

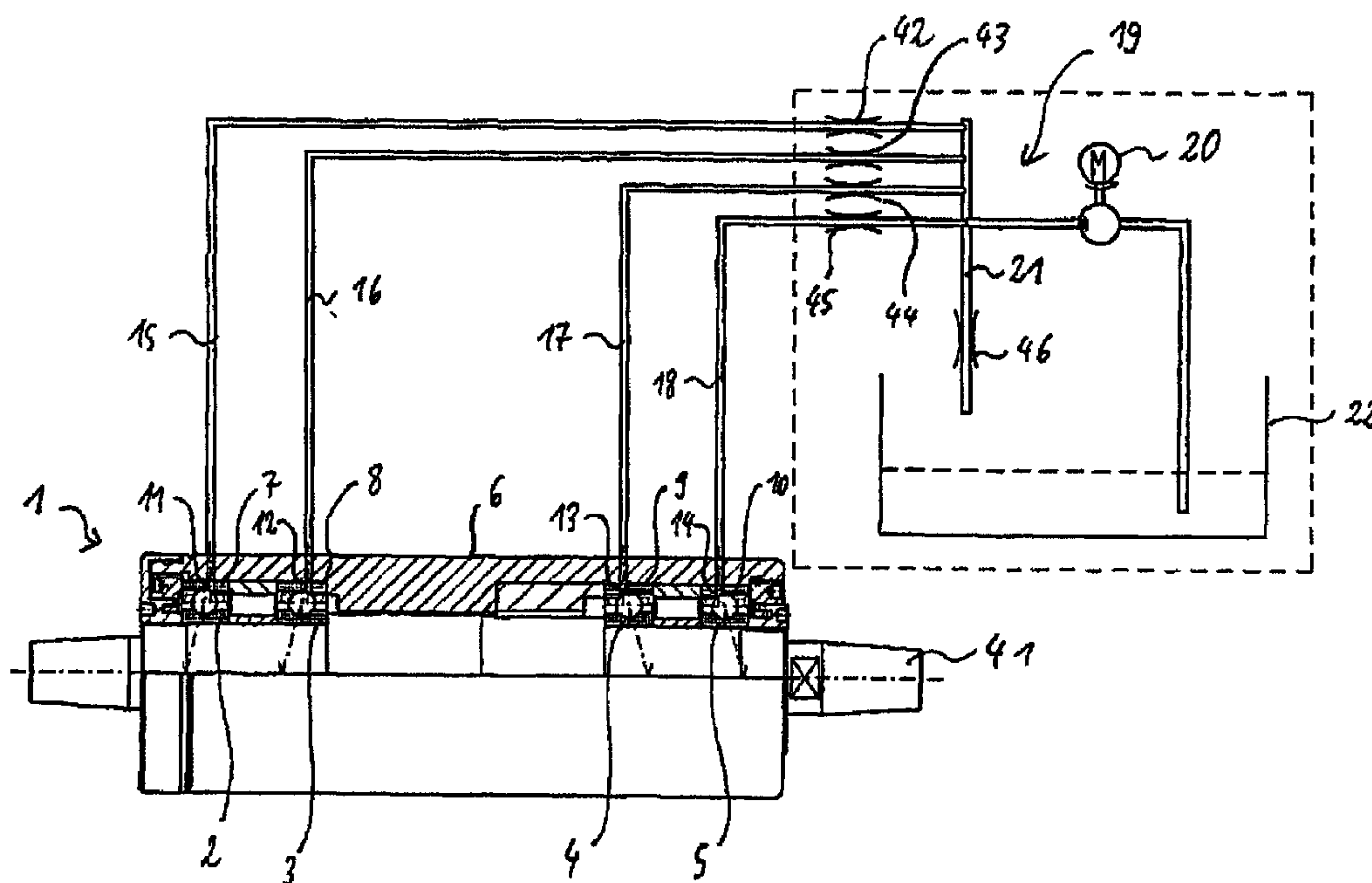


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(54) Titre : BROCHE POUR MACHINE-OUTIL AVEC ELEMENT PALIER A CONDUIT CAPILLAIRE POUR
L'ALIMENTATION EN LUBRIFIANT

(54) Title: SPINDLE FOR A MACHINE TOOL, COMPRISING A BEARING ELEMENT WITH A CAPILLARY FEED LINE
FOR SUPPLYING LUBRICANTS



(57) Abrégé/Abstract:

The invention relates to a spindle (1) for a machine-tool, especially an engine spindle, comprising a housing (6) for receiving an electric engine, a shaft received in bearing elements (2, 3, 4, 5) and driven by the electric engine, and especially a tool receiving element for a tool for machining workpieces, at least one bearing element (2, 3, 4, 5) comprising a capillary feeding line (15, 16, 17, 18) for supplying lubricant by means of a pump element (20). The invention also relates to a bearing element (2, 3, 4, 5) for one such spindle (1), said bearing element comprising at least one recess (11, 12, 13, 14) for receiving a capillary feeding line (15, 16, 17, 18) for supplying lubricant by means of a pump element (20). The invention further relates to a method for operating one such spindle for a machine-tool, whereby a temporal and/or quantitative dosing of lubricant is carried out according to the evaluation of a sensor element, in order to sufficiently lubricate at least one bearing element.

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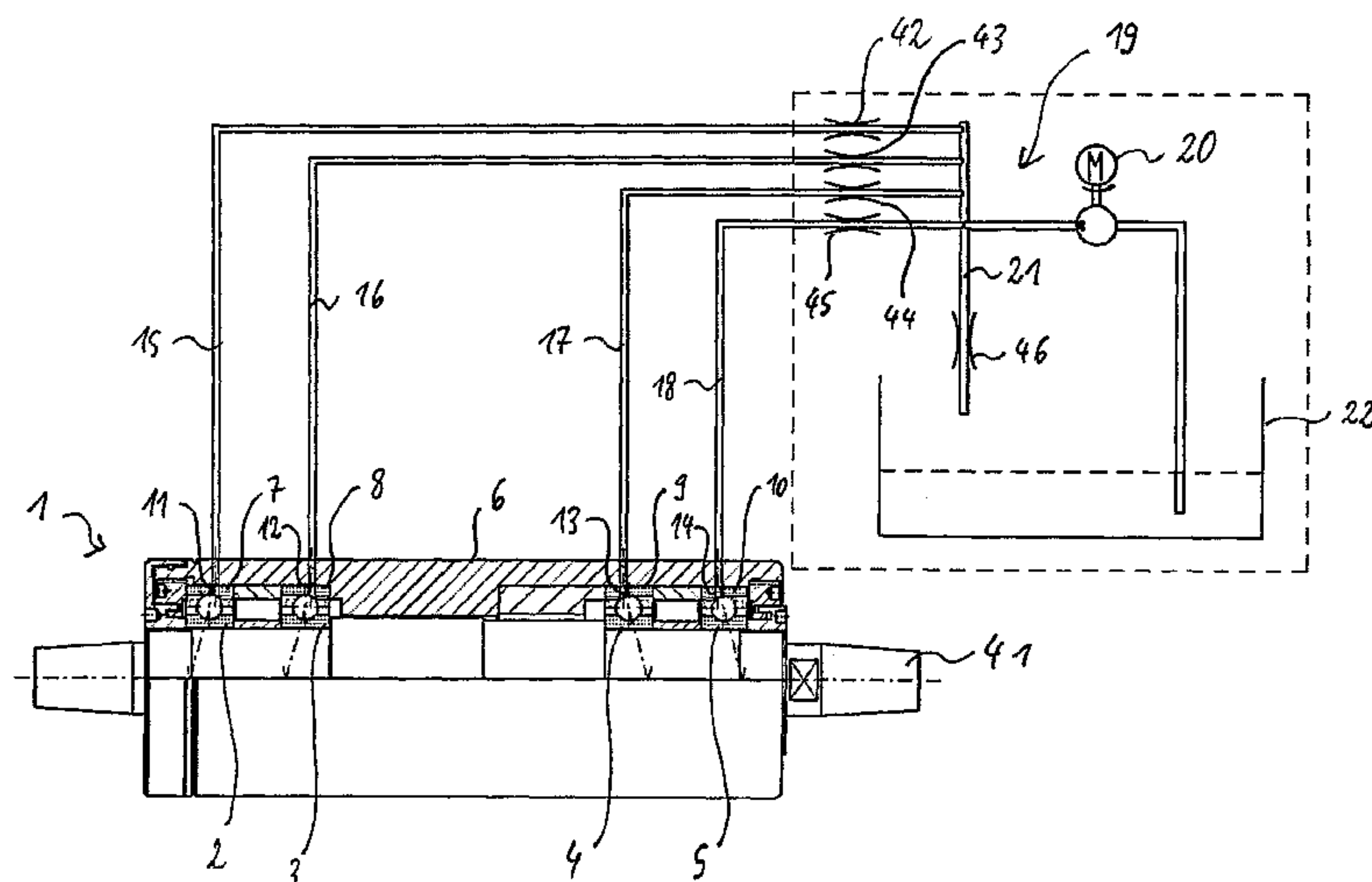
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(54) Title: SPINDLE FOR A MACHINE-TOOL COMPRISING A BEARING ELEMENT PROVIDED WITH A CAPILLARY
FEEDING LINE FOR SUPPLYING LUBRICANTS(54) Bezeichnung: SPINDEL FÜR EINE WERKZEUGMASCHINE MIT EINEM LAGERELEMENT MIT EINER KAPILLA-
REN ZULEITUNG ZUR ZUFÜHRUNG VON SCHMIERSTOFF

(57) Abstract: The invention relates to a spindle (1) for a machine-tool, especially an engine spindle, comprising a housing (6) for receiving an electric engine, a shaft received in bearing elements (2, 3, 4, 5) and driven by the electric engine, and especially a tool receiving element for a tool for machining workpieces, at least one bearing element (2, 3, 4, 5) comprising a capillary feeding line (15, 16, 17, 18) for supplying lubricant by means of a pump element (20). The invention also relates to a bearing element (2, 3, 4, 5) for one such spindle (1), said bearing element comprising at least one recess (11, 12, 13, 14) for receiving a capillary feeding line (15, 16, 17, 18) for supplying lubricant by means of a pump element (20). The invention further relates to a method for operating one such spindle for a machine-tool, whereby a temporal and/or quantitative dosing of lubricant is carried out according to the evaluation of a sensor element, in order to sufficiently lubricate at least one bearing element.

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Zur Erklärung der Zweibuchstaben-Codes und der anderen Abkürzungen wird auf die Erklärungen ("Guidance Notes on Codes and Abbreviations") am Anfang jeder regulären Ausgabe der PCT-Gazette verwiesen.

(57) Zusammenfassung: Die Erfindung betrifft Spindel (1) für eine Werkzeugmaschine, insbesondere Motorspindel, mit einem Gehäuse (6) zur Aufnahme eines Elektromotors und einer von diesem antreibbaren in Lagerelementen (2, 3, 4, 5) aufgenommenen Welle, insbesondere mit einer Werkzeugaufnahme für ein Werkzeug zur Werkstückbearbeitung, wobei mindestens ein Lagerelement (2, 3, 4, 5) eine kapillare Zuleitung (15, 16, 17, 18) zur Zuführung von Schmierstoff durch ein Pumpelement (20) aufweist. Ferner betrifft die Erfindung ein Lagerelement (2, 3, 4, 5) für eine derartige Spindel (1), mit mindestens einer Ausnehmung (11, 12, 13, 14) zur Aufnahme einer kapillaren Zuleitung (15, 16, 17, 18) zur Zuführung von Schmierstoff durch ein Pumpelement (20). Schließlich betrifft die Erfindung ein Verfahren zum Betreiben einer derartigen Spindel für eine Werkzeugmaschine, wobei über Auswertung eines Sensorelements eine zeitliche und/oder mengenmäßige Dosierung von Schmierstoff zur ausreichenden Schmierung mindestens eines Lagerelements stattfindet.

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Spindle For A Machine Tool, Comprising A bearing Element With A
Capillary Feed Line For Supplying Lubricants

DESCRIPTION

The invention relates to a spindle for a machine tool, in particular an engine spindle. Furthermore, the invention relates to a bearing element for a spindle of this type and a method for operating a spindle of this type.

A conventional oil-air lubrication has already been known for a long time as prior art for supplying oil as lubricant to the bearing elements of spindles for machine tools. In an oil-air lubrication of this type, oil quantities are supplied in a pulse-like manner at specific intervals, whereby the supplied oil quantities may not fall below a certain minimum amount.

The object of the invention is to provide a spindle for a machine tool in which a bearing element can also be supplied with minimal amounts and uniformly with lubricant. Furthermore, a bearing element and a method for operating a spindle of this type are proposed.

According to one aspect of the invention there is provided a spindle for a machine tool, in particular an engine spindle, comprising a housing for accommodating an electromotor and a shaft accommodated in bearing elements and driven by them, in particular with a tool carrier for a tool for machining workpieces, characterized in that at least one bearing element has a capillary feed line for supplying lubricant through a pump element. The spindle can be characterized in that the bearing element has a recess in the outer or inner ring for receiving the capillary feed line. The spindle as described herein may be

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characterized in that several capillary feed lines are provided which are connected with the pump element via a distributor element. The spindle can be characterized in that the distributor element has a further capillary line as bypass. The spindle as described herein may be characterized in that the spindle has two adjacent bearing elements with a capillary feed line each. The spindle as described herein can be characterized in that the spindle has two bearing elements which are adjacent and spaced to one another with a capillary feed line. The spindle according to any one of the preceding claims, characterized in that a borehole is provided for supplying air for picking up lubricant flowing out of a capillary feed line.

According to a further aspect of the invention there is provided a bearing element for a spindle for a machine tool, in particular for a spindle as described herein, characterized in that the bearing element has at least one recess for receiving a capillary feed line for supplying lubricants through a pump element.

According to another aspect of the invention there is provided a method for operating a spindle for a machine tool, in particular for a spindle as described herein, characterized in that a temporal and/or quantitative dosing of lubricant is carried out via a control circuit to sufficiently lubricate at least one bearing element.

In the spindle according to the invention, oil is supplied as

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lubricant via at least one capillary feed line to at least one bearing element. In contrast to the known oil-air lubrication, the oil is not conveyed by an air current, but within the capillary feed lines (capillary hoses or tubes) which are continually filled with oil, so that, when the supply is increased, an immediate reaction and oil supply takes place without delay at the required location, i.e. at the end of the respective capillary feed line, due to existing capillary feed lines. A uniform lubrication of even the smallest amounts, in particular of 10 - 100 μl / h (microliters per hour), is made possible.

According to another aspect of the invention there is provided a spindle for a machine tool, comprising a housing for accommodating an electromotor and a shaft accommodated in bearing elements and driven by them, wherein at least one bearing element has a capillary feed line for supplying lubricant through a pump element and a bore is provided for the supply of air for collecting lubricant that emerges from the capillary feed line.

According to yet another aspect of the invention there is provided a method for operating a spindle for a machine tool, the spindle comprising a housing for accommodating an electromotor and a shaft accommodated in bearing elements and driven by the bearing elements, wherein at least one bearing element has a capillary feed line for supplying lubricant through a pump element and a bore is provided for the supply of air for collecting lubricant that emerges from the capillary feed line, wherein at least one of a temporal dosing and a quantitative dosing of lubricant is carried out via a control circuit to sufficiently lubricate at least one bearing element.

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The capillary feed lines typically have an aperture diameter of less than 2/10 mm, whereby feed lines according to conventional oil-air lubrication typically have an aperture diameter of at least 2 mm.

Advantageously, the capillary feed line is received in a recess (borehole) in the inner or outer ring of the bearing element (e.g. of a roller bearing, radially inclined ball bearing) and the lubricant is supplied directly to the rubbing contact without air as a transport medium. As a result, in comparison to the conventional oil-air lubrication, the bearing cannot be dried by blowing.

In an alternative embodiment, the oil is supplied almost directly to the bearing element through the capillary feed line and a final path to the bearing element is overcome by taking along oil at the end of the capillary line by means of the admission of air.

In an advantageous embodiment, the pump element is configured, for example, as a micro gear-ring pump or as a microvalve (e.g. in the form of piezoactors).

In an advantageous embodiment, the pump element is connected with

a distributor element from which several capillary feed lines go off. As a result, a reliable distribution of the lubricant can be made possible for several bearing elements in the spindle.

The flow resistance of a capillary is proportional to the 4th power of the aperture diameter (Hagen-Poiseuille's law). The oil quantity supplied can be reduced to a few percent of the nominal volume flow of the pump element via an additional capillary return line (bypass) since the oil quantity conveyed by the pump element is divided in the ratio of the flow resistance of supply capillaries and bypass capillaries. As a result, the pump element can operate in an advantageous operating range.

The capillaries can be integrated in the pump element as a part of the oil supply or as capillary throttles (e.g. as a microsystematically produced meander or the like).

In an alternative embodiment, the pump element can be designed in such a way, e.g. by corresponding defined leakage flows or defined aperture geometries, that the properties of the bypass are realized by the pump characteristics themselves.

The cleanliness of the lubricant can be permanently increased in the secondary flow by a filter element in the bypass. The oil quantity conveyed by the pump element is divided in the ratio of the cross sections of a supply capillary or capillaries and bypass capillary.

According to an advantageous embodiment, the pump element, the distributor element and further elements can be integrated in the housing of the spindle in a space-saving manner.

The bearing element according to the invention has at least one recess for receiving a capillary feed line for supplying lubricants through a pump element. Bearing elements of this type can be used for a spindle that is designed as described and can

be used to connect with capillary feed lines for supplying lubricants for lubricating the bearing body and the bearing.

With the method for operating the spindle according to the invention, a temporal and/or quantitative dosing of lubricant is carried out via an evaluation of a sensor element, in order to sufficiently lubricate at least one bearing element.

The invention is described in greater detail with reference to examples of embodiments in the drawings, showing:

- Fig. 1 a schematic overview of a spindle with capillary feed lines for supplying lubricants,
- Fig. 2 a first embodiment of bearing elements in a spindle according to Fig. 1,
- Fig. 3 a further embodiment of bearing elements of a spindle according to Fig. 1, and
- Fig. 4 a control circuit for a requirement-dependent lubricant dosing.

Fig. 1 shows a schematically illustrated spindle 1 for a machine tool (processing spindle) with a shaft accommodated in bearing elements 2, 3, 4 and 5, which are received in a housing 6 of the spindle 1. The outer rings 7, 8, 9 and 10 of the bearing elements 2, 3, 4 and 5 have recesses 11, 12, 13 and 14 (boreholes) for accommodating capillary feed lines 15, 16, 17 and 18, shown schematically and thus enlarged, which are configured e.g. as known capillary hoses.

In total, four capillary feed lines 15, 16, 17 and 18 are shown which are connected to a pump element 20 via a distributor 19. Furthermore, the distributor 19 can have capillary throttles 42, 43, 44 and 45 and has an additional capillary line 21, namely a

bypass, which can also have a capillary throttle 46. The capillary throttles can be individually adjusted and be used to dose the conveyed quantity flows into the individual capillary feed lines and in the bypass.

The pump element 20 conveys lubricant, e.g. oil, from a storage vessel 22 and supplies the conveyed lubricant to the four capillaries 15, 16, 17 and 18. A part of the lubricant is diverted through the further capillary line 21 and, optionally filtered, supplied to the storage vessel 22.

Fig. 2 shows one possible arrangement of bearing elements 23 and 24 directly adjacent to one another in a housing 6 of a spindle 1 according to Fig. 1. The outer rings 25 and 26 of the bearing elements 23 and 24 have recesses 27 and 28 for accommodating schematically illustrated capillary lines 29 and 30.

In a further embodiment, Fig. 3 shows bearing elements 31 and 32 which are accommodated at a distance from one another in the housing 6 of a spindle 1. A distributor element 33, into which capillary feed lines 34 and 35 lead, are situated between the bearing elements 31 and 32. These capillary feed lines 34 and 35 end at the extremities 36 and 37 and are laterally connected with the bearing elements 31 and 32 by connecting passages 38 and 39. Air is supplied via a borehole 40 and oil is picked up in the end regions 36 and 37 of the capillary feed lines 34 and 35 and supplied to the bearing elements 31 and 32 via the connecting passages 38 and 39.

A self-explanatory control circuit can be seen in Fig. 4 which enables a requirement-dependent lubrication control. Operating parameters of the driven spindle 1 (e.g. rotational speed, engine temperature, coolant temperature, bearing temperature) can be detected via sensor elements and the strength of an oil film in the existing bearing elements can be estimated by known correlations. If a threshold value is fallen below in this case,

an increased amount of lubricant can be supplied to the lubricating control via the dosing element, as a result of which the spindle bearing receives an additional oil film and thus remains adequately lubricated.

The dosing of the lubricant quantity and with it the change in the activity of the pump element can take place e.g. according to the following strategies:

- with fixed values over the entire operation time of the machine in dependency on the type of spindle, bearing design, etc. (comparable to previous lubricating methods) or
- controlled on the basis of characteristic fields, e.g. oil quantity = f (rotational speed of the spindle) or
- control on the basis of a direct oil film measurement on the bearing (currently, there is no reliable method available)
- control on the basis of an estimate of the thickness of the oil film with aid of easy-to-measure variables (bearing temperature, etc.).

All of the strategies can be applied individually or in combination.

The estimated thickness of the lubricating film can be used as a control variable, the lubricant quantity as a control variable.

REFERENCE NUMBERS

1	Spindle
2, 3, 4, 5	Bearing element
6	Housing
7, 8, 9, 10	Outer ring
11, 12, 13, 14	Recess
15, 16, 17, 18	Capillary feed line
19	Distributor
20	Pump element
21	Capillary feed line
22	Storage vessel
23, 24	Bearing element
25, 26	Outer ring
27, 28	Recess
29, 30	Capillary feed line
31, 32	Bearing element
33	Distributor element
34, 35	Capillary feed line
36, 37	Extremity
38, 39	Connecting passage
40	Borehole
41	Shaft
42, 43, 44, 45, 46	Throttle

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The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A spindle for a machine tool, comprising a housing for accommodating an electromotor and a shaft accommodated in bearing elements and driven by them, wherein at least one bearing element has a capillary feed line for supplying lubricant through a pump element and a bore is provided for the supply of air for collecting lubricant that emerges from the capillary feed line.
2. The spindle according to claim 1, wherein the bearing element has a recess in the outer or inner ring for receiving the capillary feed line.
3. The spindle according to claim 1 or 2, wherein several of the capillary feed lines are connected with the pump element via a distributor element.
4. The spindle according to claim 3, wherein the distributor element has a further capillary line as bypass.
5. The spindle according to any one of claims 1 to 4, wherein each capillary feed line has two adjacent bearing elements.
6. The spindle according to any one of claims 1 to 4, wherein the capillary feed line has two bearing elements which are adjacent and spaced to one another.
7. A method for operating a spindle for a machine tool, the spindle comprising a housing for accommodating an electromotor and a shaft accommodated in bearing elements

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and driven by the bearing elements, wherein at least one bearing element has a capillary feed line for supplying lubricant through a pump element and a bore is provided for the supply of air for collecting lubricant that emerges from the capillary feed line, wherein at least one of a temporal dosing and a quantitative dosing of lubricant is carried out via a control circuit to sufficiently lubricate at least one bearing element.

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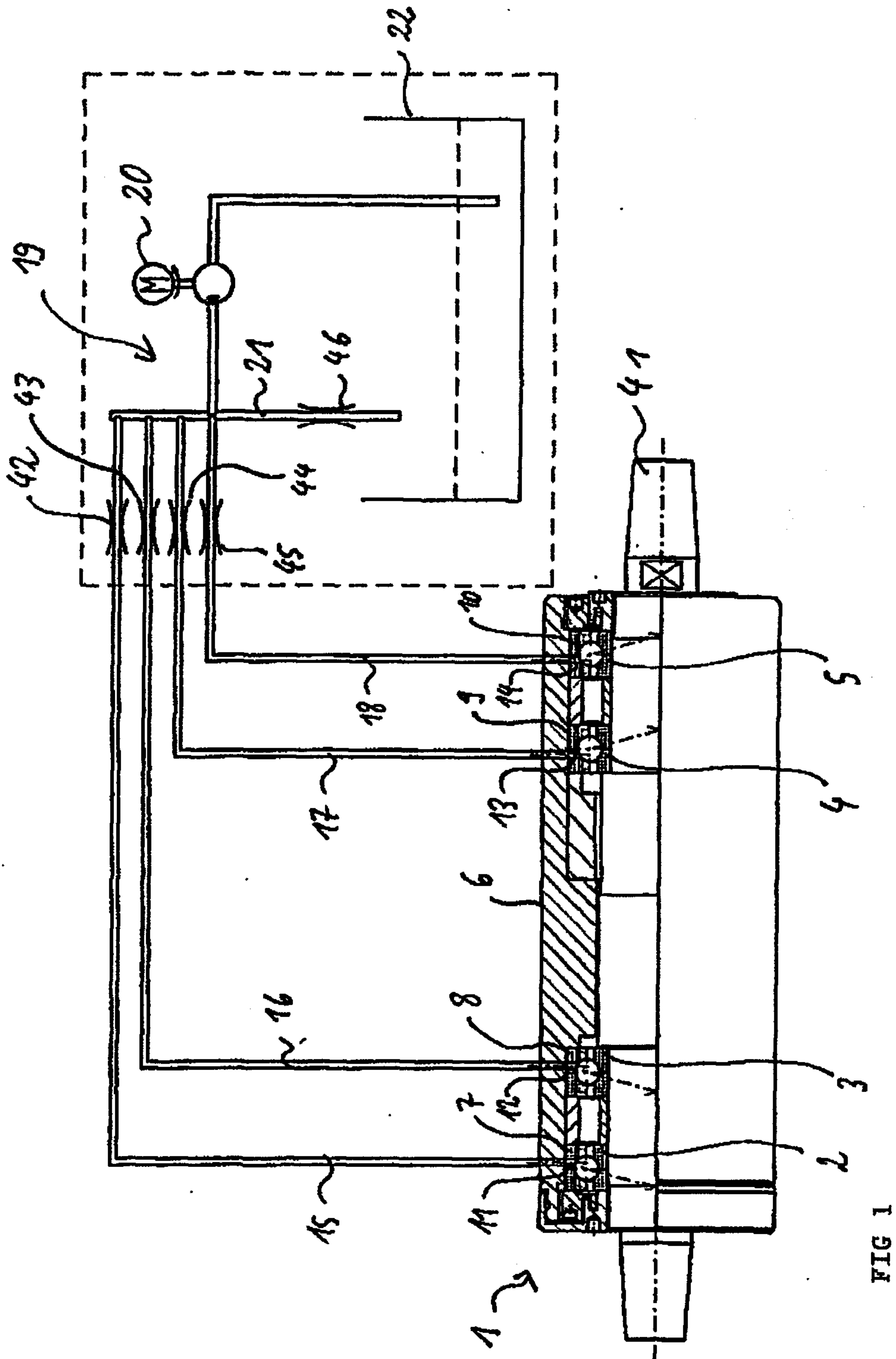


FIG 1

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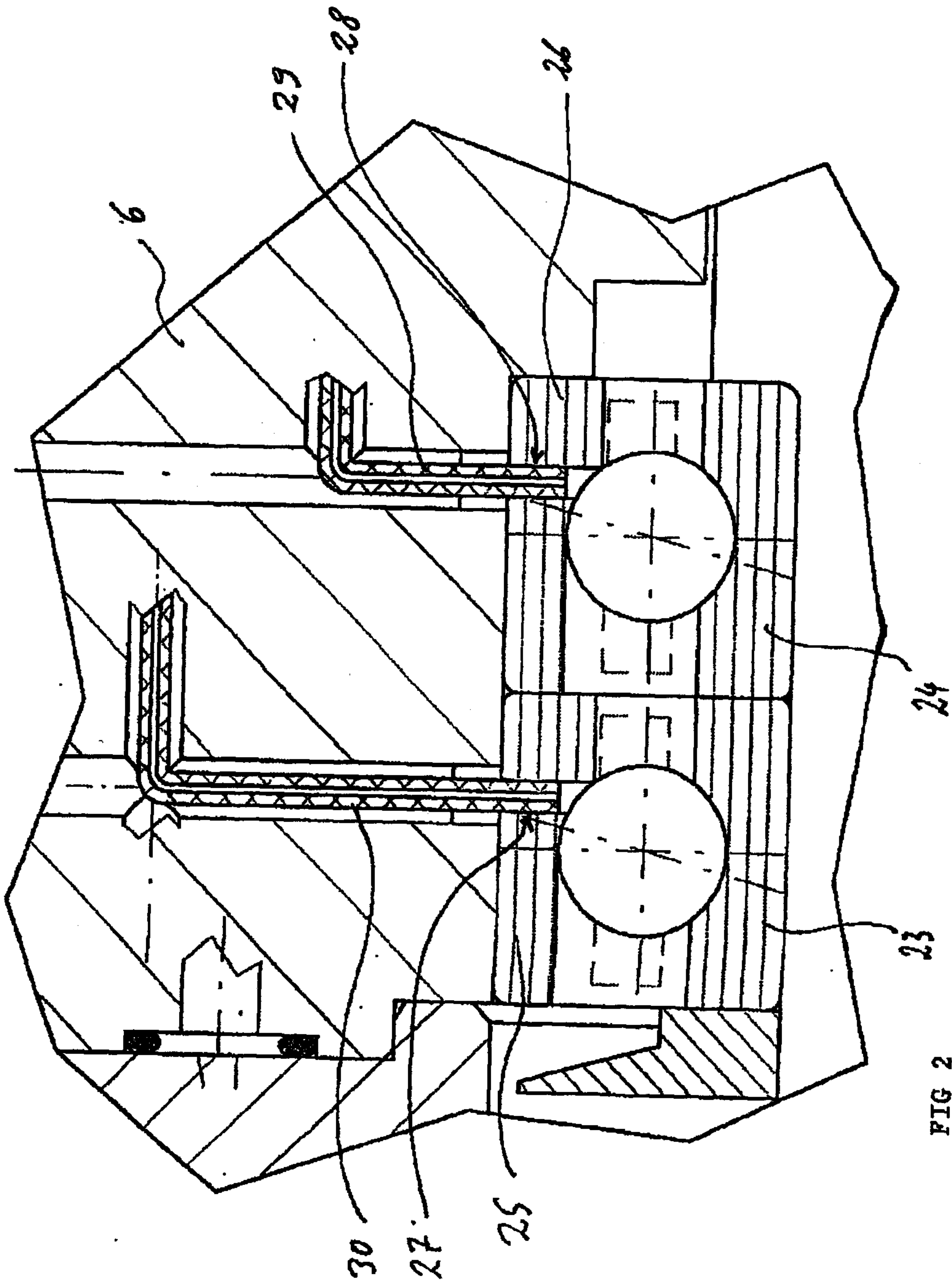


FIG. 2

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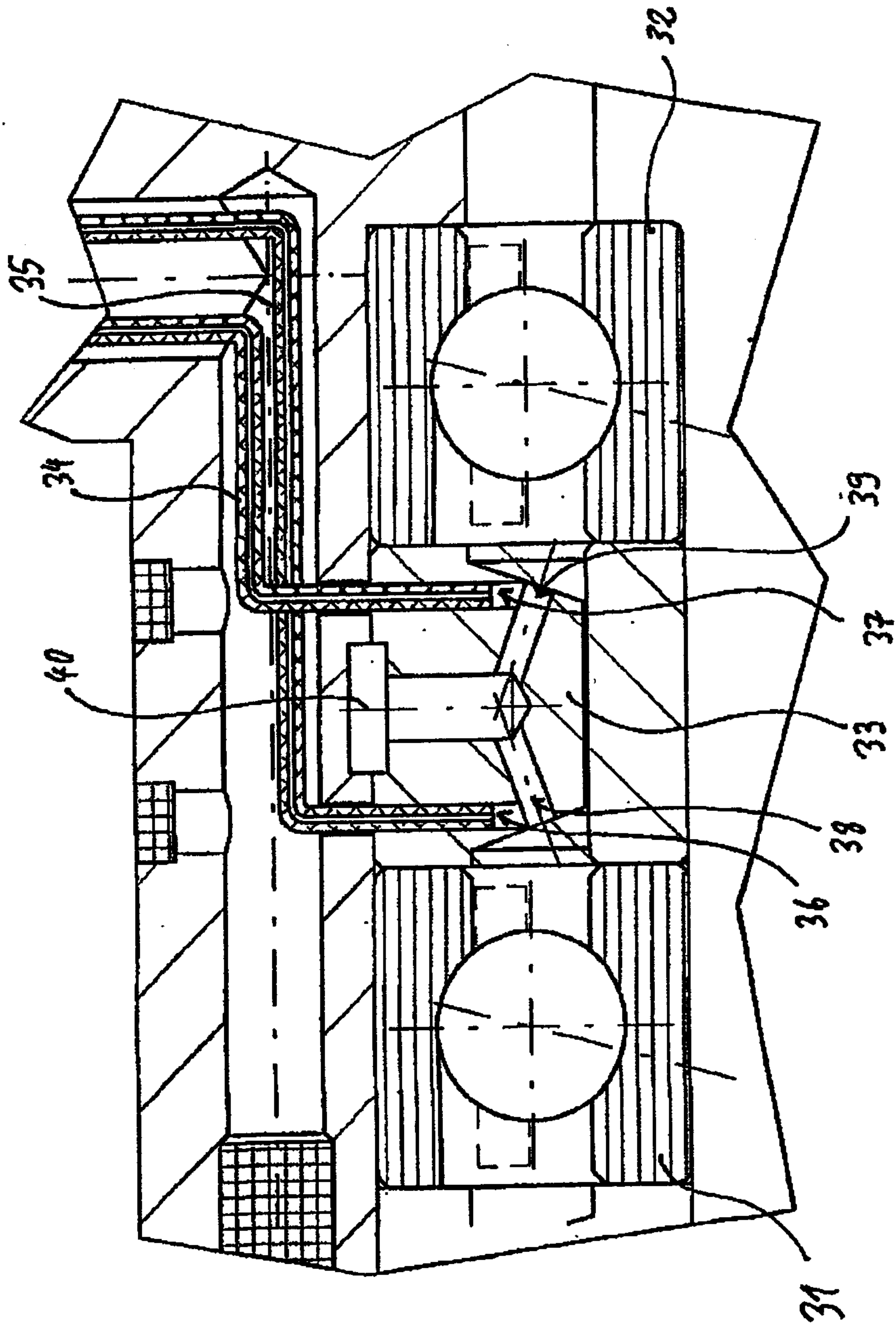


FIG 3

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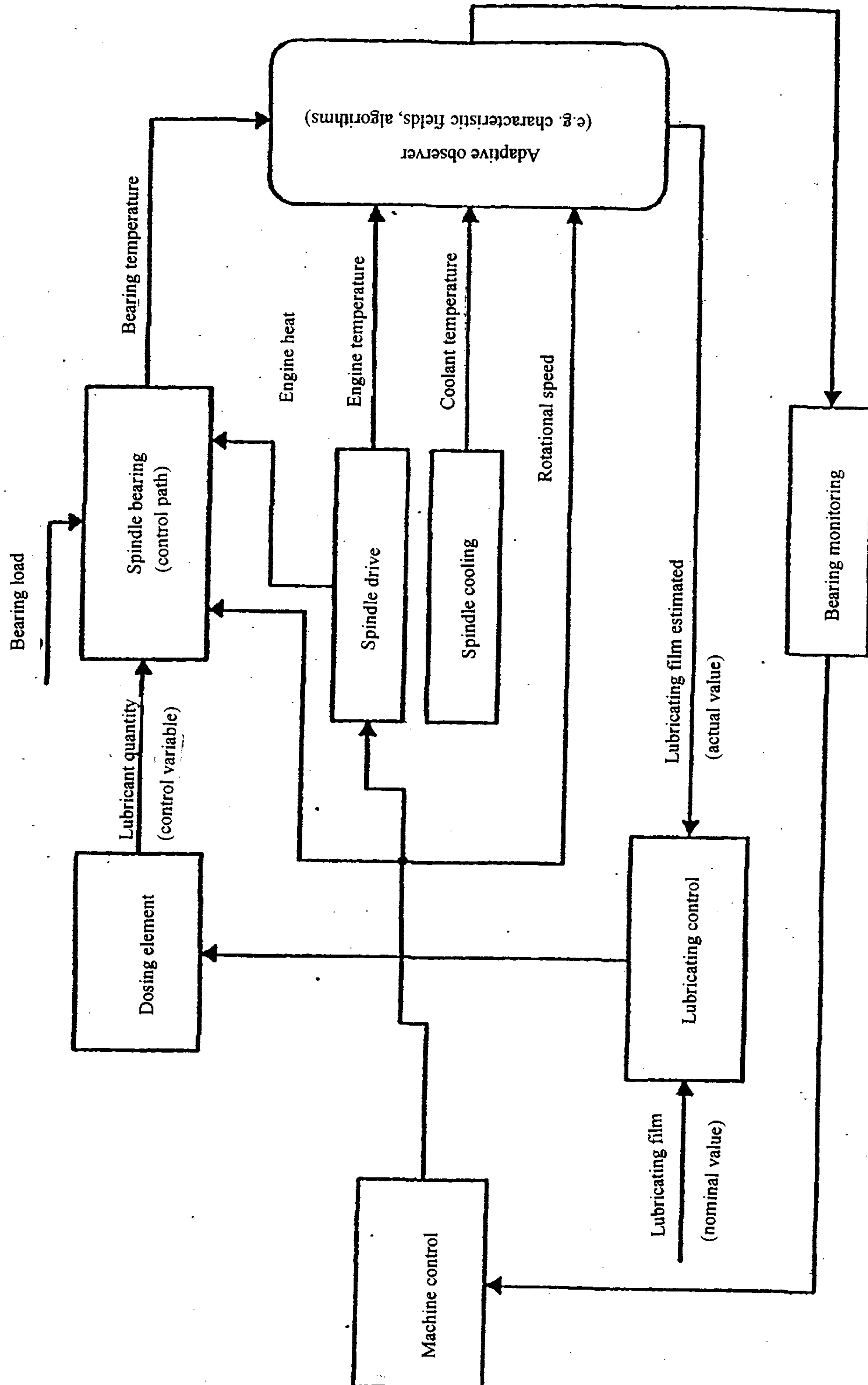


FIG 4

