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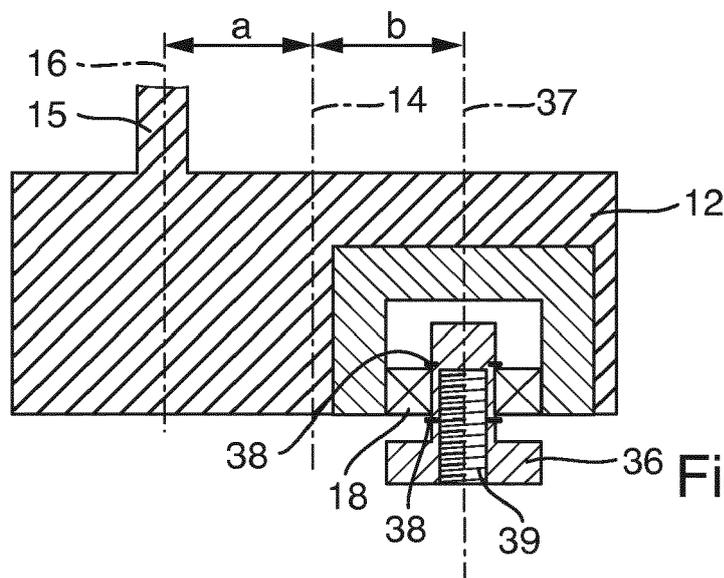
(54) **HAND HELD OR HAND GUIDED GRINDING OR POLISHING MACHINE TOOL**

(57) The invention refers to a hand held or hand guided grinding or polishing machine tool (1), the tool (1) comprising:

- a working element holder (12) having a first connection element (36) for connecting the working element holder (12) to a disk-like working element (9) and a center axis (14),
- the first connection element (36) for connecting the working element holder (12) to the working element (9) having a rotational axis (37) running parallel to the working element holder's (12) center axis (14),
- the working element holder (12) further having a second

connection element (15) for connecting the working element holder (12) to a motor shaft (22) of the grinding or polishing machine tool (1) in a torque proof manner, and

- the second connection element (15) for connecting the working element holder (12) to the motor shaft (22) having a longitudinal axis (16) running parallel to the first connection element's (36) rotational axis (37) and to the working element holder's (12) center axis (14). In order to provide for a larger orbit of the working element (9) and to reduce vibrations of the tool (1) it is suggested that all three axes (14, 16, 37) are spaced apart from one another by predefined distances.



**Fig. 4a**

## Description

**[0001]** The present invention refers to a hand held or hand guided grinding or polishing machine tool actuated electrically or pneumatically. The machine tool comprises:

- a working element holder having a first connection element for connecting the working element holder to a disk-like working element and a center axis,
- the first connection element for connecting the working element holder to the working element having a rotational axis running parallel to the working element holder's center axis,
- the working element holder further having a second connection element for connecting the working element holder to a motor shaft of the grinding or polishing machine tool in a torque proof manner, and
- the second connection element for connecting the working element holder to the motor shaft having a longitudinal axis running parallel to the first connection element's rotational axis and to the working element holder's center axis.

**[0002]** In general, hand held or hand guided power tools can be electrically or pneumatically operated. They can be embodied, for instance, as grinders, sanders, polishers or others. The prior art clearly distinguishes between sanders or grinders on the one hand and polishers on the other hand. Although both types of power tools serve for working a varnished or lacquered surface of a vehicle body, for example of a car or a boat, sanders or grinders and polishers have significantly different designs and features and are operated differently in order to obtain different effects on the varnished or lacquered surface.

**[0003]** Basically, a working surface of a vehicle body is sanded or grinded before providing it with a new coating, in order to obtain an even surface for the subsequent coating. Sanding or grinding is performed, for example, after having applied filler or stopper material to the surface in order to even out depressions and dents. This may also be performed to eliminate corroded or otherwise scruffy regions of the vehicle body. During sanding or grinding a thick layer of varnish or lacquer if not all of the varnish or lacquer is removed or stripped from the vehicle body. Usually, even part of the vehicle body material is removed. The properly sanded or grinded working surface can then be provided with one or more layers of a new coating, usually in the form of varnish and/or lacquer.

**[0004]** The polishing of the vehicle body is performed only on properly coated vehicle body in order to give the coating a more appealing appearance. Hence, polishing is performed after coating the vehicle body with a varnish and/or a lacquer. Usually, no further coating of the vehicle body is applied after polishing. Therefore, it is mandatory, that the varnish or lacquer is not removed but only worked

on and finished on its top surface. Almost none of the varnish or lacquer is removed during polishing and almost no dust is generated.

**[0005]** Sanders or grinders are often designed as palm sanders, which can be held with one hand and which are pressed on the varnished or lacquered working surface by the palm of the holding hand. A lever of a switch for turning on and off the sander is typically located on the top surface of the sander so when holding the sander and pressing it onto the working surface the lever is pressed down by the palm and the sander is activated. Sanders can have a circular, rectangular or delta-shaped working pad actuated by the sanders' electric or pneumatic motor. The working pad can perform an orbital, a random orbital, a rotary orbital or a linear back-and-forth movement depending on the type of working pad used and the desired effect to be achieved on the sander. A sheet of abrasive material can be attached to the bottom surface of the working pad by means of adhesion or a hook-and-loop fastener (Velcro®). With a rectangular working pad, the sheet of abrasive material can be clamped to the bottom surface by clamping devices located laterally at the side of or on top of the working pad. The abrasive sheet material can be an emery or sand paper or a textile sheet material with emery or sand grains inserted therein or attached thereto.

**[0006]** Sanders and grinders or their abrasive sheet material, respectively, typically remove or strip off a rather large amount of varnish or lacquer from the surface. It is even possible that sanders remove part of the surface itself, for example, after having applied filler or stopper material to the surface in order to even out depressions and dents. Therefore, during a sanding process a lot of dust is generated which is preferably actively removed from the working surface by means of a dust extraction system as an integral part of the sander and/or external dust extraction systems, for example a vacuum cleaner attached to a dust discharge nozzle of the sander. Finally, sanders and grinders typically operate at a rather high speed in order to allow easy and fast removal of the rather thick layers of varnish or lacquer. Known sanders and grinders can operate at up to 15.000 rpm.

**[0007]** In contrast thereto, polishers are usually designed and adapted for a two handed use. One hand holds the polisher and the other hand presses the polisher on the varnished or lacquered working surface. A switch for turning on and off the polisher is typically located where the holding hand is located in order to allow actuation of the switch by a finger of the holding hand. Polishers usually have a circular working element actuated by the polishers' electric or pneumatic motor. The working pad can perform an orbital, a mere rotary, a random orbital or a rotary orbital movement depending on the type of working pad used and the desired effect to be achieved on the polisher. A sheet of polishing material can be attached to the bottom surface of the working pad by means of adhesion, a hook-and-loop fastener (Velcro®) or any other type of fastener. The polishing sheet

material can be a sponge, a microfiber or real or synthetic lambs' wool. The polishing sheet material is often used together with a polishing paste.

**[0008]** Polishers or the polishing sheet material, respectively, do not remove or strip part of the varnish or lacquer from the surface. At the most, a very small amount of the varnish or lacquer is removed from the surface due to the effect of the polishing paste. However, the dust is bound by the polishing paste. Therefore, during a polishing process practically no dust is generated which in any event would obviate a satisfying polishing of the working surface because the dust would cause scratches on the surface to be polished. Polishing is performed in a scrupulously clean environment in order to avoid scratches in the surface to be polished. Finally, polishers operate at a significantly lower speed than sanders or grinders. Known rotary polishers typically operate at 1.500-2.000 rpm. Known random orbital polishers typically operate at up to 5.000-6.000 rpm. Random orbital polishers and grinders can operate at up to 10.000-12.000 rpm.

**[0009]** Known grinders have a maximum orbit of 12-15 mm. Known polishers even have a maximum orbit of 21 mm in diameter. A problem with large orbits are vibrations of the machine tool caused by the eccentric masses rotating at relatively high rotational speeds.

**[0010]** Basically, there are two different types of working element holders for grinding or polishing machine tools with a working element performing an orbital (random orbital or rotary orbital) movement known in the art. For a random orbital movement these two types of working element holders are shown in Figs. 1a and 1b. Both types of working element holders have a center axis. Furthermore, they have a first connection element mounted freely rotatable to the working element holder, for example by means of one or more ball bearings. The first connection element has a rotational axis running in parallel or congruent to the working element holders's center axis. Furthermore, the working element holder has a second connection element for a torque proof connection to a shaft of a motor of the grinding or polishing machine tool. The second connection element has a rotational axis running in parallel or congruent to the working element holders's center axis.

**[0011]** In the first known type of a working element holder shown in Fig. 1a the orbit of the working element's orbital movement is obtained by spacing apart the second connection element with its longitudinal axis from the working element holder's center axis, wherein the first connection element's rotational axis is congruent to the working element holder's center axis. The working element's orbit corresponds to twice the distance between the second connection element's longitudinal axis and the working element holder's center axis.

**[0012]** In the second known type of a working element holder shown in Fig. 1b the orbit of the working element's orbital movement is obtained by spacing apart the first connection element with its rotational axis from the work-

ing element holder's center axis, wherein the second connection element's longitudinal axis is congruent to the working element holder's center axis. The working element's orbit corresponds to twice the distance between the first connection element's rotational axis and the working element holder's center axis.

**[0013]** Fig. 3a and 3b show two different types of working elements adapted for connection to the working element holder's first connection element. The working elements each have a rotational axis and a connection element extending along the working elements' rotational axis for connecting the working elements to the working element holder of the machine tool. In a top view the working elements may have a round circumferential shape. In a sectional view (see figs. 3a and 3b) the working elements may have a truncated cone shape, wherein the working elements' top surface has a smaller diameter than the bottom surface. On the bottom surface a sheet-like working material can be attached, for instance a polishing material comprising but not limited to a sponge, a microfiber, and real or synthetic lambs' wool or a sanding material comprising but not limited to a sanding paper or a sanding textile. The working material 13 can be attached to the bottom surface of the working element by means of a loop-and-hook fastener (or Velcro®), a glued surface or adhesive layer or in any other suitable way. The working element may be made of a semi-rigid material, preferably a plastic or silicone material, which on the one hand is rigid enough to carry and support the working material during the intended use of the machine tool and to apply a force to the working material in a direction essentially parallel to the working element's rotational axis and which on the other hand is flexible enough to avoid damage or scratching of the surface to be worked by the working element or the working material, respectively.

**[0014]** In the first type of working element shown in Fig. 3a the connection element is embodied as a stud which at its bottom end is preferably molded into the material of the working element during its manufacture. The stud has an external threading corresponding to an internal threading of a bore located in the working element holder's first connection element along the rotational axis. For fastening and loosening the working element shown in Fig. 3a to/from the working element holder the first connection element has to be held in order to block and prevent its rotation about the rotational axis.

**[0015]** In the second type of working element shown in Fig. 3b the connection element comprises a separate screw which can be inserted from the working element's bottom surface through a hole extending through the working element along its rotational axis. The screw has a head and a threaded section with an external threading corresponding to the internal threading of the bore of the working element holder's first connection element. The hole in the working element comprises a first section at the bottom surface of the working element, the first section having a larger diameter than the hole for receiving

the screw's head, in order to avoid protrusion of the screw when fastened to the working element holder's first connection element. The hole in the working element further comprises a second section at the top surface of the working element, the second section having a larger diameter than the hole and an inner circumferential form corresponding to the outer circumferential form of the first connection element. The second section is adapted for receiving the first connection element therein in a positive fitting. After inserting the first connection element into the second section of the hole the screw is inserted into the hole and screwed into the bore of the first connection element thereby securing the working element to the working element holder.

**[0016]** In the polishers known from the prior art, the larger the working element's orbit is, the larger the distance between the longitudinal axis of the working element holder's second connection element (corresponding to the motor shaft) and the second connection element's rotational axis is, inevitably leading to larger dimensions of the tool and stronger vibrations. In the prior art, one of the two axes is congruent with the working element's holder center axis.

**[0017]** A well-known polisher developed, produced and sold by the applicant under the trademark BIGFOOT® has a maximum orbit of 21 mm in diameter. The BIGFOOT polisher has

- a disk-like working element rotatable about a rotational axis and having a connection element extending along the working element's rotational axis, the connection element adapted for connecting the working element to a working element holder of the polishing machine tool,
- the working element holder, to which the working element is connected, having a first connection element for connecting the working element holder to the working element and a center axis,
- the first connection element for connecting the working element holder to the working element having a rotational axis running parallel to the working element holder's center axis,
- the working element holder further having a second connection element for connecting the working element holder to a motor shaft of the polishing machine tool in a torque proof manner, and
- the second connection element for connecting the working element holder to a motor shaft having a longitudinal axis running parallel to the first connection element's rotational axis and to the working element holder's center axis.

Both types of working elements shown in Figs. 3a and 3b can be attached to the working element holder as described above.

**[0018]** In order to reduce the vibrations on the one hand and achieve relatively large orbits on the other hand, the BIGFOOT® polisher has a working element's rotational

axis identical or coaxial to the center axis of the working element holder. The working element holder's second connection element for connecting the working element holder to the motor shaft is located eccentrically in respect to the working element holder's center axis. A working element holder like the one used in the known BIGFOOT® polisher is shown in Fig. 1a. It can be clearly seen that the longitudinal axis of the working element holder's connection element is spaced apart from and located in a predefined distance to the working element holder's center axis and, consequently, to the working element's rotational axis, respectively.

**[0019]** The object of the present invention is to provide for an alternative hand held or hand guided grinding or polishing machine tool, which can perform even larger orbits, preferably larger than 21 mm, and at the same time has very reduced vibrations.

**[0020]** This object is achieved by a hand held or hand guided grinding or polishing machine tool of the above identified kind, wherein the three axes are all spaced apart from one another by predefined distances. In contrast to the known polishers, where either the first connection element's 36 rotational axis or the second connection element's longitudinal axis is congruent (identical or coaxial) to the center axis of the working element holder, in the present invention all three axes are spaced apart from one another by a given distance. The distances between the three axes can be designed such that the resulting orbit of the working element is particularly large, preferably larger than 21 mm, in diameter without provoking bigger dimensions and larger vibrations. With other words, in the prior art the orbit of the working element corresponds to twice the distance either between the first connection element's rotational axis and the center axis of the working element holder or between the second connection element's longitudinal axis and the center axis of the working element holder. In contrast thereto, the orbit of the working element of the present invention corresponds to twice the sum of the distances between the first connection element's rotational axis and the center axis of the working element holder on the one hand and between the second connection element's longitudinal axis and the center axis of the working element holder on the other hand. At the same time despite the rather large orbit the vibrations can be significantly reduced to acceptable values, in particular to values in compliance with the respective official working regulations regarding vibrations of hand guided machine tools. Alternatively, the distances between the three axes can be designed such that the resulting orbit is equal or even smaller than 21 mm, but with the vibrations being significantly reduced in respect to known polishing or grinding machine tools with similar orbits.

**[0021]** Preferred embodiments of the present invention are the subject of the dependent claims. In a first preferred embodiment the working element holder's center axis is located between the working element's rotational axis and the connection element's longitudinal axis (fig-

ure 4).

**[0022]** Furthermore, it is suggested that in a top view onto the working element holder the working element holder's center axis, the working element's rotational axis and the connection element's longitudinal axis are all located on a virtual radially extending straight center line. The center line runs through the working element holder's center axis. Alternatively, it is suggested that in a top view onto the working element holder the axis located between the other two axes is connected to a first one of the two other axes by means of a first virtual line and is connected to a second one of the two other axes by means of a second virtual line, wherein the two lines are located in an angle  $0^\circ$  and  $90^\circ$ , wherein the angle is  $\neq 0^\circ$  in respect to one another. Preferably, the point of intersection of the two lines lies at the working element holder's center axis. This embodiment has the advantage that the vibrations of the machine tool are significantly reduced. The angle between the two lines can be selected depending on the nominal rotational speed of the machine tool's working element. The larger the nominal rotational speed is, the larger the absolute value of the angle between the two lines would be selected. For example, the absolute value of the angle between the two lines is  $<30^\circ$ , preferably  $15^\circ$ . Depending on the rotational direction of the working element the angle would be positive (counter-clockwise) or negative (clockwise).

**[0023]** Preferably, the working element holder's connection element is a tool shaft designed separately from the motor shaft and connected in a torque proof manner thereto. It is possible that the motor shaft is connected to the working element holder's connection element by means of a gear or transmission mechanism located in-between. In that way a rotational speed of the motor shaft can be transmitted into a faster (with less torque) or slower (with higher torque) actuating movement of the working element. However, in order to reduce the overall size of the machine tool, in particular in order to reduce its height, it is suggested that the motor shaft is directly connected to the working element holder's connection element without any gear or transmission mechanism located in-between. It is even possible that the working element holder's connection element is constituted by the motor shaft itself or that the working element holder's connection element constitutes the motor shaft, respectively.

**[0024]** Preferably, the working element's connection element is held freely rotatable in the working element holder. In this manner a random orbital working movement of the working element can be realized. Alternatively, the working element is held in the working element holder in a torque proof manner in a fixed orientation. In this manner an orbital working movement of the working element can be realized.

**[0025]** The grinding or polishing machine tool can comprise a pneumatic or an electric motor. The motor has a motor shaft performing a rotating movement around its longitudinal axis. The rotating movement of the motor shaft is transmitted to the working element holder such

that the working element performs its predefined working movement. The working movement can be a roto-orbital or a random-orbital working movement. Preferably, the grinding or polishing machine tool comprises an electric motor for rotating the motor shaft and actuating the working element in order to provoke its roto-orbital or random-orbital working movement. The electric motor can be actuated by means of a power supply voltage taken from a power supply network via a power supply cable. The power supply network provides a voltage of 230V or 110V depending on the country in which the machine tool is operated. The machine tool can be embodied to automatically adapt to the respective voltage without the user of the machine tool having to manually switch the machine tool to the respective voltage.

**[0026]** Further, the electric motor can be operated by means of the electric power from a rechargeable battery at a voltage of approximately 6V, 12V, 24V or 48V. Of course, the battery can provide other voltages, too, if desired. The rechargeable battery can be incorporated into the machine tool's housing either in a manner fixed inside the housing or in such a way that it is received in a recess of the machine tool's housing so it can be easily extracted from the housing, for example to replace it with a fully loaded battery. It is possible that a power transformer connected to a power supply cable is inserted into the recess provided in the machine tool's housing for receiving the rechargeable battery, when the battery is extracted from the recess. To this end, the machine tool can be operated either by means of a power supply network (via the transformer) or alternatively by means of the battery.

**[0027]** Preferably, the electric motor is a brushless direct current (BLDC) motor. The electric motor can be of the outrunner or of the conventional inrunner type. In the outrunner type the motor's stator is located statically in the center of the motor and the rotor runs outside the stator circumferentially surrounding the stator. This allows a particularly compact motor having only a reduced height, which allows a compact design of the machine tool.

**[0028]** It is particularly preferred that the distances between the working element holder's center axis, the working element's rotational axis and the connection element's longitudinal axis are specified in such a manner that the resulting orbit of the working element is at least 21 mm in diameter. Preferably, the orbit is at least 25 mm in diameter. Despite this rather large orbit, the machine tool according to the present invention is very compact and creates only very reduced vibrations due to the particularly advantageous distribution of the various axes of the working element holder and the working element.

**[0029]** The drawings show preferred embodiments of the present invention. In particular they show:

55 Fig. 1a a sectional view of a first type of a working element holder known from the prior art;

Fig. 1b a sectional view of a second type of a working

- element holder known from the prior art;
- Fig. 2a a top view of the working element holder of Fig. 1a and a working element attached thereto;
- Fig. 2b a top view of the working element holder of Fig. 1b and a working element attached thereto;
- Fig. 3a a sectional view of a first type of a working element for connection to the working element holder of Figs. 1a and 1b known from the prior art;
- Fig. 3b a sectional view of a second type of a working element for connection to the working element holder of Figs. 1a and 1b known from the prior art;
- Fig. 4a a sectional view of a working element holder of a grinding or polishing machine tool according to a preferred embodiment of the present invention;
- Fig. 4b a sectional view of a first type of a working element for connection to the working element holder of Fig. 4a;
- Fig. 4c a sectional view of a second type of a working element for connection to the working element holder of Fig. 4a;
- Fig. 5 a top view of the working element holder of Fig. 4a and a working element of one of the Figs. 4b or 4c attached thereto;
- Fig. 6 a top view of a working element holder according to an alternative to Fig. 5;
- Fig. 7 a top view of a working element holder according to another alternative to Fig. 5;
- Fig. 8 a sectional view of an electric motor of a grinding or polishing machine tool according to a preferred embodiment of the present invention;
- Fig. 9 a top view of the electric motor of Fig. 8;
- Fig. 10 a sectional view of the rotor of the electric motor of Fig. 8;
- Fig. 11 a bottom view of the rotor of Fig. 10;
- Fig. 12 a perspective view of a grinding or polishing machine tool according to a preferred embodiment of the present invention;
- Fig. 13 a sectional view of a front part of a grinding or polishing machine tool according to a preferred embodiment of the present invention; and
- Fig. 14 a sectional view of a front part of a grinding or polishing machine tool according to another preferred embodiment of the present invention.
- [0030]** Fig. 12 shows an example of a random orbital polishing machine tool 1 according to the present invention. The polisher 1 has a housing 2, essentially made of a plastic material. The polisher 1 is provided with a handle 3 at its rear end and a grip 4 at its front end. An electric power supply line 5 with an electric plug at its distal end exits the housing 2 at the rear end of the handle 3. At the bottom side of the handle 3 a switch 6 is provided for activating and deactivating the machine tool 1. The switch 6 can be continuously held in its activated position by means of a push button 7. The machine tool 1 can be provided with a rotary adjustment means (not shown) for adjusting the rotational speed of the tool's motor. The housing 2 can be provided with cooling openings 8 for allowing heat from electronic components and/or the electric motor both located inside the housing 2 to dissipate into the environment.
- [0031]** The machine tool 1 shown in fig. 12 has an electric motor (see for example figs. 8 to 11, 13 and 14). Of course, the machine tool according to the present invention could also be equipped with a pneumatic motor, which is especially advantageous in explosive environments, where sparks from an electric motor could provoke an explosion of an explosive mixture (e.g. oxygen and very fine dust) contained in the environment. Furthermore, instead of the connection of the machine tool 1 to a mains power supply by means of the electric cable 5, the machine tool 1 could alternatively be equipped with a rechargeable battery (not shown) located inside the housing 2. In that case the electric energy for driving the electric motor 21 would be provided by the battery.
- [0032]** The machine tool 1 has a disk-like working element 9 (see figs. 4b and 4c) rotatable about a rotational axis 10 and having a connection element 11 extending along the working element's rotational axis 10. The connection element 11 is adapted for connecting the working element 9 to a working element holder 12. The bottom surface of the working element 9 is provided with means for attaching a sheet-like working material 13, for instance a polishing material comprising but not limited to a sponge, a microfiber, and real or synthetic lambs' wool. The sheet-like working material 13 could also be a sanding material comprising but not limited to a sanding paper or a sanding fabric. The attachment means can comprise a first layer of a hook-and-loop fastener (or Velcro®), wherein the top surface of the sheet-like working material 13 is provided with the second layer of the hook-and-loop fastener. The two layers of the hook-and-loop fastener

interact with one another in order to releasably but safely fix the working material 13 to the working element 9.

**[0033]** The working element 9 is made of a semi-rigid material, preferably a plastic material, which on the one hand is rigid enough to carry and support the working material 13 during the intended use of the machine tool 1 and to apply a force to the working material 13 in a direction essentially parallel to the working element's rotational axis 10 and which on the other hand is flexible enough to avoid damage or scratching of the surface to be worked by the working element 9 or the working material 13, respectively. The working element's connection element 11 can be embodied as a stud which at its bottom end is preferably molded into the material of the working element 9 during its manufacture (see Fig. 4b). Alternatively, the working element's connection element 11 comprises a separate screw which can be inserted from the working element's 9 bottom surface through a hole 40 extending through the working element 9 along its rotational axis 10 (see Fig. 4c).

**[0034]** Fig. 4a shows a working element holder 12 for a grinding or polishing machine tool 1 according to the present invention with a working element 9 performing a random orbital movement. The working element holder 12 has a center axis 14. The center axis 14 is preferably the axis of gravity of the working element holder 12. The axis of gravity could be defined with or without the working element 9. The axis of gravity could further be defined with or without a sheet-like working material 13 being attached to the bottom surface of the working element 9. Preferably, the axis of gravity is defined with the working element 9 attached to the working element holder 12 and with a typical sheet-like working material 13 attached to the bottom surface of the working element 9.

**[0035]** Furthermore, the working element holder 12 has a first connection element 36 mounted freely rotatable to the working element holder 12, for example by means of one or more ball bearings 18. The first connection element 36 can be secured to the ball bearings 18 by means of one or more self-locking retaining rings 38 (e.g. Seegerings). Alternatively, the first connection element 36 can be secured to the ball bearings 18 by means of a press fit. In the drawings the ball bearings 18 are connected to the working element holder by means of a separate bearings seat inserted into the working element holder 12. Of course, this bearings seat could be made as an integral part of the working element holder 12. The first connection element 36 has a rotational axis 37 running in parallel or congruent to the working element holders's 12 center axis 14. Further, the working element holder 12 has a second connection element 15 for a torque proof connection to a shaft 22 of the motor 21 of the grinding or polishing machine tool 1. The second connection element 15 has a rotational axis 16 running in parallel or congruent to the working element holders's 12 center axis 14.

**[0036]** The second connection element 15 can be embodied as a tool shaft which at its bottom end is tightly

fixed to the working element holder 12, for example by welding, or is made from a single piece together with the working element holder 12. The working element holder 12 is made of a rigid material, preferably a metal, for example aluminum. Both types of working elements 9 shown in Figs. 4b and 4c can be mounted to the first connection element 36 of the working element holder 12 as described in detail above.

**[0037]** In contrast to the known polishers, where either the first connection element's 36 rotational axis 37 or the second connection element's 15 longitudinal axis 16 is congruent (identical or coaxial) to the center axis 14 of the working element holder 12 (see Figs. 1a and 1b), in the present invention all three axes 37, 16 and 14 are spaced apart from one another by a given distance (see Fig. 4a). The distances between the three axes 37, 14, 16 (see Fig. 5) can be designed such that the resulting orbit of the working element 9 is particularly large, preferably larger than 21 mm, in diameter without provoking larger vibrations. All this can be achieved without enhancing the overall dimensions of the working element and consequently of the entire tool, which remains very compact and light weight.

**[0038]** With other words, in the prior art the orbit of the working element 9 corresponds to twice the distance either between the first connection element's 36 rotational axis 37 and the center axis 14 of the working element holder 12 (see Fig. 1b) or between the second connection element's 15 longitudinal axis 16 and the center axis 14 of the working element holder 12 (see Fig. 1a). In contrast thereto, the orbit of the working element 9 of the present invention (see Fig. 4a) corresponds to twice the sum of the distances between the first connection element's 36 rotational axis 37 and the center axis 14 of the working element holder 12 on the one hand and between the second connection element's 15 longitudinal axis 16 and the center axis 14 of the working element holder 12 on the other hand. Despite the rather large orbit at the same time the vibrations and the dimensions can be significantly reduced. Alternatively, the distances between the three axes 37, 14, 16 can be designed such that the resulting orbit of the working element 9 is equal or even smaller than 21 mm, but with the vibrations and the dimensions being significantly reduced in respect to known polishing or grinding machine tools with similar orbits. Of course, respective counter weights could be incorporated into the working element holder 12 either as separate parts or as an integral part of the working element holder 12, in order to further reduce vibrations of the tool 1.

**[0039]** The machine tool 1 according to the present invention has the advantage that the working element 9 can perform very large orbital working movements, preferably with an orbit of more than 21 mm in diameter, in particular with an orbit of approximately 25 mm in diameter. At the same time the machine tool 1 generates only minor vibrations. This is due to the particularly advantageous positioning of the axes 37, 14, 16. It is suggested that the three axes 37, 14, 16 are all spaced apart from

one another by predefined distances. According to the embodiment of Fig. 4a the working element holder's center axis 14 is located between the longitudinal axis 16 of the working element holder's second connection element 15 and the first connection element's rotational axis 37. This embodiment has the advantage that it allows a highly equilibrated design of the working element holder 12, resulting in minor vibrations of the machine tool 1. Furthermore, this embodiment permits the realization of very large orbits equal to twice the sum of the two distances (orbit =  $2 \times (a+b)$ ), wherein a is the distance between the axes 14 and 16 and b is the distance between the axes 37 and 14.

**[0040]** The machine tool 1 shown in fig. 12 is embodied as a polisher with the round disk-like working element 9 performing a random orbital movement. Of course, the machine tool according to the present invention could also be embodied as a grinding machine tool or any other type of machine tool having a working element 9 of any desired form and performing an orbital, a random orbital or a rotary orbital working movement. For example, in the case of a random orbital polisher the working element 9 could have a triangle form or in the case of an orbital polisher the working element 9 could have a rectangular form.

**[0041]** Figs. 5 to 7 show top views of the working element holders 12 partly with the working element 9 (Fig. 5). It can be clearly seen that in the embodiment of Fig. 5 the three axes 37, 14, 16 are located on an imaginary line 19. In the embodiment the diameter of the orbit is twice the distance between the axes 37 and 16 ( $2 \times (a+b)$ ). In order to further reduce vibrations of the machine tool 1 during operation it may be advantageous to locate the axes 37, 14, 16 on two different imaginary lines 19, 20 instead of only on one line 19 as shown in Fig. 5. Such embodiments are shown in figs. 6 and 7. It can be clearly seen that in both embodiments a first imaginary line 19 runs through the axes 37, 14 and that a second imaginary line 20 runs through the axes 14, 16. The two lines 19, 20 intersect in a given angle  $\alpha$  in respect to each other at the working element holder's 12 center axis 14. Starting from the first line 19 the angle  $\alpha$  can be a positive value (counter-clockwise as shown in fig. 6) or a negative value (clockwise as shown in fig. 7). The value of the angle  $\alpha$  and whether it has a positive or a negative value depends on a plurality of factors. These can be, for example, the direction of rotation (clockwise or counter-clockwise) about the longitudinal axis 16, the rotational speed of the rotation, the value of the rotating masses, etc. The polisher 1 shown in fig. 12 can achieve very good results if the angle  $\alpha$  has an absolute value of approximately  $15^\circ$ .

**[0042]** Figs. 13 and 14 show further preferred embodiments of the machine tool 1 according to the present invention. It can be seen that approximately at the front end of the machine tool 1 inside the housing 2 there is an electric motor 21 having a motor shaft 22. In the embodiment of Fig. 13 the motor shaft 22 is connected to

the working element holder's 12 second connection element 15 by means of a gear or transmission mechanism 23. The gear or transmission mechanism 23 has a drive shaft 24 and an output shaft 25. The drive shaft 24 is connected to the motor shaft 22 in a torque proof manner and the output shaft 25 is connected to the tool shaft 15 of the working element holder 12 in a torque proof manner. The gear or transmission mechanism 23 can translate the rotational speed of the motor shaft 22 into a higher or lower rotational speed of the tool shaft 15. At the same time the torque applied to the tool shaft 15 can be reduced or enhanced. In the embodiment of fig. 14 the motor shaft 22 is directly connected to the working element holder's 12 second connection element 15 without any gear or transmission mechanism located in-between. This embodiment has the advantage that the machine tool 1 or its housing 2, respectively, can be designed very compact, in particular very small in height.

**[0043]** In Figs. 13 and 14 the working element holder 12 and the working element 9 are designed according to the embodiment of Fig. 4a with the center axis 14 of the working element holder 12 located between the other two axes, the rotational axis 37 of the first connection element 36 of the working element holder 12 and the longitudinal axis 16 of the second connection element 15 of the working element holder 12.

**[0044]** Figs. 8 to 11 show a preferred embodiment of the electric motor 21 used in the machine tool 1 according to the invention. The motor is preferably embodied as an outrunner brushless direct current (BLDC) motor. The BLDC motor 21 has a centrally disposed stator 26 extending along a longitudinal axis 27 of the motor shaft 22. The stator 26 has a total of twelve wire coils two of which are shown in fig. 8. The motor shaft 22 extends through the center of the stator 26 and is supported by two bearings 29, 30 at the top and the bottom of the motor 21. A self-locking retaining ring Seegerring 31 holds the motor shaft 22 in place within the stator 26. A stator flange is designated with reference sign 32. A motor housing is designated with reference sign 33. A cup-shaped rotor 28 rotates around and relative to the stator 26. Permanent magnets 34 are fastened circumferentially on the inside of the rotor 28. A rotor flange is designated with reference sign 35.

**[0045]** Of course, it is possible to combine the features of the various embodiments described with respect to the Figs. 1 to 14 in any desired way in order to arrive at a particularly advantageous machine tool 1 according to the present invention.

## Claims

1. Hand held or hand guided grinding or polishing machine tool (1), the grinding or polishing machine tool (1) comprising:

- a working element holder (12) having a first

- connection element (36) for connecting the working element holder (12) to a disk-like working element (9) and a center axis (14),
- the first connection element (36) for connecting the working element holder (12) to the working element (9) having a rotational axis (37) running parallel to the working element holder's (12) center axis (14),
  - the working element holder (12) further having a second connection element (15) for connecting the working element holder (12) to a motor shaft (22) of the grinding or polishing machine tool (1) in a torque proof manner, and
  - the second connection element (15) for connecting the working element holder (12) to the motor shaft (22) having a longitudinal axis (16) running parallel to the first connection element's (36) rotational axis (37) and to the working element holder's (12) center axis (14), **characterized in that** all three axes (14, 16, 37) are spaced apart from one another by predefined distances.
2. Hand held or hand guided grinding or polishing machine tool (1) according to claim 1, wherein the working element holder's (12) center axis (14) is located between the first connection element's (36) rotational axis (37) and the second connection element's (15) longitudinal axis (16) .
  3. Hand held or hand guided grinding or polishing machine tool (1) according to one of the preceding claims, wherein in a top view onto the working element holder (12) the working element holder's (12) center axis (14), the first connection element's (37) rotational axis (36) and the second connection element's (15) longitudinal axis (16) are located on a virtual center line (19) radially extending from the center axis (14).
  4. Hand held or hand guided grinding or polishing machine tool (1) according to claim 1 or 2, wherein in a top view onto the working element holder (12) the axis (14; 16) located between the other two axes (37, 16; 37, 14) is connected to a first one (37; 14) of the two other axes (37, 16; 37, 14) by means of a first virtual line (19) and is connected to a second one (16; 37) of the two other axes (37, 16; 37, 14) by means of a second virtual line (20), wherein the two lines (19, 20) are located in an angle between 0° and 90°, wherein the angle is  $\neq 0^\circ$  in respect to one another.
  5. Hand held or hand guided grinding or polishing machine tool (1) according to claim 4, wherein the angle between the two lines (19, 20) is  $< 30^\circ$ , preferably  $15^\circ$ .
  6. Hand held or hand guided grinding or polishing machine tool (1) according to one of the preceding claims, wherein the working element holder's (12) second connection element (15) is a tool shaft designed separately from the motor shaft (22).
  7. Hand held or hand guided grinding or polishing machine tool (1) according to one of the preceding claims, wherein the motor shaft (22) is directly connected to the working element holder's (12) second connection element (15) without any gear or transmission mechanism (23) located in-between.
  8. Hand held or hand guided grinding or polishing machine tool (1) according to one of the preceding claims, wherein the working element (9) is rotatable about a rotational axis (10) and comprises a third connection element (11) extending along the working element's (9) rotational axis (10), wherein the working element's (9) connection element (11) is connected to the first connection element (36), wherein the working element's (9) rotational axis (10) is congruent with the first connection element's (36) rotational axis (37).
  9. Hand held or hand guided grinding or polishing machine tool (1) according to one of the preceding claims, wherein the first connection element (36) is held in the working element holder (12) by means of at least one ball bearing (18).
  10. Hand held or hand guided grinding or polishing machine tool (1) according to one of the preceding claims, wherein the grinding or polishing machine tool (1) comprises an electric motor (21) for rotating the motor shaft (22) and actuating the working element (9) in order to provoke its roto-orbital or random-orbital working movement.
  11. Hand held or hand guided grinding or polishing machine tool (1) according to claim 10, wherein the electric motor (21) is a brushless direct current (BLDC) motor.
  12. Hand held or hand guided grinding or polishing machine tool (1) according to one of the preceding claims, wherein the distances between the working element holder's (12) center axis (14), the first connection element's (37) rotational axis (37) and the second connection element's (15) longitudinal axis (16) are specified in such a manner that the resulting orbit of the working element (9) is at least 21 mm in diameter.
  13. Working element holder (12) for use in a hand held or hand guided grinding or polishing machine tool (1) according to one of the preceding claims, the working element holder (12) having:

- a center axis (14),  
 - a first connection element (36) adapted for connecting the working element holder (12) to a disk-like working element (9), the first connection element (36) having a rotational axis (37) running parallel to the working element holder's (12) center axis (14),  
 - a second connection element (15) adapted for connecting the working element holder (12) to a motor shaft (22) of a motor (21) of a grinding or polishing machine tool (1) in a torque proof manner, the second connection element (15) having a longitudinal axis (16) running parallel to the first connection element's (36) rotational axis (37) and to the working element holder's (12) center axis (14), **characterized in that** all three axes (14, 16, 37) are spaced apart from one another by predefined distances.

14. Working element holder (12) according to claim 13, wherein the center axis (14) is defined as the axis of gravity of the working element holder (12).

15. Working element holder (12) according to claim 13, wherein the center axis (14) is defined as the axis of gravity of the working element holder (12) with a working element (9) being fixed to the working element holder (12) and with a sheet-like working material (13) being attached to a bottom surface of the working element (9).

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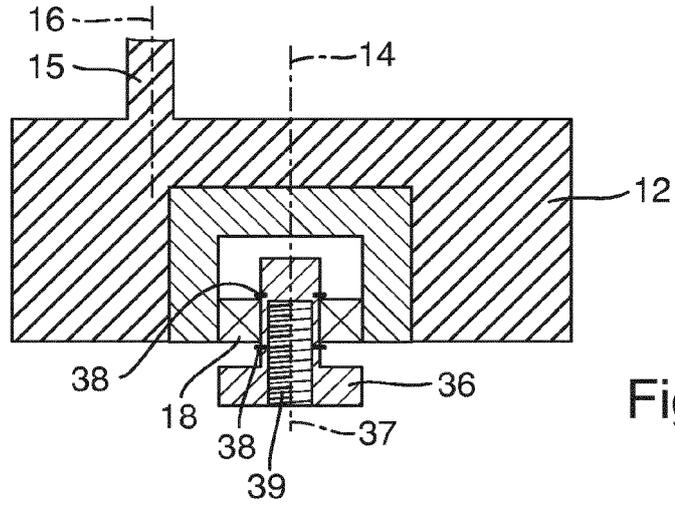


Fig. 1a

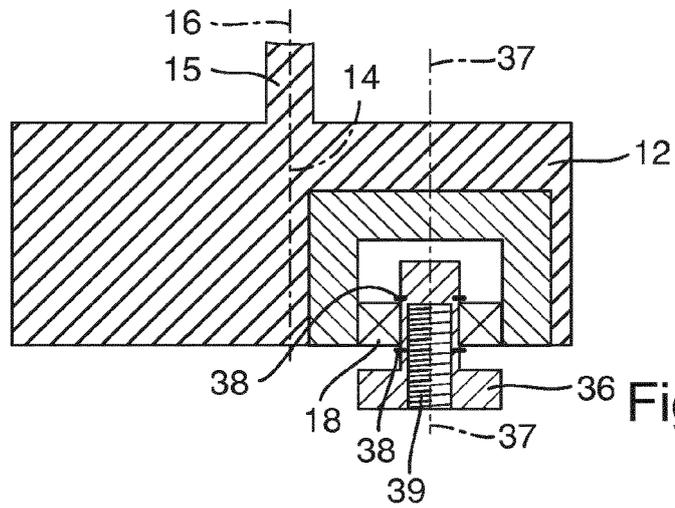


Fig. 1b

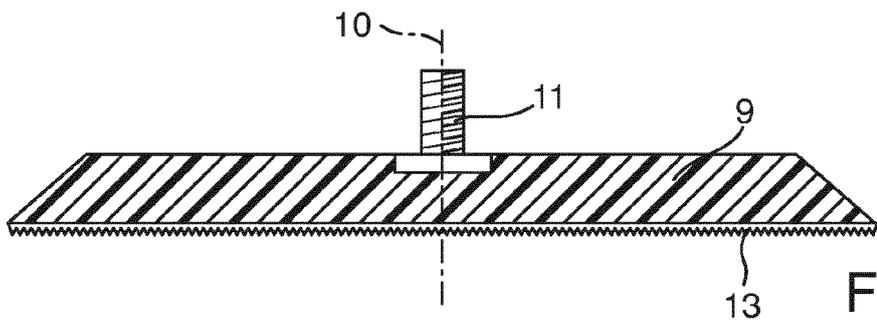


Fig. 3a

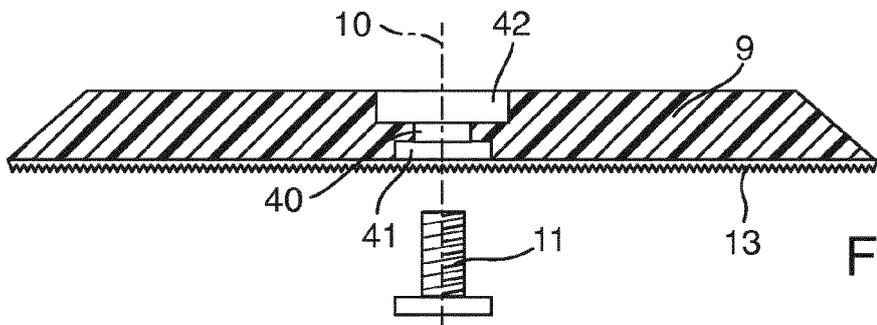
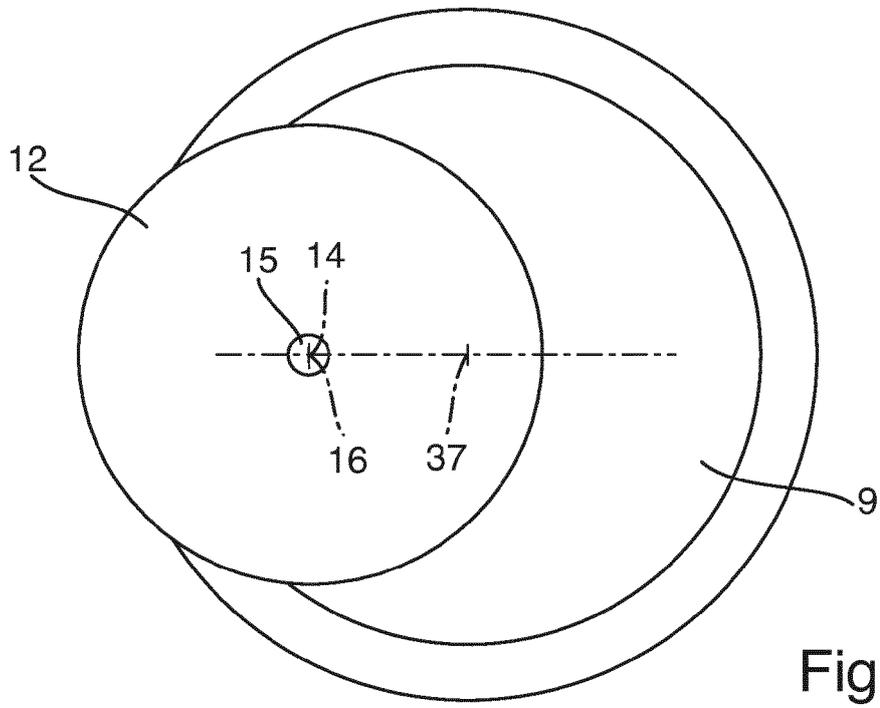
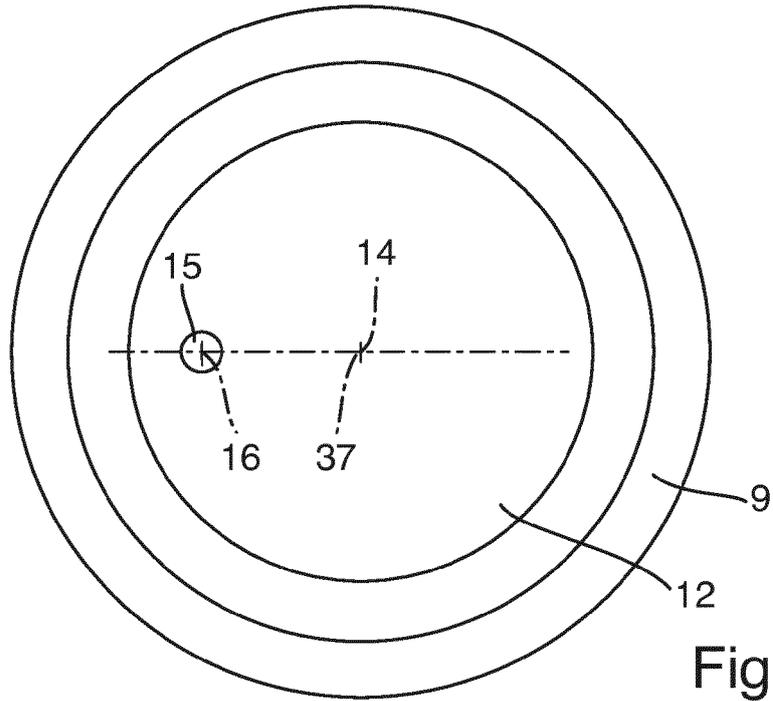
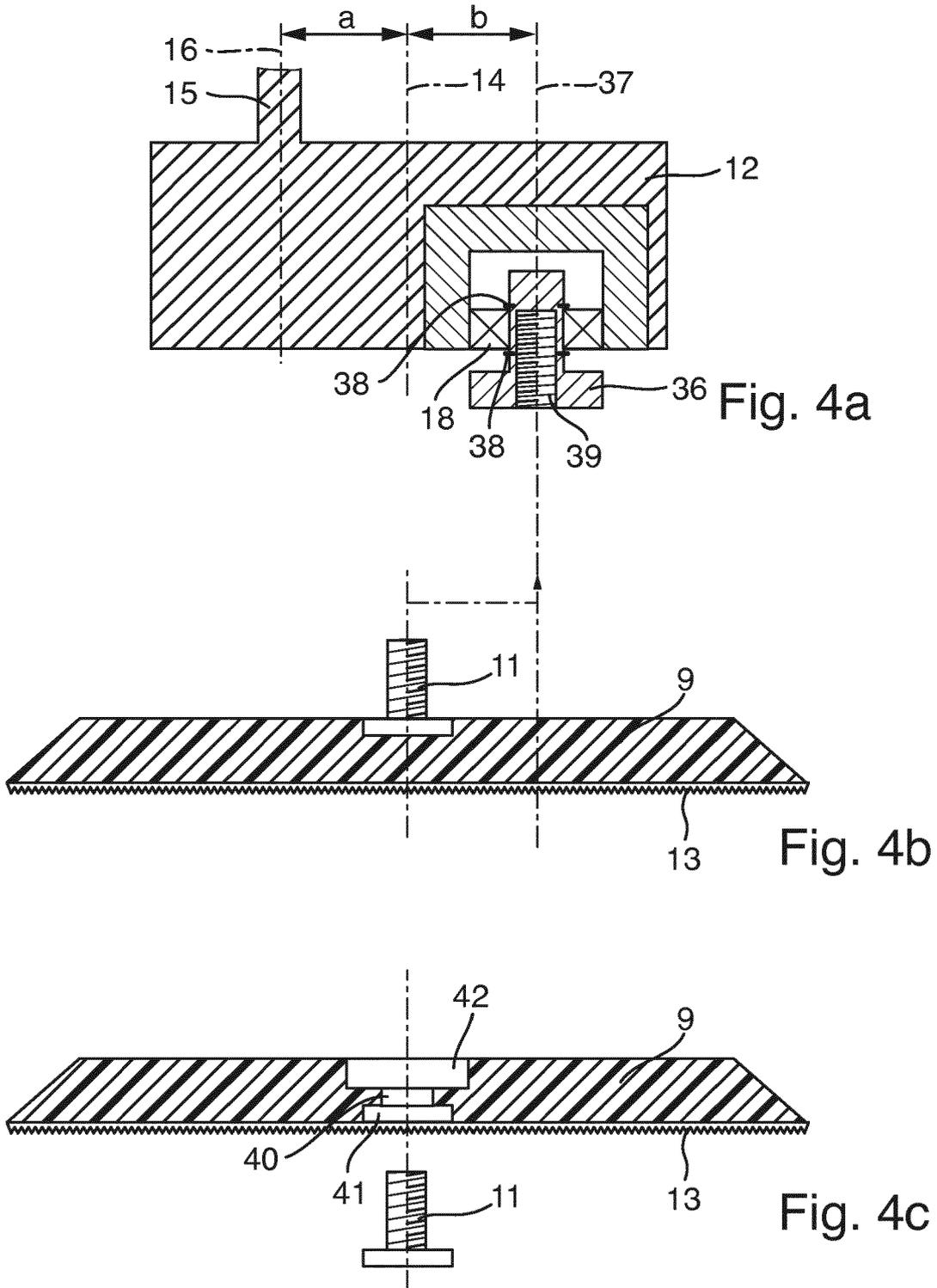


Fig. 3b





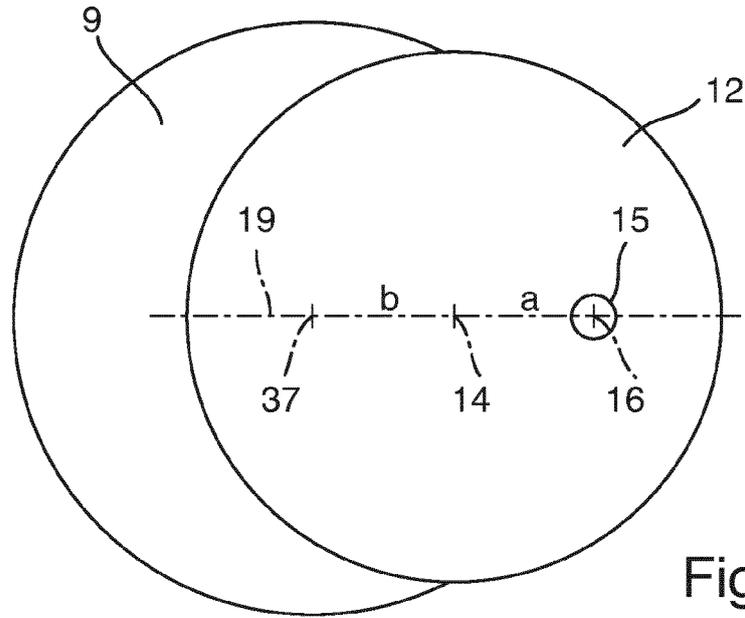


Fig. 5

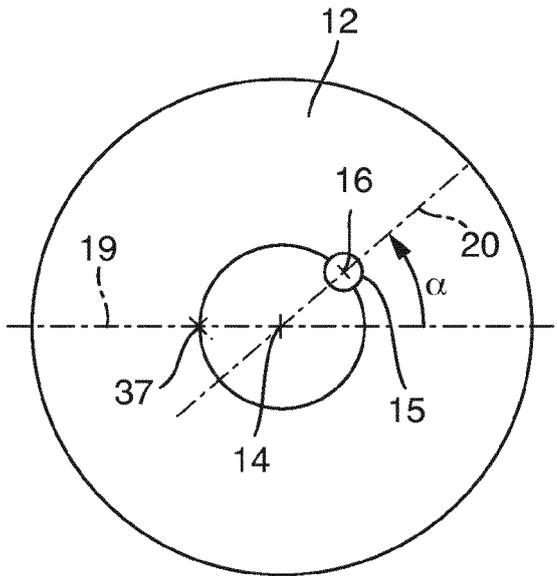


Fig. 6

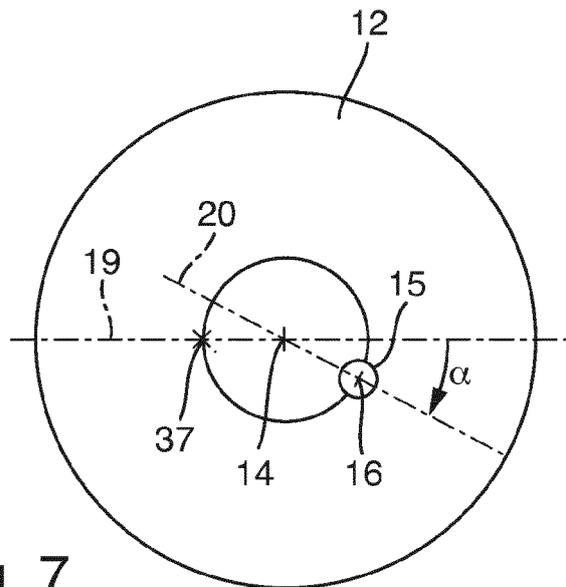
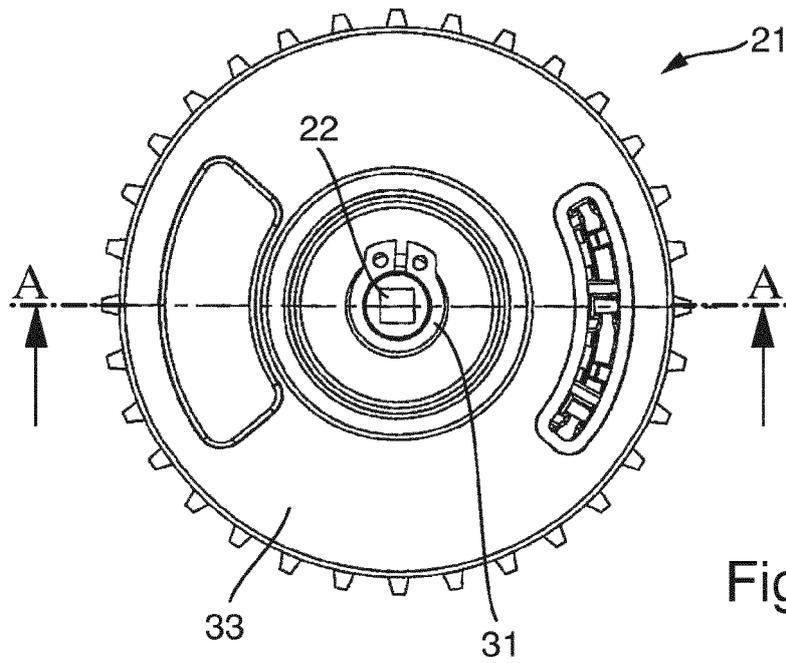
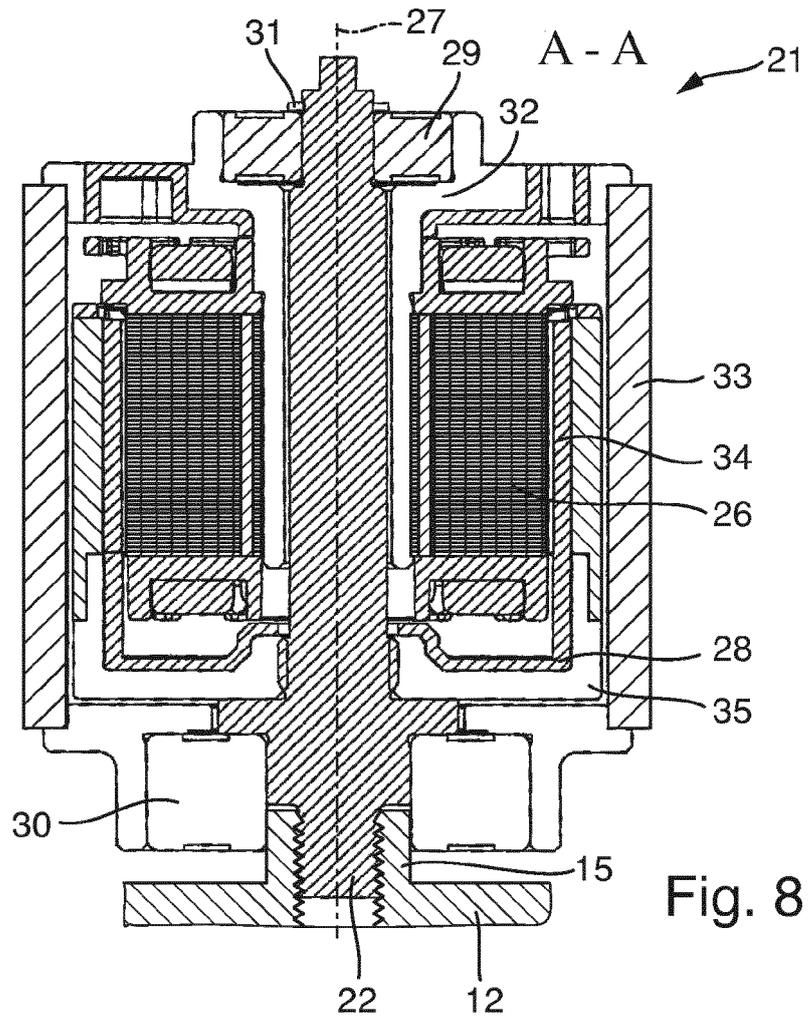


Fig. 7



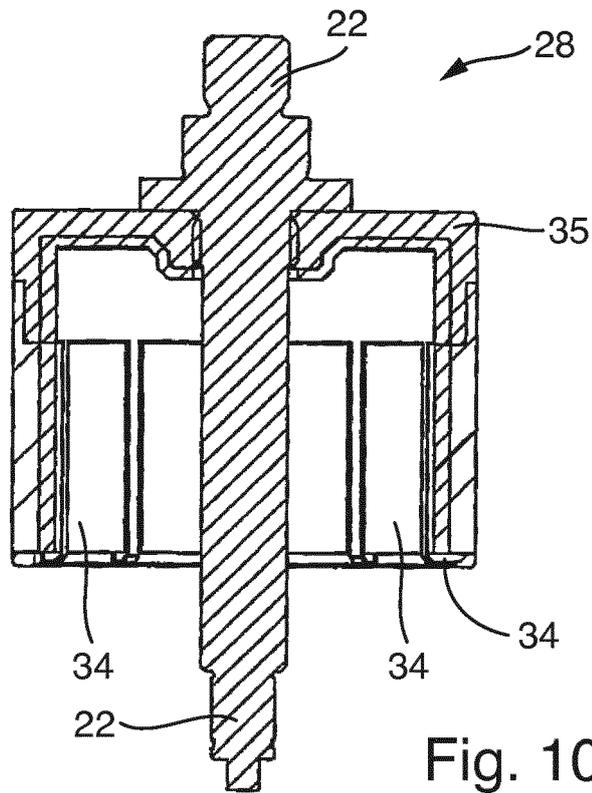


Fig. 10

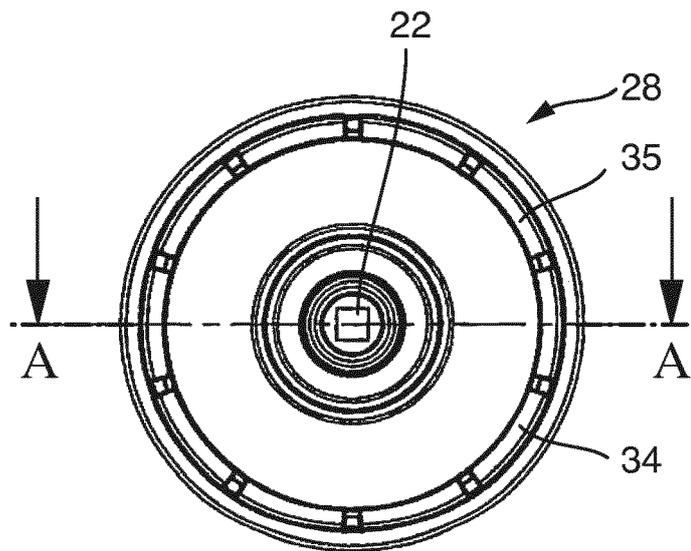


Fig. 11

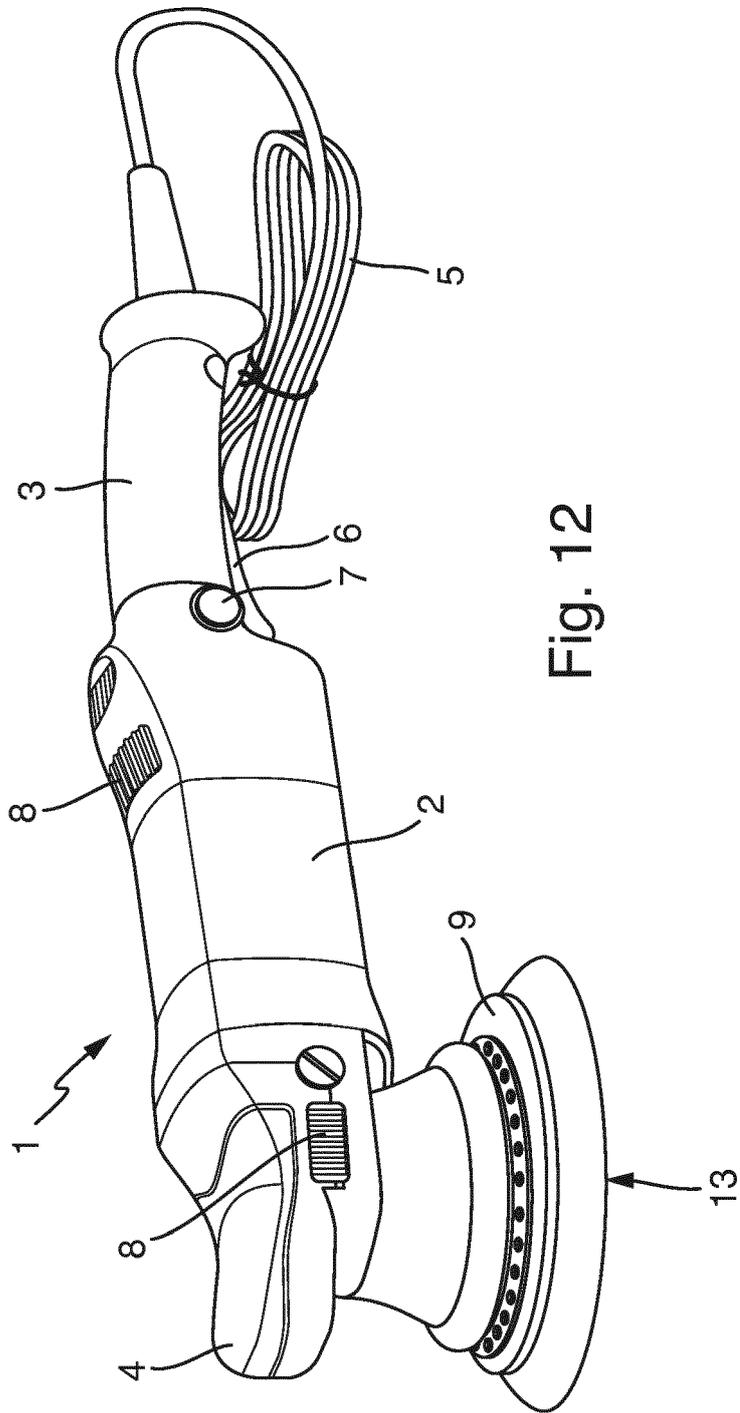


Fig. 12

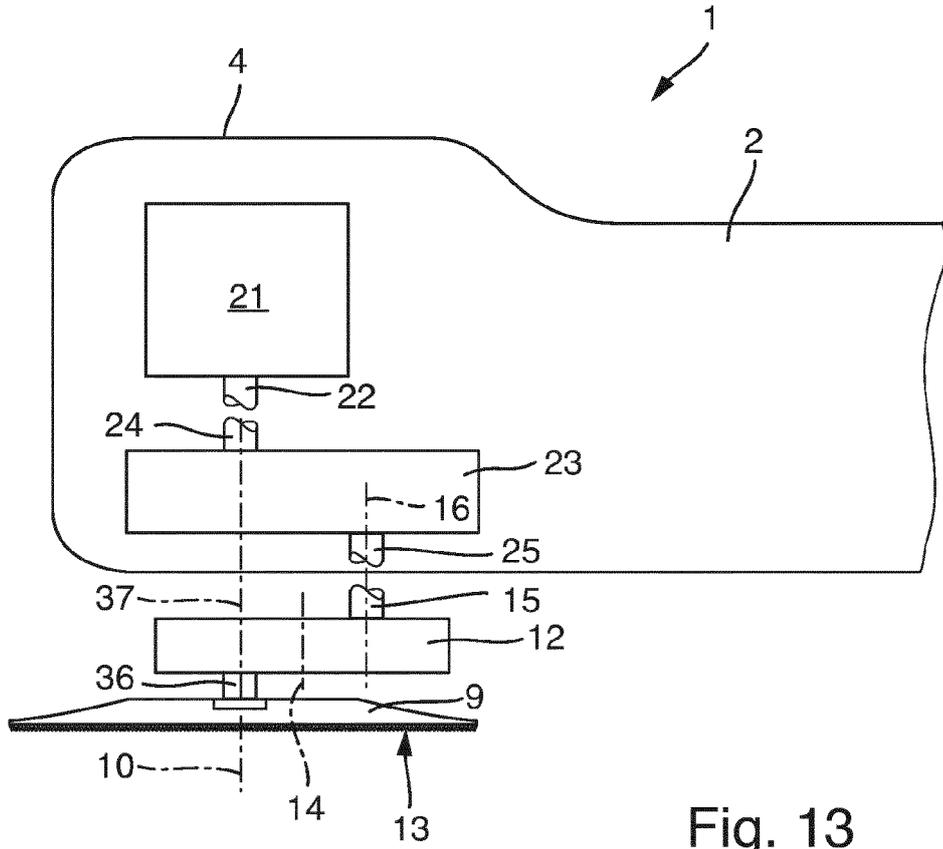


Fig. 13

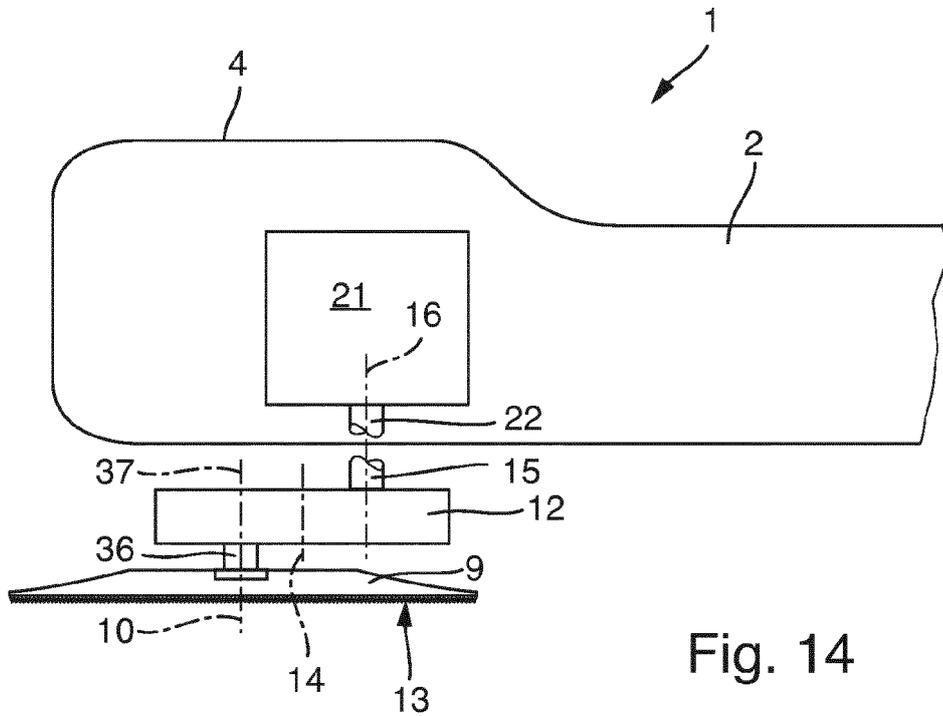


Fig. 14



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Application Number  
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