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(54) Title: HIGH FREQUENCY IGNITION SYSTEM

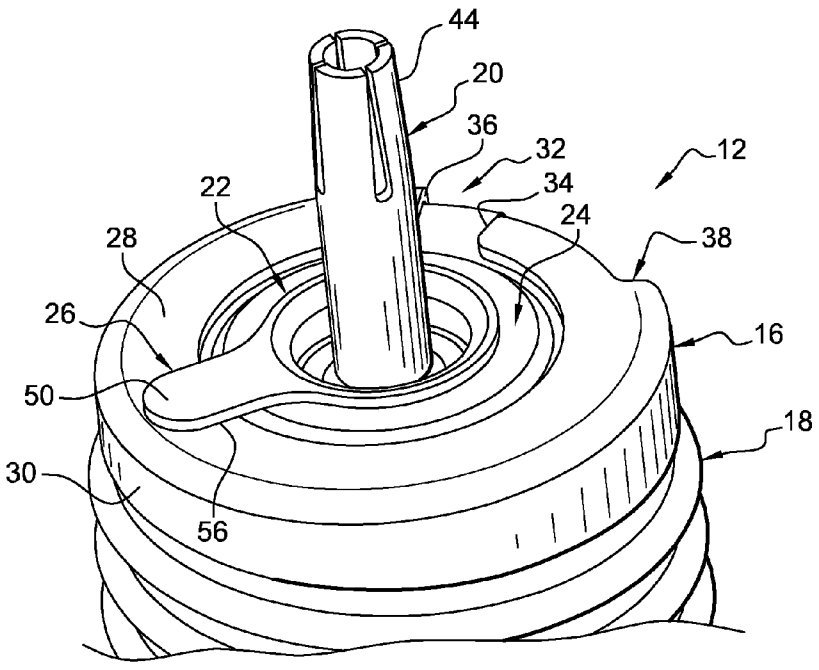


Fig. 2

[Continued on next page]

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(57) Abstract: High frequency resonance based ignition system comprising a generator, a resonance structure, and a heat release interface, the resonance structure having a high frequency coil, characterized in that it further comprises a tuning element provided for varying the inductance to the desired resonance frequency during the manufacturing of the parts.

High frequency ignition system

TECHNICAL FIELD

The present invention relates generally to an ignition system for direct injection combustion engine.

BACKGROUND OF THE INVENTION

The traditional ignition system consists of a sparkplug acting as an electrical feed into a combustion chamber of a gasoline engine, providing concentrated thermal energy release, in the form of a spark, to initiate the combustion. A conventional transformer is used, incorporating electronics to condition and to feed energy from the electrical network in vehicles (Battery, Generator).

Future direct injection combustion systems are targeting stratified fuel injection, promising significant fuel reduction at low speed and partial load. These stratified gasoline mixtures tend to be difficult to ignite with existing ignition systems, mostly because of the limited energy and the very local distribution of the released heat of the spark itself.

Alternatives are intelligently controlled resonance structures which allow emitting heat over larger space, constant over time, and at extended time compared to existing ignition systems. These systems require at minimum, the resonance structure, and a driving generator.

As shown on figure 1, a resonance based ignition system comprises of a resonator 10, a generator 10 and a heat release interface 14. The resonance structure is operated beneficially under ISM (Industrial Scientific and Medical) radio bands, which were originally reserved internationally for the use of RF electromagnetic fields for industrial, scientific and medical purposes other than communications.

Beneficial but not exclusive are the following ISM frequencies: 13,56MHz, 27,12MHz, 40,68MHz.

The operating frequency in such a structure is defined by the inductance and capacitance of the structure.

Equation 1: the resonance frequency is: $f \sim \frac{1}{\sqrt{LC}}$

The inductance can be described by a helical form, single layer wound, high frequency coil. This structure represents technically a typical capacitive loaded quarter-wave transmission line.

The ISM frequency bands suitable for these techniques are very narrow, less than 1% of the resonance frequency. This implies the mechanical elements representing the Coil and capacitor according to equation 1 have to be built to suit the target ISM frequency. At or close to the resonance frequency such ignition system will provide sufficient voltage to break the dielectric environment inside the combustion chamber, which is needed to release the heat to ignite the gasoline mixtures.

However, the geometric realistic tolerances of the characteristic elements (12, 14) will imply that a significant portion of parts built will have their resonance frequency outside the required ISM band.

It is an objective of the present invention to solve the above mentioned problem in a simple and economic way.

SUMMARY OF THE INVENTION

In order to solve the above mentioned problem, the present invention provide a tuning feature at the High Frequency (HF) coil termination which is an integral part of a resonance based ignition system in the low to mid RF range.

The tuning feature is provided at the lowest voltage side of the resonance structure which is the feeding connection between the HF generator and the HF Resonator. At the low voltage side of the helical coil, voltages inferior to 2.000 Volt (peak) can be expected, which allows the operation of such tuning interfaces with conventional means, even using air as dielectric insulation. The tuning element varies the inductance to the desired Frequency. Variable capacitance adjustment could be achieved from another tuning device to give additional adjustment if required.

The invention provides a high frequency resonance based ignition system comprising a generator, a resonance structure, and a heat release interface, the resonance structure having a high frequency coil with terminations and a

terminal ferrule connecting the low voltage input of the generator to a first coil termination, characterized in that it further comprises a tuning element provided for adjusting the inductance to the desired resonance frequency during the manufacturing of the resonance structure, said tuning element comprising :

- a formed terminal cap connected to a coil termination in order to form the last turn of the coil, and

- a salient finger provided on the terminal ferrule to contact with the terminal cap for connecting the low voltage input to the resonance structure via the terminal cap,

the inductance being adjusted depending on the circumferential position of the salient finger with regards to the terminal cap.

The invention allows overcoming tiny manufacturing tolerance in the manufacturing of the resonance structure.

According to other features of the present invention:

- the terminal cap has a brake around its circumference to emulate the last turn of the coil;

- the permanent connection of the terminal cap to the terminal of the coil is done by welding or soldering;

- said terminal cap is anchored on the low voltage end of the resonance structure;

- an additional tuning device is provided for variable capacitance adjustment;

- the bottom part of the ferrule is provided with a coaxial cup member designed to be received in the tubular end of the core member of the resonance structure, and the salient finger extends radially from a peripheral edge of the cup member;

- said salient finger extends radially and is provided with a tubular portion coaxial to the terminal ferrule, said terminal ferrule being inserted into the tubular portion;

- each coil termination is provided with a similar terminal cap for allowing inductance adjustment from each end of the resonance structure;

The present invention also proposes a method of manufacturing said high frequency resonance based ignition system as further explained in the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is now described by way of example with reference to the accompanying drawings in which:

- figure 1 is a bloc-diagram showing a resonance based ignition system;
- figure 2 is a schematic perspective view showing partially the resonance structure according to the invention;
- figure 3 is a similar view to the view of figure 2 showing more particularly the terminal cap of the resonance structure without the terminal part of the structure;
- figure 4 is a similar view to the view of figure 2 showing more particularly the terminal part of the resonance structure comprising a terminal ferrule and a salient finger;
- figure 5 is a cross section view showing an alternative embodiment of the terminal cap, salient finger and ferrule of figure 4.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

According to the present invention, it is provided a resonance structure 12 having a variable last turn HF coil termination, anchored on the low voltage end of the resonator, comprising of a formed terminal cap 16 of sufficient conductive material permanently connected to the HF inductor coil 18 by means of weld or solder. The terminal cap 16 has a brake around its circumference to emulate the last turn of the coil 18. The form of the contact surface of the terminal cap 16 can have ripples divided into equal parts of constant degrees for enhancing the mating terminal location, or of a smooth surface as shown in figure 3.

A terminal ferrule 20 connects the low voltage input to the resonator 12 via the terminal cap 16. This terminal ferrule 20 has the addition of a formed shape 22 that is used to position and secure the part into the core 24 of the resonator 12. It is also isolated from the terminal cap 16. The terminal ferrule 20

has a salient finger 26 used to contact with the terminal cap 16, as shown in figure 4.

After the terminal cap 16 and the terminal ferrule 20 have been assembled a calibration is made to fine tune the resonance frequency F which is affected by equation 1. A weld or solder process is then carried out to permanently connect the terminals, in order to obtain the assembly as shown in figure 2.

It has to be noted that the resonance structure 12 has to withstand high voltages for its ignition function, and due to the nature of a quarter-wave transmission line, the high voltage will be built up along the helical coil 18.

As can be seen on figures 2 and 3, the terminal cap 16 has a general annular shape made of a radial wall 28 and of a cylindrical wall 30, the annulus being opened to delimit an intermediate free space 32, or gap, between the two circumferential ends 34, 36 of the terminal cap 16. The terminal cap 16 has, near a first circumferential end 34, a step portion 38 onto which the corresponding coil termination 40 comes into abutment and is attached by welded or soldered connection such that said coil termination 40 is in electrical contact with the terminal cap 16.

As can be seen on the figures, the second circumferential end 36 of the terminal cap 16 has a reduced axial thickness, with regards to the first circumferential end 34, such that said second circumferential end 36 is not in electric contact with the adjacent coil portion, delimiting an axial gap 42 with said coil portion. Preferably, the cylindrical wall 30 length decreases essentially continuously from the first circumferential end 34 to the second circumferential end 36. Thus, the terminal cap 16 prolongs the coil 18 from its termination 40 and forms the last turn of the coil.

Preferably, the terminal cap 16 is made of non ferrous material such as copper material.

As represented on figures 2, 4, and 5, a salient finger 26 is provided on the terminal ferrule 20 to contact with the terminal cap 16 for connecting the terminal ferrule 20 to the coil 18. Depending on the salient finger 26 contact point on the radial wall 28 of the terminal cap 16, the inductance L can be adjusted since the circumferential position of the salient finger 26 contact point determines the coil length and the coil last turn length. The circumferential position of the

salient finger 26 is selected during the manufacturing process of the resonance structure 12 and, once it has been selected, the salient finger 26 is fixed permanently to the terminal cap 16, for example by welding or soldering.

Advantageously, considering the figures, the terminal ferrule 20 has an essentially tubular shape with an upper free end 44 to be connected to a complementary connector element (not shown) of the generator 10. The lower end 46 of the terminal ferrule 20 is provided with a formed cup 22 coaxial with the core member 24 of the resonance structure 12 and designed to be received in the upper end portion of the central bore 48 extending through out the core member 24.

The salient finger 26 is formed of a tab 50 extending radially from the peripheral outer edge 52 of the formed cup 22 and having a radial upper surface 54 and a radial lower surface 56, said radial lower surface 56 being in flat contact against the radial wall 28 of the terminal cap 16. Advantageously, the salient finger 26 is made of one piece with the formed cup 22.

According to an alternative embodiment which is shown on figure 5, the formed cup 22 could be replaced by a tubular portion 58 arranged at the inner end of the salient finger 26 and the terminal ferrule 20 is fitted into said tubular portion 58.

As can be seen on figure 5, at the final stage of the resonance structure 12 assembly, the core member 24 and the coil 18 are encapsulated in a dielectric insulator 60 and received in a metallic sleeve housing 62.

The salient finger 26 and the terminal ferrule 20 are made of electrically conductive material.

According to an alternative embodiment (not shown), each coil termination may be provided with a similar terminal cap 16 for allowing inductance L adjustment from each end of the resonance structure 12.

The present invention also proposes a method of manufacturing a high frequency resonance based ignition system comprising a generator 10, a resonance structure 12, and a heat release interface 14, wherein the manufacturing of the resonance structure 12 comprises the following steps:

- providing a core member 24,

- arranging a high-frequency inductor coil 18 around the core member 24,

- arranging a terminal cap 16 at a first end of the core member 24, said terminal cap 16 being connected to the first coil termination 40 and forming the last turn of the coil 18,

- providing a terminal ferrule 20 with a salient finger 26, said terminal ferrule 20 being connected to said terminal cap 16 via said salient finger 26,

- positioning said salient finger 26 circumferentially with regards to said terminal cap 16 in order to adjust the inductance L to the desired resonance frequency F,

- affixing permanently said salient finger 26 to said terminal cap 16,

- connecting the low voltage input of the generator 10 to said terminal ferrule 20.

CLAIMS

1. High frequency resonance based ignition system comprising a generator (10), a resonance structure (12), and a heat release interface (14), the resonance structure (12) having a high frequency coil (18) with terminations (40) and a terminal ferrule (20) connecting the low voltage input of the generator (10) to a first coil termination (40), characterized in that it further comprises a tuning element (16, 26) provided for adjusting the inductance (L) to the desired resonance frequency (F) during the manufacturing of the resonance structure (12), said tuning element (16, 26) comprising :

- a formed terminal cap (16) connected to a coil termination (40) in order to form the last turn of the coil (18), and

- a salient finger (26) provided on the terminal ferrule (20) to contact with the terminal cap (16) for connecting the low voltage input to the resonance structure (12) via the terminal cap (16),

the inductance (L) being adjusted depending on the circumferential position of the salient finger (26) with regards to the terminal cap (16).

2. System according to claim 1, characterized in that the terminal cap (16) has a brake around its circumference to emulate the last turn of the coil (18).

3. System according to claim 1 or 2, characterized in that the permanent connection of the terminal cap (16) to the terminal (40) of the coil (18) is done by welding or soldering.

4. System according to any of the preceding claims, characterized in that said terminal cap (16) is anchored on the low voltage end of the resonance structure (12).

5. System according to any of the preceding claims, characterized in that an additional tuning device is provided for variable capacitance adjustment.

6. System according to anyone of the preceding claims, characterized in that the bottom part of the ferrule (20) is provided with a coaxial cup member (22) designed to be received in the tubular end of the core member (24) of the resonance structure (12), and in that the salient finger (26) extends radially from a peripheral edge (52) of the cup member (22).

7. System according to any of claims 1 to 5, characterized in that said salient finger (26) extends radially and is provided with a tubular portion (58) coaxial to the terminal ferrule (20), said terminal ferrule (20) being fitted into the tubular portion (58).

8. System according to any of the preceding claims, characterized in that each coil termination (40) is provided with a similar terminal cap (16) for allowing inductance (L) adjustment from each end of the resonance structure (12).

9. Method of manufacturing a high frequency resonance based ignition system comprising a generator (10), a resonance structure (12), and a heat release interface (14), wherein the manufacturing of the resonance structure (12) comprises the following steps:

- providing a core member (24),
- arranging a high-frequency inductor coil (18) around the core member (24),
- mounting a terminal ferrule (20) at a first end of the core member (24),
- connecting said terminal ferrule (20) to a first coil termination (40),
- connecting the low voltage input of the generator (10) to said terminal ferrule (20),

characterized in that it further comprises the following steps:

- arranging a terminal cap (16) at said first end of the core member (24), said terminal cap (16) being connected to the first coil termination (40) and forming the last turn of the coil (18),
- providing said terminal ferrule (20) with a salient finger (26), said terminal ferrule (20) being connected to said terminal cap (16) via said salient finger (26),

- positioning said salient finger (26) circumferentially with regards to said terminal cap (16) in order to adjust the inductance (L) to the desired resonance frequency (F),

- affixing permanently said salient finger (26) to said terminal cap (16).

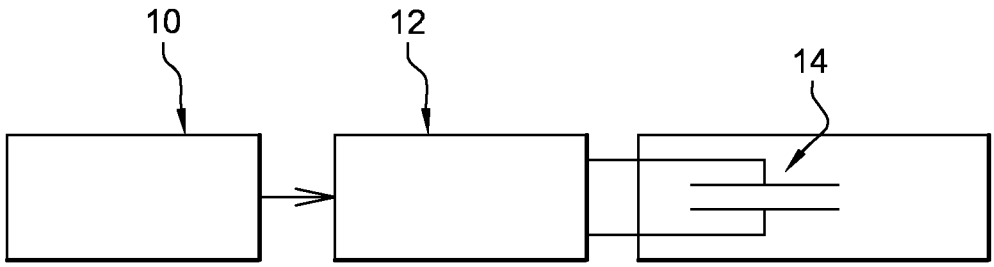


Fig. 1

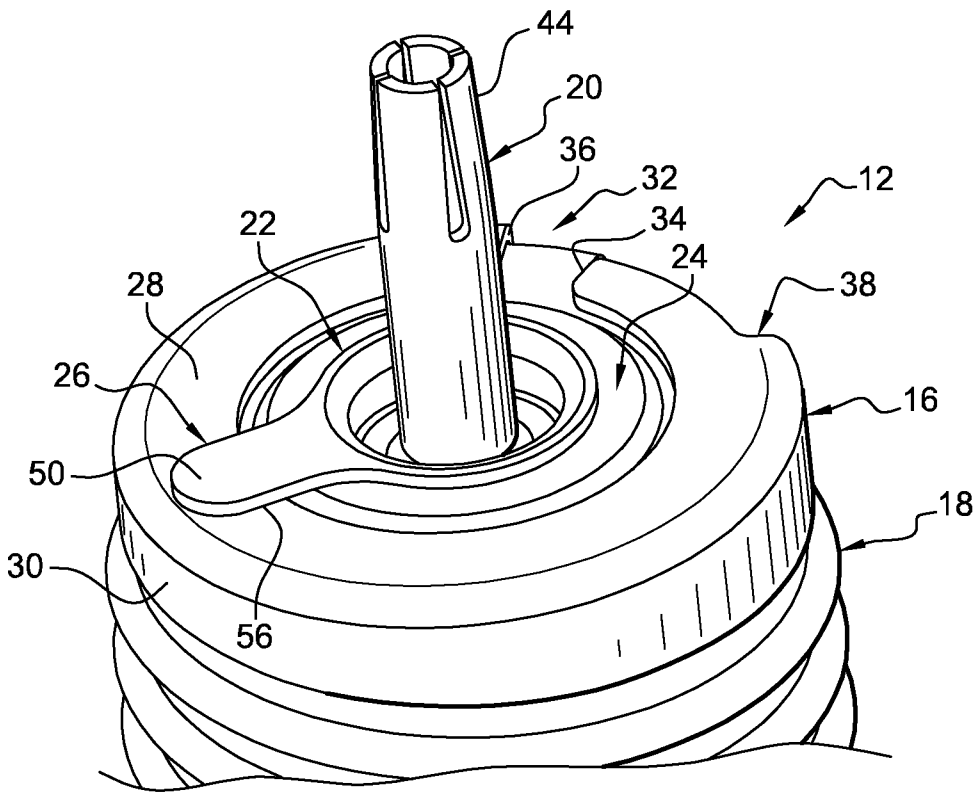


Fig. 2

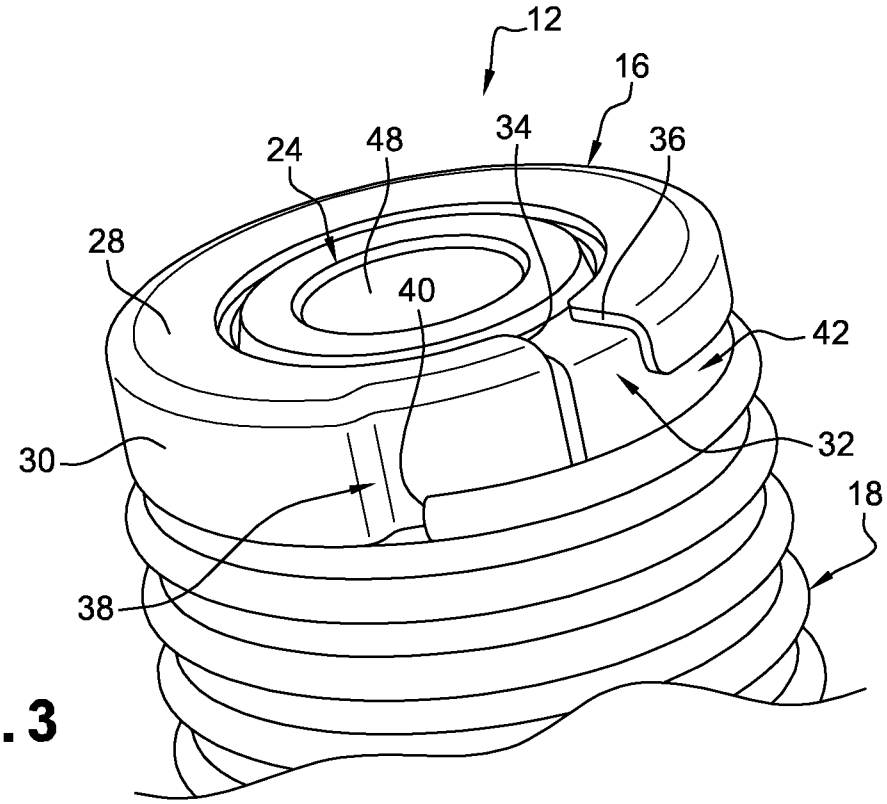


Fig. 3

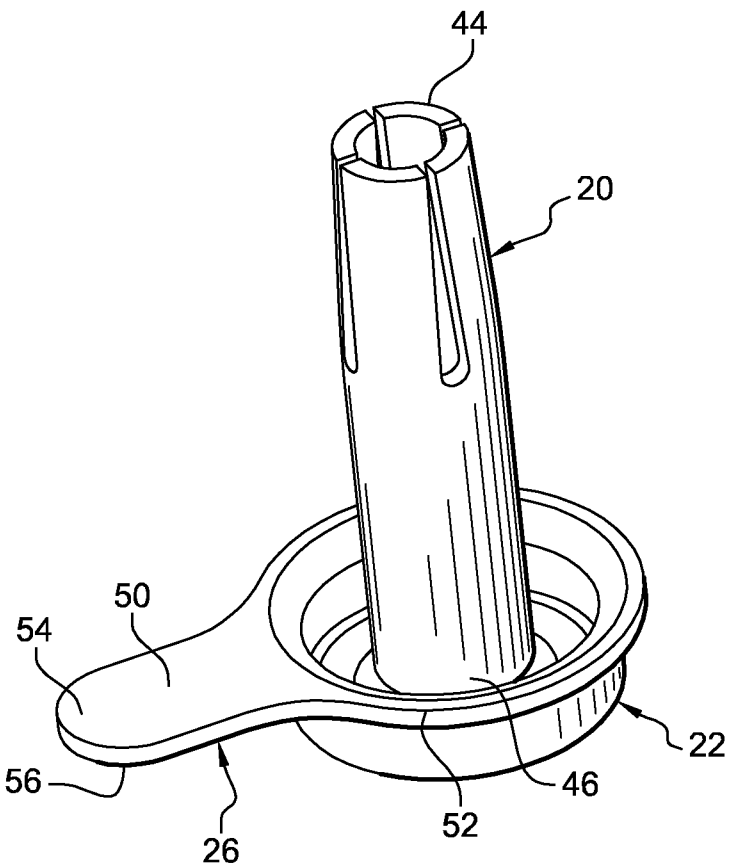


Fig. 4

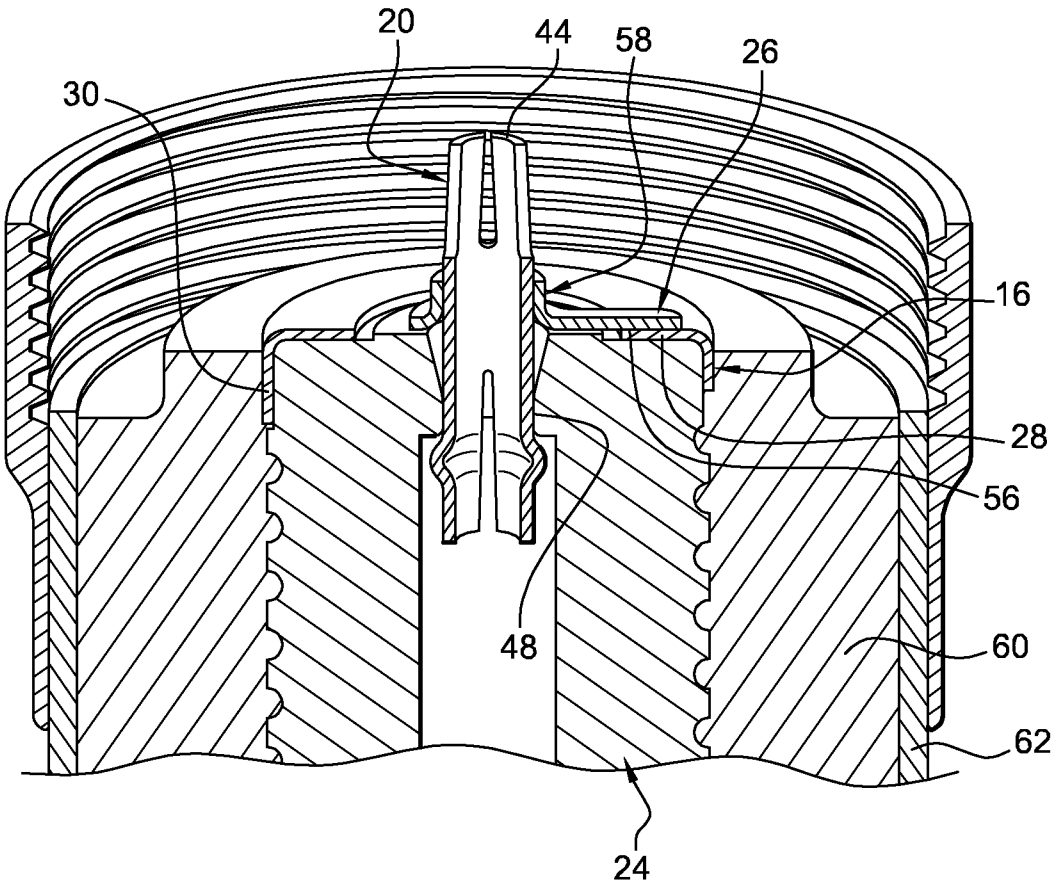


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/063121

A. CLASSIFICATION OF SUBJECT MATTER
INV. F02P3/01 F02P9/00 F02P23/04 H01F29/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F02P H01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	abstract; figure 1 column 5, lines 30-46	9
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
29 January 2010	04/02/2010

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/063121

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

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