment, the electric motors rotate equally as to power and torque, have their centerlines arranged symmetrically, and have respective pinion gears in mesh engagement with the gear wheel keyed to the spindle shaft.

[0010] In another preferred embodiment, the body of the spindle is coaxial with said cylinder actuator and connected rigidly to the piston rod of the cylinder.

[0011] In another preferred embodiment, the spindle body is bored and holds the spindle shaft rotatively, said spindle body forming the piston rod of said spindle-setting cylinder actuator.

[0012] In another preferred embodiment, the bottom chamber of said cylinder actuator has a larger working area than the top chamber overlying the cylinder piston.

[0013] The advantages of this invention are: the masses involved in the spindle holding abrasive tool heads are balanced such that the spindle center of gravity lies on the axis of the spindle itself and the overall mass is adequate to dampen vibration. This results in lessened transfer of vibration from the tooling to the spindle shaft, the vibration being more easily taken up by the metal supporting structure because unamplified by any offset mass.

[0014] In addition, the aligned cylinder actuator, by having its piston rod coincident with the spindle body, allows a more compact design, more reliable construction, more convenient servicing, and does away with outward projecting lugs from the spindle body. Also, the increased mass of the spindle, head, reduction gear, and electric motors effectively increases the inertia of the spindle assembly for greatly improved self-dressing of the abrasive tools. The thrust from the cylinder is counterbalanced, directed along the spindle axis, and adequate to take said mass of the spindle assembly and withstand the pressure on the material by virtue of the differential cylinder design and the controlled air pressure.

[0015] Finally, the tubular housing for holding the spindle securely on the metal support structure allows, through the upper spherical support and the spherical guide at the other end, the directional setting of the abrasive tool head to be

achieved readily and precisely, thereby to accommodate errors or inaccuracies of the metal structure advantageously-constructed by welding.

[0016] An embodiment of the invention is shown by way of example in the accompanying four drawings, in which Figure 1 is a schematic axial section view of the inventive spindle driven off standard electric motors and having its shaft bored to allow the water supply line therethrough; Figure 2 is a schematic sectional view of the coupling of said motors to the spindle shaft; Figure 3 is a schematic sectional view of the cylinder actuator incorporated to the spindle body; Figure 4 is a schematic sectional view of the spindle-holding tubular housing as assembled to the supporting structure.

[0017] Shown at 1 in Figure 1 is the spindle carrying the abrasive tool head, not shown, and at 2 the metal structure of the machine tool for calibrating, smoothing and polishing slabs of granite, hard stone, marble, or possibly hard-fired porcelain tiles. The spindle is attached to the structure 2 through the swinging tubular housing 3 provided with a spherical ring 4 that bears through a flange 5 on an added ring 6, also spherical in shape, which is attached to said metal supporting structure 2 of the machine tool. The flange 5 is secured by screws 7, and the other end of the tubular housing 3 is guided by the spherical band 8 of the tubular housing being in contact with the cylindrical seat 9 of the metal supporting structure 2. The tubular housing 3, and with it the spindle 1, is further secured by the elastic fastening arrangement 10 acting on the added flange 11 at the latter end of the tubular housing.

[0018] Figure 1 also shows that the body 12 of the spindle 1 can slide along its axis and is provided with a piston 13 movable inside the cylinder liner 14, having at one end an integral cap 15 and at the other end the added cap 16 that acts as a tubular slideway for said body. The flange 17 is clamped onto said body 12 to cover said tubular slideway of said added cap 16 with a tube 18. A tongue 19 intervening between said tubular slideway and the tube 18 allows mutual sliding movement and inhibits rotation. Fast with the flange 17 is the body of the reduction gearbox 20 that carries the electric motors 21, the latter being attached to the cover 22 of the reduction gearbox by means of set rings 23. The electric motors are provided each with a pinion gear 24 that is keyed to their shaft to mesh with the center wheel 25, itself keyed to the hub 26 of the bored shaft 27.

[0019] Finally, shown in Figure 1 is a drilled sleeve 28 set coaxially with the shaft 27 to allow a water supply line 29 therethrough that leads to the abrasive tool head. The drilled shaft is rigid with the face joint 30 to the shaft of the spindle 31, also drilled through, at the opposite end whereof said abrasive tool head, not shown, is mounted. The head is conventionally mounted detachably on the end flange 32 of the shaft of the spindle 31 for rotation therewith. The reaction pin abuts the detent 33 that is rigid with the spindle body 12 for axial sliding movement therewith, so as to transmit the necessary torque to said head.

[0020] Depicted, though not referenced, in Figures 2 and 3 are bearings mounted on stationary parts to support rotary parts, screw fasteners for the parts, and ring seals between the rotary and stationary parts.

[0021] Figure 3 shows the seals 34 for the end caps 15 and 16 of the cylinder actuator 35 in which the piston 13 is slidable, the piston being provided with a seal 36. The cylinder 35 is supplied a working fluid, advantageously air, in either direction through a line 37 in communication with the bottom chamber 38 having a larger working area, and through a line 39 communicated to the top chamber 40 having a smaller working area. The working area differential is obtained by reducing the diameter of the body 12 in the bottom chamber 38, with regards to the diameter of said body in top chamber 40. The screws 7 used for securing the flange 5 of the tubular housing 3 are passed through clearance holes to thread into wide washers 41; the clearance in the holes being ample to allow the fasteners to be tightened even when a substantial tilt angle exists between the metal structure 2 and the tubular housing 3.

[0022] Finally, Figure 4 shows the slant setting 42 afforded for the tubular housing 3, and hence the spindle 1 with the tool head, relative to the metal supporting structure 2 in order to accommodate assembling inaccuracies in the metal parts of the structure 2.

[0023] The spindle assembly 1 is mounted on the metal supporting structure 2 by inserting the tubular housing 3 into the structure 2 and, after a precise setting is achieved, tightening the screws 7. The screws are tightened to secure the tubular housing in a possibly slanted position 42 by swinging movement about the ball joint 4 between the flange 5 of the tubular housing and the ring 6 affixed to the structure 2. At the other end of the tubular housing, the spherical band 8 allows the tubular housing to be set at said position 42 without losing contact with the cylindrical surface of the seat 9 to which it is attached. This end connection is enhanced by the elastic fasteners 10 acting on the tubular housing 3 through the added flange 11 to which it is rigidly connected.

[0024] The spindle is driven through the center gear wheel 25, which is keyed to the hub 26 of the hollow shaft 27. The electric motors 21 are standard motors, since the coolant supply line 29 to the tooling is not passed through the motors 21. The mass distribution is inherently balanced by having two or more motors 21 placed at equal intervals around the position circumference of the pinion gears 24 keyed to the respective motor shaft.

[0025] The cylinder actuator 35 is operated to feed the rotary head toward the slab workpiece by supplying the pressurized fluid, advantageously air, into one of the chambers on either side of the piston 13. A small pressure in the bottom chamber 38 of larger area will raise the spindle assembly to a "floating" position, accommodating the substantial mass of the assembly of the spindle 1 over the work material. On the other hand, a controlled pressure in the top chamber 40 will urge the rotary tool head toward and against the surface of the material being processed, thereby adjusting the

working pressure exerted on the material for the desired value. This substantial mass, having considerable inertia, dampens vibration and slows down the "floated" assembly to produce a constant working pressure on the work surface that effectively improves the abrasive tool self-dressing feature.

[0026] Where a calibrating head is used, the cylinder actuator 35 is positioned under a high pressure, and the working depth is set externally by means of a conventional micrometric adjuster, not shown. The cylinder actuator 35, when held in the position shown under said pressure, allows the tool to be quickly moved away from the work material as the calibrating process is discontinued.

Claims

1. A spindle for tool heads used in calibrating, smoothing or polishing natural stone slabs and/or ceramic tiles, comprising: a tubular housing (3) in which the spindle body is movable, the spindle body including a shaft (31) carrying a rotary abrasive tool head at one end (32, 33); a cylinder actuator for setting the position of the spindle body and its associated tool head relative to a metal support structure (2); an electric motor (21) for rotating the spindle (1), and a drive connecting said motor to the spindle shaft; wherein said tubular housing (3) can be swung around spherical surface (4) supporting an end flange (5) of the tubular housing (3), the other end having a spherical guide band (8) for guiding the latter end across a mating cylindrical surface (9), and includes a clamping arrangement (7, 10) for locking the tubular housing (3) and the spindle (1) in a set position; the clamping arrangement comprising screws (7) which are passed through clearance holes in said end flange (5) and engage in wide washers (41); **characterized in that** the clamping arrangement comprises elastic fasteners (10) for a second flange (11) added to said other end of the tubular housing (3).
2. A spindle according to Claim 1 above; **characterized in that** said body (12) of the spindle (1) is coaxial (35) with said cylinder actuator and rigidly connected to the piston rod thereof.
3. A spindle according to Claim 2 above, **characterized in that** said spindle body (12) is bored and holds the spindle shaft (27, 31) rotatively, said spindle body forming the piston rod of said spindle-setting cylinder actuator (35).
4. A spindle according to either Claim 2 or 3 above, **characterized in that** said cylinder actuator (35) has a bottom chamber (38) with a larger working area than the top chamber (40) overlying the cylinder piston (13).
5. A spindle according to Claim 1 above, **characterized in that** said motor and drive combination is replaced by two or more motors (21) drivingly connected to the spindle shaft (27) by means of gearing (24, 25) arranged to spread their mass and the drive torque evenly, as well as to allow the coolant supply line (29) to the head tooling through the hollow interior of the spindle shaft (31), using standard electric motors (21).
6. A spindle according to Claim 5 above, **characterized in that** the electric motors rotate equally as to power and torque, have their centerlines arranged symmetrically, and have the respective pinion gears (24) in mesh engagement with the gear wheel (25) keyed to said spindle shaft (27).
7. A spindle according to either Claim 5 or 6 above, **characterized in that** a face joint (30) is provided between a first bored shaft section (27) connected to the electric motors through the gear drive (24, 25) and the bored spindle shaft (31) holding the abrasive tool head.

Patentansprüche

1. Spindel für Werkzeugköpfe zum Kalibrieren, Glätten und Polieren von Natursteinplatten und/oder Keramikfliesen, umfassend: ein rohrförmiges Gehäuse (3), in dem der Spindelkörper bewegbar angeordnet ist, wobei der Spindelkörper eine Welle (31) umfasst, die einen drehenden abrasiven Werkzeugkopf an einem Ende (32, 33) trägt; einen Zylinder-Aktuator zum Einstellen der Position des Spindelkörpers und des zugeordneten Werkzeugkopfes bezogen auf eine metallene Halteanordnung (2); einen elektrischen Motor (21) zum Drehen der Spindel (1) und einen Antrieb, der den Motor mit der Spindelwelle verbindet; wobei das rohrförmige Gehäuse (3) um eine sphärische Fläche (4) geschwenkt werden kann, die einen Endflansch (5) des rohrförmigen Gehäuses (3) trägt, während das andere Ende ein sphärisches Führungsband (8) zum Führen des letztgenannten Endes an einer passenden zylindrischen Fläche (9) aufweist, und eine Befestigungseinrichtung (7, 10) zum Arretieren des rohrförmigen Gehäuses (3) und der Spindel (1) in einer bestimmten Position beinhaltet; wobei die Befestigungseinrichtung Schrauben (7) umfasst, die

durch Durchgangslöcher in dem Endflansch (5) greifen und mit großen Unterlegscheiben (41) zusammenwirken, **dadurch gekennzeichnet, dass** die Befestigungseinrichtung elastische Befestigungsmittel (10) für einen zweiten Flansch (11) umfassen, der dem anderen Ende des rohrförmigen Gehäuses (3) hinzugefügt ist.

- 5 2. Spindel nach Anspruch 1, **dadurch gekennzeichnet, dass** der Spindelkörper (12) der Spindel (1) koaxial (35) zum Zylinder-Aktuator angeordnet und fest mit dessen Kolbenstange verbunden ist.
- 10 3. Spindel nach Anspruch 2, **dadurch gekennzeichnet, dass** der Spindelkörper (12) gebohrt ist und die Spindelwelle (27, 31) rotierend hält, wobei der Spindelkörper die Kolbenstange des die Spindel einstellenden Zylinder-Aktuators (35) bildet.
- 15 4. Spindel nach Anspruch 2 oder 3, **dadurch gekennzeichnet, dass** der Zylinder-Aktuator (35) eine untere Kammer (38) mit einer größeren Arbeitsfläche als die obere Kammer (40) aufweist, die den Zylinderkolben (13) abdeckt.
- 20 5. Spindel nach Anspruch 1, **dadurch gekennzeichnet, dass** die Motor- und Antriebskombination durch zwei oder mehr Motoren (21) ersetzt ist, die antriebsmäßig mit der Spindelwelle (27) durch Getriebemittel (24, 25) verbunden sind, die angeordnet sind, deren Masse und deren Antriebsmoment gleichmäßig zu verteilen und auch zu ermöglichen, dass die Kühlmittelzuführungsleitung (29) zu dem Kopfwerkzeug durch das hohle Innere der Spindelwelle (31) verläuft, wobei gewöhnliche elektrische Motoren (21) verwendet werden.
- 25 6. Spindel nach Anspruch 5, **dadurch gekennzeichnet, dass** die elektrischen Motoren hinsichtlich Leistung und Drehmoment gleich ausgelegt sind, deren Mittellinien symmetrisch angeordnet sind und entsprechende Antriebszahnräder (24) in kämmendem Eingriff mit einem Zahnrad (25) aufweisen, das mit der Spindelwelle (27) verkeilt ist.
7. Spindel nach Anspruch 5 oder 6, **dadurch gekennzeichnet, dass** eine Stirnverbindung (30) zwischen einem ersten gebohrten Wellenabschnitt (27), der mit den elektrischen Motoren über den Zahnradantrieb (24, 25) verbunden ist, und der gebohrten Spindelwelle (31) vorgesehen ist, die den abrasiven Werkzeugkopf hält.

30 Revendications

- 35 1. Broche pour têtes d'outil utilisées pour le calibrage, le lissage ou le polissage de dalles en pierre naturelle et/ou de carreaux de céramique, comprenant : un logement tubulaire (3) dans lequel le corps de broche est mobile, le corps de broche comprenant un arbre (31) supportant une tête d'outil abrasive rotative à une extrémité (32, 33) ; un actionneur à vérin pour régler la position du corps de broche et sa tête d'outil associée par rapport à une structure de support métallique (2) ; un moteur électrique (21) pour faire tourner la broche (1), et un entraînement reliant ledit moteur à l'arbre de broche ; dans laquelle ledit logement tubulaire (3) peut osciller autour d'une surface sphérique (4) supportant une bride d'extrémité (5) du logement tubulaire (3), l'autre extrémité comportant une bande de guidage sphérique (8) pour guider cette dernière extrémité à travers une surface cylindrique d'accouplement (9), et comprend un agencement de serrage (7, 10) pour verrouiller le logement tubulaire (3) et la broche (1) dans une position réglée ; l'agencement de serrage comprenant des vis (7) qui passent à travers des trous de dégagement dans ladite bride d'extrémité (5) et viennent en prise dans des rondelles larges (41) ; **caractérisée en ce que** l'agencement de serrage comprend des éléments de fixation élastiques (10) pour une seconde bride (11) ajoutée à ladite autre extrémité du logement tubulaire (3).
- 45 2. Broche selon la revendication 1 ci-dessus, **caractérisée en ce que** ledit corps (12) de la broche (1) est coaxial (35) avec ledit actionneur à vérin et relié de façon rigide à la tige de piston de celui-ci.
- 50 3. Broche selon la revendication 2 ci-dessus, **caractérisée en ce que** ledit corps de broche (12) est alésé et retient l'arbre de broche (27, 31) de façon rotative, ledit corps de broche formant la tige de piston dudit actionneur à vérin (35) de réglage de broche.
- 55 4. Broche selon la revendication 2 ou 3 ci-dessus, **caractérisée en ce que** ledit actionneur à vérin (35) comporte une chambre inférieure (38) avec une superficie de travail supérieure à la chambre supérieure (40) recouvrant le piston de vérin (13).
5. Broche selon la revendication 1 ci-dessus, **caractérisée en ce que** ladite combinaison de moteur et d'entraînement est remplacée par deux moteurs (21) ou plus reliés de façon entraînante à l'arbre de broche (27) au moyen d'en-

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grenages (24, 25) agencés pour distribuer leur masse et le couple d'entraînement uniformément, ainsi que pour permettre la conduite d'alimentation en liquide de refroidissement (29) jusqu'à l'outillage de tête à travers l'intérieur creux de l'arbre de broche (31), à l'aide de moteurs électriques standard (21).

- 5 **6.** Broche selon la revendication 5 ci-dessus, **caractérisée en ce que** les moteurs électriques présentent des puissances et couples égaux, ont leurs axes centraux agencés symétriquement, et ont les engrenages à pignon respectifs (24) en prise avec la roue d'engrenage (25) calée sur ledit arbre de broche (27).
- 10 **7.** Broche selon la revendication 5 ou 6 ci-dessus, **caractérisée en ce qu'un** joint face à face (30) est prévu entre une première section d'arbre alésée (27) reliée aux moteurs électriques par l'intermédiaire de l'engrenage entraînement (24, 25) et l'arbre de broche alésé (31) maintenant la tête d'outil abrasive.

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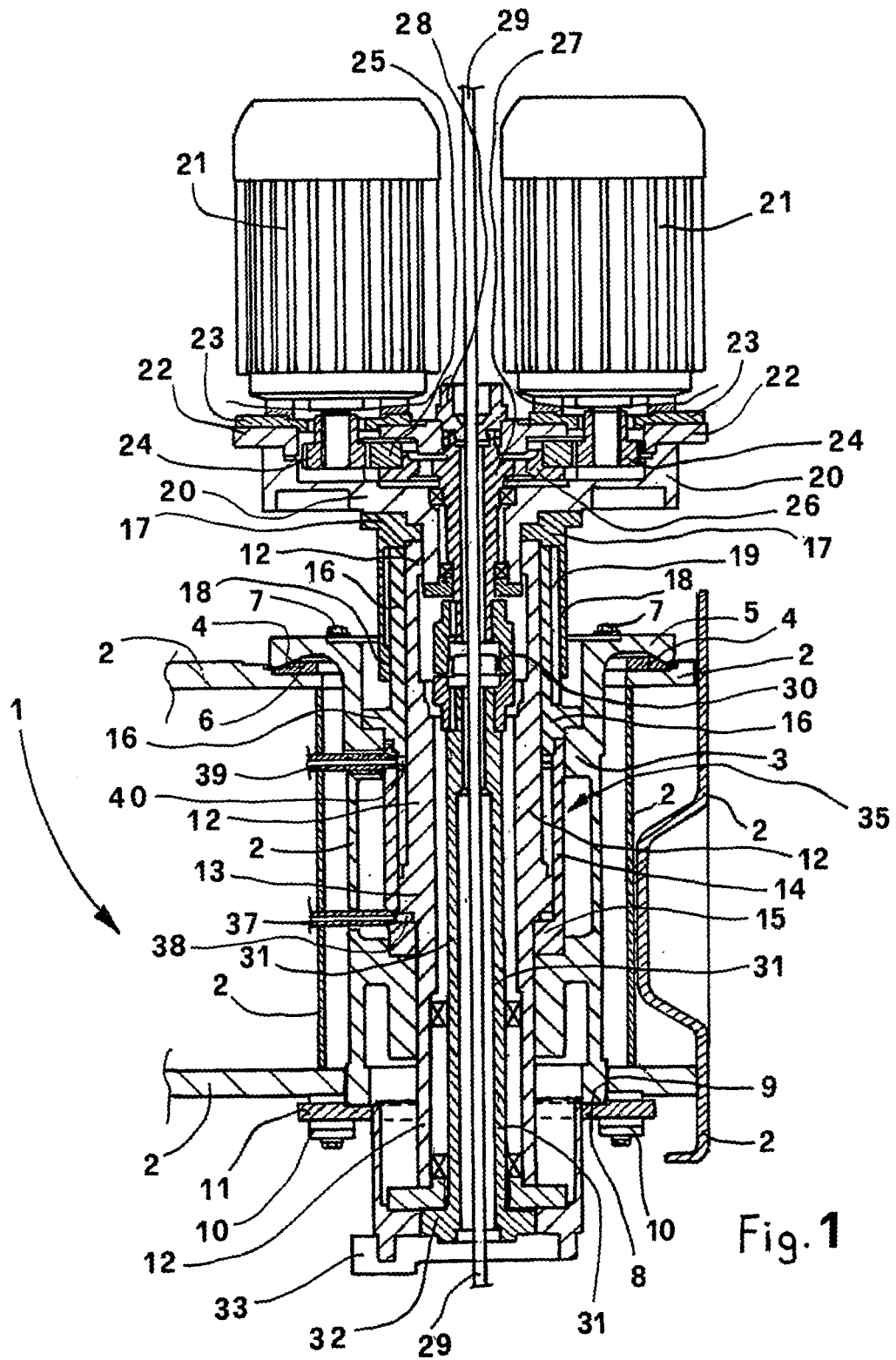
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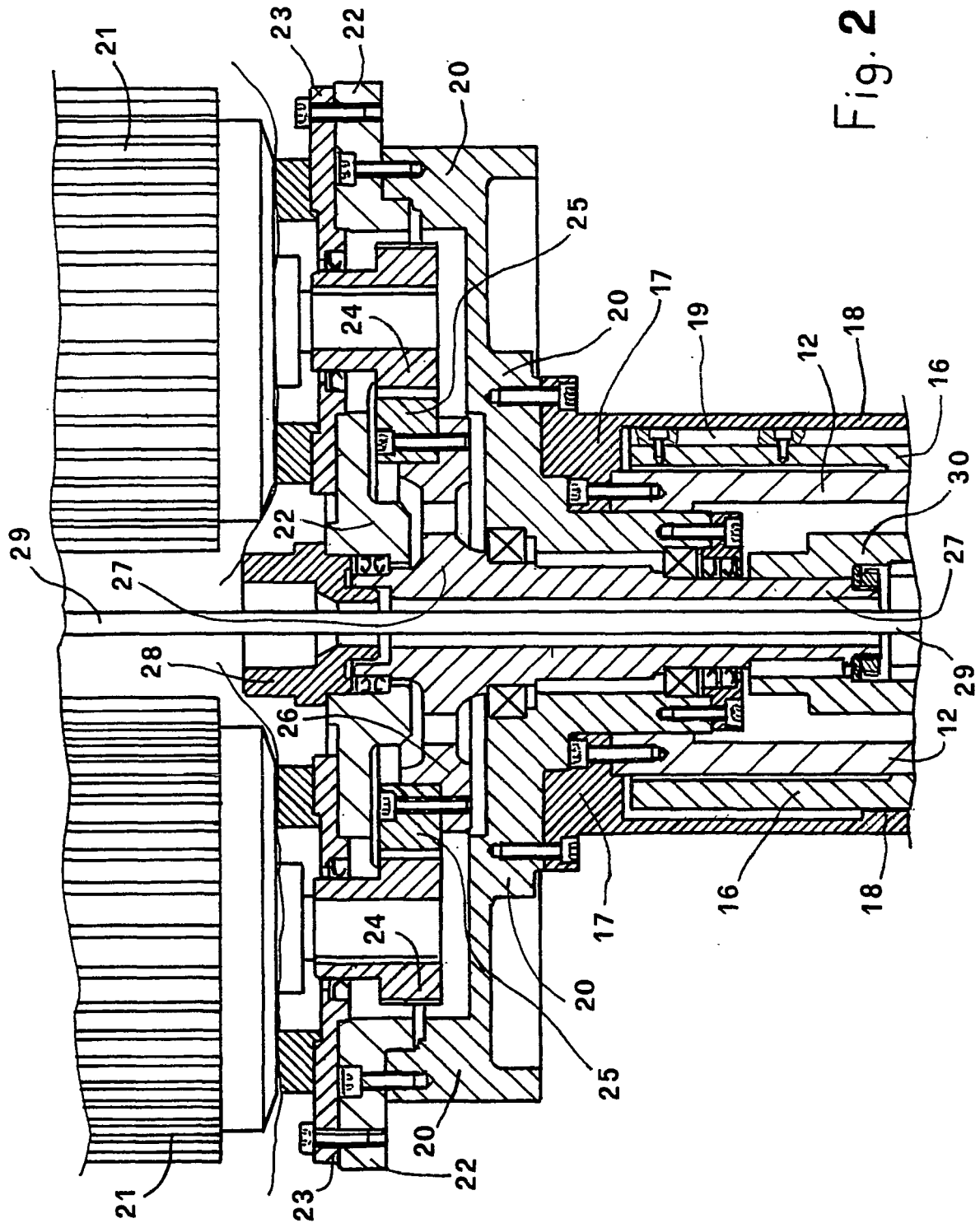
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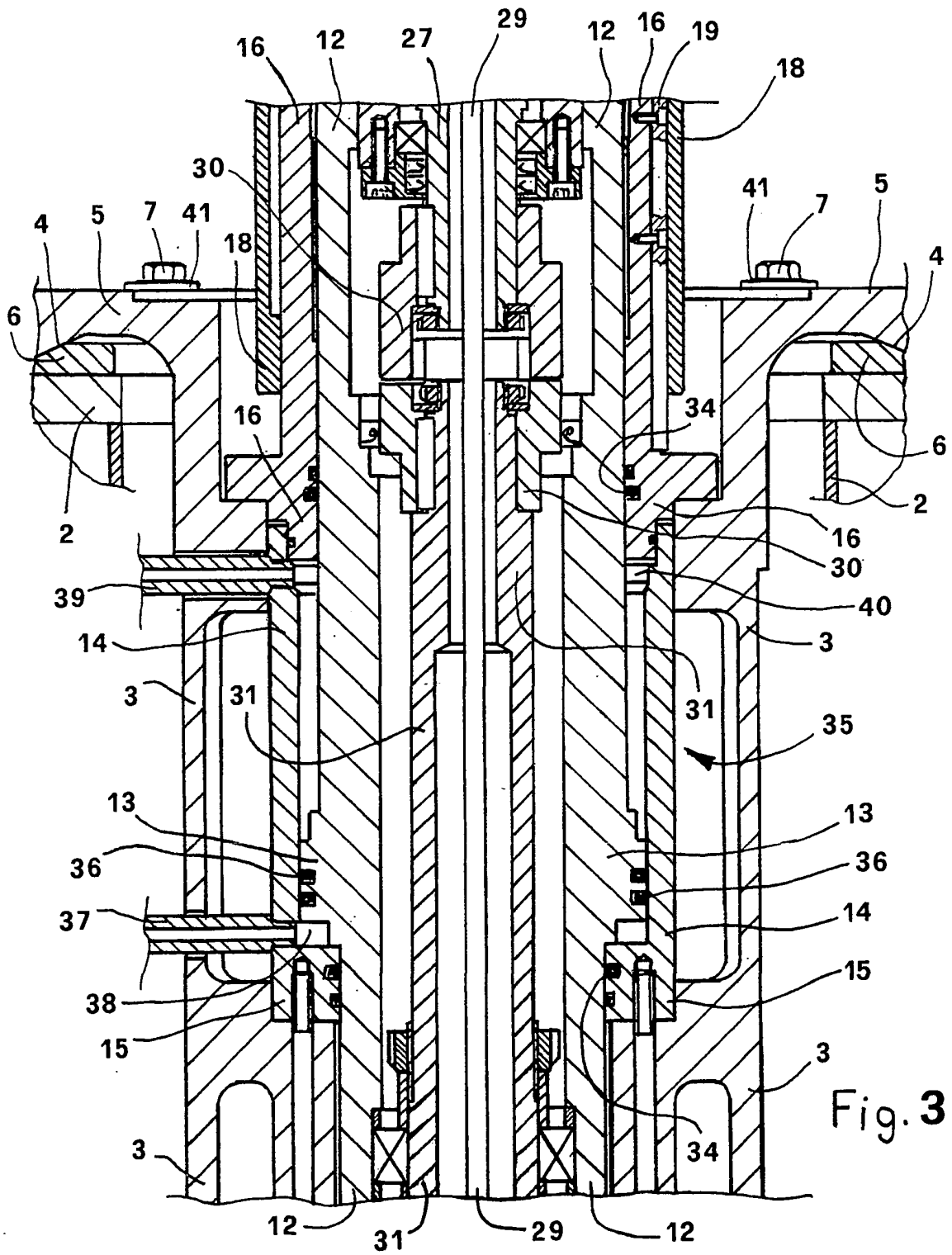
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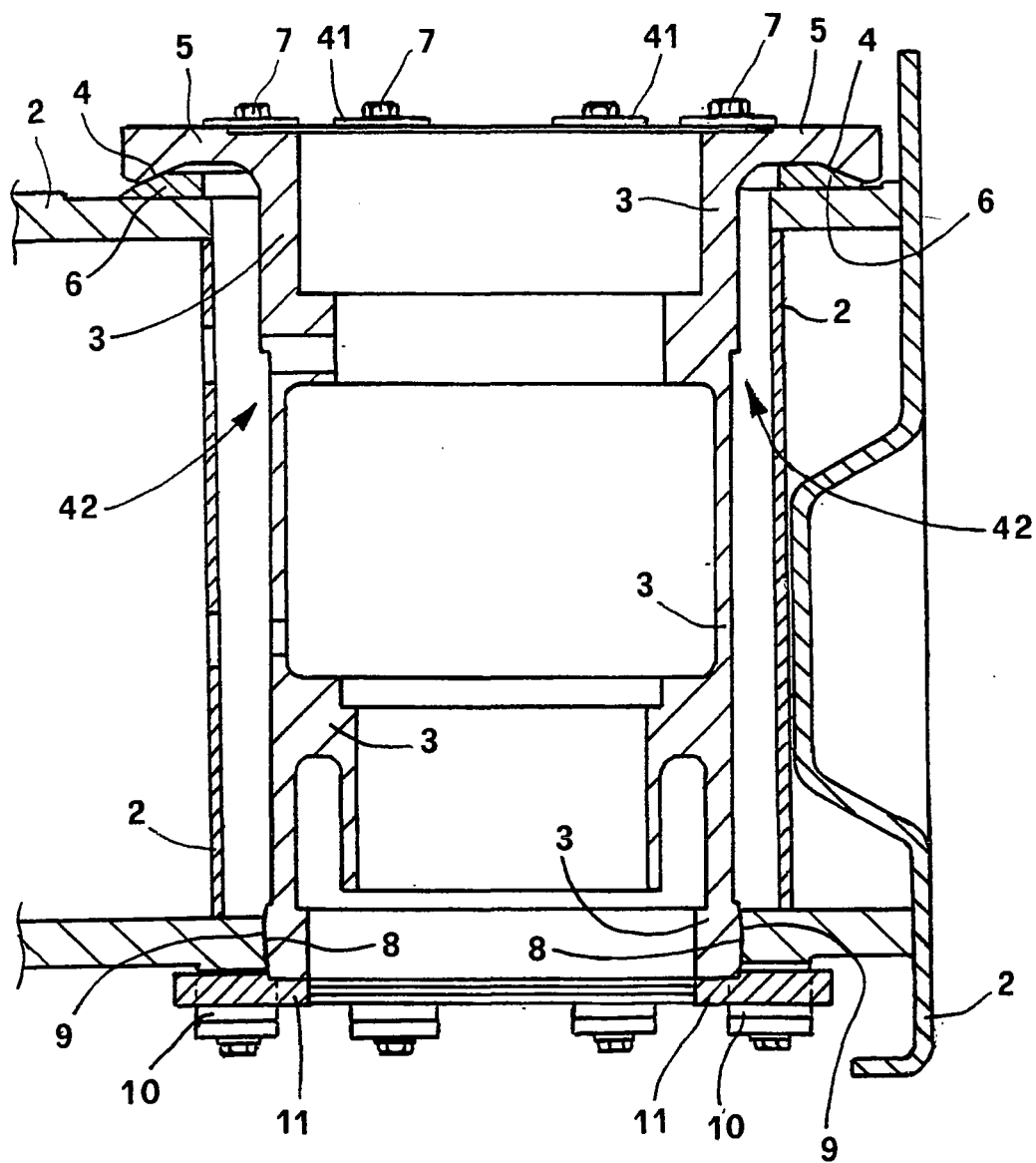


Fig. 4