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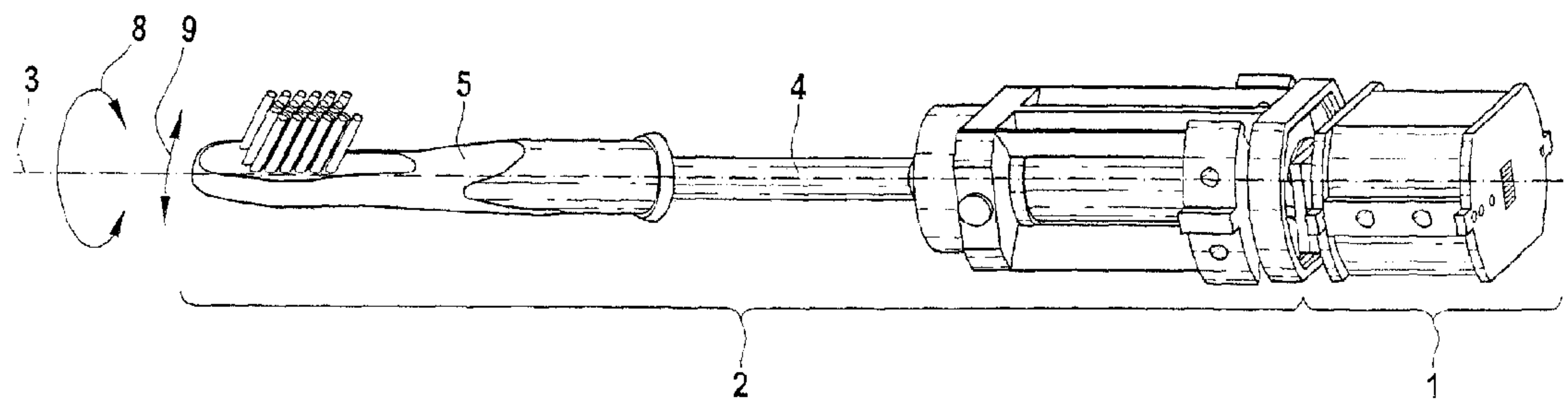
(54) **Titre : DISPOSITIF D'ENTRAINEMENT SERVANT A ENTRAINER UN ELEMENT DE BROSSAGE DE BROSSE A DENTS ELECTRIQUE**

(54) **Title: DRIVE DEVICE FOR DRIVING A BRUSH ELEMENT OF AN ELECTRIC TOOTHBRUSH**



(57) **Abrégé/Abstract:**
The invention relates to a drive device for driving a brush element (5) of an electric toothbrush. Said drive device comprises a first drive component (25) for generating a magnetic field and a second drive component (26) which can be driven in both a translational and rotational manner under the influence of the magnetic field. The drive device according to the invention also comprises a transmission element (4) that can be deflected out of a pre-determined position for the transmission of a translational movement and a rotary movement of the second drive component (26) along a longitudinal axis (3) of the transmission element (4) to the brush element (5). The drive device according to the invention is characterised in that the deflection of the transmission element (4) out of the pre-determined position varies along the longitudinal axis (3) of the transmission element (4).

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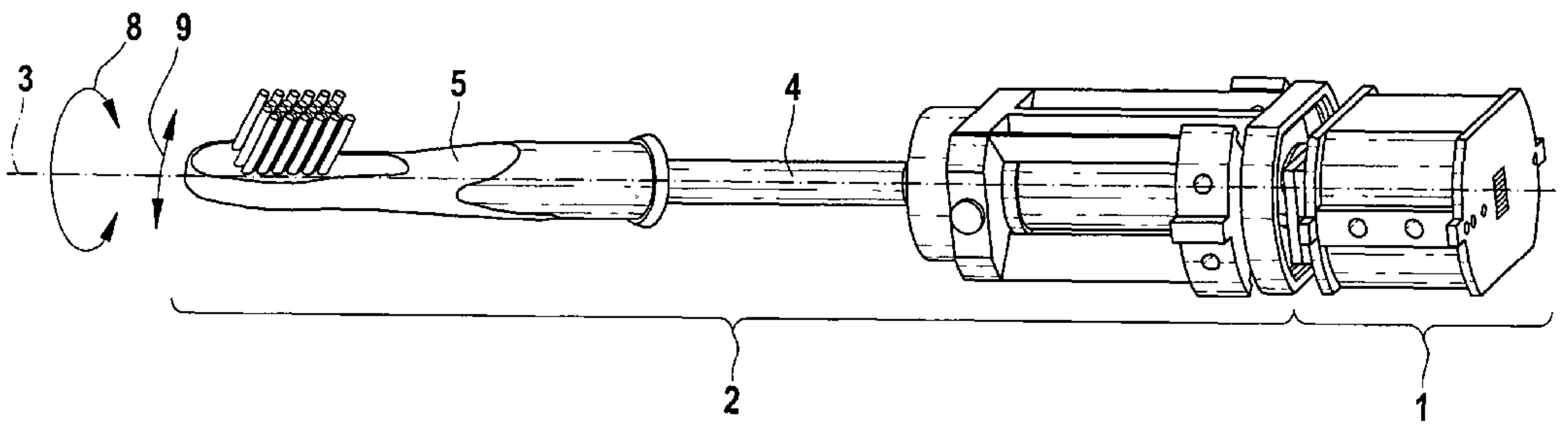
(54) Title: DRIVE DEVICE FOR DRIVING A BRUSH ELEMENT OF AN ELECTRIC TOOTHBRUSH

(54) Bezeichnung: ANTRIEBSVORRICHTUNG ZUM ANTREIBEN EINES BÜRSTENELEMENTS EINER ELEKTRISCHEN ZAHNBÜRSTE



(57) Abstract: The invention relates to a drive device for driving a brush element (5) of an electric toothbrush. Said drive device comprises a first drive component (25) for generating a magnetic field and a second drive component (26) which can be driven in both a translational and rotational manner under the influence of the magnetic field. The drive device according to the invention also comprises a transmission element (4) that can be deflected out of a pre-determined position for the transmission of a translational movement and a rotary movement of the second drive component (26) along a longitudinal axis (3) of the transmission element (4) to the brush element (5). The drive device according to the invention is characterised in that the deflection of the transmission element (4) out of the pre-determined position varies along the longitudinal axis (3) of the transmission element (4).

(57) Zusammenfassung: Die Erfindung bezieht sich auf eine Antriebsvorrichtung zum Antreiben eines Bürstenelements (5) einer elektrischen Zahnbürste. Die erfindungsgemäße Antriebsvorrichtung weist eine erste Antriebskomponente (25) zur Erzeugung eines Magnetfelds und eine zweite Antriebskomponente (26) auf, die durch Einwirkung des Magnetfelds sowohl translatorisch als auch rotatorisch antreibbar ist. Weiterhin weist die erfindungsgemäße Antriebsvorrichtung ein aus einer vorgegebenen Position auslenkbares Übertragungselement (4) zur Übertragung einer translatorischen und einer rotatorischen Bewegung der zweiten Antriebskomponente (26) entlang einer Längsachse (3) des Übertragungselements (4) auf das Bürstenelement (5) auf. Die Besonderheit der erfindungsgemäßen Antriebsvorrichtung besteht darin, daß die Auslenkung des Übertragungselements (4) aus der vorgegebenen Position entlang der Längsachse (3) des Übertragungselements (4) variiert.

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DRIVE DEVICE FOR DRIVING A BRUSH ELEMENT OF AN ELECTRIC TOOTHBRUSH

The invention relates to a drive device for driving a brush element of an electric toothbrush. In addition, the invention relates to an electric toothbrush having such a drive device and to a method for operating such a drive device.

EP 1 193 844 A1 describes a linear oscillator with which a rotor that executes a back and forth movement is arranged in a housing designed as a stator. The housing also contains a spindle in a movable arrangement for controlling the amplitude of oscillation of the rotor. The rotor and spindle are connected by springs to one another and to the housing. The rotor may be connected to the housing by a helical spring in particular, one end of the helical spring being attached to the housing and the other end being attached to the rotor. In compression and stretching with this arrangement, the spring not only exerts a force in the axial direction but also causes the rotor to rotate slightly, resulting in an oscillating rotational movement in particular when the excitation occurs at the resonant frequency of the oscillating rotational movement. The oscillating rotational movement generated in this way is coupled to the linear vibrating movement and necessarily presupposes that the linear vibrating movement is excited. Furthermore, the oscillating rotational movement always has the same frequency as the linear vibrating movement, so the possible variations are very limited.

DE 103 55 446 A1 describes an electric motor for a small electric appliance having a magnetic arrangement with at least one permanent magnet and a coil for generating a magnetic field. The magnetic field generates a force in its interaction with the magnetic arrangement to induce a linear vibrating movement and a torque to induce a rotational vibrating movement. The linear vibrating movement may be oriented in parallel with or perpendicular to the axis of the rotational vibrating movement.

The aspect of the invention is to drive a brush element of an electric toothbrush in the most optimal possible manner.

According to one aspect of the present invention there is provided an electric toothbrush drive device configured to drive a brush element, the drive device comprising a first drive component configured to generate a magnetic field; a second drive component configured to be driven to both translatory movement and rotational movement by the influence of the magnetic field; and a transmission element configured to be deflected out of a predefined position to transmit a translatory movement and a rotational movement of the second drive component to the brush element; wherein deflection of the transmission element out of the predefined position varies along a longitudinal axis of the transmission element; wherein the second drive component is arranged axially next to the first drive component; and wherein the magnetic field generated by the first drive component extends axially towards the second drive component to engage the second drive component.

According to a further aspect of the present invention there is provided a drive device for driving a brush element of an electric toothbrush, the drive device comprising a first drive component configured to generate a magnetic field; a second drive component configured to be driven to both translatory and rotational movement by action of the magnetic field; and a transmission element configured to be deflected out of a predefined position to transmit a translatory movement and a rotational movement of the second drive component to the brush element along a longitudinal axis of the transmission element; wherein the transmission element is attached to a suspension between two freely movable axial ends of the transmission element; wherein the second drive component is arranged axially next to the first drive component; and wherein the magnetic field generated by the first drive component extends axially towards the second drive component to engage the second drive component.

According to another aspect of the present invention there is provided a drive device for driving a brush element of an electric toothbrush, the drive device comprising a first drive component configured to generate a magnetic field; and a second drive component comprising a magnetic arrangement arranged axially next to the first drive component and comprising a plurality of magnetic regions, wherein the magnetic field generated by the first drive component extends axially towards the plurality of magnetic regions of the second drive component to engage the plurality of magnetic regions, and wherein the magnetic regions in the magnetic arrangement are arranged according to a pattern that is neither axially symmetrical nor point symmetrical.

According to a still further aspect of the present invention there is provided an electric toothbrush, comprising a shaft configured to accept an attachable brush element thereon; a first drive component connected to the shaft and configured to generate a magnetic field; and a second drive component comprising a magnetic arrangement arranged axially next to the first drive component and comprising a plurality of magnetic regions comprising at least one of permanent magnets and magnetizable regions, wherein the magnetic field generated by the first drive component extends axially to the magnetic arrangement of the second drive component to engage the magnetic arrangement; and wherein the magnetic arrangement is designed with respect to the dimensions and the magnetic orientation of the magnetic regions so that when the magnetic field generated by the first drive component is in effect, a force and a torque are exerted on the second drive component to drive the shaft and the brush element of the electric toothbrush.

The inventive drive device for driving a brush element of an electric toothbrush has a first drive component for generating a magnetic field and a second drive component, which can be driven both translationally and rotationally by the action of the magnetic field. In addition, the inventive drive device has a transmission element, which can be deflected out of a predefined position for transmission of a translatory movement and a rotational movement of the second drive component to the brush element along a longitudinal axis of the transmission element. The special feature of the inventive drive device consists of the fact that the deflection of the transmission element out of the predefined position is varied along the longitudinal axis of the transmission element.

The advantage of the invention is that a rotational movement and a translatory movement can be generated with comparatively little effort and transmitted to the brush element. It is especially advantageous that the drive device is designed as a direct drive and generates the rotational and translatory movement directly through the action of the magnetic field on the second drive component. Thus, this does not require a gear that would generate a translatory movement from a rotational movement or, conversely, a rotational movement from a translatory movement.

Additional advantages consist of the fact that no roller bearings or friction bearings are necessary for supporting the moving components of the drive device, and a wide range of movement patterns can be generated with the drive device, such that minor design changes must be made in the drive device at any rate. Furthermore, it is advantageous that hardly any unwanted vibrations are generated by the drive device.

The predefined position of the transmission element preferably corresponds to an equilibrium position assumed by the transmission element permanently without the influence of the magnetic field on the second drive component. The drive device may be constructed so that the action of the magnetic field on the second drive component has its maximum value in the equilibrium position. A force acting externally, which may occur due to the pressure of the brush element in toothbrushing, for example, would then result in a displacement in the transmission element and thus a reduction in the drive force of the drive device. However, it is also possible to design the drive device so that the equilibrium position is arranged outside of a position of the transmission element in which the action of the magnetic field on the second drive component is at a maximum value. Such an embodiment of the drive device has the advantage that the driving force of the drive device first increases with an increase in the contact pressure of the brush element, thereby preventing a collapse of the movement of the brush element with an increase in the contact pressure.

In a preferred exemplary embodiment of the drive device, at least one axial position of the transmission element in the transmission of the translatory and rotational movement of the second drive component executes only a rotational movement. This has the advantage that the transmission of unwanted vibrations can be minimized by suspension of the transmission element in such an axial position.

The drive device is preferably designed so that a component of the deflection of the transmission element out of the predefined position along the longitudinal axis of the transmission element is varied linearly or depending on a nonlinear function, said component being oriented across the longitudinal axis of the transmission element. It is likewise possible that the deflection of the transmission element out of the predefined position has a first direction within the first range along the longitudinal axis of the transmission element and at the same time has a second direction opposite the first direction within a second range along the longitudinal axis of the transmission element.

It is especially advantageous if the transmission element can be excited to a translatory vibration and to a rotational vibration. This makes it possible to achieve a high efficiency of the drive device. The translatory and rotational vibrations preferably have different resonant frequencies. This has the advantage that selective excitation of the translatory and rotational vibration is possible. In particular the transmission element can be excited to a pendulum vibration about a pendulum axis running across the longitudinal axis of the transmission element. Relatively great deflections can be achieved in this way, and it is easily possible to implement a desired step-down or step-up ratio for transmission of the movement of the second drive component to the brush element through the choice of the axial position of the pendulum axis. It is also possible for the transmission element to be excitable to a bending vibration across the longitudinal axis of the transmission element. Relatively high vibration frequencies can thus be achieved and only a comparatively low drive force is required. Furthermore, a desired step-up or step-down ratio can be predefined via the adjustment in stiffness of the transmission element including the brush element. Another advantage is that the vibrating masses are already equalized within the transmission element and thus hardly any unwanted vibrations are generated. It is especially advantageous if the transmission element is optionally excitable to the pendulum vibration or to bending vibration. This creates the possibility of selecting between different movement patterns and thus allowing an individual adaptation of a preferred movement pattern on the part of the user of the electric toothbrush.

The drive device has at least one suspension for supporting the transmission element, allowing rotational and/or translatory vibration of the transmission element. Different suspensions are preferably provided for the rotational and translatory vibration of the transmission element. This has the advantage that the suspensions can be optimally coordinated with the respective vibrating movements and the load per suspension is low. In a preferred exemplary embodiment of the drive device, the suspension is arranged in the area of the pendulum axis of the transmission element or in the area of a vibration node of the transmission element. The load on the suspension is the lowest there, and at any rate unwanted vibrations are transmitted there via the suspension only to a very slight extent. In addition, there is the possibility that the suspension is arranged in the area of an axial end of the transmission element. It is especially advantageous if at least one suspension is designed as or has an elastic element. Such a suspension is inexpensive to implement and is not subject to any mentionable wear. Furthermore, the friction can be minimized. Another advantage is that such a suspension may also be used as a restoring element for the vibrating movement of the transmission element. In particular, all the suspensions may be designed as or may have elastic elements. In this case, the cost of roller bearings or friction bearings to support the transmission element can be eliminated completely.

The transmission element may have a coupling area for connecting the brush element. It is advantageous if the ratio of the vibration amplitudes between the translatory vibration and the rotational vibration of the transmission element is variable in the coupling area of the transmission element. This allows individual adjustment of a desired movement pattern by the user of the electric toothbrush. In a preferred exemplary embodiment of the drive device, the coupling area predetermines through its shape the orientation of the brush element relative to the transmission element, so that bristles arranged on the brush element form an acute angle with the direction of deflection of the translatory vibration of the transmission element. In this way, a good cleaning effect can be achieved with the electric toothbrush.

The transmission element is preferably connected to the second drive component in a rotationally fixed manner. The transmission element is rigidly connected to the second drive component in particular. In this way, reliable transmission of the movement of the second drive component to the transmission element can be assured with little effort. The transmission element is designed as a shaft, for example.

In a preferred exemplary embodiment of the drive device, the second drive component is arranged axially next to the first drive component. This has the advantage that the translatory movement of the second drive component in the radial direction is not impaired by the first drive component. The first drive component preferably has a coil. However, since the first drive component moves slightly, a cable line which is necessary for supplying electric power to the coil, does not cause interference. In addition, the first drive component may have a pole shoe arrangement with an internal pole shoe element and an external pole shoe element, which surrounds the internal pole shoe element radially. In this way, a favorable field distribution of the magnetic field generated by the first drive component may develop, and therefore the desired movements can be generated very efficiently. The second drive component preferably has at least one permanent magnet. This has the advantage that no cable connection of the second drive component is required. The first drive component and the second drive component are preferably arranged inside a housing made of a ferromagnetic material. Magnetic stray fields can be shielded effectively in this way.

The invention also relates to an electric toothbrush having the drive device described above for driving the brush element.

In the inventive method for operation of a drive device of an electric toothbrush, a magnetic field is generated by a first drive component. A second drive component is induced to a translatory movement and rotational movement through the action of the magnetic field. The translatory movement and the rotational movement of the second drive component are transmitted to a brush element by deflection of a transmission element out of a predefined position along a longitudinal axis of the transmission element. The inventive method is characterized in that the deflection of the transmission element out of the predefined position is varied along the longitudinal axis of the transmission element.

The invention will be explained in greater detail below on the basis of the exemplary embodiments illustrated in the drawings, in which:

Fig. 1 shows an exemplary embodiment of an electric toothbrush designed according to the present invention in a perspective diagram,

Fig. 2 shows the exemplary embodiment of the electric toothbrush from Fig. 1 in a side view,

Fig. 3 shows an exemplary embodiment of the bearing of the shaft in a perspective diagram,

Fig. 4 shows the shaft supported according to Fig. 3 for a first vibrational state in a side view,

Fig. 5 shows the shaft supported according to Fig. 3 for a second vibrational state in a side view,

Fig. 6 shows an exemplary embodiment of a spring carrier to receive the first spring and the second spring in a perspective diagram,

Fig. 7 shows an exemplary embodiment of the vibrating system in a perspective diagram,

Fig. 8 shows an exemplary embodiment of a set of plate spring modules in a perspective diagram,

Fig. 9 shows a first basic diagram of the electric motor,

Fig. 10 shows a second diagram of the electric motor,

Fig. 11 shows a third basic diagram of the electric motor,

Fig. 12 shows an exemplary embodiment of the electric motor in a perspective diagram,

Fig. 13 shows another exemplary embodiment of the electric motor in a perspective diagram,

Fig. 14 shows the pole shoe arrangement of the exemplary embodiment of the electric motor from Fig. 12, shown here in a view from above,

Fig. 15 shows the magnetic arrangement of the exemplary embodiment of the electric motor from Fig. 12, shown here in a perspective diagram,

Fig. 16 shows the exemplary embodiment of the electric motor from Fig. 13, without the magnetic arrangement and without the pole shoe arrangement, shown here in a perspective diagram,

Fig. 17 shows the pole shoe arrangement of the exemplary embodiment of the electric motor from Fig. 16, shown here in a perspective diagram, and

Fig. 18 shows the magnetic arrangement of the exemplary embodiment of the electric motor from Fig. 16 in a perspective diagram.

Fig. 1 shows an exemplary embodiment of an electric toothbrush embodied according to the invention, shown in a perspective diagram. Fig. 2 shows the exemplary embodiment of the electric toothbrush from Fig. 1, shown here in a side view.

The electric toothbrush is shown without the housing to allow a view of the components arranged inside the housing. The electric toothbrush has an electric motor 1 and a vibrating system 2 arranged adjacent to one another axially along a common longitudinal axis 3. The vibrating system 2 has in particular a shaft 4 onto which an attachable brush 5 is attached. The attachable brush 5 is shown only in Fig. 1. Fig. 2 shows the electric toothbrush without the attachable brush, so that the area of the shaft 4 holding the attachable brush 5 is visible.

Within this area, a flattened area 6 and a recess 7 are formed, serving to secure the attachable brush 5 and the shaft 4 in a rotationally and axially secured manner. The additional components of the vibrating system 2 and the components of the electric motor 1 are described in greater detail below.

The electric motor 1 serves to induce a defined vibrational state in the vibrating system 2. A rotational vibrating movement of the attachable brush 5 can be induced around the longitudinal axis 3 in particular, which is represented by a directional arrow 8, and a translatory vibrating movement of the attachable brush 5 can be induced across the longitudinal axis 3, which is represented by a directional arrow 9.

Fig. 3 shows an exemplary embodiment of the bearing of the shaft 4 in a perspective diagram. In the exemplary embodiment illustrated here, the shaft 4 is supported by a first spring 10 and a second spring 11. The first spring 10 is arranged axially between the two ends of the shaft 4 and allows a pendulum movement of the shaft 4 about a pendulum axis 12, which is defined by the first spring 10 and runs across the longitudinal axis 3. This pendulum movement is explained in greater detail with reference to Fig. 4.

The second spring 11 is arranged in the area of the axial end of the shaft 4 opposite the receptacle area for the attachable brush 5 and has a great stiffness in a direction parallel to the pendulum axis 12 and has a low stiffness in a direction perpendicular to the pendulum axis 12 and to the longitudinal axis 3. The second spring 11 thus acts as an additional guidance of the shaft 4 in a pendulum movement by suppressing movements parallel to the pendulum axis 12 and allowing movements around the pendulum axis 12.

Fig. 4 shows a side view of the shaft 4, which is mounted according to Fig. 3, for a first vibrational state. The first vibrational state is characterized in that the shaft 4 executes a periodic pendulum movement about the pendulum axis 12. Fig. 4 shows two snapshots of this pendulum movement. A first snapshot is based on an equilibrium state in which the shaft 4 would remain if it were not excited to a vibrating movement. For the equilibrium state, Fig. 4 shows the outlines of the shaft 4 and the two springs 10 and 11. At periodic intervals during the pendulum movement, the shaft 4 assumes a position corresponding to the equilibrium state. The position of the shaft 4 is illustrated by its center line in Fig. 4, where a reference numeral 13 is assigned to the center line in the equilibrium state.

In addition, Fig. 4 shows a deflected state. For the deflected state, only the center line of the shaft 4 is shown in Fig. 4 and is labeled with reference numeral 13'. In the deflected state, the shaft 4 is tilted about the pendulum axis 12 in comparison with the equilibrium state, so that the center line 13' of the shaft 4 in the deflected state and the center line 13 of the shaft 4 in the equilibrium state form an angle to one another. This means that the deflection of the shaft 4 out of the resting position is varied along the shaft 4 and there is a deflection toward opposite sides on the two sides of the pendulum axis 12 at the same point in time. The deflection here is understood to be the distance of a point on the shaft 4 in the deflected state from the same point in the resting state. In addition to the dependence of deflection on location, there is also a dependence of deflection on time during the pendulum movement, so that the deflection varies over time for a fixed axial position on the shaft 4.

The lever effect of the shaft 4 between its end driven by the electric motor 1 on the one hand and its end holding the attachable brush 5 on the other hand can be varied by means of the axial position of the pendulum axis 12 and thus the first spring 10. In other words, the step-down or step-up ratio between the electric motor 1 and the attachable brush 5 is determined by the axial position of the first spring 10.

The pendulum vibration described above constitutes a fundamental vibration of the shaft 4. In addition to this fundamental vibration, higher intrinsic modes may also be excited. The higher intrinsic modes each correspond to a bending vibration in the form of a standing wave 4. Fig. 5 illustrates one example of such a bending vibration.

Fig. 5 shows the shaft 4 supported according to Fig. 3 for a second vibrational state in a side view. The second vibrational state is characterized in that the shaft 4 executes a first harmonic in the form of the bending vibration shown. The first harmonic has two vibration nodes 14 in which the shaft 4 remains in its equilibrium position. Outside of the vibration nodes 14, the deflection of the shaft 4 varies over time. In addition, the deflection of the shaft 4 outside of the vibration node 14 varies along the shaft 4 due to the bending at a given point in time.

The first spring 10 is preferably arranged in the area of one of the vibration nodes 14. As a result, the bending vibration of the shaft 4 is not hindered by the first spring 10 and hardly any vibrations are transmitted via the first spring 10 to the housing of the electric toothbrush which is not shown in the figure.

The transmission ratio of the movement between the driven end of the shaft 4 and the attachable brush 5 can be influenced via the stiffness of the shaft 4 and of the attachable brush 5. This makes it possible to implement both step-up and step-down ratios.

Fig. 6 shows an exemplary embodiment of a spring carrier 15 to receive the first spring 10 and the second spring 11 in a perspective diagram. The spring carrier 15 receives the first spring 10 in a first receptacle frame 16, the shape of which is coordinated with the first spring 10, and the second spring 11 in a second receptacle frame 17, whose shape is coordinated with the second spring 11. The two receptacle frames 16 and 17 are rigidly connected to one another by means of webs 18 running parallel to the longitudinal axis 3.

Fig. 7 shows an exemplary embodiment of the vibrating system 2 in a perspective diagram. The vibrating system 2 has the spring carrier 15 illustrated in Fig. 6. Four plate springs 19, each designed as a rectangle with one end attached to the spring carrier 15, are mounted in proximity to the first receptacle frame 16 of the spring carrier 15. For example, the plate springs 19 are each clamped at one end between the spring carrier 15 and the clamping piece 20. The longitudinal sides of the plate springs 19 extend in the axial direction based on the shaft 4. The narrow sides of the plate springs 19 extend in the radial direction based on the shaft 4. With their free ends, the plate springs 19 are each attached in pairs to a retaining block 21. Such an arrangement of plate springs 19 suppresses relative movements between the retaining blocks 21 and the spring carrier 15 parallel to the axial direction of the shaft 4 and parallel to the radial direction of the shaft 4. However, within certain limits, the spring carrier 15 can be rotated relative to the retaining blocks 21.

The embodiment of the vibrating system 2 described above thus allows a rotational vibration of the spring carrier 15 including the shaft 4 about the longitudinal axis 3 in relation to the retaining blocks 21 in addition to the pendulum vibration and/or bending vibration of the shaft 4 already explained in detail above. The rotational vibration preferably has a different resonant frequency than the pendulum vibration and/or bending vibration. This makes it possible to stimulate the pendulum vibration and/or bending vibration or the rotational vibration preferentially through the choice of the exciting frequency relative to the resonant frequency. The preferred excitation of the pendulum vibration on the one hand or the bending vibration on the other hand may take place via the choice of the excitation frequency if the pendulum vibration and the bending vibration have different resonant frequencies. A combined vibrating movement can be excited through an excitation frequency between the resonant frequencies. It is likewise also possible to induce an excitation having multiple frequency components which are preferably near the respective resonant frequencies and in this way to generate a combined vibrating movement.

Fig. 8 shows an exemplary embodiment for a set of plate spring modules 22 in a perspective diagram. The plate spring modules 22 may be used for fixation of the spring carrier 15 on the retaining blocks 21 in a rotationally mobile manner instead of the individual plate springs 19 shown in Fig. 7. Each plate spring module 22 here replaces two plate springs 19. The plate spring modules 22 are each embodied as punched/bending parts with two plate springs 19 integrated into each. The two plate springs 19 are joined at their ends by means of one strap 23 each. The straps 23 are designed in one piece with the plate springs 19.

Through the use of the plate spring modules 22 instead of the plate springs 19, the number of components to be mounted is reduced by two. Furthermore, accurate alignment of the plate springs 19 is simplified. As a result, the installation complexity is reduced.

Fig. 9 shows a first basic diagram of the electric motor 1. The shaft 4 and a spring element 24 are also shown in Fig. 9, thereby indicating the vibrating system 2. The electric motor 1 has a stator 25 and a rotor 26 arranged axially side by side.

The stator 25 has a coil 27, a coil core 28 and a coil housing 29. The coil 27 is wound around the coil core 28 and arranged inside the coil housing 29. The coil core 28 and the coil housing 29 are both made of ferromagnetic material.

The rotor 26 has a magnetic arrangement 30, which is mechanically connected to the shaft 4. The connection is preferably designed to be rigid. In the exemplary embodiment in Fig. 9, the magnetic arrangement 30 has a permanent magnet 31 whose north/south extent runs across the longitudinal extent of the coil core 28. Likewise, two permanent magnets 31 may also be provided, their north/south directions each running parallel to the longitudinal axis 3 and being arranged side by side with an antiparallel polarity. This substitution option also exists with magnetic arrangements 30 having a different design.

When a current flows through the coil 27, a magnetic field is generated, its direction depending on the direction of current in the coil 27. Through the action of the magnetic field on the permanent magnet 31, a magnetic force is generated parallel to the north/south extent of the permanent magnet 31 and the magnetic arrangement 30 is thereby deflected out of its equilibrium position. The spring element 24 generates a restoring force directed toward the equilibrium position. In the equilibrium position, the magnetic arrangement 30 is arranged centrally relative to the coil core 28. By periodic reversal of polarity or at least activation and deactivation of the coil current, preferably at a frequency near the resonant frequency of the vibrating system 2, which also includes the magnetic arrangement 30, the vibrating system 2 is excited to pendulum vibrations or bending vibrations as already described above. No rotational vibration is excited because no torque is generated.

Fig. 10 shows a second basic diagram of the electric motor 1. The second basic diagram differs from Fig. 9 with regard to the magnetic arrangement 30. Instead of a single permanent magnet 31, the magnetic arrangement 30 has two permanent magnets 31 arranged side by side with an antiparallel polarity. This orientation of the permanent magnets 31 results in a torque being generated by the action of the magnetic field generated by the coil 27 on the magnetic arrangement 30, thereby rotating the magnetic arrangement 30 out of the equilibrium position. In the equilibrium position the north/south extents of the permanent magnets 31 are oriented at a right angle to the longitudinal extent of the coil core 28. The spring element 24 generates a reverse moment directed toward the equilibrium position. Through a periodic change in the magnetic field generated by the coil 27, which can be generated by a corresponding change in the coil current, the vibrating system 2 can be excited to a rotational vibration. No pendulum vibrations or bending vibrations are excited because only torques are generated.

Fig. 11 shows a third basic diagram of the electric motor 1. In the third basic diagram, the rotor 26 has a magnetic arrangement 30, which corresponds to a combination of the magnetic arrangements 30 according to the first and second basic diagrams. The permanent magnet 31 according to the first basic diagram is arranged between the two permanent magnets 31 according to the second basic diagram. The action of the magnetic field generated by the coil 27 on the middle permanent magnet 31 creates a force; the action of the magnetic field generated by the coil 27 on the two external permanent magnets 31 creates a torque. Thus a pendulum vibration and/or a bending vibration as well as a rotational vibration can be excited. There is the possibility of exciting predominately a pendulum vibration, a bending vibration or a rotational vibration in by far the majority of cases through the choice of the excitation frequency relative to the resonant frequency. In a desired amplitude ratio, it is likewise possible to excite a pendulum vibration and/or a bending vibration on the one hand and also to excite a rotational vibration on the other hand. A desired amplitude ratio of different types of vibration can also be achieved by superimposing several excitation frequencies.

The force generated by the action of the magnetic field generated by the coil 27 on the magnetic arrangement 30 is at its maximum when the magnetic arrangement 30 is positioned centrally above the coil core 28, i.e., in the equilibrium position. If the magnetic arrangement 30 is shifted out of the equilibrium position by an external force, then the force created by the action of the magnetic field will decline. The external force may be in particular the contact pressure to which the attachable brush 5 is exposed when brushing the teeth. There is thus the possibility of deactivating the excitation of the pendulum vibration and/or bending vibration above a predefined contact pressure.
In addition, it is possible to modify the electric motor 1 so that the magnetic arrangement 30 is arranged eccentrically with the coil core 28 in the equilibrium state. In this modification, an increasing contact pressure of the attachable brush 5 initially causes increased excitation of pendulum and/or bending vibrations. The maximum excitation of the pendulum and/or bending vibration occurs when the magnetic arrangement 30 is positioned centrally with respect to the coil core 28 due to the contact pressure. A further increase in contact pressure results in the magnetic arrangement 30 leaving the central position with respect to the coil core 28 and then there is also a reduction in the excitation of the pendulum and/or bending vibration accordingly.

Fig. 12 shows an exemplary embodiment of the electric motor 1 in a perspective diagram. In the exemplary embodiment shown here, the coil housing 29 is closed on one axial end with a closing plate 32 made of a ferromagnetic material. A connection between the coil core 28 and the coil housing 29 is formed via the closing plate 32, such that a magnetic flux can be passed over this connection. On the other axial end of the coil housing 29, a pole shoe arrangement 33 is provided over which the magnetic field generated by the coil 27 emerges. The magnetic arrangement 30 is arranged directly next to the pole shoe arrangement 33 axially and has a carrier 34, preferably made of a ferromagnetic material, to receive the permanent magnets 31. The coil housing 29 may also be designed so that it extends beyond the magnetic arrangement 30. The magnetic stray fields can be minimized in this way.

Fig. 13 shows another exemplary embodiment of the electric motor 1 in a perspective diagram. This exemplary embodiment differs from the exemplary embodiment illustrated in Fig. 12 essentially with regard to the magnetic arrangement 30 and the pole shoe arrangement 33. As also explained in greater detail below, the pole shoe arrangement 33 and the magnetic arrangement 30 are essentially more complex in design than in the exemplary embodiment according to Fig. 12.

Fig. 14 shows the pole shoe arrangement 33 of the exemplary embodiment of the electric motor shown in Fig. 12, seen here in a view from above. The pole shoe arrangement 33 has an internal pole shoe element 35 and an external pole shoe element 36, which, together with the internal pole shoe element 35, is arranged in a plane and surrounds the internal pole shoe element 35 radially. The internal pole shoe element 35 is designed essentially as a rectangle. The external pole shoe element 36 has a shape that is coordinated with the coil housing 29 and protrudes radially beyond the coil housing 29. In its internal area, the external pole shoe element 36 has a recess 37, the shape of which is coordinated with the internal pole shoe element 35 and accordingly has a rectangular cross section. The internal pole shoe element 35 is arranged in the recess 37. The internal pole shoe element 35 is attached to the coil core 28 in the installed state. The external pole shoe element 36 is attached to the coil housing 29 in the installed state. Except for a clearance between the internal pole shoe element 35 and the external pole shoe element 36, the coil housing 29 is closed by the pole shoe arrangement 33.

Fig. 15 shows the magnetic arrangement 30 of the exemplary embodiment of the electric motor 1 from Fig. 12, shown here in a perspective diagram. The perspective here is selected so that the side of the magnetic arrangement 30 facing the pole shoe arrangement 33 in the installed state is visible. The magnetic arrangement 30 has two permanent magnets 31 arranged side by side on the carrier 34 with an antiparallel polarity. In parallel with their north/south extent, the permanent magnets 31 have the same dimensions. Across the north/south extent, the permanent magnet 31 shown at the right in Fig. 15 has dimensions that are twice as large as those of the permanent magnet 31 shown at the left in Fig. 15. The different dimensions of the permanent magnets 31 result in a force as well as a torque being exerted on the magnetic arrangement 30 in energization of the coil 27. In this way, as described in detail with reference to Fig. 11, a pendulum vibration and/or a bending vibration and rotational vibration of the magnetic arrangement 30 including the components associated therewith can be generated.

As an alternative to using multiple permanent magnets 31, a single permanent magnet 31 having differently magnetized regions may also be used. This also applies to magnetic arrangements 30 designed differently than those shown in Fig. 15.

Fig. 16 shows the exemplary embodiment of the electric motor 1 shown in Fig. 13 without the magnetic arrangement 30 and without the pole shoe arrangement 33 in a perspective diagram. The coil core 28 shown there is designed as an octagon and has an axial extension 38 on the axial end of the pole shoe arrangement 33, said extension 38 having a rectangular cross section. The coil 27 surrounds the coil core 28 with an approximately constant cross section. The coil housing 29 is also designed to have an octagonal cross section, so there is only a slight distance between the coil 27 and the coil housing 29, and the coil 27 together with the coil core 28 fills up the coil housing 29 almost completely.

Fig. 17 shows the pole shoe arrangement 33 of the exemplary embodiment of the electric motor 1 from Fig. 13, shown in a perspective diagram here. By analogy with Fig. 14, the pole shoe arrangement 33 in turn has an internal pole shoe element 35 and an external pole shoe element 36, surrounding the internal pole shoe element 35 radially. The internal pole shoe element 35 is arranged in the recess 37 of the external pole shoe element 36 and is embodied as a circular disk 39 having four radial extensions 40, all arranged in pairs opposite one another with different radial extents. In the area of the center of the circular disk 39, the internal pole shoe element 35 has a rectangular perforation 41, which is coordinated with the outside contour of the axial extension 38 on the coil core 28, so that the internal pole shoe element 35 can be pushed onto the axial extension 38 of the coil core 28. A similar type of fastening may be selected for the exemplary embodiment of the pole shoe arrangement 33 shown in Fig. 14.

The recess 37 in the external pole shoe element 36 is coordinated with the internal pole shoe element 35 and has two planes of symmetry perpendicular to one another, intersecting one another at the center of the recess 37. The external pole shoe element 36 here has four protrusions 42, which extend radially inward into the recess 37 and are rotated by 45° with respect to the radial extensions 40 of the internal pole shoe element 35.

Fig. 18 shows the magnetic arrangement 30 of the exemplary embodiment of the electric motor 1 from Fig. 13, shown here in a perspective diagram. By analogy with Fig. 15, the magnetic arrangement 30 in Fig. 18 also has a plurality of permanent magnets 31 arranged on the carrier 34. The arrangement of permanent magnets 31 is in the form of two half-shells arranged opposite one another at a distance with opposite polarities, a rectangularly shaped permanent magnet 31 being arranged between them. By means of the pole shoe arrangement 33 shown in Fig. 17, a force and a torque can be exerted on the magnetic arrangement 30 illustrated in Fig. 18 when electric current flows through the coil 27. Through the configuration of the permanent magnets 31, it is possible to predetermine which partial areas of the magnetic arrangement 30 will serve to generate the force and which partial areas will serve to generate the torque.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. An electric toothbrush drive device configured to drive a brush element, the drive device comprising:

a first drive component configured to generate a magnetic field;

a second drive component configured to be driven to both translatory movement and rotational movement by the influence of the magnetic field; and

a transmission element configured to be deflected out of a predefined position to transmit a translatory movement and a rotational movement of the second drive component to the brush element;

wherein deflection of the transmission element out of the predefined position varies along a longitudinal axis of the transmission element;

wherein the second drive component is arranged axially next to the first drive component; and

wherein the magnetic field generated by the first drive component extends axially towards the second drive component to engage the second drive component.

2. The drive device according to claim 1, wherein the predefined position of the transmission element corresponds to an equilibrium position characterized by an absence of action of the magnetic field on the second drive component.

3. The drive device according to claim 2, wherein the equilibrium position is outside of a maximum working range of the transmission element.

4. The drive device according to claim 1, wherein the transmission element executes a primarily rotational movement in at least one position along its length in the transmission of the translatory movement and the rotational movement to the second drive component.

5. The drive device according to claim 1, wherein a component of the deflection of the transmission element oriented across the longitudinal axis of the transmission element varies linearly.

6. The drive device according to claim 1, wherein the deflection of the transmission element out of the predefined position comprises a first range in a first direction and a second range in a second direction opposite the first direction along a longitudinal axis of the transmission element.

7. The drive device according to claim 1, wherein the transmission element is excitable to a translatory vibration and to a rotational vibration.

8. The drive device according to claim 7, wherein the translatory vibration and the rotational vibration are of different resonant frequencies.

9. The drive device according to claim 7, wherein the transmission element can be excited to a pendulum vibration about a pendulum axis running across the longitudinal axis of the transmission element.

10. The drive device according to claim 7, wherein the transmission element can be excited to a bending vibration across the longitudinal axis of the transmission element.

11. The drive device according to claim 10, wherein the transmission element can be selectively excited to at least one of the pendulum vibration and the bending vibration.

12. The drive device according to claim 7, further comprising a suspension configured to support the transmission element and to allow at least one of rotational and translational vibration of the transmission element.

13. The drive device according to claim 12, comprising multiple suspensions configured to allow, separately, the rotational vibration and the translatory vibration of the transmission element.

14. The drive device according to claim 12, wherein the suspension is arranged in one of an area of the pendulum axis of the transmission element, an area of a vibration node of the transmission element, and an area of an axial end of the transmission element.

15. The drive device according to claim 12, wherein, at least one suspension comprises an elastic element.

16. The drive device according to claim 1, wherein the transmission element has a coupling area configured to couple the brush element and wherein a ratio of vibration amplitudes can be varied between the translatory vibration and the rotational vibration of the transmission element in the coupling area of the transmission element.

17. The drive device according to claim 16, wherein the coupling area predefines through its shape an orientation of the brush element relative to the transmission element, so that bristles arranged on the brush element form an acute angle with a deflection direction of the translatory vibration of the transmission element.

18. The drive device according to claim 1, wherein the transmission element is rigidly connected to the second drive component in a rotationally fixed manner.

19. The drive device according to claim 1, wherein the first drive component comprises a coil.

20. The drive device according to claim 1, wherein the first drive component comprises a pole shoe arrangement with an internal pole shoe element and an external pole shoe element radially surrounding the internal pole shoe element.

21. The drive device according to claim 1, wherein the second drive component comprises a permanent magnet.

22. The drive device according to claim 1, wherein the first drive component and the second drive component are arranged inside a housing comprising a ferromagnetic material.

23. A drive device for driving a brush element of an electric toothbrush, the drive device comprising:

a first drive component configured to generate a magnetic field;

a second drive component configured to be driven to both translatory and rotational movement by action of the magnetic field; and

a transmission element configured to be deflected out of a predefined position to transmit a translatory movement and a rotational movement of the second drive component to the brush element along a longitudinal axis of the transmission element;

wherein the transmission element is attached to a suspension between two freely movable axial ends of the transmission element;

wherein the second drive component is arranged axially next to the first drive component; and

wherein the magnetic field generated by the first drive component extends axially towards the second drive component to engage the second drive component.

24. The drive device according to claim 23, wherein the suspension comprises an elastic element.

25. The drive device according to claim 23, further comprising a rotatable plate spring arrangement configured to generate a rotational vibration.

26. A drive device for driving a brush element of an electric toothbrush, the drive device comprising:

a first drive component configured to generate a magnetic field; and

a second drive component comprising a magnetic arrangement arranged axially next to the first drive component and comprising a plurality of magnetic regions, wherein the magnetic field generated by the first drive component extends axially towards the plurality of magnetic regions of the second drive component to engage said plurality of magnetic regions, and

wherein the magnetic regions in the magnetic arrangement are arranged according to a pattern that is neither axially symmetrical nor point symmetrical.

27. The drive device according to claim 26, wherein the magnetic regions comprise at least one of permanent magnets and magnetizable regions of different sizes.

28. An electric toothbrush, comprising:

a shaft configured to accept an attachable brush element thereon;

a first drive component connected to the shaft and configured to generate a magnetic field; and

a second drive component comprising a magnetic arrangement arranged axially next to the first drive component and comprising a plurality of magnetic regions comprising at least one of permanent magnets and magnetizable regions, wherein the magnetic field generated by the first drive component extends axially to the magnetic arrangement of the second drive component to engage said magnetic arrangement; and

wherein the magnetic arrangement is designed with respect to the dimensions and the magnetic orientation of the magnetic regions so that when the magnetic field generated by the first drive component is in effect, a force and a torque are exerted on the second drive component to drive the shaft and the brush element of the electric toothbrush.

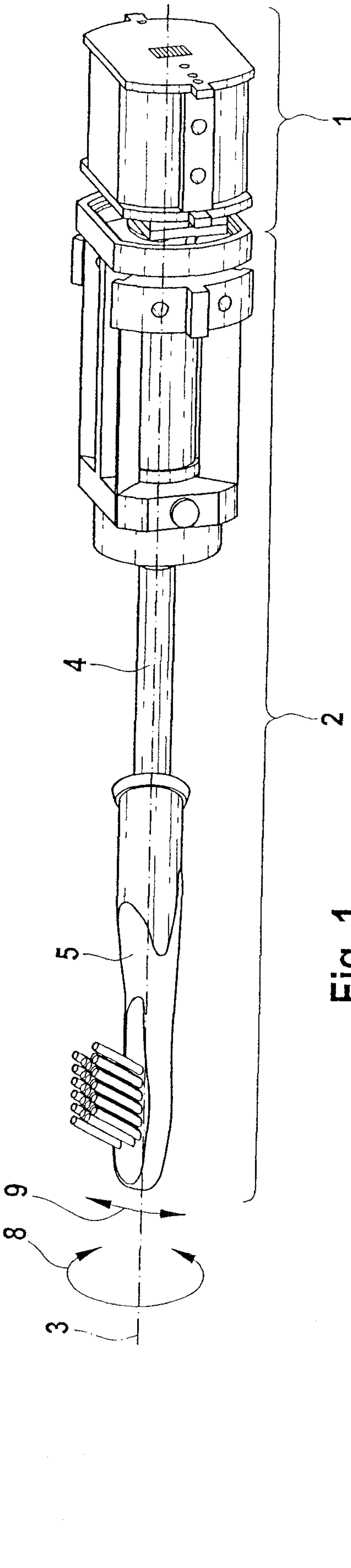


Fig. 1

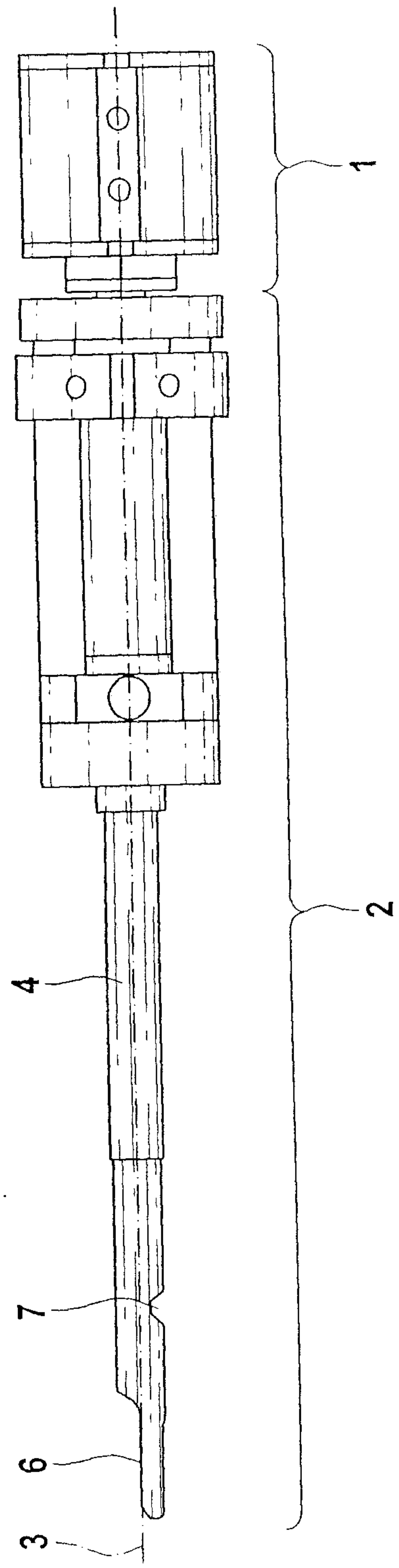


Fig. 2

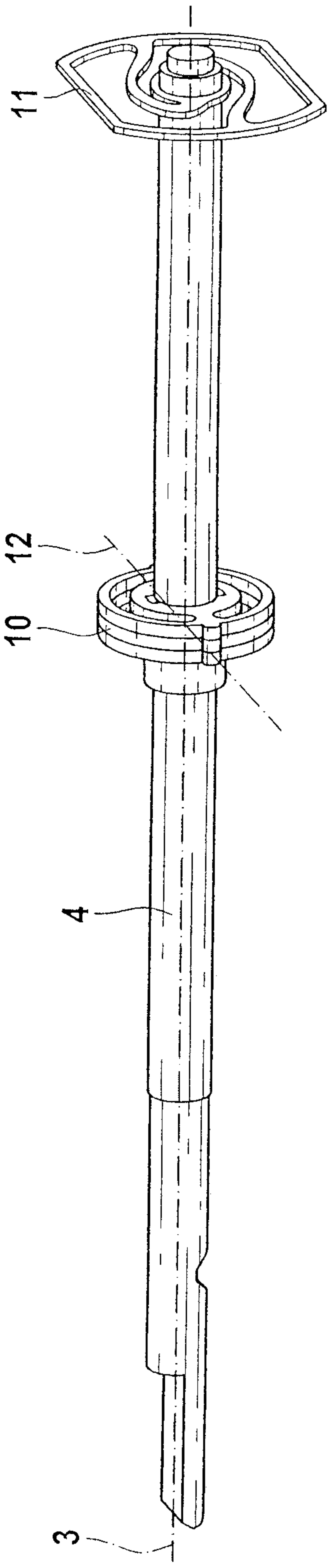


Fig. 3

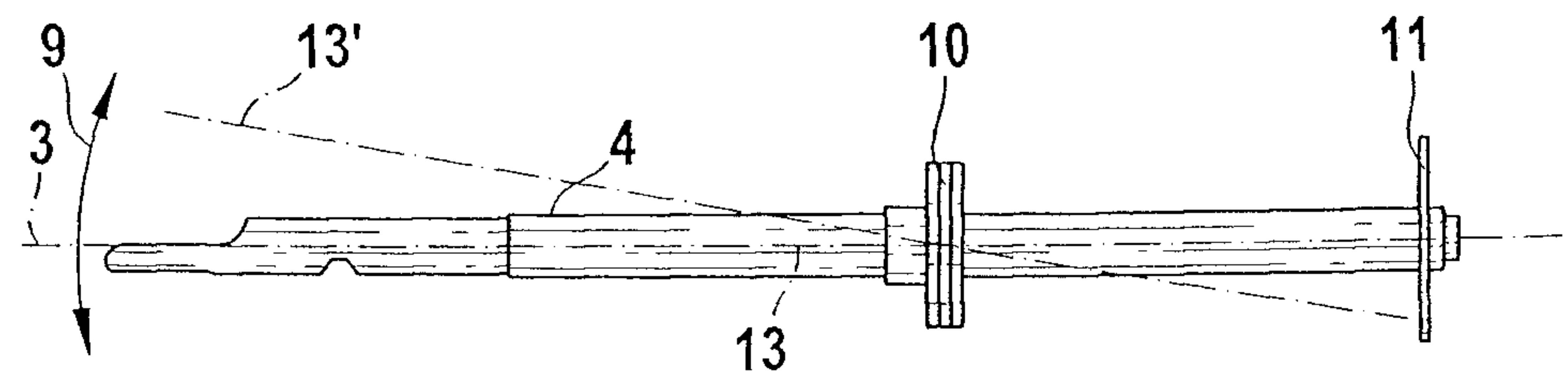


Fig. 4

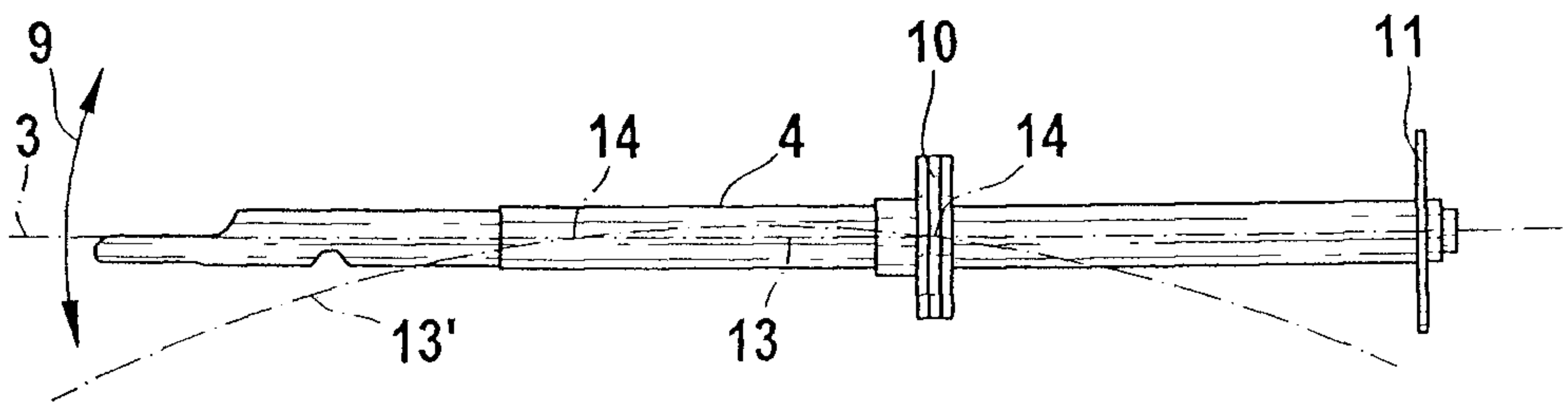


Fig. 5

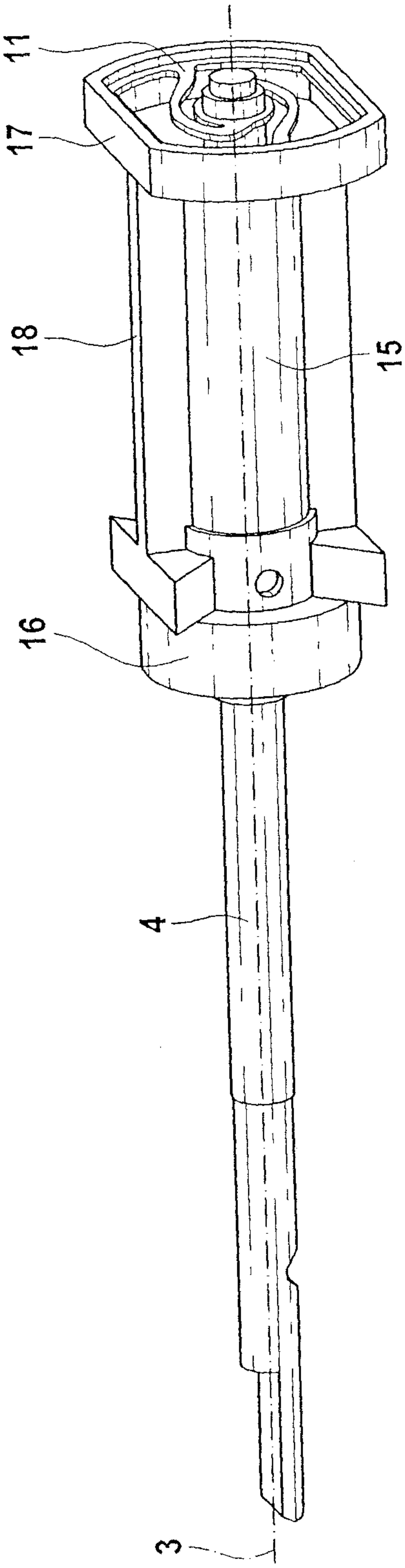


Fig. 6

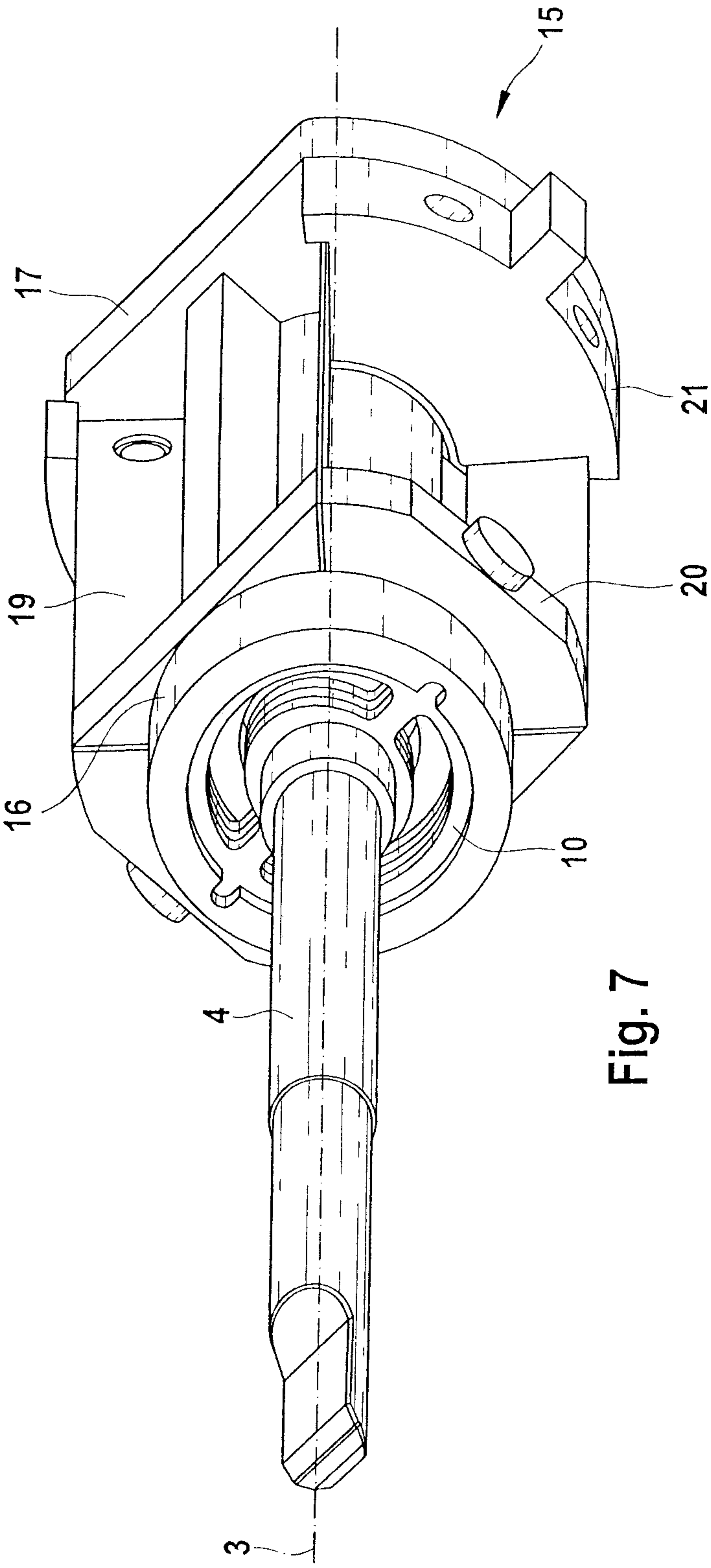


Fig. 7

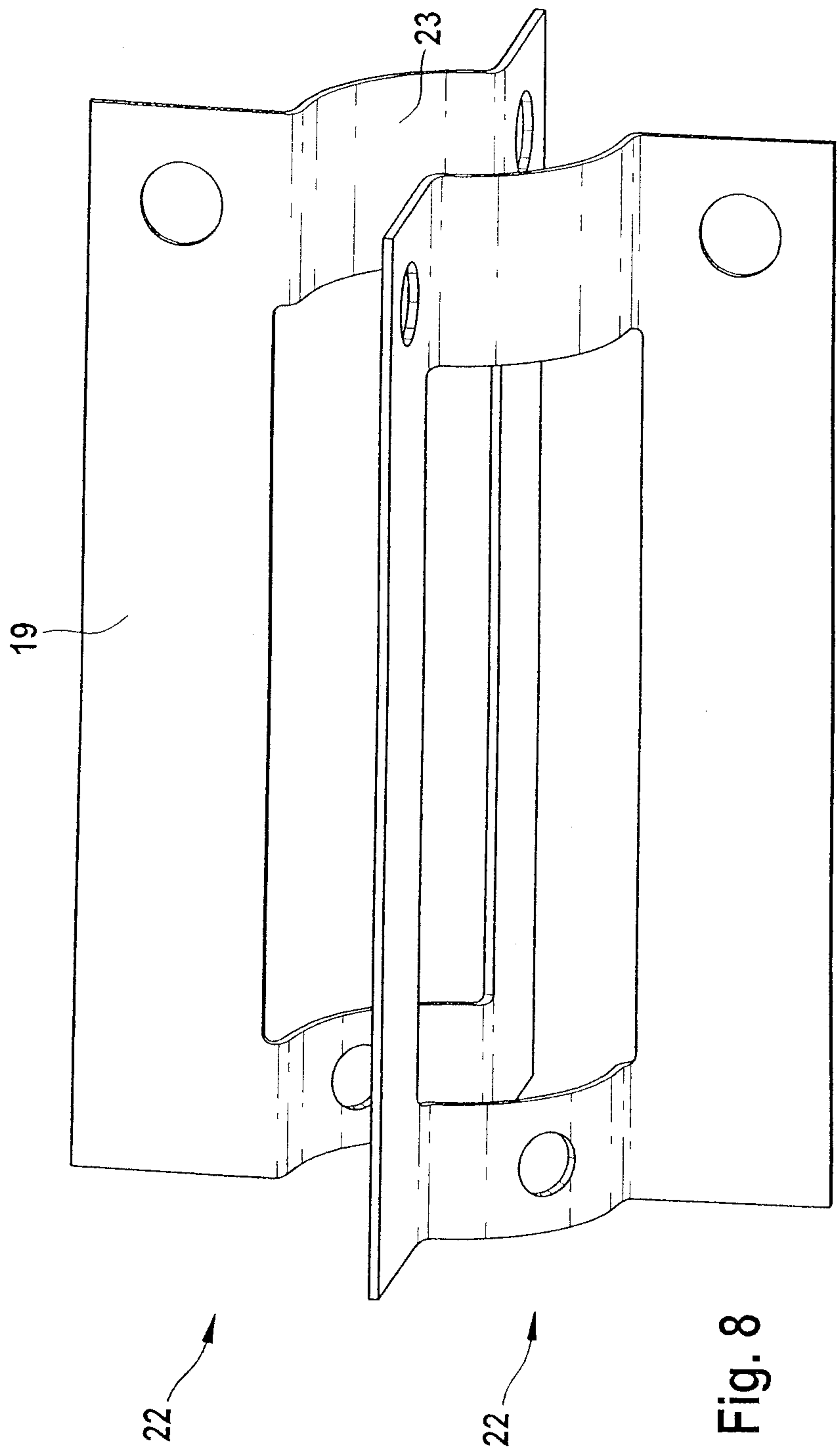


Fig. 8

Fig. 9

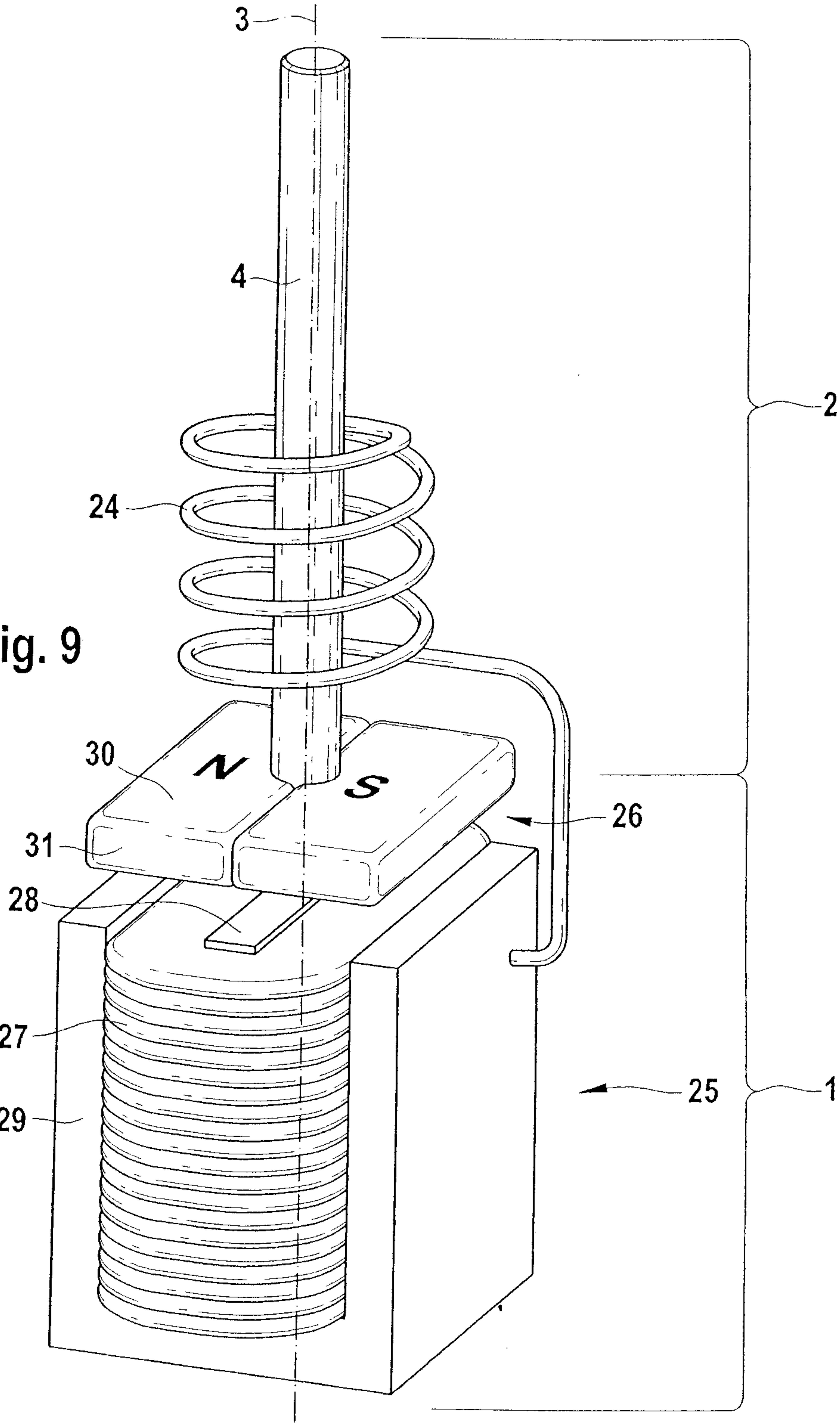


Fig. 10

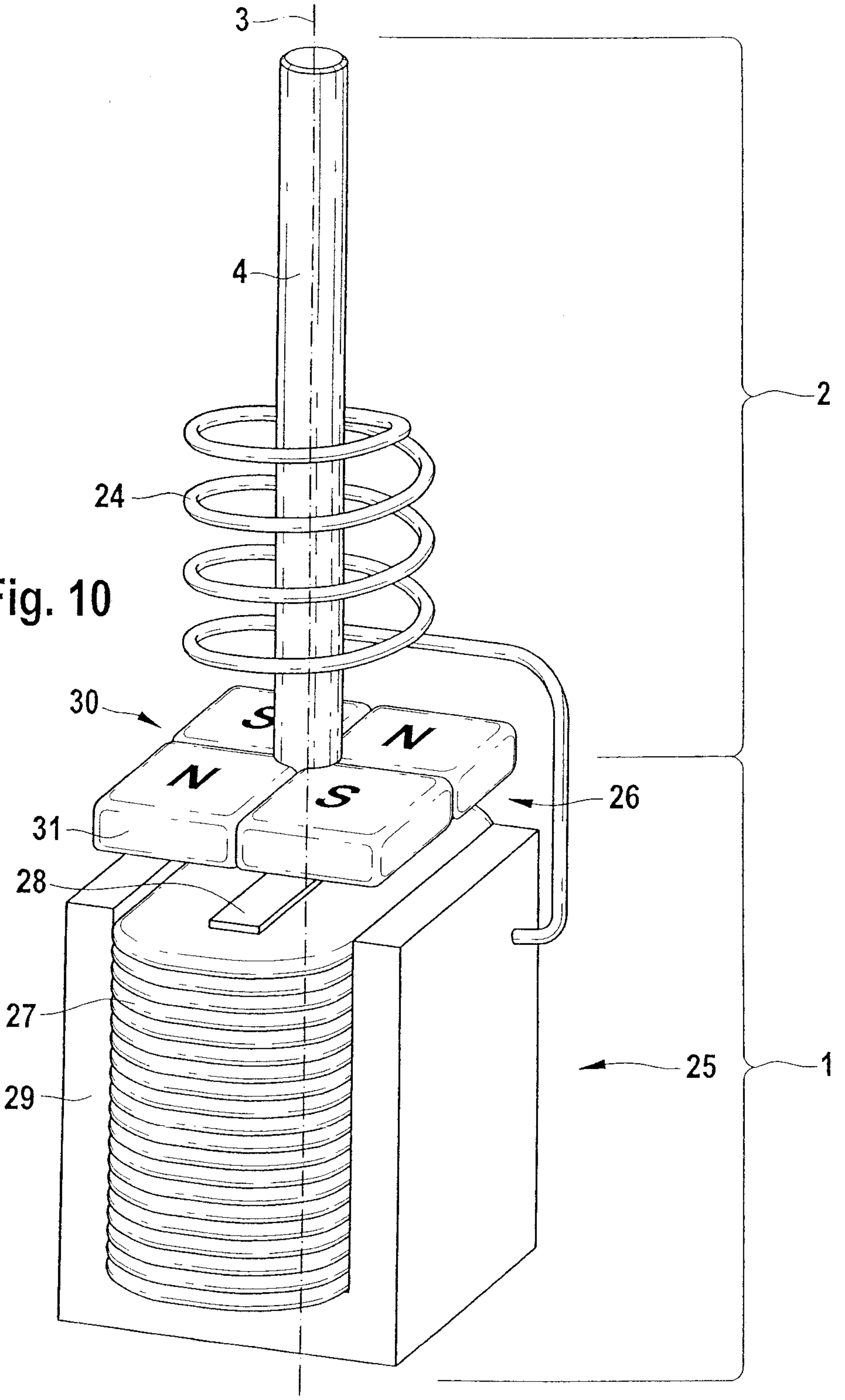
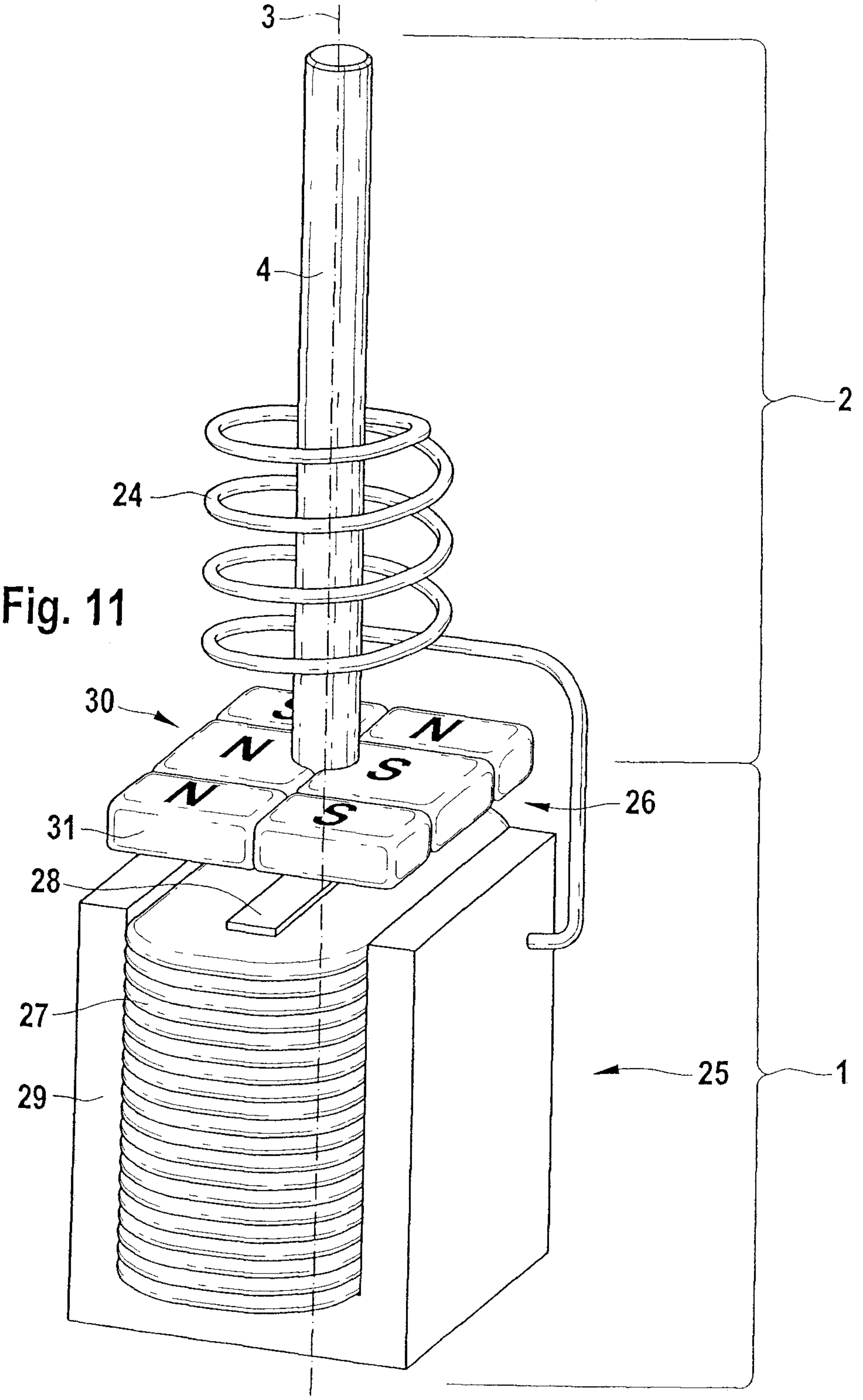


Fig. 11



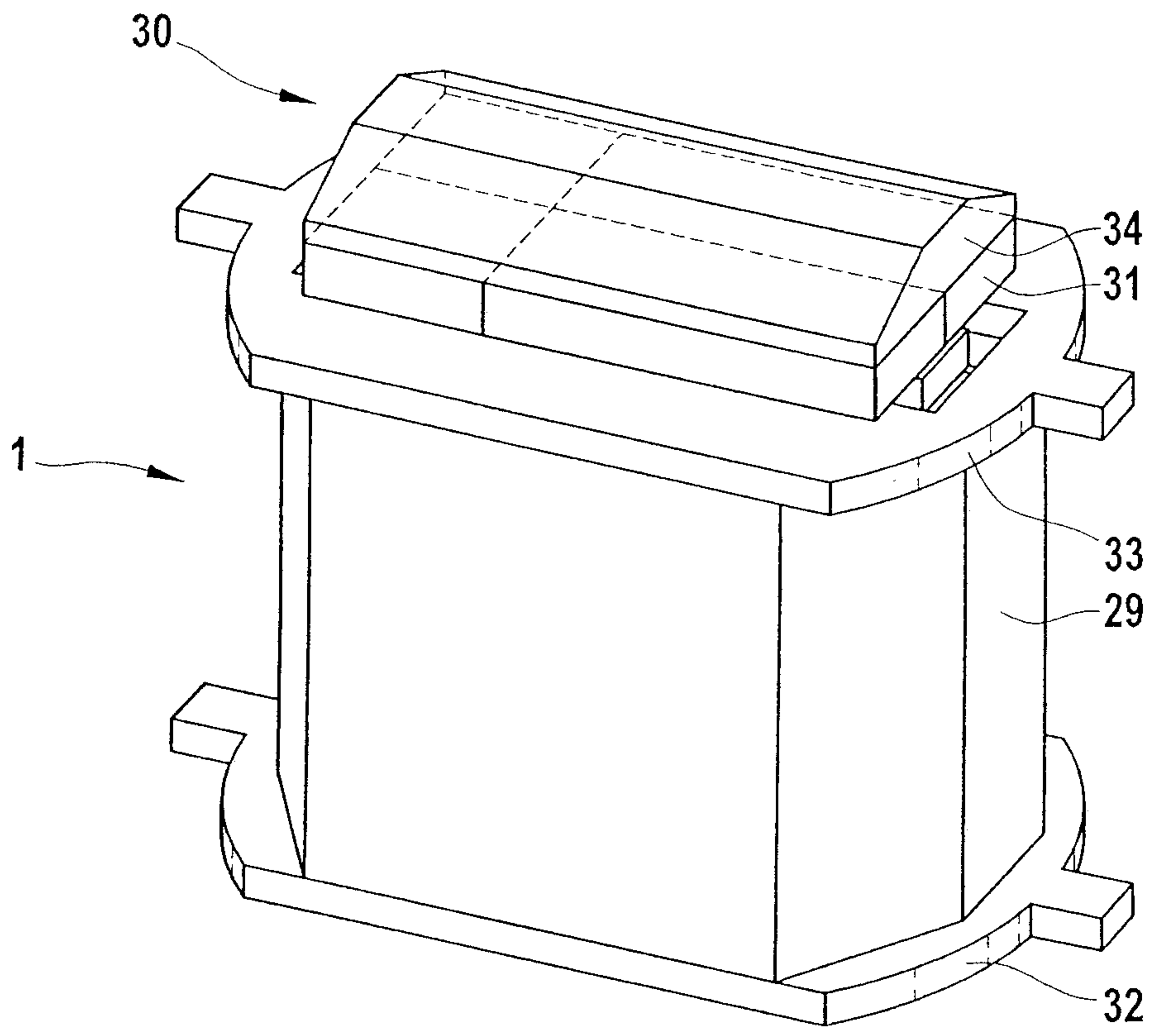


Fig. 12

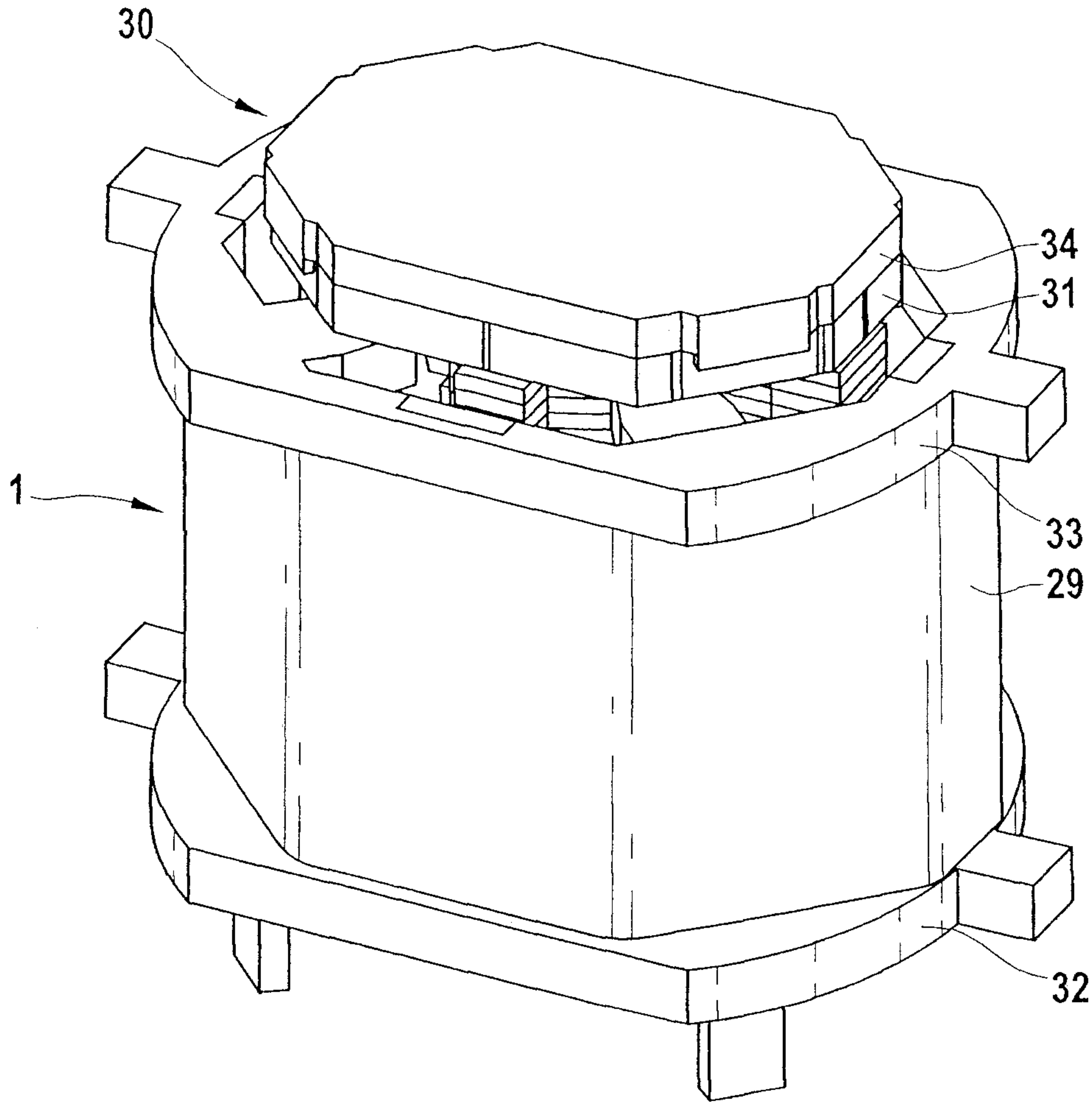


Fig. 13

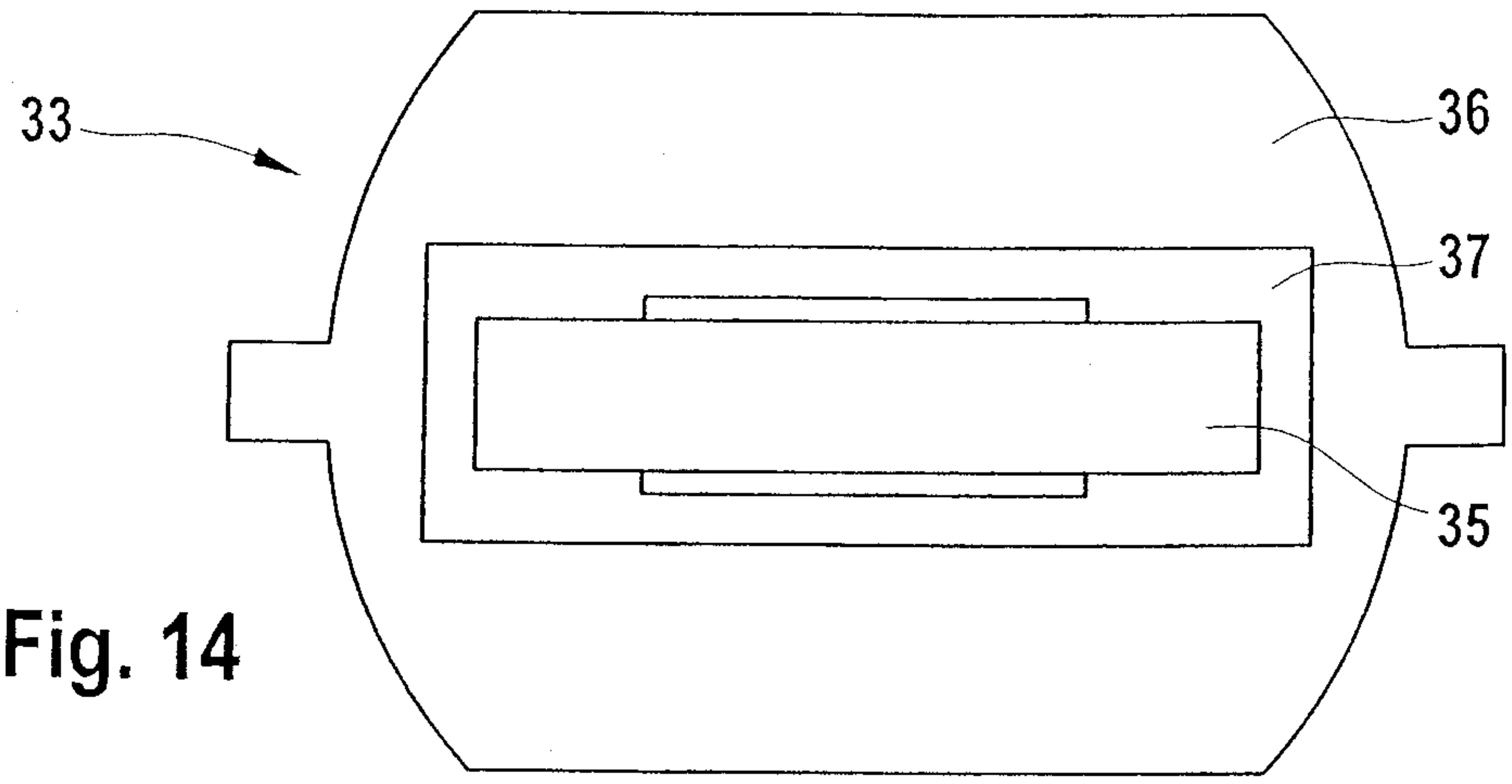


Fig. 14

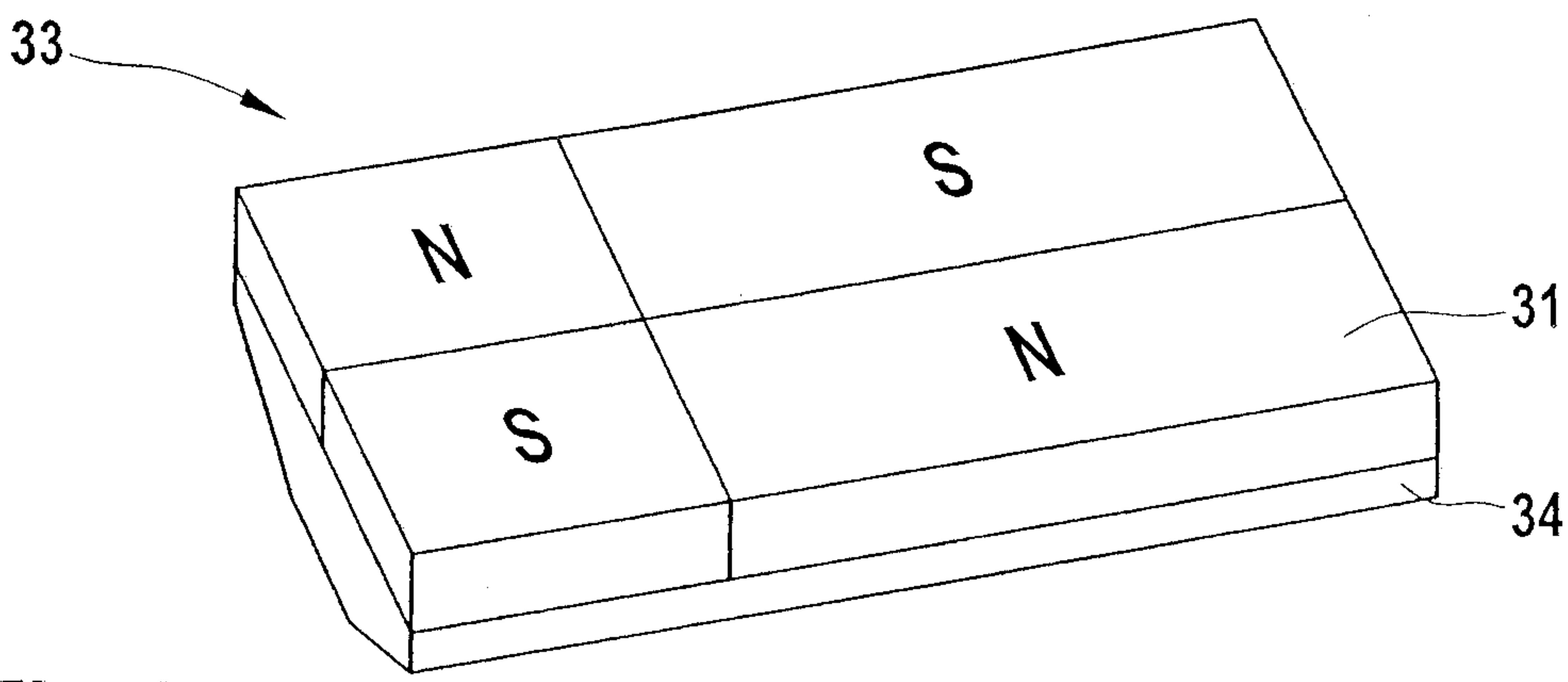


Fig. 15

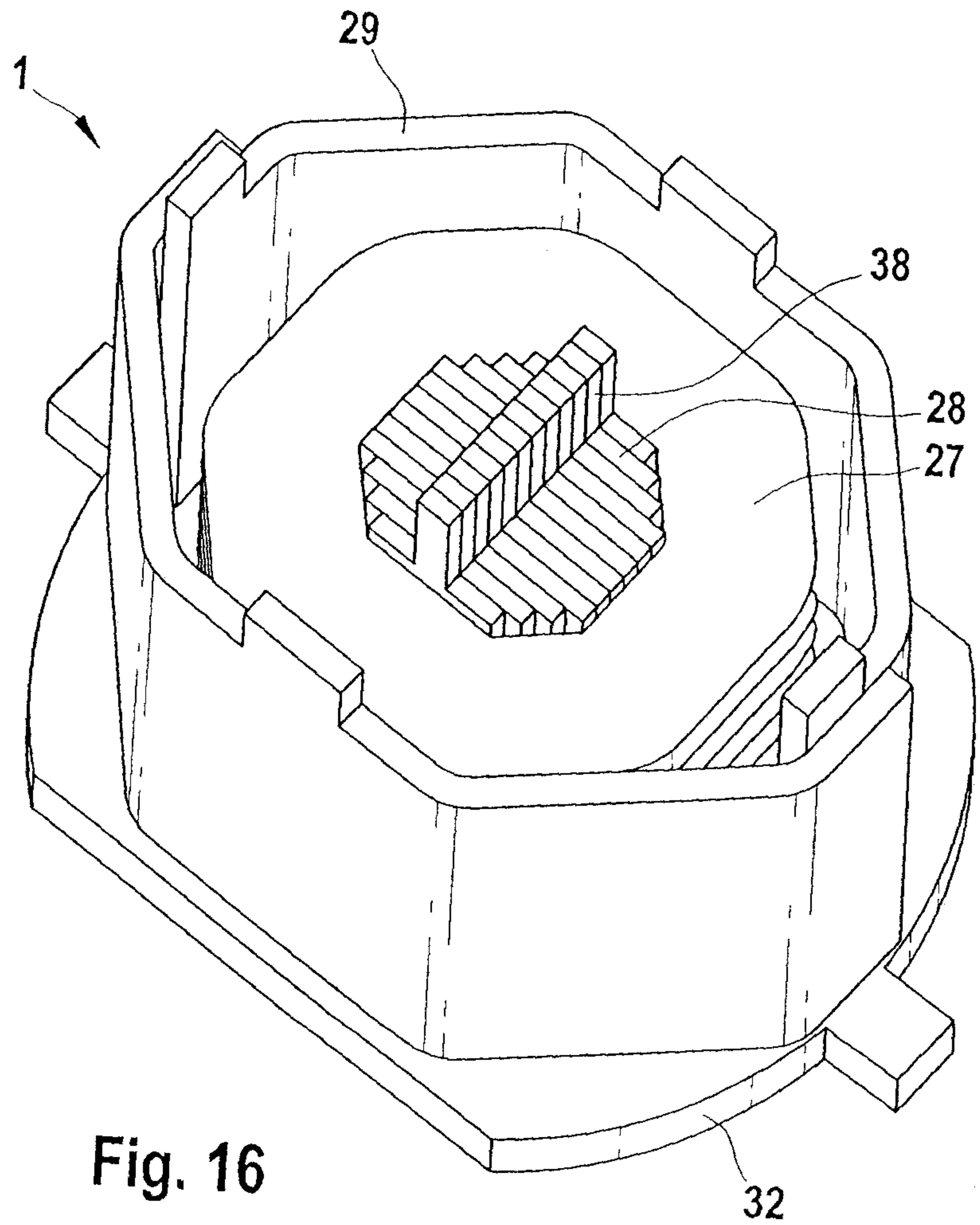


Fig. 16

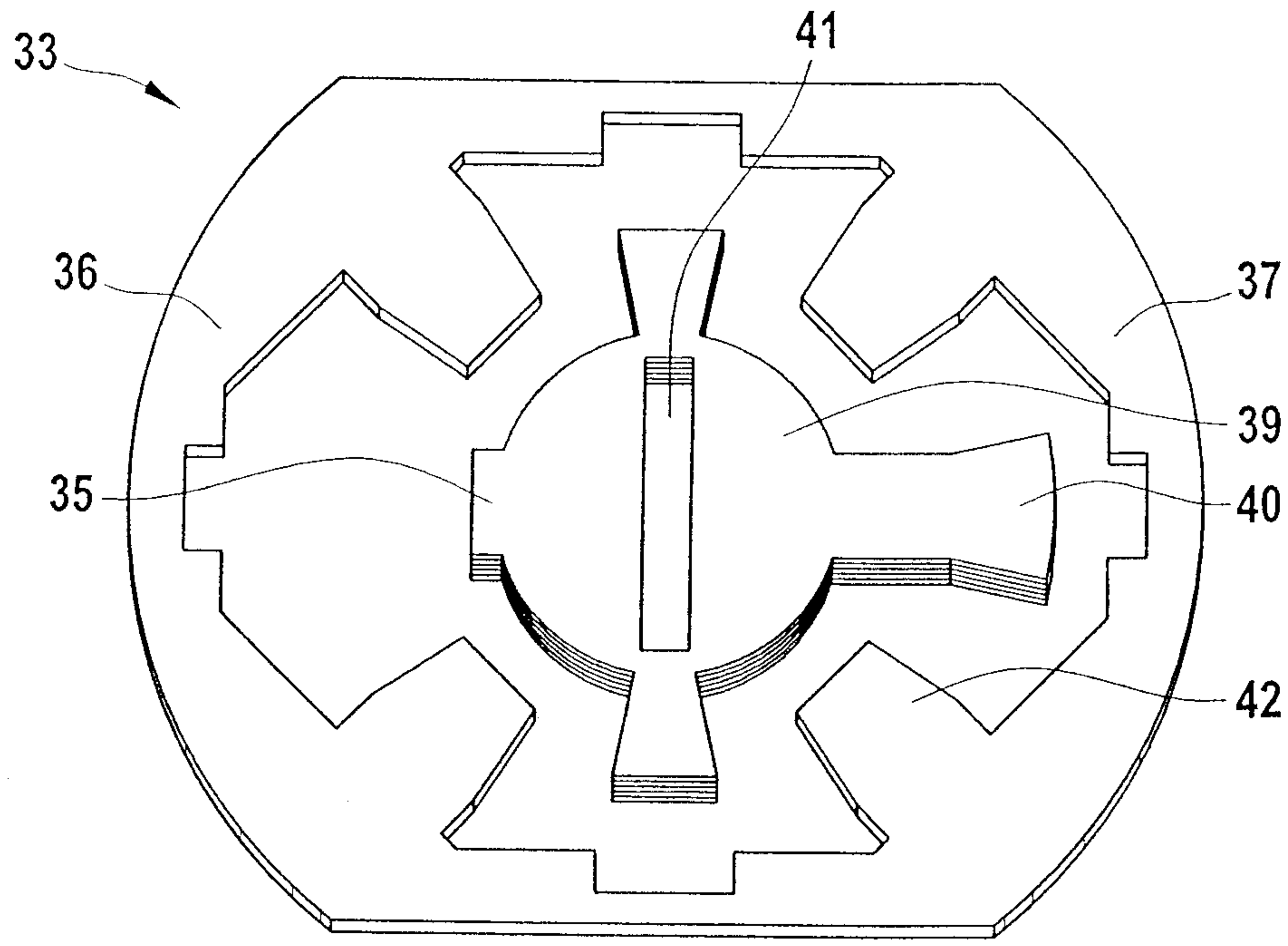


Fig. 17

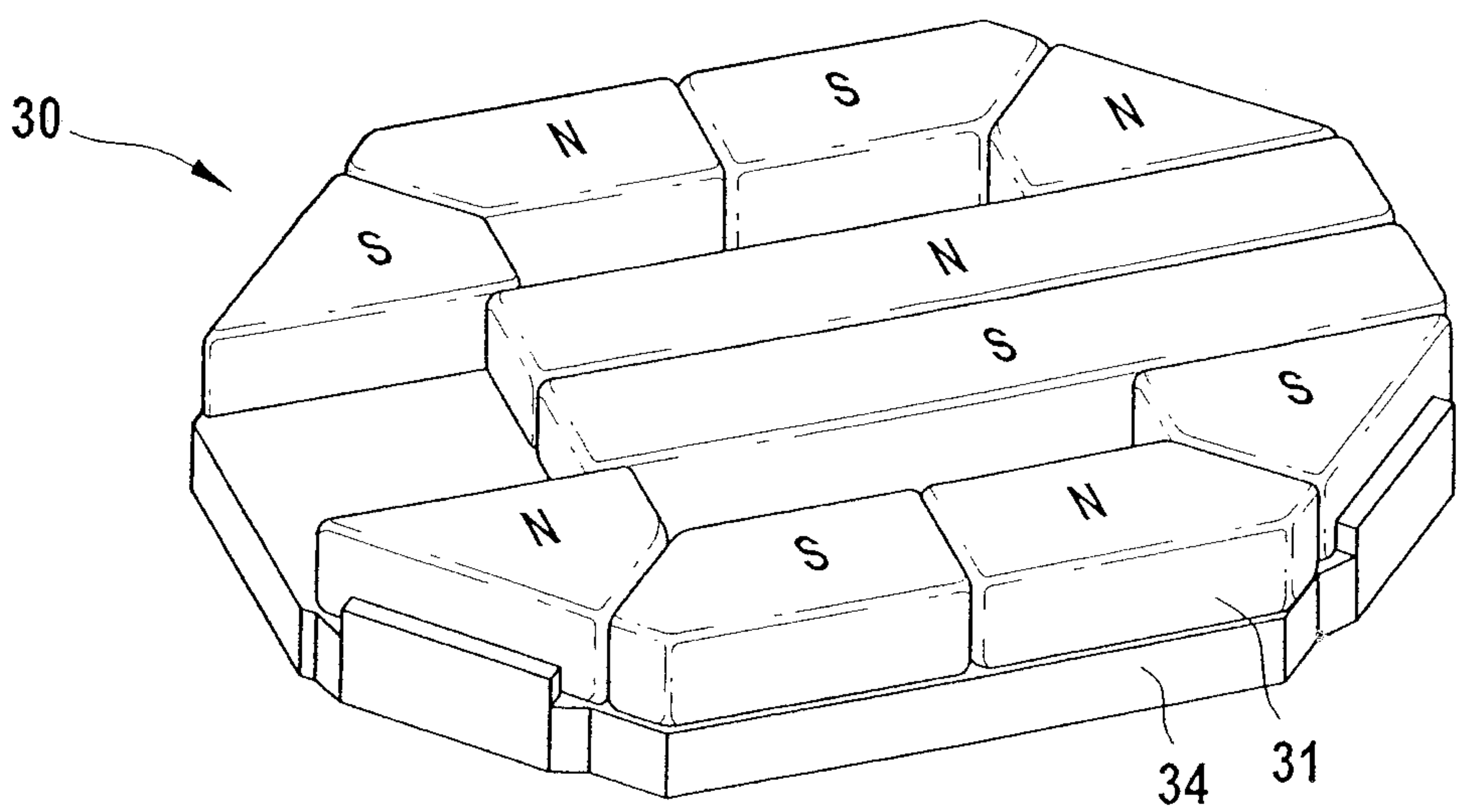
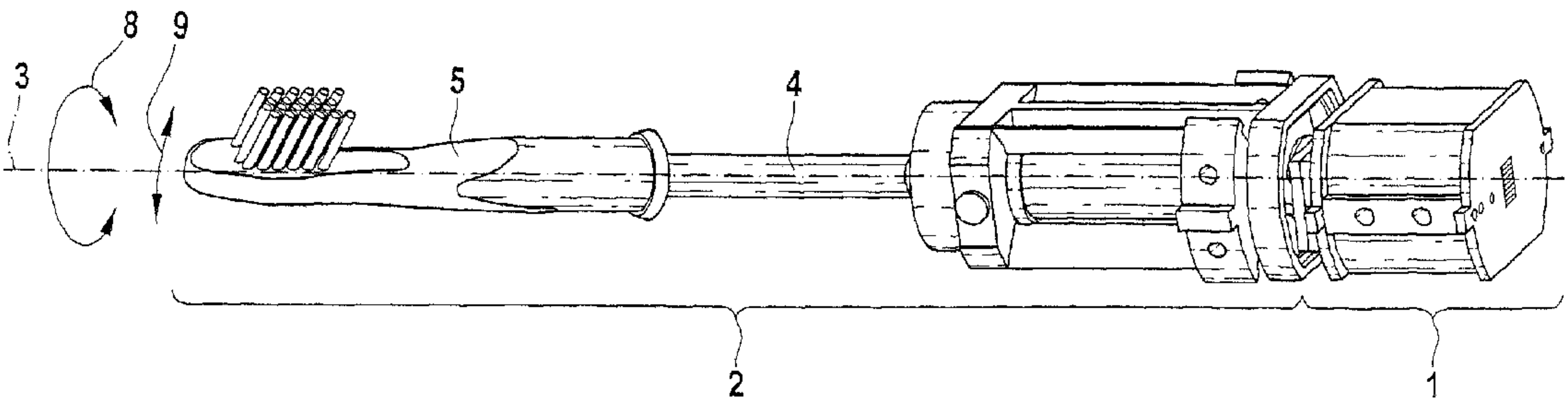


Fig. 18



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