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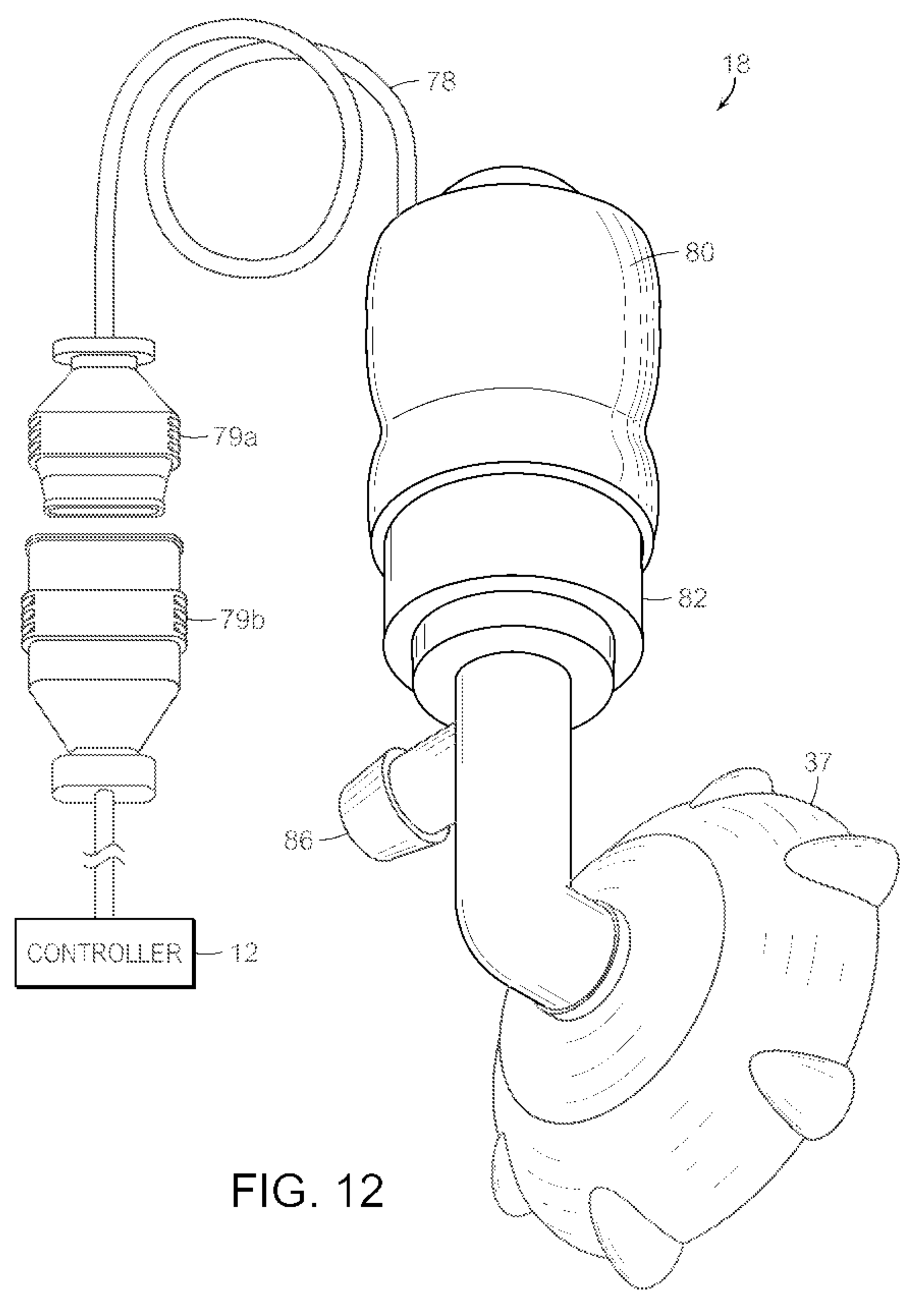

FIG. 12

(57) Abrégé/Abstract:
A PCV valve and pollution control system for combustion engines. The PCV valve has an inlet and an outlet adapted to vent blow-by gasses from the crank case of a combustion engine. The inlet of the PCV valve is in fluid communication with a port on an engine oil cap on an engine oil inlet tube. The PCV valve may be integral with the engine oil cap or connected thereto by a hose. The outlet of the PCV valve directs vented blow-by gasses to a fuel/air inlet to the combustion chamber of the engine. The combination of the PCV valve with the engine oil cap facilitates installation of the system on a combustion engine.

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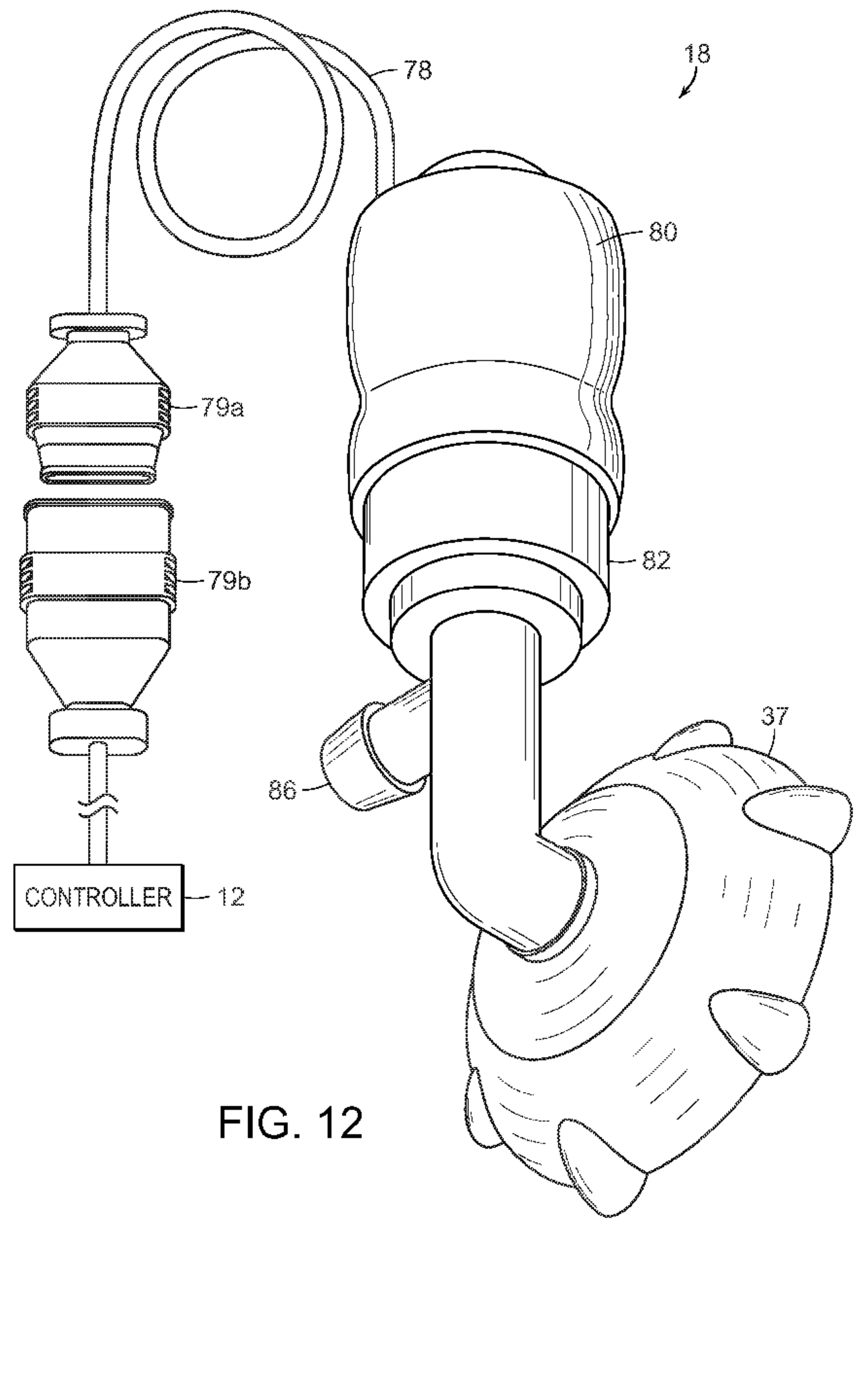

FIG. 12

(57) Abstract: A PCV valve and pollution control system for combustion engines. The PCV valve has an inlet and an outlet adapted to vent blow-by gasses from the crank case of a combustion engine. The inlet of the PCV valve is in fluid communication with a port on an engine oil cap on an engine oil inlet tube. The PCV valve may be integral with the engine oil cap or connected thereto by a hose. The outlet of the PCV valve directs vented blow-by gasses to a fuel/air inlet to the combustion chamber of the engine. The combination of the PCV valve with the engine oil cap facilitates installation of the system on a combustion engine.

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PCV VALVE AND POLLUTION CONTROL SYSTEM

DESCRIPTION

FIELD OF THE INVENTION

[Para 1] The present invention generally relates to a system for controlling pollution. More particularly, the present invention relates to a system that filters engine fuel by-products for recycling through a PCV valve assembly in order to reduce emissions and improve engine performance.

BACKGROUND OF THE INVENTION

[Para 2] The basic operation of standard internal combustion engines vary somewhat based on the type of combustion process, the quantity of cylinders and the desired use/functionality. For instance, in a traditional two-stroke engine, oil is pre-mixed with fuel and air before entry into the crankcase. The oil/fuel/air mixture is drawn into the crankcase by a vacuum created by the piston during intake. The oil/fuel mixture provides lubrication for the cylinder walls, crankshaft and connecting rod bearing in the crankcase. In a standard gasoline engine, the fuel is then compressed in the combustion chamber and ignited by a spark plug that causes the fuel to burn. There are no spark plugs in a diesel engine, so combustion in a diesel engine occurs only as a result of the heat and compression in the combustion chamber. The piston is then pushed downwardly and the exhaust fumes are allowed to exit the cylinder when the piston exposes the exhaust port. The movement of the piston pressurizes the remaining oil/fuel in the crankcase and allows additional fresh oil/fuel/air to rush into the cylinder, thereby simultaneously pushing the remaining exhaust out the exhaust port. Momentum drives the piston back into the compression stroke as the process repeats itself.

[Para 3] Alternatively, in a four-stroke engine, oil lubrication of the crankshaft and connecting rod bearing is separate from the fuel/air mixture. Here, the crankcase is filled mainly with air and oil. It is the intake manifold that receives and mixes fuel and air from separate sources. The fuel/air mixture in the intake manifold is drawn into the combustion chamber where it is ignited by the spark plugs (in a standard gasoline engine) and burned. In a diesel engine, the fuel/air mixture is ignited by heat and pressure in the combustion chamber. The combustion chamber is largely sealed off from the crankcase by a set of piston rings that are disposed around an outer diameter of the pistons within the piston cylinder. This keeps the oil in the crankcase rather than allowing it to burn as part of the combustion stroke, as in a two-stroke engine. Unfortunately, the piston rings are unable to completely seal off the piston cylinder. Consequently, crankcase oil intended to lubricate the cylinder is, instead, drawn into the combustion chamber and burned during the combustion process. Additionally, combustion waste gases comprising unburned fuel and exhaust gases in the cylinder simultaneously pass the piston rings and enter the crankcase. The waste gas entering the crankcase is commonly called “blow-by” or “blow-by gas”.

[Para 4] Blow-by gases mainly consist of contaminants such as hydrocarbons (unburned fuel), carbon dioxide or water vapor, all of which are harmful to the engine crankcase. The quantity of blow-by gas in the crankcase can be several times that of the concentration of hydrocarbons in the intake manifold. Simply venting these gases to the atmosphere increases air pollution. Although trapping the blow-by gases in the crankcase allows the contaminants to condense out of air and accumulate therein over time. Condensed contaminants form corrosive acids and sludge in the interior of the crankcase that dilutes the lubricating oil. This decreases the ability of the oil to lubricate the cylinder and the crankshaft. Degraded oil that fails to properly lubricate the crankcase components (e.g. the crankshaft and connecting rods) can be a factor in poor engine performance. Inadequate crankcase lubrication contributes to unnecessary wear on the piston rings which simultaneously reduces the quality of the seal between the combustion chamber and the crankcase. As the engine ages, the gaps between the piston rings and cylinder walls increase resulting in larger quantities of blow-by gases entering the crankcase. Too much blow-by gases entering the crankcase can cause power loss and even engine failure. Moreover, condensed water in the blow-by gases can cause engine parts to rust.

[Para 5] These issues are especially problematic in diesel engines. Diesel engines burn diesel fuel which is much more oily and heavy than gasoline. As it burns, diesel fuel produces carcinogens, particulate matter (soot), and NOx (nitrogen contaminants). This is why most diesel engines are associated with the images of a big rig truck belching black smog from its exhaust pipes. Similarly, the blow-by gas produced in the crankcase of a diesel engine is much more oily and heavy than gasoline blow-by gas. Hence, crankcase ventilation systems for diesel engines were developed to remedy the existence of blow-by gases in the crankcase. In general, crankcase ventilation systems expel blow-by gases out of a positive crankcase ventilation (PCV) valve and into the intake manifold to be re-burned. In a diesel engine, the diesel blow-by gases are much heavier and oilier than in a gasoline engine. As such, the diesel blow-by gases must be filtered before they can be recycled through the intake manifold.

[Para 6] PCV valves recirculate (i.e. vent) blow-by gases from the crankcase back into the intake manifold to be burned again with a fresh supply of air/fuel during combustion. This is particularly desirable as the harmful blow-by gases are not simply vented to the atmosphere. A crankcase ventilation system should also be designed to limit, or ideally eliminate, blow-by gas in the crankcase to keep the crankcase as clean as possible. Early PCV valve comprised simple one-way check valves. These PCV valves relied solely on pressure differentials between the crankcase and intake manifold to function correctly. When a piston travels downward during intake, the air pressure in the intake manifold becomes lower than the surrounding ambient atmosphere. This result is commonly called “engine vacuum”. The vacuum draws air toward the intake manifold. Accordingly, air is capable of being drawn from the crankcase and into the intake manifold through a PCV valve that provides a conduit therebetween. The PCV valve basically opens a one-way path for blow-by gases to vent from the crankcase back into the intake manifold. In the event the pressure difference changes (i.e. the pressure in the intake manifold becomes relatively higher than the pressure in the crankcase), the PCV valve closes and prevents gases from exiting the intake manifold and entering the crankcase. Hence, the PCV valve is a “positive” crankcase ventilation system, wherein gases are only allowed to flow in one direction – out from the crankcase and into the intake manifold. The one-way check valve is basically an all-or-nothing valve. That is, the valve is completely open during periods when the pressure in the intake manifold is relatively less than the pressure in the crankcase. Alternatively, the valve is completely closed when the pressure in the crankcase is relatively lower than the pressure in the intake manifold. One-way check valve-based PCV valves are unable to account for changes in the quantity of blow-by gases that exist in the crankcase at any given time. The quantity of blow-by gases in the crankcase varies under different driving conditions and by engine make and model.

[Para 7] PCV valve designs have been improved over the basic one-way check valve and can better regulate the quantity of blow-by gases vented from the crankcase to the intake manifold. One PCV valve design uses a spring to position an internal restrictor, such as a cone or disk, relative to a vent through which the blow-by gases flow from the crankcase to the intake manifold. The internal restrictor is positioned proximate to the vent at a distance proportionate to the level of engine vacuum relative to spring tension. The purpose of the spring is to respond to vacuum pressure variations between the crankcase and intake manifold. This design is intended to improve on the all-or-nothing one-way check valve. For example, at idle, engine vacuum is high. The spring-biased restrictor is set to vent a large quantity of blow-by gases in view of the large pressure differential, even though the engine is producing a relatively small quantity of blow-by gases. The spring positions the internal restrictor to substantially allow air flow from the crankcase to the intake manifold. During acceleration, the engine vacuum decreases due to an increase in engine load. Consequently, the spring is able to push the internal restrictor back down to reduce the air flow from the crankcase to the intake manifold, even though the engine is producing more blow-by gases. Vacuum pressure then increases as the acceleration decreases (i.e. engine load decreases) as the vehicle moves toward a constant cruising speed. Again, the spring draws the internal restrictor back away from the vent to a position that substantially allows air flow from the crankcase to the intake manifold. In this situation, it is desirable to increase air flow from the crankcase to the intake manifold, based on the pressure differential, because the engine creates more blow-by gases at cruising speeds due to higher engine RPMs. Hence, such an improved PCV valve that solely relies on engine vacuum and spring-biased restrictor does not optimize the ventilation of blow-by gases from the crankcase to the intake manifold, especially in situations where the vehicle is constantly changing speeds (e.g. city driving or stop and go highway traffic).

[Para 8] One key aspect of crankcase ventilation is that engine vacuum varies as a function of engine load, rather than engine speed, and the quantity of blow-by gases varies, in part, as a function of engine speed, rather than engine load. For example, engine vacuum is higher when engine speeds remain relatively constant (e.g. idling or driving at a constant velocity). Thus, the amount of engine vacuum present when an engine is idling (perhaps 900 rotations per minute (rpm)) is essentially the same as the amount of vacuum present when the engine is cruising at a constant speed on a highway (for example between 2,500 to 2,800 rpm). The rate at which blow-by gases are produced is much higher at 2,500 rpm than at 900 rpm. But, a spring-based PCV valve is unable to account for the difference in blow-by gas production between 2,500 rpm and 900 rpm because the spring-based PCV valve experiences a similar pressure differential between the intake manifold and the crank case at these different engine speeds. The spring is only responsive to changes in air pressure, which is a function of engine load rather than engine speed. Engine load typically increases when accelerating or when climbing a hill, for example. As the vehicle accelerates blow-by gas production increases, but the engine vacuum decreases due to the increased engine load. Thus, the spring-based PCV valve may vent an inadequate quantity of blow-by gases from the crankcase during acceleration. Such a spring-based PCV valve system is incapable of venting blow-by gases based on blow-by gas production because the spring is only responsive to engine vacuum.

[Para 9] U.S. Patent No. 5,228,424 to Collins, the contents of which are herein incorporated by reference, is an example of a two-stage spring-based PCV valve that regulates the ventilation of blow-by gases from the crankcase to the intake manifold. Specifically, Collins discloses a PCV valve having two disks therein to regulate air flow between the crankcase and the intake manifold. The first disk has a set of apertures therein and is disposed between a vent and the second disk. The second disk is sized to cover the apertures in the first disk. When little or no vacuum is present, the second disk is held against the first disk, resulting in both disks being held against the vent. The new result is that little air flow is permitted through the PCV valve. Increased engine vacuum pushes the disks against a spring and away from the vent, thereby allowing more blow-by gases to flow from the crankcase, through the PCV valve and back into the intake manifold. The mere presence of an engine vacuum causes at least the second disk to unseat from the first disk such that small quantities of blow-by gases vent from the engine crankcase through the aforementioned apertures in the first disk. The first disk typically substantially covers the vent whenever the throttle position indicates that the engine is operating at a low, constant speed (e.g. idling). Upon vehicle acceleration, the first disk may move away from the vent to increase the rate at which the blow-by gases exit the crankcase. The first disk may also unseat from the vent when the throttle position indicates the engine is accelerating or operating at a constant yet higher speed. The positioning of the first disk is based mostly on throttle position and the positioning of the second disk is based mostly on vacuum pressure between the intake manifold and crankcase. But, blow-by gas production is not based solely on vacuum pressure, throttle position, or a combination. Instead, blow-by gas production is based on a plurality of different factors, including engine load. Hence, the Collin's PCV valve also inadequately vents blow-by gases from the crankcase to the intake manifold when the engine load varies at similar throttle positions.

[Para 10] Maintenance of a PCV valve system is important and relatively simple. The lubricating oil must be changed periodically to remove the harmful contaminants trapped therein over time. Failure to change the lubricating oil at adequate intervals (typically every 3,000 to 6,000 miles) can lead to a PCV valve system contaminated with sludge. A plugged PCV valve system will eventually damage the engine. The PCV valve system should remain clear for the life of the engine assuming the lubricating oil is changed at an adequate frequency.

[Para 11] Prior art pollution control systems have required tapping or drilling into the crankcase or similar engine compartment that contains the blow-by gasses in order to recycle the same. Such tapping or drilling into the crankcase runs the risk of damaging the engine block or otherwise harming the integrity of the engine. In addition, the act of installing a PCV valve on an engine, whether OEM or aftermarket, could be an involved or time consuming process because of the difficulty with attaching a new PCV valve in the engine compartment or accessing an existing PCV valve for removal and replacement.

[Para 12] Accordingly, there is a need for a pollution control system or corresponding PCV valve that is easier, more convenient, and less costly to install. The present invention fulfills these needs and provides other related advantages.

SUMMARY OF THE INVENTION

[Para 13] The present invention is directed to a PCV valve adapted to vent blow-by gasses from a crankcase of a combustion engine. An inlet on the inventive PCV valve is in fluid communication with a port on an engine oil cap, the engine oil cap being configured for attachment to an oil filler tube to the crankcase. An outlet on the inventive PCV valve is configured for fluid communication with a fuel/air inlet of the combustion engine. The inventive PCV valve includes a two-stage check valve between the inlet and the outlet. The first stage of the check valve is configured to be opened or closed by a solenoid mechanism responsive to a controller. The second stage of the check valve is biased in a closed position so as to open only under vacuum pressure in the combustion engine greater than a predetermined threshold.

[Para 14] The inlet of the PCV valve may be fluidly connected to the port on the engine oil cap by a hose. Alternatively, the inlet of the PCV valve may be co-extensive with the port on the engine oil cap, such that the engine oil cap is integrally formed with the PCV valve and the inlet of the PCV valve is the port on the engine oil cap. A filter screen preferably covers the port in the engine oil cap.

[Para 15] In a pollution control system, the PCV valve is again adapted to vent blow-by gasses from a crankcase of the combustion engine. The inlet of the PCV valve is in fluid communication with a port on the engine oil cap of the combustion engine such that the blow-by gasses are vented through the oil filler tube of the crankcase. An outlet of the PCV valve is in fluid communication with a fuel/air inlet of the combustion engine. The PCV valve again comprises a two-stage check valve, where the first stage is directed by the controller, and the second stage is compatible with OEM settings such that the check valve opens only under sufficient vacuum pressure in the event the controller fails. The controller is coupled to a sensor for monitoring an operational characteristic of the combustion engine. The controller is configured to selectively modulate engine vacuum pressure to adjustably increase or decrease a fluid flow rate of blow-by gasses venting from the combustion engine.

[Para 16] The inlet of the PCV valve may be co-extensive with the port on the engine oil cap, such that the PCV valve is integrally formed with the engine oil cap and the inlet of the PCV valve is the port on the engine oil cap. A filter screen may be included over the port in the engine oil cap.

[Para 17] The outlet of the PCV valve may be in fluid communication with a recycle line on an OEM pollution control system, wherein the OEM pollution control system vents directly from the crankcase and the recycle line feeds into the fuel/air inlet. The fuel/air inlet may be an intake manifold, a fuel line, an air line, or a fresh air intake. The fuel/air inlet may be a fresh air intake for an air filter that feeds into a supercharger on the combustion engine.

[Para 18] The system may also include an oil separator in fluid communication with the outlet from the PCV valve. An oil outlet from the oil separator is in fluid communication with the crankcase of the combustion engine. A gas outlet from the oil separator is in fluid communication with the fuel/air inlet of the combustion engine.

[Para 19] The combustion engine may operate on gasoline, methanol, diesel, ethanol, compressed natural gas, liquid propane gas, hydrogen, or an alcohol-based fuel.

[Para 20] The controller may decrease the engine vacuum pressure during periods of decreased production of blow-by gasses to decrease the fluid flow rate through the PCV valve, and increase the engine vacuum pressure during periods of increased production of blow-by gasses to increase the fluid flow rate through the PCV valve. The controller preferably includes a pre-programmed software program, a flash-updatable software program, or a behavior-learning software program. The controller may also include a wireless transmitter or a wireless receiver. The controller may further include a window switch coupled to an engine RPM sensor, wherein the engine vacuum pressure is modulated based on a predetermined engine RPM or multiple engine RPMs set by the window switch.

[Para 21] The controller can also include an on-delay timer so as to preclude fluid flow of blow-by gasses for a predetermined duration after activation of the combustion engine. The predetermined duration of the on-delay timer may be a function of time, engine temperature, or engine RPM. The sensor comprises an engine temperature sensor, a spark plug sensor, an accelerometer sensor, a PCV valve sensor, or an exhaust sensor. In addition, the operational characteristic comprises an engine temperature, a quantity of engine cylinders, a real-time acceleration calculation, or an engine RPM.

[Para 22] Other features and advantages of the present invention will become apparent from the following more detailed description, taken in conjunction with the accompanying drawings, which illustrate, by way of example, the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[Para 23] The accompanying drawings illustrate the invention. In such drawings:

[Para 24] FIGURE 1 is a schematic illustrating a pollution control device for diesel engines having a controller operationally coupled to numerous sensors and a PCV valve;

[Para 25] FIGURE 2 is a schematic illustrating the general functionality of the PCV valve system in a combustion-based engine;

[Para 26] FIGURE 3 is a schematic illustrating the general functionality of an alternate embodiment of the PCV valve system in a combustion-based engine;

[Para 27] FIGURE 4 is a schematic illustrating the general functionality of another alternate embodiment of the PCV valve system in a combustion-based engine;

[Para 28] FIGURE 5 is a perspective view of a PCV valve integral with an oil cap for use with the inventive system;

[Para 29] FIGURE 6 is an exploded perspective view of the PCV valve and oil cap of FIG. 5;

[Para 30] FIGURE 7 is a partially exploded perspective view of the PCV valve of FIG. 6, illustrating assembly of an air flow restrictor;

[Para 31] FIGURE 8 is a partially exploded perspective view of the PCV valve of FIG. 6, illustrating partial depression of the air flow restrictor;

[Para 32] FIGURE 9 is a cross-sectional view of the PCV valve taken along line 9-9 of FIG. 5, illustrating no air flow;

[Para 33] FIGURE 10 is a cross-sectional view of the PCV valve taken along line 10-10 of FIG. 5, illustrating restricted air flow;

[Para 34] FIGURE 11 is another cross-sectional view of the PCV valve taken along line 11-11 of FIG.5, illustrating full air flow;

[Para 35] FIGURE 12 is a perspective view of an alternate embodiment of a PCV valve integral with an oil cap for use with the inventive system;

[Para 36] FIGURE 13 is a perspective illustration of the oil separator of the present invention; and

[Para 37] FIGURE 14 is an exploded view of the oil separator of FIG. 13.

BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENTS

[Para 38] As shown in the drawings for purposes of illustration, the present invention for a pollution control system for combustion engines is referred to generally by the reference number 10. In FIGURE 1, the pollution control system 10 is generally illustrated as having a controller 12 preferably mounted under a hood 14 of an automobile 16. The controller 12 is electrically coupled to any one of a plurality of sensors that monitor and measure the real-time operating conditions and performance of the automobile 16. The controller 12 regulates the flow rate of blow-by gases by regulating the engine vacuum in a combustion engine through digital control of a PCV valve 18. The controller 12 receives real-time input from sensors that might include an engine temperature sensor 20, a battery sensor 24, a PCV valve sensor 26, an engine RPM sensor 28, and accelerometer sensor 30 and an exhaust sensor 32. Data obtained from the sensors 20-32 by the controller 12 is used to regulate the PCV valve 18, as described in more detail below.

[Para 39] The controller 12 may also control other devices in the vehicle engine. The controller 12 may control the flow of oil out of an oil filter or oil separator 19. The controller 12 may also regulate engine temperatures, and an aerated conditioning chamber, which is designed to condition fuel going back into the fuel line or back into the vacuum manifold by aerating and mixing the fuel before reintroducing it. The controller 12 may also regulate a purging system in case of failure in the pollution control system 10 - the purging system triggers the engine to revert back to an OEM system, whether an OEM PCV system or other type of blow-by gas management system. Controller 12 may also provide alerts to the operator of the engine. The alerts may blink an LED readout so as to report on the actual sensed condition of the engine and receive alerts in the case of failure. Alerts such as alarms or illuminated signals can communicate the sensed conditions. The controller 12 is fully upgradable with flash memory or other similar devices. This means that the same controller 12 and system 10 could work on virtually any type of engine with all different types of fuels. The pollution control system 10 is adaptable to any internal combustion engine. For example, the pollution control system 10 may be used with gasoline, methanol, diesel, ethanol, compressed natural gas (CNG), liquid propane gas (LPG), hydrogen, alcohol-based engines, or virtually any other combustible gas and/or vapor-based engine. This includes both two and four stroke IC engines and all light medium and heavy duty configurations.

[Para 40] FIGURES 2-4 depict schematic illustrations of the pollution control system 10 for combustion engines 36. As shown in these figures, the PCV valve 18 (and optionally oil separator 19) are disposed between a crank case 35, of an engine 36, and an intake manifold 38. In operation, the intake manifold 38 receives air via an air line 42. An air filter 44 may be disposed between the air line 42 and an air intake line 46 to filter fresh air entering the pollution control system 10. The air in the intake manifold 38 is delivered to a piston cylinder 48 as a piston 50 descends downward within the cylinder 48 from the top dead center. As the piston 50 descends downward, a vacuum is created within a combustion chamber 52. Accordingly, an input camshaft 54 rotating at half the speed of the crankshaft 34 is designed to open an input valve 56 thereby subjecting the intake manifold 38 to the engine vacuum. Thus, air is drawn into the combustion chamber 52 from the intake manifold 38.

[Para 41] Once the piston 50 is at the bottom of the piston cylinder 48, the vacuum effect ends and air is no longer drawn into the combustion chamber 52 from the intake manifold 38. At this point, the piston 50 begins to move back up the piston cylinder 48, and the air in the combustion chamber 52 becomes compressed. Next, fuel is injected directly into the combustion chamber 52 from the fuel line 40. This injection may be further aided by compressed air from a compressed air line. Depending upon the type of fuel, combustion may be generated be a spark, compression, heating, or other known methods. The fuel ignites after it is injected into the combustion chamber.

[Para 42] The rapid expansion of the ignited fuel/air in the combustion chamber 52 causes depression of the piston 50 within the cylinder 48. After combustion, an exhaust camshaft 60 opens an exhaust valve 62 to allow escape of the combustion gases from the combustion chamber 52 out an exhaust line 64. Typically, during the combustion cycle, an excess portion of exhaust gases - "blow-by gasses" - slip by a pair of piston rings 66 mounted in a head 68 of the piston 50.

[Para 43] These blow-by gases enter the crankcase 35 as high pressure and temperature gases. Over time, harmful exhaust gases such as hydrocarbons, carbon monoxide, nitrous oxide and carbon dioxide, as well as particulates, in these blow-by gasses can condense or settle out of the gaseous state and coat the interior of the crankcase 35 and mix with the oil 70 that lubricates the mechanics within the crankcase 35. The diesel pollution control system 10 is designed to recycle the contents of these blow-by gases from the crankcase 35 back to the combustion intake so as to be burned by the engine 36. This is accomplished by using the pressure differential between the crankcase 35 and intake manifold 38.

[Para 44] FIGURE 2 illustrates an embodiment wherein the PCV valve 18 is in communication with the crankcase 35 through an engine oil cap 37. The engine oil cap 37 is mounted on an oil inlet of filler tube 39 into the crankcase 35. The oil inlet tube 39 is preferably the same port through which oil is added to the engine 36. In this embodiment, the PCV valve 18 is integral with the engine oil cap 37, such that the inlet port 84 of the PCV valve 18 passes through the cap 37 and is open to the inlet tube 39. In this way, blow-by gasses are drawn from the crankcase 35, up the inlet tube 39, and through the cap 37. A filter screen 85 (FIG. 5) may be included in the interior of the cap 37 so as to trap and remove at least a portion of the oil from the blow-by gasses as they pass through the screen 85. An outlet 86 from the PCV valve 18 is in fluid communication with the intake manifold 38 so as to return the blow-by gasses to the combustion chamber 52. The blow-by gasses may be fed directly into the intake manifold 38, the air line 42, the fresh air line 46, or the fuel line 40. In certain types of engines 36, particularly those with a supercharger 45 that alternate operational states between a vacuum and positive pressure, the blow-by gasses are preferably fed into an air filter 44, prior to the supercharger 45. The PCV valve 18 is electrically connected to the controller 12 so as to be controlled as described elsewhere herein.

[Para 45] FIGURE 3 illustrates an alternate embodiment wherein the PCV valve 18 is again in communication with the crankcase 35 through the engine oil cap 37. However, in this embodiment, the PCV valve 18 is connected to the engine oil cap 37 by a hose 43. The hose 43 is connected the inlet port 84 of the PCV valve 18 with a matching port 87 through the cap 37. Similar to the earlier embodiment, blow-by gasses are drawn from the crankcase 35, up the inlet tube 39, through the cap 37 and hose 43, and into the PCV valve 18. A filter screen 85 may be included in the interior of the cap 37. The outlet 86 from the PCV valve 18 is in fluid communication with the intake manifold 38 so as to return the blow-by gasses to the combustion chamber 52. However, the outlet 86 from the PCV valve 18 may first pass through an oil separator 19, as described below. The blow-by gasses from the outlet 174 of the oil separator 19 may be fed directly into the intake manifold 38, the air line 42, the fresh air line 46, or the fuel line 40. The PCV valve 18 is electrically connected to the controller 12 so as to be controlled as described elsewhere herein.

[Para 46] FIGURE 4 illustrates another alternate embodiment wherein the PCV valve 18 is again in communication with the crankcase 35 through the engine oil cap 37. In this embodiment, the PCV valve 18 is again integral with the engine oil cap 37, but may be configured as shown in FIG. 3. As with the other embodiments, the blow-by gasses are drawn from the crankcase 35, up the inlet tube 39, and through the cap 37. Again a filter screen 85 may be included in the interior of the cap 37. In this embodiment, the PCV valve 18 is installed in conjunction with an OEM PCV valve system that is connected to an outlet port

72 on the crankcase 35. A vent line 74 connects the outlet port 72 to the OEM PCV valve 21, which is in turn connected to the intake manifold 38 or other engine inlet by a return line 76. The outlet 86 from the PCV valve 18 is in fluid communication with the return line 76 of the OEM PCV system so as to return the blow-by gasses to the combustion chamber 52 by the same means. The PCV valve 18 is electrically connected to the controller 12 so as to be controlled as described elsewhere herein. In this embodiment, the blow-by gasses will mostly pass through the PCV valve 18 of the inventive system as the path of least resistance. OEM PCV systems tend to have smaller orifices or ports than those that are found in the inventive PCV valve system 10. Since the flow rate of blow-by gasses depends upon pressure differentials, i.e., a vacuum generated during the piston cycle, the blow-by gasses will follow the least restrictive path.

[Para 47] In operation, the blow-by gases exit the relatively higher pressure crankcase 35 through the PCV valve 18 and then return to the combustion chamber 52 of the engine 36 as described. The fuel line 40 may receive fuel vapors that are more pure, while the less pure blow-by gases may be vented from the crankcase 35 to the intake manifold 38 via the blow-by line 41. This process is digitally regulated by the controller 12 shown in FIG. 1. The fuel vapors to the fuel line 40 may be passed through the fuel filter before being reintroduced to the engine 36.

[Para 48] The PCV valve 18 in FIGURE 5 is generally electrically coupled to the controller 12 via a pair of electrical connections 78. The controller 12 at least partly regulates the quantity of blow-by gases flowing through the PCV valve 18 via the electrical connections 78. In FIG. 5, the PCV valve 18 includes a rubber housing 80 that encompasses a portion of a rigid outer housing 82. The connector wires 78 extend out from the outer housing 82 via an aperture therein (not shown). Preferably, the outer housing 82 is unitary and comprises an intake orifice 84 and an exhaust orifice 86. In general, the controller 12 operates a restrictor internal to the outer housing 82 for regulating the rate of blow-by gases entering the intake orifice 84 and exiting the exhaust orifice 86.

[Para 49] FIGURE 6 illustrates the PCV valve 18 in an exploded perspective view. The rubber housing 80 covers an end cap 88 that substantially seals to the outer housing 82 thereby encasing a solenoid mechanism 90 and an air flow restrictor 92. The solenoid mechanism 90 includes a plunger 94 disposed within a solenoid 96. The connector wires 78 operate the solenoid 96 and extend through the end cap 88 through an aperture 98 therein. Similarly, the rubber housing 80 includes an aperture (not shown) to allow the connector wires 78 to be electrically coupled to the controller 12.

[Para 50] In general, engine vacuum present in the intake manifold 38 causes blow-by gases to be drawn from the crankcase 35, through the intake orifice 84 and out the exhaust orifice 86 in the PCV valve 18. The air flow restrictor 92 shown in FIG. 6 is one mechanism that regulates the quantity of blow-by gases that vent from the crankcase 35 to the intake manifold 38. Regulating blow-by gas air flow rate is particularly advantageous as the pollution control system 10 is capable of increasing the rate blow-by gases vent from the crankcase 35 during times of higher blow-by gas production and decreasing the rate blow-by gases vent from the crankcase 35 during times of lower blow-by gas production. The controller 12 is coupled to the plurality of sensors 20-32 to monitor the overall efficiency and operation of the automobile 16 and operates the PCV valve 18 in real-time to maximize recycling of blow-by gases according to the measurements taken by the sensors 20-32.

[Para 51] The operational characteristics and production of blow-by is unique for each engine and each automobile in which individual engines are installed. The pollution control system 10 is capable of being installed in the factory or post production to maximize automobile fuel efficiency, reduce harmful exhaust emissions, recycle oil and other gas and eliminate contaminants within the crankcase. The purpose of the pollution control system 10 is to strategically vent the blow-by gases from the crankcase 35 based on blow-by gas production, filter the blow-by gas, and recycle any oil and fuel that may come out of the blow-by gas. Accordingly, the controller 12 digitally regulates and controls the PCV valve 18 based on engine speed and other operating characteristics and real-time measurements taken by the sensors 20-32. The pollution control system 10 may be integrated into immobile engines used to produce energy or used for industrial purposes.

[Para 52] In particular, venting blow-by gases based on engine speed and other operating characteristics of an automobile decreases the overall quantity of hydrocarbons, carbon monoxide, nitrogen oxide, carbon dioxide, and particulate emissions. The pollution control system 10 recycles these gases and particulates by burning them in the combustion cycle. No longer are large quantities of the contaminants expelled from the engine via the exhaust. Hence, the pollution control system 10 is capable of reducing air pollution by as much as forty to fifty percent for each engine, increasing output per gallon by as much as twenty to thirty percent, increasing horsepower performance, reducing engine wear (due to low carbon retention therein) and reducing the frequency of oil changes by approximately a factor of ten. Considering that the United States consumes approximately 870 million gallons of petroleum a day, a fifteen percent reduction through the recycling of blow-by gases with the pollution control system 10 translates into a savings of approximately 130 million gallons of petroleum a day in the United States alone. Worldwide, nearly 3.3 billion gallons of petroleum are consumed per day, which would result in approximately 500 million gallons of petroleum saved every day.

[Para 53] In one embodiment, the quantity of blow-by gases entering the intake orifice 84 of the PCV valve 18 is regulated by the air flow restrictor 92 as generally shown in FIG. 6. The air flow restrictor 92 includes a rod 100 having a rear portion 102, an intermediate portion 104, and a front portion 106. The front portion 106 has a diameter slightly less than the rear portion 102 and the intermediate portion 104. A front spring 108 is disposed concentrically over the intermediate portion 104 and the front portion 106, including over a front surface 110 of the rod 100. The front spring 108 is preferably a coil spring that decreases in diameter from the intake orifice 84 toward the front surface 110. An indent collar 112 separates the rear portion 102 from the intermediate portion 104 and provides a point where a rear snap ring 114 may attach to the rod 100. The diameter of the front spring 108 should be approximately or slightly less than the diameter of the rear snap ring 114. The rear snap ring 114 engages the front spring 108 on one side and a rear spring 116 tapers from a wider diameter near the solenoid 96 to a diameter approximately the size of or slightly smaller than the diameter of the rear snap ring 114. The rear spring 116 is preferably a coil spring and is wedged between a front surface 118 of the solenoid 96 and the rear snap ring 114. The front portion 106 also includes an indented collar 120 providing a point of attachment for a front snap ring 122. The diameter of the front snap ring 122 is smaller than that of the tapered front spring 108. The front snap ring 122 fixedly retains a front disk 124 on the front portion 106 of the rod 100. Accordingly, the front disk 124 is fixedly wedged between the front snap ring 122 and the front surface 110. The front disk 124 has an inner diameter configured to slidably engage the front portion 106 of the rod 100. The front spring 108 is sized to engage a rear disk 126 as described below.

[Para 54] The disks 124, 126 govern the quantity of blow-by gases entering the intake orifice 84 and exiting the exhaust orifice 86. FIGS. 7 and 8 illustrate the air flow restrictor 92 assembled to the solenoid mechanism 90 and external to the rubber housing 80 and the outer housing 82. Accordingly, the plunger 94 fits within a rear portion of the solenoid 96 as shown therein. The connector wires 78 are coupled to solenoid 96 and govern the position of the plunger 94 within the solenoid 96 by regulating the current delivered to the solenoid 96. Increasing or decreasing the electrical current through the solenoid 96 correspondingly increases or decreases the magnetic field produced therein. The magnetized plunger 94 responds to the change in magnetic field by sliding into or out from within the solenoid 96. Increasing the electrical current delivered to the solenoid 96 through the connector wires 78 increases the magnetic field in the solenoid 96 and causes the magnetized plunger 94 to depress further within the solenoid 96. Conversely, reducing the electrical current supplied to the solenoid 96 via the connector wires 78 reduces the magnetic field therein and causes the magnetized plunger 94 to slide out from within the interior of the solenoid 96. As will be shown in more detail herein, the positioning of the plunger 94 within the solenoid 96 at least partially determines the quantity of blow-by gases that may enter the intake orifice 84 at any given time. This is accomplished by the interaction of the plunger 94 with the rod 100 and the corresponding front disk 124 secured thereto.

[Para 55] FIGURE 7 specifically illustrates the air flow restrictor 92 in a closed position. The rear portion 102 of the rod 100 has an outer diameter approximately the size of the inner diameter of the solenoid 96. Accordingly, the rod 100 can slide within the solenoid 96. The position of the rod 100 in the outer housing 82 depends upon the position of the plunger 94 due to the engagement of the rear portion 106 with the plunger 94 as shown more specifically in FIGURES 9-11. As shown in FIG. 7, the rear spring 116 is compressed between the front surface 118 of the solenoid 96 and the rear snap ring 114. This in turn compresses the rear disk 126 against the front disk 124. Similarly, the front spring 108 is compressed between the rear snap spring 114 and the rear disk 126. This allows for the rear disk 126 to be separated from the front disk 124, as shown in FIGURE 8.

[Para 56] As better shown in FIGS. 9-11 (taken along lines 9-9, 10-10, and 11-11 of FIG.5), the front disk 124 includes an extension 130 having a diameter less than that of a foot 132. The foot 132 of the rear disk 126 is approximately the diameter of the tapered front spring 108. In this manner, the front spring 108 fits over an extension 130 of the rear disk 126 to engage the planar surface of the diametrically larger foot 132 thereof. The inside diameter of the rear disk 126 is approximately the size of the external diameter of the intermediate portion 104 of the rod 100, which is smaller in diameter than either the intermediate portion 104 or the rear portion 102. In this regard, the front disk 124 locks in place on the front portion 106 of the rod 100 between the front surface 110 and the front snap ring 122. Accordingly, the position of the front disk 124 is dependent upon the position of the rod 100 as coupled to the plunger 94. The plunger 94 slides into or out from within the solenoid 96 depending on the amount of current delivered by the connecting wires 78, as described above.

[Para 57] FIG. 8 illustrates the PCV valve 18 wherein increased vacuum created between the crankcase 35 and the intake manifold 38 causes the rear disk 126 to retract away from the intake orifice 84 thereby allowing air to flow therethrough. In this situation the engine vacuum pressure exerted upon the disk 126 must overcome the opposite force exerted by the front spring 108. Here, small quantities of blow-by gases may pass through the PCV valve 18 through a pair of apertures 134 in the front disk 124.

[Para 58] FIGS. 9-11 more specifically illustrate the functionality of the PCV valve 18 in accordance with the pollution control system 10. FIG. 9 illustrates the PCV valve 18 in a closed position. Here, no blow-by gas may enter the intake orifice 84. As shown, the front disk 124 is flush against a flange 136 defined in the intake orifice 84. The diameter of the foot 132 of the rear disk 126 extends over and encompasses the apertures 134 in the front disk 124 to prevent any air flow through the intake orifice 84. In this position, the plunger 94 is disposed within the solenoid 96 thereby pressing the rod 100 toward the intake orifice 84. The rear spring 116 is thereby compressed between the front surface 118 of the solenoid 96 and the rear snap ring 114. Likewise, the front spring 108 compresses between the rear snap ring 114 and the foot 132 of the rear disk 126.

[Para 59] FIG. 10 is an embodiment illustrating a condition wherein the vacuum pressure exerted by the intake manifold relative to the crankcase is greater than the pressure exerted by the front spring 108 to position the rear disk 126 flush against the front disk 124. In this case, the rear disk 126 is able to slide along the outer diameter of the rod 100 thereby opening the apertures 134 in the front disk 124. Limited quantities of blow-by gases are allowed to enter the PCV valve 18 through the intake orifice 84 as noted by the directional arrows therein. Of course, the blow-by gases exit the PCV valve 18 through the exhaust orifice 86 as noted by the directional arrows therein. In the position shown in FIG. 10, blow-by gas air flow is still restricted as the front disk 124 remains seated against the flanges 136. Thus, only limited air flow is possible through the apertures 134. Increasing the engine vacuum consequently increases the air pressure exerted against the rear disk 126. Accordingly, the front spring 108 is further compressed such that the rear disk 126 continues to move away from the front disk 124 thereby creating larger air flow path to allow escape of the additional blow-by gases. Moreover, the plunger 94 in the solenoid 96 may position the rod 100 within the PCV valve 18 to exert more or less pressure on the springs 108, 116 to restrict or permit air flow through the intake orifice 84, as determined by the controller 12.

[Para 60] FIG. 11 illustrates another condition wherein additional air flow is permitted to flow through the intake orifice 84 by retracting the plunger 94 out from within the solenoid 96 by altering the electric current through the connector wires 78. Reducing the electrical current flowing through the solenoid 96 reduces the corresponding magnetic field generated therein and allows the magnetic plunger 94 to retract. Accordingly, the rod 100 retracts away from the intake orifice 84 with the plunger 94. This allows the front disk 124 to unseat from the flanges 136 thereby allowing additional air flow to enter the intake orifice 84 around the outer diameter of the front disk 124. Of course, the increase in air flow through the intake orifice 84 and out through the exhaust orifice 86 allows increased venting of blow-by gases from the crankcase 35 to the intake manifold 38. In one embodiment, the plunger 94 allows the rod 100 to retract all the way out from within the outer housing 82 such that the front disk 124 and the rear disk 126 no longer restrict air flow through the intake orifice 84 and out through the exhaust orifice 86. This is particularly desirable at high engine RPMs and high engine loads, where increased amounts of blow-by gases are produced by the engine. Engine load is a more reliable indicator of the quantity of blow-by gasses being produced than RPMs. In addition, immobile engines, i.e., generators, or those not geared to a transmission run at a constant RPM. Thus, the system 10 or PCV valve 18 is preferably controlled based on sensed load conditions or in a periodic on/off cycle, i.e., 2 minutes on - 2 minutes off. Of course, the springs 108, 116 may be rated differently according to the specific automobile with which the PCV valve 18 is to be incorporated in a pollution control system 10.

[Para 61] The controller 12 effectively governs the placement of the plunger 94 within the solenoid 96 by increasing or decreasing the electrical current therein via the connector wires 78. The controller 12 itself may include any one of a variety of electronic circuitry that include switches, timers, interval timers, timers with relay or other vehicle control modules known in the art. The controller 12 operates the PCV valve 18 in response to the operation of one or more of these control modules. For example, the controller 12 could include an RWS window switch module provided by Baker Electronix of Beckly, W. VA. The RWS module is an electric switch that activates above a pre-selected engine RPM and deactivates above a higher pre-selected engine RPM. The RWS module is considered a “window switch” because the output is activated during a window of RPMs. The RWS module could work, for example, in conjunction with the engine RPM sensor 28 to modulate the air flow rate of blow-by gases vented from the crankcase 35.

[Para 62] Preferably, the RWS module works with a standard coil signal used by most tachometers when setting the position of the plunger 94 within the solenoid 96. An automobile tachometer is a device that measures real-time engine RPMs. In one embodiment, the RWS module may activate the plunger 94 within the solenoid 96 at low engine RPMs, when blow-by gas production is minimal. Here, the plunger 94 pushes the rod 100 toward the intake orifice 84 such that the front disk 124 seats against the flanges 136 as generally shown in FIG. 9. In this regard, the PCV valve 18 vents small amounts of blow-by gases from the crankcase to the intake manifold via the apertures 134 in the front disk 124 even though engine vacuum is high. The high engine vacuum forces blow-by gases through the apertures 134 thereby forcing the rear disk 126 away from the front disk 124, compressing the front spring 108. At idle, the RWS module activates the solenoid 96 to prevent the front disk 124 from unseating from the flanges 136, thereby preventing large quantities of air from flowing between the engine crankcase and the intake manifold. This is particularly desirable at low engine RPMs as the quantity of blow-by gas produced within the engine is relatively low even though the engine vacuum is relatively high. Obviously, the controller 12 can regulate the PCV valve 18 simultaneously with other components of the pollution control system 10 to set the air flow rate of blow-by gases vented from the crankcase 35.

[Para 63] Blow-by gas production increases during acceleration, during increased engine load and with higher engine RPMs. Accordingly, the RWS module may turn off or reduce the electric current going to the solenoid 96 such that the plunger 94 retracts out from within the solenoid 96 thereby unseating the front disk 124 from the flanges 136 (FIG. 11) and allowing greater quantities of blow-by gas to vent from the crankcase 35 to the intake manifold 38. These functionalities may occur at a selected RPM or within a given range of selected RPMs pre-programmed into the RWS module. The RWS module may reactivate when the automobile eclipses another pre-selected RWS, such as a higher RPM, thereby re-engaging the plunger 94 within the solenoid 96. In an alternative embodiment, a variation of the RWS module may be used to selectively step the plunger 94 out from within the solenoid 96. For example, the current delivered to the solenoid 96 may initially cause the plunger 94 to engage the front disk 124 with the flanges 136 of the intake orifice 84 at 900 rpm. At 1700 rpm the RWS module may activate a first stage wherein the current delivered to the solenoid 96 is reduced by one-half. In this case, the plunger 94 retracts halfway out from within the solenoid 96 thereby partially opening the intake orifice 84 to blow-by gas flow. When the engine RPMs reach 2,500, for example, the RWS module may eliminate the current going to the solenoid 96 such that the plunger 94 retracts completely out from within the solenoid 96 to fully open the intake orifice 84. In this position, it is particularly preferred that the front disk 124 and the rear disk 126 and longer restrict air flow between the intake orifice 84 and the exhaust orifice 86. The stages may be regulated by engine RPM or other parameter and calculations made by the controller 12 and based on readings from the sensors 20-32.

[Para 64] The controller 12 can be pre-programmed, programmed after installation or otherwise updated or flashed to meet specific automobile or on-board diagnostics (OBD) specifications. In one embodiment, the controller 12 is equipped with self-learning software such that the switch (in the case of the RWS module) adapts to the best time to activate or deactivate the solenoid 96, or step the location of the plunger 94 in the solenoid 96 to optimally increase fuel efficiency and reduce air pollution. In a particularly preferred embodiment, the controller 12 optimizes the venting of blow-by gases based on real-time measurements taken by the sensors 20-32. For example, the controller 12 may determine that the automobile 16 is expelling increased amounts of harmful exhaust via feedback from the exhaust sensor 32. In this case, the controller 12 may activate withdrawal of the plunger 94 from within the solenoid 96 to vent additional blow-by gases from within the crankcase to reduce the quantity of pollutants expelled through the exhaust of the automobile 16 as measured by the exhaust sensor 32.

[Para 65] In another embodiment, the controller 12 is equipped with an LED that flashes to indicate power and that the controller 12 is waiting to receive engine speed pulses. The LED may also be used to gauge whether the controller 12 is functioning correctly. The LED flashes until the automobile reaches a specified RPM at which point the controller 12 changes the current delivered to the solenoid 96 via the connector wires 78. In a particularly preferred embodiment, the controller 12 maintains the amount of current delivered to the solenoid 96 until the engine RPMs fall ten-percent lower than the activation point. This mechanism is called hysteresis. Hysteresis is implemented into the pollution control system 10 to eliminate on/off pulsing, otherwise known as chattering, when engine RPMs jump above or below the set point in a relatively short time period. Hysteresis may also be implemented into the electronically-based step system described above.

[Para 66] The controller 12 may also be equipped with an On Delay timer, such as the KH1 Analog Series On Delay timer manufactured by Instrumentation & Control Systems, Inc. of Addison, Ill. A delay timer is particularly preferred for use during initial start up. At low engine RPMs little blow-by gases are produced. Accordingly, a delay timer may be integrated into the controller 12 to delay activation of the solenoid 96 and corresponding plunger 94. Preferably, the delay time ensures that the plunger 94 remains fully inserted within the solenoid 96 such that the front disk 124 remains flush against the flanges 136 thereby limiting the quantity of blow-by gas air flow entering the intake orifice 84. The delay timer may be set to activate release of either one of the disks 124, 126 from the intake orifice 84 after a predetermined duration (e.g. one minute). Alternatively, the delay timer may be set by the controller 12 as a function of engine temperature, measured by the engine temperature sensor 20, engine RPMs, measured by either the engine RPM sensor 28 or the accelerometer sensor 30, the battery sensor 24 or the exhaust sensor 32. The delay may include a variable range depending on any of the aforementioned readings. The variable timer may also be integrated with the RWS switch.

[Para 67] The controller 12 preferably mounts to the interior of the hood 14 of the automobile 16 as generally shown in FIG. 1. The controller 12 may be packaged with an installation kit to enable a user to attach the controller 12 as shown. Electrically, the controller 12 is powered by any suitable twelve volt circuit breaker. A kit having the controller 12 may include an adapter wherein one twelve volt circuit breaker may be removed from the circuit panel and replaced with an adapter (not shown) that connect one-way to the connector wires 78 of the PCV valve 18 so a user installing the pollution control system 10 cannot cross the wires between the controller 12 and the PCV valve 18. The controller 12 may also be accessed wirelessly via a remote control or hand-held unit to access or download real-time calculations and measurements, stored data or other information read, stored or calculated by the controller 12.

[Para 68] In another aspect of the pollution control system 10, the controller 12 regulates the PCV valve 18 based on engine operating frequency. For instance, the controller 12 may activate or deactivate the plunger 94 as the engine passes through a resonant frequency. In a preferred embodiment, the controller 12 blocks all air flow from the crankcase 35 to the intake manifold 38 until after the engine passes through the resonant frequency. The controller 12 can also be programmed to regulate the PCV valve 18 based on sensed frequencies of the engine at various operating conditions, as described above.

[Para 69] Moreover, the pollution control system 10 is usable with a wide variety of engines, including gasoline, methanol, diesel, ethanol, compressed natural gas (CNG), liquid propane gas (LPG), hydrogen, and alcohol-based engines, or virtually any other combustible gas and/or vapor-based engine. The pollution control system 10 may also be used with larger stationary engines or used with boats or other heavy machinery. Additionally, the pollution control system 10 may include one or more controllers 12 and one or more PCV valves 18 in combination with a plurality of sensors measuring the performance of the engine or vehicle. The use of the pollution control system 10 is association with an automobile, as described in detail above, is merely a preferred embodiment. Of course, the pollution control system 10 has application across a wide variety of disciplines that employ combustible materials having exhaust gas production that could be recycled and reused.

[Para 70] In another aspect of the pollution control system 10, the controller 12 may modulate control of the PCV valve 18. The primary functionality of the PCV valve 18 is to control the amount of engine vacuum between the crankcase 35 and the intake manifold 38. The positioning of the plunger 94 within the solenoid 96 largely dictates the air flow rate of blow-by gases traveling from the crankcase 35 to the intake manifold 38. In some systems, the PCV valve 18 may regulate air flow to ensure the relative pressure between the crankcase 35 and the intake manifold 38 does not fall below a certain threshold according to the original equipment manufacturer (OEM). In the event that the controller 12 fails, the pollution control system 10 defaults back to OEM settings wherein the

PCV valve 18 functions as a two-stage check valve. A particularly preferred aspect of the pollution control system 10 is the compatibility with current and future OBD standards through inclusion of a flash-updatable controller 12. Moreover, operation of the pollution control system 10 does not affect the operational conditions of current OBD and OBD-II systems. The controller 12 may be accessed and queried according to standard OBD protocols and flash-updates may modify the bios so the controller 12 remains compatible with future OBD standards. Preferably, the controller 12 operates the PCV valve 18 to regulate the engine vacuum between the crankcase 35 and the intake manifold 38, thereby governing the air flow rate therebetween to optimally vent blow-by gas within the system 10.

[Para 71] In another aspect of the pollution control system 10, the controller 12 may modulate activation and/or deactivation of the operational components, as described in detail above, with respect to, e.g., the PCV valve 18. Such modulation is accomplished through, for example, the aforementioned RWS switch, on-delay timer or other electronic circuitry and digitally activates, deactivates or selectively intermediately positions the aforementioned control components. For example, the controller 12 may selectively activate the PCV valve 18 for a period of one to two minutes and then selectively deactivate the PCV valve 18 for ten minutes. These activation/deactivation sequences may be set according to pre-determined or learned sequences based on driving style, for example. Pre-programmed timing sequences may be changed through flash-updates of the controller 12.

[Para 72] FIGURE 12 illustrates an alternate embodiment of the PCV valve 18 integral with the engine oil cap 37. Distinct from the embodiment shown in FIG. 5, this embodiment has the PCV valve 18 attached to the engine oil cap 37 by an elbow or bend connector. This elbow or bend connector orients the PCV valve 18 in a low profile, i.e., generally horizontal, position when the engine oil cap 37 is attached to the engine oil inlet 39. This low profile position of the PCV valve 18 orients the same so that it generally runs along the surface of the engine 36. This is particularly useful in engine compartments where the engine oil inlet 39 is on the top of the engine 36 and the hood 14 provides very little clearance above the engine 36. The angle or bend is preferably a ninety degree angle, but may be presented in other angles as a particular engine design may require. The PCV valve 18 functions in the same manner as the embodiment described above.

[Para 73] The wires 78 extending from the PCV valve 18 may include a waterproof connector 79a, 79b to facilitate connection to the controller 12.

[Para 74] FIGURES 13 and 14 illustrate a configuration for the oil separator 19. The oil separator 19 has a canister 134 with a top portion 166 and a bottom portion 168. Attached to the canister 134 is a handle 170 along with an inlet port 172 and an outlet port 174. FIGURE 14 shows the oil separator 19 in an exploded view with its orientation flipped from that of FIG. 13. One can see the handle 170 is attached to the top portion 166 by a screw 176 or other similar attachment means. The interior of the top portion 166 is divided into an inlet chamber 178 and an outlet chamber 180. A metal screen 182 is disposed across the openings of the inlet chamber 178 and outlet chamber 180. The screen 182 is preferably held in place by screws 184. The interior of the bottom portion 168 preferably comprises an open chamber (not shown) configured to capture oil condensed out of the blow-by gasses. The bottom portion 168 may include steel wool 186 or other similar mesh layer materials. The underside of the bottom portion 168 includes an oil drainage port 138.

[Para 75] The oil separator 19 further includes an O-ring or gasket 188 disposed between the upper portion 166 and the bottom portion 168. The O-ring 188 seals the oil separator 19 against leakage during operation under pressure. The upper portion 166 and bottom portion 168 are preferably secured together by a durable but releasable connection such as a threaded coupling, lugs and channels, or set screws. A person of ordinary skill in the art will appreciate the various means of securing the top portion 166 and bottom portion 168 together.

[Para 76] When fully assembled, the oil separator 19 brings the blow-by gasses into the inlet chamber 178 through the inlet port 172. The gasses then pass through the screen 182 into the bottom portion 168. As the blow-by gasses pass through the screen 182, a portion of the oil contained therein is condensed and drains to the bottom of the inner chamber. The blow-by gasses then pass over and through the mesh layers 186 where additional oil is further condensed out of the blow-by gasses to remain in the bottom of the inner chamber. The vacuum created by the pressure differential between the crankcase and the intake manifold then draws the blow-by gasses upward through the screen 182 into the outlet chamber 180. This second passage through the screen 182 further condenses additional oil out of the blow-by gasses. The screen 182 and mesh layers 186 also aid in filtering particulates and other contaminants in the blow-by gasses. Once drawn into the outlet chamber 180, the blow-by gasses are released through the outlet port 174 and are transported as described in the various embodiments.

[Para 77] In view of the foregoing, it is understood by one skilled in the art that the present invention for a pollution control system for diesel engines includes an oil filter and PCV valve used in conjunction with a diesel engine. In summary, during acceleration and while hauling heavy loads, the diesel engine will produce blow-by gas, which includes fuel vapor, oil, and other contaminants. This blow-by gas is vented from the crankcase to the oil filter. Here, the blow-by gas passes through a series of mesh filters where the oil and other contaminants are filtered out of the fuel vapor. The contaminants are trapped in the mesh filters, while the oil condenses to the bottom of the oil filter. The condensed oil is returned to the crankcase out of the bottom of the oil filter.

[Para 78] The purified fuel vapor is vacuumed out of the oil filter through the PCV valve to be returned to the engine for re-burning. The PCV valve is connected to a controller that allows for variable amounts of fuel vapor to pass through the valve depending on the current engine requirements. Once the fuel vapor passes through the PCV valve, it is returned to the engine either via the fuel line, or through the intake manifold.

[Para 79] Although several embodiments have been described in detail for purposes of illustration, various modifications may be made to each without departing from the scope and spirit of the invention. Accordingly, the invention is not to be limited, except as by the appended claims.

What is claimed is:

[Claim 1] A pollution control system, comprising:

a controller coupled to a sensor for monitoring an operational characteristic of a combustion engine, wherein the controller is configured to selectively modulate engine vacuum pressure to adjustably increase or decrease a fluid flow rate of blow-by gasses venting from the combustion engine; and

a PCV valve adapted to vent blow-by gasses from a crankcase of the combustion engine, an inlet of the PCV valve being in fluid communication with a port on an engine oil cap of the combustion engine such that the blow-by gasses are vented through an oil filler tube to the crankcase, and an outlet of the PCV valve being in fluid communication with a fuel/air inlet of the combustion engine, wherein the PCV valve comprises a two-stage check valve, the first stage directed by the controller, and the second stage compatible with OEM settings wherein the check valve opens only under sufficient vacuum pressure in the event the controller fails.

[Claim 2] The pollution control system of claim 1, wherein the inlet of the PCV valve is co-extensive with the port on the engine oil cap.

[Claim 3] The pollution control system of claim 2, wherein the PCV valve is integrally formed with the engine oil cap such that the inlet of the PCV valve is the port on the engine oil cap.

[Claim 4] The pollution control system of claim 1, further comprising a filter screen over the port in the engine oil cap.

[Claim 5] The pollution control system of claim 1, wherein the outlet of the PCV valve is in fluid communication with a recycle line on an OEM pollution control system, wherein the OEM pollution control system vents directly from the crankcase.

[Claim 6] The pollution control system of claim 1, wherein the fuel/air inlet comprises an intake manifold, a fuel line, an air line, or a fresh air intake.

[Claim 7] The pollution control system of claim 6, wherein the fuel/air inlet is a fresh air intake for an air filter that feeds into a supercharger on the combustion engine.

[Claim 8] The pollution control system of claim 1, further comprising an oil separator in fluid communication with the outlet from the PCV valve, an oil outlet from the oil separator in fluid communication with the crankcase of the combustion engine and a gas outlet from the oil separator in fluid communication with the fuel/air inlet of the combustion engine.

[Claim 9] The pollution control system of claim 1, wherein the combustion engine is configured to combust gasoline, methanol, diesel, ethanol, compressed natural gas, liquid propane gas, hydrogen, or an alcohol-based fuel.

[Claim 10] The pollution control system of claim 1, wherein the controller decreases the engine vacuum pressure during periods of decreased production of blow-by gasses to decrease the fluid flow rate through the PCV valve, and increases the engine vacuum pressure during periods of increased production of blow-by gasses to increase the fluid flow rate through the PCV valve.

[Claim 11] The pollution control system of claim 10, wherein the controller includes a pre-programmed software program, a flash-updatable software program, or a behavior-learning software program.

[Claim 12] The pollution control system of claim 11, wherein the controller includes a wireless transmitter or a wireless receiver.

[Claim 13] The pollution control system of claim 10, wherein the controller includes a window switch coupled to an engine RPM sensor, and wherein the engine vacuum pressure is modulated based on a predetermined engine RPM or multiple engine RPMs set by the window switch.

[Claim 14] The pollution control system of claim 1, wherein the controller includes an on-delay timer so as to preclude fluid flow of blow-by gasses for a predetermined duration after activation of the combustion engine.

[Claim 15] The pollution control system of claim 14, wherein the predetermined duration is a function of time, engine temperature, or engine RPM.

[Claim 16] The pollution control system of claim 1, wherein the sensor comprises an engine temperature sensor, a spark plug sensor, an accelerometer sensor, a PCV valve sensor, or an exhaust sensor.

[Claim 17] The pollution control system of claim 16, wherein the operational characteristic comprises an engine temperature, a quantity of engine cylinders, a real-time acceleration calculation, or an engine RPM.

[Claim 18] A PCV valve adapted to vent blow-by gasses from a crankcase of a combustion engine, the PCV valve comprising:

an inlet in fluid communication with a port on an engine oil cap, the engine oil cap configured for attachment to an oil filler tube to the crankcase;

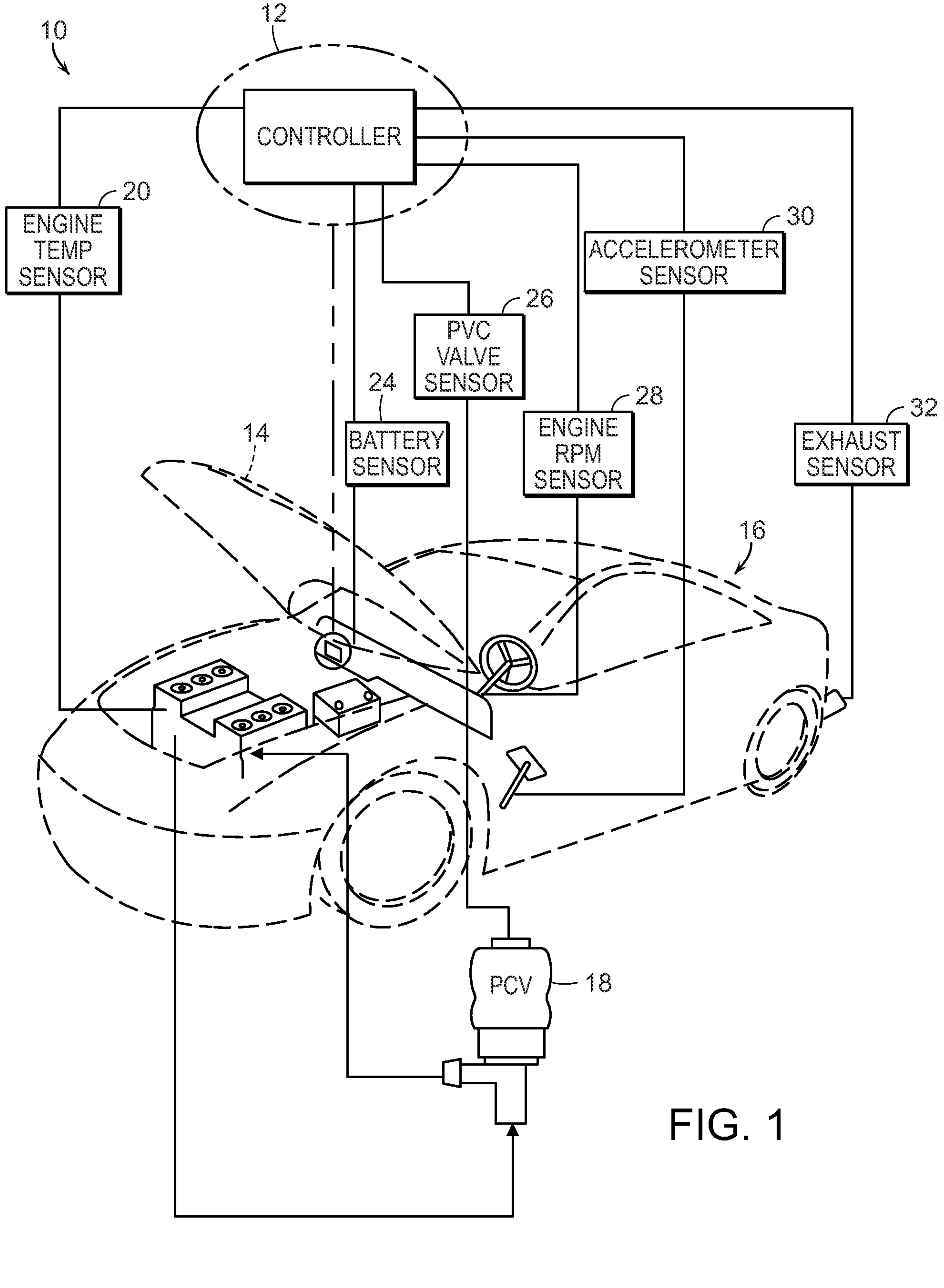
an outlet configured for fluid communication with a fuel/air inlet of the combustion engine; and a two-stage check valve between the inlet and the outlet, wherein the first stage of the check valve is configured to be opened or closed by a solenoid mechanism responsive to a controller, and the second stage of the check valve is biased in a closed position so as to open only under vacuum pressure in the combustion engine greater than a predetermined threshold.

[Claim 19] The PCV valve of claim 18, wherein the inlet of the PCV valve is fluidly connected to the port on the engine oil cap by a hose.

[Claim 20] The PCV valve of claim 18, wherein the inlet of the PCV valve is co-extensive with the port on the engine oil cap.

[Claim 21] The PCV valve of claim 20, wherein the engine oil cap is integrally formed with the PCV valve such that the inlet is the port on the engine oil cap.

[Claim 22] The PCV valve of claim 18, further comprising a filter screen covering the port in the engine oil cap.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PCV
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FIG. 1

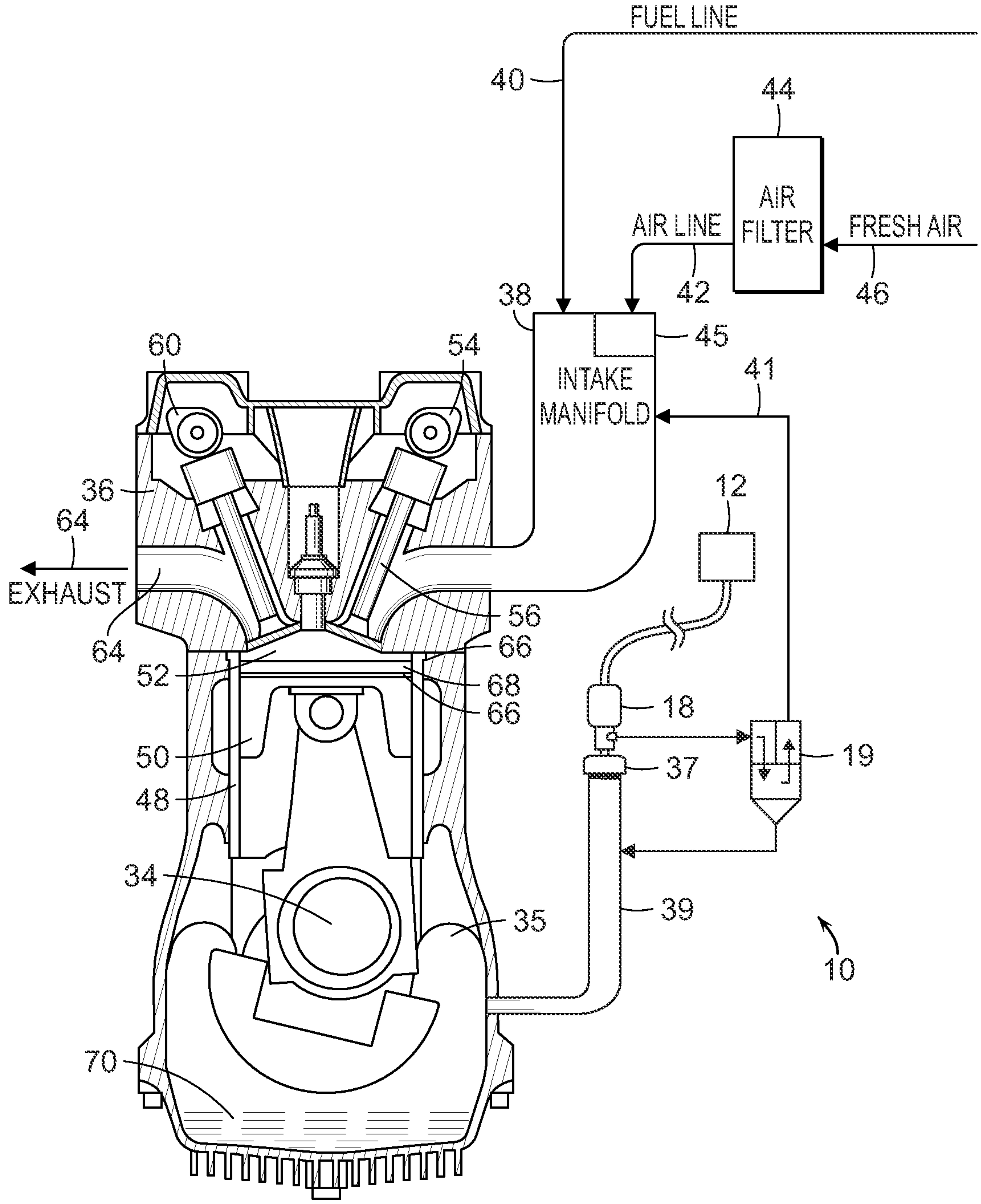
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FIG. 2

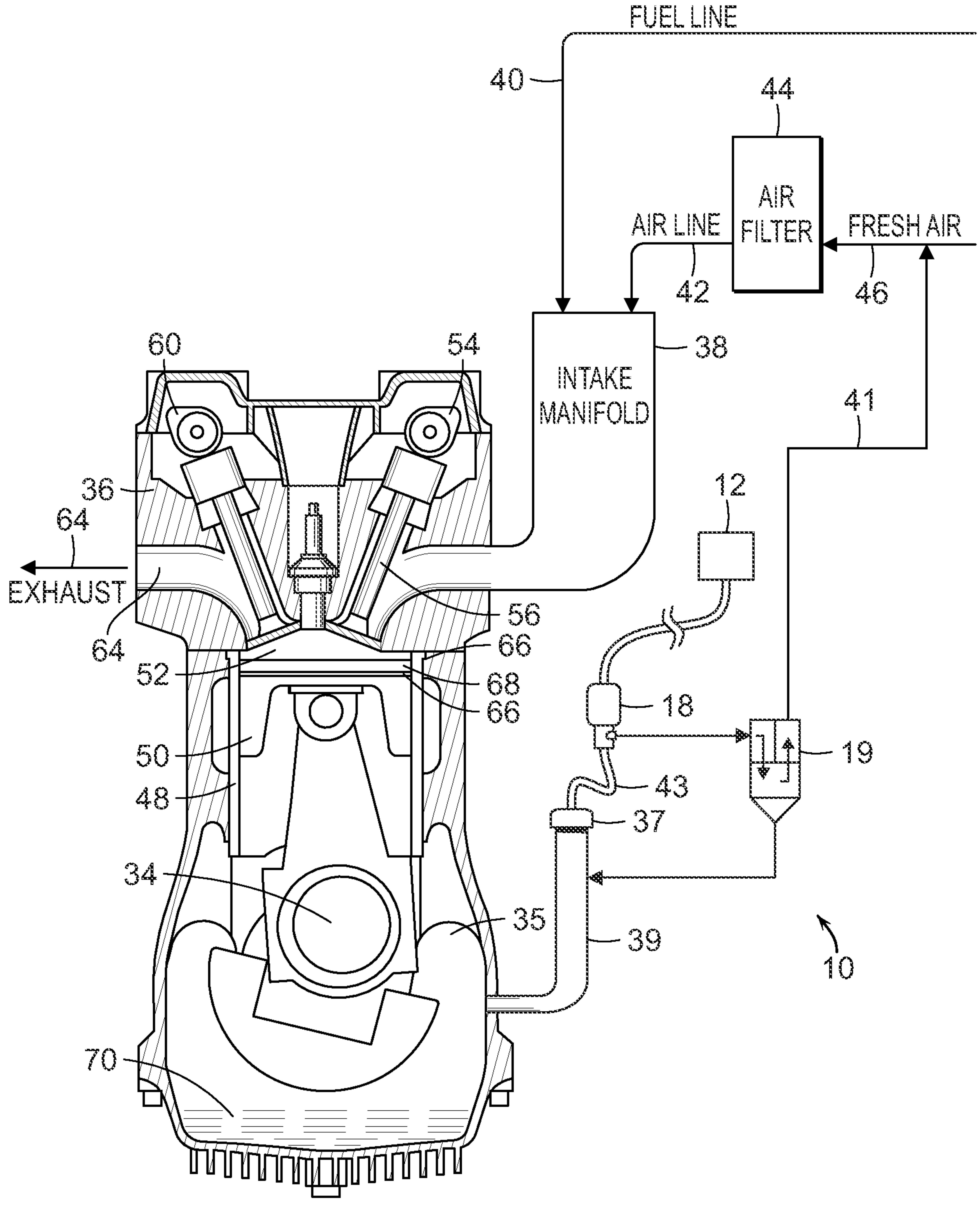
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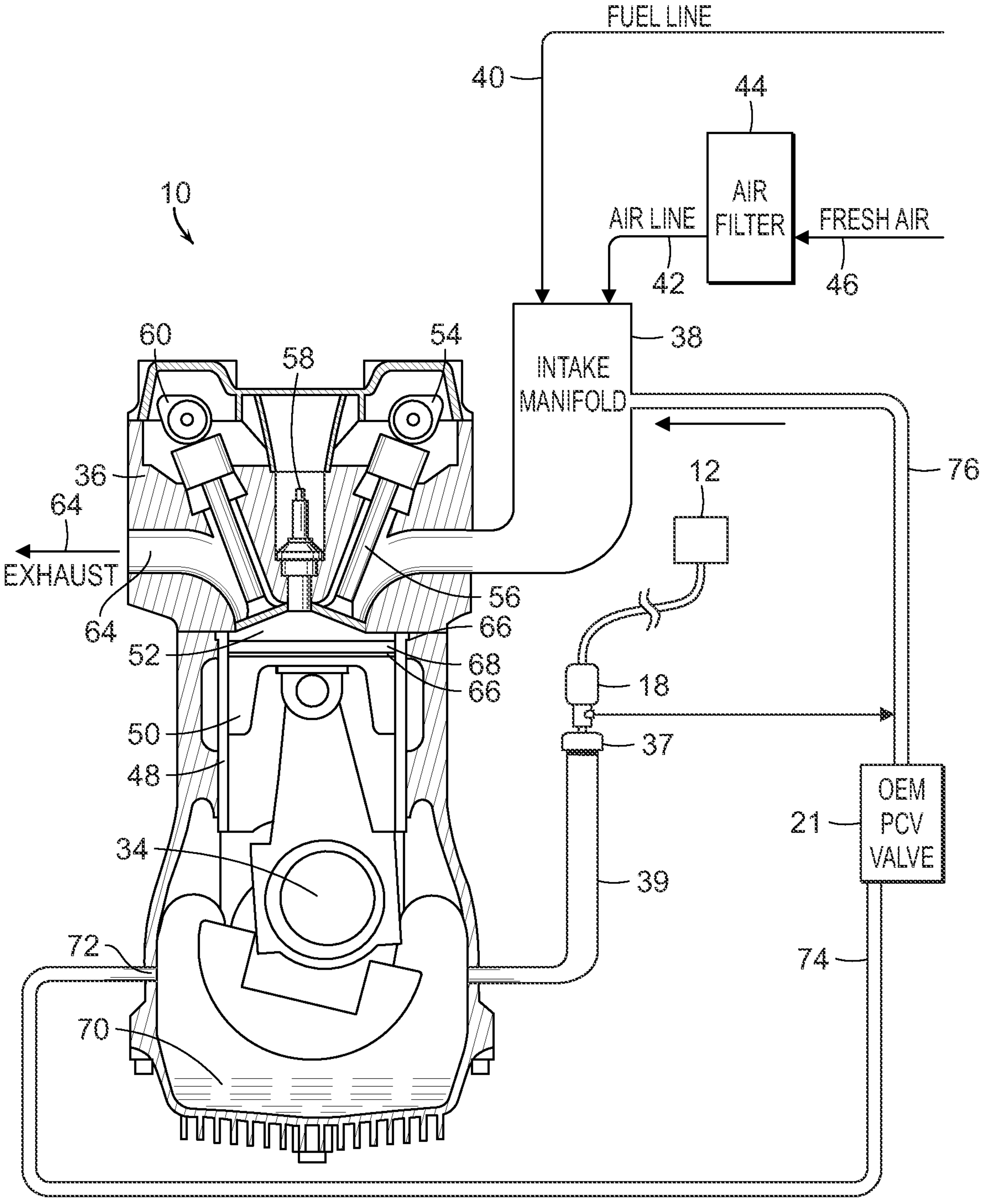
FIG. 3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OEM PCV VALVE
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FIG. 4

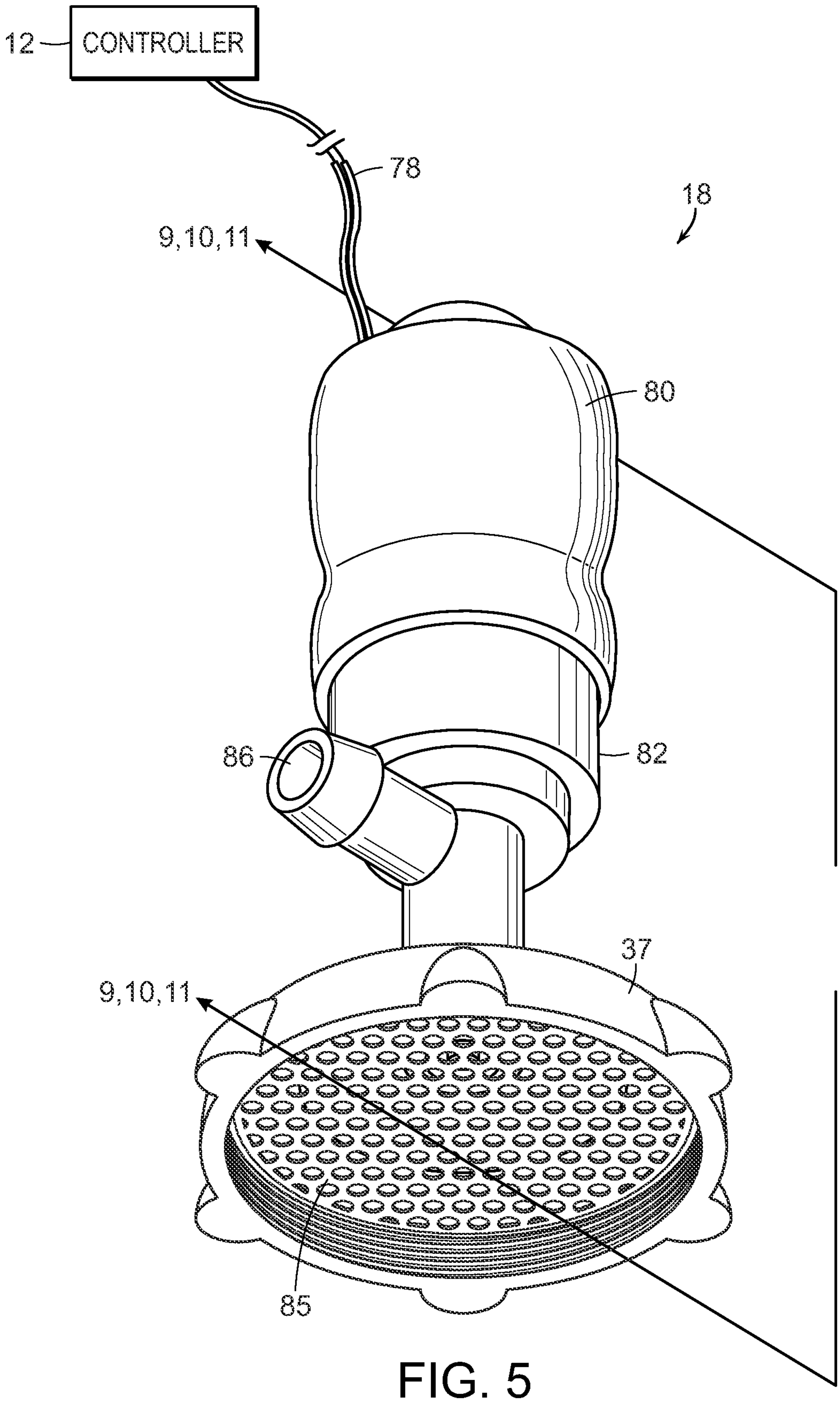

FIG. 5

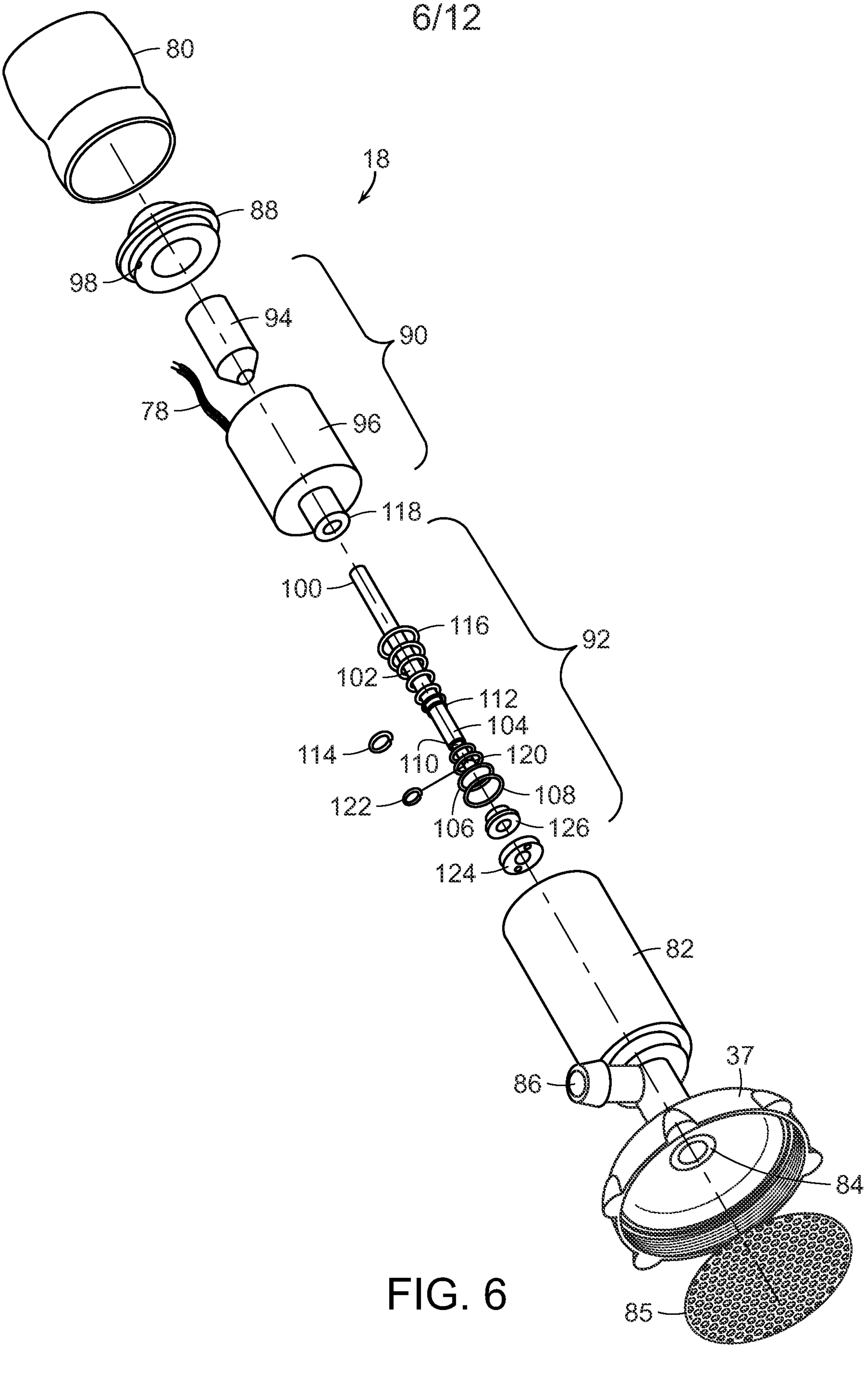
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FIG. 6

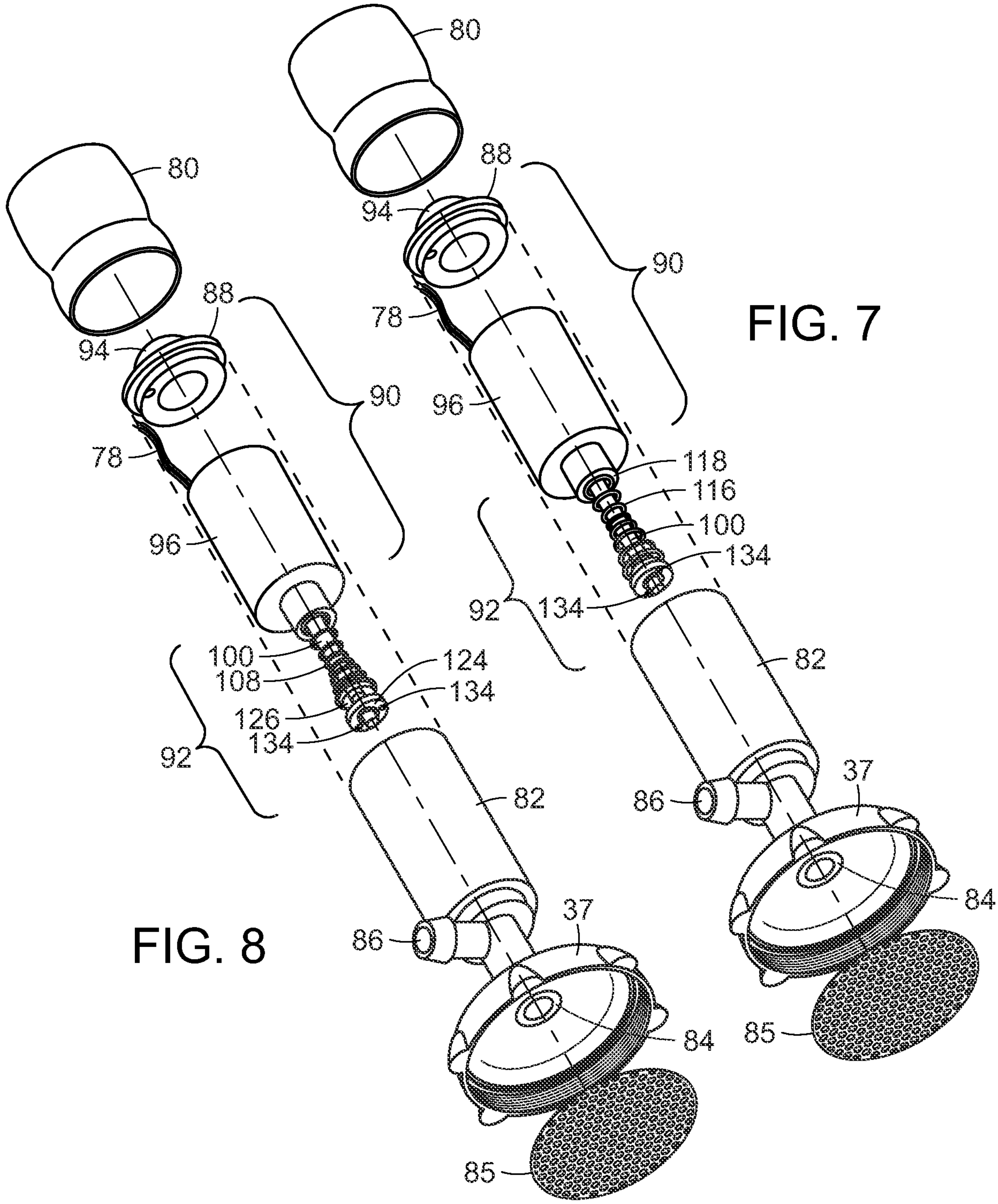
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FIG. 7

FIG. 8

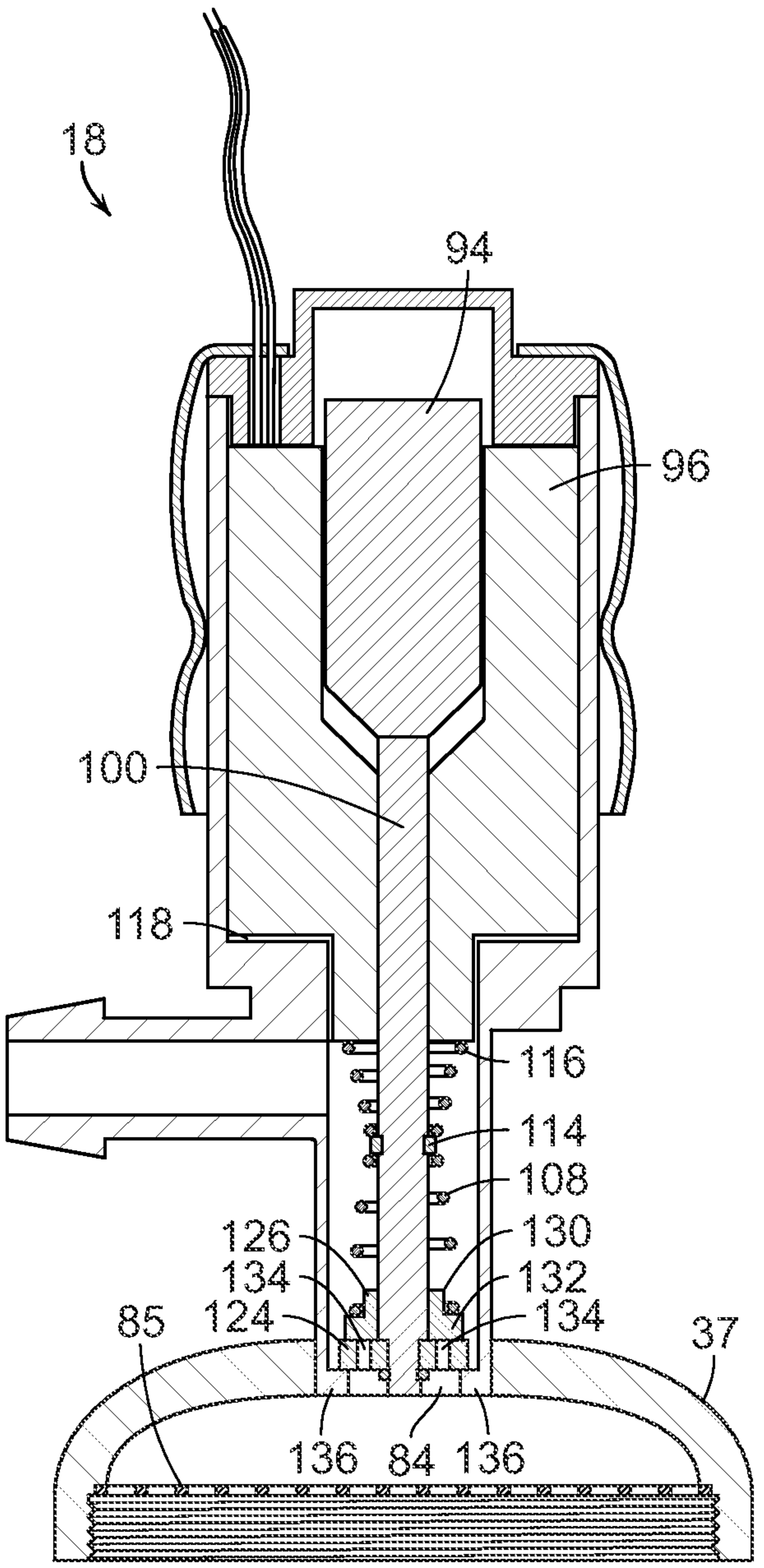
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FIG. 9

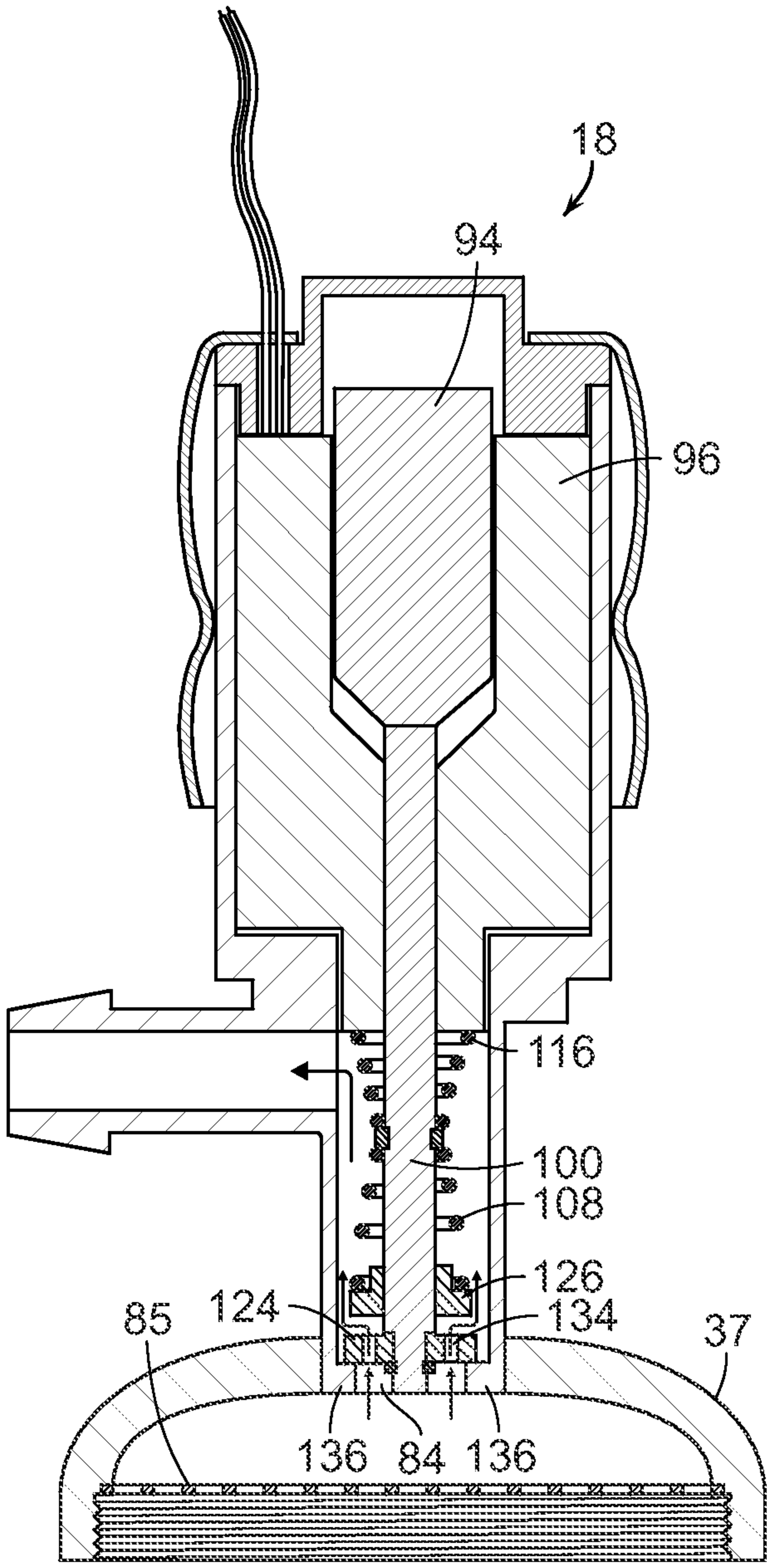
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FIG. 10

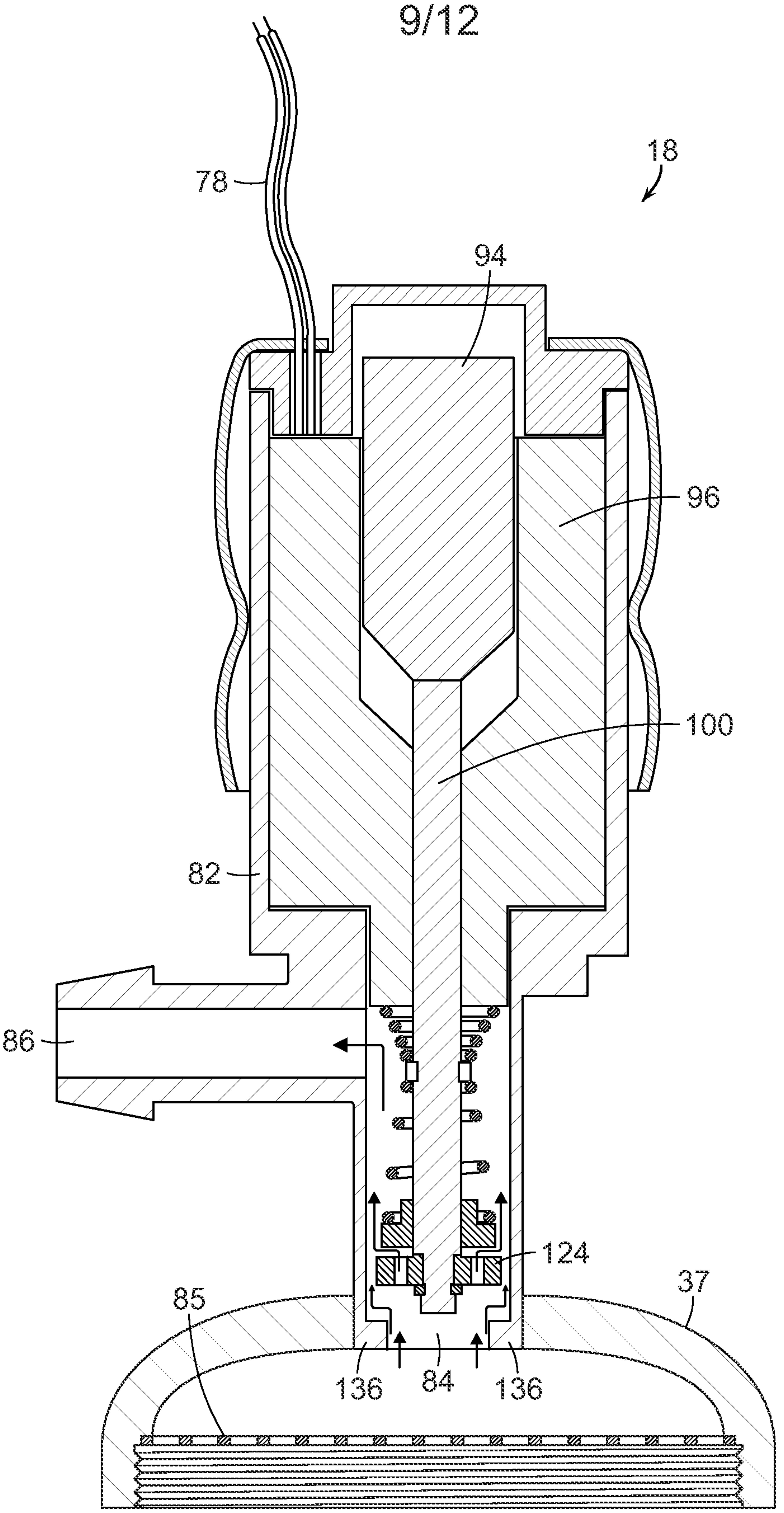

FIG. 11

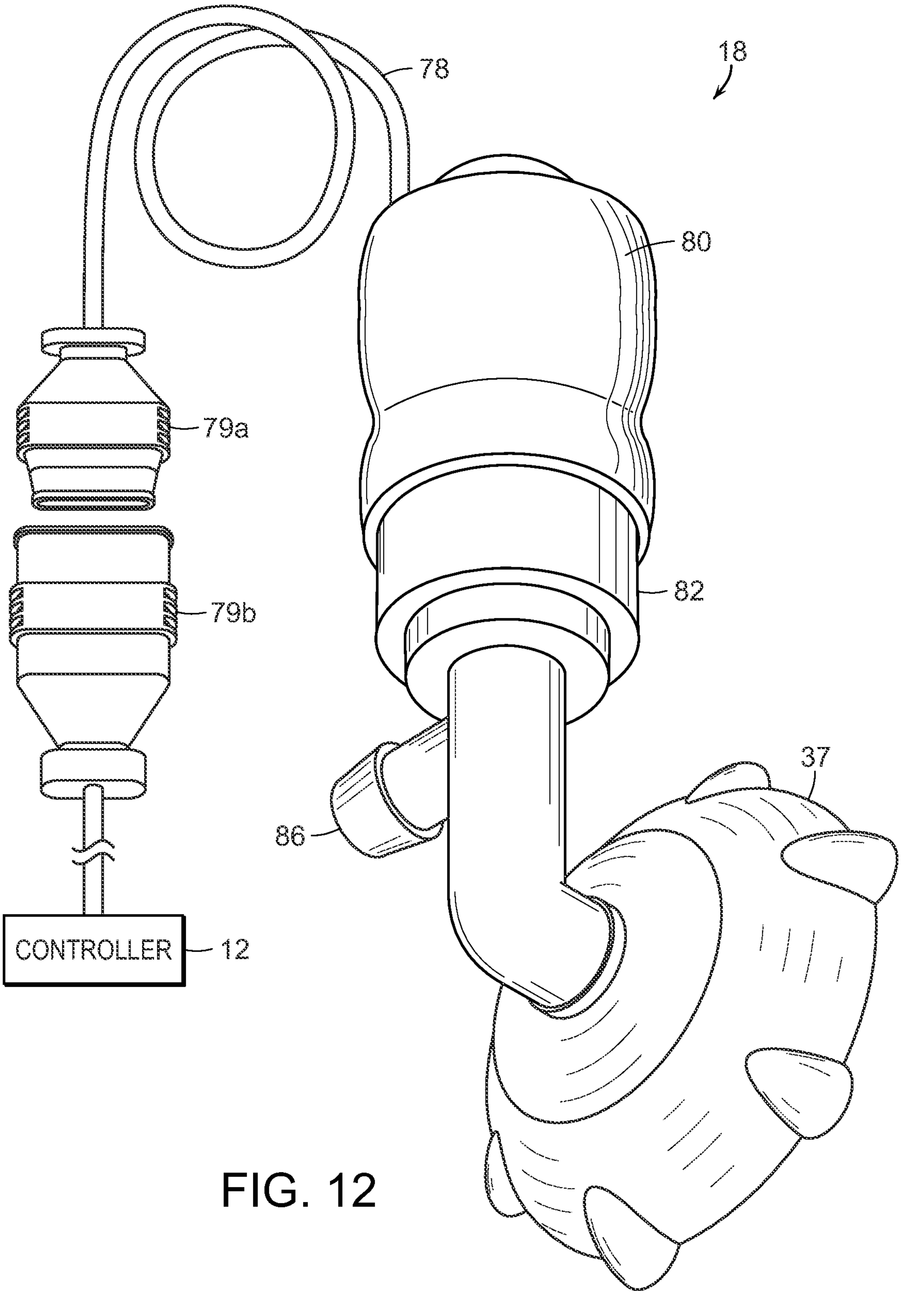

FIG. 12

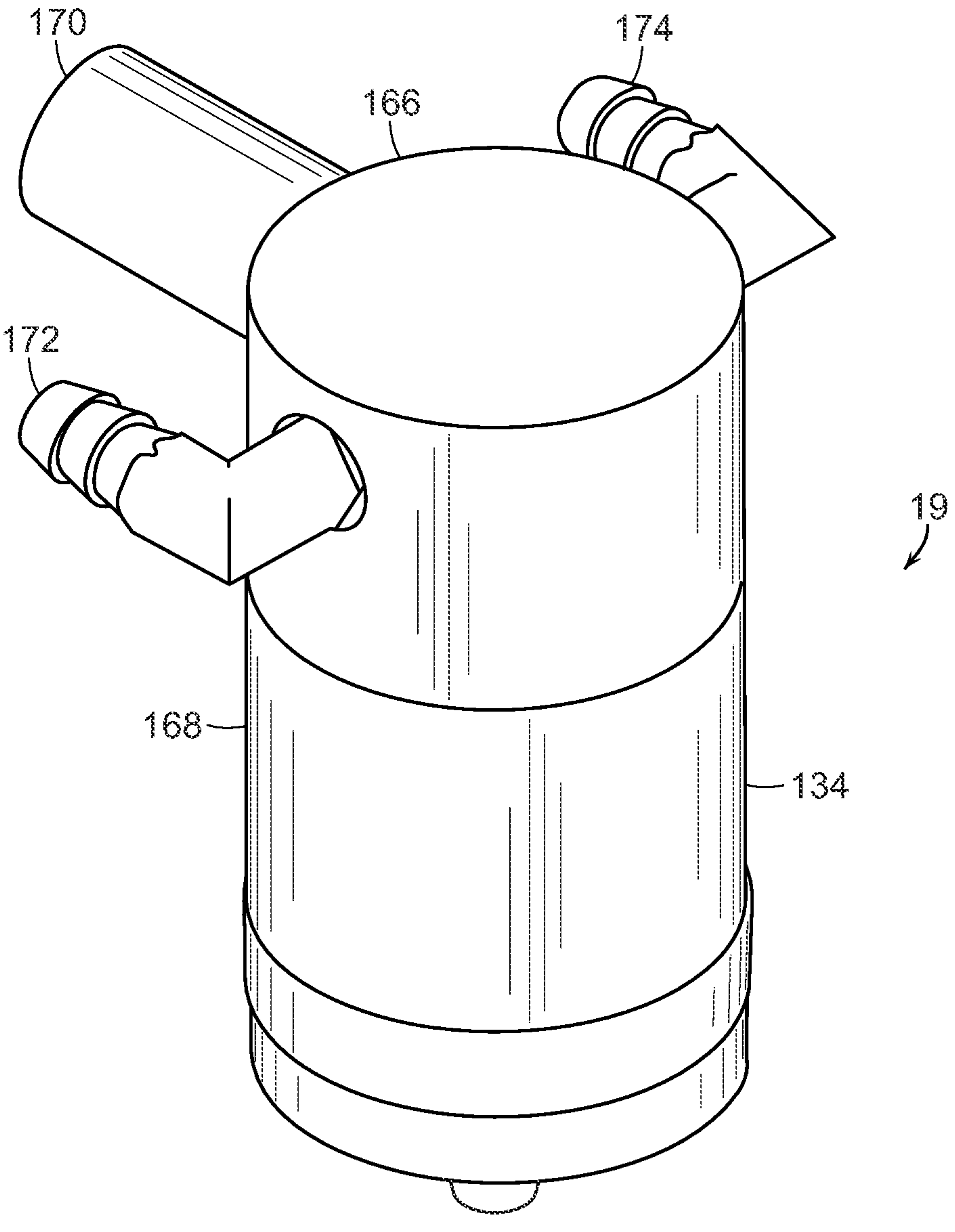

FIG. 13

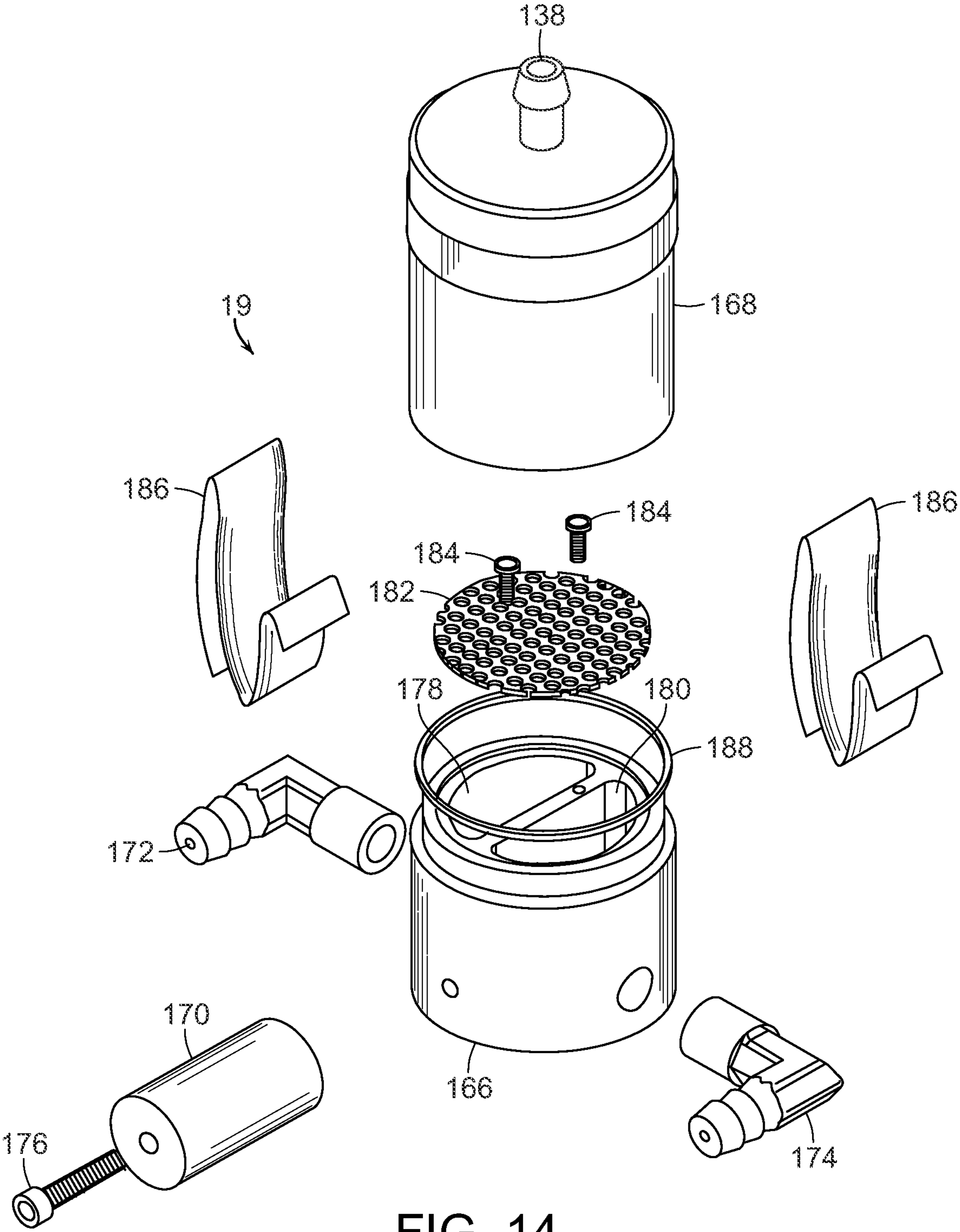

FIG. 14

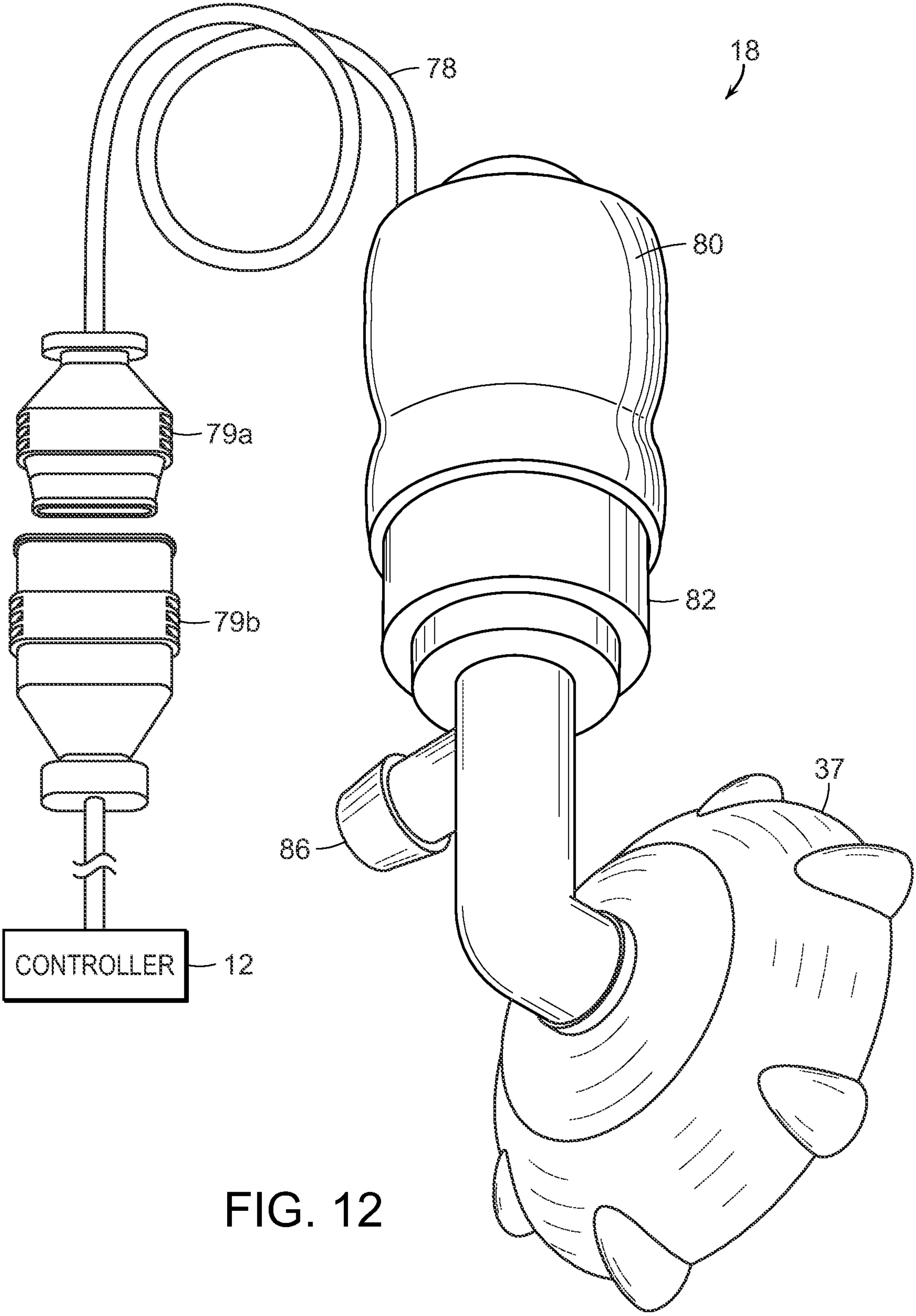

FIG. 12