(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 902 442 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
17.03.1999 Bulletin 1999/11

(51) Int. Cl.^{6}: **H01F 5/00**, H01F 27/28, H01F 38/12

(21) Application number: **97830451.7**

(22) Date of filing: **15.09.1997**

(84) Designated Contracting States:
AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV RO SI

(71) Applicant:
Cooper Industries Italia S.p.A.
20124 Milano (IT)

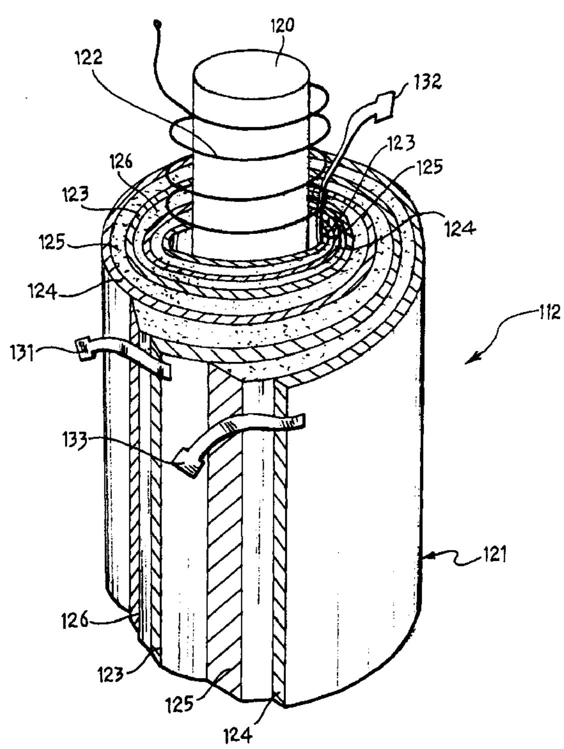
(72) Inventors:
- **Rossi, Daniele**
I-40050 Monte S.Pietro Bologna (IT)
- **Baraldi, Stefano**
I-41012 Carpi Modena (IT)
- **Pignatti,Paolo**
I-41012 Carpi Modena (IT)

(74) Representative:
Marchitelli, Mauro
Buzzi, Notaro & Antonielli d'Oulx
Corso Fiume 6
10133 Torino (IT)

(54) Coil with inductive and capacitive characteristics

(57) An ignition coil comprises a magnetic core (120), a primary electric winding (121) capable of generating a magnetic flux at least partly confined within the magnetic core (120), and a secondary electric winding (122) arranged in such a manner as to interlink with said magnetic flux. The primary winding (121) of the coil comprises at least a first and a second conductor (123, 124) electrically insulated from each other. The first conductor (123) is provided with at least a first and a second terminal (131, 132) arranged at the opposite ends of the winding (121) and the second conductor (124) is provided with at least a third terminal (133). Furthermore, the first and the second conductor (123, 124) are arranged in such a manner as to ensure substantially inductive behaviour between terminals of the same conductor and substantially capacitive behaviour between terminals of different conductors.

fig. 3



EP 0 902 442 A1

Description

[0001] The present invention concerns an ignition coil for internal combustion engines with spark ignition as described in the preamble of Claim 1 hereinbelow.

[0002] It is known that the principal components of an ignition coil consist of two electrical windings, respectively a primary winding and a secondary winding, both formed around a ferromagnetic core or a part thereof. In this way the two windings are magnetically interlinked, but electrically insulated from each other, and make it possible to transform a low voltage (just a few volts in inductive type-systems, or a few hundreds of volts in capacitor-discharge systems) applied to the ends of the primary winding into a high voltage (several tens of kilovolts) at the ends of the secondary winding.

[0003] According to a somewhat simplified description, ignition systems traditionally comprise a low-voltage generator, usually the battery of the motor vehicle, one or more ignition coils connected to the spark plugs assembled in the cylinder head, to which the said coils furnish the high voltage in order to produce the spark, and an electronic control circuit to set the ignition times and modes. The technically most valid ignition systems, and also the ones most widely used today, are the inductive-type system and the capacitor-discharge one, the two types being distinguished by the different solutions they adopt for storing the energy and transferring it from the battery to the spark plug.

[0004] In ignition systems of the inductive type, the low-voltage battery (normally 12 volt in the case of motor vehicles) is connected directly to the coil (to its primary winding) and, on receiving a steady current from the battery, the latter will generate a magnetic field. The coil is thus used at first as a device for storing energy in the magnetic field generated by the primary winding and subsequently as a transformer in order to obtain the required high voltage at the ends of the secondary winding by transferring therein the stored energy.

[0005] In the ignition system of the capacitor-discharge type, which originally came into being for use with high-performance engines, the low-voltage battery is generally followed by a voltage up-transformer and connected to a capacitor, which is charged by the direct current provided by the battery in order to store the energy needed for ignition in its own electric field. The coil operates exclusively as a transformer, converting the voltage that the capacitor discharges to the primary winding at the proper time into the high voltage required in the secondary one.

[0006] Both ignition systems therefore have the common feature of using coils as transformers in order to make possible the transmission of energy from a charge phase in which an external battery (or, more generically, an external driving circuit) supplies the energy that is accumulated in the magnetic or electric field by, respectively, the primary winding or the capacitor, to a subsequent discharge phase in which said energy, transferred to the secondary winding, will permit a spark to pass between the electrodes of the spark plug. These charge and discharge phases are directly controlled by an electronic control circuit to manage both the required quantity of energy and the spark advance times, depending upon the instantaneous operating characteristics of the engine.

[0007] Though the same component is to be found in both systems, the interchangeability between the two systems is greatly limited, particularly on account of the presence of the discrete capacitor in the case of the capacitor-discharge system. This capacitor, moreover, is associated with the disadvantage of being a rather costly component that cannot always be readily obtained.

[0008] The object of the present invention is therefore that of ensuring interchangeability of the two ignition systems by proposing a coil that can be used as an energy accumulator and as a transformer in both the described ignition systems, at the same time reducing also the overall costs by eliminating the need for a discrete capacitor.

[0009] According to the invention, this object is attained by means of an ignition coil in accordance with the characterizing part of Claim 1 hereinunder. This coil in accordance with the invention is realized in such a manner as to include in itself also the function of the capacitor as alternative to the use of the discrete component. Two electrically insulated conductors, for example two armatures facing each other and separated by a dielectric medium, are wound around the magnetic core to form the primary winding, displaying at the same time inductive behaviour (each of the wound conductors has its own resistance and inductance) and capacitive behaviour (between the two insulated conductors). These conductors of the primary winding provide a plurality of terminals and the choice of which terminals are to be connected to the other parts of the system (especially the electronic control circuit) completely defines the properties and the behaviour of the system.

[0010] The characteristics and advantages of the ignition coil in accordance with the invention will be explained in greater detail in the following detailed description of one of its embodiments given as an indicative and non-limitative example with reference to the accompanying drawings, in which:

Figure 1 shows a circuit diagram exemplifying an ignition system of the inductive type;
Figure 2 shows a circuit diagram exemplifying an ignition system of the capacitor discharge type;
Figure 3 shows a perspective view of an ignition coil in accordance with the invention having a primary winding of the cylindrical spiral type;
Figure 4 shows a perspective view of an ignition coil in accordance with the invention having a primary winding of the helix type;

Figure 5 shows a circuit diagram exemplifying a generic ignition system;

Figure 6a shows a detailed circuit diagram of the driving and control module of Figure 5 for an ignition system of the inductive type;

Figure 6b shows a detailed circuit diagram of the ignition coil of Figure 5 for an ignition system of the inductive type;

Figure 6c shows a detailed circuit diagram of the driving and control module of Figure 5 for an ignition system of the capacitor discharge type; and

Figure 6d shows a detailed circuit diagram of the ignition coil of Figure 5 for an ignition system of the capacitor discharge type.

[0011] Figures 1 and 2 illustrate the circuit diagrams for the two ignition systems recalled in the introductive part of the present description. The following brief analysis is intended to highlight the individual components of such systems and their function, as well as their connections to the ignition coil, and convey a proper understanding of the manner in which the system functions in both the charge and the discharge phase.

[0012] Referring first to Figure 1, the circuit diagram shown is that of an ignition system of the inductive type that employs a separate coil assembled with each corresponding spark plug; more particularly, this figure illustrates a part of the complete system regarding a single spark plug 10 and its associated ignition coil 12. The stable (apart from such variations as may be due to the state of charge of the battery or the operating temperature) supply voltage V_{BATT}, is connected directly to the terminal A of the primary winding 21 of the coil 12. The terminal B at the other end of the winding is connected to the collector of a transistor Q1, the emitter of which is connected to ground via a resistor R1, while its base receives the control signal 40 coming from an electronic control unit (ECU) 42. During the charge phase, the ECU 42 commands the switch Q1 to close, thus opening a direct path to ground for the steady current flowing in the primary winding 21; the flow of this current generates a magnetic flux. When the ECU 42 commands the opening of the switch Q1 (discharge phase), the current flowing in the primary winding becomes suddenly interrupted and the coil acts as a transformer, thus causing the energy stored in the magnetic field to be transferred to the secondary winding 22 and, consequently, producing also a voltage peak (several tens of kilovolts) at the electrodes of the spark plug 10.

[0013] Referring now to Figure 2, it is shown the circuit diagram of an ignition system of the capacitor-discharge type, always regarding to a solution using a separate coil assembled with each corresponding spark plug; more particularly, this figure illustrates a part of the complete system regarding a single spark plug 10 and its associated ignition coil 12. The stable (apart from such variations as may be due to the state of charge of the battery or the operating temperature) supply voltage V_{BATT}, is converted into a voltage of the order of several hundred volts by a transformer 44, while the current, via a safety diode D1 , charges a capacitor C1 of predetermined capacity. An armature of the capacitor C1 is connected directly to the terminal A of the primary 21 winding of the coil 12, while the second armature, whose terminal corresponding to the anode of the diode D1 we shall designate by C, is connected to the other terminal B of the primary winding 21 (connected to ground) via a controlled diode or thyristor D2. The said thyristor D2 is controlled by a control unit (ECU) 42. During the charge phase the diode D2 is maintained open and the current that flows from the supply source and through the diode D1 serves to charge the capacitor C1 in series with the primary winding 21 and to accumulate energy in its electric field. During the discharge phase, on the other hand, when the ECU commands closure of the diode D2, the capacitor C1 is in parallel with the primary winding 21, and the terminal C coincides with the grounded terminal B. The energy accumulated in the capacitor electric field is transferred to the primary winding of the coil, and the voltage which establishes between the ends A and B of the said primary winding is transformed into a voltage of several tens of kilovolts across the terminals of the secondary winding 22 and therefore also across the terminals of the spark plug 10.

[0014] The invention hereinafter described in detail for two implementation forms illustrated, respectively, by Figures 3 and 4 concerns the realization of a coil capable of storing energy and acting as a transformer in both the previously described cases, thus making it possible to eliminate the discrete capacitor C1 that plays a part in the capacitor-discharge system and maintaining the same simplicity as regards the connection of its terminals to the supply source and the control circuit.

[0015] The coil 112 according to the invention illustrated by these drawings is of the "cigar-shaped" type, i.e., it has a magnetic core 120 of cylindrical shape and a primary winding 121 and a secondary winding 122 that are both coaxial with it. A coil of the "cigar-shaped" type is described, for example, in the European patent application No. EP-97 830 306.3 by the same applicant. However, the principal characteristics of the invention do not depend on the particular coil model taken into consideration and can apply also to other structures known in the technical field.

[0016] The primary winding 121 consists of two electrically insulated metallic armatures 123 and 124 that face each other and are separated by an insulating dielectric 125. These two armatures have the form of a ribbon and are wound coaxially with the magnetic core 120 to form a multiplicity of electric turns in accordance with two possible winding patterns. In Figure 3 the ribbon is wound as a cylindrical spiral surrounding the magnetic core 120 and the secondary winding 122. An additional layer 126 of insulating dielectric is used to separate the armatures of the various concentric turns that come to face each other. In Figure 4, on the other hand, the ribbon is wound in the manner of a helix coaxial with the core 120. A second layer 126 of insulating dielectric is used to insulate the armatures of the primary winding as much as possible from the conductor of the secondary winding, which is likewise coaxial with the core and wound inside the primary winding.

[0017] In a structure of this kind, each wound armature 123 or 124 behaves like a series of turns carrying a current and therefore constitutes an inductor in the truest sense of the term. At one and the same time an electric capacity comes into being between these selfsame facing armatures separated by the dielectric 125, so that the said armatures will also form the equivalent of a capacitor. Appropriate terminals are attached to the armatures 123 and 124, thus making it possible for the whole of the primary winding 121 to be connected to the external electronic circuits. In particular, a first terminal 131 and a second terminal 132 are attached to the armature 123 , at the two ends of the winding, and inductive behaviour can therefore be recognized between these terminals. A third terminal 133 is attached to the armature 124 at the particular end of the winding that is more readily accessible; a capacitive behaviour becomes established between this terminal and a terminal of the other winding.

[0018] Referring to the circuit diagrams shown in Figures 1 and 2, one can readily understand the use modalities of the coil 112 . The physical terminal 131 corresponds to the electric terminal designated in the circuit diagrams by the letter A, the physical terminal 132 coresponds to the electric terminal B, the physical terminal 133 corresponds to the electric terminal C. As will be described further on, only two of these terminals are used to connect the coil to the external electronic circuits.

[0019] Figure 5 shows a generalized circuit diagram of an entire ignition system - irrespective of whether it is of the inductive or the capacitor-discharge type - that includes the driving and control module 50 and the ignition coil in accordance with the invention 112. These two blocks are described in greater detail in Figures 6a and 6d.

[0020] When realizing an ignition system of the inductive type, the driving and control module 50 is made up as shown by the circuit diagram of Figure 6a (derived directly from the circuit of Figure 1) and is connected to the terminals A and B of the electrical equivalent of the coil 112 illustrated by Figure 6b. This means that the terminal 133 (C) of the primary winding is left free, so that the armature 124 does not play any part at all and the armature 123 alone behaves like an ordinary inductor magnetically coupled with the secondary winding 122.

[0021] When realizing an ignition system of the capacitor discharge type, on the other hand, the driving and control module 50 is made up as shown by the circuit diagram of Figure 6c (derived directly from the circuit of Figure 2) and is connected to the terminals C and B of the electric equivalent of the coil 112 illustrated by Figure 6d. The terminal 131 (A) is left free, with the result that the capacitance between the two armatures and the inductance provided by the armature 123 wound around the core will be connected in series between the other two terminals.

[0022] In this way, one and the same coil can be used with the two distinct circuit layouts of the driving and control module 50 by simply choosing the appropriate terminals according to the type of ignition system it is proposed to realize. Nor is it to be excluded that in some future application even the driving and control module 50 could be reduced to some common layout valid for both alternatives, thus rendering possible complete interchangeability between the two described ignition systems.

Claims

1. An ignition coil comprising:

- a magnetic core (120);
- a low-voltage primary electric winding (121) capable of generating a magnetic flux at least partly confined within the magnetic core (120); and
- a secondary electric winding (122) arranged in such a way as to interlink with said magnetic flux,

characterized in that said primary winding (121) comprises at least a first and a second conductor (123, 124) electrically insulated from each other, where the first conductor (123) is provided with at least a first and a second terminal (131, 132) arranged at the opposite ends of the winding (121) and the said second conductor (124) is provided with at least a third terminal (133), said first and second conductor (123, 124) being arranged in such a manner as to ensure substantially inductive behaviour between terminals belonging to the same conductor and substantially capacitive behaviour between terminal belonging to different conductors.

2. An ignition coil in accordance with Claim 1, characterized in that said first and second conductor (123, 124) are substantially ribbon-shaped.

3. An ignition coil in accordance with Claim 2, characterized in that said ribbon-shaped first and second conductor (123, 124) are arranged so as to face each other and are separated by an insulating dielectric (125).

4. An ignition coil in accordance with Claim 3, characterized in that said ribbon-shaped first and second conductor are wound in the manner of a helix which is coaxial with the at least part of the magnetic core (120).

5. An ignition coil in accordance with Claim 3, characterized in that said ribbon-shaped first and second conductor (123, 124) are wound in the manner of a cylindrical spiral surrounding at least part of the magnetic core (120).

fig. 1

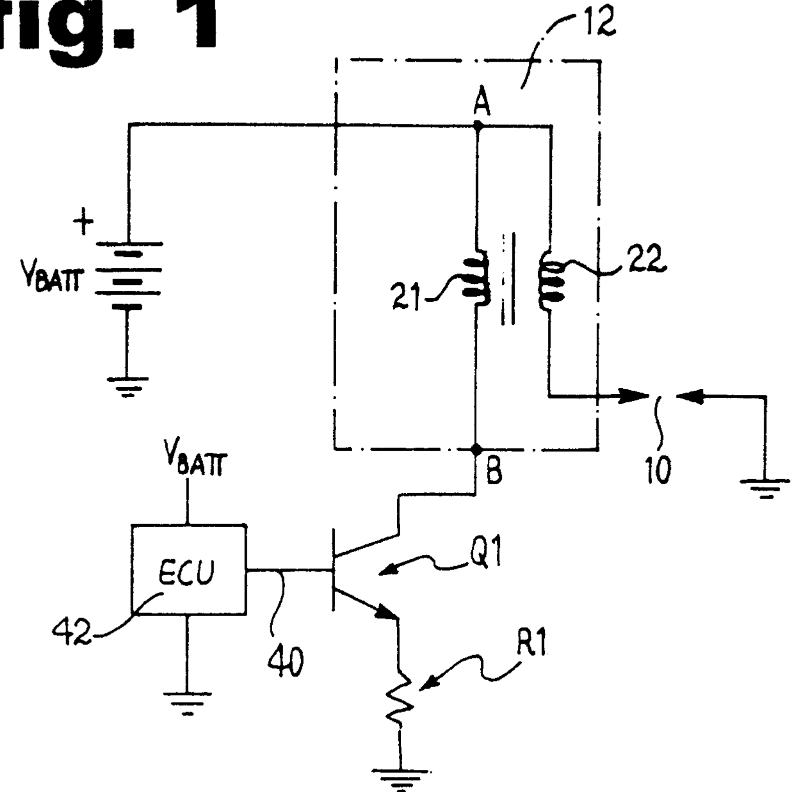

12
A
+
VBATT
21
22
10
B
VBATT
ECU
Q1
42
40
R1

fig. 2

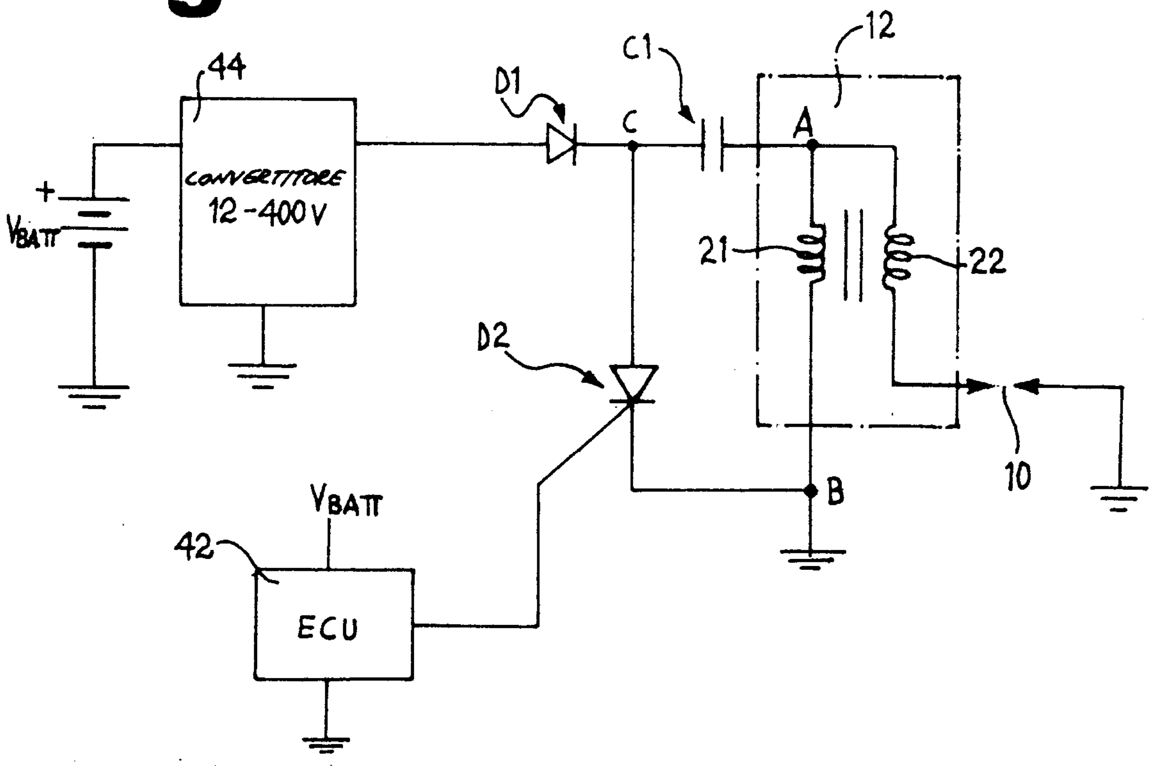

44
D1
C1
12
C
A
+
VBATT
CONVERTITORE
12-400V
21
22
D2
10
B
VBATT
42
ECU

fig. 3

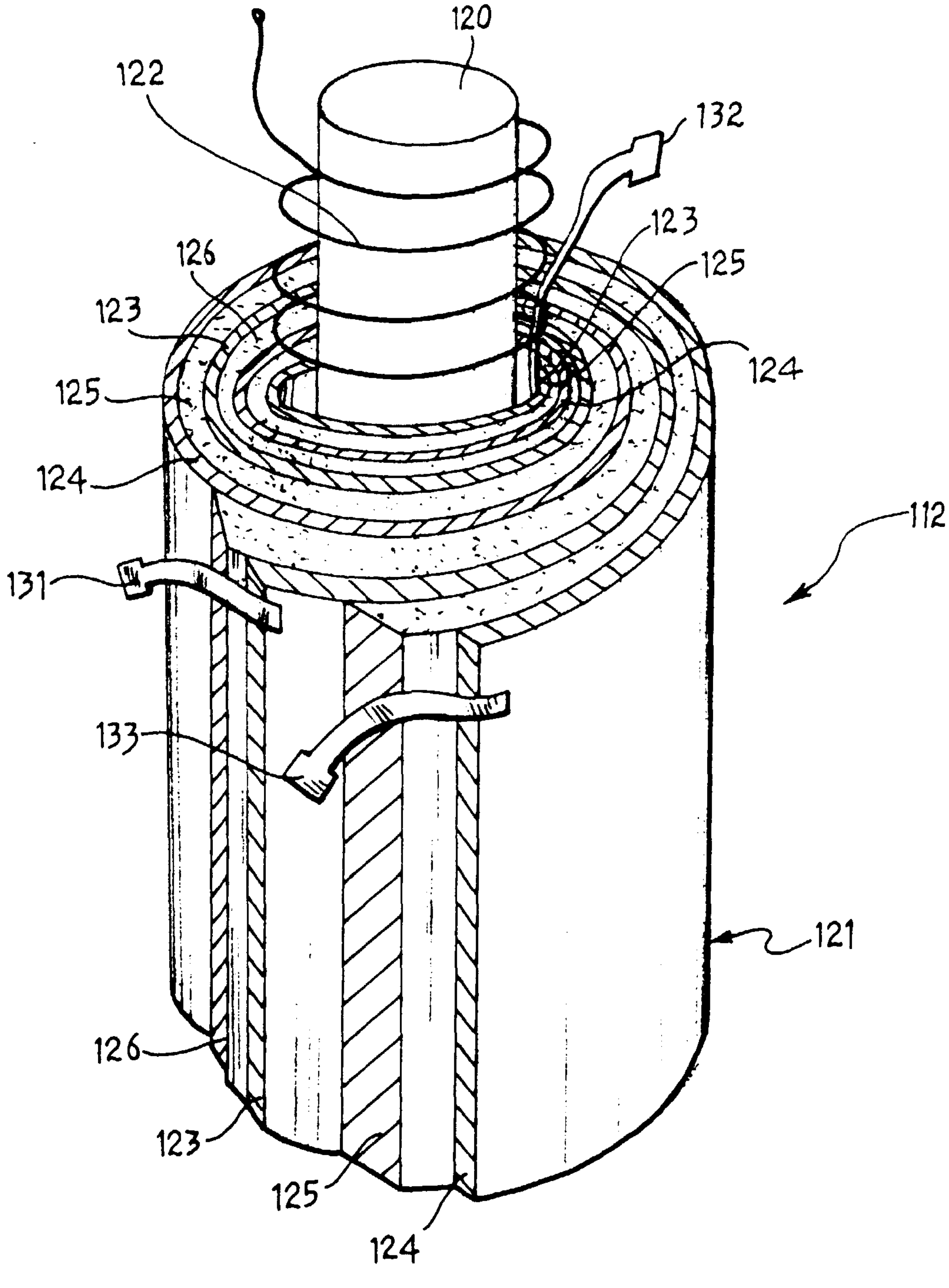

120
122
132
123
126
125
123
124
125
124
112
131
133
121
126
123
125
124

fig. 4

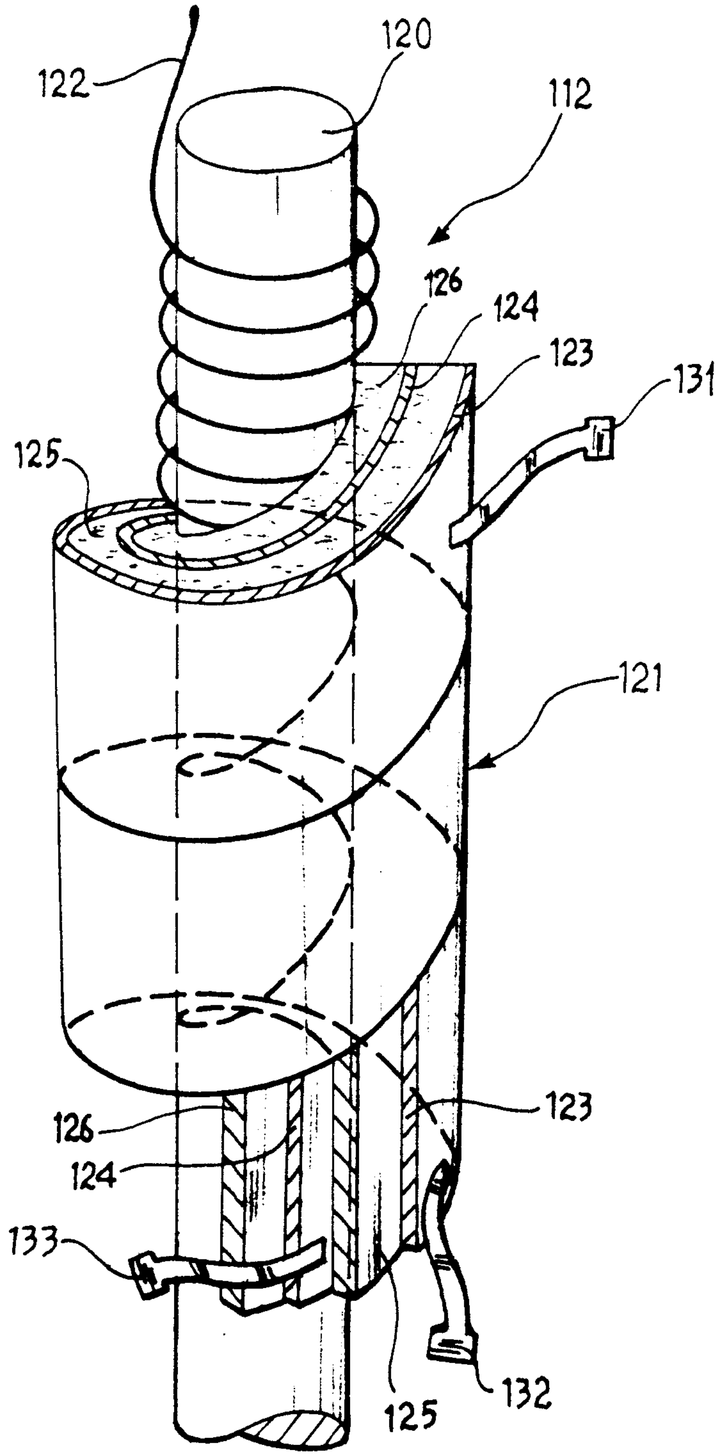


fig. 5

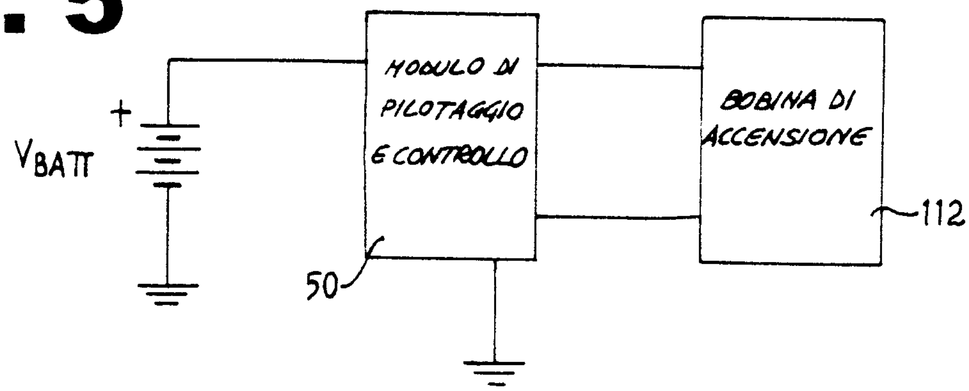


fig. 6a

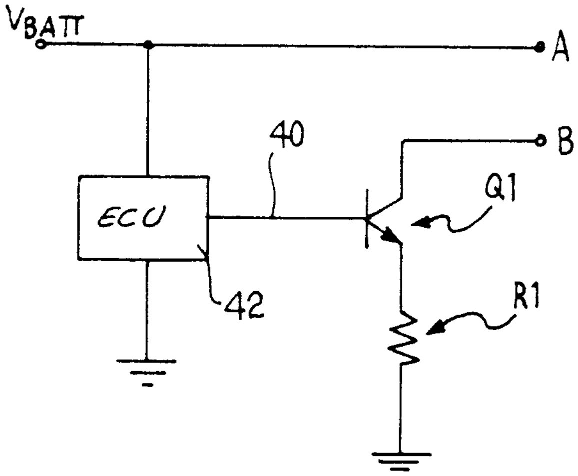


fig. 6b

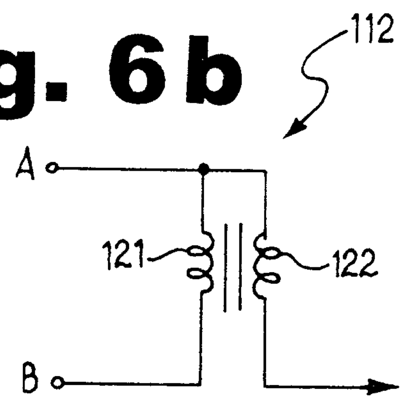


fig. 6c

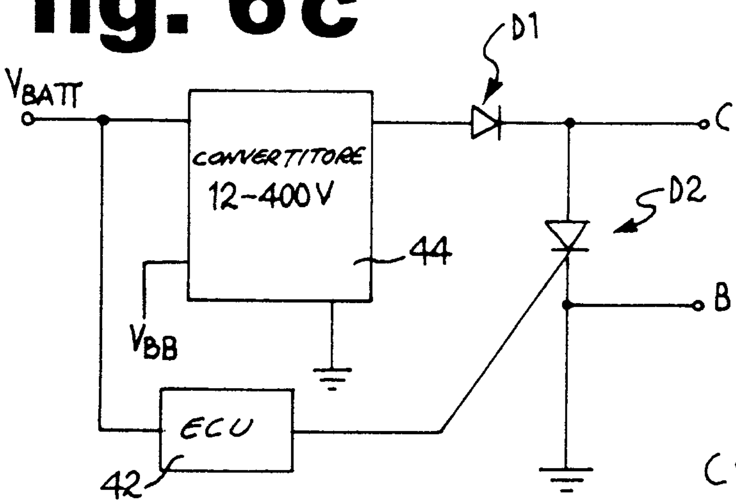
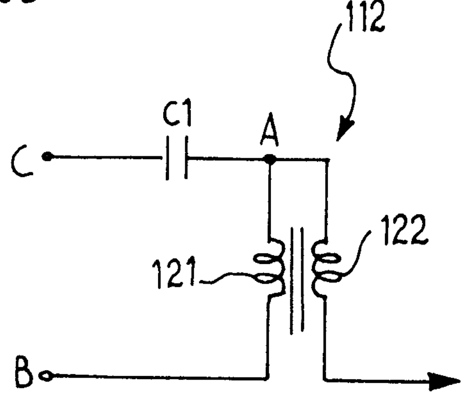


fig. 6d



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 97 83 0451

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.6)
X	WO 89 05035 A (DUCATI ENERGIA SPA) * page 4, line 10 - page 5, line 17 *	1-3,5	H01F5/00 H01F27/28 H01F38/12
X	GB 2 137 427 A (MCCULLOCH CORP) * page 4, line 5 - page 5, line 14 *	1-3,5	
X	WO 89 10622 A (DUCATI ENERGIA SPA) * page 3, line 1 - page 4, line 4 *	1-3,5	
X	EP 0 742 369 A (MAGNETI MARELLI SPA) * column 2, line 7 - column 3, line 58 *	1-3,5	
A	GB 982 561 A (ASSOCIATED ELECTRICAL INDUSTRIES LTD.) * figure 4 *	4	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			H01F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	4 February 1998	Vanhulle, R

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document