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(54) Title: INJECTION SYSTEM FOR TWO-STROKE ENGINES

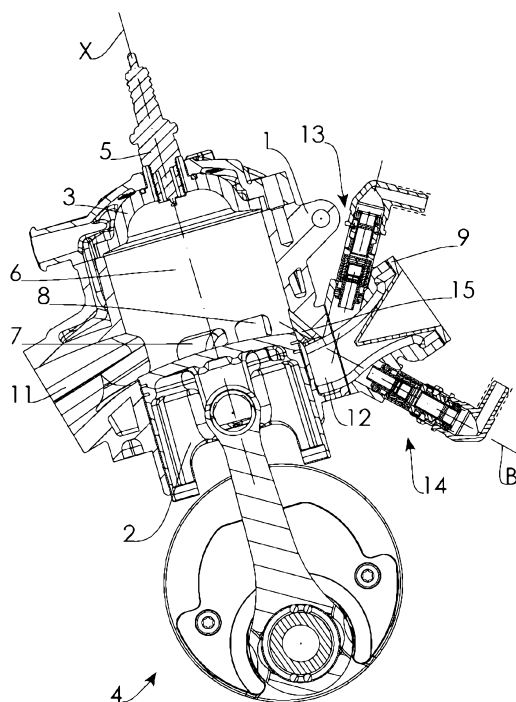


FIG. 3

(57) Abstract: An electronic injection two-stroke endothermic engine comprising an upper fuel injector (13) and a lower fuel injector (14), both accommodated in an intake duct (12) directly facing the cylinder (1), the latter closed by a head to form a combustion chamber (6) with one or more spark plugs (5) and connected to a pump-crankcase underneath via a plurality of side transfer ports (7, 8) which a central transfer port (15) is added to and crosses said intake duct (12) and allows the fuel sprayed by said lower injector (14) to reach the inside of the cylinder (1).

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DESCRIPTION

Title

Injection system for two-stroke engines.

Technical field

5 The present invention refers to the field of two-stroke
endothermic engines, of the fuel injection and spark
controlled-ignition type, typically used for light
vehicles, including motorcycles, scooters, or 4-wheel
motorbikes, or even for use in water or for motorizing
10 vehicles or gardening equipment.

Specifically, the invention belongs to the field of engines
equipped with low-pressure injectors and is particularly
advantageous in the case of injectors that simultaneously
inject fuel and lubricant.

15 Present status of the art

In principle, it is known that fuel-injection two-stroke
endothermic engines are controlled-ignition engines,
wherein air is directly carbureted in the cylinders or
before the suction valves, by way of intermittent jets of
20 gasoline produced by injectors.

When injection is made directly in the cylinder, a good
washing of the cylinder and of the combustion chamber can
be made by way of air, hence without waste of fuel and with
a considerable reduction in noxious emissions; it is also
25 possible to realize a fuel dosing more accurate than with a
carburetor at any number of revolutions and during
transients.

However, in injection two-stroke engines it is more
difficult to obtain a homogeneous mixture of fuel with
30 comburent air, because fuel has a shorter period of time at
its disposal to mix with air; it has been attempted to
reduce this disadvantage by creating a strong swirl to
improve combustion.

An improved combustion is essential to reduce emissions of polluting substances, i.e. mainly unburnt hydrocarbons and carbon and nitrogen oxides.

Another cause of pollution consists of the mixing of lubricant with fuel, whereby the percentage of unburnt fuel is also impaired by the presence of residues of lubricant, because in two-stroke engines lubrication is usually performed by using lubricant-added fuel.

In order to obviate these drawbacks, direct gasoline injection two-stroke engines have been set-up. In particular, let's remember WO 2004/106714 A1, which illustrates a two-stroke engine with an injector inserted in the cylinder according to such an angle as to spray gasoline toward the head of the engine in an instant when the piston just closed the air inlet ports; in these conditions pressure is still low in the combustion chamber and a high-pressure injector is not necessary to overcome it.

However, this system presents a number of drawbacks, mainly because of the limited quantity of fuel that can be injected by one injector only.

This drawback also affects WO 2006/007614A1, wherein, on the other hand, air is not injected into the cylinder, but rather into the pump-crankcase.

It is generally not recommended to increase the injector opening time, on the contrary, in order to minimize the risk of a fresh mixture leakage, it is rather advisable to end injection after closing the exhaust port; this is the reason why particularly powerful two-stroke engines provided with two injectors per cylinder have been developed for a long time, as shown in WO 9322545 A1 or in US 2011/0220059 A1.

The latter patent application explains that if the

injectors are arranged in the cylinder symmetrically with respect to the exhaust port, the axes intersecting the longitudinal axis (X) of the cylinder, symmetry conditions are achieved which foster the distribution of fuel in the combustion chamber whenever the engine runs at high numbers of revolutions and both injectors are active, whereas such favorable conditions do not exist in correspondence with low numbers of revolutions when one injector only operates. Furthermore, this configuration implies that the injected streams meet in the middle zone of the cylinder, thus developing a significant component of speed directed toward the exhaust port, with a consequent emission of considerable quantities of unburnt hydrocarbons.

Conversely, if the injectors are not arranged symmetrically, then the ideal conditions could not be achieved when the engine runs at the highest numbers of revolutions, but only at the lowest ones. Therefore US 2011/0220059 A1 teaches to arrange the injectors in such a way that their axis reciprocally intersect on that side of the axis of the cylinder which faces the exhaust port and extend toward the transfer ports located on the opposite sides of the diametral plane respectively.

This solution presents a number of important criticalities: first of all it makes it necessary to equip the engine with a separate lubrication circuit, for instance by way of an electric pump, to properly lubricate the crank-gear accommodated in the pump-crankcase, because the lubricant alone added to fuel would always remain inside the cylinder.

Furthermore, the stream of fuel unavoidably concentrates on the crown of the piston, this way increasing noxious emissions of unburnt hydrocarbons; on the other hand, the construction of the piston shall include appropriate slots

to make it possible for fuel to pass through, a solution that is particularly expensive.

The patent application US 5249557 A shows the use of two injectors in a two-stroke supercharged endothermic engine.

5 The embodiment shown in figure 5 comprises two injectors that discharge the fuel into two separate injection chambers, both communicating with the cylinder. The upper injection chamber is placed directly downstream of an accumulation chamber through which receives the airflow
10 coming from the compressor; the airflow produced by the compressor also reaches the lower injection chamber. The upper injector ensures the operation in normal conditions, while the lower injector comes into operation when more power is required.

15 The engine shown in US 5249557 A is designed to maintain, even during scavenging, the stratification of the fuel sprayed from the upper injector; this result is achieved by injecting the fuel in the upper injection chamber through which the airflow pushed by a compressor must pass. In this
20 solution at least an injection chamber and a compressor are required to obtain the homogenization of the charge, with evident disadvantages.

Summary of the invention

Embodiments described in the present patent application
25 provide a two-stroke endothermic engine, of the controlled-ignition type, that is capable of reducing noxious emissions and consumption, while simultaneously improving performances and guaranteeing a high specific power.

According to one aspect there is provided an engine
30 comprising at least one cylinder which is put in contact with the external world via an intake duct wherein two injectors are accommodated downstream the lamellar pack; the cylinder is closed by a head with at least one spark

plug on the upper side and is closed by a pump-crankcase on the lower side, which accommodates the crank-gears and is connected to the cylinder via side transfer ports; said intake duct is also crossed by a further transfer port, 5 called central transfer port, so that the upper injector sprays fuel in the duct and orients it toward the axis of the cylinder and downwards, whereas the lower injector sprays fuel toward the axis of the cylinder and upwards, whereby it is directed toward the cylinder after first 10 crossing the intake duct and subsequently covering the upper section of the central transfer port.

The exhausted gases are finally ejected from the cylinder via an exhaust duct.

For the reasons explained above, the aim is to delay fuel 15 injection as much as possible, compatibly with transfer port timing, so as to perform the first part of washing with air only or with a very lean mixture. As power demand increases, both injectors operate. The upper injector warranties a good mixing, as necessary to get high power 20 values.

In a practical embodiment of the invention, fuel is a gasoline, which an appropriate quantity of lubricant has been added to, so as to eliminate the need for a dedicated lubricant tank and for pumps for its transfer.

25 Advantageously the system used to control the injector of the engine according to the present patent application is of a type comprising at least one electronic control unit, so that the injectors can be operated individually independently of each other.

30 According to a typical operating sequence, whenever the engine runs at a low number of revolutions and at a low load, the lower injector is operated in such a way as to end fuel injection well in advance with respect to the

closing of the transfer port by the piston; this way the lower injector transfers most of the necessary quantity of fuel, whereas the upper injector is only operated with the purpose of guaranteeing the minimum flow rate necessary for lubricating the crank-gears in the pump-crankcase.

The lower injector is positioned in such a way that the fuel jet that comes out therefrom perfectly follows the air stream that in that moment, during the descending stroke of the piston, is going up along the central transfer port and is directed toward the electrode of the spark plug.

In this way the first part of the washing will take place with a very lean mixture of air and fuel, i.e. with few fuel, thus allowing to considerably reduce fuel losses upon exhaust.

As power demand increases, the quantity of fuel transferred by the lower injector increases, up to reaching a condition wherein the latter is not capable any longer of meeting a further request for fuel; therefore, the quota of fuel injected by the upper injector will progressively increase.

Then the fuel injected by the upper injector goes down into the pump-crankcase wherefrom it will transfer into the combustion chamber via the transfer ports, during the subsequent descent of the piston toward the lower dead point; this process caters for a good air-fuel homogenization as necessary to generate the maximum power values available.

Brief description of the drawings

Fig. 1 shows a rear view of the cylinder of the endothermic engine according to the present patent application in an embodiment wherein the suction channel presents a first part integral with the cylinder (1) and a second part consisting of a stand-alone element, the latter comprising seats for an upper injector (13), a lower injector (14),

and for a lamellar pack (9). The view also shows the trace of the cutting plane of the cross-section shown in the following figure.

Fig. 2 shows a cross-section view wherein it is possible to
5 look at inside the cylinder (1), with its respective longitudinal axis (X), connected to the external world via an intake duct (12) and an exhaust duct (11).

Fig. 3 shows a cross-sectional view of an embodiment of the
10 endothermic engine according to the present patent application which allows to look at the peculiar features of the invention; the piston is shown in its lower dead point.

The figure shows the cylinder (1), which presents an
exhaust duct (11), side transfer ports (7, 8), and a
15 central transfer port (15). The upper inner part of said cylinder, closed by the head (3) which comprises a seat for a spark plug (5), operates as a combustion chamber (6).

The figure shows an embodiment whereby the intake duct (12)
is split into two parts, a former part being integral with
20 the cylinder (1) and comprising an intersection with the central transfer port (15), and a second part, on the right-hand side of the drawing, wherein seats for the accommodation of the upper injector (13) and of the lower injector (14) are obtained, as well as a seat for the
25 lamellar pack (9).

In the side walls of the cylinder (1) the ducts for the engine cooling thermal vector fluid, typically an aqueous mixture, are visible.

A crank-gear (4) is housed inside a pump-crankcase, the
30 latter not being shown.

The figure also shows the longitudinal axis (X) of the

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cylinder and the longitudinal axis (B) of the lower injector which, in proximity of the lower dead point, reaches the combustion chamber with no intersection at all, by transversally crossing the intake duct (12) and subsequently entering the upper section of the central transfer port (15).

Fig. 4 shows a cross-sectional view of the embodiment shown in Fig. 3, the piston being at the upper dead point. With respect to the references of the previous figure, the drawing shows the longitudinal axis (A) of the upper injector and the lower section of the central transfer port (15) placed between the intake duct (12) and the pump-crankcase.

Detailed description of an embodiment of the invention

The following detailed description, which is made for explanatory not limitative purposes with reference to the attached drawings, highlights the further features and advantages deriving therefrom and which are an integral part of the subject invention.

In a particularly compact and economical embodiment, the controlled ignition two-stroke endothermic engine according

to the present patent application comprises at least one cylinder (1), featuring a substantially circular cross-section, which slidably accommodates internally thereto a substantially cylindrical piston (2), and is connected on
5 the top side to a head (3) in such a way as to define a combustion chamber (6) with at least one spark plug (5).

The cylinder (1) is connected on the bottom side to a pump-crankcase, the latter communicating with said cylinder (1) by way of at least one central transfer port (15) and,
10 usually, also by way of one or several side transfer ports (7, 8); the cylinder (1) also includes an exhaust duct (11) and an intake duct (12), the latter accommodates an upper fuel injector (13) and a lower fuel injector (14).

The two injectors may have different characteristics and
15 their operation is controlled independently by an appropriate drive and control system which, advantageously, is controlled electronically.

Furthermore, in proximity of the wall of the cylinder (1), the intake duct (12) is crossed by a further transfer port
20 (15) called central transfer port.

The upper injector (13) is accommodated in the higher part of the intake duct (12) and the speed of the fuel sprayed by it has both a component parallel to the axis (X) of the cylinder (1) directed toward the pump-crankcase, and a
25 component orthogonal to the central axis of said cylinder (1) directed toward the inside of the cylinder (1).

The lower injector (14) is housed in the lower part of said intake duct (12) so that the fuel sprayed by it reaches the inside of said cylinder (1) after first crossing said
30 intake duct (12) and subsequently going along the upper section of said central transfer port (15).

In a particularly simple and practical embodiment the outer end of said intake duct (12) includes a seat for mounting

the lamellar pack (9) thereon.

Advantageously said intake duct (12), in which seats are obtained for housing said upper injector (13) and said lower injector (14), is aligned with the suction port
5 obtained on said cylinder (1) which it is integrally coupled with.

In a convenient embodiment the intake duct (12) is diametrically opposed to the exhaust duct (11).

The intake duct (12) can be completely obtained in a part
10 of the cylinder (1), or be split into two or more parts, a first part of which is integral with the cylinder (1) and a second part consists of a stand-alone element, integrally connected to the cylinder (1) via coupling means of a known type.

15 In the embodiment illustrated in the drawings attached to the present patent application, the part integral with the cylinder (1) comprises a section wherein the intake duct (12) crosses the central transfer port (15), whereas the part consisting of a stand-alone element comprises the seat
20 for the injectors (13, 14) and the lamellar pack (9), thus forming a stand-alone sub-assembly which can also be used on different cylinders, provided the latter have all presettings necessary for coupling with said sub-assembly.

Throughout the specification and the claims that follow,
25 unless the context requires otherwise, the words "comprise" and "include" and variations such as "comprising" and "including" will be understood to imply the inclusion of a stated integer or group of integers, but not the exclusion of any other integer or group of integers.

30 The reference to any prior art in this specification is not, and should not be taken as, an acknowledgement of any form of suggestion that such prior art forms part of the common general knowledge.

It will be appreciated by those skilled in the art that the invention is not restricted in its use to the particular application described. Neither is the present invention restricted in its preferred embodiment with regard to the
5 particular elements and/or features described or depicted herein. It will be appreciated that the invention is not limited to the embodiment or embodiments disclosed, but is capable of numerous rearrangements, modifications and substitutions without departing from the scope of the
10 invention as set forth and defined by the following claims.

CLAIMS

1. A controlled ignition two-stroke endothermic engine, of a type comprising at least one cylinder that slidingly
5 houses a piston inside, and is connected to a head on the upper side, so as to determine a combustion chamber with at least one spark plug, and is connected to a pump-crankcase on the lower side, the latter being in communication with said cylinder at least via a central transfer port, said
10 cylinder being in communication with the external world via an exhaust duct and an intake duct, **characterized in that** said intake duct is crossed by said central transfer port and houses an upper fuel injector on its top side and a lower fuel injector on its bottom side, the latter oriented
15 so that the fuel sprayed from it reaches the inside of said cylinder after first having crossed said intake duct and subsequently running the upper part of said central transfer port which connects said intake duct with said cylinder.
- 20 2. An engine according to the previous claim, **characterized in that** said cylinder also communicates with said pump-crankcase via one or several side transfer ports.
3. An engine according to the previous claim 1 or 2, **characterized in that** the speed of the fuel sprayed by said
25 upper fuel injector has a component parallel to the axis of said cylinder directed toward the pump-crankcase and a component orthogonal to the central axis of said cylinder directed toward the inside of the cylinder.
4. An engine according to any of the previous claims,
30 **characterized in that** said central transfer port crosses the part of said intake duct between said upper and lower fuel injectors and said cylinder.
5. An engine according to any of the previous claims,

characterized in that said lower fuel injector is housed in the lower part of said intake duct so that the axis according to which it sprays the fuel crosses the central transfer port up to reaching the inner of said cylinder.

5 **6.** An engine according to any of the previous claims, **characterized in that** said intake duct is subdivided into two or several parts, of which a first part integral with the cylinder and a second part consisting of a separate element, integrally connected to the cylinder through
10 coupling means of a known type, so as to form a stand-alone sub-assembly which might even be used on different cylinders.

7. An engine according to the previous claim, **characterized in that** said first part of said intake duct comprises the
15 intersection with the central transfer port, whereas said second part of said intake duct comprises the seats for said upper fuel injector and for said lower fuel injector and for the lamellar pack.

8. An engine according to any of the previous claims,
20 **characterized in that** said central transfer port is directed toward the electrode of said spark plug.

9. A method for the operation of a two-stroke engine as claimed in any one of claims 1 to 8, **characterized in that** whenever the power demand is low the lower injector is
25 operated in such a way as to end fuel injection before said central transfer port is closed by said piston, by injecting the fuel into the air stream that during the descending stroke of the piston is flowing up along the central transfer port, and in that the upper injector is
30 operated just at the minimum rate necessary to lubricate the crank-gear located in the pump-crankcase.

10. A method for the operation of a two-stroke engine according to the previous claim, **characterized in that**, as

the power demand increases, the amount of fuel transferred by the lower injector increases up to the maximum it is capable of delivering, afterwards the upper injector progressively increases its own delivery of fuel which goes
5 down into the pump-crankcase from which, during the next descent of said piston, it will enter the combustion chamber through the transfer port.

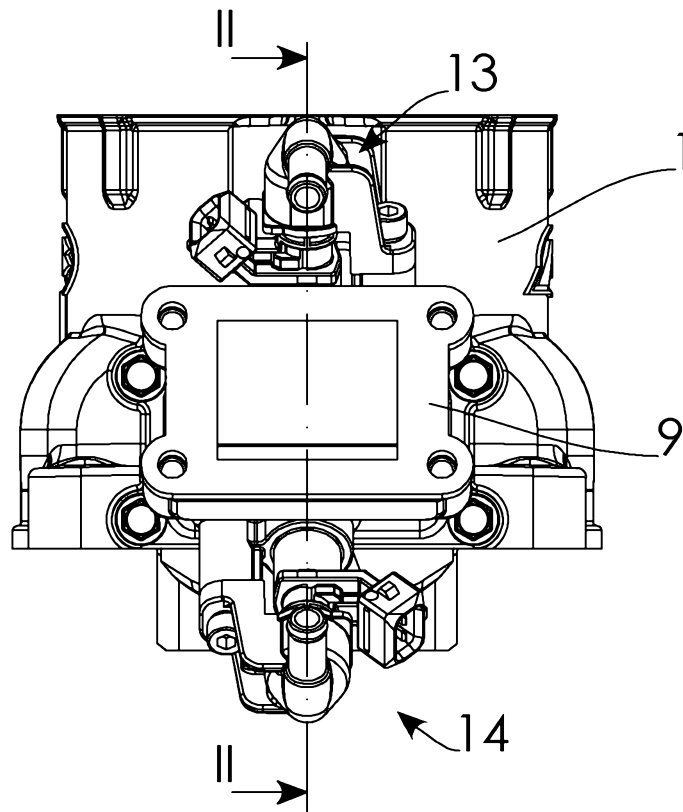


FIG. 1

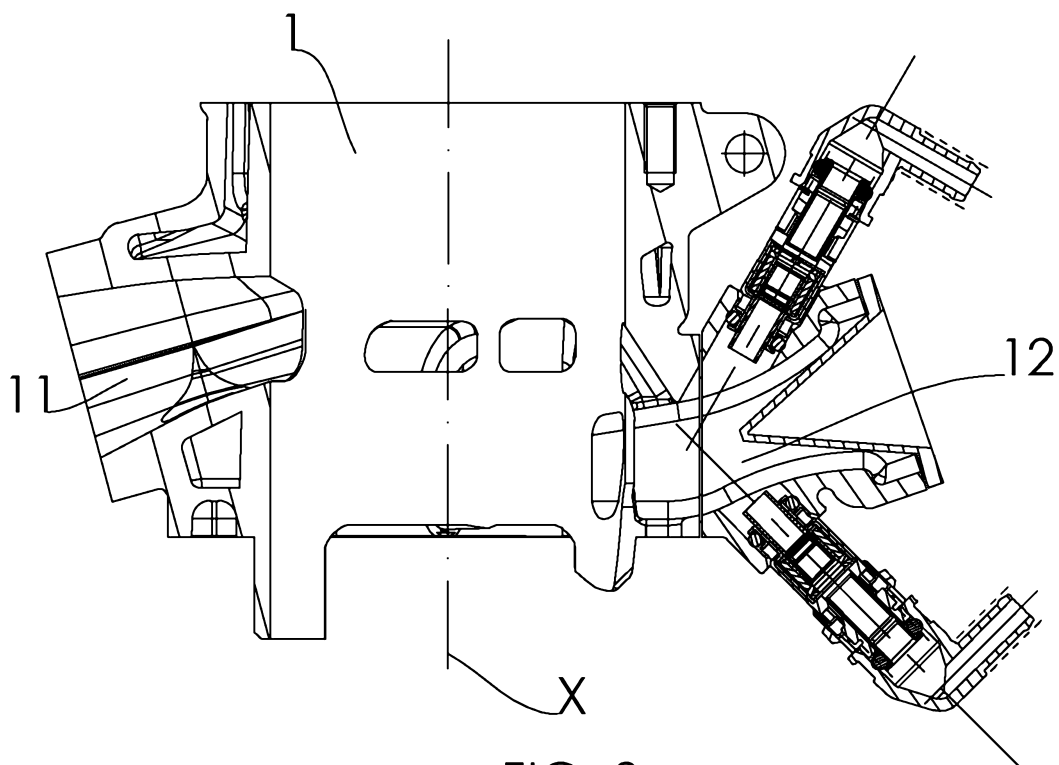


FIG. 2

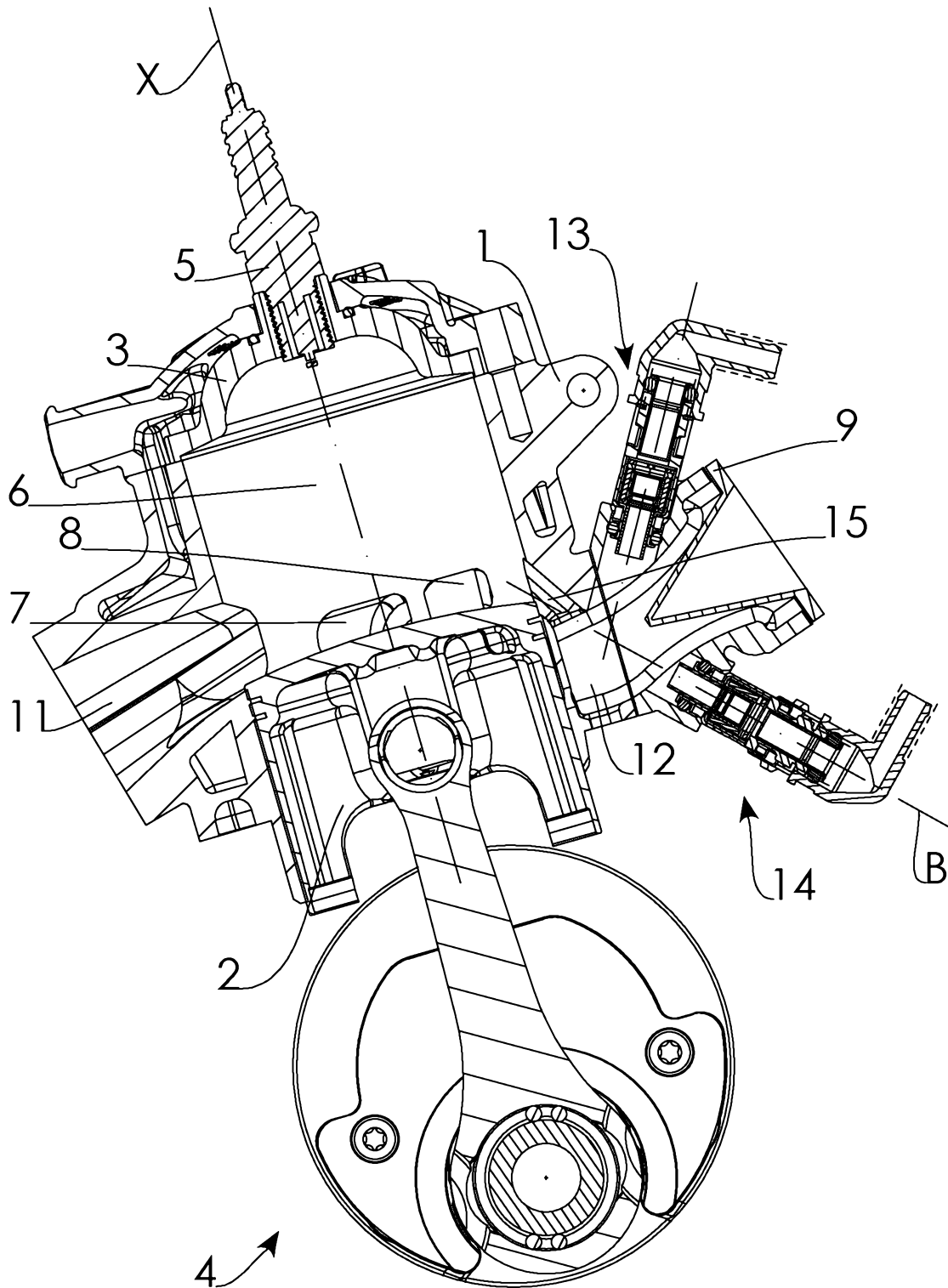


FIG. 3

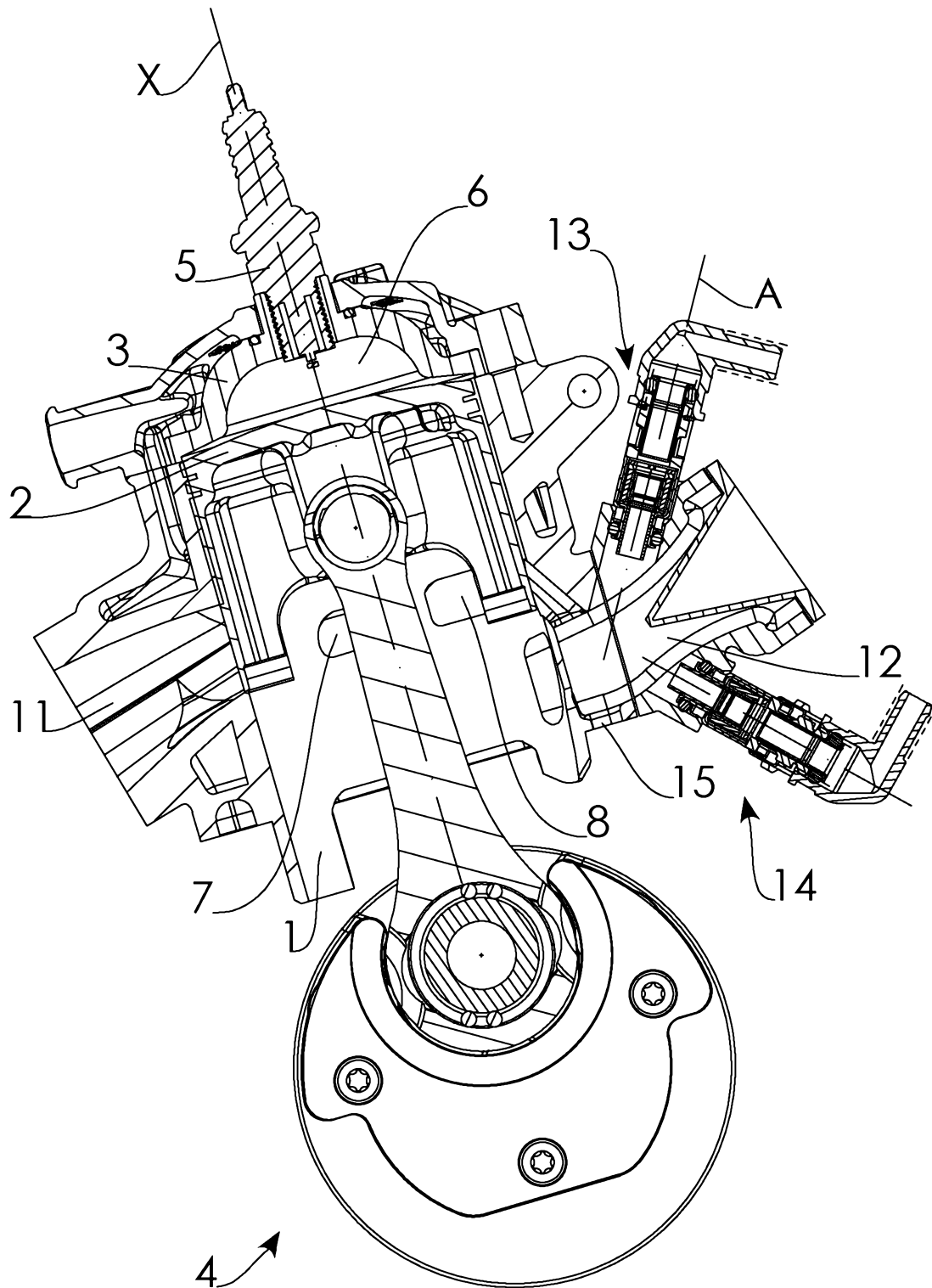


FIG. 4