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(54) Electrical switchgear.

(57) Electrical Switchgear having a pair of main electrodes in contact in a first ON position, an arcing electrode electrically connected to and rigidly connected to one of the main electrodes and a resilient contact element electrically connected to and resiliently mounted with respect to the other main electrode.

In operation the main electrodes move relative to one another from the first ON position through a second intermediate position to a third OFF position where, in the intermediate position the resilient contact element is in contact with the arcing electrode and in the OFF position the first and arcing electrodes are out of contact with the second electrode and resilient contact element. The switchgear being arranged such that the main electrodes can be moved from the third OFF position to the first ON position without the resilient contact element contacting the arcing electrode.

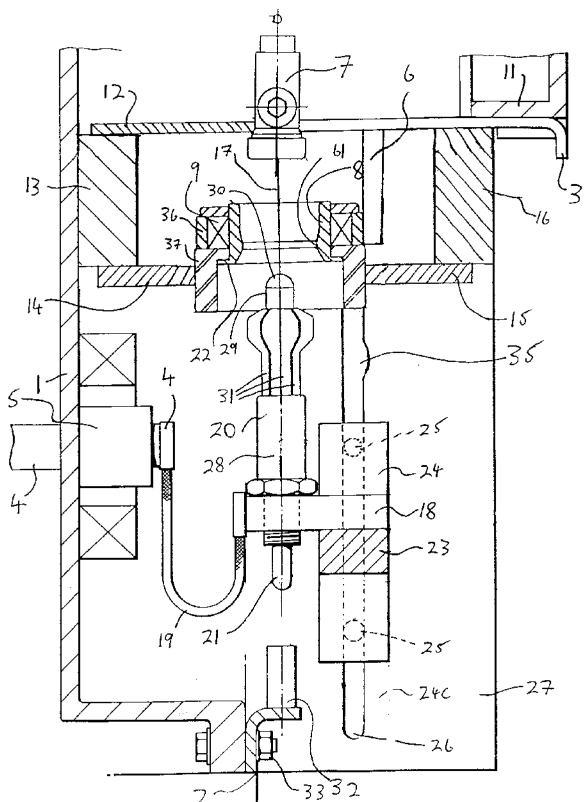

FIG. 1

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This invention relates to electrical switchgear, and particularly to circuit breakers.

Circuit breakers have to stop current flow in a circuit as rapidly as possible in the event of an accident or overload. A problem encountered by circuit breakers, particularly when stopping high current flows, is arcing as the circuit breaker opens and the circuit is broken. Such arcing can cause considerable damage and while the arc exists current continues to flow in the circuit, preventing rapid shut off. One known method of dealing with this problem is to provide separate main and arcing contacts in electrical parallel and to separate the main contacts before the arcing contacts to open the circuit breaker. This ensures that arcing occurs only between the arcing contacts which can be designed to withstand arcing while the main contacts can be designed purely for good current transmission.

There are two main problems with this arrangement, the first is caused by the fact that it is normal to place an arc extinguishing coil adjacent to and in electrical series with the arcing contacts so that the magnetic field generate by the coil helps extinguish the arc. Although the use of such a coil is necessary to ensure rapid arc extinction and has been used in known circuit breakers of this type for safety, the presence of a large reactive component in a power supply is electrically undesirable. The second problem is simply that known designs of this type use very complex mechanical drive systems to ensure that the two sets of contacts move at the correct times, the use of complex mechanical drives is generally undesirable on grounds of cost, but is particularly undesirable in a circuit breaker which must remain in a current transmitting position for long periods of time, generally months to years, and reliably move to a current blocking position in fractions of a second on demand.

Athough they are most pronounced in circuit breakers these problems are encountered in electrical switchgear generally, the larger the currents being switched the greater the problems become.

This invention was intended to produce electrical switchgear at least partially overcoming these problems.

This invention provides electrical switchgear comprising first and second main electrodes a third arcing electrode and a resilient contact element, the first and third electrodes being electrically connected together and attached to a first member and the resilient element being connected to the second electrode and the second electrode being connected to a second member, the second member being able to move relative to the first member between a first ON position and through a second intermediate position to a third OFF position, where in the ON position the main electrodes are in contact and the resilient element and the arcing electrode are out of contact, in the intermediate position the main electrodes are out of contact and the resilient element is in contact with the arcing electrode and in the OFF position the main electrodes are out of contact and the arcing electrode is out of contact with the resilient element, and also being able to move between the third OFF position to the first ON position without the resilient element and the arcing electrode coming into contact.

Apparatus employing the invention will now be described by way of example only with reference to the accompanying diagrammatic figures in which;

Figure 1 shows a cut away view of a first circuit breaker unit according to the invention;

Figure 2a shows the main part of the circuit breaker unit of Figure 1 in a first "OFF" position;

Figure 2b shows the same parts in a second "ON" position;

Figure 2c shows the same parts in a third "EARTH" position;

Figure 3 shows a perspective view of the moving electrode assembly of the circuit breaker unit of Figure 1 in perspective;

Figure 4 shows a cut away of a first design of the second main electrode and spring fingers of the circuit breaker unit of Figure 1 sectioned along the axis 17;

Figure 5 shows a cut away view of a second circuit breaker unit according to the invention;

Figure 6 shows a cut away of an alternative design of second main electrode and spring fingers suitable for use in either of the circuit breaker units of Figure 1 or Figure 5, identical parts having the same reference numerals throughout.

Referring to Figures 1 to 4 an A.C. circuit breaker unit is shown. This is a single phase unit and one such unit will be required for each phase of the electrical supply being switched, for example a conventional three-phase supply will need three such units.

The entire circuit breaker unit is enclosed within a sealed conductive earthed casing 1 containing sulphur hexafluoride (SF_6) gas. The casing 1 is earthed at a point 2. Not all of the casing 1 is shown.

In operation, alternating current passes through the circuit breaker unit between a first conductor 3 which is linked to a current source and a second conductor 4 which is linked to a current using circuit. The second conductor 4 passes through the casing 1 inside an insulating bush 5.

The first conductor 3, a contact block 6, a first, main, electrode 7, a third, arcing, electrode 8 and an arc extinguishing coil 9 are all rigidly connected to form a fixed contact assembly. The fixed contact assembly is fixed relative to the casing 1 and is attached to the casing 1 by a first insulating support 11 attaching the conductor 3 to the casing 1, and a second insulating support 12 attaching the first, main electrode 7 to a first insulating block 13 which is in turn attached to the casing 1 and third and fourth insulating supports 14 and 15 attaching the third, arcing, electrode

8 and the arc extinguishing coil 9 to the first insulating block 13 and a second insulating block 14 respectively, the second insulating block 14 is attached to the casing 1 and also provides support to the first conductor 3.

The first conductor 3 is in electrical contact with the contact block 6 and the first, main, electrode 7 which it supports. The third, arcing, electrode 8 is rotationally symmetrical about an axis 17 and is a substantialy cylindrical tube with an end portion 22 of increased radius. The arc extinguishing coil 9 is wound around the third, arcing, electrode 8 and the inner turn of the coil 9 is in electrical contact with the third arcing electrode 8. The outermost turn of the coil 9 is in electrical contact with the contact block 6. The coil 9 is surrounded and supported by a coil retaining ring 36 and a coil support moulding 37.

The second conductor 4 is electrically linked to a contact support bar 18 by a flexible connector 19. The contact support bar 18 supports and is electrically connected to a second, main, electrode 20 and a fourth, earthing, electrode 21. The contact support bar 18 and electrodes 20 and 21 form a moving contact assembly.

The contact support bar 18 is attached to an insulating support 23 which is in turn attached at one end to a carrier 24. The carrier 24 has a pair of pins 25 attached to it which pass through a slot 26 in a moulding 27 in the form of a planar sheet.

The insulating support 23 is attached at its second end to a second carrier 24 with pins 25 passing through a second slot 26 in a second moulding 27. This arrangement is identical to that described above and is omitted in Figure 1 for clarity.

Thus the moving contact assembly is normally constrained to only be able to move linearily parallel to the slots 23.

The second, main electrode 20 and fourth, earthing, electrode 21 are formed by the two ends of a single elongate conductor passing through the contact support bar 18.

Although this is a convenient method of providing the second, main, electrode 20 and fourth, earthing electrode 21, other constructions could of course be used.

The second, main, electrode 20 is rotationally symmetrical about the axis of symmetry 17 of the arcing electrode 8, which is parallel to the slots 26 so that as the moving contact assembly moves the second, main, electrode 20 moves along the axis 17.

The second, main, electrode 20 comprises a main body portion 28 adjacent the contact support bar 18, a head portion 29 having a rounded end 30 and five spring fingers 31 extending from the main body portion 28 and surrounding part of the head portion 29. The second, main, electrode 20 and spring fingers 31 are shown in more detail in Figure 4. Each spring finger 31 has a first portion 37 having a small radius and secured to the head portion 29 of the second, main, electrode 20 at the end of the spring finger 31 nearest the main body portion 28 of the electrode 20 and a second portion 38 of variable radius at the other end of the spring finger 31 which bulges away from the head portion 29 of the electrode 20, leaving a gap between the spring finger 31 and the head portion 29, and then comes back into contact with the head portion 29 of the electrode 20 at its end 39 nearest the rounded end 30 of the electrode 20. The ends 39 of the spring fingers 31 are free to move relative to the second, main, electrode 20 so that the second portions 38 of each spring finger 31 can flex. The outer surfaces of the spring fingers 31 are curved around the axis 17 so that all of the spring fingers 31 together form a structure circular in cross section and symmetrical about the axis 17. The outermost diameter of the spring fingers 31 is slightly less than the minimum inner diameter of the third, arcing, electrode 8.

A sixth earthing electrode 32 is fixed to the casing 1 by a bolt 33 and is in electrical contact with the casing 1.

In Figures 1 and 2A the moving contact assembly is shown in an OFF position.

When the moving contact assembly is in the ON position as shown in Figure 2B the first, main, electrode 20 and second, main, electrode 7 are in contact while the third, arcing, electrode 8 and spring fingers 31 are not in contact because the outside diameter of the spring fingers 31 is less than the inner diameter of the third, arcing, electrode 8, leaving a small clearance. This small clearance is sufficient because in the ON position the arcing electrode 8 and spring fingers 31 are at the same electrical potential. In the ON position the pins 25 are at first ends of the slots 26 and further movement of the moving contact assembly towards the fixed contact assembly is prevented by stops in the actuating mechanism (not shown) which operates the moving contact assembly. The contact of the pins 25 with the ends of the slots 26 could be used in place of the stops to prevent further movement but this is not preferred.

In the ON position a current path exists from the first conductor 3 through the first, main, electrode 7, the second, main, electrode 20, the contact support bar 18, and the flexible connector 19 to the second conductor 4.

In order to break the current path the moving contact assembly is moved along the slots 26 away from the fixed contact assembly (downwards in Figure 1) towards the OFF position shown in Figure 2A.

En-route the second, main, electrode 20 separates from the first, main, electrode 7 and as electrical contact between these two electrodes is broken an arc forms between them between the first, main, electrode 7 and the rounded head portion 30 of the second, main, electrode 20. This head portion 30 is formed of an arc resistant (also known as anti-arc) material. As the moving electrode assembly continues to move along the axis 17 one of the pins 25 in each slot 26 is urged into a detent 35 in one side of its respective slot 26. The detents 35 are positioned so that when the pins 25 are urged into them as the moving electrode assembly moves down the slots 26 the second, main, electrode 20 is moved sideways off the axis 17 into an intermediate position such that one of the spring fingers 31 is forced into contact with a raised ridge 61 of reduced diameter running around the inside of the third, arcing, electrode 8.

At this point in the movement of the moving electrode assembly from the ON to the OFF position a current path exists from the first conductor 3 to the second conductor 4, this current path passes from the first conductor 3 through the contact block 6, through the coil 9, and the third, arcing, electrode 8, through the spring fingers 31 and the second, main, electrode 20 to the electrode mounting block 18 and then through the flexible connector 19 to the second conductor 4. The current passes along this path in preference to the arc between the first, main, electrode 7 and the second, main electrode 20 and as a result this arc is extinguished.

As the moving electrode assembly continues its movement the pins 25 in the slots 26 leave the detents 35, recentering the spring fingers 31 on the axis 17 and as a result the spring fingers 31 move out of contact with the ridge 36 on the third, arcing, electrode 8. This breaking of contact generates an arc between the spring fingers 31 and the third, arcing, electrode 8 and as the moving contact continues to move towards the OFF position this arc transfers from the spring fingers 31 to the rounded head 30 of the second, main, electrode 20.

The separatiion of the second, main, electrode 20 and the third, arcing, electrode 8 continues to increase until the moving contact assembly stops in the OFF position shown in Figure 2A. In the OFF position the head portion 29 of the second, main, electrode 20 is positioned on the axis 17.

The arc between the second, main, and third, arcing, electrodes 20 and 8 is extinguished by the atmosphere of sulphur hexafluoride within the casing 1 and by the arc rotating magnetic field produced by the arc current passing through the coil 9. Both of these methods of arc extinction are well known and need not be discussed in detail here.

When the moving contact assembly reaches the OFF position the head portion 29 of the second, main, electrode 20 is situated on the axis 17 of the third, arcing, electrode 8 and coil 9, giving a symmetrical arrangement to give good arc rotation to ensure rapid arc extinction.

The larger radius end portion 22 of the third, arcing, electrode 8 and the rounded end 30 of the head portion 29 of the second, main, electrode 20 minimise the damage done by the arcing between them.

In the OFF position there is no current path between the first and second conductors 3 and 4.

From the OFF position of Figure 2A the moving contact assembly can be moved still further away from the fixed contact assembly into an EARTH position, shown in Figure 2C, where the fourth, earthing, electrode 21 is in contact with the fifth, earthing, electrode 32. In the earthing position the pins 25 are at the second ends of the slots 26 and the moving contact assembly is at its farthest possible position from the fixed contact assembly. This provides an earthing current path for the conductor 4 by way of the flexible connector 19, contact support bar 18, the fourth and fifth earthing electrodes 21 and 32 and the casing 1, earthing the external circuit supplied by the conductor 4.

When the moving contact assembly is moved from the OFF position shown in Figure 2A to the ON position shown in Figure 2B the pins 25 are urged against the opposite sides of the slots 26 which are flat and have no detents so the second, main, electrode 20 remains on the axis 17 throughout this movement and as a result no contact is made between the spring fingers 31 and the third, arcing, electrode 8 during this movement and the first electrical contact is made between the first and second main electrodes 7 and 20.

Referring to Figure 5 a second AC circuit breaker is shown which operates in substantially the same manner as the circuit breaker of Figure 1 and as described with reference to Figures 2a to 2c but employs a different mechanism for moving the second, main, electrode 20.

As can be seen the circuit breaker is substantially the same as the circuit breaker shown in Figure 1. In this case the contact support bar 18 supports and is in electrical contact with a second, main, electrode 20 and a fourth, earthing, electrode 21 to form a moving contact assembly and is attached to an insulating support 51. The contact support bar 18 is attached to the insulating support so as to allow sliding movement of the contact support bar 18 relative to the insulating support 51 in a direction perpendicular to the axis 17. The extent of this sliding movement is controlled by surfaces of the contact support bar 18 and insulating support 51 coming into contact and a spring 52 is provided to bias the contact support bar 18 relative to the insulating support 51 at one end of its available range of movement where the second, main, electrode 20 is on the axis 17.

The insulating support 51 is attached at one end to a carrier 53. The carrier 53 has four rollers 54 attached to it for rotation about four respective parallel axes 55. The rollers 54 rotate in contact with and two on each side of a track member 56.

The track member 56 has two parallel planar faces 57 and 58 on which the rollers 54 bear.

The insulating support 51 is similarly attached at its opposite end to a second carrier 53 bearing four rollers 54 arranged on two sides of a second track member 56. This arrangement is identical to that described above and is omitted from Figure 5 for clarity.

Thus the moving contact assembly is normally constrained to only be able to move linearly parallel to the track member 56 and the axis 17 and as a result the second, main, electrode 20 is normally constrained to move along the axis 17.

A racheting cam mechanism 59 is arranged to have a projecting cam portion 60 which contacts the end of the contact support bar 18 remote from the second, main, electrode 20 as the moving contact assembly moves along the track member 56 from the ON position to the OFF position and vice versa

When the moving contact assembly is moved from the OFF position to the ON position the racheting cam mechanism 59 allows the contact support bar 18 to travel past the cam 60 without moving the contact support bar 18 out of the rest position it is biased into by the spring 52. As a result when the moving contact assembly moves from the OFF position to the ON position the second, main, electrode 20 travels only along the axis 17 and the spring fingers 31 do not come into contact with the arcing electrode 8.

When the moving contact assembly is moving from the ON position to the OFF position the cam 60 of the racheting cam mechanism 59 urges the contact support bar 18 to slide relative to the insulating support 51 against the bias of the spring 52 as the variable radius portions 38 of the spring fingers 31 are passing through the arcing electrode 8. The cam 60 causes the contact support bar 18 and thus the second, main, electrode 20 and attached spring fingers 31 to be moved off the axis 17 sufficiently to bring the variable radius portion 38 of at least one of the spring fingers 31 into contact with the raised ridge 61 of reduced diameter inside the third, arcing, electrode 8.

As a result the making and breaking of contact and arc formation and extinction are substantially the same in operation as in the circuit breaker described with reference to Figures 1 to 4.

In either example, the spring fingers 31 could by have flat facets instead of being curved, or have a combination of flat and curved surfaces in the region 38 or could be replaced by some other form of resilient conductive element.

Referring to Figure 6 an alternative construction of the second, main, electrode 20 is shown in cross section along its axis of symmetry 40. In this case the second, main, electrode 20 comprises a main body portion 41, a head portion 42 having a rounded end 43 and five spring fingers 44.

In this design the main body portion 41 does not extend all the way to the contact support bar 18 but is separated from a contact support bar 18 by a substantially cylindrical conductive sleeve 45. The conductive sleeve 45 has an inwardly projecting circular flange 46 within it to define a cup shaped volume. A bolt 47 passes through a bore 49 in the contact support bar 18 along the axis of the conductive sleeve 45 and into a cylindrical threaded bore 49 within the main body portion 41 so that when the bolt 47 is tightened within the threaded bore 49 the main body portion 41 of the second, main, electrode 20 is pulled towards the flange 46.

In this case the spring fingers 44 are arranged with their ends remote from the head portion 42 of the second, main, electrode 20 folded inwards so that they lie between the end of the main body portion 41 and the flange 46. As a result tightening of the bolt 47 within the threaded bore 49 holds the spring fingers 44 as well as the main body portion 41 in place.

In this design, it is not possible to form the earthing electrode from the main body portion of the second, main, electrode 20 as in the previous example because the main body portion 41 in this design does not pass through the contact support bar 18. In the example shown the earthing electrode is formed by a conductive strip 50 secured to the contact support bar 18 by the head of the bolt 47 and bent through a right angle to form an earthing electrode parallel to the axis 40.

It will be realised of course that there are many other ways of finding an earthing electrode in arrangements of this type.

The connection of the contact support bar 18 to the second conductor 4 has been omitted from Figures 3 and 6 for clarity.

Any other electronegative gas could be used to replace the sulphur hexafluoride.

In the switchgear of Figures 1 to 5 the flexible connector 19 could be replaced by a sliding or pivoting contact arrangement.

There are of course many alternative mechanical constructions which could be used in the switchgear. In particular the structure used to support and electrically link the fixed contacts could be altered and any mouldings used could be replaced by equivalent structures formed in other ways.

Claims

1. Electrical switchgear comprising first and second main electrodes a third arcing electrode and a resilient contact element, the first and third electrodes being electrically connected together and attached to a first member and the resilient element being connected to the second electrode and the second electrode being connected to a second member, the second member being able to move relative to the first member between a first ON position and through a second intermediate position to a third OFF position, where in the ON position the main electrodes are in contact and the

resilient element and the arcing electrode are out of contact, in the intermediate position the main electrodes are out of contact and the resilient element is in contact with the arcing electrode and in the OFF position the main electrodes are out of contact and the arcing electrode is out of contact with the resilient element, and also being able to move between the third OFF position to the first ON position without the resilient element and the arcing electrode coming into contact.

2. Electrical switchgear as claimed in claim 1 where a plurality of resilient elements are secured to the second electrode.

3. Electrical switchgear as claimed in claim 2 where the resilient elements surround the second electrode.

4. Electrical switchgear as claimed in any preceding claim where the or each resilient element is a spring finger.

5. Electrical switchgear as claimed in any preceding claim in which the second member bears a pair of pins which move along a slot which is fixed relative to the first member, the slot having two walls with different profiles and the pins being constrained to follow one wall when moving from the ON to the OFF position and the other wall when moving from the OFF to the ON position such that the path followed by the second member relative to the first member is different when moving in each direction.

6. Electrical switchgear as claimed in claim 5 in which one wall of the slot is straight along its entire length and the other wall of the slot is straight along most of its length but bears a detent into which one of the pins is urged when the pin is moving along the slot in one direction only.

7. Electrical switchgear as claimed in any one of claims 1 to 4 in which cam and rachet means are provided, the cam and rachet means being arranged to act on the second member so that the path followed by the second member relative to the first member is different when moving from the ON to the OFF position from the path followed when moving from the OFF to the ON position.

8. Electrical switchgear as claimed in claim 7 in which the cam and rachet means comprises a rachet mechanism which causes a cam to act on the second member when moving in one direction only.

9. Electrical switchgear as claimed in claim 8 in which the cam acts on the second member only when moving from the ON to the OFF position.

10. Electrical switchgear as claimed in any preceding claim where the electrical switchgear is a circuit breaker.

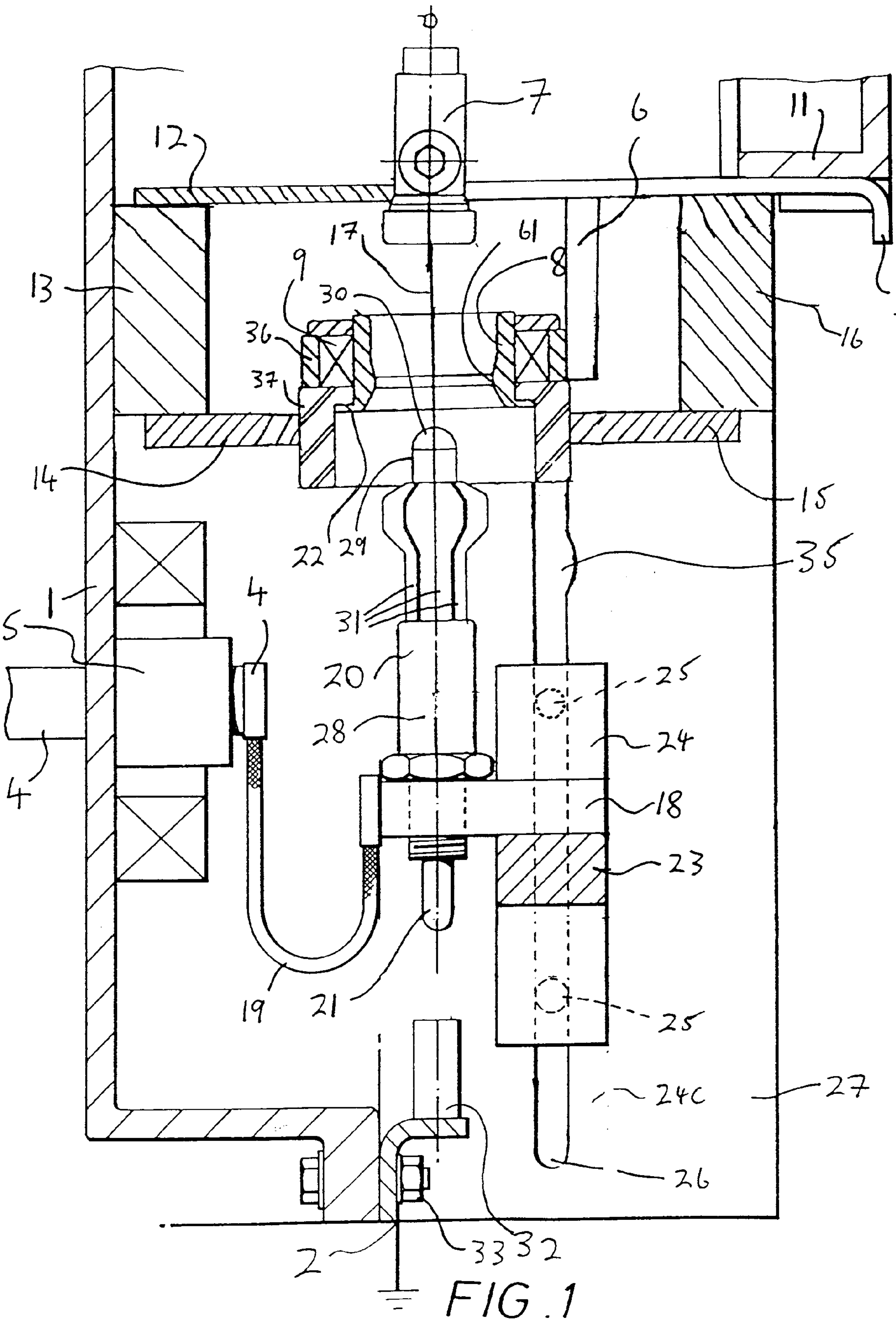
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FIG.1

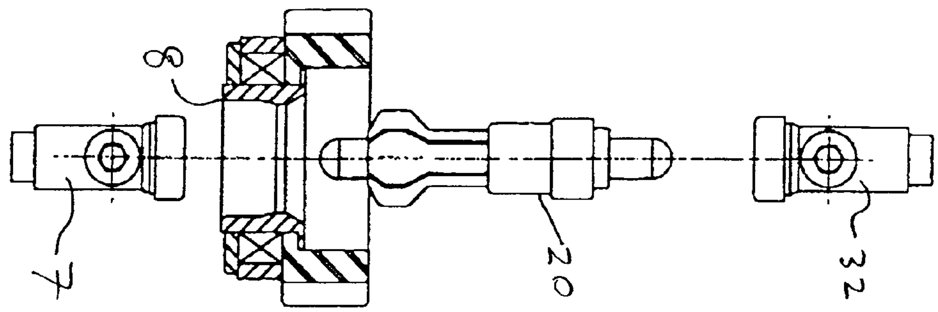

Fig 2 A

OFF

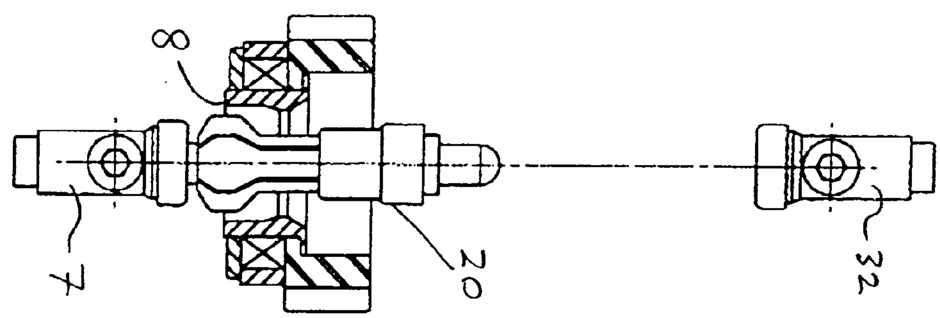

Fig 2 B

ON

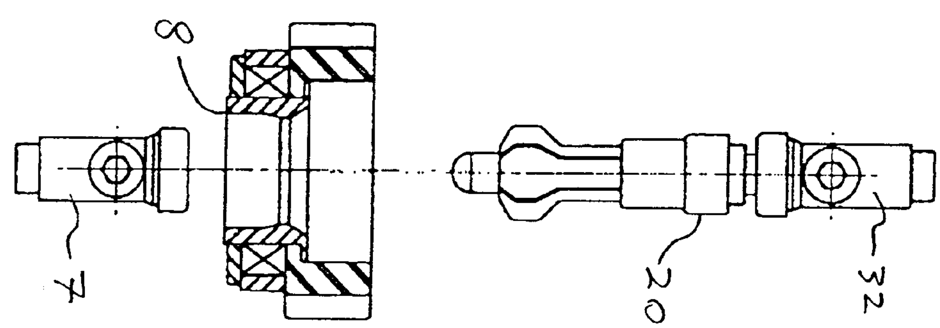

Fig 2 C

EARTH

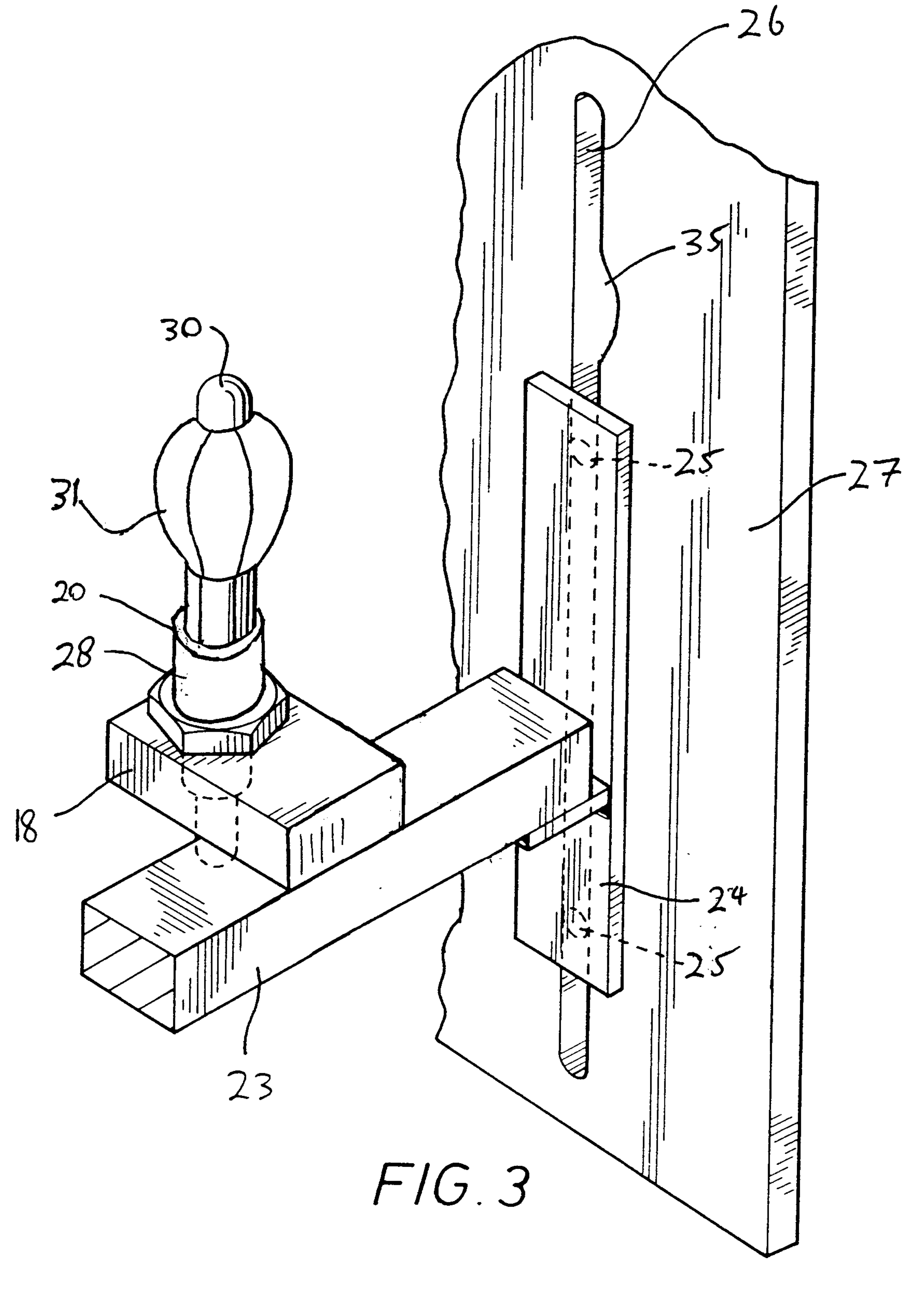

FIG. 3

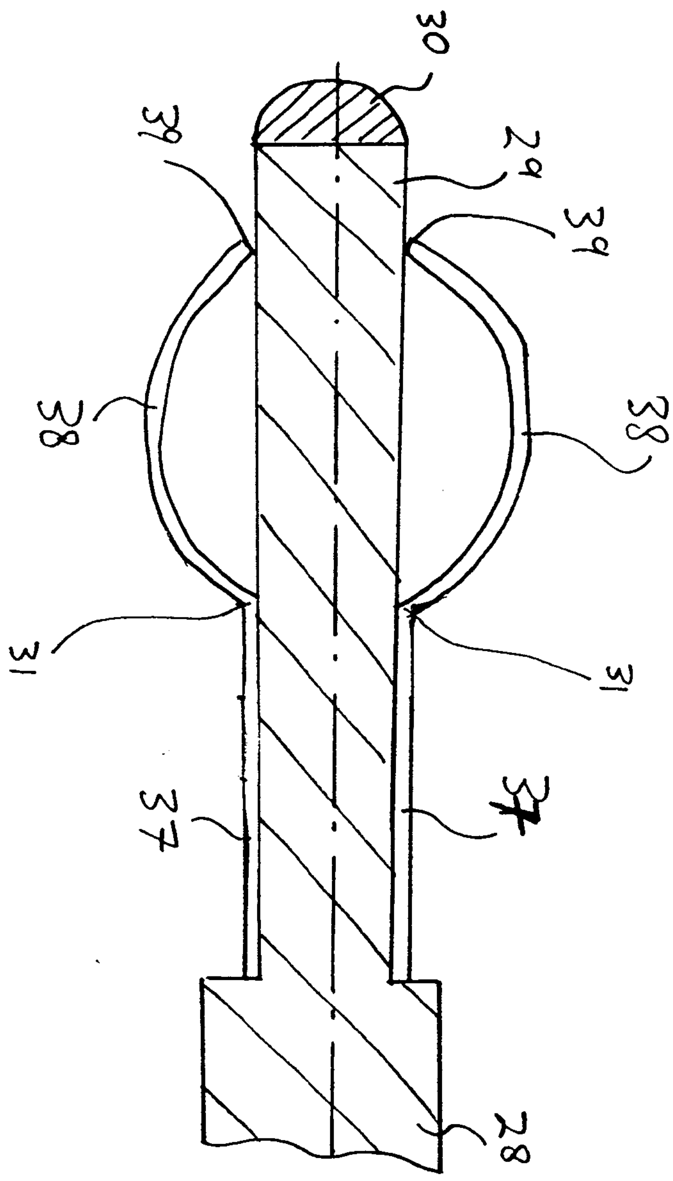

Fig 4

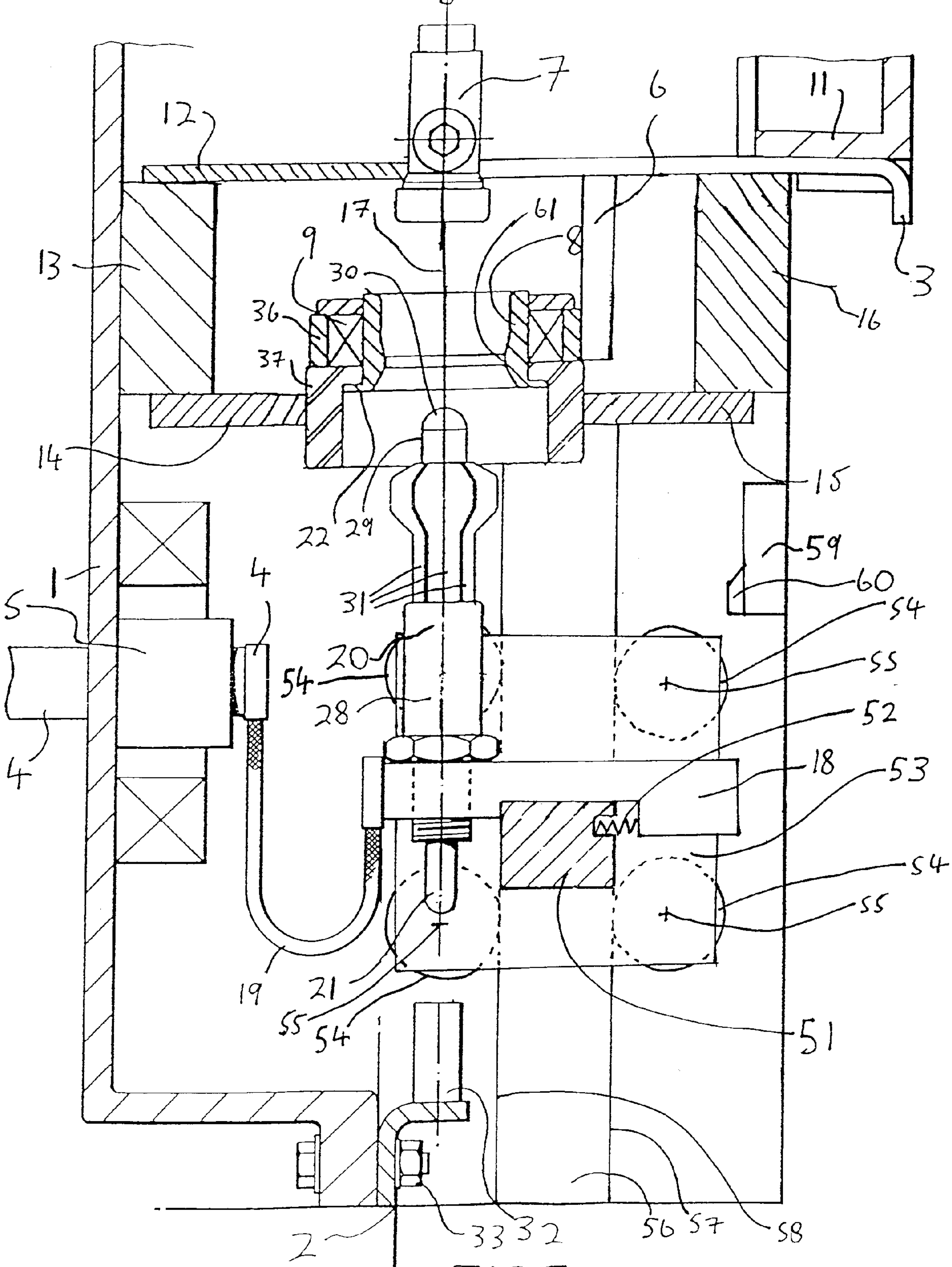
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FIG 5

Fig 6