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(54) ECCENTRIC ELEMENT FOR USE IN A HAND-HELD POWER TOOL

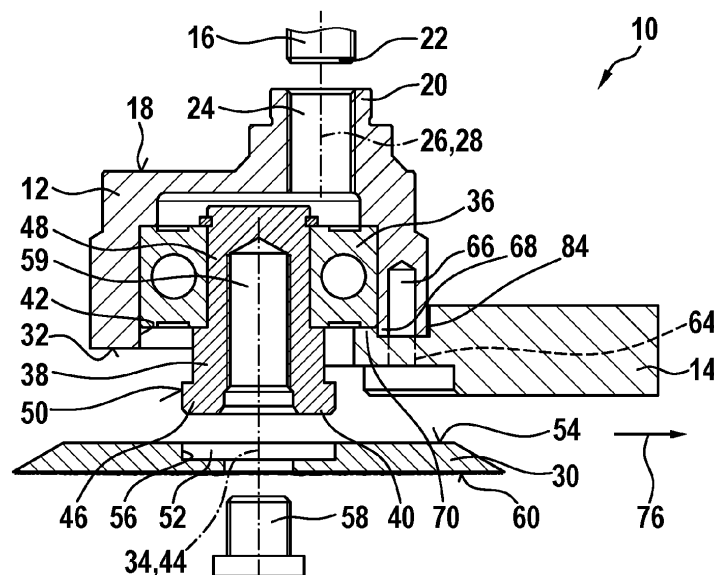
(57) The invention refers to an eccentric element (10) configured for use in a hand-held power tool comprising a tool motor for driving a tool shaft (16), in particular for use in an orbital sanding or polishing machine. The eccentric element (10) comprises:

- an eccentric part (12) with a top surface (18) attachable to a distal end (22) of the tool shaft (16) or forming an integral part therewith so as to transmit a torque from the tool shaft (16) to the eccentric element (10) and to rotate the eccentric part (12) about a first rotational axis (28) upon activation of the tool motor, a bottom surface (32) to which a working element (30) of

the power tool is releasably attachable in a manner freely rotatable about a second rotational axis (34), and

- a counterweight part (14) attached to the eccentric part (12).

The eccentric part (12) and the counterweight part (14) are separate components and formed such that they enter into a mutual interlocking relationship upon attachment of the counterweight part (14) to the eccentric part (12), the interlocking relationship acting in at least one direction (76; 82; 86).

Fig. 3

Description

[0001] The present invention refers to an eccentric element configured for use in a hand-held power tool comprising a tool motor for driving a tool shaft. The eccentric element is in particular configured for use in an orbital sanding or polishing machine. The eccentric element comprises:

- an eccentric part with
 - a top surface releasably attachable or fixedly attached to a distal end of the tool shaft or forming an integral part of the tool shaft so as to transmit a torque from the tool shaft to the eccentric element and to rotate the eccentric part about a first rotational axis of the eccentric part upon activation of the tool motor,
 - a bottom surface to which a working element of the power tool, in particular a backing plate, a sanding plate or a polishing plate, is releasably attachable in a manner freely rotatable about a second rotational axis of the eccentric part, and
- a counterweight part attached to the eccentric part.

[0002] The counterweight part of the eccentric element can be separate from the eccentric part and attached thereto by at least one fastening element, in particular in the form of one or more screws. Alternatively, it is also possible that the counterweight part forms an integral part with the eccentric part, both parts being made of the same material and manufactured as a single integral part during a common production step.

[0003] The first and second rotational axes of the eccentric part extend parallel to and spaced apart from each other. With the top surface of the eccentric part being attached to the tool shaft of the power tool in a torque proof manner and with the working element being attached to the bottom surface of the eccentric part in a manner freely rotatable about the second rotational axis of the eccentric part, the working element may perform a random-orbital working movement about the first rotational axis upon activation of the tool motor. The eccentric element performs a rotational movement about the first rotational axis at the same speed as the tool shaft to which it is attached in a torque proof manner. The working element is freely rotatable in respect to the eccentric element about the second rotational axis. A superposition of the two movements leads to the random-orbital working movement of the working element. If free rotation of the working element in respect to the power tool is restricted or even completely prevented, the working element may perform an orbital (vibrating or oscillating) working movement.

[0004] The power tool has a tool housing and the motor, which can be electrically or pneumatically actuated, is located inside the tool housing. Upon activation,

the motor drives the tool shaft directly or indirectly, for instance by means of a gear transmission. A distal end of the tool shaft may protrude from the tool housing in order to enable attachment of the eccentric element to the distal end of the tool shaft. Instead of being directly attached to the tool shaft, the eccentric element could also be attached to a component fixedly attached to the tool shaft or forming an integral part therewith. Alternatively, the eccentric part could also form an integral part with the tool shaft or the component.

[0005] The bottom surface of the eccentric part may be provided with at least one bearing configured to receive a rotational pin in a manner freely rotatable about the second rotational axis of the eccentric part. A distal end of the pin is configured to be releasably attached to the working element. In particular, the at least one bearing is provided in a cavity provided at the bottom surface of the eccentric element. In order to prevent the at least one bearing from falling out of the cavity during intended use of the power tool, one or more Seeger rings are provided for holding the at least one bearing in the axial direction extending parallel to the second rotational axis. This results in a large number of parts which the eccentric element is made up of.

[0006] Further, during intended use of the power tool, the eccentric element rotates at rather high speeds about the first rotational axis. The centrifugal force acting on the counterweight part of the eccentric element is rather large due to its large distance to the first rotational axis and due to its high weight, which should be so large as to compensate for the weight of the working element and reduce vibrations to a minimum during intended use of the power tool. In the case where the eccentric part and the counterweight part are two separate components attached to each other, there are large centrifugal forces acting on the counterweight part and possibly also rather high shear forces acting on any fastening element, provided in the eccentric element for attaching the counterweight part to the eccentric part.

[0007] Apart from the centrifugal forces acting in a radial direction, there may also be other forces, e.g., forces acting in a circumferential direction during (positive and negative) acceleration of the eccentric element. In order to avoid safety issues during use of the power tool, the at least one fastening element must be designed very strongly, resulting in a large, bulky and heavy fastening element and the entire eccentric element.

[0008] It is an object of the present invention to overcome the above-mentioned drawbacks of the known eccentric elements. This object is solved by an eccentric element comprising the features of claim 1. In particular, starting from the eccentric element of the above-identified kind, it is suggested that the eccentric part and the counterweight part are separate components and are formed such that they enter into a mutual interlocking relationship upon attachment of the counterweight part to the eccentric part, the interlocking relationship acting in at least one direction.

[0009] The idea of the present invention is to effect a force relief within the two parts of the eccentric element at least in one direction during intended use of the power tool merely by means of an interlocking form of the two parts, so that one or more fastening elements can be designed with smaller dimensions or can be dispensed with completely. This results in an eccentric element made up of less parts and of smaller and lighter design.

[0010] Preferably, when bringing the two parts of the eccentric element into the interlocking relationship, the two parts are also attached to each other by means of a press-fit connection. This requires that the eccentric part and the counterweight part, at least in regions thereof which effect the interlocking relationship and the press-fit connection, are manufactured with a particularly high accuracy, but on the other hand has the advantage that separate fastening means, e.g., screws or the like, can be dispensed with completely.

[0011] Two-part eccentric elements have the advantage that the scrap during their manufacture, e.g., by milling, can be reduced. When manufacturing a single large eccentric element, where the eccentric part and the counterweight part are manufactured in one common component, there is more scrap than when two smaller parts are manufactured and then attached to each other. The present invention solves a long-standing problem of fastening the two components together in a particularly efficient as well as safe and secure manner.

[0012] When, for the purposes of the present invention, it is said that the eccentric part and the counterweight part are in a mutual interlocking relationship with each other, it is meant that they engage behind each other in such a way that they are firmly in contact with each other in at least one direction. For this purpose, both parts have corresponding undercut portions which are brought into engagement with each other as part of the attachment of the counterweight part to the eccentric part. The undercut sections each have at least one abutment wall. The corresponding abutment walls of the undercut portions of the two parts are brought into abutment with each other in an abutment direction as part of the attachment of the parts to each other, and abut each other at least regionally, preferably along their entire surface extensions, when the parts have been brought into engagement with each other. The abutment walls prevent further relative movement of the parts in the abutment direction.

[0013] Preferably, the abutment walls have a corresponding form and extension so as to abut each other along their entire surface extensions. The surface extensions can be flat or curved, the curvature can be two-dimensional around a single axis (e.g., corresponding to a cylindrical surface) or three-dimensional around two axes (e.g., corresponding to a spherical surface). However, the surface extension can also be any free-form surface. The abutment walls may have positioning means (e.g., at least one protrusion on one wall and at least one corresponding recess on the other wall) which can enter into engagement with each other when the two

parts are attached to each other in order to position the two parts relative to each other. The positioning can take place in a two- or three-dimensional space.

[0014] If the undercut portions of the two parts each have a plurality of abutment walls at a certain angle (not equal to 0° and 180°), preferably at a right angle (90°), corresponding abutment walls of the two parts are in turn brought into abutment with each other in a plurality of abutment directions at the respective angle (e.g., 90°). The abutment walls prevent further movement of the parts relative to each other in the plurality of abutment directions. Of course, with two abutment walls extending at an angle in respect to each other, further relative movement of the parts in respect to each other is also prevented in a plurality of other directions that lie within the angle between the two abutment directions.

[0015] If, for example, the undercut portions of the two parts each have two corresponding abutment walls at an angle of 90° to each other, further relative movement of the two parts in respect to each other in two abutment directions perpendicular to each other is prevented, for example in a first direction extending radially outwards in respect to the second rotational axis and in a second circumferential direction extending clockwise (or counter-clockwise) about the second rotational axis.

[0016] According to one embodiment of the invention, the mutual interlocking relationship between the eccentric part and the counterweight part may act in a radial direction in respect to the first rotational axis of the eccentric part, at least during activation of the tool motor and rotation of the eccentric element about the first rotational axis. In this embodiment, the mutual interlocking relationship between the eccentric part and the counterweight part serves for effecting a relief for centrifugal forces acting during rotation of the eccentric element about the first rotational axis. Preferably, the mutual interlocking relationship acts and provides for a force relief only in a direction directed radially outwards. Thus, when the counterweight part is applied with a force directed radially outwards in respect to the eccentric part due to the centrifugal force, the mutual interlocking relationship between the two parts prevents the counterweight part from moving radially outwards in respect to the eccentric part. However, the mutual interlocking relationship may be designed such that when the counterweight part is moved in the opposite direction radially inwards (or in any other direction apart from radially outwards), the mutual interlocking relationship may be released and the counterweight part may be detached from the eccentric part.

[0017] According to another embodiment of the present invention, the mutual interlocking relationship between the eccentric part and the counterweight part may act in a circumferential direction in respect to the first rotational axis of the eccentric part. In this embodiment, the mutual interlocking relationship between the eccentric part and the counterweight part serves for effecting a relief for forces acting during acceleration and/or

braking of the eccentric element. However, the mutual interlocking relationship may be designed such that when the counterweight part is moved in respect to the eccentric part in another direction apart from a centrifugal direction, the mutual interlocking relationship may be released and the counterweight part may be detached from the eccentric part.

[0018] According to yet another embodiment of the present invention, the mutual interlocking relationship between the eccentric part and the counterweight part may act in an axial direction extending parallel to the first rotational axis of the eccentric part. In this embodiment, the mutual interlocking relationship between the eccentric part and the counterweight part serves for effecting a relief for axial forces acting during a slow rotation or standstill of the eccentric element, due to the gravitational forces. However, the mutual interlocking relationship may be designed such that when the counterweight part is moved in respect to the eccentric part in another direction apart from an axial direction, the mutual interlocking relationship may be released and the counterweight part may be detached from the eccentric part.

[0019] Besides, the mutual interlocking relationship between the eccentric part and the counterweight part may be designed such that it not only serves as a relief for one or more forces acting in at least one direction, but that it also can receive and absorb a torque about at least one axis. For instance, during acceleration and braking of the eccentric element, a torque about the first rotational axis can act between the eccentric part and the counterweight part. the mutual interlocking relationship between the eccentric part and the counterweight part may be designed such that it receives and absorbs a torque during acceleration or braking or during both acceleration and braking of the eccentric element.

[0020] It is suggested that the first rotational axis of the eccentric part corresponds to a rotational axis of the tool shaft once the eccentric part is attached to the tool shaft. Additionally or alternatively, the second rotational axis of the eccentric part may correspond to a rotational axis of the working element, once it is attached to the eccentric part. Preferably, the first and second rotational axes of the eccentric part extend parallel to and spaced apart from each other.

[0021] According to a preferred embodiment of the invention, it is suggested that the eccentric element comprises at least one fastening element, in particular a screw, configured for holding the counterweight part in respect to the eccentric part in their mutual interlocking relationship before, during and after activation of the tool motor. Preferably, the fastening element acts and holds the counterweight part in respect to the eccentric part in the axial direction extending essentially parallel in respect to the first rotational axis.

[0022] According to another preferred embodiment of the present invention, it is suggested that the eccentric element comprises at least one bearing associated to the bottom surface of the eccentric part and configured to

receive a rotational pin in a manner freely rotatable about the second rotational axis of the eccentric part, wherein a distal end of the pin is configured to be releasably attached to the working element. Preferably, the at least one bearing is located in a recess provided in the bottom surface of the eccentric part and having a cylindrical form. A rotational axis of the bearing corresponds to the second rotational axis of the eccentric part. The rotational pin may be axially held in the at least one bearing by means of a press-fit connection or in any other manner (e.g., gluing, welding, clamping, a detent connection, etc.). The working element may be attached to the distal end of the rotational pin by means of a threaded connection or in any other manner.

[0023] For instance, the working element, for instance in the form of a backing plate, a sanding plate or a polishing plate, may have a threaded rod, which may be screwed into a respective threaded hole provided at the distal end of the rotational pin. Alternatively, the working element, for instance in the form of a backing plate, a sanding plate or a polishing plate, may have a threaded hole adapted to receive a respective threaded rod formed at the distal end of the rotational pin and which may be screwed into the threaded hole.

[0024] According to another embodiment, it is suggested that the distal end of the rotational pin comprises a head portion having a larger diameter than that part of the rotational pin, which is received in the at least one bearing, and having a non-rotational symmetric outer circumferential surface. The head portion is configured to be received by a respective cavity or recess provided in the working element and having an inner circumferential surface corresponding to the outer circumferential surface of the head portion. The working element is preferably secured to the rotational pin in an axial direction by means of a fastening element, in particular a screw, after insertion of the head portion into the respective cavity or recess. By inserting the head portion into the cavity or recess in an axial direction, a torque proof connection in a plane extending perpendicular to the second rotational axis is provided. Insertion and removal of the head portion into/ out of the cavity or recess is effected in the axial direction. After insertion and before removal, the fastening element secures the working element in respect to the distal end of the rotational pin in the axial direction.

[0025] According to yet another preferred embodiment, it is suggested that a part of the counterweight part facing the second rotational axis of the eccentric part after attachment of the counterweight part to the eccentric part, holds the at least one bearing in an axial direction in respect to the eccentric part. Preferably, the part of the counterweight part facing the second rotational axis holds the at least one bearing in a cavity or recess provided in the bottom surface of the eccentric part. Thus, attachment of the counterweight part to the eccentric part not only provides for the mutual interlocking relationship between the two parts but also secures

the at least one bearing in/ at the eccentric part. No additional components, e.g., Seeger rings or the like, are necessary for securing the at least one bearing in the axial direction in respect to the eccentric part. The overall number of parts the eccentric element is made up of can be further reduced having advantages in terms of manufacturing of the eccentric element as well as in terms of a compact and light design.

[0026] It is further suggested that the top surface of the eccentric part comprises a threaded hole, a longitudinal axis of the hole corresponding to the first rotational axis of the eccentric part, and the hole being configured to receive for releasable threaded attachment a threaded distal end of the tool shaft or of a component fixedly attached to the tool shaft or forming an integral part therewith.

[0027] Preferably, the second rotational axis extends through a centre of gravity of the eccentric part. This may also be the centre of gravity of the entire eccentric element with the counterweight part and the working element attached to the eccentric part. The first rotational axis extends eccentrically in respect to the centre of gravity. However, in an alternative embodiment, it would also be possible that the first rotational axis extends through a centre of gravity of the eccentric part and the eccentric element, respectively, and that the second rotational axis extends eccentrically in respect to the centre of gravity.

[0028] According to a preferred embodiment of the present invention, it is suggested that in a top view parallel to the first and/or second rotational axes of the eccentric part, the eccentric part has a circular form with the second rotational axis forming a centre of the circular form or a centre axis of the eccentric part.

[0029] According to another preferred embodiment, in a bottom view parallel to the first and/or second rotational axes of the eccentric part, the counterweight part has a circular form or the form of a circular sector, wherein a centre of the circular form or of the circular sector or a centre axis of the counterweight part, respectively, is spaced apart from the second rotational axis. Preferably, the centre of the circular form or of the circular sector or a centre axis of the counterweight part, respectively, is also spaced apart from the first rotational axis.

[0030] Preferably, the counterweight part or its centre of gravity, respectively, is located on a side of the first rotational axis opposite to the second rotational axis. With other words, in respect to the first rotational axis, the counterweight part is located opposite to the working element, which is attached to the eccentric part at the second rotational axis. In this way, the eccentricity caused by the working element can be optimally compensated by the counterweight part.

[0031] It is suggested that the first rotational axis extends through an imaginary straight line interconnecting the centre of the circular form or of the circular sector of the counterweight part and the second rotational axis. Thus, the counterweight part or its centre of gravity,

respectively, is located on a side of the first rotational axis diametrically opposite to the second rotational axis.

[0032] Preferably, the eccentric part is made of metal, in particular steel or aluminium, or of a plastic material having metal inserts. In particular, the metal inserts may be provided near or around the first rotational axis, where the eccentric part is attached to the distal end of the tool shaft or to a component attached to the tool shaft or forming an integral part therewith, and/or near or around the second rotational axis, where the working element is attached to the eccentric part in a manner freely rotatable about the second rotational axis. The metal insert near or around the first rotational axis may be designed as a hollow cylinder or a cylindrical liner with an internal thread, into which a threaded distal end of the tool shaft or of the component is screwed. The metal insert near or around the second rotational axis may be designed as a hollow cylinder or a cylindrical liner into which at least one bearing for the rotational pin may be inserted. The one or more metal inserts may be inserted into the plastic material after its manufacture, e.g., by pressing the inserts into respective recesses in the plastic material. Alternatively, the one or more metal inserts may be provided in the plastic material during its manufacture, e.g., by means of a co-moulding process, where the heated plastic material is injected around the inserts.

[0033] The counterweight part could also be made of plastic material. In order to achieve a desired weight to be able to fulfil the vibration reducing functionality, metal inserts, preferably consisting of a solid metal material, may be provided in the plastic material.

[0034] According to another preferred embodiment, the counterweight part is made of metal, in particular steel.

[0035] Further features and advantages of the present invention will become apparent from the following description of preferred embodiments and the accompanying figures. It is emphasized that each one of the features shown in the figures may be important for the present invention on his own, even if not explicitly mentioned in the description and/or shown in the figures. Further, different features shown in the same or different figures may be important for the invention in any combination with each other, even if that combination is not explicitly mentioned in the description and/or shown in the figures. The figures show:

Fig. 1 an eccentric element according to a first embodiment of the present invention in a perspective view from above;

Fig. 2 the eccentric element of Fig. 1 in a perspective view from below;

Fig. 3 the eccentric element of Figs. 1 and 2 in a sectional view along a vertical cutting plane;

Fig. 4 the eccentric element of Figs. 1 to 3 in a view

- from below;
- Fig. 5 the eccentric element of Figs. 1 to 4 in a view from above;
- Fig. 6 an eccentric element according to a second embodiment of the present invention in a view from below;
- Fig. 7 an eccentric element according to a third embodiment of the present invention in a sectional view along a vertical cutting plane;
- Fig. 8 an enlarged view of one embodiment of a mutual interlocking relationship between an eccentric part and a counterweight part of the eccentric element according to the present invention; and
- Fig. 9 an eccentric element known from the prior art in a view from below.

[0036] All Figs. show eccentric elements 10, which are made up of two separate components which are attached to each other. The two components comprise an eccentric part 12 and a counterweight part 14. The eccentric part 12 provides for an attachment to a tool shaft 16 (see Fig. 3) of a power tool (not shown) on a top surface 18 of the eccentric part 12. The attachment is preferably releasable. In the shown embodiments of Figs. 1 to 8, the top surface 18 is provided with an attachment element 20, to which a distal end 22 of the tool shaft 16 is attached. In the shown embodiments the attachment element 20 has the form of a threaded hole 24. A longitudinal axis 26 of the threaded hole 24 is congruent with a first rotational axis 28 of the eccentric part 12. A threaded distal end 22 of the tool shaft 16 may be screwed into the threaded hole 24. When the tool shaft 16 is rotated about the first rotational axis 28, e.g., by an electric or pneumatic motor (not shown) of the power tool, a torque is transmitted to the eccentric part 12 and the entire eccentric element 10, respectively.

[0037] Furthermore, the eccentric part 12 provides for an attachment of a working element 30 (see Fig. 3), for instance in the form of a backing plate, a sanding plate or a polishing plate, to a bottom surface 32 of the eccentric part 12 in a manner freely rotatable about a second rotational axis 34. The working element 30 is shown in a schematical view in Fig. 3 in the form of a backing plate. Attachment and rotation of the working element 30 about the second rotational axis 34 may be achieved in many possible ways. Figs. 1 to 8 show a preferred embodiment for attachment and rotation of the working element 30 which, however, can be replaced by other ways of attaching a working element 30 to an eccentric part 12 in a freely rotatable manner.

[0038] In the preferred embodiments of Figs. 1 to 8, the eccentric element 10 comprises at least one bearing 36

associated to the bottom surface 32 of the eccentric part 12 and configured to receive a rotational pin 38 in a manner freely rotatable about the second rotational axis 34 of the eccentric part 12. A distal end 40 of the pin 38 is configured to be releasably attached to the working element 30. Preferably, the at least one bearing 36 is located in a recess 42 provided in the bottom surface 32 of the eccentric part 12 and, in a view from above or below, having a cylindrical form. A rotational axis 44 of the bearing 36 corresponds to the second rotational axis 34 of the eccentric part 12. The rotational pin 38 may be axially held in the at least one bearing 36 by means of a press-fit connection or in any other manner (e.g., gluing, welding, clamping, a detent connection, etc.). The working element 30 may be attached to the distal end 40 of the rotational pin 38 by means of a threaded connection or in any other manner.

[0039] For instance, in an embodiment not shown in the Figs., the working element 30, e.g., in the form of a backing plate, a sanding plate or a polishing plate, may have a threaded rod, which may be screwed into a respective threaded hole provided at the distal end 40 of the rotational pin 38. Alternatively, in another embodiment not shown in the Figs., the working element 30, e.g., in the form of a backing plate, a sanding plate or a polishing plate, may have a threaded hole adapted to receive a respective threaded rod formed at the distal end 40 of the rotational pin 38 and which may be screwed into the threaded hole.

[0040] According to the embodiments shown in the Figs. 1 to 8, it is suggested that the distal end 40 of the rotational pin 38 comprises a head portion 46 having a larger diameter than that part 48 of the rotational pin 38, which is received in the at least one bearing 36 (see Figs. 3 and 7), and having a non-rotational symmetric outer circumferential surface 50 (see Figs. 2, 4 and 6). The head portion 46 is configured to be received by a respective cavity or recess 52 provided in a top surface 54 of the working element 30 and having an inner circumferential surface 56 corresponding to the outer circumferential surface 50 of the head portion 46. The working element 30 is preferably secured to the rotational pin 38 in an axial direction by means of a fastening element 58, in particular a screw, after insertion of the head portion 38 into the respective cavity or recess 52. The screw 58 may be screwed into a respective threaded hole 59 provided at a distal end 40 of the rotational pin 38. By inserting the head portion 38 into the cavity or recess 52 in an axial direction, a torque proof connection in a plane extending perpendicular to the second rotational axis 34 is provided. Insertion and removal of the head portion 38 into/ out of the cavity or recess 52 is effected in the axial direction. After insertion and before removal, the fastening element 58 secures the working element 30 in respect to the distal end 40 of the rotational pin 38 in the axial direction.

[0041] The backing plate 30 of Fig. 3, shown as an example for a working element, comprises an attachment surface 60 on its bottom surface. A polishing or sanding

member (not shown) can be releasably attached to the attachment surface 60. To this end, the polishing or sanding member may comprise a corresponding attachment surface on its top surface. The attachment surface 60 and the corresponding attachment surface on the top surface of the polishing or sanding member may each comprise a hook-and-loop connection surface comprising hooks and/or loops. The polishing member may comprise a polishing pad made of or comprising foam, wool, micro-fibre or the like. The sanding member may comprise a sanding plate, e.g., a sanding paper or a sanding fabric.

[0042] The counterweight part 14 and the eccentric part 12 are two separate components, which are attached to each other during manufacturing of the eccentric element 10. In particular, it is suggested that the two parts 12, 14 are attached to each other by means of separate fastening elements, in particular in the form of screws 62. Of course, other ways of attachment of the two parts 12, 14 are conceivable, too. The screws 62 can be guided through corresponding openings 64 (see Figs. 3 and 7) in the counterweight part 14 and screwed into corresponding internally threaded holes 66 in the eccentric part 12.

[0043] In order to reduce the overall number of separate parts of the eccentric element 10 and in order to provide for a more compact and light weight eccentric element 10, the present invention (see Figs. 1 to 8) suggests that the eccentric part 12 and the counterweight part 14 are separate components and formed such that they enter into a mutual interlocking relationship upon attachment of the counterweight part 14 to the eccentric part 12, the interlocking relationship acting in at least one direction.

[0044] The idea of the present invention is to effect a force relief at least in one direction during intended use of the power tool or the eccentric element 10, respectively, so that one or more fastening elements 62 can be designed with smaller dimensions or they can be dispensed with completely (see Fig. 6). This results in an eccentric element 10 made up of less parts and of smaller and lighter design.

[0045] When, for the purposes of the present invention, it is said that the eccentric part 12 and the counterweight part 14 are in a mutual interlocking relationship with each other, it is meant that they engage behind each other in such a way that they are firmly in contact with each other in at least one direction. For this purpose, both parts have corresponding undercut portions 68, 70 (see Fig. 8) which are brought into engagement with each other as part of the attachment of the counterweight part 14 to the eccentric part 12. The undercut sections 68, 70 each have at least one abutment wall 72, 74 (see Fig. 8). The corresponding abutment walls 72, 74 of the undercut portions 68, 70 of the two parts 12, 14 are brought into abutment with each other in an abutment direction (i.e., the counterweight part 14 is moved in an abutment direction 76 in respect to the eccentric part 12; or the

eccentric part 12 is moved in the opposite abutment direction in respect to the counterweight part 14) as part of the attachment of the parts 12, 14 to each other. The abutment walls 72, 74 abut each other at least regionally, preferably along their entire surface extensions, when the parts 12, 14 have been brought into engagement with each other. The abutment walls 72, 74 prevent further relative movement of the parts 12, 14 in the abutment direction 76.

[0046] Preferably, the abutment walls 72, 74 have a corresponding form and extension so as to abut each other along their entire surface extensions. The surface extensions can be flat or curved, the curvature can be two-dimensional around one or more parallel axes (e.g., corresponding to a cylindrical or an elliptical surface) or three-dimensional around two intersecting axes (e.g., corresponding to a spherical or an ellipsoid surface). However, the surface extension can also be any free-form surface. The abutment walls 72, 74 may have positioning means (e.g., at least one protrusion on one wall 72; 74 and at least one corresponding recess on the other wall 74; 72) which can enter into mutual engagement with each other when the two parts 12, 14 are attached to each other in order to position and possibly also hold (e.g., by means of a press-fit connection) the two parts 12, 14 relative to each other. The positioning can be effected in a two- or three-dimensional space.

[0047] If the undercut portions 68, 70 of the two parts 12, 14 each have a plurality of corresponding abutment walls 72, 74 (acting in a radial direction 76 in respect to the second rotational axis 34); 78, 80 (acting in a circumferential direction 82 about the second rotational axis 34) at a certain angle (not equal to 0° and 180°), preferably at a right angle (see Fig. 6), corresponding abutment walls 72, 74; 78, 80 of the two parts 12, 14 are in turn brought into abutment with each other in a plurality of abutment directions 76, 82 at the respective angle (e.g., 90°). Of course, the abutment walls 78, 80 could also be designed to act in a circumferential direction 82 about the first rotational axis 28. The abutment walls 72, 74; 78, 80 prevent further movement of the parts 12, 14 relative to each other in the plurality of abutment directions 76, 82. With two or more abutment walls 72, 74; 78, 80 extending at an angle in respect to each other, further relative movement of the parts 12, 14 in respect to each other is also prevented in a plurality of other directions that lie within the angle between the two abutment directions 76, 82.

[0048] Preferably, the two parts 12, 14 are attached to each other in a press-fit connection holding the counterweight part 14 in respect to the eccentric part 12. Possibly provided one or more fastening elements 62, e.g., each comprising a screw, merely secure the counterweight part 14 in respect to the eccentric part 12 in an axial direction 86 extending essentially parallel in respect to the first rotational axis 28, in order to prevent unintentional loosening and separation of the two parts 12, 14 during intended use of the eccentric element 10.

[0049] It is contemplated that the eccentric element 10 comprises more than one counterweight part 14 attached to the eccentric part 12. Preferably, two separate counterweight parts 14 are attached to radially opposite lateral sides the eccentric part 12. Further, preferably, two separate counterweight parts 14 are attached to the eccentric part 12 at different heights in the axial direction. Even further, preferably, the two separate counterweight parts 14 have different weights in order to not only compensate forces but also a torque provoked by the working element 30 eccentrically attached to the eccentric part 12 in respect to the first rotational axis 28.

[0050] If, for example, the undercut portions 68, 70 of the two parts 12, 14 each have two corresponding abutment walls 72, 78; 74, 80 at an angle of 90° to each other, further relative movement of the two parts 12, 14 in respect to each other in two abutment directions 76, 82 perpendicular to each other is prevented, for example in a first direction 76 extending radially outwards in respect to the second rotational axis 34 and in a second circumferential direction 82 extending clockwise (or counter-clockwise) about the second rotational axis 34 (see Fig. 6).

[0051] According to one embodiment of the invention shown in Figs. 3 and 8, the mutual interlocking relationship between the eccentric part 12 and the counterweight part 14 acts in a radial direction 76 in respect to the first or second rotational axis 28, 34 of the eccentric part 12, at least during activation of the tool motor and rotation of the eccentric element 10 about the first rotational axis 28. In this embodiment, the mutual interlocking relationship between the eccentric part 12 and the counterweight part 14 serves for effecting a relief for centrifugal forces acting during rotation of the eccentric element 10 about the first rotational axis 28. Preferably, the mutual interlocking relationship acts and provides for a force relief only in a direction 76 directed radially outwards. To this end, a gap 84 is provided between an external circumferential surface of the eccentric part 12 and an opposite surface of the counterweight part 14 facing the external circumferential surface of the eccentric part 12. Thus, when the counterweight part 14 is applied with a force directed radially outwards in respect to the eccentric part 12 due to the centrifugal force, the mutual interlocking relationship between the two parts 12, 14 prevents the counterweight part 14 from moving radially outwards in respect to the eccentric part 12. The mutual interlocking relationship may be designed such that when the counterweight part 14 is moved slightly in the opposite direction radially inwards thereby reducing the width of the gap 84 (or in any other direction apart from radially outwards), the mutual interlocking relationship may be released and the counterweight part 14 may be detached from the eccentric part 12.

[0052] According to another embodiment of the present invention shown in Fig. 6, the mutual interlocking relationship between the eccentric part 12 and the counterweight part 14 acts in a circumferential direction 82 in respect to the first or second rotational axis 28, 34 of the

eccentric part 12. In this embodiment, the mutual interlocking relationship between the eccentric part 12 and the counterweight part 14 serves for effecting a relief for forces acting during acceleration and/or braking of the eccentric element 10. The mutual interlocking relationship may be designed such that when the counterweight part 14 is moved in respect to the eccentric part 12 in another direction apart from a centrifugal direction, in particular radially inwards towards the eccentric part 12, the mutual interlocking relationship may be released and the counterweight part 14 may be detached from the eccentric part 12. In the embodiment of Fig. 6, the mutual interlocking relationship acts in a circumferential direction 82 as well as in a radial direction 76.

[0053] According to yet another embodiment of the present invention shown in Fig. 7, the mutual interlocking relationship between the eccentric part 12 and the counterweight part 12 acts in an axial direction 86 extending parallel to the first and second rotational axes 28, 34 of the eccentric part 12. In this embodiment, the mutual interlocking relationship between the eccentric part 12 and the counterweight part 14 serves for effecting a relief for axial forces acting during a slow rotation or standstill of the eccentric element 12, due to the gravitational forces. The mutual interlocking relationship may be designed such that when the counterweight part 14 is moved in respect to the eccentric part 12 in another direction apart from an axial direction 86, the mutual interlocking relationship may be released and the counterweight part 14 may be detached from the eccentric part 12. In the embodiment of Fig. 7, the mutual interlocking relationship acts in an axial direction 86 as well as in a radial direction 76.

[0054] The mutual interlocking relationship between the eccentric part 12 and the counterweight part 14 may be designed such that it not only serves as a relief for one or more forces acting in at least one direction 76; 82; 86, but that it also can receive and absorb a torque about at least one axis.

[0055] The first rotational axis 28 of the eccentric part 12 may correspond to a rotational axis of the tool shaft 16 once the eccentric part 12 is attached to the tool shaft 16. The second rotational axis 34 of the eccentric part 12 may correspond to a rotational axis of the working element 30, once it is attached to the eccentric part 12. Preferably, the first and second rotational axes 28, 34 of the eccentric part 12 extend parallel to and spaced apart from each other in order to achieve a random-orbital working movement of the working element 30 during activation of the tool motor and intended use of the power tool.

[0056] As already mentioned, the eccentric element 12 may comprise at least one fastening element 62, in particular a screw, configured for holding the counterweight part 14 in respect to the eccentric part 12 in their mutual interlocking relationship before, during and after activation of the tool motor. Preferably, the fastening element 62 acts and holds the counterweight part 14 in respect to the eccentric part 12 in an axial direction 86

extending essentially parallel in respect to the first rotational axis 28.

[0057] In the eccentric element 10 of the prior art shown in Fig. 9, a Seeger ring 88 is visible for securing the bearing 36 in the recess 42 provided in the bottom surface 32 of the eccentric part 12. One of the advantages of the present invention is that it can dispense with such a Seeger ring 88, as will be explained in further detail hereinafter.

[0058] As can be seen in Figs. 3, 7 and 8, a part of the counterweight part 14 facing the second rotational axis 34 of the eccentric part 12 after attachment of the counterweight part 14 to the eccentric part 12, in particular part of the undercut portion 70 of the counterweight part 14, holds the at least one bearing 36 in an axial direction 86 in respect to the eccentric part 12. Preferably, the part of the counterweight part 14 facing the second rotational axis 34 holds the at least one bearing 36 in the cavity or recess 42 provided in the bottom surface 32 of the eccentric part 12. Thus, attachment of the counterweight part 14 to the eccentric part 12 not only provides for the mutual interlocking relationship between the two parts 12, 14 but also secures the at least one bearing 36 in/ at the eccentric part 12. No additional components, e.g., a Seeger ring 88 (see Fig. 9) or the like, are necessary for securing the at least one bearing 36 in the axial direction 86 in respect to the eccentric part 12. With this, the overall number of parts the eccentric element 10 is made up of can be further reduced having advantages in terms of manufacturing of the eccentric element 10 as well as in terms of a compact and light design.

[0059] The second rotational axis 34 may extend through a centre of gravity of the eccentric part 12 or through the centre of gravity of the entire eccentric element 10 with the counterweight part 14 and the working element 30 attached to the eccentric part 12. The first rotational axis 28 may extend eccentrically in respect to the centre of gravity. However, it would also be possible that the first rotational axis 28 extends through a centre of gravity of the eccentric part 12 or the eccentric element 10, respectively, and that the second rotational axis 34 extends eccentrically in respect to that centre of gravity.

[0060] In a top view parallel to the first and/or second rotational axes 28, 34 of the eccentric part 12, the eccentric part 12 may have a circular form (see Fig. 5) with the second rotational axis 34 forming a centre of the circular form or a centre axis of the eccentric part 12 (see Figs. 4 and 6).

[0061] In a bottom view parallel to the first and/or second rotational axes 28, 34 of the eccentric part 12, the counterweight part 14 may have a circular form or the form of a circular sector (see Figs. 4 and 6), wherein a geometrical centre of the circular form or of the circular sector or a centre axis 90 of the counterweight part 14, respectively, is spaced apart from the second rotational axis 34. Preferably, the centre of the circular form or of the circular sector or a centre axis 90 of the counterweight part 14, respectively, is also spaced apart from the first

rotational axis 28 (see Fig. 5).

[0062] The counterweight part 14 or its centre axis 90, respectively, is located on a side of the first rotational axis 28 opposite to the second rotational axis 34. With other words, in respect to the first rotational axis 28, the counterweight part 14 is located opposite to the working element 30, which is attached to the eccentric part 12 at the second rotational axis 34. In this way, the eccentricity caused by the working element 30 during intended use of the power tool can be optimally compensated by the counterweight part 14.

[0063] The first rotational axis 28 may extend through an imaginary straight line 92 interconnecting the centre of the circular form or of the circular sector or the centre axis 90 of the counterweight part 14 and the second rotational axis 34 (see Fig. 5). Thus, the counterweight part 14 or its centre axis 90, respectively, is located on a side of the first rotational axis 28 diametrically opposite to the second rotational axis 34.

[0064] The eccentric part 12 may be made of metal, in particular steel or aluminium, or of a plastic material having metal inserts (not shown in the Figs.). In particular, the metal inserts may be provided near or around the first rotational axis 28 or the attachment element 20, where the eccentric part 12 is attached to the distal end 22 of the tool shaft 16 or to a component attached to the tool shaft 16 or forming an integral part therewith. Inserts may also be provided near or around the second rotational axis 34 or the bearing 36 with the rotational rod 38, respectively, where the working element 30 is attached to the eccentric part 12 in a manner freely rotatable about the second rotational axis 34. The metal insert near or around the first rotational axis 28 may be designed as a hollow cylinder or a cylindrical liner with an internal thread, into which the threaded distal end 22 of the tool shaft 16 is screwed. The metal insert near or around the second rotational axis 34 may be designed as a hollow cylinder or a cylindrical liner into which the at least one bearing 36 for the rotational pin 38 is inserted. The one or more metal inserts may be inserted into the plastic material after its manufacture, e.g., by pressing the inserts into respective recesses in the plastic material. Alternatively, the one or more metal inserts may be provided in the plastic material during its manufacture, e.g., by means of a co-moulding process, where the heated plastic material is injected around the inserts.

[0065] The counterweight part 14 is preferably made of metal, in particular steel or aluminium. However, it could also be made of plastic material. In order to achieve a desired weight to be able to fulfil the vibration reducing functionality, metal inserts, preferably consisting of a solid metal material, may be provided in the plastic material.

Claims

1. Eccentric element (10) configured for use in a hand-

held power tool comprising a tool motor for driving a tool shaft (16), in particular for use in an orbital sanding or polishing machine, the eccentric element (10) comprising:

- an eccentric part (12) with

a top surface (18) releasably attachable or fixedly attached to a distal end (22) of the tool shaft (16) or forming an integral part of the tool shaft (16) so as to transmit a torque from the tool shaft (16) to the eccentric element (10) and to rotate the eccentric part (12) about a first rotational axis (28) of the eccentric part (12) upon activation of the tool motor,
a bottom surface (32) to which a working element (30) of the power tool, in particular a backing plate, a sanding plate or a polishing plate, is releasably attachable in a manner freely rotatable about a second rotational axis (34) of the eccentric part (12), and

- a counterweight part (14) attached to the eccentric part (12),

characterized in that

the eccentric part (12) and the counterweight part (14) are separate components and formed such that they enter into a mutual interlocking relationship upon attachment of the counterweight part (14) to the eccentric part (12), the interlocking relationship acting in at least one direction (76; 82; 86).

2. Eccentric element (10) according to claim 1, wherein the mutual interlocking relationship between the eccentric part (12) and the counterweight part (14) acts in a radial direction (76) in respect to the first rotational axis (28) of the eccentric part (12), at least during activation of the tool motor.
3. Eccentric element (10) according to claim 1 or 2, wherein the mutual interlocking relationship between the eccentric part (12) and the counterweight part (14) acts in a circumferential direction (82) in respect to the first or second rotational axis (28; 34) of the eccentric part (12).
4. Eccentric element (10) according to one of the preceding claims, wherein the mutual interlocking relationship between the eccentric part (12) and the counterweight part (14) acts in an axial direction (86) extending parallel to the first or second rotational axis (28; 34) of the eccentric part (12).

5. Eccentric element (10) according to one of the preceding claims, wherein the first rotational axis (28) of the eccentric part (12) corresponds to a rotational axis of the tool shaft (16) once the eccentric part (12) is attached to the tool shaft (16) and/or the second rotational axis (34) of the eccentric part (12) corresponds to a rotational axis of the working element (30), once it is attached to the eccentric part (12).

6. Eccentric element (10) according to one of the preceding claims, wherein the eccentric element (10) comprises at least one fastening element (62), in particular a screw, configured for holding the counterweight part (14) in respect to the eccentric part (12) in their mutual interlocking relationship before, during and after activation of the tool motor.

7. Eccentric element (10) according to one of the preceding claims, wherein the eccentric element (10) comprises at least one bearing (36) associated to the bottom surface (32) of the eccentric part (12) and configured to receive a rotational pin (38) in a manner freely rotatable about the second rotational axis (34) of the eccentric part (12), wherein a distal end (40) of the rotational pin (38) is configured to be releasably attached to the working element (30).

8. Eccentric element (10) according to claim 7, wherein the distal end (40) of the rotational pin (38) comprises a head portion (46) having a larger diameter than that part (48) of the rotational pin (38), which is received in the at least one bearing (36), and having a non-rotational symmetric outer circumferential surface (50), the head portion (46) being configured to be received by a respective cavity (52) provided in the working element (30) and having an inner circumferential surface (56) corresponding to the outer circumferential surface (50) of the head portion (46), and wherein the working element (30) is preferably secured to the rotational pin (38) in an axial direction by means of a fastening element (58), in particular a screw.

9. Eccentric element (10) according to claim 7 or 8, wherein a part of the counterweight part (14) facing the second rotational axis (34) of the eccentric part (12) after attachment to the eccentric part (12), holds the at least one bearing (36) in an axial direction in respect to the eccentric part (12).

10. Eccentric element (10) according to one of the preceding claims, wherein the top surface (18) of the eccentric part (12) comprises a threaded hole (24), a longitudinal axis (26) of

the hole (24) corresponding to the first rotational axis (28) of the eccentric part (12), and the hole (24) being configured to receive for releasable threaded attachment a threaded distal end (22) of the tool shaft (16) or of a component fixedly attached to the tool shaft (16) or forming an integral part therewith. 5

11. Eccentric element (10) according to one of the preceding claims, wherein
in a top view parallel to the first and/or second rotational axes (28; 34) of the eccentric part (12), the eccentric part (12) has a circular form with the second rotational axis (34) forming a centre of the circular form. 10
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12. Eccentric element (10) according to one of the preceding claims, wherein
in a bottom view parallel to the first and/or second rotational axes (28; 34) of the eccentric part (12), the counterweight part (14) has a circular form or the form of a circular sector and wherein a centre (90) of the circular form or of the circular sector is spaced apart from the second rotational axis (34). 20
13. Eccentric element (10) according to claim 12, wherein
the first rotational axis (28) extends through a straight line (92) interconnecting the centre (90) of the circular form or of the circular sector of the counterweight part (14) with the second rotational axis (34). 25
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14. Eccentric element (10) according to one of the preceding claims, wherein
the eccentric part (12) is made of metal, in particular steel or aluminium, or of a plastic material having metal inserts. 35
15. Eccentric element (10) according to one of the preceding claims, wherein
the counterweight part (14) is made of metal, in particular steel. 40

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Fig. 1

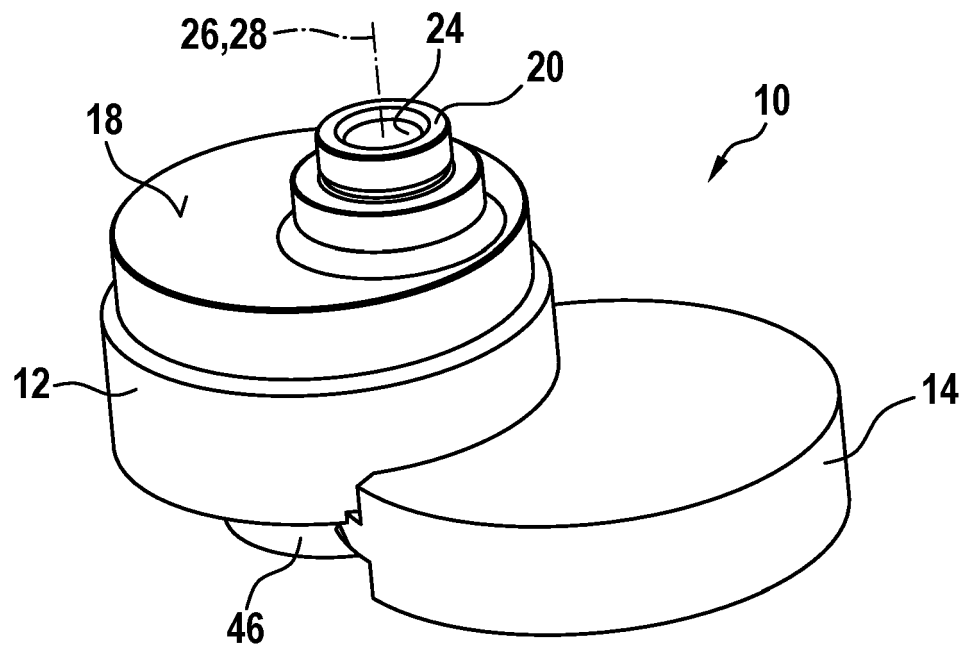


Fig. 2

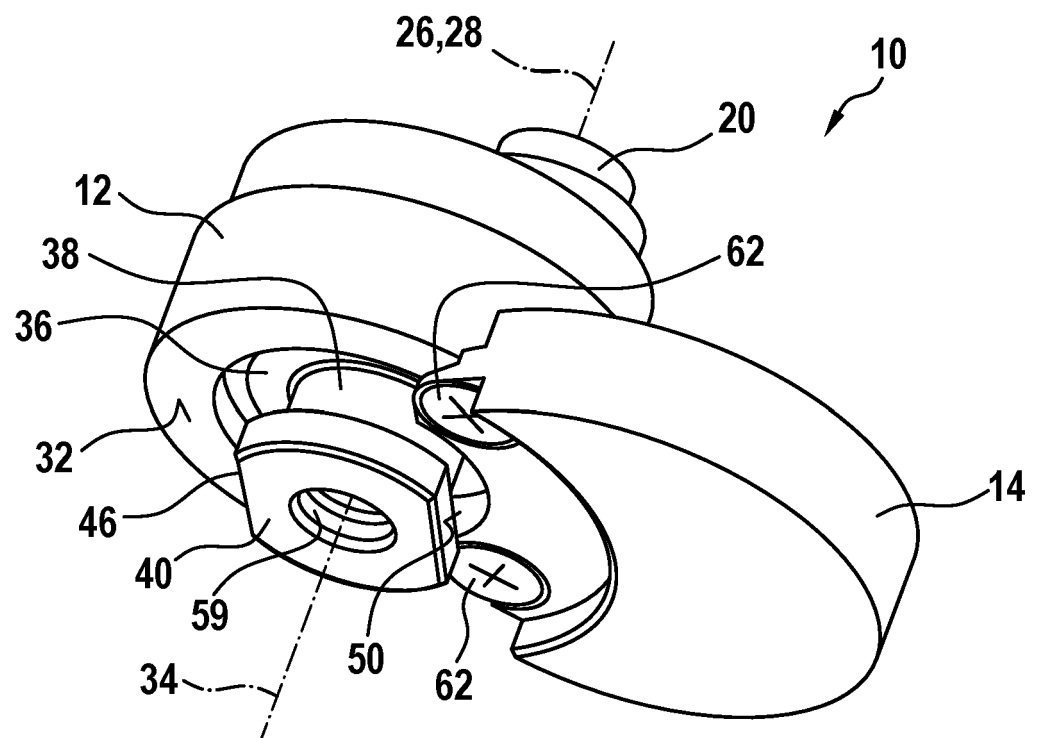


Fig. 3

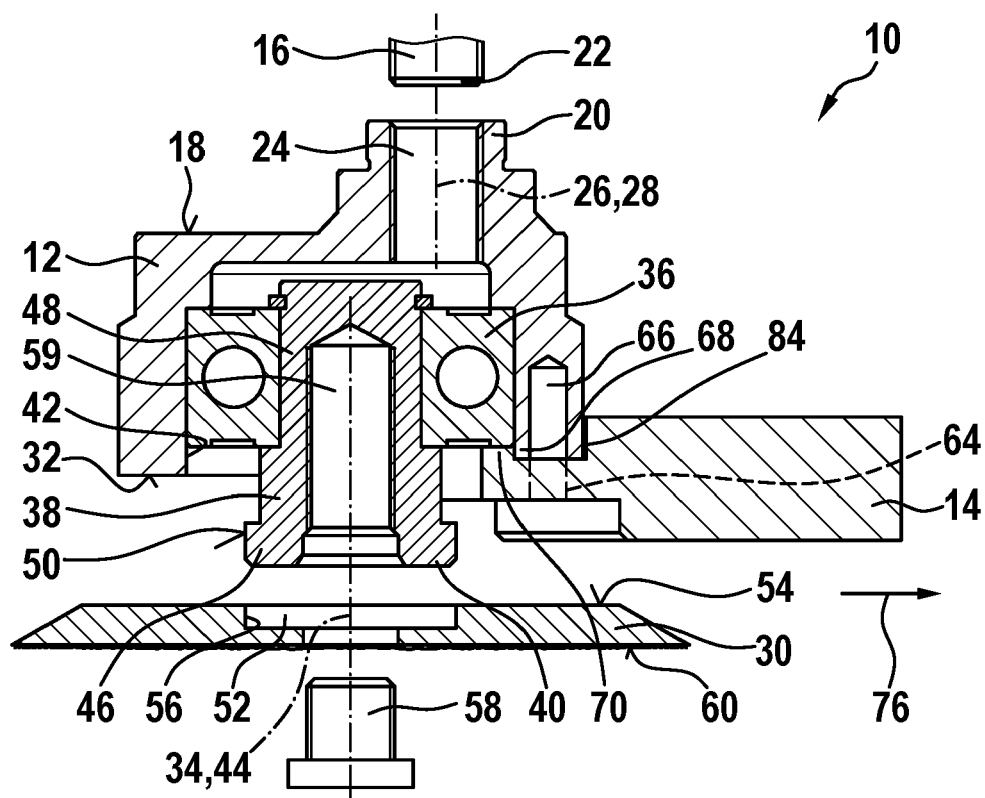


Fig. 4

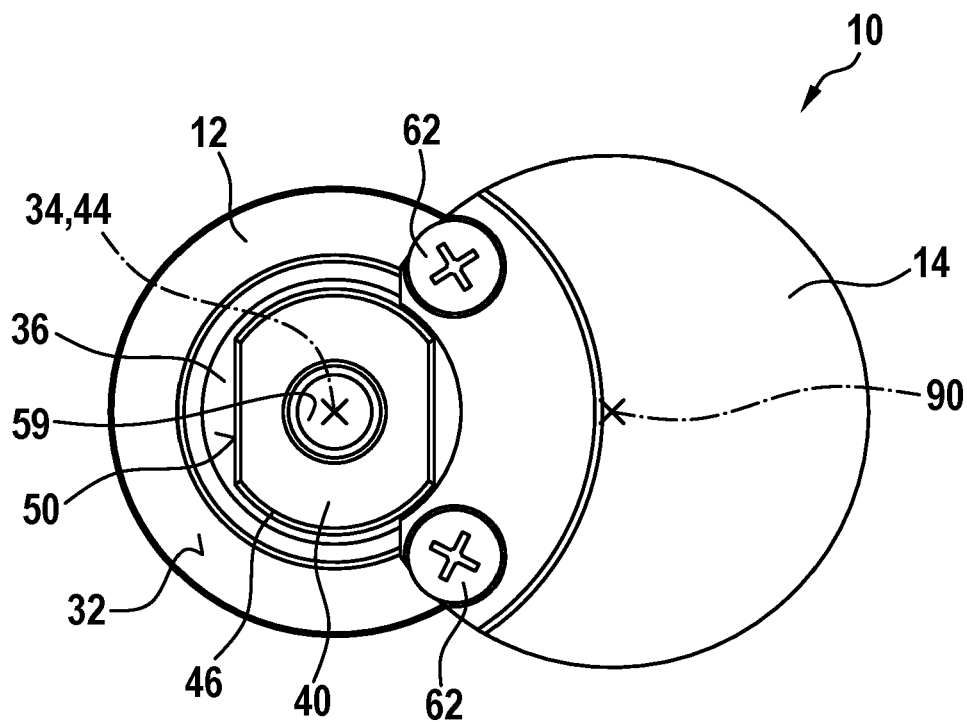


Fig. 5

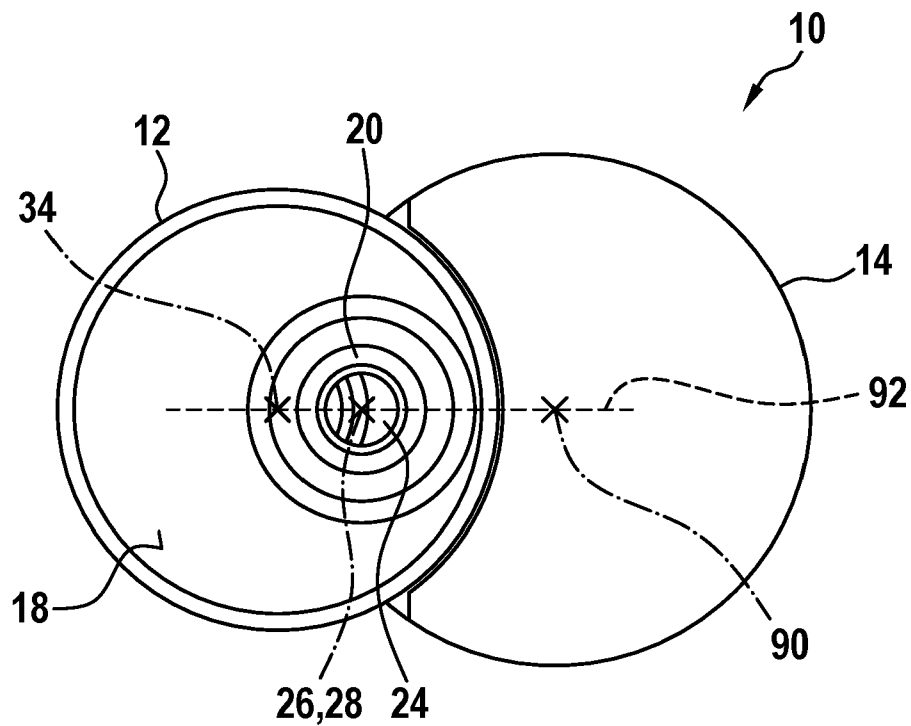


Fig. 6

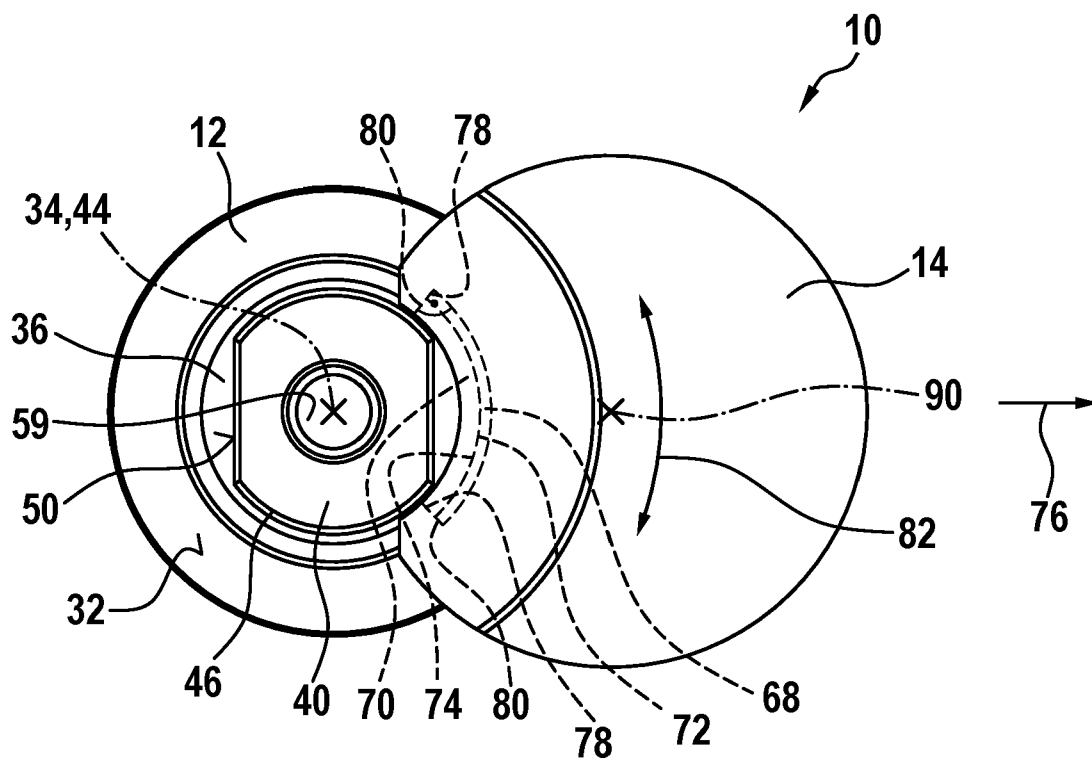


Fig. 7

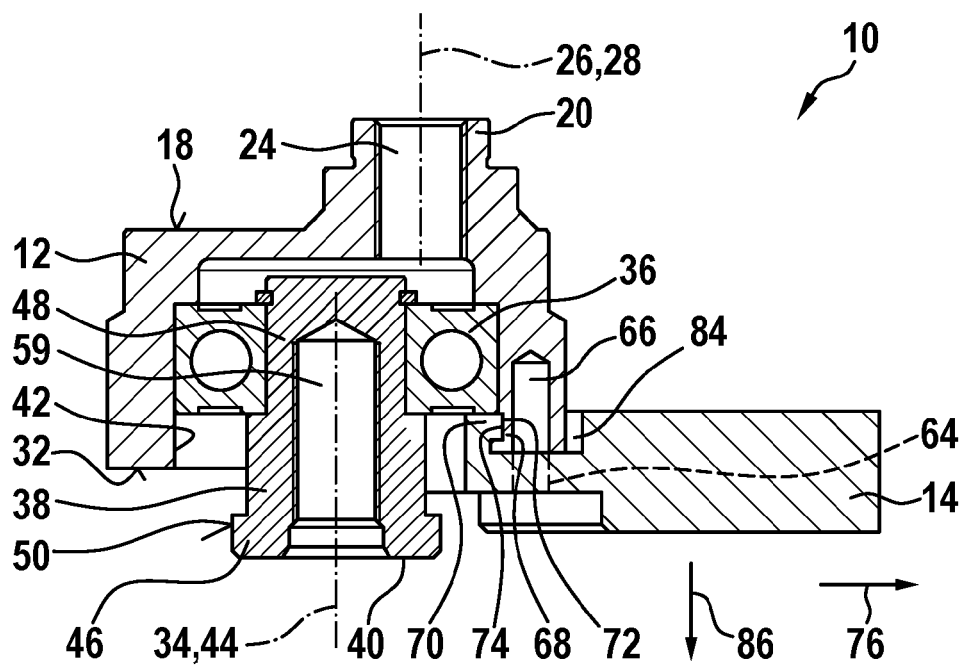


Fig. 8

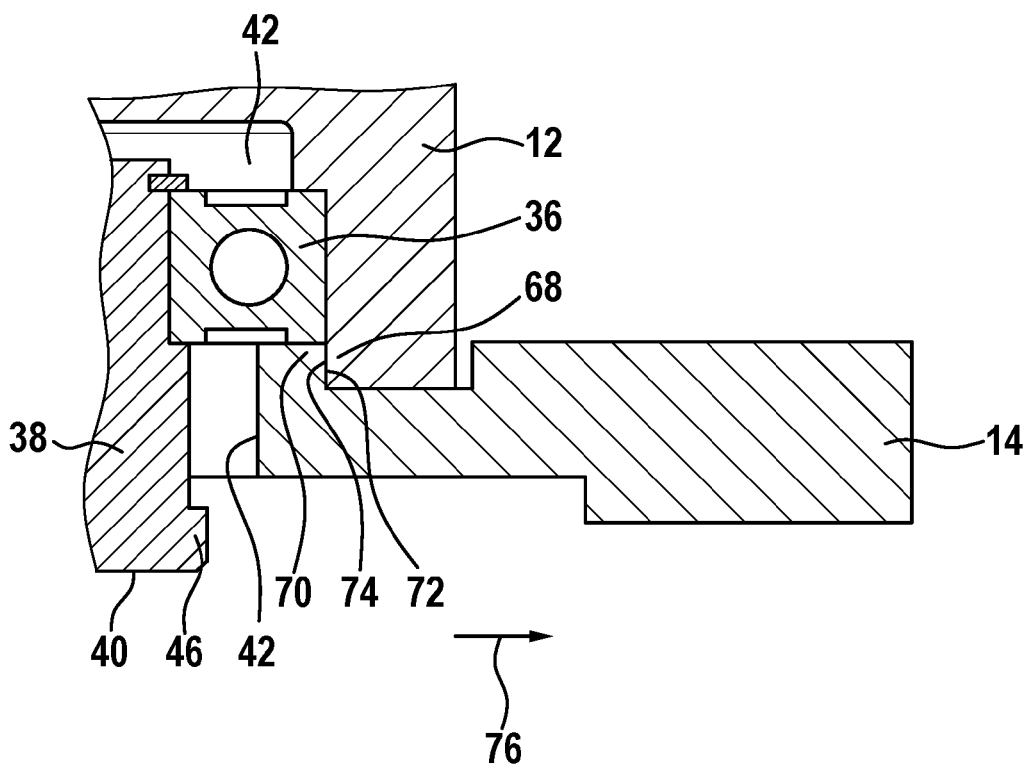
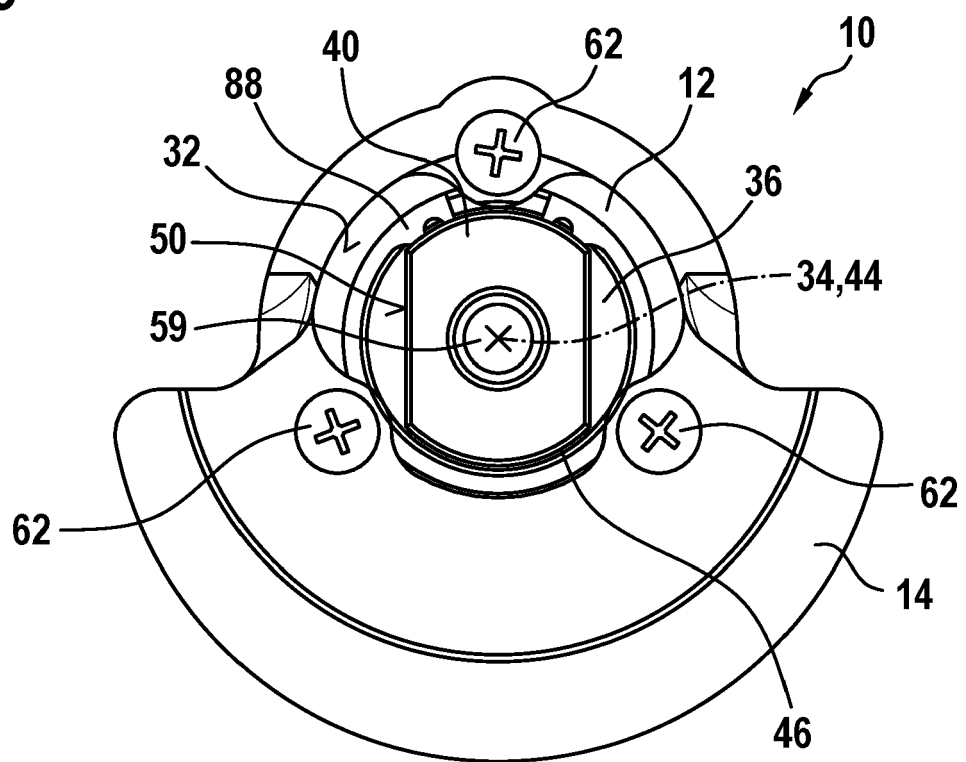


Fig. 9





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Application Number

EP 23 20 1833

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			B24B B24D
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
Munich		22 March 2024	Forciniti, Marco
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

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