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(54) **Magnetic sensor module for a ground fault circuit interrupter.**

(57) The neutral excitation transformer and differential current transformer (15,16) of a ground fault circuit interrupter device are mounted on a common electrically insulated support having downwardly extending pins for inserting into the printed wire board (18) of the electronic signal processor circuit. A metal can electromagnetic shield having four prongs extending from its bottom end is mounted to the support by means of three of the prongs while the fourth prong is inserted within the printed wire board for electrical connection with the signal processor circuit.

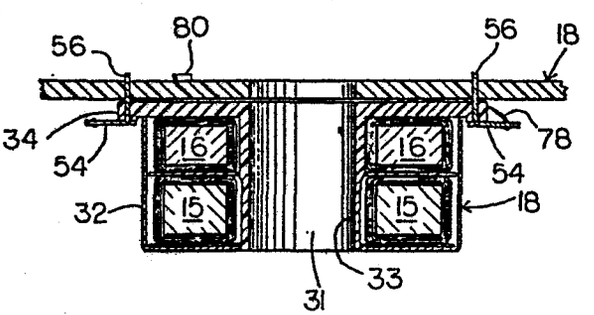


FIG.5

EP 0 154 171 A1

# MAGNETIC SENSOR MODULE FOR A GROUND FAULT CIRCUIT INTERRUPTER

## BACKGROUND OF THE INVENTION

Ground fault circuit interrupting (GFCI) devices, as currently available, are capable of interrupting fault current in the range of 4 to 6 milliamps. Circuits for such devices are described in U.S. Patents 4,345,289 and 4,348,708, both of which are in the name of Edward K. Howell. The circuits described therein basically include a current sensor or magnetics, a signal processor or electronics and an electronic switch. The magnetics consist of a differential current transformer which responds to a current imbalance in the line and neutral conductors of the distribution circuit. This current imbalance is amplified by the signal processor pursuant to triggering the electronic switch and thereby complete an energization circuit for the trip solenoid. The current sensor also includes a neutral excitation transformer for responding to a ground fault on the neutral conductor.

A mounting arrangement for the GFCI device is described in U.S. Patents 3,950,677 and 4,001,652 to

Keith W. Klein et al. In the Klein et al GFCI device, the signal processor electronics is carried on a printed wire board and is positionally mounted and retained in one shell compartment of a GFCI receptacle casing. The magnetics are positionally mounted in another shell compartment within the receptacle and are locked in place by the insertion of single turn transformer winding elements. This GFCI assembly, although compact, does not readily lend to a fully automated assembly process since the magnetics contain two separate transformers which require electrical interconnection with each other as well as with the circuit electronics. To date, the electrical interconnection of the magnetics with the electronics has accounted for a good percentage of the time involved in the GFCI assembly process.

The purpose of this invention is to provide a plug-in magnetic sensor module which contains both the differential current transformer and neutral excitation transformer in a single unitary structure which can be robotically pre-assembled.

## SUMMARY OF THE INVENTION

A GFCI device is adapted for completely automated assembly by a pre-assembled magnetic sensor module consisting of a unitary arrangement of the neutral excitation transformer and differential current transformer on an insulating support having electrically conductive stabs for plug-in connection with the printed wire board electronics. An electromagnetic shield is provided by electrically connecting the metallic closure surrounding the sensor module with the printed wire board. Metal tabs formed at the bottom of the closure serve to mechanically fasten the closure to the insulating support and to electrically connect the closure with the wire board electronics without requiring any wires.

## BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a front perspective view of a GFCI assembly according to the prior art;

Figure 2 is an electrical schematic of the signal processor electronics used within the GFCI of Fig. 1;

Figure 3 is an exploded front perspective view of the magnetic sensor module of the invention prior to assembly;

Figure 4 is a bottom view of the insulating pedestal shown in the magnetic sensor module of Fig. 3;

Figure 5 is a front view of the pedestal of Fig. 4 in partial section;

Figure 6 is an exploded top perspective view of the GFCI components prior to assembly; and

Figure 7 is a front perspective view of the GFCI components completely assembled.

## GENERAL DESCRIPTION OF THE INVENTION

The electrical interconnect arrangement of the invention for allowing plug-in of a magnetic sensor module within an automated GFCI device can be better understood by referring first to the state of the art GFCI device 10 depicted in Figure 1 and the electronics module 11 depicted in Figure 2. The electronics module is described in detail in the aforementioned patents to Howell which are incorporated herein for purposes of reference. The magnetics 12 consists of a differential current transformer core 13 and a neutral transformer core 14 for encircling the line and neutral conductors L, N. The differential transformer secondary winding 15 and the neutral excitation transformer secondary winding 16 interconnect with an amplifier chip 17 for amplifying the ground fault currents detected and for operating an SCR and trip coil solenoid TC to open the switch

contacts. A plurality of discrete circuit elements such as capacitors $C_1$-$C_6$ and resistors such as $R_1$-$R_6$ are required for current limitation and noise suppression. A test switch SW is used for directly connecting the trip coil solenoid through a current limiting resistor, such as $R_3$, whereby the circuit between the line and neutral conductors is complete and the switch contacts are opened to test the circuit.

The arrangement of the electronics module 11 within the prior art GFCI device 10 is provided by means of a printed wire board 18 which carries the discrete elements such as the resistors, capacitors, SCR and the amplifier chip 17. The electronics module 11 is interconnected with the magnetics 12 by means of a plurality of wires generally indicated as 19. The magnetics consisting of differential current transformer 21, containing core 13 and winding 15, and neutral excitation transformer 20 containing core 14 and winding 16, are secured to the underside of a mounting platform 27. The line and neutral conductors L, N connect with the magnetics 12, electronics module 11 and with the switch SW consisting of movable and fixed contacts 22, 23 supported on the mounting platform 27 by means of a pedestal 25. The TC solenoid is mounted subjacent the movable and fixed contacts 22, 23 and operates to open the contacts upon the occurrence of ground fault current through either or both of the transformers. Four posts 28 depending from the bottom of the mounting platform 27 provide requisite clearance between the mounting platform and the bottom cover (not shown) of the device for the printed wire board 18.

It was determined that by concentrically arranging the differential current transformer 21 and the neutral excitation transformer 20 in a compact assembly around a

common aperture, the pedestal 25 and mounting platform 27 could be eliminated and the magnetics 12 could then be directly mounted to the printed wire board 18 eliminating the connecting wires 19. Further, the line and neutral conductors L, N could be sensed by tubular conductors through the assembly aperture, without the need for passing the conductors through the centers of the neutral excitation and differential current transformers as with the prior art.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The GFCI magnetic sensor module 30 is assembled as depicted in Fig. 3 as follows. The insulating pedestal 34 is formed with an upright insulating cylinder 33 and three formed slots 81 along the outer perimeter and one slot 82 formed inboard from the perimeter. The perimeter slots receive three corresponding tabs 80 depending from the bottom of the metallic closure 32, which tabs are bent under the pedestal to secure the closure when the module assembly is completed. The fourth tab 80 is inserted through slot 82 for purposes which will be discussed in some detail below. Four angular slots 83 are formed along the perimeter of pedestal 34 for receiving the secondary leads 78 connecting with the neutral transformer winding 16 toward the front of pedestal 34 and the differential transformer leads 77 connecting with the differential transformer winding 15 through the slots 83 toward the rear of the pedestal. Both pairs of leads 77, 78 are wrapped and soldered to terminals 54, also provided along the perimeter of the pedestal. The raised platform 84 supporting each of the terminals 54 electrically insulate the terminals from the metallic closure 32 when mounted to the pedestal. The neutral

winding 16 is first arranged around the insulated cylinder 33 and a first insulating disk 79 is placed over the neutral winding. The differential transformer winding 15 is arranged on the first insulating disk 79 and a second insulating disk 79 is placed over the differential transformer winding to insulate the winding from the metallic closure 32.

The completely assembled magnetic sensor module 30 is shown in Figure 4 as viewed from the bottom with the concentric aperture 31 extending through the pedestal 34. Tabs 80 are shown folded over the bottom of the pedestal within peripheral slots 81 with tab 80 extending through slot 82. Four pins 56 depend vertically from the pedestal and electrically connect with the four terminals 54. The neutral secondary winding leads 78 and the differential current secondary winding leads 77 are connected to the four plugs.

The connection between the magnetic sensor module 30 and the printed wire board 18 that carries the electronic circuitry for the GFCI device is shown in Figure 5. The electrical interconnection arrangement which is inserted within the central aperture 31 after plugging the magnetic sensor module into the wire board is omitted along with the circuit elements mounted on the printed wire board for purposes of clarity. The downward depending pins 56 are received within the printed wire board for electrical connection between the differential transformer and neutral transformer windings with the electronic circuit carried by the printed wire board. The metallic closure tab 80 also extends into the printed wire board in order to electrically connect the closure which allows the

closure to provide electromagetic shielding to the sensitive differential current and neutral secondary windings 15, 16, as indicated. When the interconnections are made within the central aperture 31 as described within U.S. Patent Application 579,336 , which application is incorporated herein for purposes of reference, the magnetic sensor module 30 then becomes a plug-in subassembly as generally depicted at 29 in Figure 6.

The magnetic sensor subassembly 29 is shown in Fig. 6 plugged into the printed wire board 18. Also shown mounted on the wire board is the trip solenoid 65 located between the line and neutral terminal screws 52, 53. The magnetic sensor module subassembly and printed wire board are placed within the GFCI case 57 and cover 66 is then positioned over the case and screws 67 are inserted through holes 68 to attach the cover to the case and complete the assembly. The mechanism assembly shown generally at 62 is the subject of U.S. Patent Application 579,627 , which application is incorporated herein for purposes of reference. Details concerning the operation of the mechanism assembly can be obtained by referring to that application. Prior to mounting the mechanism assembly within case 57, yoke 58 is attached to the case by fitting slots 59 which are formed within the yoke side rails 74 over corresponding detents 60 formed in the case. Yoke 58 has mounting screws 61 for ease in attaching the GFCI device. A neutral terminal screw slot 76 and a line terminal screw slot 75 are formed on opposite sides of the case and are located such that the line terminal and neutral terminal screws 52, 53 are accessible when the printed wire board 18 and magnetic sensor module subassembly 29 are inserted within the case.

The completely assembled GFCI device 69 is shown in Fig. 7 with a test button 71 and a reset button 72 arranged above a single outlet receptacle 70 which extend through yoke 58. Both the line terminal screw 52, load line terminal screw 64 and ground screw 73 are conveniently accessible for electrical connection.

It is thus seen that an automated assembly process for GFCI devices is made possible by positioning the magnetic sensor module subassembly 29 within the printed wire board 18 prior to connection with the mechanism assembly 62 already assembled within case 57 as depicted in Fig. 6. The configuration and order of assembly of the components within the magnetic sensor module 30 depicted in Fig. 3 which provide for the electrical interconnection of the differential transformer secndary winding 15 and the neutral transformer secondary winding 16 with printed wire board 18 without the need for external wire connections is a key factor in allowing the assembly process to become automated.

CLAIMS

1. A magnetic sensor comprising:
first and second transformers arranged on an electrically insulative support;
terminal means on said support for providing electrical connection with windings within said transformers; and
closure means around said transformers for retaining said transformers on said support.

2. The sensor of claim 1 wherein said first transformer comprises a first annular core member and wherein one of said windings is arranged around said first core.

3. The sensor of claim 2 wherein said first transformer comprises a differential current transformer for providing an output voltage when electric current flow through a first conductor arranged through said annular core differs from electric current flow through a second conductor arranged through said first core.

4. The sensor of claim 1 wherein said second transformer comprises a second annular core member and wherein the other of said windings is arranged around said second core.

5. The sensor of claim 4 wherein said second transformer comprises a neutral excitation transformer.

6. The sensor of claim 1 further including an electrically insulative spacer between said first and second transformers.

7. The sensor of claim 1 wherein said insulative support comprises a base and a cylinder, said cylinder extending upright from said base and having an aperture which extends through said base.

8. The sensor of claim 7 wherein said first and second transformers are arranged one over the other around said cylinder.

9. The sensor of claim 8 wherein said base and said cylinder are integrally formed from plastic material.

10. The sensor of claim 7 wherein said terminal means comprises a plurality of metal pins arranged around opposite corners of said base and extending downward through said base to provide means for connecting said sensor to a printed wire board.

11. The sensor of claim 10 wherein a first pair of said metal pins are electrically connected to said first transformer and a second pair of said metal pins are electrically connected to said second transformer.

12. The sensor of claim 7 wherein said closure means comprises a cylinder having a top, botton and continuous side wall extending between said top and said bottom.

13. The sensor of claim 12 wherein said cylinder top includes an opening concentric to said first and second transformers for receiving a pair of electrical conductors through said first and second transformers.

14. The sensor of claim 13 wherein said cylinder bottom is open for receiving said insulative support base.

15. The sensor of claim 14 further including a plurality of tabs extending from said side wall proximate said bottom for mechanically engaging with said insulative support base.

16. The sensor of claim 15 wherein a number of said tabs are bent around a bottom of said insulative support base and one of said tabs extends through a slot formed within said support base.

17. The sensor of claim 16 wherein said cylinder comprises an electrically conductive metal and wherein said one extending tab provides electrical connection with said cylinder through said support base.

18. The sensor of claim 17 wherein said cylinder further comprises a magnetic metal for providing electromagnetic-shielding to said first and second transformers.

19. The sensor of claim 12 wherein said insulative support base includes a plurality of slots outboard from said base aperture for allowing passage of wire through said insulative support base for connecting with said first and second transformers.

20. The sensor of claim 1 wherein one of said first and second transformers comprises a current transformer.

21. The sensor of claim 19 wherein said wire slots are immediately subjacent an outer diameter of said first and second transformers and an inner diameter of said closure cylinder for facilitating passage of said wire through said support base.

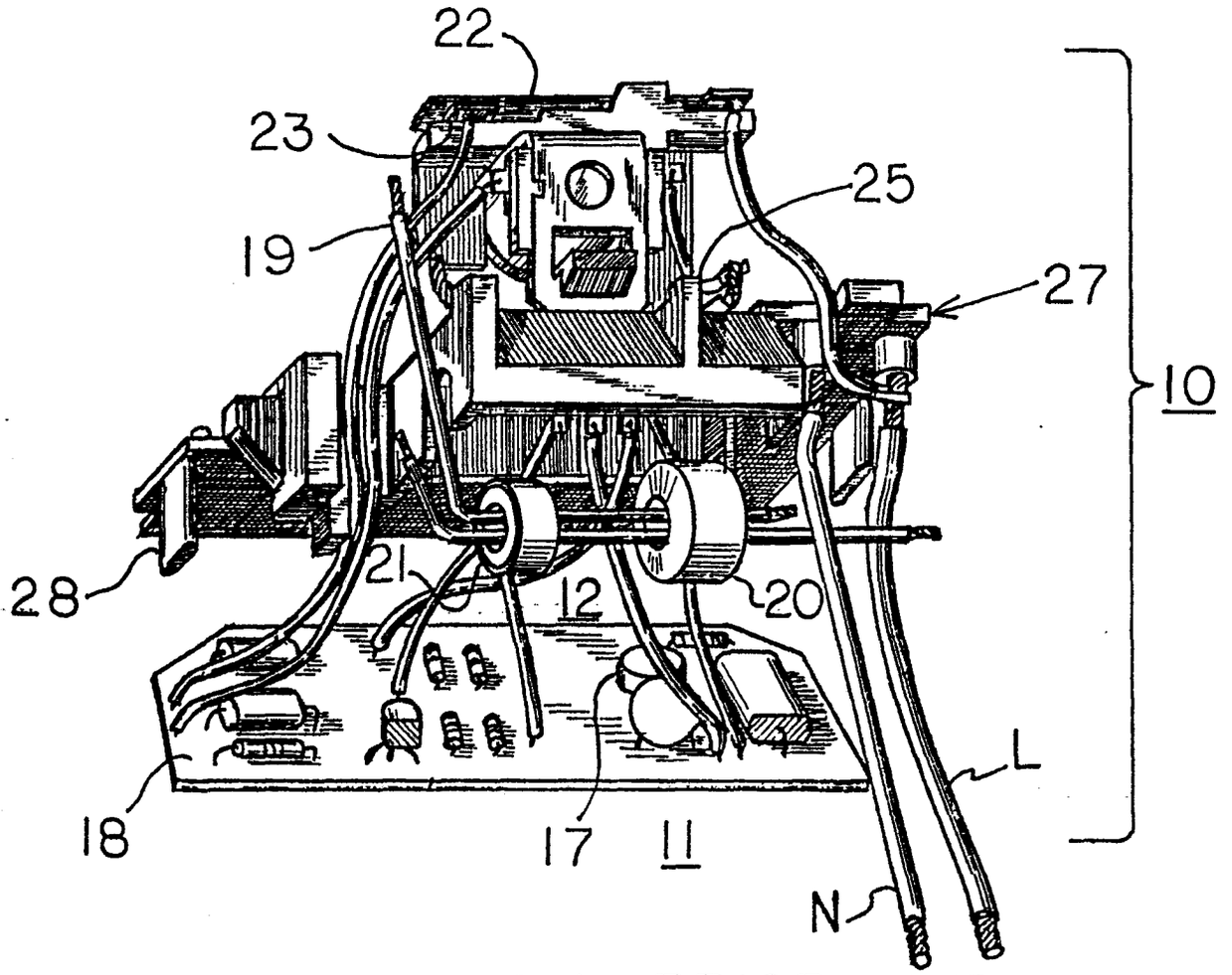


FIG.1 PRIOR ART

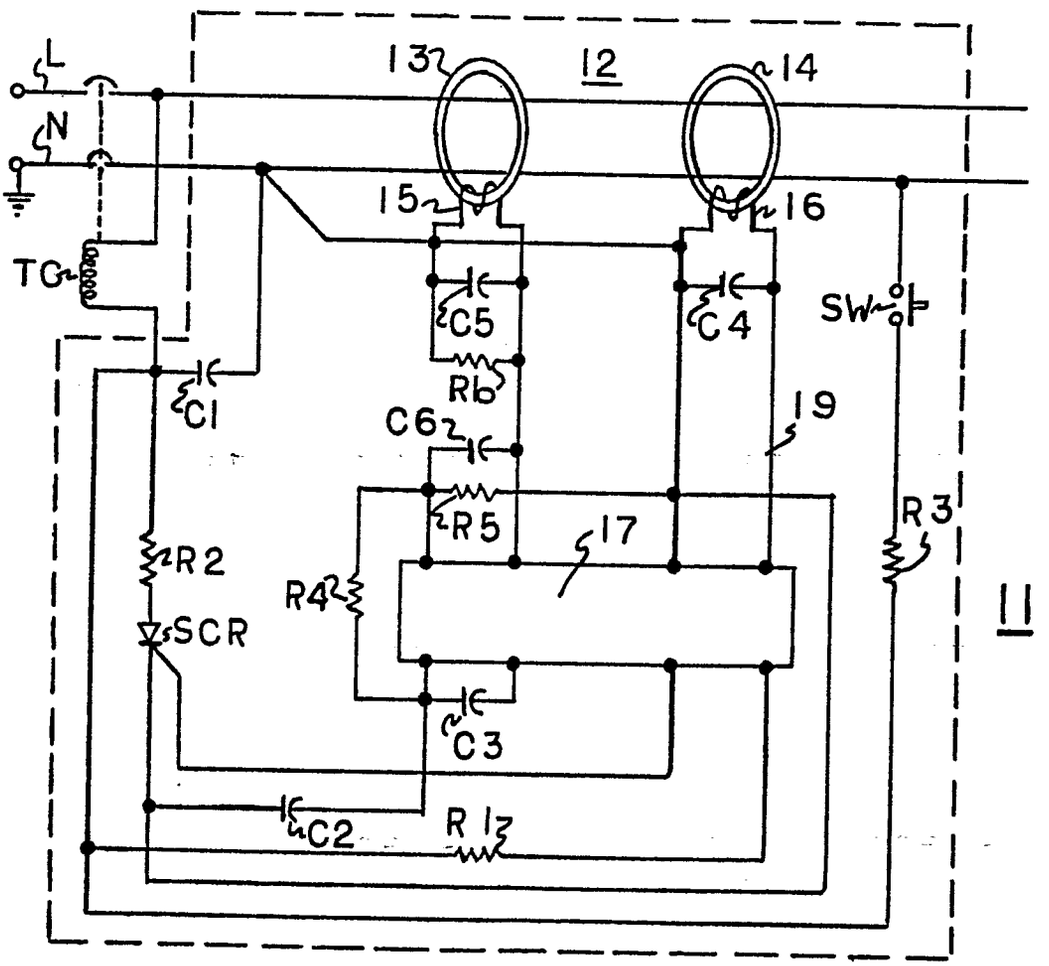


FIG.2 PRIOR ART

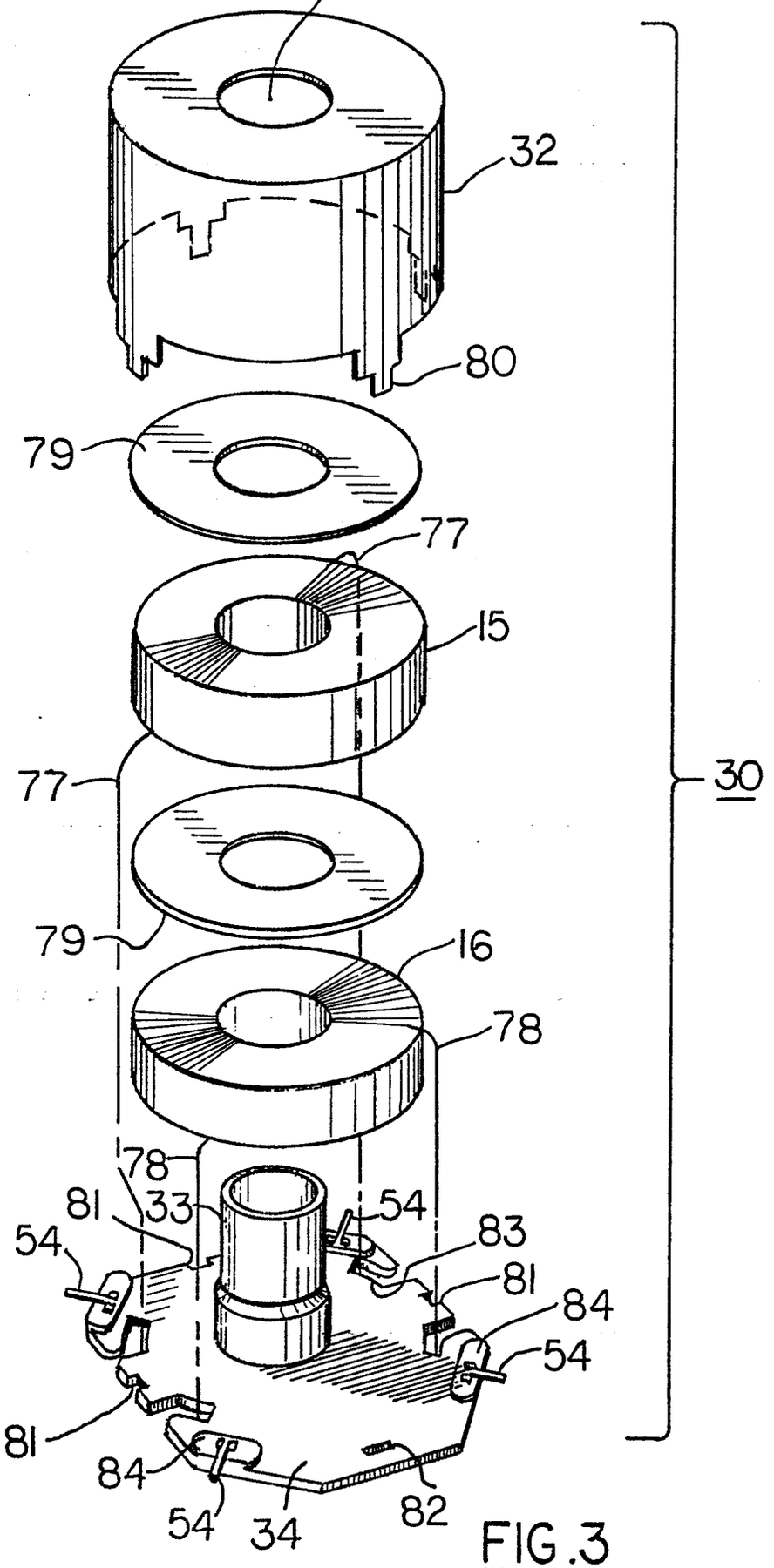
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FIG.3

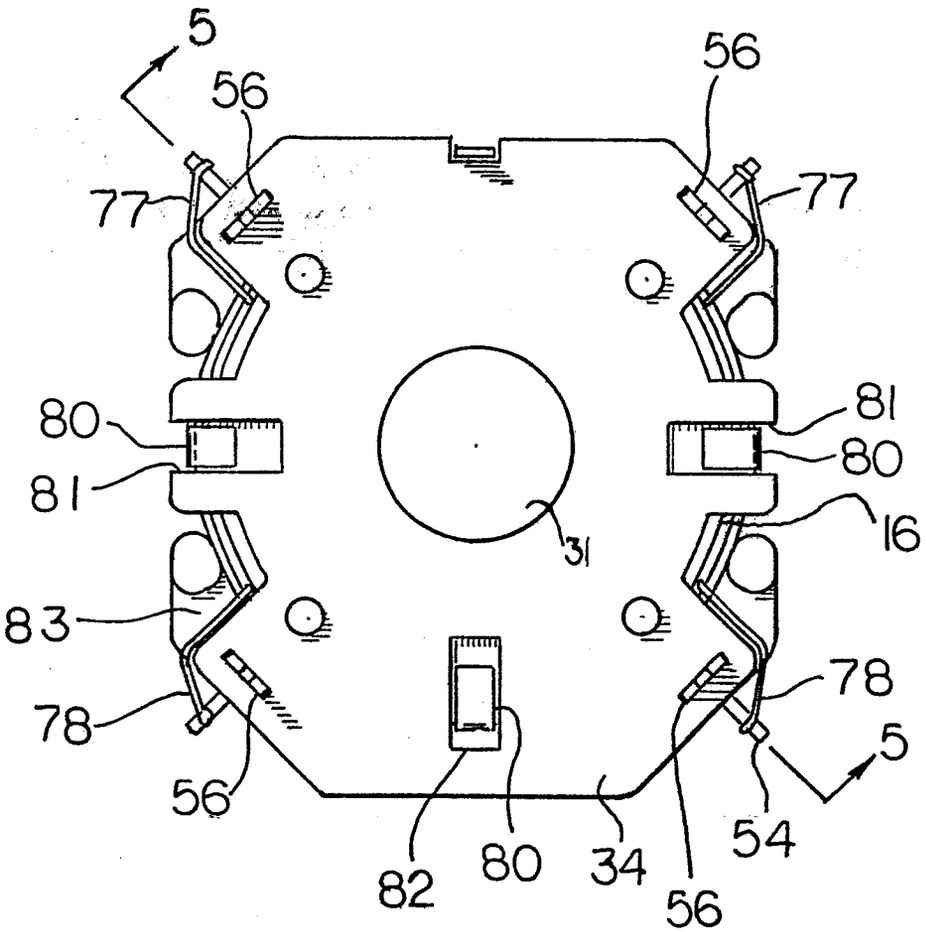
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FIG.4

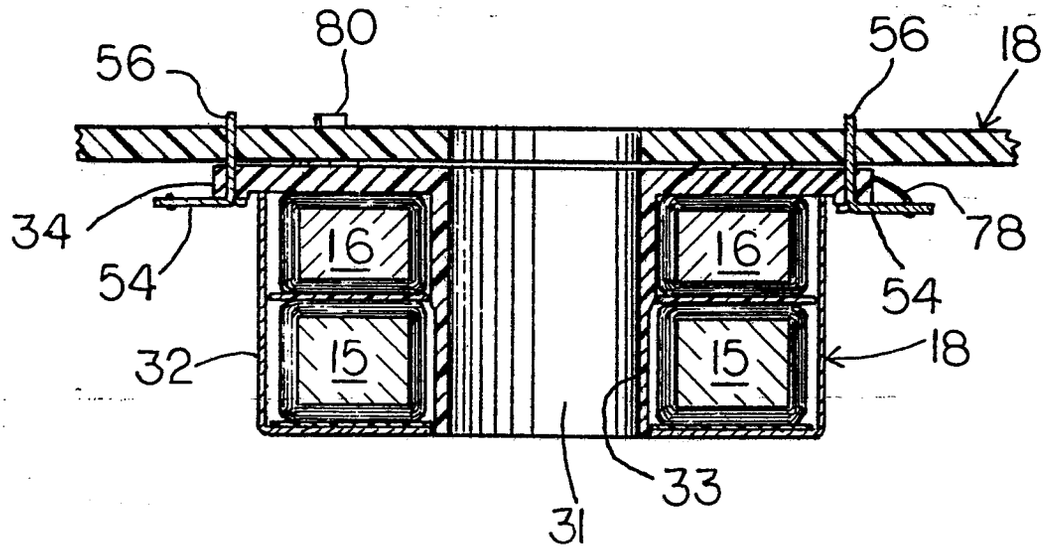
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FIG.5

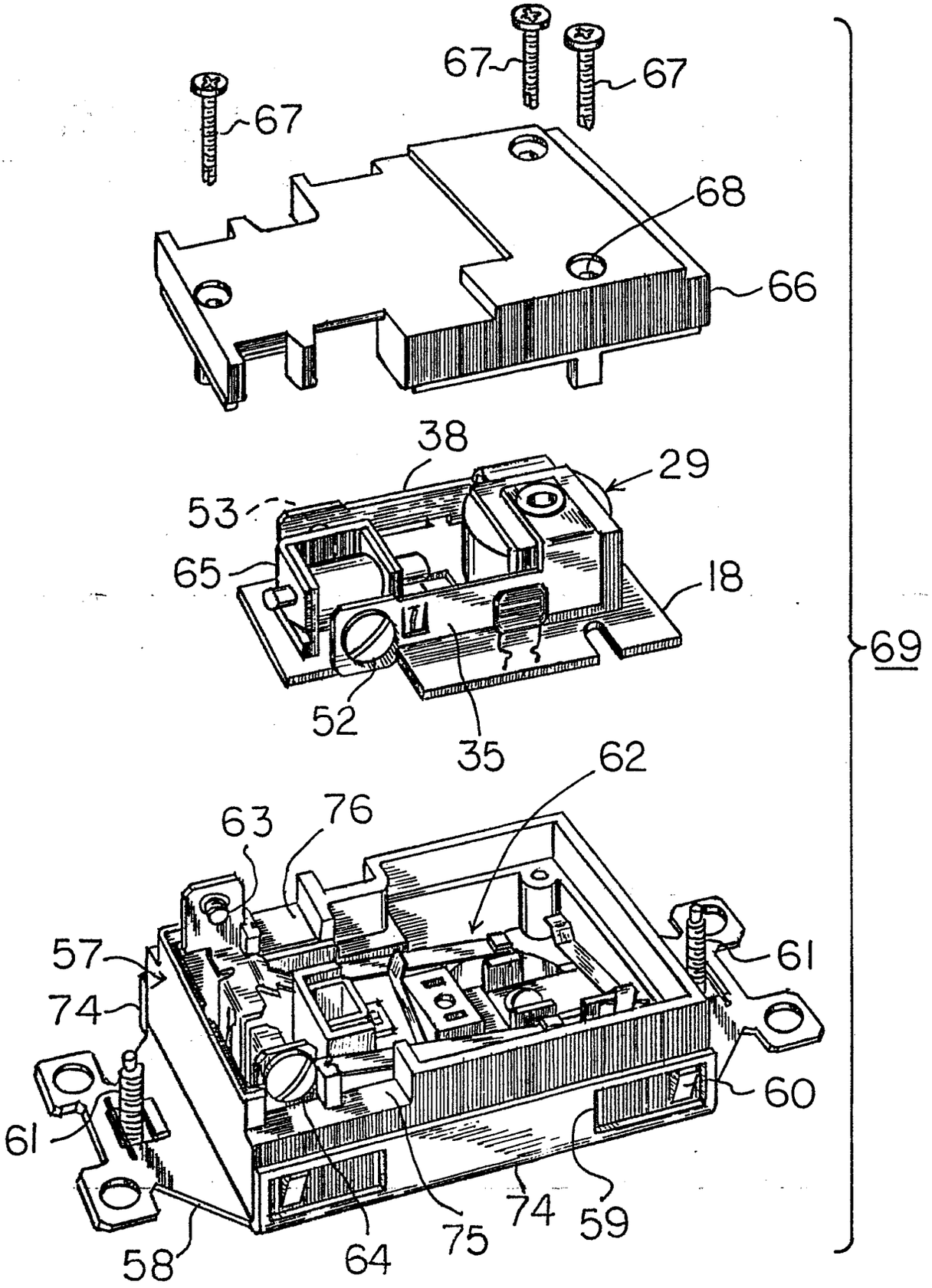
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FIG.6

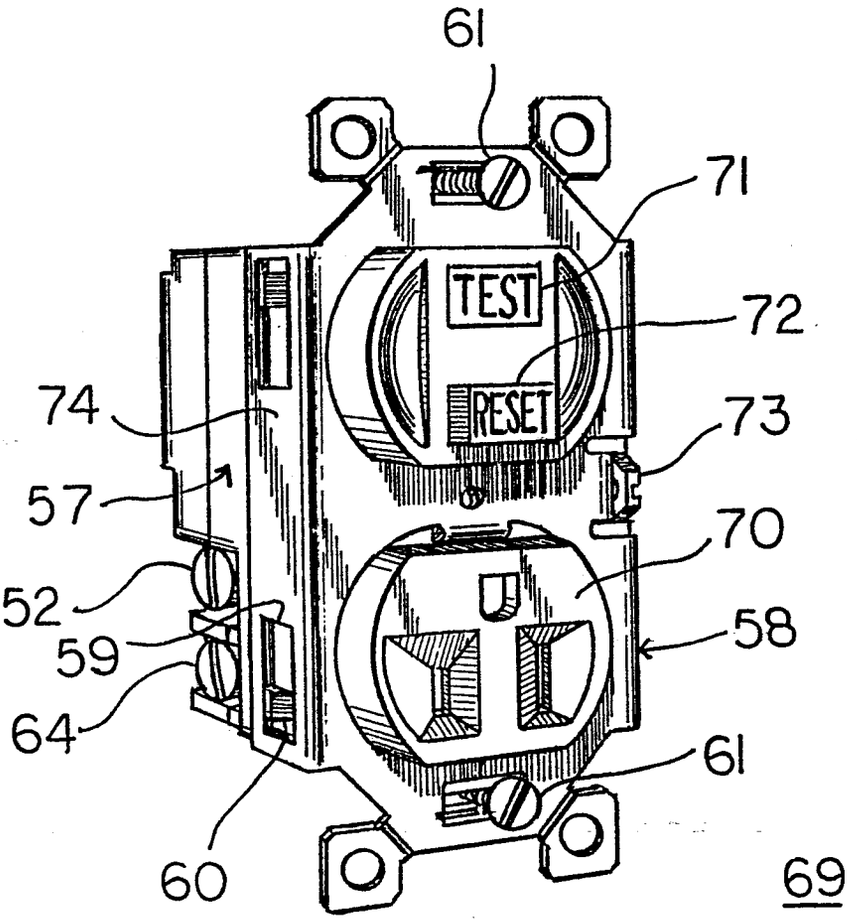


FIG.7

European Patent Office

# EUROPEAN SEARCH REPORT

0154171
Application number

EP 85 10 1121

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl 4) |
|---|---|---|---|
| D,Y | US-A-3 950 677 (K.W. KLEIN et al.)<br>* Claim 1; figures 4,5 * | 1-9 | H 01 H 71/12<br>H 01 H 83/14 |
| A | | 19,20 | |
| | --- | | |
| Y | DE-B-1 285 609 (BUSCH-JAEGER DÜRENER METALLWERKE)<br>* Column 1, lines 27-64; figures 1,3 * | 1-9 | |
| A | * Figures 1,3; claim 1 * | 12,13, 18 | |
| | --- | | |
| A | DE-B-1 115 819 (BUSCH-JAEGER DÜRENER METALLWERKE)<br>* Claim 6 * | 10,11 | TECHNICAL FIELDS SEARCHED (Int. Cl.4) |
| | --- | | |
| A | DE-U-8 011 197 (FELTEN & GUILLEAUME CARLSWERK)<br>* Pages 2,3; figures 1,2 * | 7 | H 01 H 69/00<br>H 01 H 71/12<br>H 01 H 83/14<br>H 02 H 3/33 |
| | ----- | | |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| BERLIN | 10-05-1985 | LEMMERICH J |

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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P : intermediate document

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E : earlier patent document, but published on, or after the filing date
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