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(71) Applicant: **Magneti Marelli Holding S.p.A.**
20011 Corbetta (IT)

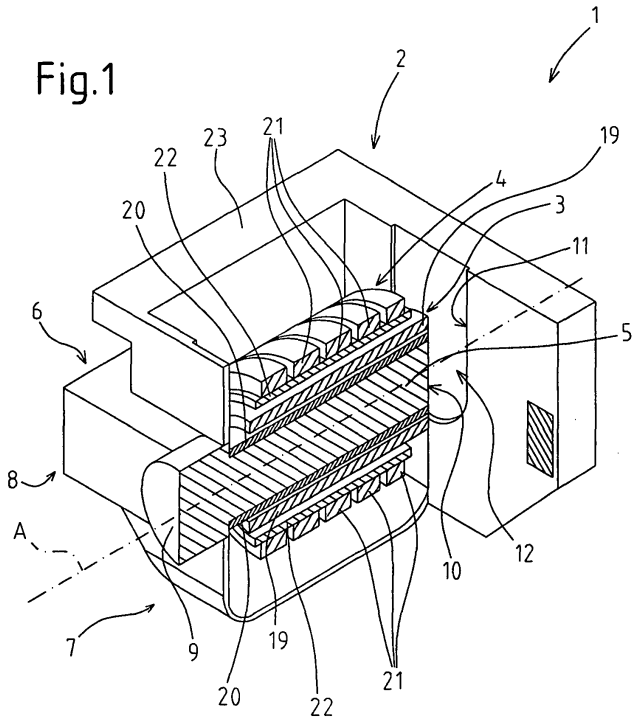
(72) Inventors:
- **Colombo, Maurizio**
  20129 Milano (IT)
- **Guccione, Augusto**
  28041 Arona (IT)
- **Pinna, Sesto Roberto**
  20128 Milano (IT)

(74) Representative: **Franzolin, Luigi et al**
STUDIO TORTA S.r.l.,
Via Viotti, 9
10121 Torino (IT)

(54) Ignition coil and assembly method thereof

(57) An ignition coil (1; 30) for triggering combustion in a controlled ignition endothermic engine displays: a magnetic circuit (2; 31) having a core (5; 32) and a cladding (6; 33); a primary electrical circuit (3) wound around the core (5; 32); a secondary electrical circuit (4) wound around the core (5; 32) and concatenated with the primary electrical circuit (3); at least one air gap (12; 39) defined by the magnetic circuit (2; 31); the magnetic circuit (2; 31) being formed by at least one first part and one second part (7, 8; 34, 35) capable of sliding one with respect to each other to adjust the dimensions of the air gap (12; 39).

Fig.1



EP 1 887 586 A1

Description

[0001] The present invention relates to an ignition coil. In particular, the present invention relates to an ignition coil for triggering combustion in a controlled ignition endothermic engine.

[0002] An ignition coil of the known type comprises a magnetic circuit, which comprises a core and a cladding and is adapted to define two air gaps; a primary circuit wound around the core; a secondary electrical circuit wound around the core and concatenated with the primary electrical circuit. The core of the magnetic circuit extends along a main axis and the cladding extends along a closed loop path about the core on a plane containing the core axis. The empty spaces comprised between the opposite ends of the core from which the flux lines of the magnetic field exit and the cladding respectively define two air gaps.

[0003] The dimensions of each air gap are generally defined during the design step of the ignition coil. However, when the ignition coil is assembled, minor variations in the predetermined dimensions of each air gap occur, which cause variations of inductance in the magnetic circuit giving rise to non-negligible effects in terms of ignition coil performance.

[0004] The reluctance of the magnetic circuit of the ignition coil is mainly determined by the reluctance of the air gap, because the reluctance of the ferromagnetic material of the magnetic circuit is negligible thanks to the very high magnetic permeability values (μ_R >>1000) of the foils employed to construct the magnetic circuit.

[0005] The effects determined by the dimensions of the air gap are of various nature. The ignition coil, indeed, not having an appropriate reluctance, and therefore inductance, value cannot be operated in a controlled manner with repercussions both on performance (less energy output to the spark plug) and on reliability (higher thermal stress due to Joule effect and possible breakage due to thermal overheating).

[0006] The air gap inductance depends widely on the dimensions of the air gap and consequently variations in the dimensions of the air gap may influence operation of the ignition coil. In particular, the distance between the two faces facing the air gap of the magnetic circuit has a large influence on the inductance of the magnetic circuit.

[0007] The current trend is to reduce the distance between the two faces of the air gap to minimum so as to maximise the inductance of the entire magnetic circuit to the extent that, in particular applications, even the roughness of the surface of the air gap faces considerably affects the magnetic inductance of the entire circuit. In fact, some parameters cannot be controlled, neither at a design level nor at a assembly level. Consequently it is not possible to obtain ignition coils with a design inductance value and, above all, it is not possible to obtain a inductance value sufficiently constant for all coils in the same production lot.

[0008] To overcome such drawbacks, in some coils of the known type, the facing faces defining the air gap are finished by grinding to minimise surface roughness of such faces and the total air gap tolerance.

[0009] However, this type of processing entails a series of problems of decay of the foils employed to construct the magnetic circuit, which are short-circuited during processing causing increased loss due to eddy currents during operation of the ignition coil, and is not practicable on large scale because of the expenses.

[0010] It is an object of the present invention to provide an ignition coil which is free from the drawbacks of the prior art illustrated herein; in particular, it is an object of the present invention to construct an ignition coil capable of optimising the inductance value of the magnetic circuit. It is a further object of the present invention to construct a reliable ignition coil capable of high performance and at the same time manufacturable with low costs.

[0011] In accordance with such objects, the present invention relates to an ignition coil for triggering the combustion in a controlled ignition endothermic engine, the ignition coil comprising: a magnetic circuit comprising a core and a cladding and adapted to define at least one air gap; a primary electrical circuitwound around the core; a secondary electrical circuitwound around the core and concatenated with the primary electrical circuit; the ignition coil being characterised in that the magnetic circuit is divided into at least one first part and one second part capable of sliding with respect to each other to adjust the dimensions of the air gap.

[0012] The ignition coil according to the present invention displays the following advantages.

[0013] Firstly, the division of the magnetic circuit into two or more reciprocally sliding parts allows to adjust the dimensions of the air gap simply, efficaciously and cost-effectively during assembly.

[0014] Furthermore, the ignition coil constructed according to the present invention allows to adjust the dimensions of the air gap by means of simple operations based on the measurement of macroscopic and, therefore, easily controllable, quantities.

[0015] The present invention also relates to an assembly method of an ignition coil.

[0016] According to the present invention an assembly method for an ignition coil is provided; the method comprising the arrangement of the primary electrical circuit and the secondary electrical circuit around the coil; the method being characterised by the arrangement of the first part and the second part in reciprocal contact; by the sliding of the first and the second part one with respect to the other and at the same time by the detection of a signal correlated to the dimensions of the air gap; and by the adjustment of the relative position of the first and second part according to said signal and to a predetermined acceptability range of said signal.

[0017] Further features and advantages of the present invention will be apparent in the description of the following two non-limitative examples, with reference to the

figures in the accompanying drawings, in which:

- figure 1 is a perspective view, with parts in cross-section and parts removed for clarity, of an ignition coil made according to the present invention;
- figure 2 is a schematic view, with parts removed for clarity, of a detail of the ignition coil in figure 1;
- figure 3 is a schematic view, with parts removed for clarity, of a detail of the ignition coil made according to a second embodiment of the present invention.

[0018] In figure 1, reference number 1 indicates an ignition coil for triggering combustion in a controlled ignition endothermic engine.

[0019] Ignition coil 1 comprises a magnetic circuit 2, a primary electrical circuit 3 and a secondary electrical circuit 4.

[0020] Magnetic circuit 2 comprises a core 5, which extends mainly along an axis A, and a cladding 6, which extends along a closed loop path about core 5 and lays essentially on the same plane as axis A of core 5. Core 5 and cladding 6 are formed by abutting ferromagnetic material foils.

[0021] In particular, magnetic circuit 2 is divided into at least one first part 7 and one second part 8 capable of sliding one with respect to the other. The first part 7 comprises core 5 and a head 9, which is integral with core 5 and defines a portion of cladding 6. The second part 8 of magnetic circuit 2 defines the remaining part of cladding 6.

[0022] With reference to figure 2, core 5 displays a face 10, which is orthogonally arranged with respect to axis A in distal position with respect to head 9 and at a close distance from a respective face 11 of the second part 8 of magnetic circuit 2, parallel to face 10.

[0023] The empty space between face 10 of core 5, from which the magnetic field flux lines exit, and face 11 of the second part 8 of magnetic circuit 2, into which the magnetic field flux lines enter, defines an air gap 12.

[0024] The first part 7 and the second part 8 of magnetic circuit 2 are arranged in reciprocal contact. In particular, the first part 7, at head 9, displays two sliding surfaces 13 and 14, which are parallel to axis A and reciprocally opposite.

[0025] The second part 8 of magnetic circuit 2 presents two terminal edges 15 and 16, each of which presents a respective sliding surface 17 and 18, which is parallel to axis A and faces a respective sliding surface 13 and 14 of head 9.

[0026] With reference to figure 1, primary electrical circuit 3 comprises a first winding 19, which is arranged about core 5 of the first part 7 of magnetic circuit 2.

[0027] Between the first winding 19 and core 5 there is comprised a first layer 20 of insulating material which fully encompasses core 5.

[0028] Primary electrical circuit 3 is also connected in the known way to a voltage source which is controlled by an ignition control unit (not shown in the figure for the sake of simplicity).

[0029] Secondary electrical circuit 4 comprises a second winding 21, which is arranged around the first winding 19 of primary electrical circuit 3 and is connected in the known way to an engine spark plug (not shown for the sake of simplicity). Between the first winding 19 and the second winding 21 there is comprised a second layer 22 of insulating material.

[0030] Primary electrical circuit 3, secondary electrical circuit 4 and magnetic circuit 2 are enclosed in a casing 23 made preferably of resin to ensure assembly tightness.

[0031] In use, ignition coil 1 is regulated by the ignition control unit which acts on a command capable of connecting primary electrical circuit 3 to a voltage source for a time, designated "dwell time", determined as a function to the engine requirements. During the "dwell time", the primary circuit electrical current 3 increases inducing a flux in magnetic circuit 2, in which magnetic energy is stored. When a predetermined magnetic energy value is reached, primary electrical circuit 3 is opened and magnetic energy is concatenated with secondary electrical circuit 4, inducing on an engine spark plug, the voltages and the currents responsible for igniting the combustion chamber.

[0032] The assembly of ignition coil 1 envisages that primary electrical circuit 3 and secondary electrical circuit 4 are arranged around core 5 and that the first part 7 and the second part 8 are arranged in reciprocal contact. At this point, the first part 7 and the second part 8 are induced to slide one with respect to the other along a direction parallel to axis A and at the same time a signal correlated to the dimensions of air gap 12 is detected. In particular, such a signal is correlated either directly to the distance between faces 10 and 11 of air gap 12 for macroscopic regulation, or to the inductance value of magnetic circuit 2 for fine tuning. Observe that inductance is directly proportional to the distance between faces 10 and 11 of air gap 12.

[0033] Finally, the first part 7 and the second part 8 are locked onto each other and magnetic circuit 2, primary electrical circuit 3 and secondary electrical circuit 4 are closed inside casing 23.

[0034] Figure 3 shows a second embodiment of the magnetic circuit of an ignition coil 30, in which the remaining components are essentially identical to those shown with respect to figure 1.

[0035] In this second embodiment, ignition coil 30 comprises a magnetic circuit 31, a primary electrical circuit and a secondary electrical circuit. Magnetic circuit 31 comprises a core 32, which extends mainly along an axis B, and a cladding 33, which extends along a closed loop path about core 32 and lies essentially on the same plane as axis B of core 32. Core 32 and cladding 33 are formed by abutting ferromagnetic material foils.

[0036] The primary electrical circuit and the secondary electrical circuit are not shown in figure 3 for the sake of simplicity and because they remain essentially unvaried

with respect to the previously described first embodiment beingwound around core 32 of magnetic circuit 31.

[0037] In particular, magnetic circuit 31 is divided into at least one first part 34 and one second part 35 capable of sliding with respect to each other.

[0038] The first part 34 is essentially T-shaped and comprises core 32 and a head 36, which is integral with core 32 and which defines a portion of cladding 33.

[0039] The second part 35 of magnetic circuit 31 defines the remaining part of cladding 33.

[0040] Core 32 presents a face 37, which is orthogonally arranged with respect to axis B in distal position with respect to head 36 and at a close distance from a respective face 38 of the second part 35 of magnetic circuit 31, parallel to face 37.

[0041] The empty gap between face 37 of core 32, from which the magnetic field flux lines exit, and face 38 of the second part 35 of magnetic circuit 31, into which the magnetic field flux lines enter, define an air gap 39.

[0042] The first part 34 and the second part 35 of the magnetic circuit 31 are arranged in reciprocal contact. In particular, head 36 displays, at its ends, two sliding surfaces 40, 41 which are reciprocally parallel and oblique with respect to axis B.

[0043] The second part 35 displays two terminal edges 42 and 43, each of which displays a respective sliding surface 44 and 45, which is oblique with respect to axis B and parallelly faces a respective sliding surface 40 and 41 of head 36.

[0044] Ignition coil 30 comprises a casing (not shown in figure 3) which encloses the primary electrical circuit, the secondary electrical circuit and magnetic circuit 31 and which is possibly made of resin to ensure tightness of the assembly.

[0045] The operation of ignition coil 30 according to the this second embodiment remains essentially identical to the operation of ignition coil 1 according to the first previously described embodiment.

[0046] Also the assembly method of ignition coil 30 according to this second embodiment remains essentially unvaried with respect to the previously described method except for the fact that the first part 34 and the second part 35 of magnetic circuit 31 are made to slide along an oblique direction, not parallel to axis B of core 32.

Claims

1. An ignition coil (1; 30) for triggering combustion in an endothermic control ignition engine; the ignition coil (1; 30) comprising: a magnetic circuit (2; 31) comprising a core (5; 32) and a cladding (6; 33) and adapted to define at least one air gap (12; 39); a primary electrical circuit (3) wound around the core (5; 32); a secondary electrical circuit (4) wound around the core (5; 32) and concatenated with the primary electrical circuit (3); the ignition coil (1; 30) being **characterised in that** the magnetic circuit (2; 31) is divided into at least one first part (7; 34) and one second part (8; 35) capable of sliding one with respect to the other to adjust the dimensions of the air gap (12; 39).

2. An ignition coil according to claim 1, **characterised in that** the air gap (12; 39) is an empty space delimited by two parallel faces (10, 11; 37, 38) of the magnetic circuit (2; 31); the adjustment of the air gap (12; 39) consisting in adjusting the distance between said two faces (10, 11; 37, 38).

3. An ignition coil according to claim 1 or 2, **characterised in that** the first and the second part (7, 8; 34, 35) of the magnetic circuit (2; 31) are capable of sliding in contact with each other.

4. An ignition coil according to claims 2 and 3, **characterised in that** said first and second part (7, 8; 34, 35) of the magnetic circuit (2; 31) are in reciprocal contact along the sliding surfaces (13, 14, 17, 18; 40, 41, 44, 45); said sliding surfaces (13, 14, 17, 18; 40, 41, 44, 45) being reciprocally parallel and not being parallel to said faces (10, 11; 37, 38) of the air gap (12; 39).

5. An ignition coil according to any one of the preceding claims, **characterised in that** said sliding surfaces (13, 14, 17, 18; 40, 41, 44, 45) are arranged along the cladding (6; 33) of the magnetic circuit (2; 31).

6. An ignition coil according to claim 5, **characterised in that** the first part (7; 34) of the magnetic circuit (2; 31) comprises the core (5; 32), which extends mainly along an axis (A; B), and a portion (9; 36) of cladding (6; 33); the second part (8; 35) of magnetic circuit (2; 31) defining the remaining portion of the cladding (6; 33).

7. An ignition coil according to claim 6, **characterised in that** the cladding (6; 33) extends along a closed loop path about the core (5; 32) and lies essentially on the same plane as axis (A; B) of the core (5; 32).

8. An ignition coil according to claim 6 or 7, **characterised in that** said sliding surfaces (13, 14, 17, 18) are parallel to the axis (A) of the core (5); the faces (10; 11) of air gap (12) being orthogonal to the axis (A) of the core (5).

9. An ignition coil according to claim 6 or 7, **characterised in that** said sliding surfaces (40, 41, 44, 45) are oblique with respect to the axis (B) of the core (32); the faces (37; 38) of air gap (39) being orthogonal to the axis (B) of the core (32).

10. An ignition coil according to claim 1, **characterised in that** it comprises a casing (23; 46), which encloses

the primary electrical circuit (3), the secondary electrical circuit (4) and the magnetic circuit (2; 31) .

11. An ignition coil according to claim 1, **characterised in that** it comprises insulating means (20; 22), which serve to isolate the primary electrical circuit (3), the secondary electrical circuit (4) and the magnetic circuit (2; 31).

12. An assembly method of an ignition coil (1; 30) carried out according to any one of the preceding claims; the method comprising the arrangement of the primary electrical circuit (3) and the secondary electrical circuit (4) about the coil (5; 32); the method being **characterised by** the arrangement of the first part and the second part (7, 8; 34, 35) in reciprocal contact; by the induction of the sliding of the first and the second part (7, 8; 34, 35) one with respect to the other and at the same time by the detection of a signal correlated to the dimensions of the air gap (12; 39); and by the adjustment of the relative position of the first and second part (7, 8; 34, 35) as a function of said signal and of a predetermined acceptability range of said signal.

13. A method according to claim 12, **characterised in that** said signal is correlated to the distance between the faces (10, 11; 37, 38) of the air gap (12; 39).

14. A method according to claim 12, **characterised in that** said signal is correlated to the inductance of the magnetic circuit (2; 31).

15. A method according to any one of the preceding claims from 13 to 14 **characterised in that** the first and second part (7, 8; 34, 35) are locked to each other, and once the dimension of the gap has been adjusted (12; 39).

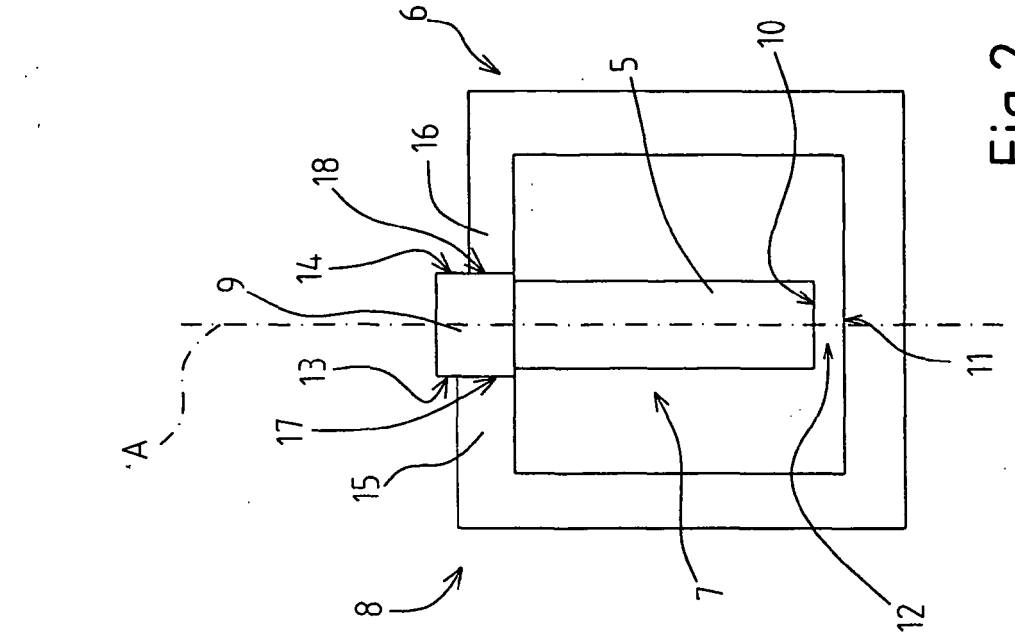

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Fig.2

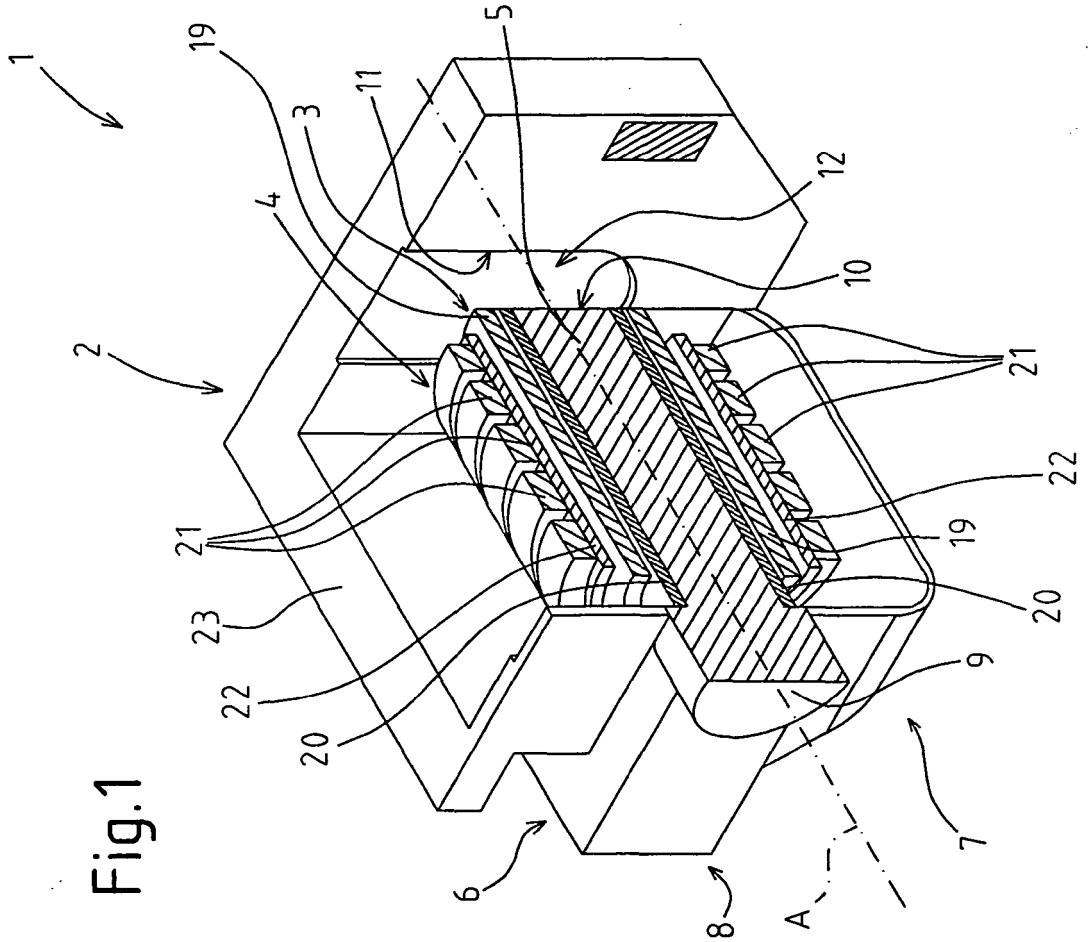
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Fig.1

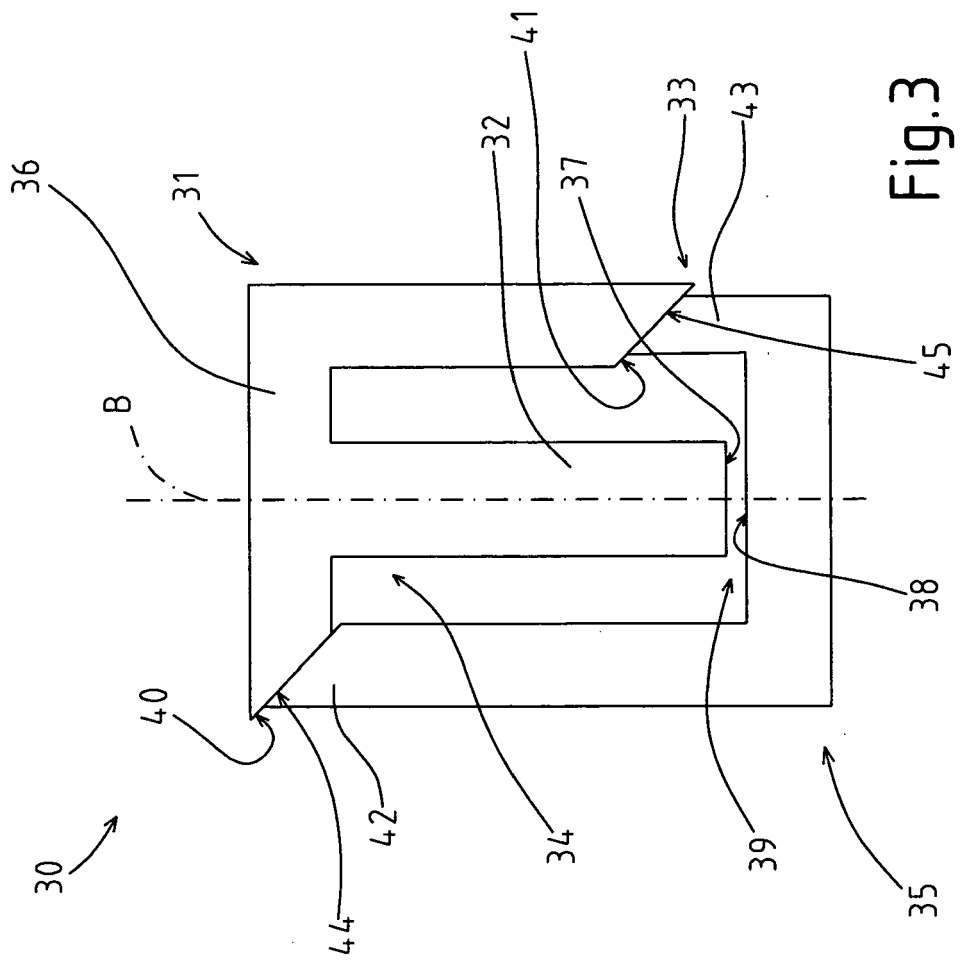

Fig.3

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EUROPEAN SEARCH REPORT

Application Number
EP 06 42 5581

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 4 480 377 A (HOUSE RONNALEE [US] ET AL) 6 November 1984 (1984-11-06) * column 1, line 5 - line 62 * * column 2, line 46 - column 4, line 67; figures 1-3 *	1-15	INV. H01F3/14 H01F38/12
X	US 3 209 294 A (CORNELL ARCHIE R) 28 September 1965 (1965-09-28) * column 1, line 10 - line 55 * * column 2, line 14 - line 52; figure 1 * * column 3, line 2 - line 30; figures 3,4 * * column 3, line 67 - line 72; figure 6 * * column 4, line 29 - line 42; figures 7,8 * * column 4, line 65 - line 74 *	1-15	
X	DE 34 02 278 A1 (VOGT GMBH & CO KG [DE]) 1 August 1985 (1985-08-01) * the whole document *	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

H01F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	15 January 2007	Teske, Ekkehard

CATEGORY OF CITED DOCUMENTS

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15-01-2007

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