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- (54) **Title:** A COMBINED DECOMPRESSION AND PRIMING VALVE FOR AN INTERNAL COMBUSTION ENGINE, AND AN ENGINE PROVIDED WITH THE VALVE

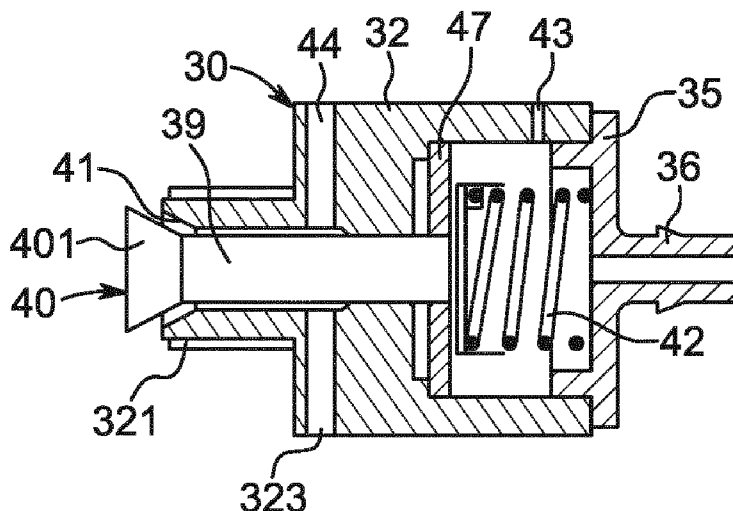


FIG. 6

(57) **Abstract:** To make a small two-stroke engine of the kind used primarily in handheld working tools, such as chainsaws, for example, easier to start, it is provided with a combined decompression and priming valve (30), which can be actuated manually, or by an electronic control unit or by pressure differences arising upon rotation of the crankshaft (16) of the engine and acting on a piston (34) in a piston and cylinder assembly included in the valve (30). The combined decompression and priming valve (30) has an inlet (323) connected to an induction conduit (20) for an air-fuel mixture by a conduit (201), so as to prime the engine (1) when the downwards moving piston (7) of the engine creates an underpressure in the engine cylinder (9).

A COMBINED DECOMPRESSION AND PRIMING VALVE FOR AN INTERNAL COMBUSTION ENGINE, AND AN ENGINE PROVIDED WITH THE VALVE

5 DESCRIPTION

TECHNICAL FIELD

The present invention relates to a combined decompression and priming valve adapted to be connected to a combustion chamber of a two-stroke internal combustion engine for
10 reducing compression and priming the engine in order to facilitate the starting thereof.

It also relates to a two-stroke internal combustion engine having a cylinder, a reciprocating piston movable back and forth in the cylinder, a crankcase, a combustion chamber in the cylinder that has a wall and an intake port provided in the cylinder wall, an induction
15 conduit for passing an air-fuel mixture to the intake port, and a throttle valve for controlling the amount of air-fuel mixture passing through the induction conduit.

BACKGROUND ART

Hand-held working tools usually are driven by two-stroke internal combustion engines. To
20 make two-stroke engines easier to start, they can be equipped with automatic decompression valves. US 6,253,723 B1 discloses an arrangement including an automatic valve for reducing compression in order to facilitate starting of a two-stroke internal combustion engine includes a movable valve adapted to control a gas flow through an opening provided in a wall of the combustion chamber of the engine. A spring is adapted to
25 move the movable valve to an open position, and a drive actuated by underpressure is adapted to move the movable valve to a closed position against the action of the spring. The driver includes a cylinder, a piston movable in the cylinder and connected to the movable valve, and a conduit connecting the cylinder to a source of underpressure, *viz.* a duct for transferring the air-fuel mixture from the crankcase to the combustion chamber. A check
30 valve is provided in the conduit for allowing an air flow in a direction away from the driver cylinder only, and a leak passage is adapted to allow a small flow of air into the for facilitating the opening of the movable valve when operation of the engine has been stopped.

35 In this context, the term “underpressure” is used to designate a pressure below that of the surrounding atmosphere.

Further, to make two-stroke internal combustion engines easier to start, they have hitherto also been primed by a start pump, usually a bulb-type pump made of rubber, which can be actuated manually to draw or purge a gaseous phase, usually referred to as fuel vapor, and stale liquid fuel from the carburetor via a fuel passage upstream of the start pump and to
5 direct the fuel vapor and liquid fuel into a induction conduit downstream of the throttle valve of the carburetor. No priming systems passing an air-fuel fixture from an induction conduit through a separate conduit directly into the combustion chamber of a two-stroke internal combustion engine are known.

10 Two-stroke engines with automatic decompression valves are also disclosed in US 4,619,228, US 6,892,688 B2, US 7,228,843 B2 and JP9112394A, for example. However, in no case where two-stroke engines are equipped with automatic decompression valves, a combined decompression and priming valve has been used. In fact, such a combined valve appears to be novel.

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SUMMARY OF THE INVENTION

One object of the present invention is to provide a novel type of valve, namely a combined decompression and priming valve, which as is obvious from its denomination cannot just temporarily reduce the compression of the gases in the combustion chamber of an internal
20 combustion engine by discharging a portion of said gases, but which also can prime the engine by supplying an air-fuel mixture directly into the combustion chamber in order to facilitate the starting of the engine.

This object is achieved in that such a novel combined decompression and priming valve in
25 accordance with the present invention comprises:

- a) a valve housing;
- b) a valve member movable in said housing between a first position, where the valve is fully open, and a second position, where the valve is closed;
- c) first means for holding the valve member in the fully open first position, a pressure
30 created by combustion of a fuel-air mixture in the combustion chamber overcoming the holding force of the first means and moving the valve member to its second position, where the valve is closed;
- d) second means for holding the valve member in the closed second position when the engine is running;
- 35 e) an outlet from the housing for discharging gases passing from the combustion chamber past the valve member when the valve is open; and
- f) an inlet for a priming air-fuel mixture into the housing and past the valve member into the combustion chamber when the valve is open.

In a preferred embodiment of the invention, the valve member includes a valve head and a valve stem, the valve housing has a seat for the valve head, at least one of said means includes a recess in the valve stem and a spring biased locking member in the valve housing, and the valve member (is snap locked in the fully open first position and the closed position. Such a valve is simple and reliable.

Then, the two means include together either a common spring biased locking member and two recesses that are axially spaced along the valve stem, or a common recess and two axially spaced spring biased locking members.

Preferably, the valve stem has a circular cross-section and the recess is a peripheral groove around the periphery of the stem. Then, the spring biased locking member is supplemented with two additional spring biased locking members, all three being equiangularly spaced from one another for simultaneous engagement of them in the peripheral groove.

In an inexpensive first design, the valve member is displaceable manually.

In a second design, the valve member is displaceable in response to a signal from an electronic control unit, the valve may be an automatic piezoelectric or solenoid valve.

In a third design, the valve member is displaceable in response to pressure differences between the combustion chamber and a gas conduit upstream of the combustion chamber, and the valve is an automatic pneumatically operated valve.

Usually, it is recommendable that at least one of the outlet and the inlet is provided with a check valve to permit flow in a desired direction only.

Another object of the present invention is to provide an engine that is easy to start.

This object is achieved in that the engine specified in the second paragraph above in accordance with the present invention is equipped with a combined decompression and priming valve that is connected to the combustion chamber for reducing compression and priming the engine in order to facilitate starting thereof, said valve having an inlet for a priming air-fuel mixture, a conduit being interconnected between the induction conduit and the inlet for passing an air-fuel mixture directly from the induction conduit through the valve into the combustion chamber to prime the engine. Thereby, that starting of the engine will be so facilitated that in some cases, no choke will be needed.

Preferably, the combined decompression and priming valve comprises:

- a) a valve housing having said inlet;
 - b) a valve member movable in said housing between a first position, where the valve is fully open, and a second position, where the valve is closed;
 - 5 c) first means for holding the valve member in the fully open first position, a pressure created by combustion of a fuel-air mixture in the combustion chamber overcoming the holding force of the first means and moving the valve member to its second position, where the valve is closed;
 - 10 d) second means for holding the valve member in the closed second position when the engine is running; and
 - e) an outlet from the housing for discharging gases passing from the combustion chamber past the valve member when the valve is open.
- 15 In an inexpensive first design, the valve member is displaceable manually.

In a second design, the valve member is displaceable in response to a signal from an electronic control unit, the valve may be an automatic piezoelectric or solenoid valve.

- 20 In a third design, the valve member is displaceable in response to pressure differences between the combustion chamber and a gas conduit upstream of the combustion chamber, and the valve may be an automatic pneumatically operated valve.

Then, the valve preferably includes a pressure transmitting member operatively connected
25 to the valve member, and a conduit, *e.g.* a hose, for transferring pneumatic pressure from an underpressure source to the pressure transmitting member to displace the valve member, a check valve is provided for preserving the underpressure so as to keep the decompression valve closed when the engine is running, and a bleed conduit and a vent are provided for eliminating the underpressure within a few seconds after the engine has stopped so as to
30 open the valve. Thereby, the valve can operate automatically.

The pressure transmitting member is one of a piston in a piston and cylinder assembly or a membrane. A compression spring may be provided for biasing the valve member toward its open first position, and the size of the vent and the force from the compression spring are
35 matched against the underpressure in the conduit. While a piston requires the compression spring, the resilience of a membrane may make the compression spring unnecessary.

The two-stroke engine has a transfer duct that leads from the crankcase to a transfer port in the cylinder wall, and optionally a conduit ported by the engine piston for supply of additional air into the interior of the cylinder for scavenging. Then, the underpressure source suitably is one of the crankcase, the transfer duct, the air-fuel mixture conduit, and the scavenging air conduit.

To facilitate achievement of desired flow conditions, the outlet may be larger than the inlet and suitably have a diameter of 2–15 mm, preferably 5–10 mm.

The gases from the outlet are preferably discharged either through a conduit to an exhaust conduit from the engine cylinder or directly to surrounding atmosphere or to a fresh air conduit downstream of an air filter but upstream of a carburetor and a possible branching of the fresh air conduit into a conduit through the carburetor and another conduit for supply of additional fresh air to the engine cylinder.

If desired, a check valve is provided for preventing gases from passing in a wrong direction through the outlet.

In a special embodiment, the outlet may also form the inlet. Then, during a first portion of the period of time that the valve is open, gases from the combustion chamber are discharged through the valve and the conduit into the induction conduit, while during a second portion of the period of time the flow through the conduit is reversed and air-fuel mixture from the induction conduit is passed through the valve directly into the combustion chamber.

Suitably, the volume of the gases leaving the combustion chamber through the combined automatic decompression and priming valve is at least twice the size of the internal volume of the conduit connecting said inlet with the induction conduit at a position downstream of the throttle valve. Preferably, ratio between the volumes is at least 7:1.

Further, to ensure optimum conditions during the start of the engine, the combined automatic decompression and priming valve is mounted to direct the flow of priming air-fuel mixture toward the vicinity of the spark.

When the conduit connecting the inlet with the induction conduit is a hose, the hose suitably has an internal diameter of 1–10 mm, preferably 6 mm, and suitably a length of 5–25 cm, preferably 10 cm.

To get a desired mixing ratio in the air-fuel mixture to be passed directly from the induction conduit through the valve into the combustion chamber, the conduit from the induction conduit to the inlet of the valve preferably starts at a position downstream of the throttle valve.

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BRIEF DESCRIPTION OF THE DRAWINGS

In the following, the invention will be described in more detail with reference to preferred embodiments and the appended drawings.

10 Fig. 1 is a side view of a manual decompression and priming valve shown partly in cross-section and having a two-groove snap lock with a spring biased locking member for locking the valve in a fully open and a closed position.

15 Fig. 2 is a side view of a manual decompression and priming valve shown partly in cross-section and having a single-groove snap lock with axially spaced spring biased locking members for locking the valve in a fully open and a closed position.

Fig. 3 is a cross-sectional view of the manual decompression and priming valve shown either of Figs. 1 and 2 and showing the spring biased locking members.

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Fig. 4 is a side view of a solenoid-type decompression and priming valve shown partly in cross-section.

25 Fig. 5 is a side view of a pneumatically operated decompression and priming valve shown partly in cross-section and having a compression spring trying to keep the valve open and a piston and cylinder assembly trying to close the valve against the force of the spring.

30 Fig. 6 is a side view of a pneumatically operated decompression and priming valve shown partly in cross-section and having a compression spring trying to keep the valve open and a membrane trying to close the valve against the force of the spring.

35 Fig. 7 is a simplified principle sketch of a crankcase-scavenged two-stroke internal combustion engine having an automatic decompression and priming valve arranged in the cylinder head of the engine in accordance with one preferred embodiment of the present invention.

Fig. 8 is a simplified principle sketch of a crankcase-scavenged two-stroke internal combustion engine having an automatic decompression and priming valve arranged in the cylinder wall in a position close to the cylinder head of the engine in accordance with another preferred embodiment of the present invention.

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Fig. 9 is a partial section of a two-stroke internal combustion engine incorporating an automatic decompression and priming valve of the type shown in Fig. 5 but having a separate outlet for exhaust gas and a separate inlet for priming air-fuel mixture according to a preferred embodiment of the present invention.

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Fig. 10 is a partial section similar to Fig. 9 but having a first check valve provided in the outlet for exhaust gas.

Fig. 11 is a partial section similar to Fig. 10 but having a second check valve provided in the inlet for exhaust priming air-fuel mixture.

15

MODE(S) FOR CARRYING OUT THE INVENTION

Fig. 1 is a side view of a decompression and priming valve **30** in accordance with a first preferred embodiment of the present invention and shown partly in cross-section. The valve **30** comprises a valve housing **32** and a valve member **40** that is axially movable in the housing **32** between a first position, where the valve **30** is fully open, and a second position, where the valve **30** is closed. The valve member **40** has a valve head **401** and a valve stem **39** having a first end carrying the valve head **401**. The housing **32** has a seat **41**, against which the head **401** seals when the valve **30** is closed. Further, the housing **32** has a tubular first end, which radially outside the seat **41** has an external thread **321** for threaded engagement with a mating threaded through bore in a cylinder head or cylinder wall of a two-stroke internal combustion engine. In addition, the housing **32** has an outlet **44** for exhaust gas from the combustion chamber of the engine and an inlet **323** for a priming air-fuel mixture from a suitable source, such as an induction conduit downstream of a throttle valve of a carburetor, for example, to be passed to the combustion chamber. In both directions, the gases are passed through a radial space between the valve stem **39** and an inner wall of the housing **32**. If desired and as shown, the outlet **44** may be provided with a check valve **441** to prevent gas from being sucked back through the outlet into the valve **32**. Similarly, the inlet **323** may be provided with a check valve **325** to prevent exhaust gas from trying to leave the valve housing **32** through the inlet **323**. To facilitate achievement of desired flow conditions, the outlet **44** may be larger than the inlet **323** and suitably have a diameter of 2–15 mm, preferably 5–10 mm.

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The valve shown in Fig. 1 is designed to be operated manually. The valve stem **39** has a second end, which extends out of the housing **32** and is provided with a knob **403** or the like that offers a grip for the fingers of an operator. Further, the valve **30** is provided with first means **326**, **405** for holding the valve member **40** in the fully open first position. A pressure created by combustion of a fuel-air mixture in the combustion chamber **13** will overcome the holding force of the first means and move the valve member to its second position, where the valve **30** is closed. Further, the valve **30** is provided with second means **326**, **404** for holding the valve member **40** in the closed second position when the engine is running. In the embodiment shown in Fig. 1 the first and second means are formed by a conventional snap lock mechanism that includes two spaced circumferential grooves **404** and **405** provided on the valve stem **39** and a spring biased locking member **326**, e.g. a ball, located in the wall of the housing **32** for engaging in either of the grooves **404** and **405** and thereby locking the valve in a fully open and a closed position. In the preferred embodiment shown in the cross-sectional view of Fig. 3, the snap lock mechanism includes three equiangularly spaced spring biased balls **326**. A tubular thin sheet metal cover **327** around the area, where the bores in which the spring biased locking members are located, retains the springs in their intended places and maintains the intended biasing force.

Fig. 2 shows an alternative embodiment, which differs from that of Fig. 1 in that the valve stem **39** is provided with a single circumferential groove **404**, and instead there are two axially spaced sets of spring biased locking balls **326** or the like. The single circumferential groove **404** and the left-hand set of spring biased locking members **326** form the first means for holding the valve member **40** in the fully open first position, while the second means is formed by the single groove **404** and the right-hand set of spring biased locking members **326**. As before, the valve **30** will be locked in its fully closed and its fully open positions.

When an operator wants to start a two-stroke internal combustion engine provided with the manual decompression and priming valve, he presses the knob **403** to move the valve member **40** from its closed to its open position, where it is locked by the snap lock mechanism. Then he pulls the starting cord of the engine. As the combined decompression and priming valve **30** is open, exhaust gas from the combustion chamber will pass through the valve **30** and be discharged through its outlet **44**. When the engine piston has moved so far that suction is created in the engine cylinder, a priming air-fuel mixture from a suitable source will be sucked through the inlet **323** into the valve **30** and further into the cylinder. When the spark from the spark plug ignites the air-fuel mixture in the combustion chamber, the created pressure wave will overcome the holding force of the snap lock mechanism and close the valve **32**. Then, the valve will be closed until the operator will start the engine a

second time and once more presses the knob **403** to move the valve member **40** from its closed to its open position.

Instead of being manually operated, the decompression and priming valve may be a
5 solenoid valve or a piezoelectric valve operated by signals from an electronic control unit, not shown. Fig. 4 is a simplified principle sketch of a solenoid-type decompression and priming valve **30** shown partly in cross-section. Here, the combination of a solenoid **46** and a compression spring **42** supported by an end wall **35** of the housing **32** and acting on the end surface of the second end of the valve stem **39** is substituted for the push knob **403** and
10 the snap lock mechanism, i.e. grooves **404**, **405** and spring biased locking member **326**. The signals from the electronic control unit are generated only when the crankshaft of the engine rotates, and they decide whether the solenoid **46** will keep the valve member **40** in its closed position by pulling against the force of the compression spring **42**, or the compression spring **42** will keep the valve member **40** in its open position. Thus, in this
15 embodiment the first means is formed by the compression spring **42**, and the second means by the solenoid **46** (actuated by the electronic control unit).

In another preferred embodiment, the decompression and priming valve is operated pneumatically, i.e. by differences in gas pressure. Fig. 5 is a side view of a pneumatically
20 operated decompression and priming valve **30** shown partly in cross-section and having a compression spring **42** trying to keep the valve **30** open and a piston and cylinder assembly trying to close the valve **30** against the force of the spring **42**. The piston and cylinder assembly includes a piston **34** fixed to the second end of the valve stem **39**, and the piston **34** is axially movable in a matching cylinder **33** formed by the inside of a wall of the
25 housing **32**. Further, the housing **32** has an end wall **35**, and the compression spring **42** is placed between the piston **34** and the end wall **35** to keep the distance between them as large as possible. The end wall **35** is provided with a nipple **36** or other suitable connector for a conduit, e.g. a hose, not shown, connecting the piston and cylinder assembly to a suitable underpressure source, not shown. To ensure that atmospheric pressure will always
30 be present on the left-hand side of the piston **34** in Fig. 5, the left-hand end of the cylinder **33** is provided with a small bore **43** to surrounding atmosphere. Consequently, in this embodiment the first means is formed by the compression spring **42**, and the second means includes the piston and cylinder assembly **33**, **34** (actuated by the underpressure source (generally designated **50**, Figs. 9–11) via the interconnecting conduit **37** as shown in Figs.
35 9–11).

In Fig. 5, the valve member **40** is shown in its open position, in which gases from the combustion chamber of the engine may pass the valve head **401** and be discharged to

atmosphere via the outlet (generally designated **44**). The opening **44** may be connected via a passage (not shown) to the left-hand end of the cylinder **33**, whereby the bore **43** may be omitted. The valve member **40** is held in the open position by the spring **42**, whereby when the crankshaft is rotated in order to start the engine, the compression in the engine cylinder

5 **9** will be substantially lower than its normal value, and this essentially reduces the power required for rotating the crankshaft to start the engine. When the engine piston has moved so far that suction is created in the engine cylinder, a priming air-fuel mixture from a suitable source will be sucked through the inlet **323** into the valve **30** and further into the engine cylinder. When a spark from the spark plug ignites the air-fuel mixture in the

10 combustion chamber and starts the engine, the created pressure wave in combination with the underpressure acting on the right-hand side of the piston **34** will overcome the force of the compression spring **42** and close the valve **32** by moving the valve member **40** to make the valve head **401** seal against the valve seat **41**.

15 When the engine has stopped, the combined decompression and priming valve **30** opens, in that the spring **42** displaces the valve member **40** from its closed to its open position. It is important that the opening takes place without any essential delay in order to facilitate immediate restart of the engine, if required. Therefore, the underpressure in the valve cylinder **33** must be restored rapidly to atmospheric pressure, and to this end the valve

20 piston **34** suitably has a small gap **45** allowing a controlled flow of atmospheric air to pass the piston **34**. The air flow is preferably selected so as to open the valve member **40** within a preferred, short period of time, for example 1–2 seconds after the engine has stopped. Preferably, the combined decompression and priming valve **30**, which in this case includes the source of underpressure **50** and the conduit **37**, is arranged such that the valve **30** opens

25 already at an idle speed of the engine or close to idle speed. This is favorable as the combustion chamber will then be primed through the valve **30**, i.e. added with fuel, when running on idle, which e.g. implies a smoother run on idle. Said idle speed is typically chosen about 1000 rpm, but can of course be chosen differently such as a speed in the range 1000 to 1500 rpm or in the range 800 to 1000 rpm. Instead of the gap **45**, a corresponding

30 bleed opening allowing a controlled entry of atmospheric air may be provided in the conduit between the valve cylinder **33** and the underpressure source (**50** Figs. 9–11).

Fig. 5 also shows an embodiment where the valve housing **32** is modified in that the outlet **44** for exhaust gas from the combustion chamber and the inlet **323** for a priming air-fuel

35 mixture to be passed to the combustion chamber are combined. Consequently, with such a valve, compressed exhaust gas from the combustion chamber will pass through the valve **30** and be discharged through its combined inlet-outlet through a conduit to a source of air-fuel mixture. When the engine piston has moved so far that suction is created in the engine

cylinder, a priming air-fuel mixture from a suitable source will be sucked through the conduit, the combined inlet-outlet into the valve **30** and further into the engine cylinder. Such a design is possible when the total internal volume of the gas passage between the engine cylinder and the source of air-fuel mixture is small in comparison to the volumes of exhaust gas and priming air-fuel mixture passing through the valve **32**.

Fig. 6 shows an embodiment that basically is similar to that of Fig. 5, but a membrane **47** is substituted for the piston and cylinder assembly. The membrane **47** has a center that is attached to the second end of the valve stem **39** and a periphery that is clamped in the cylinder **33** formed by the inside of the wall of the housing **32**. Like in the other embodiments, a compression spring **42** may be provided to keep to valve **32** open, but if desired, the spring may be omitted and the membrane **47** made so rigid, that a deformation of the membrane **47** by underpressure on its right-hand side in Fig. 6 will bias the valve member **40** toward its open position and eliminate the need for the compression spring **42**. To ensure that underpressure will not remain on the right-hand side of the membrane **47** in Fig. 6 when the engine has stopped, the right-hand end of the cylinder **33** is provided with a small bore **43** to surrounding atmosphere. The bore **43** is so small, that it does not affect the operation of the valve **32**, when the engine is running, and air entering through the bore **43** is immediately sucked away to the underpressure source (**50**, Figs. 9–11). Further, in the embodiment shown in Fig. 6, the inlet **323** for a priming air-fuel mixture and the outlet **44** for exhaust gas from the combustion chamber are separated from each other, and no check valves are provided therein.

Fig. 7 is a simplified principle sketch of a crankcase-scavenged two-stroke internal combustion engine **1** having an automatic decompression and priming valve **30** arranged in the cylinder head of the engine **1** in accordance with one preferred embodiment of the present invention. The automatic decompression and priming valve **30** shown in Fig. 7 could be either one of the two of Figs. 5 and 6, and with an obvious, slight modification of the maneuvering of the valve **30**, also any one of the valves of Figs. 1–4 could be used.

The engine **1** shown in Fig. 7 has a cylinder **9** with cylinder bore having a cylinder wall **29**. A piston **7** is intended to be movable back and forth in the cylinder bore. The piston is connected to a crankshaft **16** via a piston rod **18**. The cylinder is attached to a crankcase **17**. The underside of the piston **7** and the crankcase **17** forms a crankcase volume **4** that will vary when the piston moves up and down. The upper side of the piston **7** and the cylinder wall **29** defines a combustion chamber **13** that will vary when the piston moves up and down. The cylinder **9** includes an exhaust port **6** ported by the piston **7** for exiting exhaust

gases at defined piston positions. A spark plug **26** is provided in the cylinder head for igniting the air-fuel mixture in the combustion chamber **13**.

At least one transfer duct **3** connects the crankcase volume **4** with a transfer port **5** which at defined piston positions connects to the combustion chamber **13**; here the transfer duct **3** starts in a first part **23** in the crankcase. For clarity reasons the cylinder **9** and crankcase **17** is shown in a longitudinal cross-section, but the piston **7** is shown in a side view. This makes it easier to see the recess **24** in the piston. Also the piston is partially cut away to make all ports in the cylinder wall visible. This engine has two transfer ducts **3**, but only one is visible, but could also have three, four or five or possibly one. This means that the recess **24** shown in the piston cooperate with ports above the plane of the paper while the recess on the not visible backside of the piston cooperate with the shown ports **5**, **22**. In addition, the engine has an induction conduit **20** that leads from a fuel supply unit, here shown as a carburetor **12**, and to an intake port **27** in the cylinder wall **29**. The air-fuel inlet port **27** is ported by the piston **7** and a mixture of air and fuel will be sucked down into the crankcase volume **4** through the intake port **27** when the piston has risen above the intake port **27**.

Two additional air conduits **21** each connects to a corresponding air supply port **22** of the cylinder wall **29** for supply of additional air to the transfer ducts **3**. The air supply port **22** is connected to the transfer port **5** via a recess **24** in the piston **7** at certain piston positions. In the described embodiment there are two air ducts **21** each leading to an air supply port **22**. But there could also be a single air duct **21** and a branch in the cylinder wall so that the air branches off to the two different air supply ports **22**. When the first recess **24** in the piston will register with air supply port **22** and transfer port **5**, air will be sucked down into the transfer ducts **3**. Air will fill the transfer ducts **3** almost completely. This reduces fuel losses through the exhaust port **6**, when the piston **7** moves toward a bottom position and is a normal operation for a piston-ported crankcase scavenged two-stroke engine with additional air.

The carburetor **12** includes a choke valve **15** and a throttle valve **14**. The additional air conduit **21** has an additional air valve **19**, preferably a butterfly valve. Suitably the additional air valve **19** is connected to the throttle valve **14** by a coupling member (not shown) that provides a lost motion connection between the additional air valve **19** and the throttle valve **14**. The lost motion connection enables a certain motion of the throttle valve **14** for the air-fuel mixture before throttle valve for the additional air starts moving, whereby no additional air will be supplied at lower end speeds, including idle speed. Since the additional air valve **19** is closed, at least partly, during the start of the engine; the

underpressure created downstream of the additional air valve **19** in the additional air conduit **21** is increased. Example of a suitable lost motion couplings are described in WO2004005692A1 and WO 2008/111880 A1, which hereby are incorporated by reference. The carburetor **12** and the additional air conduit **21** receive clean air from a single air filter **48** via an air manifold **49**.

To facilitate starting, the engine **1** is provided with an automatic decompression and priming valve **30** that in Fig. 7 is actuated by underpressure from the crankcase volume **4**, but underpressure from any other suitable underpressure source (**50**, Figs. 9–11), such as the transfer duct **3**, the air-fuel mixture conduit **20**, and the scavenging air conduit **21**, for example, could be used. In Fig. 7, a conduit **37** connecting the underpressure source **50** (**3**; **4**; **20**; or **21**) to the decompression and priming valve **30** is shown as being a hose or a pipe, which has a check valve (**38**, Figs. 9–11) permitting flow toward the underpressure source **50** (**3**; **4**; **20**; or **21**) but blocking flow in the opposite direction. This will be described more in detail in connection with Figs. 9–11.

To enable the decompression task of the valve **30**, the pressurized exhaust gases from the combustion chamber **13** usually leave the valve either through the outlet **44** directly to the surrounding atmosphere or via a conduit (not shown) to the exhaust conduit **6** from the engine cylinder **9**, or to the clean air manifold **49** downstream of the air filter **48**.

Similarly, to enable the priming task of the valve **30**, the inlet **323** for priming air-fuel mixture into the valve **30** is connected to the induction conduit **20** downstream of the throttle valve **14** via a conduit **201**. As described above with reference to Fig. 5, the outlet **44** of the valve **30** for exhaust gas from the combustion chamber and the inlet **323** for a priming air-fuel mixture to be passed to the combustion chamber may be combined. Consequently, with such a valve, compressed exhaust gas from the combustion chamber will pass through the valve **30** and be discharged through its combined inlet-outlet through the conduit **201** to the induction conduit **20**. When the engine piston **7** has moved so far that suction is created in the engine cylinder **9**, a priming air-fuel mixture from the induction conduit **20** will be sucked through the conduit **201**, the combined inlet-outlet, into the valve **30** and further into the engine cylinder **9**. Such a design is possible when the total internal volume of the gas passage between the engine cylinder **9** and the induction conduit **20** is small in comparison to the volumes of exhaust gas and priming air-fuel mixture passing through the valve **32**. Suitably, the volume of the gases leaving the combustion chamber **13** through the combined automatic decompression and priming valve **30** is at least twice the size of the internal volume of the conduit **201** connecting the inlet **323** with the induction conduit **20** at a position downstream of the throttle valve **14**. Preferably, the ratio between

the volumes is at least 7:1. In the embodiment shown in Fig. 7, the conduit connecting the inlet **323** with the induction conduit **20** is a hose **201**, and then the hose **201** suitably has an internal diameter of 1–10 mm, preferably 6 mm, and suitably a length of 5–25 cm, preferably 10 cm. However, if desired, the conduit **201** may be embedded in the material of the engine cylinder **9**. To facilitate achievement of desired flow conditions when a separate outlet and a separate inlet are used, the outlet **44** may be larger than the inlet **323** and suitably have a diameter of 2–15 mm, preferably 5–10 mm.

To achieve an efficient use of the priming air-fuel mixture supplied through the combined decompression and priming valve **30**, the valve should be designed and placed in manner that the flow of priming air-fuel mixture from the valve **30** into the engine cylinder **9** will be directed toward the vicinity of the electrodes of the spark plug **26**. If desired, the valve head **401** may be of a shape that is more like a plug than like a disk.

The embodiment shown in Fig. 8 differs from that of Fig. 7 only in that the combined decompression and priming valve **30** is not mounted in the cylinder head but in a top portion of the cylinder **9** just below the cylinder head.

Figs. 9–11 are enlarged and more detailed of a section of Fig. 8 and show that the combined decompression and priming valve **30** is provided in the wall of the engine cylinder **9** slightly below the top dead center of the piston **7** and is connected to the interior of the cylinder **9** via a bore **31** in the cylinder wall **29**. The combined decompression and priming valve **30** is basically of the type shown in Fig. 5, but is also equipped with a separate outlet **44** for exhaust gases from the engine cylinder **9**. The valve **30** comprises a housing **32** that defines a valve cylinder **33** having a valve piston **34** movable therein. Together they form a piston and cylinder assembly. The housing **32** has an end wall **35** provided with a nipple **36**, which is connected via a conduit **37** to an underpressure source (**50**, Figs. 9–11), which may be any one of the crankcase volume **4**, the transfer duct **3**, the induction conduit **20**, or the conduit **21** for scavenging fresh air. The conduit **37** has a check valve **38** therein. The check valve **38** permits air flow in a direction from the combined decompression and priming valve **30** toward the underpressure source (**50**, Figs. 9–11) and prevents air flow from the underpressure source toward the combined decompression and priming valve **30**. If the check valve **38** in conduit **37** risks becoming exposed to small amounts of oil in the passing flow of gas so that the proper functioning of the valve will be impaired, it is recommendable to select or the conduit **21** for scavenging fresh air as underpressure source **50**.

The piston **34** is connected by means of a valve stem **39** to a valve member **40** cooperating with a valve seat **41**. The valve cylinder **33** has a compression spring **42** therein resiliently actuating the piston **34** to be moved to the left-hand side in the drawings so as to bring the valve member **40** to assume an open position. The left-hand end of the cylinder **33** is
5 connected to the atmosphere via a bore **43** in the cylinder wall, thereby ensuring that atmospheric pressure will always be present on the left-hand side of the piston **34**.

While in Fig. 9 the outlet **44** and the inlet **323** are free from flow blocking or restricting components, Fig. 10 shows an embodiment where the outlet **44** is provided with a check
10 valve **441** to prevent gas from being sucked back through the outlet into the valve **32**. In the embodiment of Fig. 11, also the inlet **323** is provided with a check valve **325** to prevent exhaust gas from trying to leave the valve housing **32** through the inlet **323**. Of course, the embodiment that uses a combined inlet and outlet (Fig. 5) cannot use any one of the check
15 valves **325** and **441**.

In Figs. 9–11, the valve member **40** is shown in its open position, in which gases from the engine cylinder **9** may pass the valve member **40** and be discharged at least indirectly to atmosphere via at least one radial bore **44** in the valve housing **32**. The outlet **44** may be connected via a passage (not shown) to the left-hand end of the valve cylinder **33**, whereby
20 the bore **43** may be omitted. The valve member **40** is held in the open position by the spring **42**, whereby when the crankshaft is rotated in order to start the engine, the compression in the engine cylinder **9** will be substantially lower than its normal value, and this essentially reduces the power required for rotating the crankshaft to start the engine. When the engine starts, an underpressure is created in the underpressure source **50** (**3**; **4**; **20**; or **21**), and this
25 underpressure actuates the piston **34** via the conduit **37** so as to move the piston **34** to the right-hand side in the drawing against the action of the spring **42**, whereby the decompression valve **30** will be closed by the valve member **40** sealing against the valve seat **41**.

In operation of the engine, an overpressure will be created alternately in the crankcase **17**, namely during the phase in which the air/fuel mixture is compressed by the downward movement of the piston **7**. As the check valve **38** is closed in this phase, actuation of the combined decompression and priming valve **30** by the overpressure is prevented, and the valve member **40** remains in the closed position. When the engine is running, the
35 combustion pressure in the engine cylinder **9** also contributes to maintaining the valve member **40** in its closed position. When the engine is running, the degree of opening/closing of the additional air valve **19** is controlled by a linkage between the throttle valve of the carburetor and the additional air valve **19**. Since the additional air valve **19** will

be open at high engine speeds, there will be less undesirable reduction of the compression in the engine.

When the engine has stopped, the combined decompression and priming valve **30** opens in that the spring **42** displaces the valve member **40** from its closed to its open position. It is important that the opening takes place without any essential delay in order to facilitate immediate restart of the engine, if required. Therefore, the underpressure in the valve cylinder **33** must be restored rapidly to atmospheric pressure, and to this end the valve piston **34** has a small gap **45** allowing a controlled flow of atmospheric air to pass the piston **34**. The air flow is preferably selected so as to open the valve member **40** within a preferred, short period of time, for example 1–2 seconds after the engine has stopped. Instead of the gap **45**, a corresponding bleed opening allowing a controlled entry of atmospheric air may be provided in the conduit **37** between the valve cylinder **33** and the check valve **38**.

The present invention is not restricted to the preferred embodiments shown in the drawings but can be varied within the scope of the appended claims. As an example, the number, position and orientation of the conduits or ducts and their associated ports may be as disclosed in anyone of US 2002/0043227 A1, US 2003/0029398 A1, WO 2004/005692 A1, WO 2008/111880 A1 and US 6,928,996 B2, if desired. Also, although the present invention above is described with reference to a carburetor engine, it is applicable to an injection engine.

INDUSTRIAL APPLICABILITY

The invention is applicable for providing small two-stroke engines used primarily in handheld working tools, such as chainsaws, for example, with a combined decompression and priming valve to make them easier to start.

CLAIMS:

1. A combined decompression and priming valve (30) adapted to be connected to a combustion chamber (13) of a two-stroke internal combustion engine (1) for reducing compression and priming the engine (1) in order to facilitate the starting thereof,
5 **comprising:**
 - a) a valve housing (32);
 - b) a valve member (40) movable in said housing (32) between a first position, where the valve (30) is fully open, and a second position, where the valve (30) is closed;
 - 10 c) first means (326, 405; 326, 404; 42) for holding the valve member (40) in the fully open first position,
 - d) an outlet (44) from the interior of the housing (32) for discharging gases passing from the combustion chamber (13) past the valve member (40) when the valve (30) is open; and
 - 15 e) an inlet (323) for leading priming air-fuel mixture into the interior of the housing (32) such that the air-fuel mixture can continue past the valve member (40) and into the combustion chamber (13) when the valve (30) is open.
2. A valve as claimed in claim 1, wherein at least one of the outlet (44) and the inlet (323)
20 is provided with a check valve (325).
3. A valve as claimed in any one of the claims 1 or 2, wherein said outlet (44) is larger than said inlet (323) and suitably has a diameter of 2–15 mm, preferably 5–10 mm.
- 25 4. A valve as claimed in any one of the claims 1 or 2, wherein said outlet (44) also forms said inlet (323).
5. A valve as claimed in any one of the preceding claims, wherein the first means (42) is a spring (42), preferably a compression spring, biasing the valve member (40) towards its
30 first open position.
6. A valve as claimed in any one of the preceding claims including a pressure transmitting member (34; 47) operatively connected to the valve member (40), said member (34; 47) defining a decreasable volume together with interior walls of the housing (32), wherein
35 said volume is adapted to be connected to a source of underpressure (50) via a conduit (37), and the pressure transmitting member (34; 47) being displaceable in response to a pressure drop inside the source of underpressure (50).

7. A valve as claimed in claim 6, wherein said source of underpressure (50) is a gas conduit (3; 4; 20; 21) upstream of the combustion chamber (13), preferably a crank case volume (4).
- 5 8. A valve as claimed in claim 6 or 7 comprising a bleed conduit (43) connected to the decreasable volume for connecting said volume with the atmosphere.
9. A valve as claimed in any one of the claims 6-8, wherein the pressure transmitting member (34; 47) comprises a membrane (47) which forms a seal between the
10 decreasable volume and the combustion chamber (13).
10. A valve as claimed in any one of the claims 6-8, wherein the pressure transmitting member (34; 47) comprises a piston (34) of a piston and cylinder assembly.
- 15 11. A valve as claimed in any of the claims 1-4 including second means (326, 404) for holding the valve member (40) in the closed second position when the engine is running, wherein the valve member (40) includes a valve head (401) and a valve stem (39), the valve housing (32) has a seat (41) for the valve head (401), at least one of said first- or second means (326, 404; 326, 405) includes a recess (404) in the valve stem
20 (39) and a spring biased locking member (326) in the valve housing (32), and the valve member (40) is snap locked in the fully open first position and the closed position.
12. A valve as claimed in claim 11, wherein the two means (326, 404; 326, 405) include together either a common spring biased locking member (326) and two recesses (404,
25 405) that are axially spaced along the valve stem (39), or a common recess (404) and two axially spaced spring biased locking members (326).
13. A valve as claimed in claim 11 or 12, wherein the valve stem (39) has a circular cross-section and the recess is a peripheral groove (404, 405) around the periphery of the stem
30 (39).
14. A valve as claimed in claim 13, wherein the spring biased locking member (326) is supplemented with two additional spring biased locking members (326), all three being substantially equiangularly spaced from one another for simultaneous engagement of
35 them in the peripheral groove (404, 405).
15. A valve as claimed in any one of claims 11-14, wherein the valve member (40) is manually displaceable.

16. A valve as claimed in any one of the claims 1-5, wherein a solenoid valve (46) is arranged to displace the valve member (40) to the second closed position in response to a signal from an electronic control unit.
- 5
17. An engine including the valve (30) according to any one of the preceding claims.
18. A two-stroke internal combustion engine (1) having a cylinder (9), a crankcase (17), and a reciprocating piston (7) movable back and forth in the cylinder (9) and defining a combustion chamber (13) in a top portion of the cylinder (9), the cylinder (9) having a cylinder wall (29) and an intake port (27) provided in the cylinder wall (29), the engine further having an induction conduit (20) for passing an air-fuel mixture to the intake port (27), and a throttle valve (14) for controlling the amount of air-fuel mixture passing through the induction conduit (20), characterized in that the engine
- 10
- 15 comprises a combined decompression and priming valve (30) connected to the combustion chamber (13) for reducing compression and priming the engine (1) in order to facilitate starting thereof, said valve (30) having an inlet (323) for a priming air-fuel mixture, and a conduit (201) being interconnected between the induction conduit (20) and the inlet (323) for passing an air-fuel mixture directly from the induction conduit (20) through the valve (30) into the combustion chamber (13) to prime the engine (1) when the valve (30) is open.
- 20
19. An engine as claimed in claim 18, wherein the combined decompression and priming valve (30) comprises:
- 25
- a) a valve housing (32) having said inlet (323);
- b) a valve member (40) movable in said housing (32) between a first position, where the valve (30) is fully open, and a second position, where the valve (30) is closed;
- c) first means (326, 405; 326, 404; 42) for holding the valve member (40) in the fully open first position, a pressure created by combustion of a fuel-air mixture in the combustion chamber (13) overcoming the holding force of the first means (326, 405) and moving the valve member (40) to its second position, where the valve (30) is closed;
- 30
- d) second means (326, 404; 37, 50) for holding the valve member (40) in the closed second position when the engine is running; and
- 35
- e) an outlet (44) from the housing (32) for discharging gases passing from the combustion chamber (13) past the valve member (40) when the valve (30) is open.

20. An engine as claimed in claim 19, wherein the valve member (40) is manually displaceable.
21. An engine as claimed in claim 19, wherein the valve member (40) is displaceable in response to a signal from an electronic control unit.
22. An engine claimed in claim 19, wherein the valve member (40) is displaceable in response to pressure differences between the combustion chamber (13) and a gas conduit (3; 4; 20; or 21) upstream of the combustion chamber (13).
23. An engine as claimed in claim 22, wherein the valve (30) includes
- a pressure transmitting member (34; 47) operatively connected to the valve member (40),
 - a conduit (37) for transferring pneumatic pressure from an underpressure source (50) to the pressure transmitting member (34; 47) to displace the valve member (40),
 - a check valve (38) for preserving the underpressure so as to keep the decompression valve (30) closed when the engine (1) is running, and
 - a bleed conduit (45) and a vent (43) for eliminating the underpressure within a few seconds after the engine (1) has stopped so as to open the valve (30).
24. An engine as claimed in claim 23, wherein the pressure transmitting member (34; 47) is one of a piston (34) in a piston and cylinder assembly or a membrane (47).
25. An engine as claimed in claim 24, wherein a compression spring (42) is provided for biasing the valve member (40) toward its open first position, and the size of the vent (43) and the force from the compression spring (42) are matched against the underpressure in the conduit (37).
26. An engine as claimed in any one of claims 23-25, wherein the conduit (37) is a hose.
27. An engine as claimed in any one of claims 23-26, wherein the engine has a transfer duct (3) that leads from the crankcase (17) to a transfer port (5) in the cylinder wall (29), and optionally a conduit (21) ported by the engine piston (7) for supply of additional air into the interior of the cylinder (9) for scavenging, and wherein the underpressure source (50) is one of the crankcase volume (4), the transfer duct (3), the air-fuel mixture conduit (20), or the scavenging air conduit (21).
28. An engine as claimed in any one of claims 23-27, wherein said outlet (44) is larger than said inlet (323) and suitably has a diameter of 2–15 mm, preferably 5–10 mm.

29. An engine as claimed in any one of claims 19-28, wherein gases from the outlet (44) are discharged either through a conduit to an exhaust conduit (6) from the engine cylinder (9) or directly to surrounding atmosphere or to a fresh air conduit (49) downstream of an air filter (48) but upstream of a carburetor (12) and possibly upstream of a possible branching of the fresh air conduit into a conduit (20) through the carburetor (12) and another conduit (21) for supply of additional fresh air to the engine cylinder (9).
30. An engine as claimed in any one of claims 19-29, wherein a check valve (441) is provided for preventing gases from passing in a wrong direction through the outlet (44).
31. An engine as claimed in any one of claims 19-27, wherein said outlet (44) also forms said inlet (323).
32. An engine as claimed in claim 31, wherein the volume of the gases leaving the combustion chamber (13) through the combined automatic decompression and priming valve (30) is at least twice the size of the internal volume of the conduit (201) connecting said inlet (323) with the induction conduit (20) at a position downstream of the throttle valve (14).
33. An engine as claimed in claim 32, wherein the ratio between the volumes is at least 7:1.
34. An engine as claimed in any one of claims 18-33, wherein the engine has a spark plug (26) for forming an igniting spark, and the combined automatic decompression and priming valve (30) is mounted to direct the flow of priming air-fuel mixture toward the vicinity of the spark.
35. An engine as claimed in any one of claims 18-34, wherein the conduit connecting said inlet (323) with the induction conduit (20) is a hose (201), suitably having an internal diameter of 1–10 mm, preferably 6 mm, and suitably a length of 5–25 cm, preferably 10 cm.
36. An engine as claimed in any one of claims 18-35, wherein a throttle valve (14) is provided in the induction conduit (20), and the conduit (201) for the priming air-fuel mixture is connected to the induction conduit (20) at a point downstream of the throttle valve (14).

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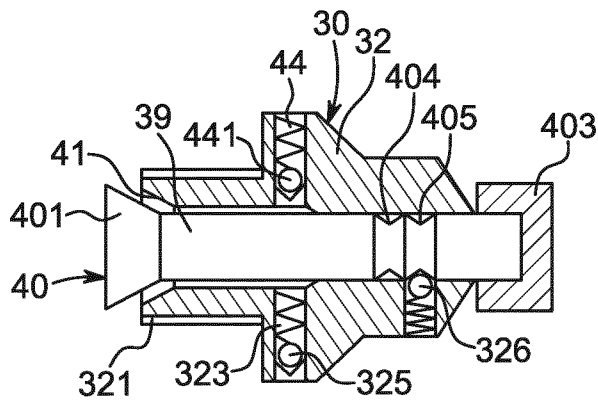


FIG. 1

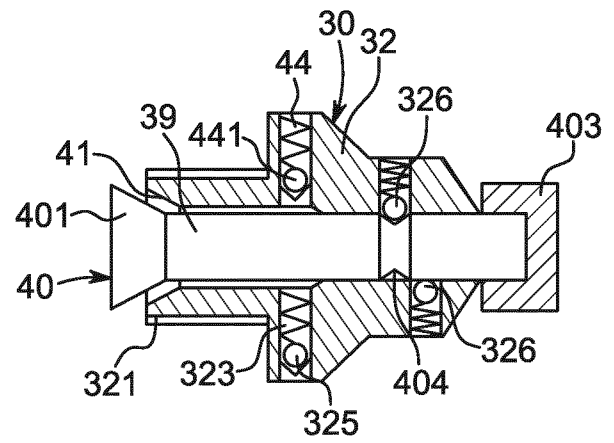


FIG. 2

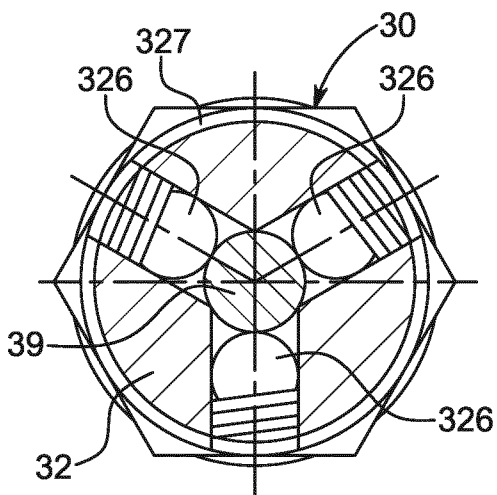


FIG. 3

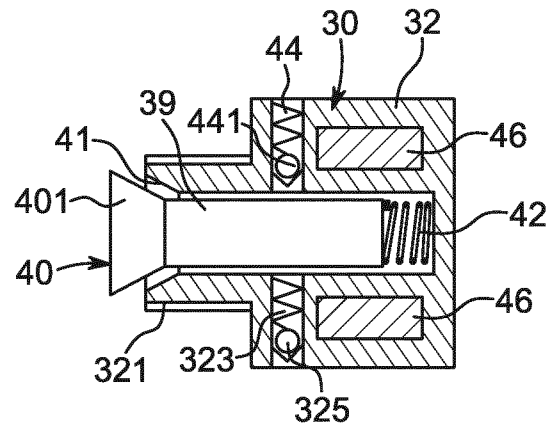


FIG. 4

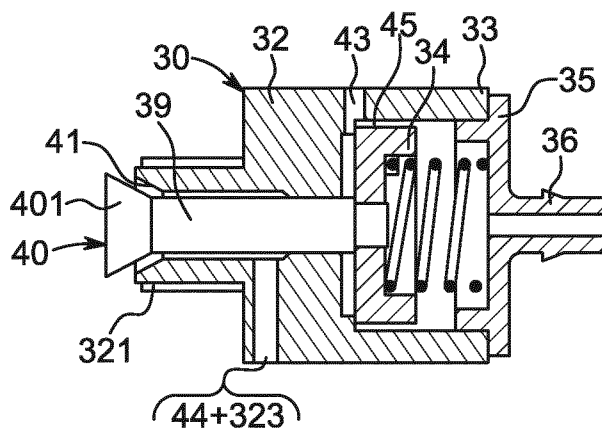


FIG. 5

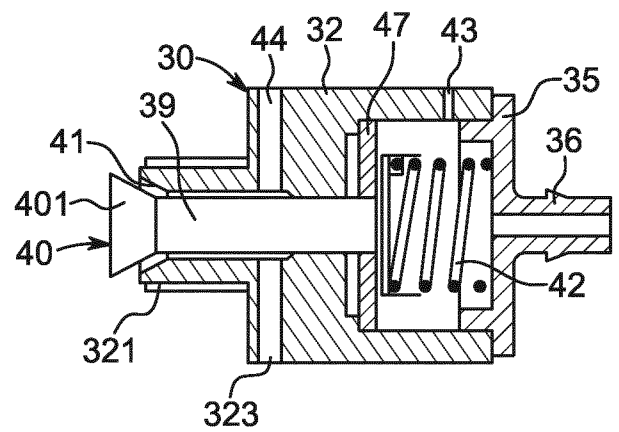


FIG. 6

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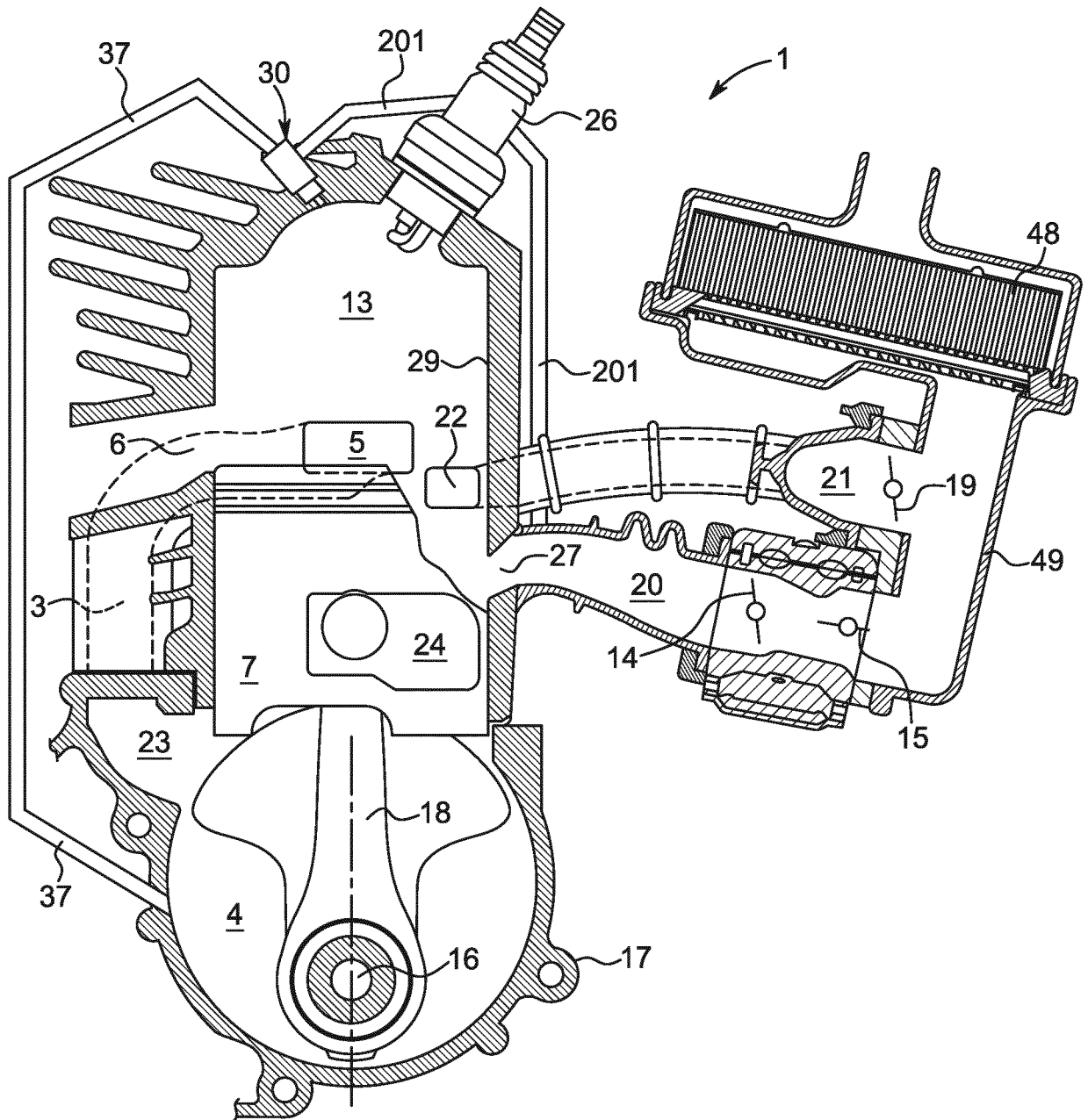


FIG. 7

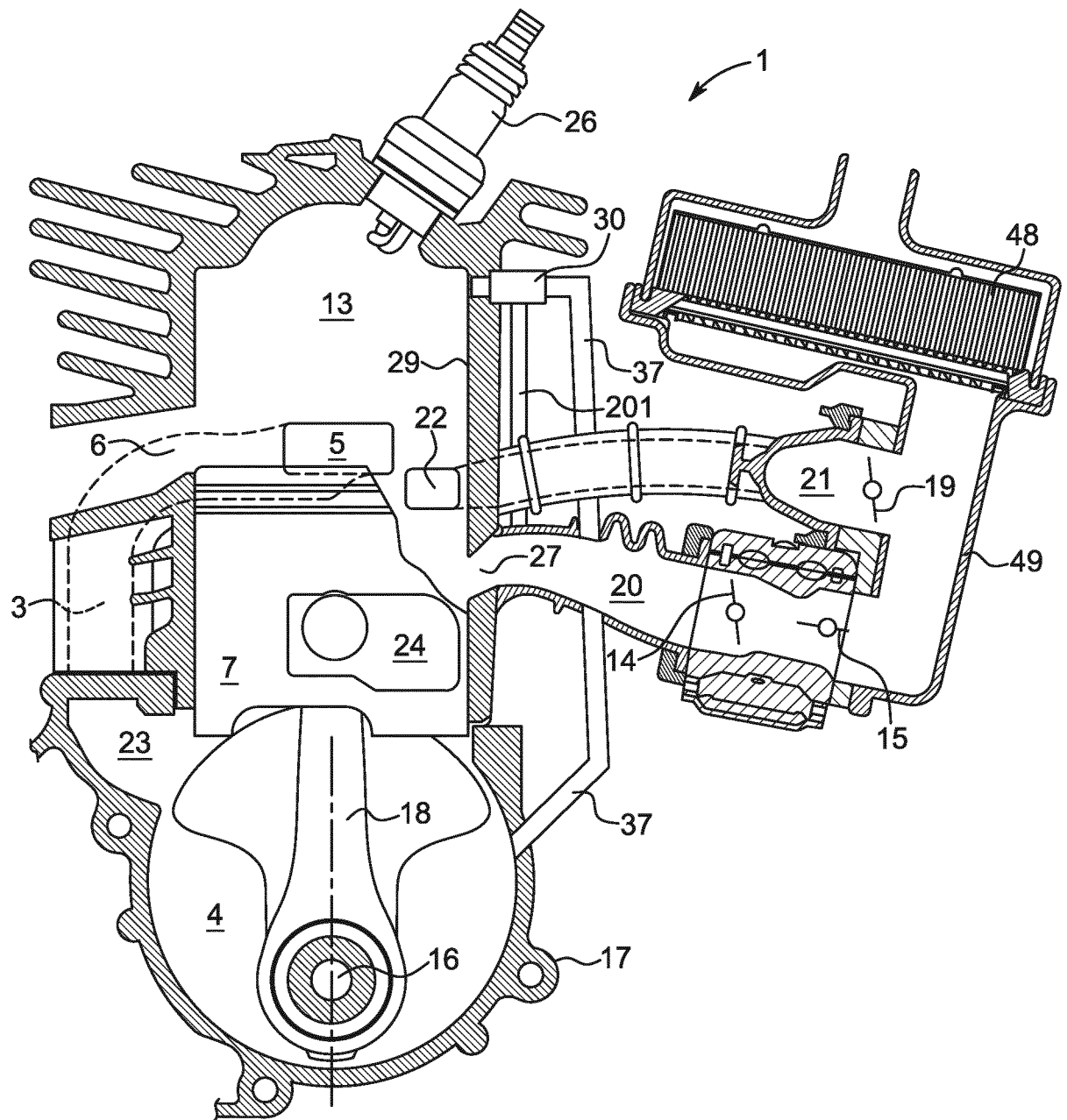


FIG. 8

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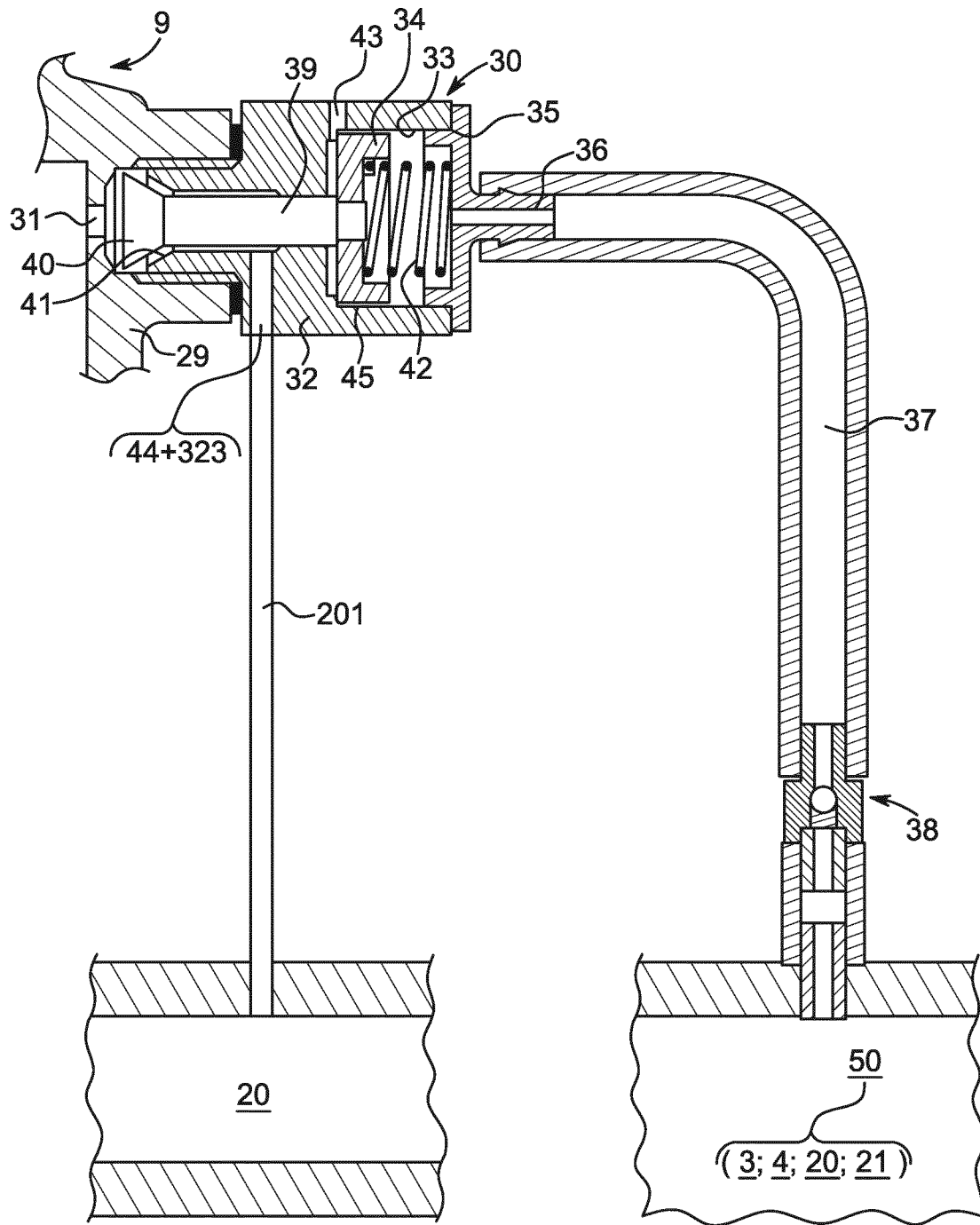


FIG. 9

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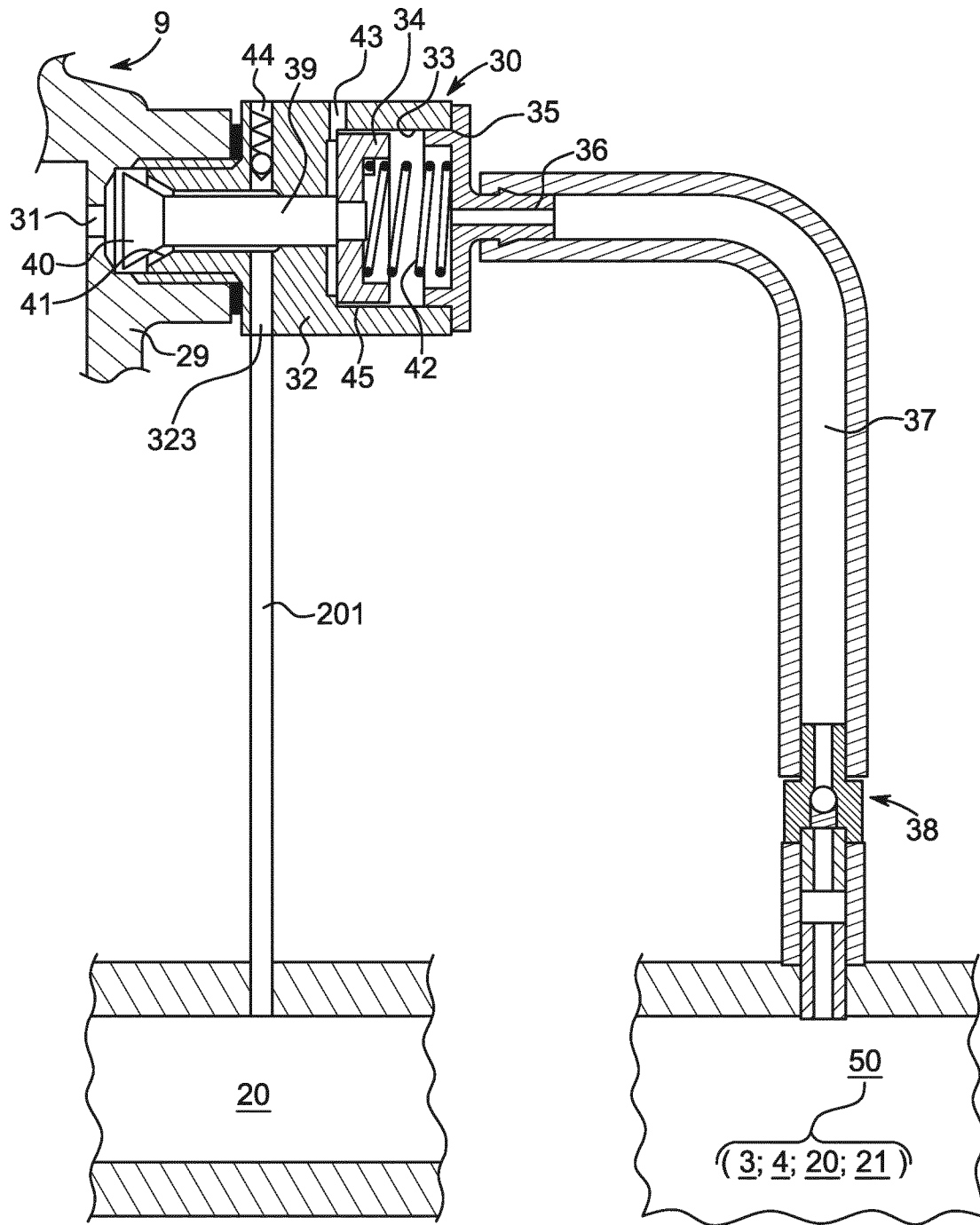


FIG. 10

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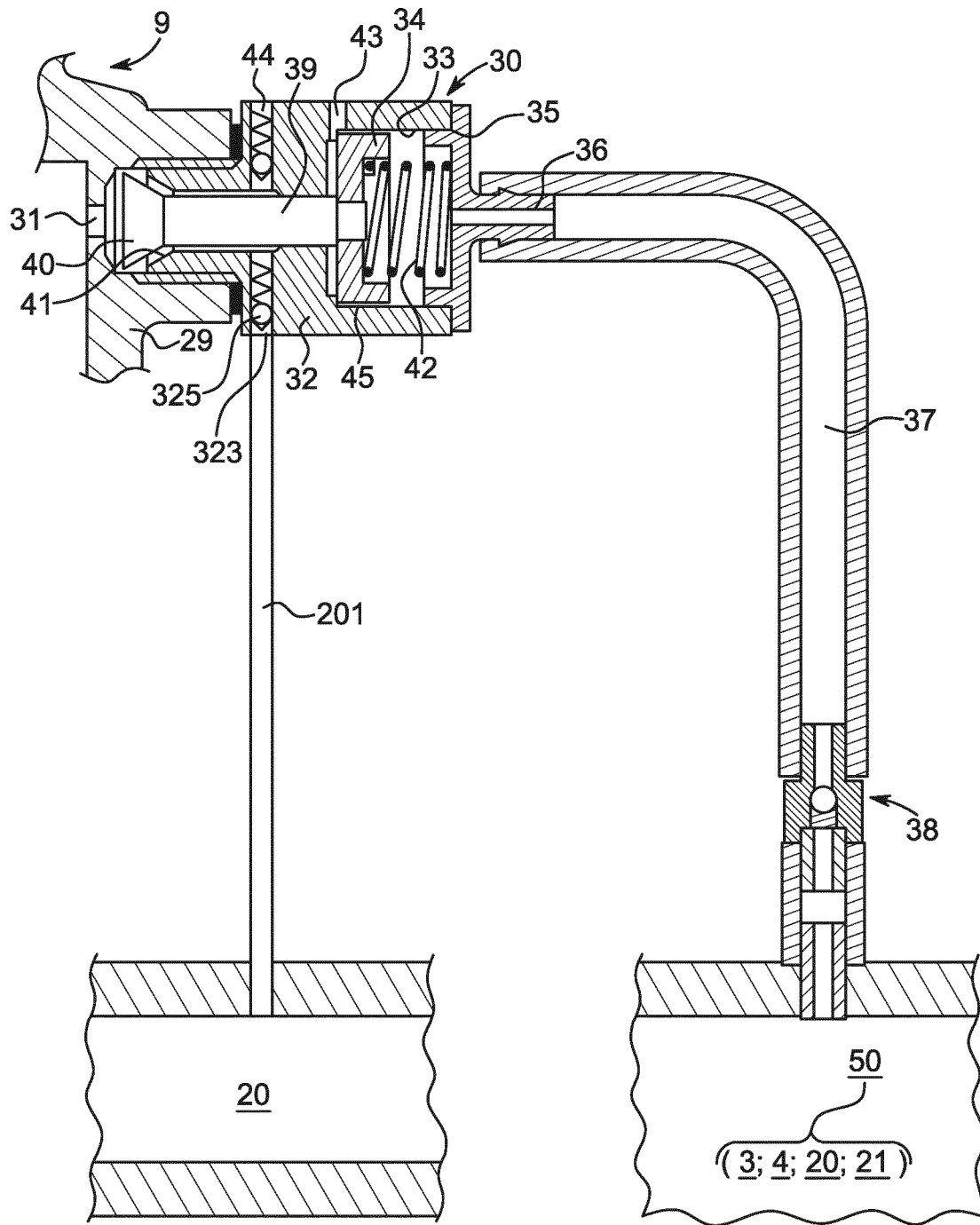


FIG. 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/050744

A. CLASSIFICATION OF SUBJECT MATTER
INV. F01L1/36 F01L13/08
ADD.

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)
F01L F02D F02M F02B

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 practicable, 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.
A	US 2005/166897 A1 (OSBURG GERHARD [DE] ET AL) 4 August 2005 (2005-08-04) paragraph [0001] paragraph [0004] paragraph [0009] paragraph [0011] - paragraph [0015] figures -----	1,18
A	US 1 579 985 A (WELLS WHEELER) 6 April 1926 (1926-04-06) page 1, line 9 - line 26 page 2, line 19 - line 114 figures ----- -/-	1,3-5, 11,15, 17-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

24 October 2013

Date of mailing of the international search report

30/10/2013

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
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Authorized officer

Paquay, Jeannot

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2013/050744

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 993 372 A (MOTT CONSTANTIN [CA] ET AL) 19 February 1991 (1991-02-19) column 1, line 8 - line 9 column 2, line 61 - column 3, line 5 figures -----	1,18
A	GB 141 901 A (JOHN ADOLPH ALBRECHT) 29 April 1920 (1920-04-29) page 1, line 4 - line 5 page 1, line 32 - page 2, line 4 page 3, line 15 - line 27 figures -----	1,2, 17-20

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2013/050744

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			US 2005166897 A1	04-08-2005

US 1579985	A	06-04-1926	NONE	

US 4993372	A	19-02-1991	NONE	

GB 141901	A	29-04-1920	NONE	
