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B4C C11A

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EP 1464449 A2 **EP 1439038 A1**
EP 1415768 A1 **EP 1252976 A1**
US 4478293 A

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UK CL (Edition X) **B4C**
INT CL^7 **B25D, F16F**
Other: **WPI, EPODOC**

(54) Abstract Title**: Vibration dampening mechanism**

(57) A hammer drill comprising: a body 2 in which is located a motor; a tool holder 6 capable of holding a tool bit; a hammer mechanism, driven by the motor when the motor is activated, for repetitively striking an end of the tool bit when the tool bit is held by the tool holder 6; a counter mass (20, fig 2) slideably mounted within the body 2 which is capable of sliding in a forward and rearward direction between two end positions; biasing means (22, fig. 2) which biases the counter mass (20, fig 2) to a third position located between the first and second positions; wherein the counter mass is located above the centre of gravity 9 of the hammer; the mass of the counter mass (20, fig 2) and the strength of the biasing means (22, fig. 2) being such that the counter mass (20, fig. 2) slidingly moves in forward and rearward direction to counteract vibrations generated by the operation of the hammer mechanism. The biasing means may be a leaf spring (32, 34, fig. 4) or a helical spring (22, fig. 2). The leaf spring (32, 34, fig. 4) may be constructed in a layer fashion. The counter mass (20, fig. 2) may be slideably supported on rods (18, fig. 2) and may be able to twist about a number of axes.

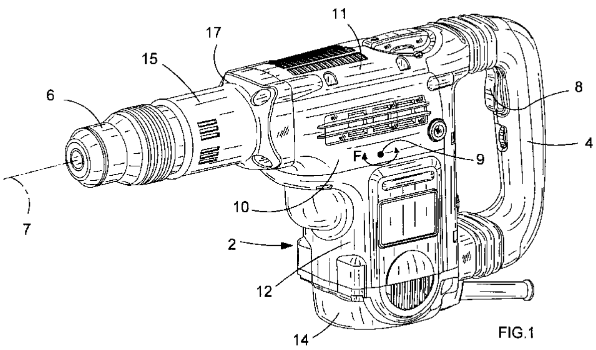

FIG.1

GB 2 429 675 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995

22 12 05

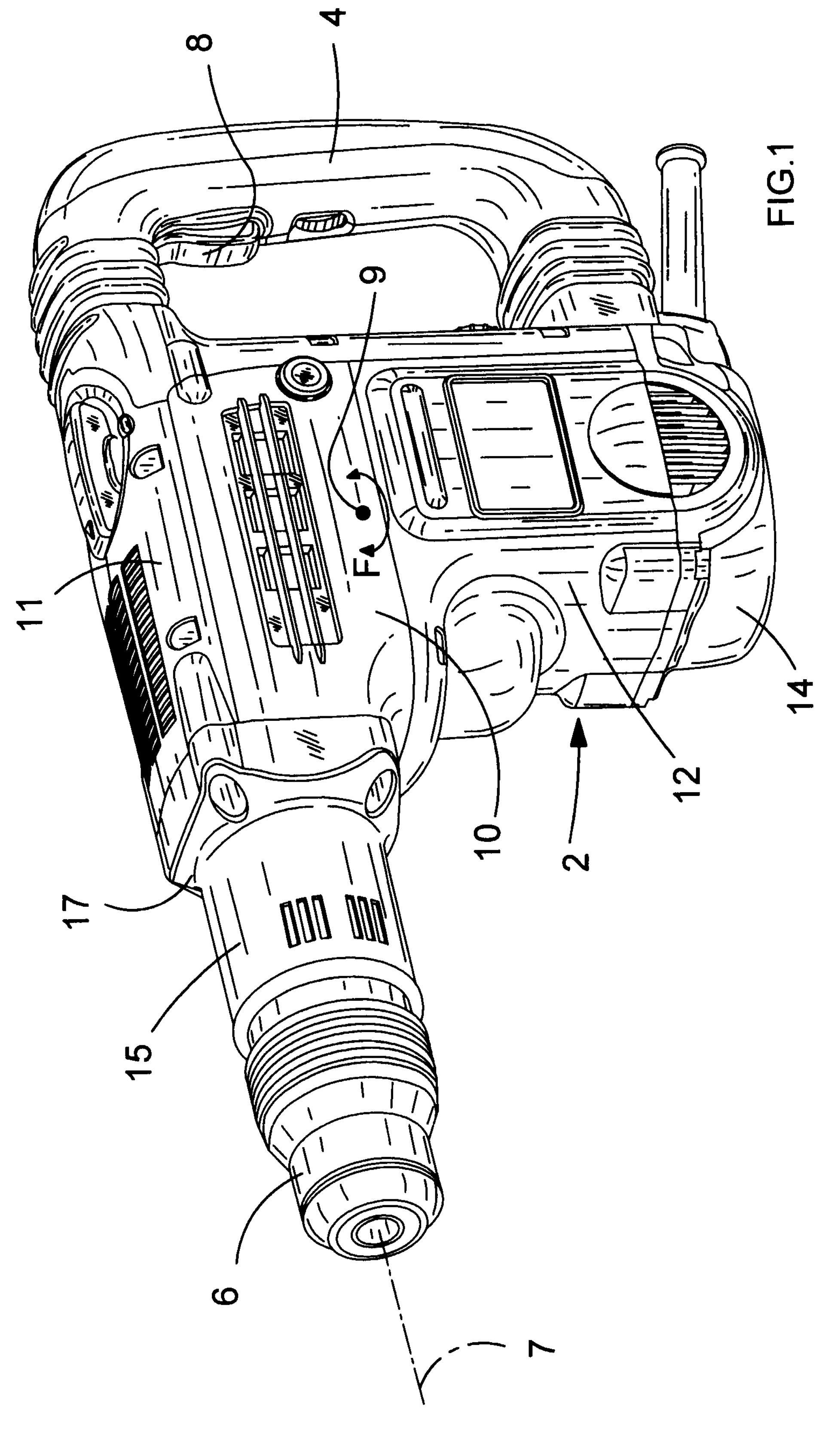

FIG.1

22 12 05

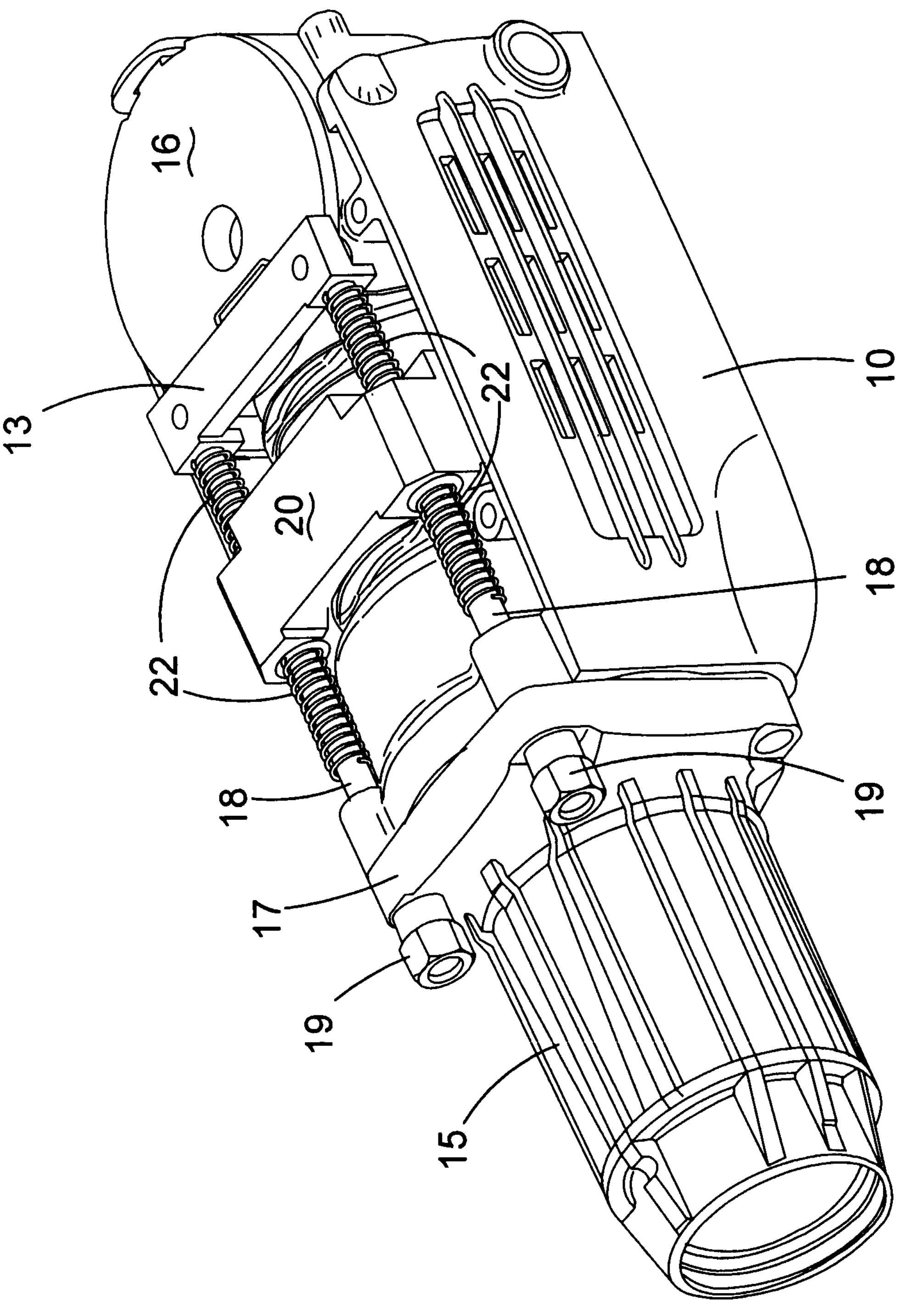

FIG.2

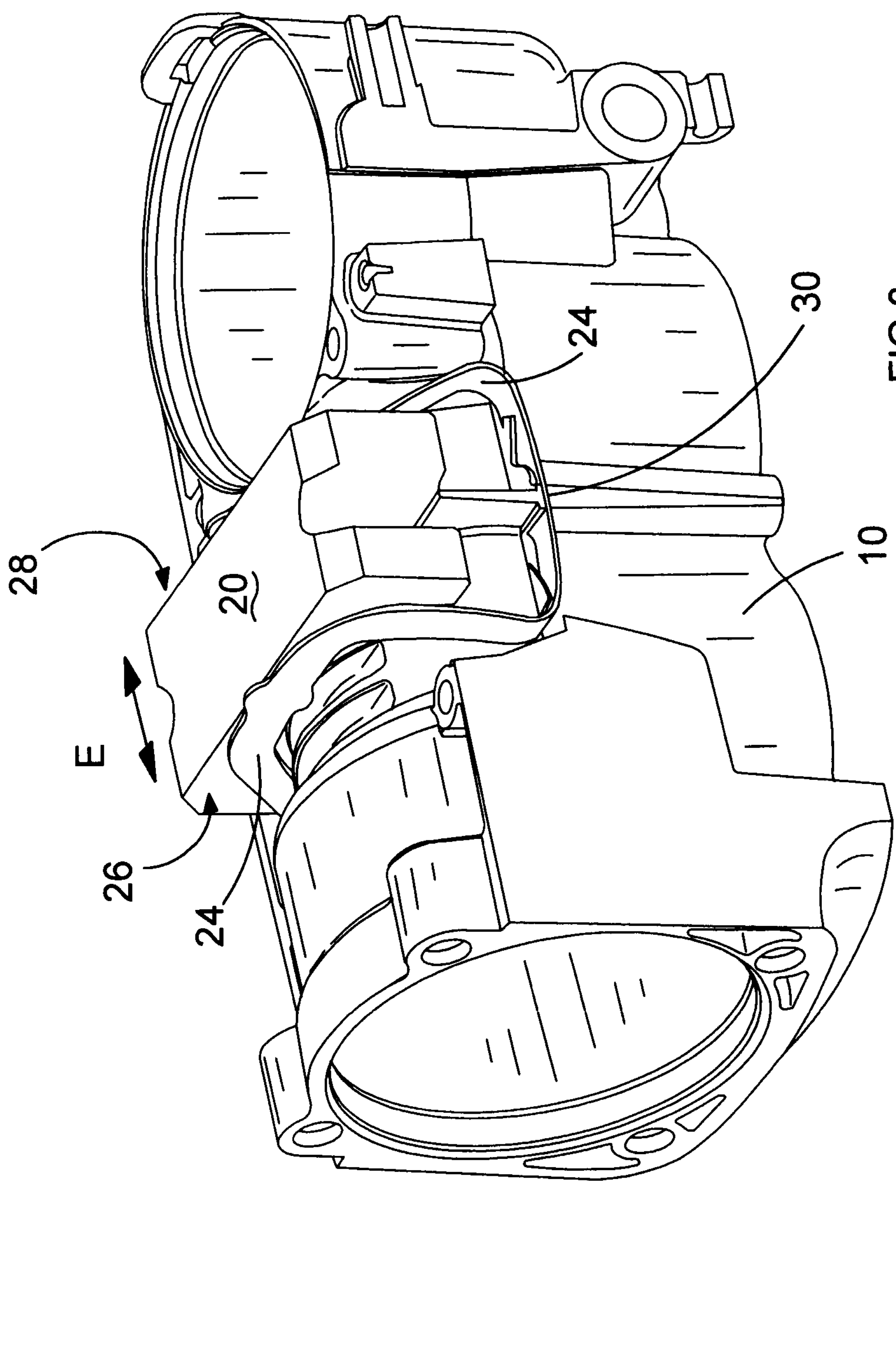

FIG.3

22 12 05

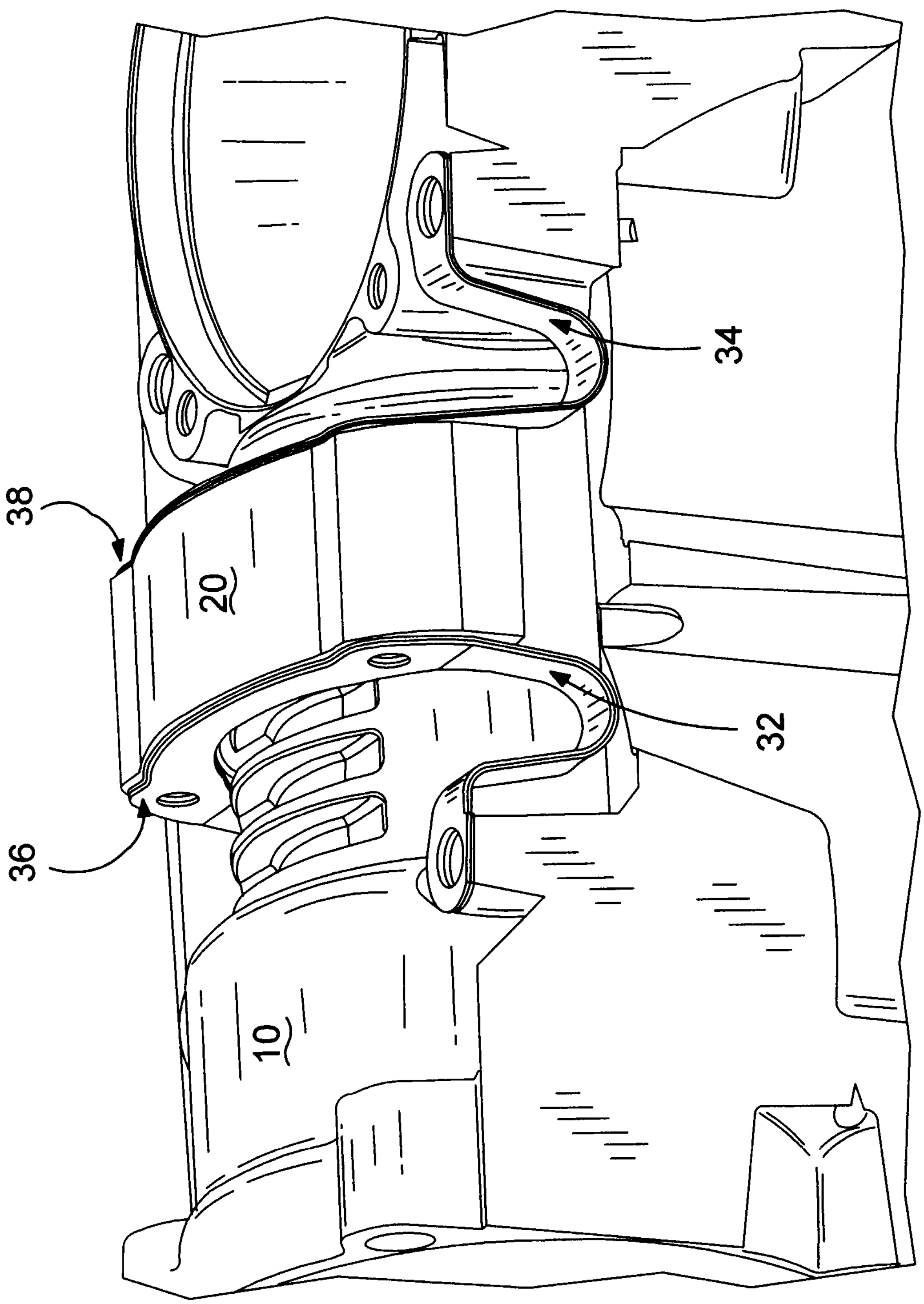

FIG.4

22.12.05

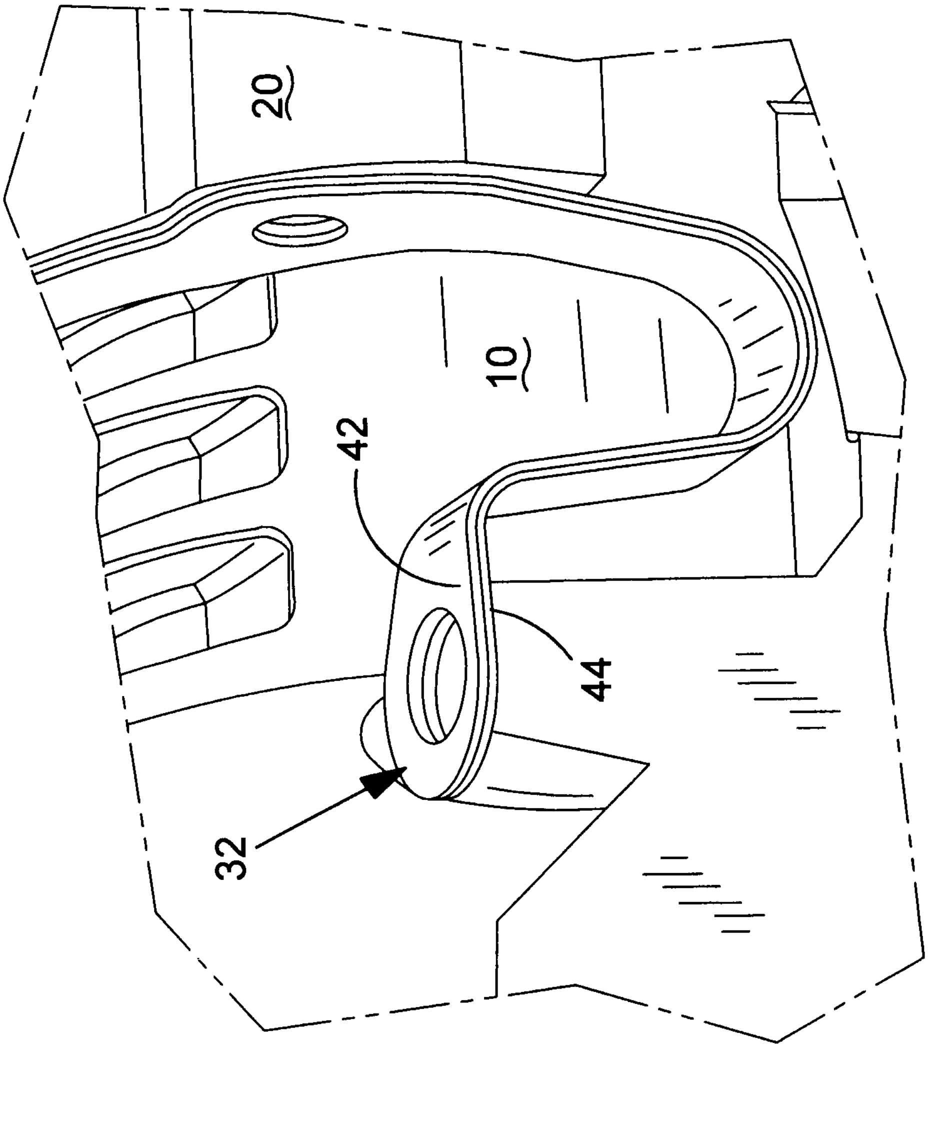

FIG.5

22 12 05

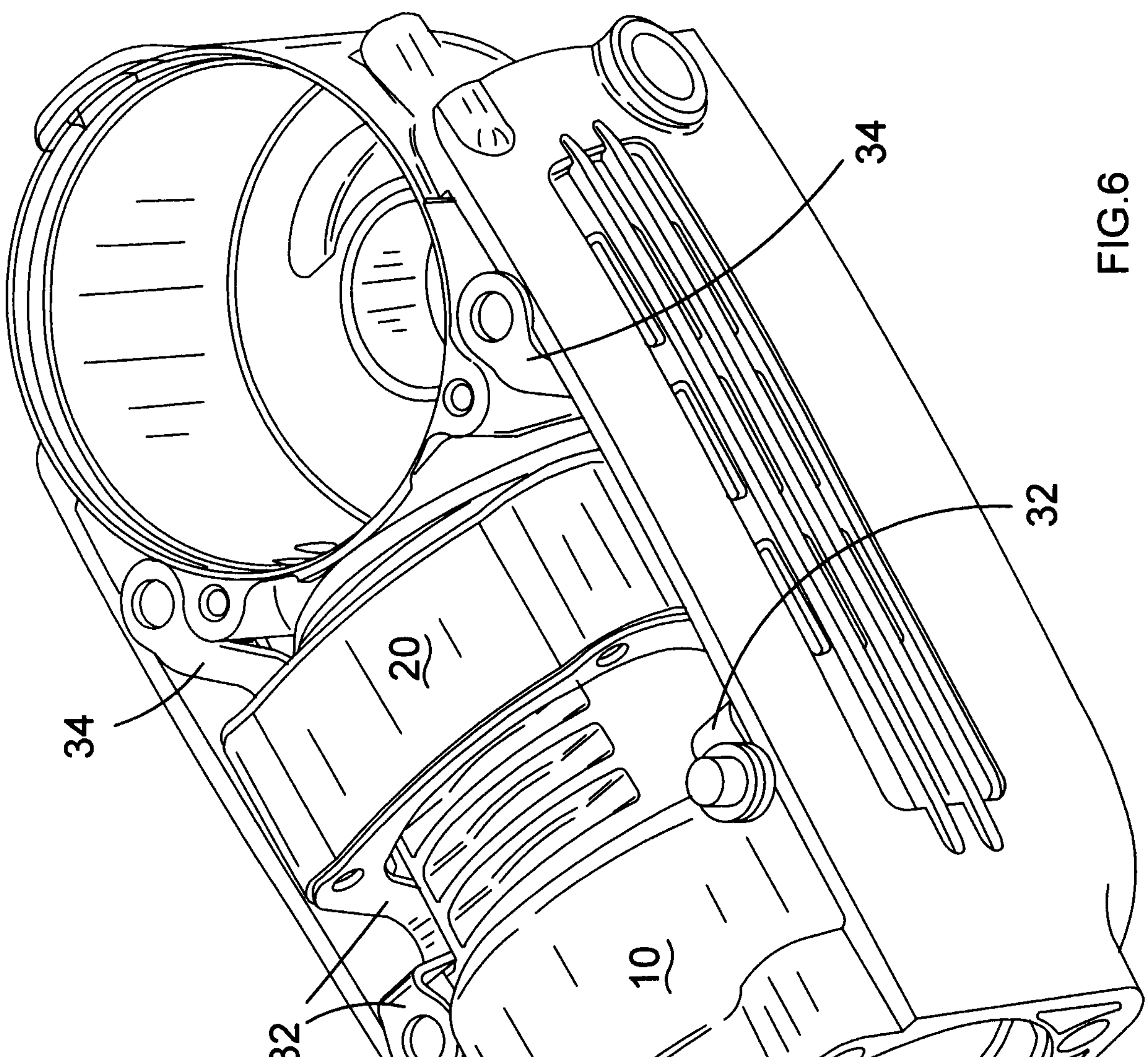

FIG.6

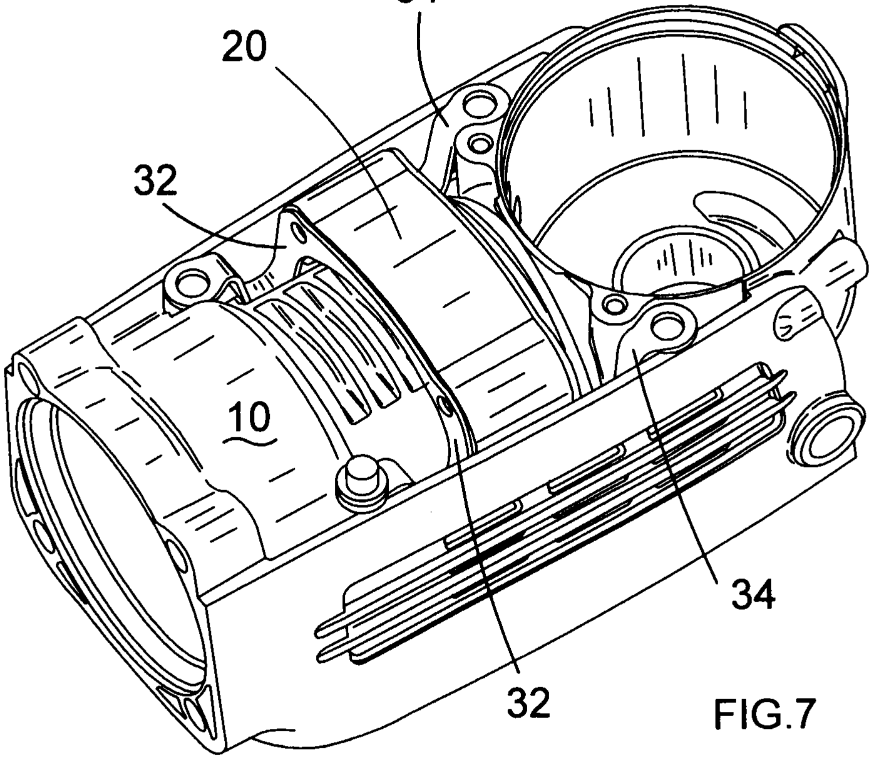

FIG.7

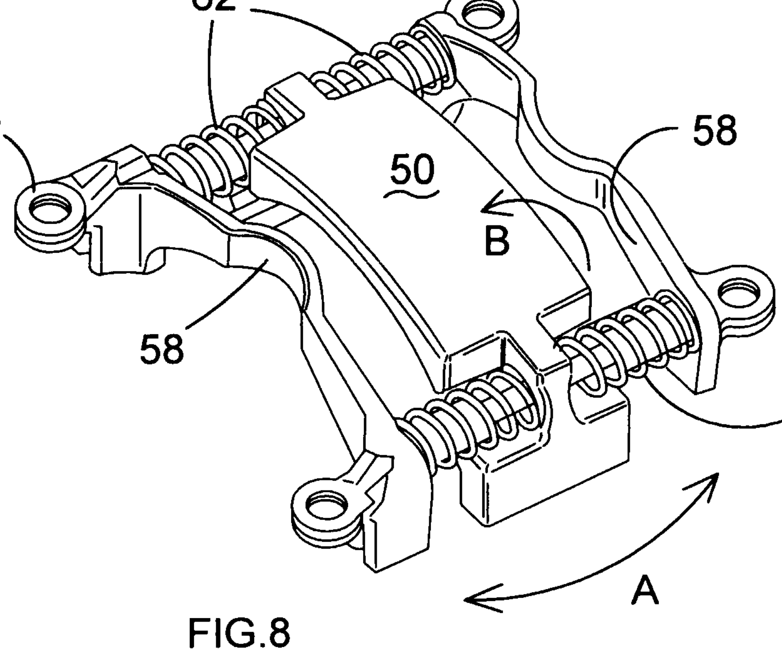

FIG.8

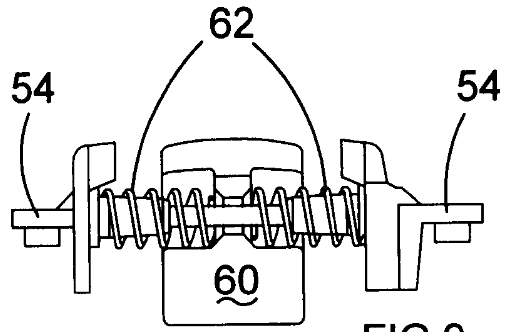

FIG.9

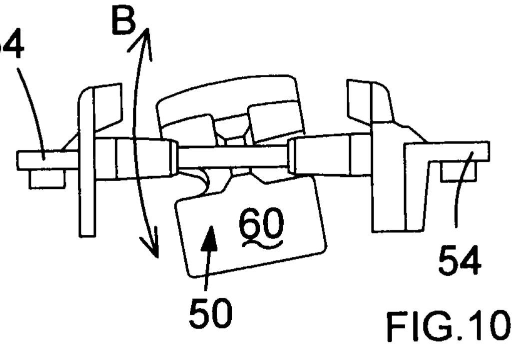

FIG.10

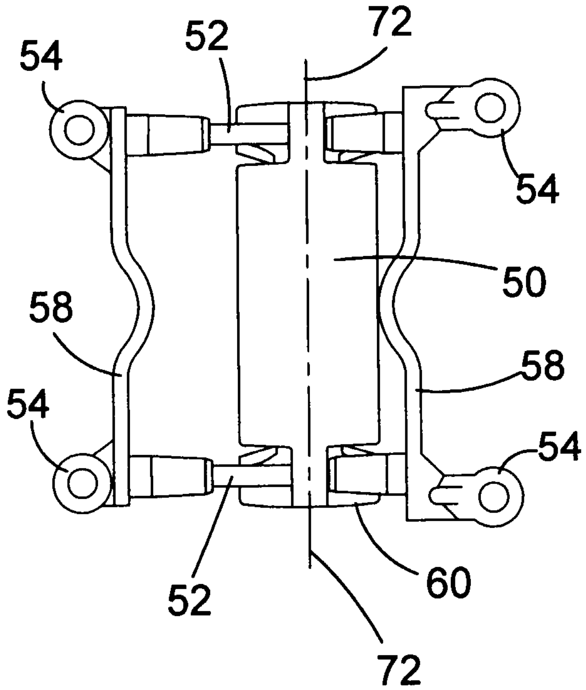

FIG.11

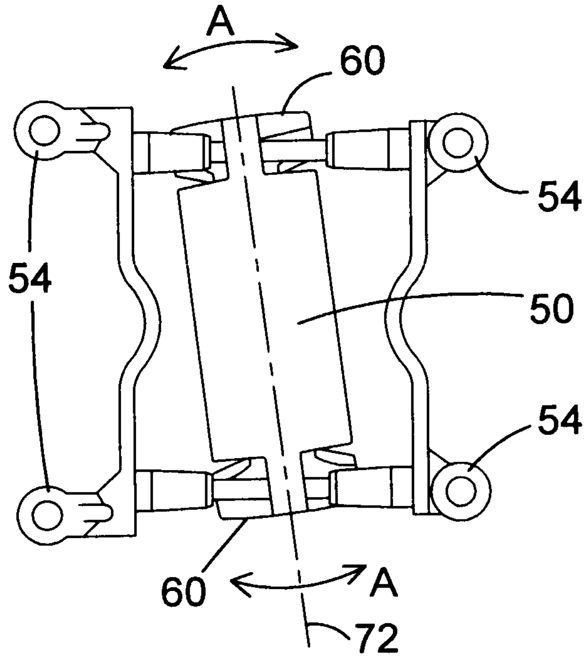

FIG.12

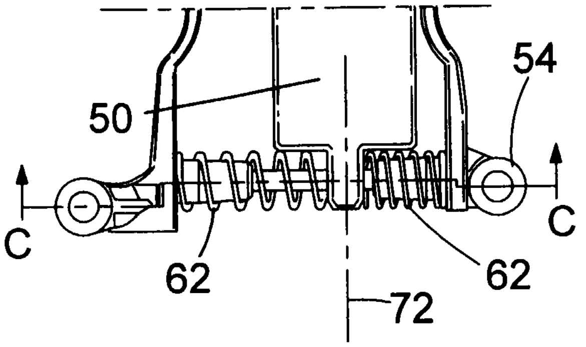

FIG.13A

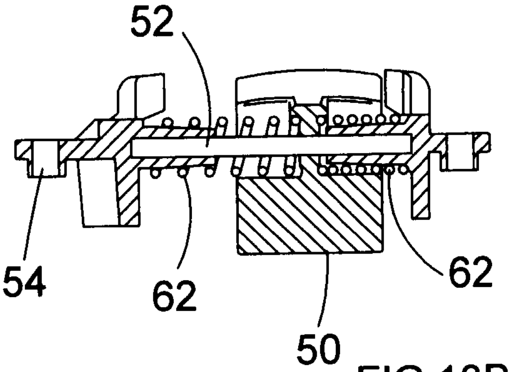

FIG.13B

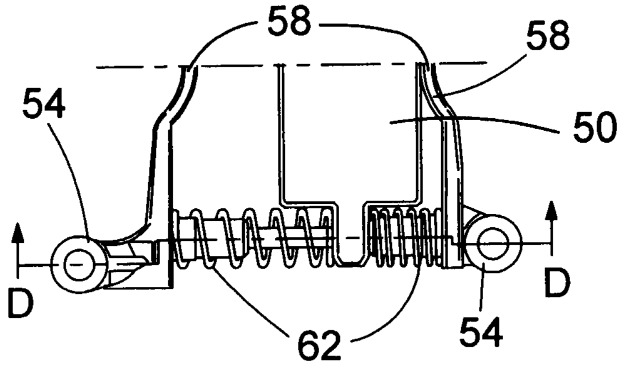

FIG.14A

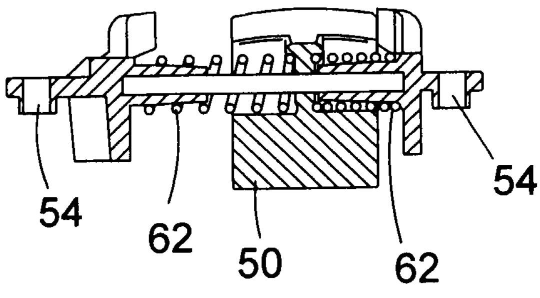

FIG.14B

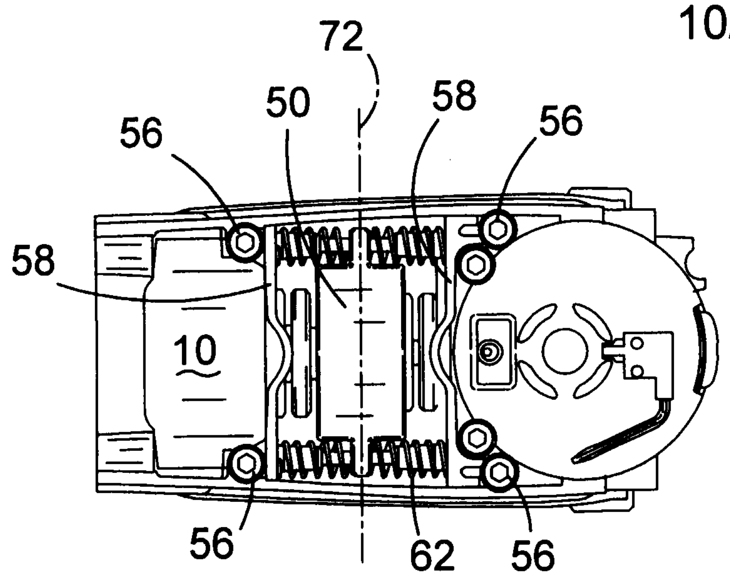

FIG.15

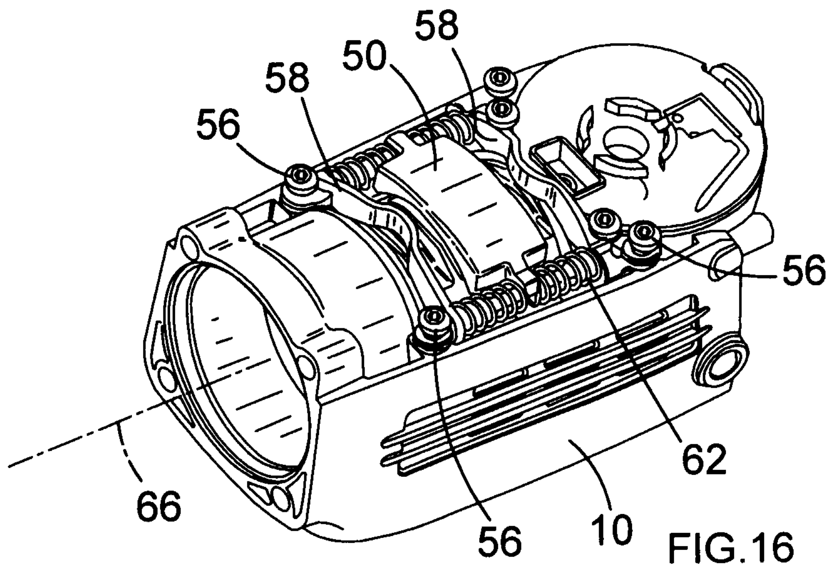

FIG.16

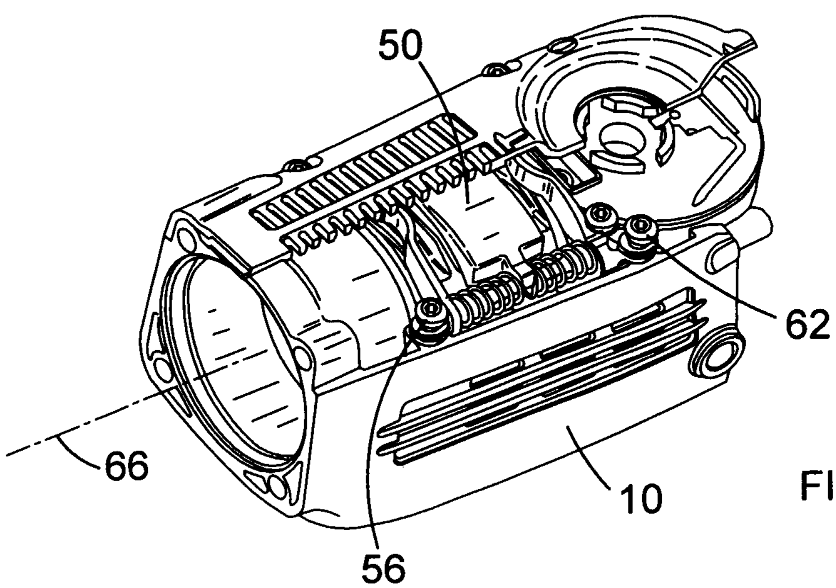

FIG.17

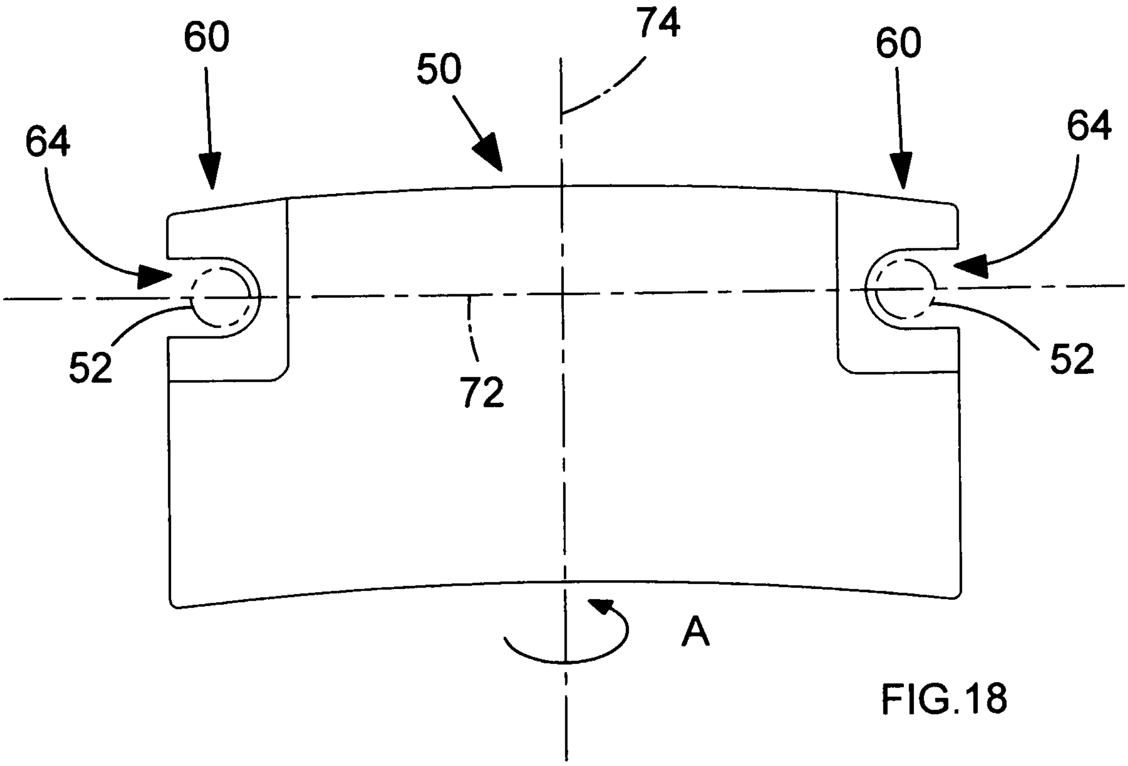

FIG.18

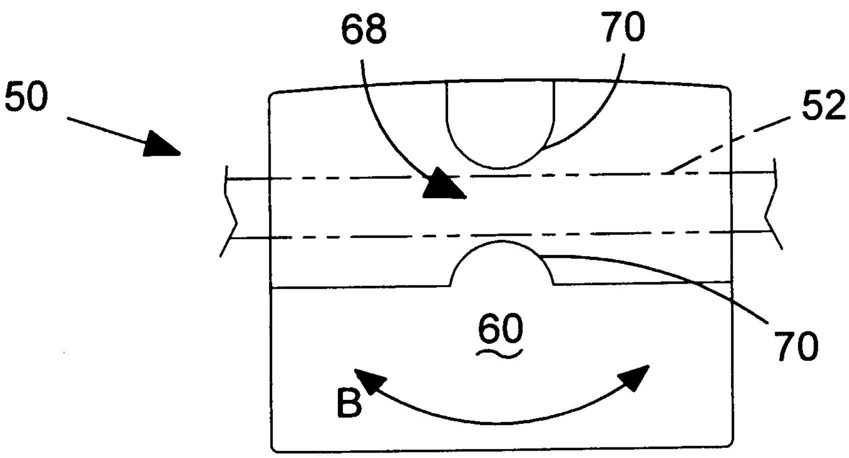

FIG.19

VIBRATION DAMPENING MECHANISM

The present invention relates to hammer drills, and in particular, to vibration dampening in hammer drills.

A typical hammer drill comprises a body attached to the front of which is a tool holder in which a tool bit such as a chisel or a drill bit is capable of being mounted. Within the body is a motor which reciprocatingly drives a piston mounted within a cylinder via a wobble bearing or crank. The piston reciprocatingly drives a ram which repetitively strikes a beat piece which in turn hits the rear end of the chisel of tool bit in well known fashion. In addition, in certain types of hammer drill, the tool holder can rotationally drive the tool bit.

EP1157788 discloses an example of a typical construction of a hammer drill.

The reciprocating motion of the piston, ram and striker to generate the hammering action cause the hammer to vibrate. It is therefore desirable to minimise the amount of vibration generated by the reciprocating motion of the piston, ram and striker.

Accordingly, there is provided a hammer drill comprising:

a body in which is located a motor;

a tool holder capable of holding a tool bit;

a hammer mechanism, driven by the motor when the motor is activated, for repetitively striking an end of the tool bit when the tool bit is held by the tool holder 6;

a counter mass slideably mounted within the body which is capable of sliding in a forward and rearward direction between two end positions;

biasing means which biases the counter mass to a third position located between the first and second positions;

wherein the counter mass is located above the centre of gravity of the hammer;

the mass of the counter mass and the strength of the biasing means being such that the counter mass slidingly moves in forward and rearward direction to counteract vibrations generated by the operation of the hammer mechanism.

Four embodiments of the present invention will now be described with reference to the accompanying drawings of which:-

Figure 1 shows a perspective view of hammer drill;

Figure 2 shows a first embodiment of the anti-vibration mechanism;

Figure 3 shows the second embodiment of the anti-vibration mechanism;

Figure 4 shows a side view of the third embodiment of the anti-vibration mechanism;

Figure 5 shows a close-up of a leaf spring of the third embodiment;

Figure 6 shows a downward perspective view of the third embodiment;

Figure 7 shows a second downward perspective view of the third embodiment;

Figure 8 shows a perspective view of the fourth embodiment of the anti-vibration mechanism;

Figure 9 shows a side view of the anti-vibration mechanism of the fourth embodiment;

Figure 10 shows a side view of the vibration counter mass mechanism, with the metal weight twisted about a horizontal axis, with the springs omitted;

Figure 11 shows a top view of the anti-vibration mechanism, with the metal weight slid to one side (right), with the springs omitted;

Figure 12 shows a top view of the anti-vibration mechanism, with the metal weight twisted about a vertical axis, with the springs omitted;

Figure 13A shows half of the anti-vibration mechanism, with the metal weight slid to one side (right);

Figure 13B shows a vertical cross section of the anti-vibration mechanism in Figure 13A in the direction of Arrows C;

Figure 14A shows half of the anti-vibration mechanism, with the metal weight slid to one side (right) further than that shown in Figure 13A;

Figure 14B shows a vertical cross section of the anti-vibration mechanism in Figure 14A in the direction of Arrows D;

Figure 15 shows a top view of the anti-vibration mechanism mounted on the top section of a hammer;

Figure 16 shows a perspective view of the anti-vibration mechanism mounted on the top section of a hammer;

Figure 17 shows a perspective view of the anti-vibration mechanism mounted on the top section of a hammer with part of the outer casing covering the vibration mechanism;

Figure 18 shows a sketch of the front of the metal weight; and

Figure 19 shows a sketch side view of the metal weight.

Referring to Figure 1, the hammer drill comprises a body 2 in which is located a motor (not shown) which powers the hammer drill. Attached to the rear of the body 2 is a handle 4 by which a user can support the hammer. Mounted on the front of the body 2 is a tool holder 6 in which a drill bit or chisel (not shown) can be mounted. A trigger switch 8 can be depressed by the operator in order to activate the motor of the hammer in order to reciprocatingly drive a hammer mechanism located within the body 2 of the hammer. Designs of the hammer mechanism by which the reciprocating and/rotational drive for the drill bit or chisel are generated from the rotational drive of the motor are well known and, as such, no further detail will be provided.

The first embodiment of the present invention will now be described with reference to Figure 2.

Referring to Figure 2, the first embodiment of the anti-vibration mechanism is shown. The top section 10 (see Figure 1) of the housing 2 is in the form of a metal cast. The top section 10 is attached to a middle section 12 which in turn is attached to a lower section 14 as best seen in Figure 1. The top section 10 encloses the hammer mechanism (of typical design) including a crank (not shown) which is located within a rear section 16 of the top section 10, a piston, ram and striker, together with a cylinder in which they are located, none of which are shown. The reciprocating motion of the piston, ram and striker within the cylinder causes the hammer to vibrate in a direction approximately parallel to the direction of travel of the piston, ram and striker. It is therefore desirable to minimise the amount of vibration generated by the reciprocating motion of the piston, ram and striker.

Rigidly attached to the top of the top section 10 are two metal rods 18 which run lengthwise along the top of the top section 10. The rear ends of the rods 18 connect to the top section 10 via a support 13 which is screwed into the top section 10. The front ends of the rods 18 pass through a bore in the top section 10 and then through a flange 17 in a front section 15 of the housing 2, which attaches to the forward end of the top section 10. Nuts 19 are screwed onto the end of the rods 18 to secure them to the front and top sections 10, 15. The rods 18 also perform the function of assisting the rigid connection between the front section 15 and the top section 10.

Mounted on the two rods is a metal weight 20 which is capable of freely sliding backwards and forwards along the two rods 18 in the direction of Arrow E. Four springs 22 are mounted on the two rods 18 between the metal weight 20 and the two ends of the rods 18 where they are attached to the upper section 10. As the body 2 of the hammer vibrates, the metal weight 20 slides backwards and forwards along the two rods 18 compressing the various springs 22 as it moves backwards and forwards. The mass of the metal weight 20 and the strength of the springs 22 have been arranged such that the metal weight 20 slides backwards and forwards out of phase with the movement of the body of the hammer and as such counteracts the vibrations generated by the reciprocating movement of the piston, ram and striker. Thus, with the use of the correct weight for the metal weight 20 and strength of springs 22, the overall vibration of the tool can be reduced.

The anti-vibration mechanism is enclosed by an outer cap 11 (see Figure 1) which attaches to the top of the top section 10.

The motor is arranged so that its spindle is vertical and is generally located within the middle 12 section. As a large proportion of the weight of the hammer is caused by the motor, which is located below the cylinder, piston, ram and striker, the centre of mass 9 is lower than the longitudinal axis of the cylinder, piston, ram and striker.

The vibration forces act on the hammer in a direction which is coaxial to the axis 7 of travel of the piston, ram and striker. Movement of the metal weight 20 along the rods 18 will counteract vibration in the hammer in a direction parallel to axis 7 of travel of the piston, ram and striker.

As the centre of mass 9 of the hammer is below the axis 7 of travel of the piston, ram and striker, there will also be a twisting moment (Arrow F) about the centre of gravity 9 caused by the vibration. As the sliding metal weight 20 is located above the centre of gravity 9, the sliding movement will also counter the twisting moments (Arrow F) about the centre of gravity 9 caused by the vibration.

Figure 3 shows a second embodiment of the anti-vibration mechanism.

This embodiment operates in a similar manner as the first embodiment. Where the same features are present in the second embodiment which are present in the first embodiment, the same reference numbers have been used.

The difference between the first and second embodiment is that the metal weight 20 is now mounted to the top section 10 by the use of a single leaf spring 24 which connects between the metal weight and the top section 10 and supports the metal weight 20 on the tope section 10. The metal weight 20 slides backwards and forwards in the direction of Arrows E in the same manner as in the first embodiment. However, due to the shape of the leaf spring 24 which is attached to the front 26 of the metal weight 20 then wraps around the metal weight 20 to the rear 28 of the metal weight 20 the centre 30 of which being attached to the top section 10, enable the metal rods to be dispensed with as the leaf spring 24 in the forwards and backwards direction, produces a resilient affect, whilst preventing the metal weight 20 from rocking in a sideways direction. This simplifies the design considerably and reduces cost. Furthermore, the use of a leaf spring 24 allows some twisting movement of the metal weight 20 about a vertical axis of rotation.

A third embodiment of the present invention is shown in Figures 4, 5, 6 and 7.

This embodiment operates in a similar manner as the second embodiment. Where the same features are present in the third embodiment which are present in the second embodiment, the same reference numbers have been used.

Referring to these figures, the single leaf spring of the second embodiment has been replaced by two leaf springs 32, 34. The first leaf spring 32 which connects to the front 36 of the metal weight 20 also connects to the upper section 10 forward metal weight 20. The second leaf 34 spring connects to the rear 38 of the metal weight 20 which then connects to the top section, to the rear of the metal weight 20. The metal weight 20 can oscillate backwards and forwards as with the other two embodiments but is prevented from sideward movement due to the rigidity of the leaf springs 32,34.

In order to improve the performance of the leaf springs 32,34, each of the two leaf springs 32,34 are constructed from two layers 40,42 of sheet metal as best seen in Figure 5. The two sheets of metal 40,42 are located on top of each other as shown. This provides an improved damping performance when used in this application. It also provides better support for the metal weight and improves the damping efficiency.

Figures 8 to 19 shows a fourth embodiment of the anti-vibration mechanism.

This embodiment operates in a similar manner as the first embodiment. Where the same features are present in the fourth embodiment which are present in the first embodiment, the same reference numbers have been used.

A metal weight 50 is slideably mounted on two rods 52, the ends of which terminate in metal rings 54. The metal rings 54 are used to attach the rods 52 to the top section 10 of the housing 2 using screws 56 which pass through the rings 54 and are screwed into the top section 10. A cross bar 58 attaches between each pair of rings 54 as shown to provide a structure as shown.

Two sides of the metal weight 50 comprise a supporting mount 60 which are each capable of sliding along one of the rods 52. A spring 62 is located between each end of the rods 52 adjacent the rings 54 and a side of the supporting mounts 60. The four springs cause the metal weight 50 to slide to the centre of the rods 52. The springs are compressed. The ends of the springs adjacent the rings are connected to the ends of the rod. The other ends, abutting the supporting mounts are not connected to the supporting mounts, but are merely biased against them by the force generated by the compression of the springs.

As the hammer vibrates, the metal weight can slide backward and forwards along the rods out of phase with the vibrational movement of the vibrations of the hammer to counteract the effects of the vibrations.

The supporting mounts 60 are designed in such a manner that they comprise a sideways facing vertical C shaped slot 64 as best seen in the sketch Figure 18 (not enclosed electronically). This provides for easy assembly. It also allows the metal weight 50 to twist in direction of Arrow A in Figure as it slides along the rods 52. This enables the metal weight 50 to twist about a vertical axis 74 enabling it to counteract vibrations in a direction other than parallel to the longitudinal axis 66 of the spindle.

The supporting mounts 60 are also designed in such a manner that they comprise a sideways horizontal slot 68 as best seen in the sketch Figure 19 (not enclosed electronically). The two sides 70 of the horizontal slot 68 are convex as shown in the sketch . This also provides for easy assembly. It also allows the metal weight 50 to twist in the direction of Arrow B in Figure 19 whilst it is mounted on the rods 52. This enables the metal weight to twist about a horizontal axis 72 which is roughly perpendicular to the longitudinal axes of the rods 52. This also allows the metal weight 50 to counteract vibrations in a direction other than parallel to the longitudinal axis 66 of the spindle.

Figure 13A shows the metal weight 50 when it is slid around approximately 66% along the length of the rods 52 towards the right. The left hand springs 62 are larger in length due to being allowed to expand. The right hand springs 62 are shorter in length due to being compressed by the movement of the metal weight 50. However, in this position, the ends of the springs 62 abut against the sides of the supporting mounts 60 due to the force of the springs 62 as they are compressed. However, if the metal weight 50 is slid further along the length of the rods 52 towards the right, the left hand spring 62 disengages with the side of the supporting mount 60 due to the length of the spring 62 being shorter than the length of rod 52 along which the metal weight 50 can travel. This results in the right hand spring 62 only being in contact with the supporting mounts 60. As such, as the metal weight 50 slides right as shown in Figure 13A until the right hand springs 62 become fully compressed, only one spring 62 per rod 52 providing a dampening force on the metal weight 50.

This alters the spring characteristics of the vibration dampener. This enables the spring dampener to be designed so that, when the vibrations on the hammer are at their most extreme and metal weight 50 is travelling at the greatest distance from the centre of the rods 52 along the length of the rods 52, the spring characteristics can be altered when the metal weight 50 is at its most extreme positions to counteract this.

CLAIMS

1. A hammer drill comprising:

a body 2 in which is located a motor;

a tool holder 6 capable of holding a tool bit;

a hammer mechanism, driven by the motor when the motor is activated, for repetitively striking an end of the tool bit when the tool bit is held by the tool holder 6;

a counter mass 20; 50 slideably mounted within the body 2 which is capable of sliding in a forward and rearward direction between two end positions;

biasing means 22; 24; 32, 34;62 which biases the counter mass 20; 50 to a third position located between the first and second positions;

wherein the counter mass is located above the centre of gravity 9 of the hammer;

the mass of the counter mass 20; 50 and the strength of the biasing means 22; 24; 32, 34;62 being such that the counter mass 20; 50 slidingly moves in forward and rearward direction to counteract vibrations generated by the operation of the hammer mechanism.

2. A hammer drill as claimed in claim 1 wherein the hammer mechanism comprises a piston and ram having an axis 7 of travel wherein the counter mass 20; 50 is located above the axis of travel 7.

3. A hammer drill as claimed in claim 2 wherein the axis 7 of travel is located above the centre of gravity 9 of the hammer.

4. A hammer drill as claimed in claim 3 wherein the mass of the counter mass 20; 50 and the strength of the biasing means 22; 24; 32, 34;62 are such that the rearward and forward sliding movement of the counter mass20; 50 further counteracts the twisting movement (Arrow F) about the centre of gravity 9 generated by the vibrations generated by the operation of the hammer mechanism.

5. A hammer drill as claimed in any previous claim wherein the counter mass 50 is mounted so that it is further capable of twisting about a substantially vertical axis 74.

6. A hammer drill as claimed in any previous claim wherein the counter mass 50 is mounted so that it is further capable of twisting about a substantially horizontal axis 72.

7. A hammer drill as claimed in claim 6 wherein the substantially horizontal axis 72 is perpendicular to the direction of travel of the counter mass 50.

8. A hammer drill as claimed in any previous claim wherein the mass 20; 50 is slideably supported on at least one rod 18; 52 and is capable of sliding along a portion of the length of the rod 18;52.

9. A hammer drill as claimed in claim 8 wherein the at least one rod 18; 52 runs in a forward and rearward direction.

10. A hammer drill as claimed in either of claims 8 or 9 wherein the biasing means 22; 62 comprises at least one spring.

11. A hammer drill as claimed in claim 10 wherein the or all of the springs 22; 62 is a helical spring which surrounds the at least one rod 18; 52.

12. A hammer drill as claimed in claim 11 wherein a first end of the or all of the springs 22; 62 is connected to an end of the at least one rod 18; 52.

13. A hammer drill as claimed in claim 12 wherein a second of end of the at least one spring 22; 62 abut against counter mass 20; 50 when it is in the third position.

14. A hammer drill as claimed in claim 13 wherein, as the counter mass 50 slides over a central region of the at least one rod 52 between the its first and second positions, the or all of the springs 62, which abut against the counter mass 50 when it is in the third position, remain in contact with the counter mass 50 but which disengage from the counter mass 50 when it leaves the central region and approaches either its first or second positions.

15. A hammer drill as claimed in any one of claims 11 to 14 wherein there are at least two helical springs 22; 62 mounted the at least one rod 18; 52, at least one spring 22; 62 being located between a first end of the rod 18; 52 and the counter mass 20; 50, at least one second spring 22; 62 being located between a second end of the rod 18; 52 and the counter mass 20; 50.

16. A hammer drill as claimed in claim 15 wherein, as the counter mass 50 slides over a central region of the at least one rod 52 between the its first and second positions, both springs 62 remain in contact with the counter mass 50;
wherein when the counter mass 50 leaves the central region and approaches its first position, one of the springs 62 disengages from the counter mass 50, the second spring 62 remaining in contact;
wherein, when the counter mass 50 leaves the central region and approaches its second position, the second spring 62 disengages from the counter mass 50, the other spring 62 remaining in contact.

17. A hammer drill as claimed in any one of claims 8 to 16 wherein there are two rods 18; 52 which are mounted in parallel to each other.

18. A hammer drill as claimed in claim 17 wherein each rod 18; 52 comprises a pair of springs.

19. A hammer drill as claimed in any one of claims 8 to 18 wherein the counter mass 50 comprises at least one sideways horizontal slot 68 which engages with the at least one rod 52 to allow the counter mass 50 to twist about a horizontal axis 72.

20. A hammer drill as claimed in any one of claims 8 to 19 wherein the counter mass 50 comprises at least one vertical c shaped slot 64 which engages with the at least one rod 52 to allow the counter mass 50 to twist about a vertical axis 74.

21. A hammer drill as claimed in any one of claims 1 to 7 wherein the counter mass 20 is suspended by the resilient means, 24; 32, 34.

22. A hammer drill as claimed in claim 21 wherein the resilient means 24; 32, 34 is at least one leaf spring.

23. A hammer drill as claimed in any one of claims 21 or 22 wherein the resilient means 24 comprises a single leaf spring.

24. A hammer drill as claimed in any one of claims 21 to 23 wherein at least part of the length of the leaf spring 32, 34 is constructed in at least two layers 40; 42 of resiliently deformable material connected to or abut against each other along all, part or parts of their lengths.

The Patent Office

13

Application No:	GB0512721.2	**Examiner:**	Sarah Barker
Claims searched:	1-24	**Date of search:**	17 November 2005

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-4	EP 1464449 A2 (MAKITA) Whole document relevant
X	1-4	EP 1439038 A1 (MAKITA) See especially figures 2-3 and paragraph 29
X	1-4, 21	EP 1415768 A1 (ATLAS) Whole document relevant
X	1-4	US 4478293 A (WEILENMANN) See especially figure 2 and column 4 lines 3 - column 5 line 11
X	1	EP 1252976 A1 (BLACK & DECKER) See especially figures 1-2 and paragraphs 33-38

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

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B4C

Worldwide search of patent documents classified in the following areas of the IPC^{07}

B25D; F16F

The following online and other databases have been used in the preparation of this search report

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