(19) Europäisches Patentamt
European Patent Office
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(11) **EP 2 801 990 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
12.11.2014 Bulletin 2014/46

(51) Int Cl.:
H01F 41/04 *(2006.01)*

(21) Application number: **14167305.3**

(22) Date of filing: **07.05.2014**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **10.05.2013 IT MI20130771**

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(54) **Electric spindle, particularly for forming coils by winding a wire around a spool**

(57) An electric spindle, particularly for forming coils by winding a wire around a spool, comprising:
- a supporting element (2);
- a spindle shaft (3) that is supported, so that it can rotate about its own axis (3a), by the supporting element (2);
- an electric motor (4) for actuating, with a rotary motion about its own axis (3a), the spindle shaft (3);
- an encoder (5) connected to the spindle shaft (3) in order to control its rotation,
the body of said electric motor (4) and the body of the encoder (5) being connected directly to the supporting element (2).

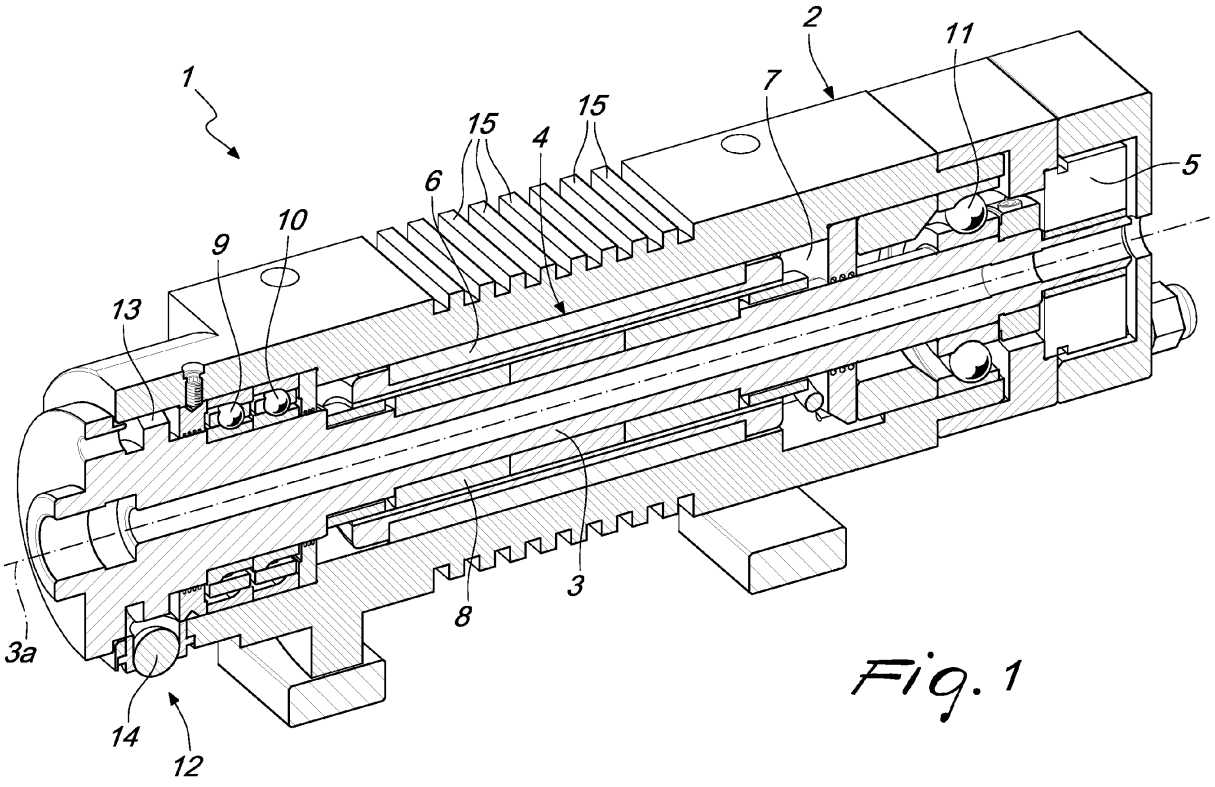

Fig. 1

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Description

[0001] The present invention relates to an electric spindle, particularly for forming coils by winding a wire around a spool.

[0002] As is known, the formation of coils by winding a wire about a spool is usually carried out using a spindle that is actuated by an electric motor and which makes the spool, on which the wire that is fed to the spool is to be wound, rotate about its own axis.

[0003] In order to achieve increasingly high productivity levels, it is necessary to achieve increasingly higher spindle rotation speeds, even higher than 15,000 rpm.

[0004] Achievement of this result, in conventional electric spindles, is impeded by the high vibrations that develop at such rotation speeds and which impede obtaining a precise winding and make the mounting of measurement devices on the winding machine difficult.

[0005] Conventional electric spindles usually comprise a supporting element that supports the spindle shaft so that it can rotate about its own axis. Such shaft is actuated by an electric motor the body or enclosure of which is fixed to the supporting element in a cantilever fashion. Fixed to the other end of the electric motor body with respect to the supporting element is an encoder, the function of which is to control the rotation of the spindle shaft so as to allow adjustment of the rotation speed of the spindle shaft by means of a feedback control system.

[0006] Such configuration of conventional electric spindles, as mentioned above, represents a limitation on reaching high rotation speeds of the spindle shaft, owing to the high vibrations that develop.

[0007] The aim of the present invention is to solve the above mentioned drawback by providing an electric spindle, particularly for forming coils by winding a wire around a spool, which is capable of reducing, to a considerable extent, the vibrations generated by the rotation of the spindle shaft so as to make it possible to achieve appreciably higher rotation speeds than those that can be achieved with conventional electric spindles.

[0008] Within this aim, an object of the invention is to provide an electric spindle that makes it possible to achieve higher productivity levels with respect to those that can be achieved with conventional electric spindles.

[0009] Another object of the invention is to provide an electric spindle that, even at high rotation speeds of the spindle shaft, ensures a high level of precision in the winding of the wire about the spool, thus ensuring a high level of quality in the finished product.

[0010] A further object of the invention is to provide an electric spindle that prevents or substantially reduces problems of overheating and the onset of unwanted currents during winding.

[0011] Another object of the invention is to provide an electric spindle that offers the highest guarantees of safety and reliability in use, and which can be produced at low cost.

[0012] This aim and these and other objects which will become better apparent hereinafter are achieved by an electric spindle, particularly for forming coils by winding a wire around a spool, comprising:

- a supporting element;
- a spindle shaft that is supported, so that it can rotate about its own axis, by said supporting element;
- an electric motor for actuating, with a rotary motion about its own axis, said spindle shaft;
- an encoder connected to said spindle shaft in order to control its rotation;

characterized in that the body of said electric motor and the body of said encoder are connected directly to said supporting element.

[0013] Further characteristics and advantages of the invention will become better apparent from the description of a preferred, but not exclusive, embodiment of the electric spindle according to the invention, which is illustrated by way of non-limiting example in the accompanying drawings wherein:

Figure 1 schematically illustrates the electric spindle according to the invention in a partially sectional perspective view;
Figure 2 is an end view of the electric spindle according to the invention, seen from an axial end thereof;
Figure 3 is an end view of the electric spindle according to the invention, seen from the opposite axial end;
Figure 4 is a schematic axial cross-sectional view of the electric spindle according to the invention, taken along the line IV-IV in Figure 3.

[0014] With reference to the figures, the electric spindle according to the invention, generally designated by the reference numeral 1, comprises a supporting element 2 that supports, rotatably about its own axis 3a, a spindle shaft 3 that is connected to an electric motor 4 that can be actuated in order to cause the actuation, with a rotary motion about its own axis 3a relative to the supporting element 2, of the spindle shaft 3.

[0015] The electric spindle in question comprises, furthermore, an encoder 5 which is connected to the spindle shaft 3 in order to control the rotation thereof. The encoder 5 is functionally connected to an electronic command and control element, conventional and not shown for the sake of simplicity, which oversees the operation of the electric spindle and which regulates the actuation of electric motor 4 as a function of the value read by the encoder 5 so as to maintain with precision the rotation speed of the spindle shaft 3 at a preset value.

[0016] According to the invention, the body of the electric motor 4 and the body of the encoder 5 are connected directly to the supporting element 2.

[0017] The term "directly" means that the electric motor body 4 and the body of the encoder 5 are both fixed to

the supporting element 2 and that, in particular, the encoder 5 is not connected to the supporting element 2 by way of the electric motor body 4, as occurs in conventional electric spindles. This does not mean that there cannot be additional connection elements, such as for example blocks, inserts, spacers or the like, between the electric motor body 4 and the supporting element 2, and also between the body of the encoder 5 and the supporting element 2.

[0018] Preferably, the supporting element 2 and the electric motor body 4 are made in one piece i.e. the supporting element 2 also constitutes the electric motor body 4.

[0019] More specifically, the supporting element 2 is provided in the form of a housing, externally for example having an at least partly prismatic or parallelepiped shape, as illustrated, and, internally, having a cavity 7 that accommodates the stator 6 and the rotor 8 of the electric motor, the encoder 5 and the spindle shaft 3.

[0020] In substance, in the electric spindle according to the invention, the body or housing of the electric motor 4 is preferably constituted by the supporting element 2 proper. In this manner, the electric motor 4 and the encoder 5 are directly coupled inside a single body.

[0021] The cavity 7 is conveniently substantially cylindrical and the spindle shaft 3 is arranged coaxially in such cavity 7.

[0022] The spindle shaft 3 is intended to be connected with an axial end thereof, which is constituted by the left-hand end in Figures 1 and 4, to a conventional spool-holder, not shown for the sake of simplicity.

[0023] The spindle shaft 3 is supported, rotatably about its own axis 3a, within the cavity 7 by way of bearings 9, 10, 11 which are arranged proximate to the axial ends thereof.

[0024] Advantageously, at least one of the bearings 9, 10 that are arranged proximate to the axial end of the spindle shaft 3 that is intended to be engaged with the spool of the coils to be produced is constituted by a ceramic ball bearing.

[0025] Preferably, proximate to the axial end thereof that is intended to be engaged with the spool of the coil to be produced, the spindle shaft 3 is supported by way of a pair of ceramic ball bearings 9, 10.

[0026] Proximate to the other axial end thereof, the spindle shaft 3 is supported by another ball bearing 11.

[0027] The rotor 8 of the electric motor 4 is preferably arranged at an intermediate region of the axial extension of the spindle shaft 3 within the cavity 7.

[0028] Advantageously, the rotor 8 of the electric motor 4 is fixed to a portion of the lateral surface of the spindle shaft 3 and the stator 6 of the electric motor 4 is fixed to the walls of the cavity 7 which face the rotor 8.

[0029] The outer surface of the supporting element 2, at the stator 6 and the rotor 8 of the electric motor 4, is conveniently provided with fins 15 in order to facilitate the removal of heat.

[0030] The encoder 5 is arranged around the spindle shaft 3 proximate to its other axial end with respect to its axial end that is intended to be connected to the spool of the coil to be produced.

[0031] Preferably, the encoder 5 is arranged outside the axial portion of the spindle shaft 3 which is arranged between the bearings 10, 11. In practice, the bearing 11 is arranged between the rotor 8 and the encoder 5.

[0032] For completeness of description, it should be noted that a device 12 is provided for the safety locking of the rotation of the spindle shaft 3.

[0033] Such device 12 for safety locking comprises, in a way that is known per se, a star wheel 13 that is integral with the spindle shaft 3 in rotation about its own axis 3a and a locking element 14 that faces the star wheel 13 laterally and which can be engaged on command with one of the recesses of the star wheel 13.

[0034] Operation of the electric spindle according to the invention is evident from what is described and explained above. In essence, the actuation of the electric motor 4 causes the rotation of the spindle shaft 3 about its own axis 3a relative to the supporting element 2. The rotation speed of the spindle shaft 3 is detected by the encoder 5 which is connected, as said above, in a way that is known per se, to an electronic command and control element that, if the rotation speed of the spindle shaft 3 drifts away from the preset speed, intervenes on the electric motor 4 so as to return the speed to the desired value.

[0035] In the electric spindle according to the invention, the particular manner with which the supporting element 2, the electric motor 4 and the encoder 5 are made and assembled considerably reduces vibrations and makes it possible to obtain fully satisfactory operation with high rotation speeds, even higher than 15,000 rpm.

[0036] Furthermore, the use of ceramic bearings in order to support the spindle shaft makes it possible to contain the development of heat and thus to prevent the overheating of the electric spindle even at high rotation speeds.

[0037] In practice it has been found that the electric spindle according to the invention fully achieves the set aim in that it can achieve without problems rotation speeds of the spindle shaft which are appreciably higher than those that can be achieved with conventional electric spindles, thus enabling the winding machine, on which it is installed, to attain considerable increases in production.

[0038] Another advantage of the electric spindle according to the invention is that it can operate at high speeds without problems of overheating.

[0039] The electric spindle, thus conceived, is susceptible of numerous modifications and variations, all of which are within the scope of the appended claims. Moreover, all the details may be substituted by other, technically equivalent elements.

[0040] In practice the materials employed, provided they are compatible with the specific use, and the dimensions, may be any according to requirements and to the

state of the art.

[0041] The disclosures in Italian Patent Application No. MI2013A000771 from which this application claims priority are incorporated herein by reference.

[0042] Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly, such reference signs do not have any limiting effect on the interpretation of each element identified by way of example by such reference signs.

Claims

1. An electric spindle, particularly for forming coils by winding a wire around a spool, comprising:

   - a supporting element (2);
   - a spindle shaft (3) that is supported, so that it can rotate about its own axis (3a), by said supporting element (2);
   - an electric motor (4) for actuating, with a rotary motion about its own axis (3a), said spindle shaft (3);
   - an encoder (5) connected to said spindle shaft (3) in order to control its rotation;

   characterized in that the body of said electric motor (4) and the body of said encoder (5) are connected directly to said supporting element (2).

2. The electric spindle according to claim 1, **characterized in that** said supporting element (2) constitutes the body of said electric motor (4).

3. The electric spindle according to claims 1 and 2, **characterized in that** said supporting element (2) is provided in the form of a box-like enclosure in which there is a cavity (7) that accommodates the stator (6) and the rotor (8) of the electric motor (4), said encoder (5) and said spindle shaft (3).

4. The electric spindle according to one or more of the preceding claims, **characterized in that** the rotor (8) of said electric motor (4) is fixed to a portion of the lateral surface of said spindle shaft (3) and the stator (6) of said electric motor (4) is fixed to the side walls of said cavity (7) which face said rotor (8).

5. The electric spindle according to one or more of the preceding claims, **characterized in that** said rotor (8) of the electric motor (4) is arranged at an intermediate region of the axial extension of said spindle shaft (3) in said cavity (7).

6. The electric spindle according to one or more of the preceding claims, **characterized in that** said spindle shaft (3) is supported so that it can rotate about its own axis (3a) inside said cavity (7) by way of bearings (9, 10, 11), at least some of said bearings (9, 10, 11) being constituted by ceramic bearings.

7. The electric spindle according to one or more of the preceding claims, **characterized in that** said spindle shaft (3) is supported so that it can rotate about its own axis (3a) inside said cavity (7), proximate to its axial end intended to be engaged with the spool of the coils to be produced, by at least one ceramic bearing (9, 10).

8. The electric spindle according to one or more of the preceding claims, **characterized in that** said encoder (5) is arranged proximate to the axial end of said spindle shaft (3) that is opposite with respect to its axial end intended to be connected to the spool of the coil to be produced.

9. The electric spindle according to one or more of the preceding claims, **characterized in that** between said rotor (8) of the electric motor (4) and said encoder (5), said spindle shaft (3) is supported by an additional bearing (11) that is interposed between said spindle shaft (3) and the side walls of said cavity (7).

10. The electric spindle according to one or more of the preceding claims, **characterized in that** it comprises a device (12) for the safety locking of the rotation of said spindle shaft (3).

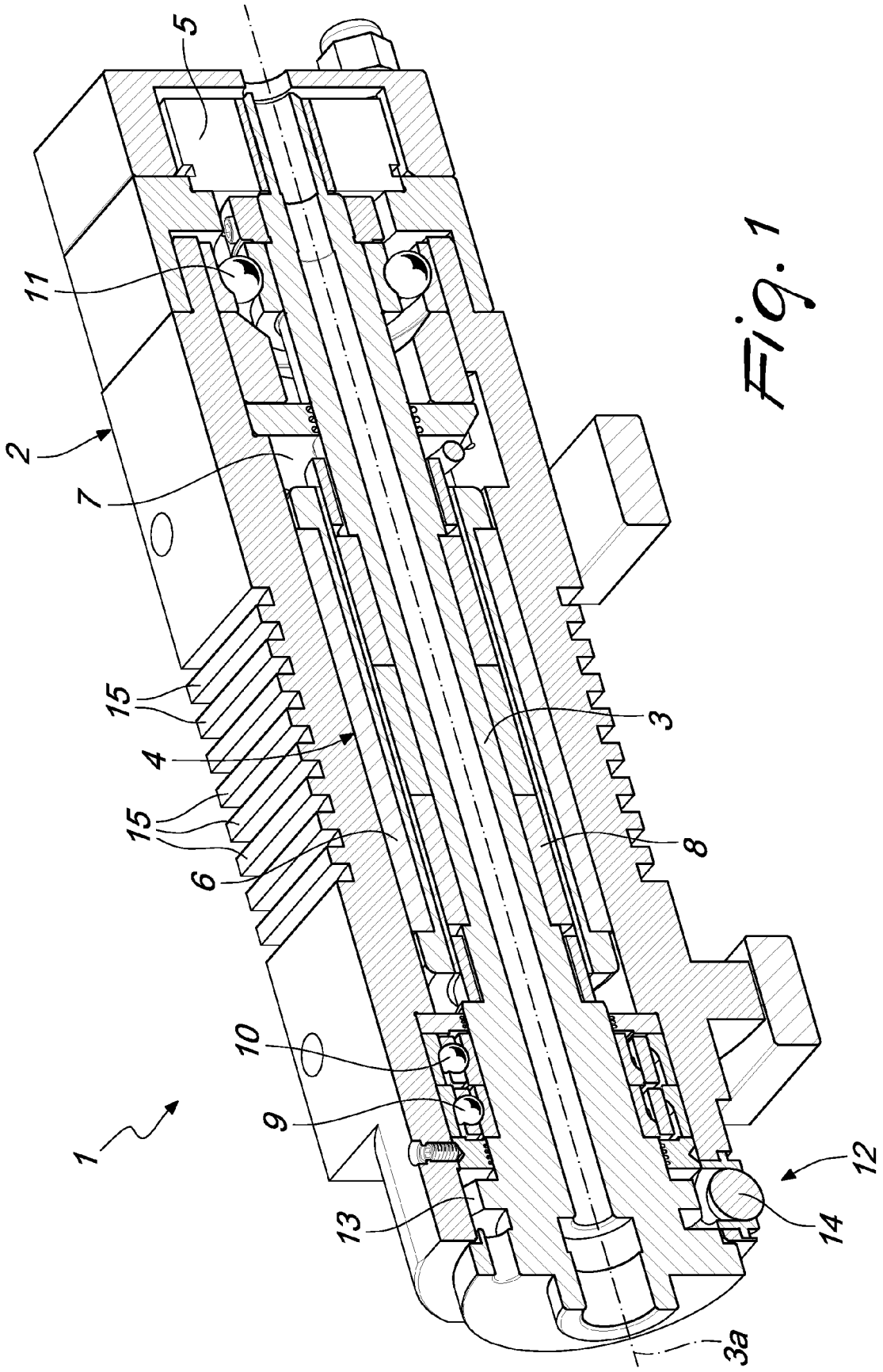

Fig. 1

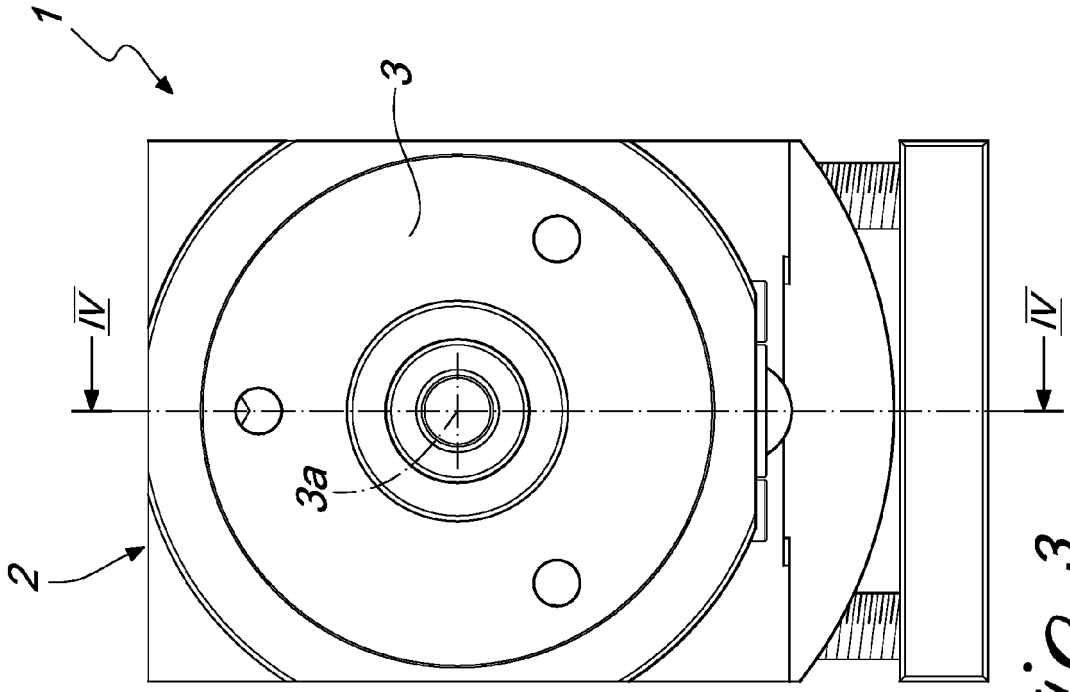

Fig. 3

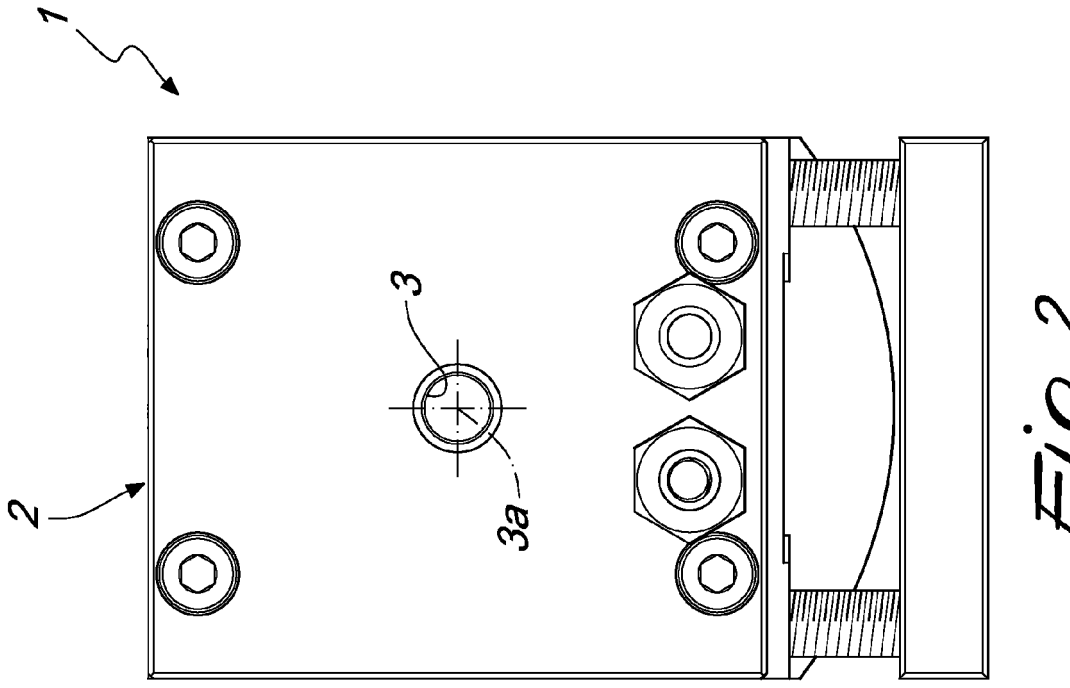

Fig. 2

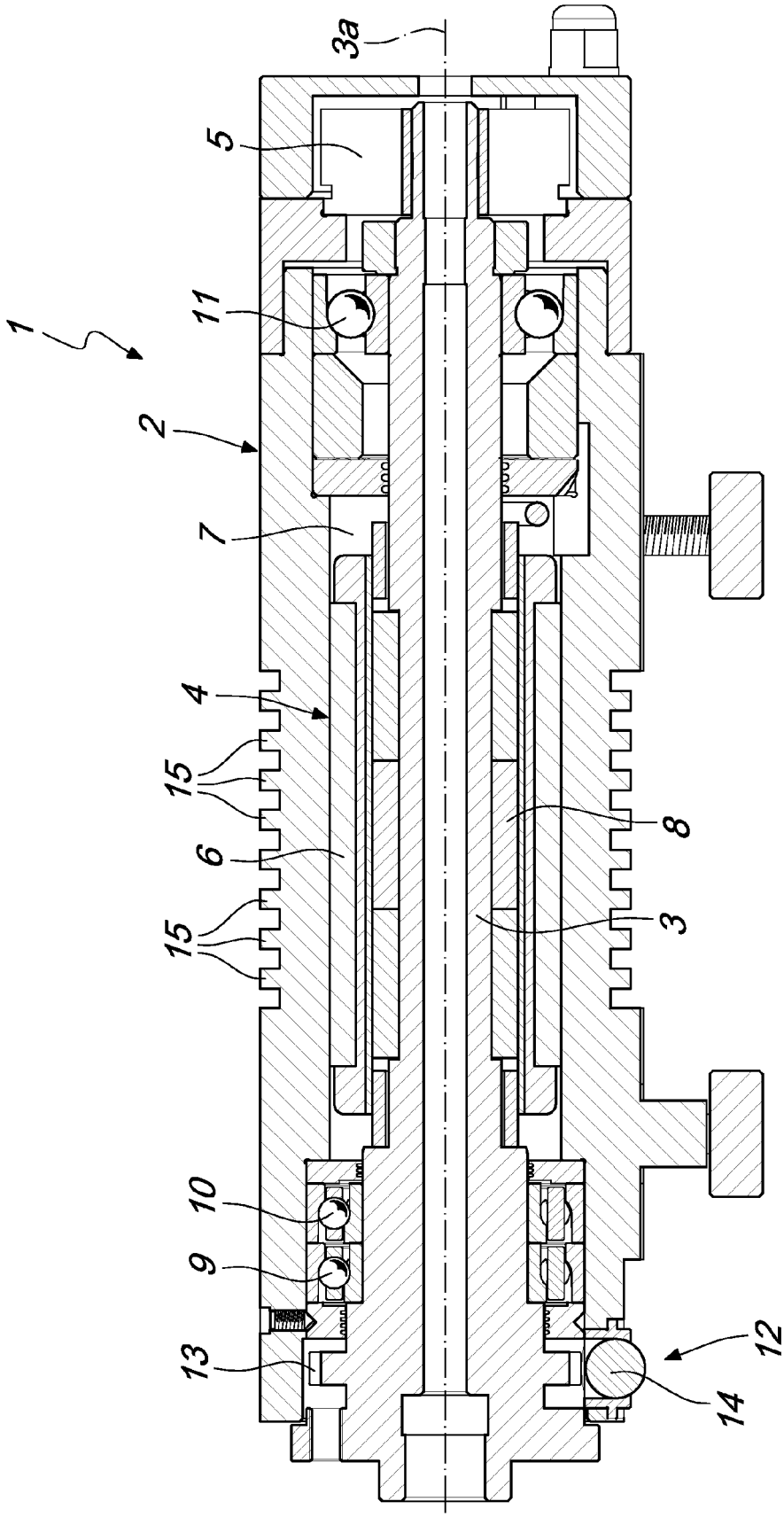

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 14 16 7305

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Y	* the whole document *	6,7	
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A	* paragraph [0011] - paragraph [0017]; figure 3 *	6,7,10	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	3 October 2014	Wozniak, Doris Anna

CATEGORY OF CITED DOCUMENTS

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REFERENCES CITED IN THE DESCRIPTION

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