

US008382072B1

(12) **United States Patent**
Galka et al.

(10) **Patent No.:** **US 8,382,072 B1**
(45) **Date of Patent:** **Feb. 26, 2013**

(54) **CHARGE FORMING DEVICE AND SOLENOID VALVE**

(75) Inventors: **William E. Galka**, Caro, MI (US);
Ronald H. Roche, Cass City, MI (US)

(73) Assignee: **Walbro Engine Management, L.L.C.**,
Tucson, AZ (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 385 days.

(21) Appl. No.: **12/726,001**

(22) Filed: **Mar. 17, 2010**

(51) **Int. Cl.**
F02M 7/12 (2006.01)

(52) **U.S. Cl.** **261/66; 251/129.15; 251/129.22;**
261/DIG. 74

(58) **Field of Classification Search** **261/35,**
261/66, 70, DIG. 74; 251/129.15, 129.21,
251/129.22, 208, 286, 315.01, 315.05–315.08
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,942,493	A *	3/1976	Linder et al.	123/699
3,996,909	A *	12/1976	Fischer	123/585
4,111,176	A *	9/1978	Fenton et al.	123/198 DB
4,132,199	A *	1/1979	Kuroiwa et al.	123/685
4,387,062	A *	6/1983	Tanaka	261/23.2
4,434,110	A *	2/1984	Highfield	261/36.2
4,501,407	A *	2/1985	Murray	251/129.15

4,838,224	A *	6/1989	Cheng	123/339.13
6,267,102	B1	7/2001	Pattullo et al.	
6,401,685	B1	6/2002	Warner	
6,585,235	B2	7/2003	Pattullo	
6,615,792	B1	9/2003	Grifka et al.	
6,672,570	B2 *	1/2004	Takano et al.	261/39.2
6,702,261	B1 *	3/2004	Shaw	261/35
6,880,812	B2 *	4/2005	Nonaka	261/26
7,028,993	B2	4/2006	Burns	
7,264,230	B2	9/2007	Burns et al.	
2006/0082005	A1 *	4/2006	Ogishi	261/34.2

FOREIGN PATENT DOCUMENTS

GB	2028431	A *	3/1980
WO	WO2009055809	A2	4/2009

OTHER PUBLICATIONS

U.S. Appl. No. 61/094,973, filed Sep. 7, 2008.

* cited by examiner

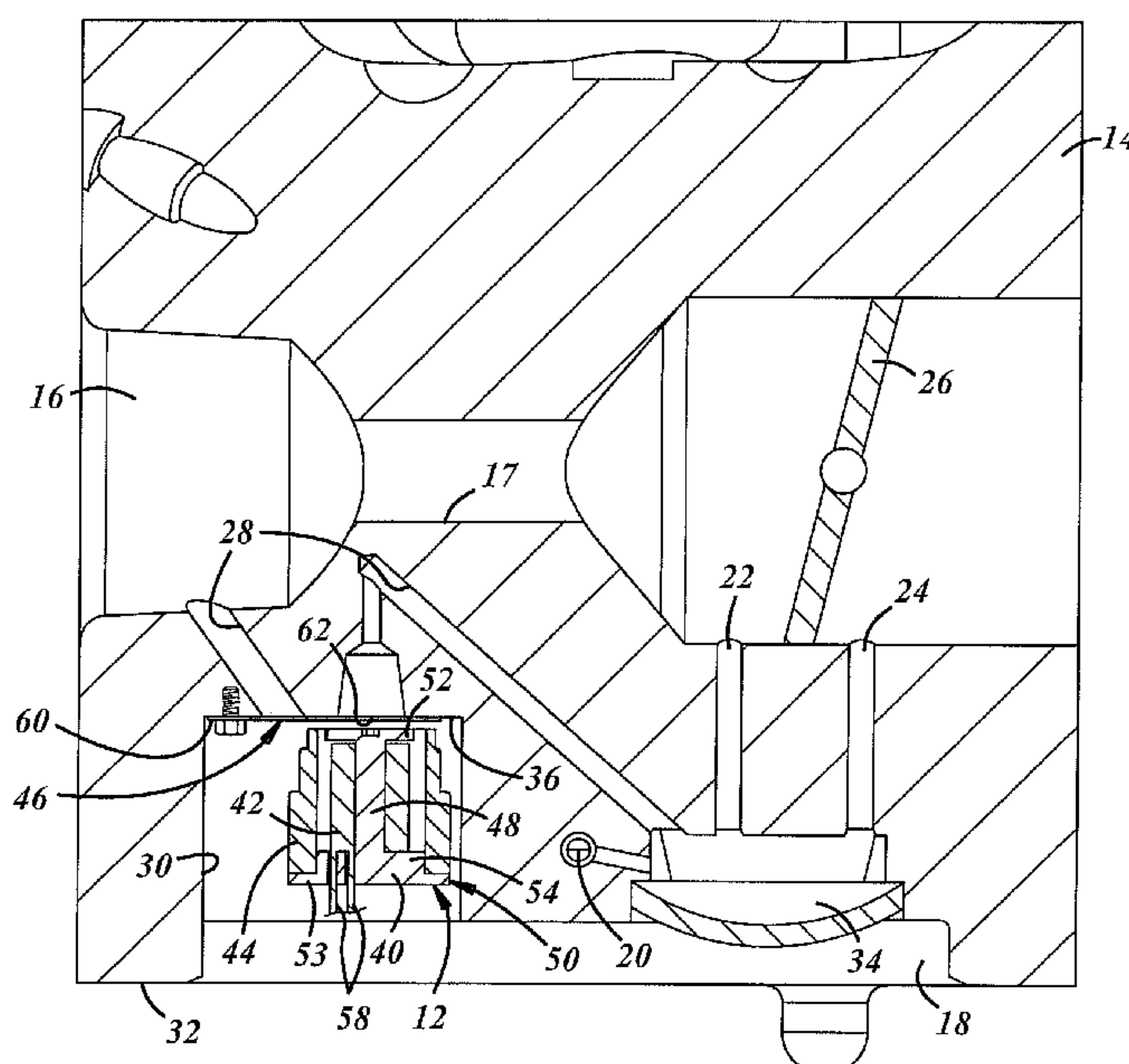
Primary Examiner — Richard L Chiesa

(74) *Attorney, Agent, or Firm* — Reising Ethington P.C.

(57) **ABSTRACT**

A fuel and air charge forming device, such as a carburetor, may include a main body, a fuel and air mixing passage in the body, a fluid passage communicating with the fuel and air mixing passage and a solenoid valve. The solenoid valve may include a coil and a valve body having a base fixed against movement and a valve head extending from the base. The valve head may be driven by the coil between a first position wherein the valve head at least partially obstructs the fluid passage and a second position wherein the valve head permits greater fluid flow in the fluid passage to control fluid flow through the fluid passage.

17 Claims, 5 Drawing Sheets



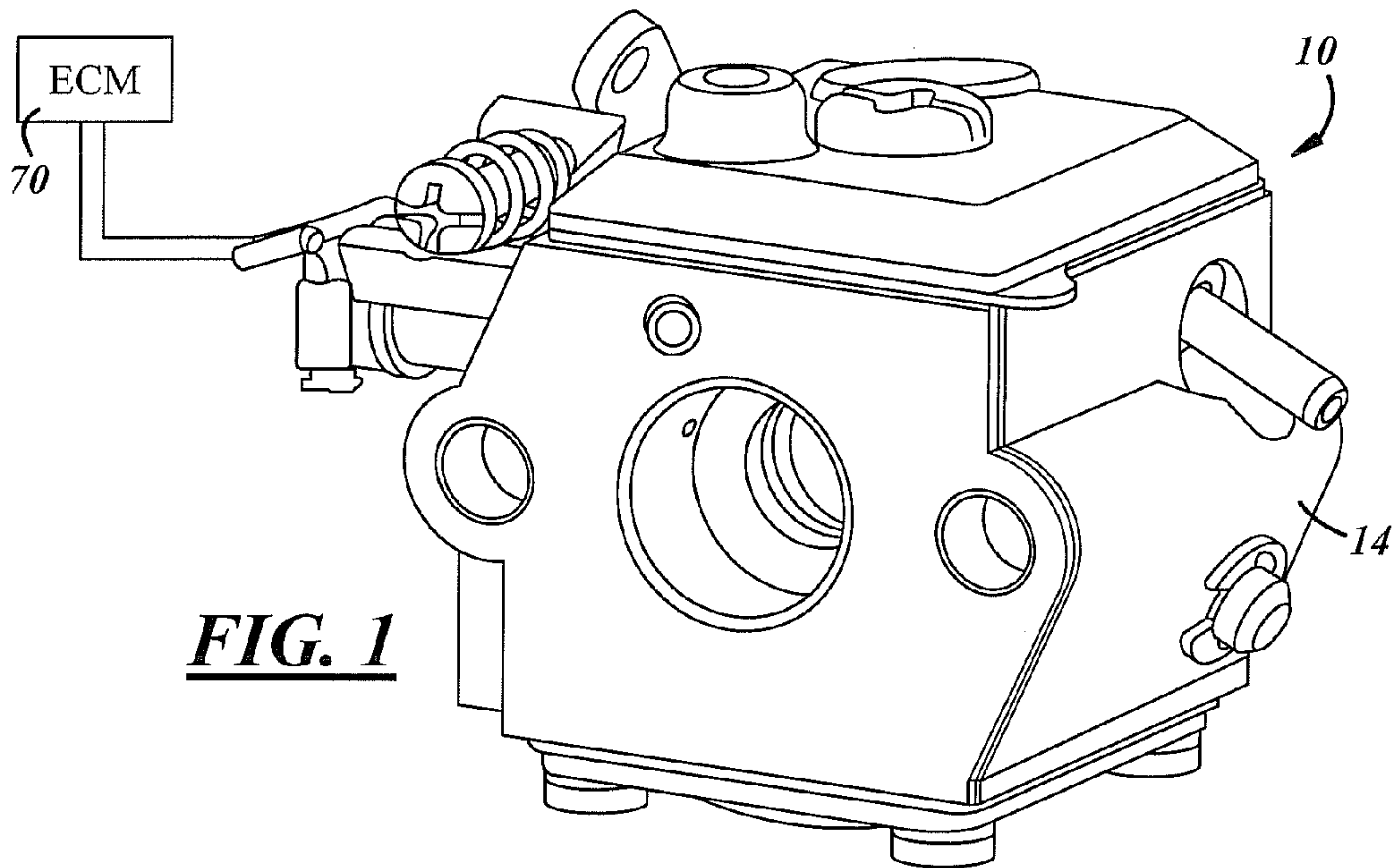


FIG. 1

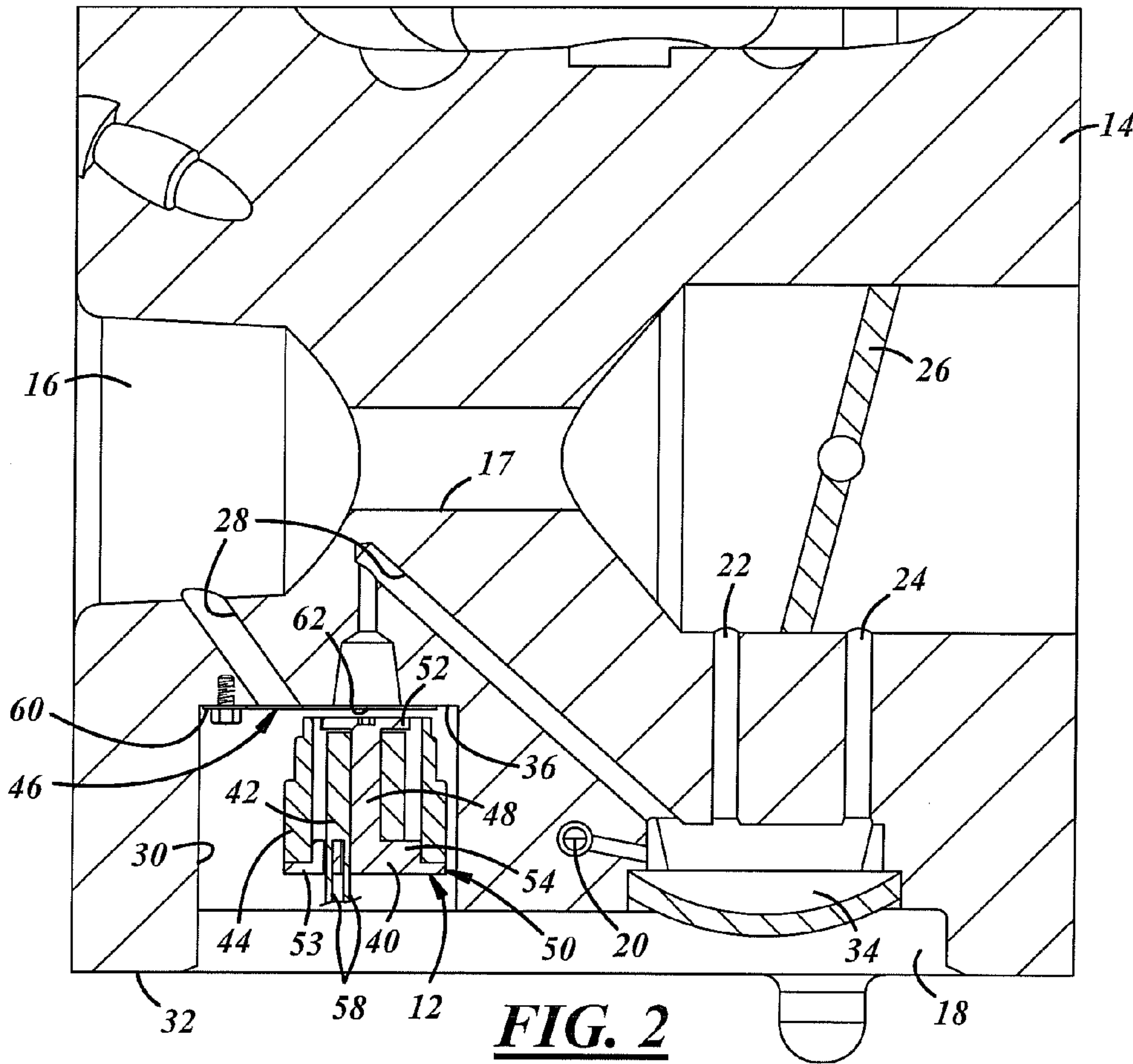


FIG. 2

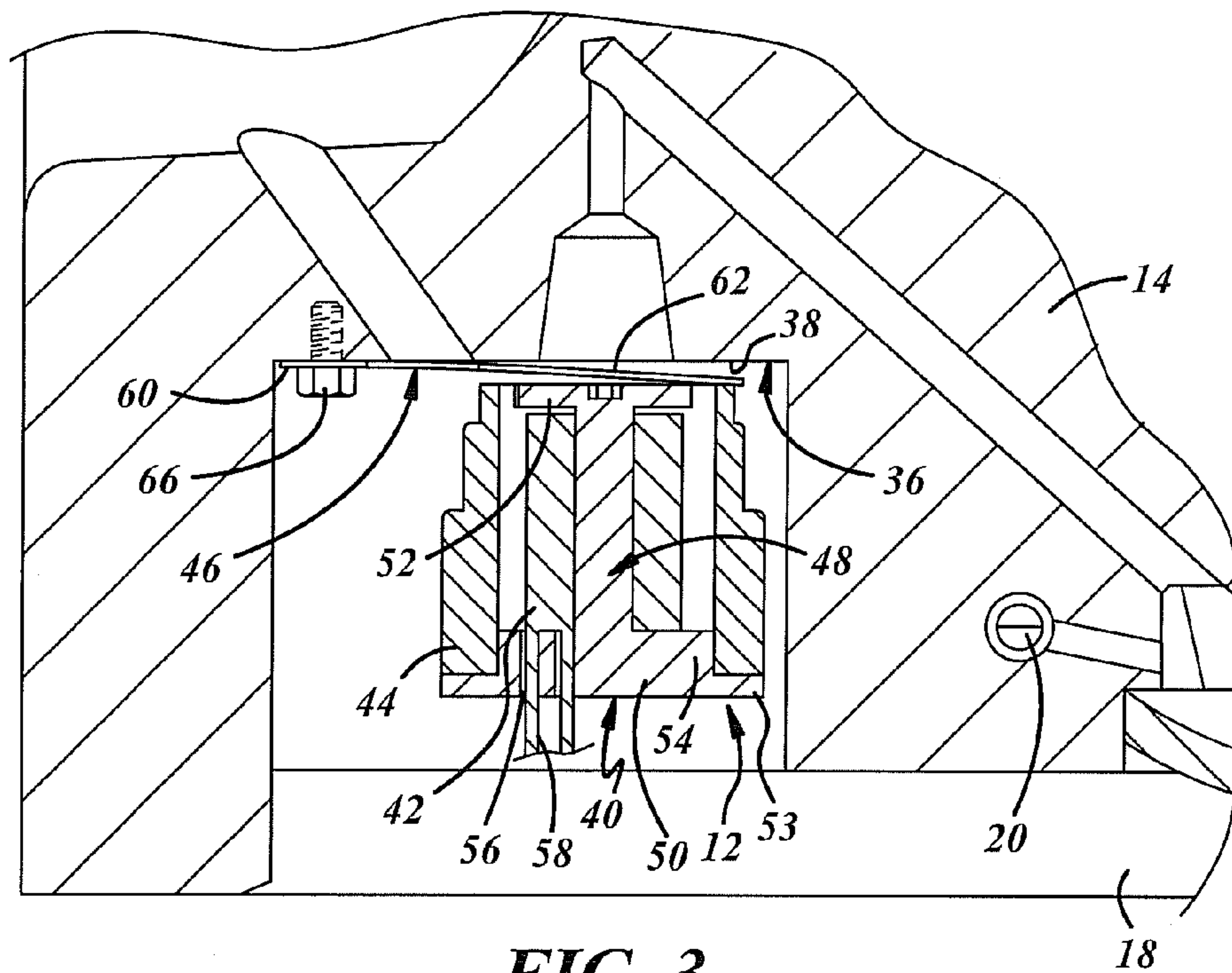


FIG. 3

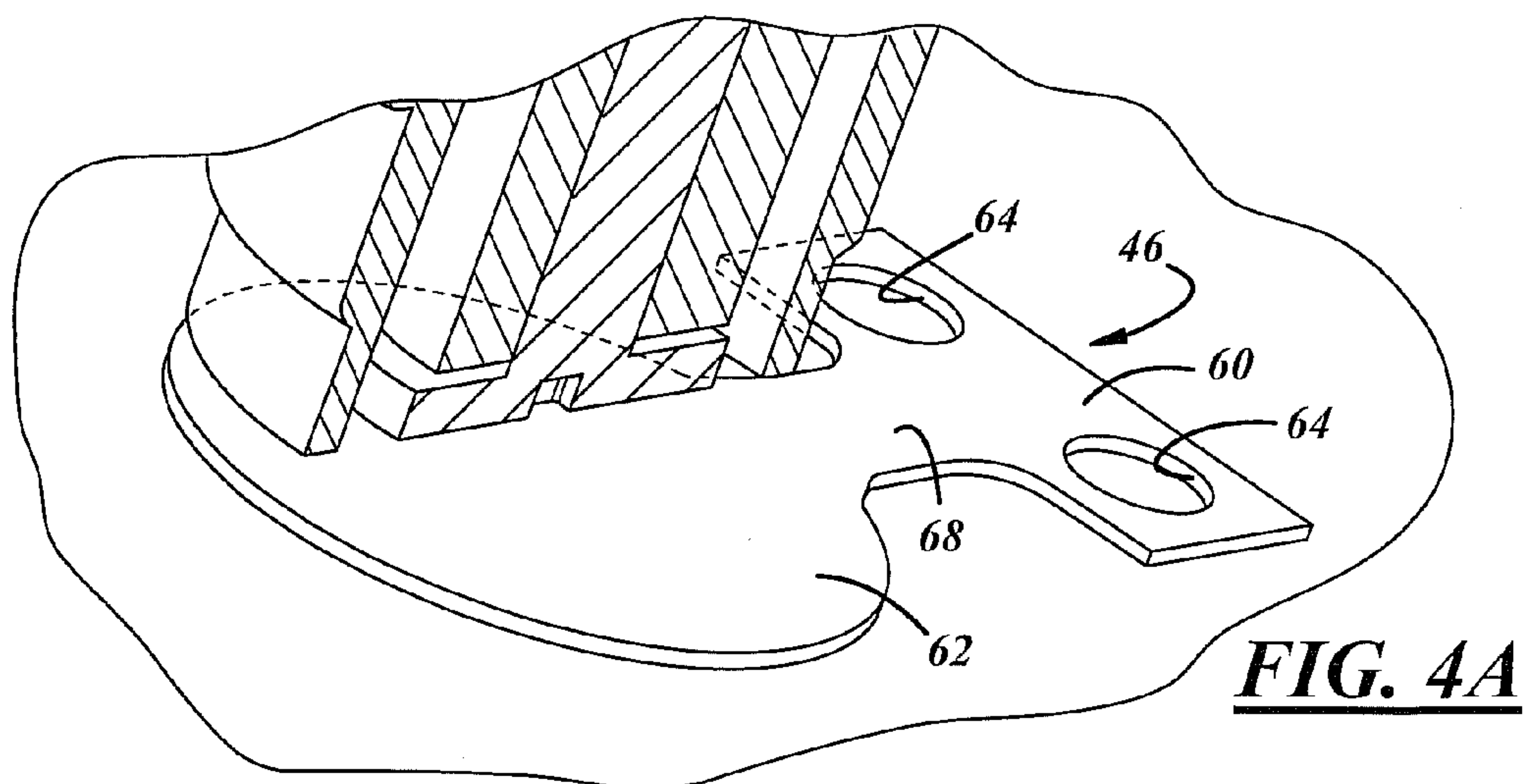


FIG. 4A

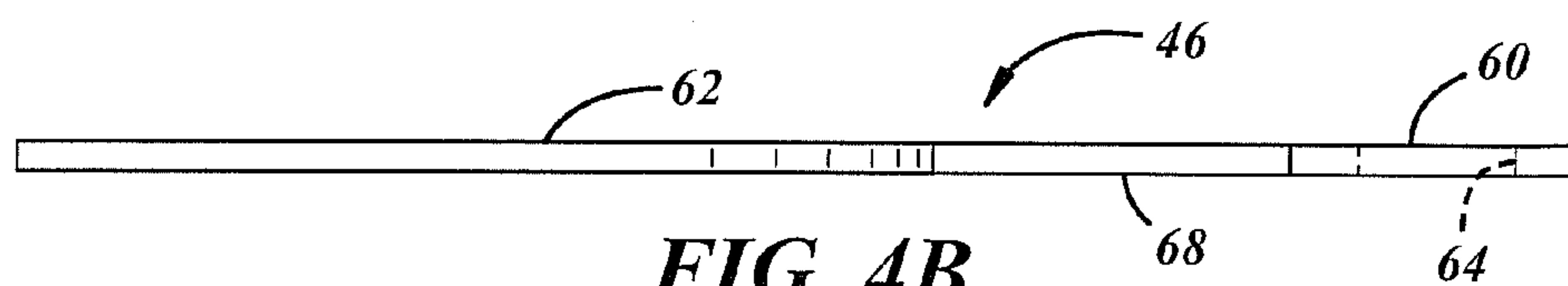
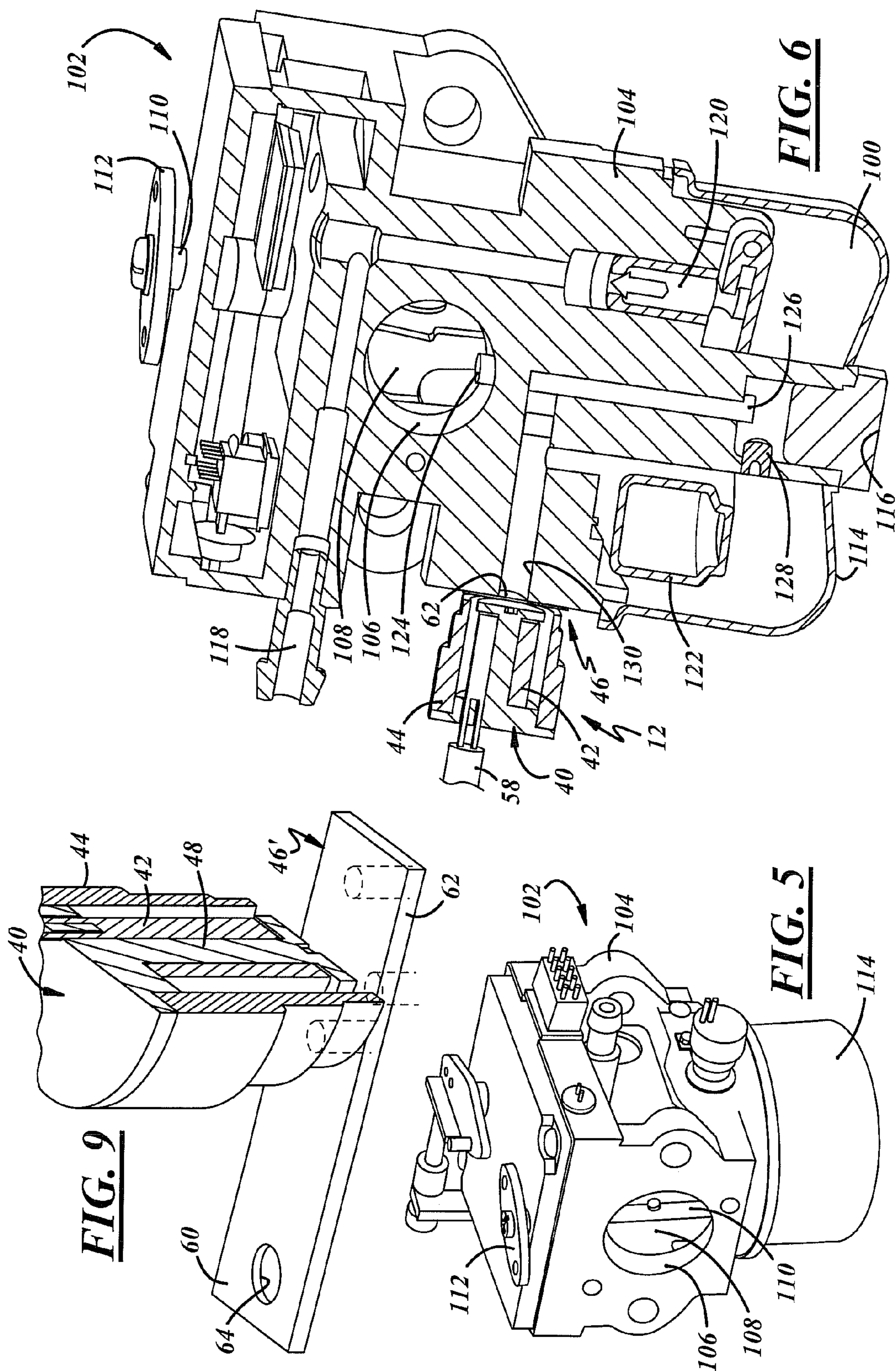


FIG. 4B



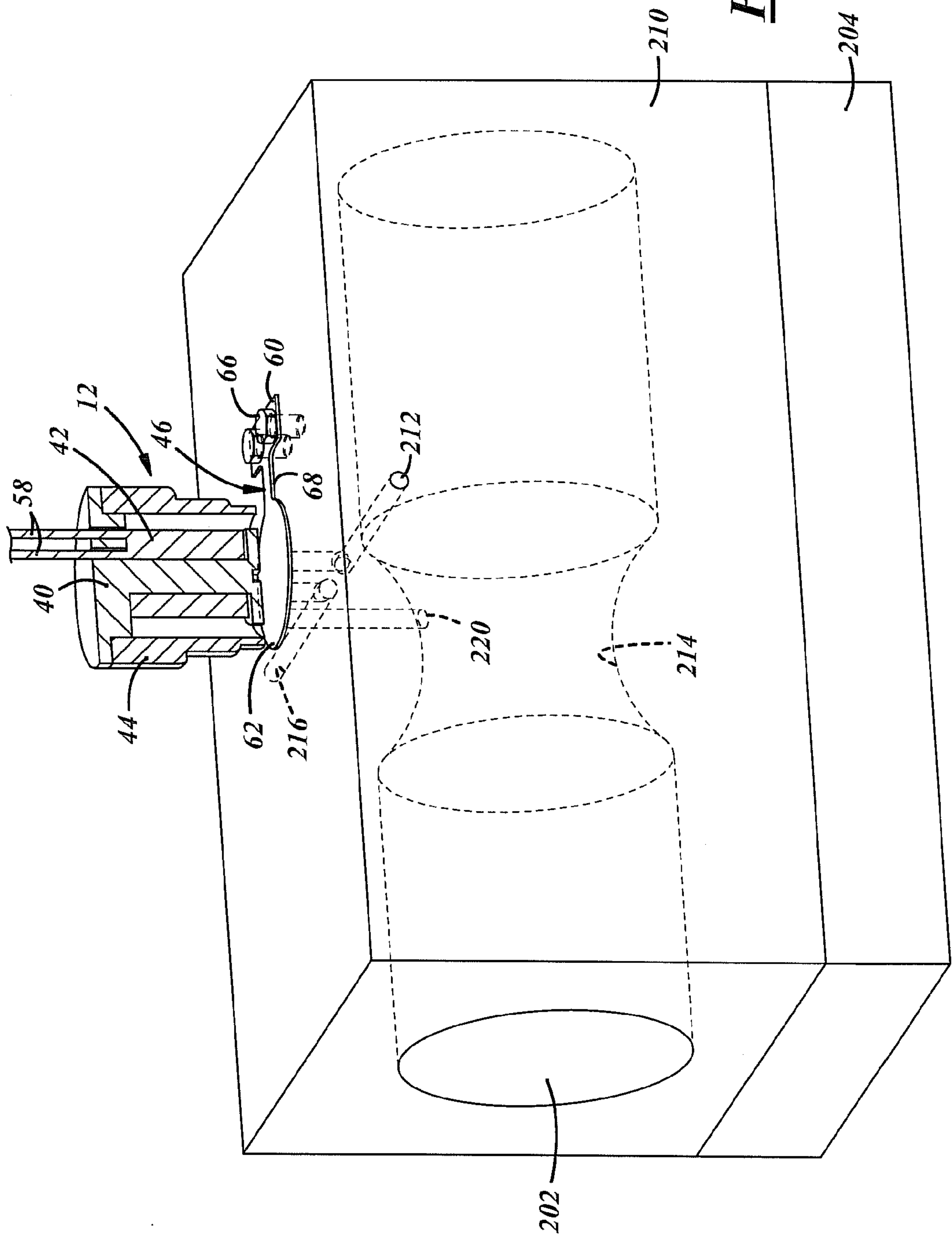
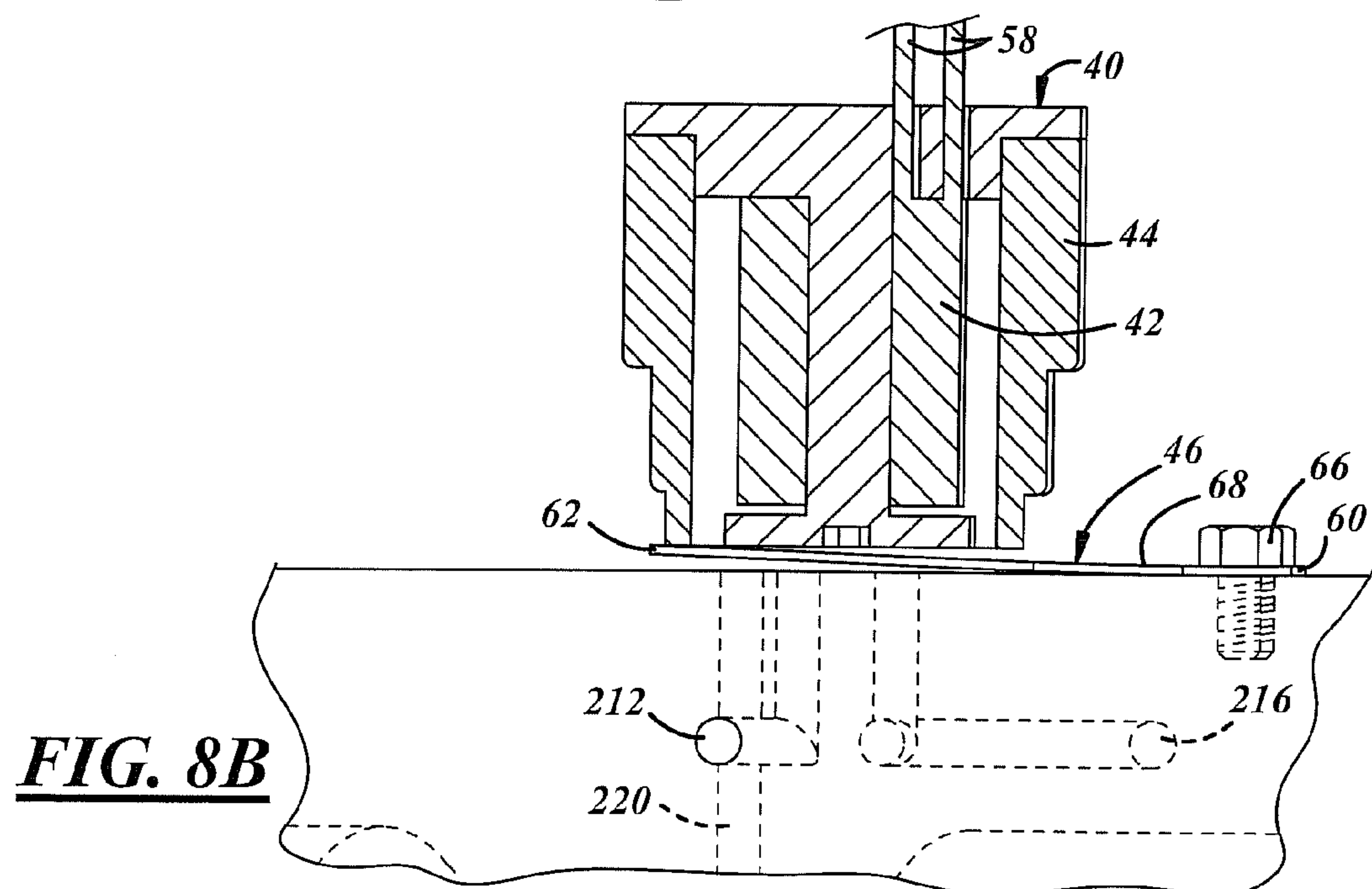
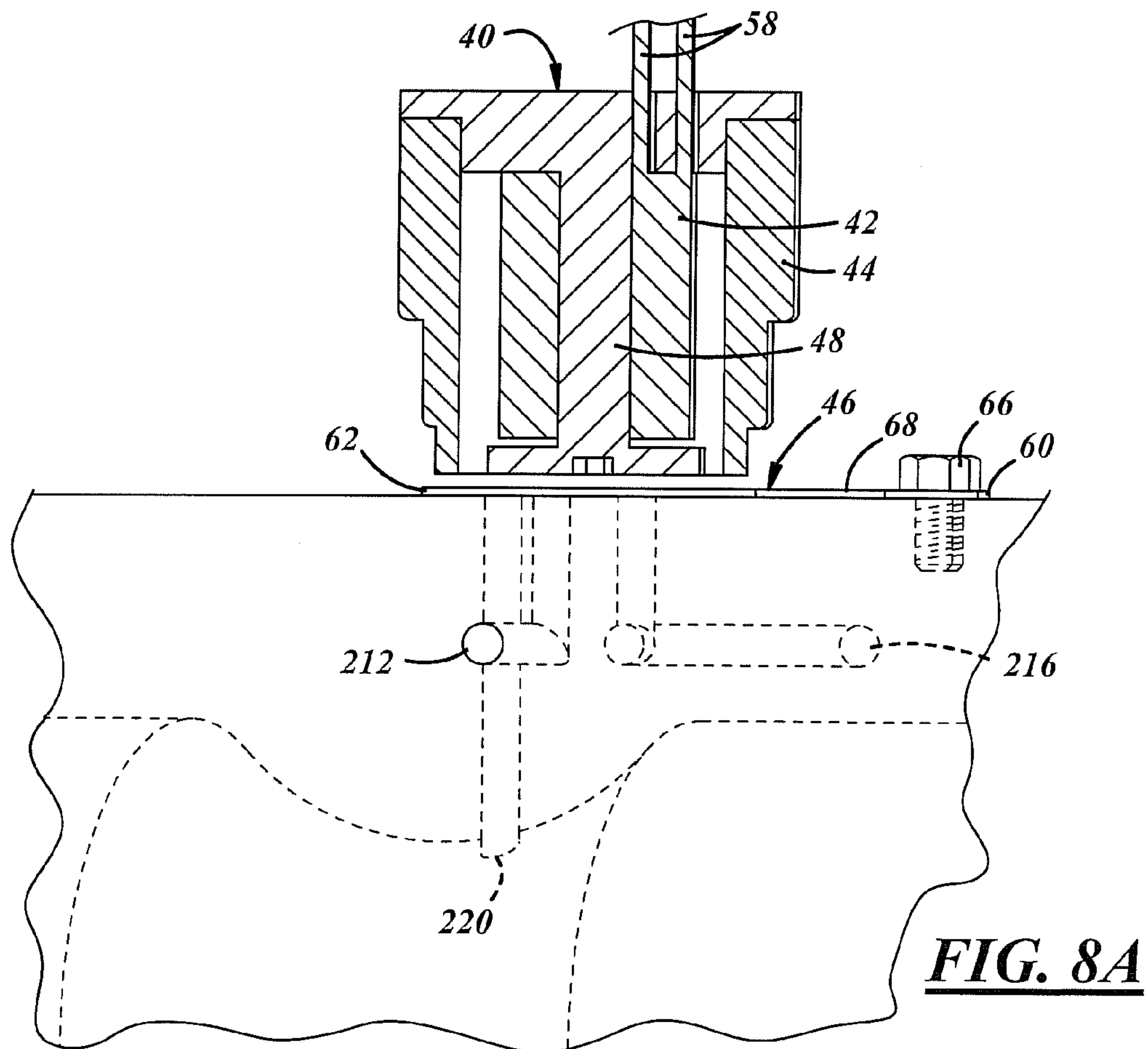


FIG. 7



1

**CHARGE FORMING DEVICE AND
SOLENOID VALVE**

TECHNICAL FIELD

This disclosure relates generally to a fuel and air charge forming device and a solenoid valve assembly.

BACKGROUND

Carburetors are used to provide fuel and air mixtures for a wide range of two-cycle and four-cycle engines, including hand held engines, such as engines for chain saws and weed trimmers, as well as a wide range of marine engine applications, for example. Diaphragm-type carburetors are particularly useful for hand held engine applications wherein the engine may be operated in substantially any orientation, including upside down. Float bowl carburetors are typically used in applications wherein they are not inverted like in lawn mowers, tractors and the like. In an attempt to achieve more efficient operation and to reduce exhaust emissions from engines, valves have been used to regulate the fuel and air mixture during at least some operating conditions.

SUMMARY

A fuel and air charge forming device, such as a carburetor, may include a main body, a fuel and air mixing passage in the body, a fluid passage communicating with the fuel and air mixing passage and a solenoid valve. The solenoid valve may include a coil and a valve body having a base fixed against movement and a valve head extending from the base. The valve head may be driven by the coil between a first position wherein the valve head at least partially obstructs the fluid passage and a second position wherein the valve head permits greater fluid flow in the fluid passage to control fluid flow through the fluid passage.

A solenoid valve may include a coil body, a coil surrounding at least a portion of the coil body to generate a magnetic field when energized, and a valve body. The valve body may have a base fixed against movement and a valve head extending from the base. The valve head may be driven from a first position to a second position by the magnetic field produced by the coil when the coil is energized and the valve head may be resilient so that it returns to its first position when the coil is no longer energized.

BRIEF DESCRIPTION OF THE DRAWINGS

The following detailed description of preferred embodiments and best mode will be set forth with reference to the accompanying drawings, in which:

FIG. 1 is a perspective view of one implementation of an exemplary carburetor including a solenoid valve;

FIG. 2 is a cross sectional view of a main body of the carburetor of FIG. 1 showing the solenoid valve;

FIG. 3 is an enlarged, fragmentary, sectional view of a portion of the carburetor of FIG. 2 showing the solenoid valve in an open position;

FIG. 4A is a perspective view of a valve body of the solenoid valve;

FIG. 4B is a side view of the valve body of FIG. 4A;

FIG. 5 is a perspective view of an exemplary float bowl carburetor;

FIG. 6 is a cross sectional view of the carburetor of FIG. 5;

2

FIG. 7 is a diagrammatic perspective view of a main body of an exemplary float bowl carburetor including a solenoid valve;

FIG. 8A is an enlarged, fragmentary, side view of a portion of the carburetor of FIG. 7 and showing the solenoid valve in a closed position;

FIG. 8B is a view similar to FIG. 8A showing the solenoid valve in an open position; and

FIG. 9 is a perspective view partially in section of a solenoid valve having an alternate valve head.

DETAILED DESCRIPTION OF PREFERRED
EMBODIMENTS

Referring in more detail to the drawings, FIGS. 1-3 illustrate a fuel and air charge forming device, such as a carburetor 10, having a solenoid valve 12, a main body 14 with a fuel and air mixing passage 16 extending therethrough (FIGS. 3 and 4) and having a throat or venturi portion 17 therein. The carburetor 10 may be a diaphragm-type carburetor, having a fuel pump, and a fuel metering assembly communicating with an outlet of the fuel pump through a diaphragm controlled valve, as disclosed in U.S. Pat. No. 6,267,102 to Pattullo et al, incorporated herein by reference in its entirety. The fuel pump draws fuel from a fuel source such as a fuel tank and delivers it to a fuel metering chamber 18 (FIGS. 2 and 3) that communicates with the fuel and air mixing passage 16 through a needle valve 20 and a pair of passages 22, 24. One of the passages 22 preferably operates as an air bleed and/or fuel feed passage, depending on the orientation of a throttle valve 26 within the fuel and air mixing passage 16, as discussed in more detail hereafter, while the other passage 24 operates primarily as a fuel and air passage.

Still referring to FIGS. 2 and 3, the body 14 has a fluid passage, shown here as an air bleed passage 28 communicating a portion of the fuel and air mixing passage 16 upstream of the venturi 17 with a portion of the fuel and air mixing passage 16 downstream of the venturi 17. The air bleed passage 28 extends through at least a portion of the body 14, shown here as extending from the fuel and air mixing passage 16 upstream of the venturi 17 to a cavity 30 that extends to an outer surface 32 of the body 14. The air bleed passage 28 extends from the cavity 30 to a fuel pocket 34 that is in communication with the passages 22, 24. Accordingly, when the throttle valve 26 is in an at least partially open position (rotated from the idle or closed position shown in FIG. 2) the air bleed passage 28 communicates with the fuel and air mixing passage 16 downstream of the venturi 17 through both passages 22, 24, and when the throttle valve 26 is in its closed or idle position (FIG. 2) the air bleed passage communicates with the fuel and air mixing passage downstream of the throttle valve 26 via the passage 24.

The cavity 30 extending into the body 14 communicates one portion of the air bleed passage 28 upstream of the cavity 30 with another portion of the air bleed passage 28 downstream of the cavity 30. A base 36, or a portion thereof, may define a valve seat 38 through which the air bleed passage 28 passes. Of course, the valve seat may be disposed at some other location along the air bleed passage 28, including at an end of the passage 28.

As shown in FIGS. 2 and 3, the solenoid valve 12 has a coil body 40, a wire coil 42, a shell 44 and a valve body 46. The coil body 40 may be constructed from a magnetically conductive metal material with a central core 48 that may be generally cylindrical and first and second end walls 50, 52 at opposite ends of the core. One such material could be a cold rolled steel such as 12L14 utilized for the coil body 40, central

3

core 48, and shell 44. The first end wall 50 may have a first radially outwardly extending flange 53 and an axially extending portion 54. The axially extending portion 54 may extend radially outwardly from the core 48 but be radially inwardly spaced from the radially outermost periphery of the flange 53. The first end wall 50 may have a slot or a pair of openings 56 through the flange 53 or both the flange 53 and the axially extending portion 54. The second end wall 52 may be provided, at least in part, in the form of a second radially outwardly extending flange. The end walls 50, 52 and core 48 define a bobbin about which the wire coil 42 may be wound.

The wire coil 42 may include a continuous winding of copper wire (which could be single strand) with wire sizes generally ranging from 36 AWG to 28 AWG depending on a desired number of coil winding turns, coil resistance, and desired inductance for a particular solenoid application. The wire typically has 1 or more layers of insulative coating, such as polyurethane enamel or polysol to preclude copper wire winding from touching adjacent turns or shorting by direct contact of the copper wire to the core 48. Ends 58 of the wire coil 42 may extend through the openings 56 in the first flange 53 so that they may be connected to an appropriate driving circuit or other source of power. Exemplary electrical energy sources may include a battery, magneto or related energy storage circuit(s) (capacitive or inductive) which may be derived from the engine ignition or charging system.

The shell 44 may surround at least a portion of the wire coil 42, and may be connected to one or both flanges 52, 53 of the coil body 40. The shell 44 may help focus or control the magnetic field generated by the solenoid 12 as well as shield the wire coil 42 from contaminants. The shell 44 may be disposed closely adjacent to the wire coil 42, or an air gap may be provided between them. In the implementation shown, the second flange 52 is smaller than the first flange 53 and the shell 44 may be coupled to or carried by the first flange 53 and spaced from the second flange 52. The shell 44 may be press fit or otherwise secured to the axially extending portion 54 of the first end wall 50 and received beneath the first flange 53. The outer surface of the shell 44 may be radially flush with the periphery of the first flange 53. The outer surface of the shell 44 may be formed in stepped fashion providing different diameter portions that may facilitate seating and sealing the solenoid in a cavity of a body, like the cavity 30 in the carburetor body. For example, each step may provide a shoulder that may directly engage the carburetor body or a seal, such as an o-ring, to seal the cavity when the solenoid valve 12 is installed. The solenoid valve 12 may also be positioned adjacent to the carburetor body 14 instead of being received at least partially within a cavity of the body 14.

The valve body 46 may be constructed from or include a material responsive to a magnetic field, such as steel, and may be provided adjacent to the second end wall 52 of the coil body 40. At least a portion of the valve body 46 may overlie one or more fluid passages and may be driven between a first position to at least partially obstruct flow through or out of a fluid passage and a second position permitting a relatively free fluid flow through or out of the fluid passage. For example, the valve may control fluid flow through the air bleed passage 28 to control the application of air from the air bleed passage 28 to the fuel and air mixture passage 16. Of course, the valve 12 may be used to control flow through passages other than the air bleed passage 28, as will be discussed in more detail herein.

In at least one implementation, the valve body 46 may be provided in the form of a flexible and resilient disc, strip, reed, plate or the like. The valve body 46 may be made from a thin, flat reed or shim stock spring steel that is magnetically con-

4

ductive. One such industry example might be unalloyed and low alloyed steels, like Sandvik Materials Technology, 20C, where the rolled steel material is processed to reduce fatigue stress and facilitate increased durability for bending and impact strength. As shown in FIGS. 2, 3, 4A and 4B, the valve body 46 may have a base 60 that is carried by the carburetor body 14 or another portion of the solenoid valve 12, such as the coil body 40 or shell 44, or the base 60 may be carried by another component. The base 60 may be fixed against movement at a location spaced from the air bleed passage 28. The valve body 46 may also include a valve head 62 that overlies and is movable relative to the air bleed passage 28 (or other passage being controlled). In the implementation shown, the solenoid valve 12 is normally closed in that the valve body 46, in its normal state or first position shown in FIG. 2, engages the valve seat 38 and covers and closes a portion of the air bleed passage 28 to prevent or at least inhibit the flow or air out of that passage 28. To move the valve 12 to its second or open position, electrical power is supplied to energize the coil 42 which generates an electromagnetic field that flexes or bends the valve body 46 so that the valve head 62 moves relative to the base 60 and away from the air bleed passage 28, as shown in FIG. 3. In the open position, the valve more readily permits fluid flow from the air bleed passage 28 to the fuel and air mixing passage 16, and may permit a substantially unrestricted fluid flow. When the coil 42 is no longer actuated, the resiliency of the valve body material returns the valve body 46 to its unflexed, closed position to inhibit or prevent fluid flow through and/or out of the air bleed passage 28.

In the implementation discussed, the only moving part of the solenoid valve 12 is a portion of the valve body 46 including the valve head 62 which moves relative to the fixed base—no springs, plungers or other moving components are needed. Of course, a spring or other biasing member may be provided to yieldably bias the valve body 46 to its closed position (for example), if desired for improved sealing, response time or other reason.

The valve body 46 may be formed in many shapes and sizes. In the example of FIGS. 2, 3, 4A and 4B, the valve body 46 has a generally rectangular base 60 with one or more holes 64 to facilitate attaching the base 60 to another body with one or more fasteners like screws 66 (FIG. 3), rivets, stakes, clips and the like. The valve body 46 may be connected to another body in any suitable way, including welding, adhering, friction fit, etc. A relatively narrow neck section 68 may interconnect the valve head 62 and base 60. The neck section 68 may facilitate flexing of the valve body 46 and the size (e.g. width, thickness) of the neck 68, as well as the other portions of the valve body 46, may be calibrated or selected to provide a desired response or movement of the valve head 62 under a given force or load. The valve head 62 may be of any shape and have a surface area suitable to close the desired port(s) and/or passage(s). The entire valve body 46 may have the same thickness, or the thickness may vary, as desired. The valve body 46 may be readily stamped from a thin sheet of material and may be planar or generally planar when not flexed (e.g. it may be planar from the point of connection to the carburetor body to the portion of the valve head overlying the ports or passages), or it may be contoured or bent in its normal state (that is, the state in which the valve body is not acted upon by another force like that created when the coil is energized) and either partially straightened, completely flattened out or further bent when the coil is energized. An exemplary alternate valve body shape and arrangement is shown in FIG. 9. In FIG. 9, the valve body 46' is formed from a planar, rectangular strip of material although other shapes

5

and arrangements may be used. The valve body **46**, **46'** may be formed from a single piece of material where the base and valve head are formed from the same piece of material, if desired, or they may be formed from more than one piece of material or from different materials. The valve body **46**, **46'** may also be formed from multiple layers of the same or different materials, and the multiple layers may extend over all or only part of the valve body. For example, one layer may provide a seal, one layer may provide a desired stiffness and one layer may provide a desired magnetic conductivity or attraction. Of course, more or less than the noted layers may be used, and the layers may have properties and/or functions different than those noted.

In use, when the coil **42** is actuated, the electromagnetic field of the coil **42** overcomes the resistance of the valve body **46** to bend or flex and thereby moves the valve head **62** away from the valve seat **38** to open the air bleed passage **28**. When the coil **42** is not actuated and no electromagnetic field acts on the valve body **46** (or none of sufficient strength to flex the valve body **46**), the resilient nature of the valve body material automatically returns the valve body to its unflexed position wherein the valve head **62** closes the air bleed passage **28** or other port(s) or passage(s) with which it is associated.

In operation, to move the valve body **46** between its retracted and extended positions, the solenoid valve assembly **12** may be in electrical communication with a controller, such as an engine control module **70** (FIG. 1) to receive signals therefrom, or the solenoid valve **12** may be driven by some other circuit or control based on any desired parameter or condition. The engine control module (ECM) **70** may be responsive to at least one, and preferably a plurality of variables that can affect the initial start-up and continued running performance of the engine, such as whether the engine is running or not, throttle position, RPM, temperature, and any other variables that affect the starting and running engine performance. Accordingly, the ECM **70** can be preprogrammed to send an electric signal to the solenoid valve assembly **12** to actuate the valve body **46**, as desired, so that the carburetor **10** operates efficiently, thereby providing an optimal starting and running performance of an engine of a vehicle incorporating the carburetor **10**.

Generally, when the engine is turned off, the valve body **46** may be in its closed position. In its closed position, the valve body **46** closes off the air bleed passage **28**. Accordingly, when the engine is started, the fuel and air mixture in the fuel and air mixing passage **16** is relatively rich since air is not channeled to or free to flow through the air bleed passage **28** to the fuel within the fuel pocket **34**. The richer fuel and air mixture discharged from the carburetor **10** facilitates a cold start of the engine, and warming-up and initial stable operation of the engine.

When the engine speed reaches a predetermined RPM value or range, as may be programmed within the ECM **70**, the ECM **70** sends a signal to the solenoid valve assembly **12** thereby energizing the coil **42**. The coil **42** provides a strong enough magnetic field to flex the valve body **46** to its retracted or open position. Accordingly, the air bleed passage **28** is opened to allow air from the fuel and air mixing passage **16** upstream of the venturi **17** to flow into and through the fuel pocket **34**, thereby providing a leaner fuel and air mixture to the fuel and air mixing passage **16** than when the air bleed passage **28** was closed. As such, the engine receives a leaner air and fuel mixture to optimize the running performance of the engine per the programmed instructions of the ECM **70**.

Therefore, the ECM **70**, pursuant to its preprogrammed instructions, operates to send electrical current to the solenoid valve assembly **12** to move the valve body **46** between its

6

opened and closed positions to control the fuel and air mixture supplied to the engine to control the running performance of the engine. For instance, while accelerating the vehicle, it may be desirable to enrich the fuel and air mixture to ensure sufficient fuel is provided to the engine to support the increase in fuel demand during acceleration. Therefore, during acceleration, the solenoid valve **12** may be in its closed position thereby closing off the air bleed passage **28** and preventing enleanment of the fuel and air mixture. On the other hand, when decelerating, and to avoid a so-called rich come-down condition wherein more fuel is provided than is needed, the ECM **70** can send a signal to the solenoid valve assembly **12** to move the valve body **46** to its opened position, thereby opening the air bleed passage **28** to lean out the fuel and air mixture. As such, it should be recognized that depending on the preprogrammed instructions within the ECM **70**, the solenoid valve assembly **12** can be operated to move between its opened and closed positions to optimize the running performance of the engine. In addition, sensors can be employed to communicate with the ECM **70** to communicate such things as the fuel and air ratio of exhaust emissions, the fuel and air mixture ratio in the fuel and air mixing passage **16**, the position of the throttle valve **26**, and the like to facilitate the optimal operation of the solenoid valve assembly **12** to provide optimum engine running efficiency and performance.

The valve **12** could also be used to control application of a positive air pressure signal to a float bowl chamber **100** (FIG. 6) in a float bowl carburetor **102**, such as shown in FIGS. 5 and 6. In one implementation, the float bowl carburetor may include a main body **104** having a fuel and air mixing passage **106** extending therethrough, and a throttle valve **108** disposed in the mixing passage and carried by a valve rotating device such as a shaft **110** extending through the body and a lever **112** connected to the shaft.

Referring to FIG. 5, the carburetor also may include a float bowl **114** sealingly carried on the body **104** by a fastener **116**, a fuel inlet passage **118**, an inlet needle **120** in communication with the inlet passage, and a float **122** to urge the inlet needle closed when a threshold level of fuel exists in the float bowl. The body may include a fuel nozzle **124** extending into the float bowl and including a nozzle passage **126** and a restriction **128** to the limit mass flow rate of fuel into the nozzle at a pressure differential across the restriction. The nozzle passage **126** extends through the nozzle **124** and is in fluid communication with and between the float bowl chamber **100** and the mixing passage **106**.

The solenoid valve **12** may be constructed in the same manner previously described and may be carried adjacent to or by the carburetor body **104**. Although not shown in this implementation, the carburetor **102** may include a pocket in which at least part of the solenoid valve **12** is received. A bleed path or control passage **130** may communicate with the atmosphere and with the mixing passage **106** via the nozzle bore **126** of the main nozzle. The valve head **62** of the solenoid valve **12** overlies and closes the control passage **130** to inhibit or prevent application of an atmospheric pressure signal to the float bowl chamber **100** via the control passage.

When the solenoid valve **12** is energized, the valve head **62** is displaced to open the control passage **130**. The atmospheric pressure signal from the control passage **130** reduces the differential pressure across the nozzle **124** established between the float bowl chamber **100** and engine manifold vacuum (and any pressure drop caused by flow through the venturi portion of the mixing passage) with a corresponding change in fuel quantity supplied through the main jet or restriction **128**. In this implementation, opening the control passage **130** causes enleanment of the fuel and air mixture

delivered from the carburetor **102**. The solenoid valve **12** may be cycled between its open and closed positions to control the fuel and air mixture ratio as desired to change engine combustion efficiency or for some other reason.

Instead of controlling an atmospheric pressure air bleed, the solenoid valve **12** may be used in a float bowl carburetor **200** to open and close a passage through which a subatmospheric pressure signal (sometimes called a negative or vacuum pressure) may be provided from, for example, a mixing passage **202** to a float bowl **204**, as shown in FIGS. **7**, **8A** and **8B**. In this regard, opening the solenoid valve **12** would provide an increased pressure differential across a nozzle (not shown) to provide more fuel flow through the nozzle and delivery of an enriched fuel and air mixture from the carburetor **200**. In the implementation shown in FIGS. **7**, **8A** and **8B**, a carburetor main body **210** includes the fuel and air mixing passage **202** and a pressure signal passage **212** may be provided open to the fuel and air mixing passage **202** downstream of a throat or a venturi **214** in the fuel and air mixing passage. Accordingly, a pressure drop generated at or by the venturi is communicated with the pressure signal passage **212**. The pressure signal passage **212** leads to the solenoid valve **12** and the valve head **62**, when closed, inhibits or prevents communication of the pressure signal from the pressure signal passage **212** to the float bowl **204**. However, when the valve head **62** is open (i.e. the valve head **62** is displaced from its valve seat), then the pressure signal passage **212** is communicated with a transfer passage **216** that is open to the solenoid valve **12** at one end and communicates with the float bowl **204** at its other end via a suitable passage or conduit. In this way, the subatmospheric pressure generated in the fuel and air mixing passage **202** can be communicated with the float bowl **204** (such as to an air space above liquid fuel in the float bowl) through the pressure signal passage **212**, the solenoid valve **12** and the transfer passage **216**. The transfer passage **216** may join or otherwise communicate with an atmospheric reference passage which provides air at atmospheric pressure to the float bowl **204**. In this way, the reference passage may be open to the float bowl **204** in any position of the solenoid valve **12** to reference the float bowl **204** to atmospheric pressure. Accordingly, when the solenoid valve **12** is open, a reduced pressure is provided to the float bowl **204**.

In at least some applications, there may be very little fuel flow required at engine idle and so there is a relatively low pressure differential on the fuel in the float bowl **204**. Because of this, it may be relatively difficult to control idle fuel flow by application of a subatmospheric pressure signal on the fuel in the float bowl **204**. Further, the pressure at the pressure signal passage **212** may not be significantly subatmospheric at idle. With this in mind, an air bleed passage **220** can be used to partially or entirely diminish any subatmospheric pressure signal that may be communicated to the float bowl **204** when the solenoid valve **12** is open and the engine is idling or nearly so. A suitable restriction (not shown) may be provided in the air bleed passage **220** to control the flow rate therethrough (e.g. to prevent undue dilution of the subatmospheric pressure signal at higher engine speeds and loads).

By way of another non-limiting example, the solenoid valve **12** could also be used in a charge forming device such as a carburetor to control flow through or from a supplemental fuel passage that, when open, provides additional fuel to the fuel and air mixing passage to enrich the fuel and air mixture provided to the engine. This may be desirable, for example, to assist engine acceleration. Of course, normal engine operation could be obtained with fuel from the supplemental fuel passage being provided and, in that case, closing the supple-

mental fuel passage would cause an enleanment of the fuel and air mixture, when desired.

The valve **12** could also be used to control the application of a reduced pressure signal (e.g. vacuum) or a positive air pressure signal to a fuel metering chamber in a diaphragm carburetor where the pressure signal would act on a fuel metering diaphragm of the carburetor. Still other exemplary float bowl and diaphragm carburetors of this type are disclosed in U.S. Patent Application Ser. No. 61/094,973, filed on Sep. 7, 2008, assigned to the same assignee of this present disclosure, and incorporated herein in its entirety by reference. These carburetors can be configured to use a solenoid valve of the type disclosed herein, rather than the solenoid valve disclosed in the above noted application.

It is to be understood that the foregoing description is not a definition of the invention but is a description of one or more preferred exemplary embodiments of the invention. The invention is not limited to the particular embodiment(s) disclosed herein but rather is defined solely by the claims below. Furthermore, the statements contained in the foregoing description relate to particular embodiments and are not to be construed as limitations on the scope of the invention or on the definition of terms used in the claims, except where a term or phrase is expressly defined above. Various other embodiments and various changes and modifications to the disclosed embodiment(s) will become apparent to those skilled in the art. All such other embodiments, changes, and modifications are intended to come within the scope of the appended claims.

As used in this specification and claims, the terms “for example”, “for instance,” and “such as,” and the verbs “comprising,” “having,” “including,” and their other verb forms, when used in conjunction with a listing of one or more components or other items, are each to be construed as open-ended, meaning that the listing is not to be considered as excluding other, additional components or items. Other terms are to be construed using their broadest reasonable meaning unless they are used in a context that requires a different interpretation.

The invention claimed is:

1. A fuel and air charge forming device, comprising:
 - a main body;
 - a fuel and air mixing passage in the main body;
 - a fluid passage communicating with the fuel and air mixing passage;
 - a solenoid including a coil and a valve body having a base fixed against movement and a valve head attached to and extending from the fixed base, wherein the valve head is driven by the coil between a first position wherein the valve head at least partially obstructs fluid flow through the fluid passage and a second position wherein the valve head permits greater fluid flow in the fluid passage to control fluid flow through the fluid passage.

2. The device of claim 1 wherein the valve head inhibits fluid flow through the fluid passage when the valve head is in its first position and the valve head more readily permits fluid flow through the fluid passage when the valve head is in its second position.

3. The device of claim 1 wherein the valve body is formed from a single piece of material with the base fixed to the main body and the valve head extending from and connected to the base, and the valve body is flexed by the force provided by the coil when the coil is energized to move the valve head to its second position and the valve head returns to its unflexed and first position when the coil ceases to be energized.

9

4. The device of claim 1 wherein the valve body is a flat and planar piece of material when not acted upon by the energized coil and includes at least a portion that is magnetically receptive.

5. The device of claim 1 wherein the valve body includes a neck section between the base and the valve head and the neck section is narrower than at least one of the base or the valve head.

6. The device of claim 1 wherein the base is fixed to the main body.

7. The device of claim 1 wherein the fluid passage includes an air bleed passage through which a supply of air may be selectively provided to the fuel and air mixing passage.

8. The device of claim 1 wherein the fluid passage includes a fuel passage through which a supply of fuel may be selectively provided to the fuel and air mixing passage.

9. The device of claim 1 wherein the fluid passage includes a control passage through which a pressure signal may be selectively provided to the fuel and air mixing passage.

10. The device of claim 9 wherein the control signal is at a subatmospheric pressure.

11. The device of claim 1 which also comprises a throttle valve in the mixing passage, a fuel pump carried by the main

10

body, and a diaphragm controlled valve communicating with a fuel outlet of the fuel pump and the fuel and air mixing passage.

12. The device of claim 1 which also comprises a fuel float bowl carried by the main body, a float received in the float bowl, and a valve opened and closed by the float to control admission of fuel into the float bowl.

13. The device of claim 12 wherein the fluid passage communicates with the float bowl.

14. The device of claim 13 which also comprises at least one passage communicating fuel in the float bowl with the fuel and air mixing passage.

15. The device of claim 1 wherein the valve body is formed from a single piece of material that may be flexed by the force provided by the coil when the coil is energized to move the valve head and the valve body returns to its unflexed position when the coil is no longer energized.

16. The device of claim 15 wherein the valve body is a flat piece of material when not acted upon by the energized coil and includes at least a portion that is magnetically receptive.

17. The device of claim 15 wherein the valve body includes a neck section between the base and the valve head and the neck section is narrower than at least one of the base or the valve head.

* * * * *