UNITED STATES DISTRICT COURT
EASTERN DISTRICT OF WISCONSIN

CHAMPION POWER EQUIPMENT, INC.

Plaintiff,

Case No: 24-cv-1281

v.

JURY TRIAL DEMANDED

GENERAC POWER SYSTEMS, INC.

Defendant.

COMPLAINT AND DEMAND FOR JURY TRIAL

CHAMPION POWER EQUIPMENT, INC. ("Champion") by and through its undersigned attorneys, , hereby files this complaint for patent infringement against GENERAC POWER SYSTEMS, INC. ("Generac") and alleges as follows:

THE PARTIES

1. Champion is a duly organized and operating Nevada corporation incorporated at 6370 S Pioneer Way, Unit 101, Las Vegas, Nevada 89113. Champion designs and sells single-fuel and multi-fuel generators, power stations, log splitters, chipper shredders, leaf blowers, tillers, chainsaws, cultivators, lawn edgers, augers, string trimmers, pressure washers, water pumps, snow blowers, winches, hoists, accessories, and other equipment.

2. Champion goes to great lengths in protecting its proprietary intellectual property and expends considerable resources in obtaining patents in the United States and other foreign jurisdictions. Champion has filed over 70 patent applications and has been awarded 61 U.S. patents.

3. Generac is a duly organized and operating Wisconsin Corporation whose principal place of business is located at S45W29290 State Road 59, Waukesha, WI 53189-9071. Upon information and belief, Generac designs, manufactures, imports, and sells single-fuel and multi-

fuel generators, power stations, and accessories that directly compete with Champion. Generac advertises its products for sale nationally and has advertised, marketed, and sold products infringing Champion's intellectual property rights within the State of Wisconsin, and all other states and territories of the United States.

4. Generac also does business under the name "Powermate"[1] and sells multi-fuel generators under the name Powermate. Powermate generators are available for purchase at https://www.powermate.com. Additionally, according to United States Patent and Trademark Office records, Generac Power Systems, Inc. is the owner of U.S. Trademark Registration No. 4,825,288 for POWERMATE with the following identification of goods in International Class 007: "Outdoor chore equipment, namely, power blowers for leaves, power-operated lawn edgers, earth augers, power-operated cultivators, power tillers, lawnmowers, power lawn and garden tools in the nature of chippers and shredders, power machines for splitting logs for firewood, and parts and accessories related to the foregoing." Doing business as Powermate, Generac designs, manufactures, imports, and sells multi-fuel generators and accessories that also directly compete with Champion.

5. Champion has sent Generac cease and desist demands regarding Generac and Powermate generators. Generac has ignored those demands and continues to sell infringing generators.

JURISDICTION AND VENUE

6. This is an action for patent infringement under the patent laws of the United States, 35 U.S.C. §§ 271, *et seq*.

7. This Court has jurisdiction over the subject matter of this patent infringement action pursuant to 28 U.S.C. §§ 1331 and 1338(a).

8. This Court has personal jurisdiction over Generac because Generac has committed acts of patent infringement within the State of Wisconsin giving rise to this action. Generac also

[1] The website https://www.powermate.com sets forth the following: "Generac Power Systems, Inc., DBA Powermate"

has manufacturing facilities in the State of Wisconsin. Further, Generac's headquarters is located in Wisconsin. Generac's electronic commerce advertisements, offers for sale, sales, and physical location have established at least minimum contacts with the forum such that the exercise of jurisdiction over it would not offend traditional notions of fair play and substantial justice.

9. Venue is proper in this judicial district pursuant to 28 U.S.C. §§ 1391(a), 1391(b), 1391(c), and 1400(b) for at least the reasons that (1) Generac resides in this district and (2) Generac has committed acts within this district giving rise to this action and does business in this district, including sales, offers for sale, and providing service and/or support to its customers in this district.

COUNT I: INFRINGEMENT OF U.S. PATENT NO. 10,221,780

10. Paragraphs 1 through 9 are incorporated by reference as if fully set forth herein.

11. U.S. Patent No. 10,221,780 is titled "DUAL FUEL LOCKOUT SWITCH FOR GENERATOR ENGINE." U.S. Patent No. 10,221,780 was duly and legally issued on March 5, 2019. A true and correct copy of U.S. Patent No. 10,221,780 is attached as Exhibit A.

12. Champion is the lawful assignee of the entire right, title, and interest in and to U.S. Patent No. 10,221,780 and possesses all rights of recovery under the patent, including the right to recover damages for past infringement.

13. Champion has acquired and inspected the following Generac/Powermate generator models that Generac has been and is making, using, selling, or offering for sale within the United States, or importing into the United States, and that infringe one or more claims of U.S. Patent No. 10,221,780:

a. Powermate Model PM4500DF, a multi-fuel generator;

b. Powermate Model PM7500DF, a multi-fuel generator;

c. Generac Model GP7500E, a multi-fuel generator; and

d. Powermate Model DF3500E, a multi-fuel generator.

14. Upon acquisition, disassembly as needed, review of owner's manuals and electrical schematics, and inspection, it was determined that each of the foregoing Generac generator models

include all of the elements of at least claims 1, 2, 6-9, 11, 14 and 15 of U.S. Patent No. 10,221,780. Each of the foregoing Generac generator models infringes:

a. Independent claim 1 by specifically including a mechanical fuel lockout switch for a dual fuel engine having a mechanical fuel valve actuateable between a first position and a second position to selectively control fuel flow to the dual fuel engine from a first fuel source through a first fuel line and a second fuel source through a second fuel line and a fuel lockout apparatus coupled to the mechanical fuel valve, wherein the mechanical fuel lockout switch communicates the first fuel source to the dual fuel engine and prevents communication between the second fuel source and the dual fuel engine when the mechanical fuel valve is in the first position and communicates the second fuel source to the dual fuel engine and interrupts the first fuel source communication with the dual fuel engine when in the second position and wherein the fuel lockout apparatus is configured to prevent the second fuel source from coupling to the second fuel line while the mechanical fuel valve is in the first position and permit the second fuel source to couple to the second fuel line while the mechanical fuel valve is in the second position, as called for in claim 1 of U.S. Patent No. 10,221,780.

b. Dependent claim 2 by specifically including all the aforementioned elements of claim 1 and, in addition, the fuel lockout apparatus prevents actuation of the mechanical fuel valve to the first position when the second fuel source communicates with the dual fuel engine, as called for in claim 2 of U.S. Patent No. 10,221,780.

c. Dependent claim 6 by specifically including all the aforementioned elements of claim 1 and, in addition, the mechanical fuel valve and the fuel lockout apparatus operate together to ensure that fuel from the first fuel source and fuel from the second fuel source are not simultaneously delivered to the dual fuel engine, as called for in claim 6 of U.S. Patent No. 10,221,780.

d. Dependent claim 7 by specifically including all the aforementioned elements of claim 6 and, in addition, the first fuel source provides liquid fuel from a liquid fuel tank to the dual fuel engine and the second fuel source provides gaseous fuel from a pressurized fuel container to the dual fuel engine, as called for in claim 7 of U.S. Patent No. 10,221,780.

e. Independent claim 8 by specifically including a mechanical fuel lockout switch for an internal combustion engine, the mechanical fuel lockout being assembled by providing an internal combustion engine configured to operate on a fuel from a first fuel source and a different fuel from a second fuel source, coupling a mechanical fuel valve to the internal combustion engine actuateable between a first position and a second position to selectively control fuel flow to the internal combustion engine from the first fuel source through a first fuel line and the second fuel source through a second fuel line, and coupling a fuel lockout apparatus to the mechanical fuel valve, wherein the fuel lockout apparatus prevents actuation of the mechanical fuel valve to the first position when the second fuel source is coupled to the internal combustion engine, as called for in claim 8 of U.S. Patent No. 10,221,780.

f. Dependent claim 9 by specifically including all the aforementioned elements of claim 8 and, in addition, the fuel lockout apparatus is further configured to prevent coupling of the second fuel source to the second fuel line while the mechanical fuel valve is in the first position and to permit coupling of the second fuel source to the second fuel line while the mechanical fuel valve is in the second position, as called for in claim 9 of U.S. Patent No. 10,221,780.

g. Dependent claim 11 by specifically including all the aforementioned elements of claim 8 and, in addition, the mechanical fuel lockout switch is assembled by coupling a fuel regulator system to the second fuel source to reduce fuel pressure therefrom and deliver fuel to the second fuel line at a pressure required for

operation of the internal combustion engine, as called for in claim 11 of U.S. Patent No. 10,221,780.

h. Dependent claim 14 by specifically including all the aforementioned elements of claim 8 and, in addition, the mechanical fuel lockout switch is assembled by providing gasoline in a liquid fuel tank as the first fuel source and a liquefied petroleum gas (LPG) in a pressurized fuel container as the second fuel source, as called for in claim 14 of U.S. Patent No. 10,221,780.

i. Independent claim 15 by specifically including a mechanical fuel lockout switch for a dual fuel engine having a mechanical fuel valve actuateable between a first position and a second position to selectively control fuel flow to the dual fuel engine from a first fuel source through a first fuel line and a second fuel source through a second fuel line and a fuel lockout apparatus coupled to the mechanical fuel valve, wherein the mechanical fuel lockout switch communicates the first fuel source to the dual fuel engine and prevents communication between the second fuel source and the dual fuel engine when the mechanical fuel valve is in the first position and communicates the second fuel source to the dual fuel engine and interrupts the first fuel source communication with the dual fuel engine when in the second position and wherein the fuel lockout apparatus prevents actuation of the mechanical fuel valve to the first position when the second fuel source communicates with the dual fuel engine.

Therefore, each of the foregoing Generac generator models listed in Paragraph 13(a)-(d) infringes at least claims 1, 2, 6-9, 11, 14 and 15 of U.S. Patent No. 10,221,780.

15. Upon information and belief, Generac has been and is now making, using, selling, or offering for sale within the United States, or importing into the United States, the following additional generator model: Powermate Model DF7500E, a multi-fuel portable generator.

16. Upon review of the owner's manual of the Powermate Model DF7500E generator shared with the Powermate Model DF3500E generator, review of images and electrical schematics

of the Powermate Model DF7500E generator, and comparison of the images and electrical schematics of the Powermate Model DF7500E generator to images and electrical schematics of the Powermate Model DF3500E generator listed in Paragraph 13(d), it was determined that the Powermate Model DF7500E generator includes all of the elements of at least claims 1, 2, 6-9, 11, 14 and 15 of U.S. Patent No. 10,221,780. The Powermate Model DF7500E generator infringes:

a. Independent claim 1 by specifically including a mechanical fuel lockout switch for a dual fuel engine having a mechanical fuel valve actuateable between a first position and a second position to selectively control fuel flow to the dual fuel engine from a first fuel source through a first fuel line and a second fuel source through a second fuel line and a fuel lockout apparatus coupled to the mechanical fuel valve, wherein the mechanical fuel lockout switch communicates the first fuel source to the dual fuel engine and prevents communication between the second fuel source and the dual fuel engine when the mechanical fuel valve is in the first position and communicates the second fuel source to the dual fuel engine and interrupts the first fuel source communication with the dual fuel engine when in the second position and wherein the fuel lockout apparatus is configured to prevent the second fuel source from coupling to the second fuel line while the mechanical fuel valve is in the first position and permit the second fuel source to couple to the second fuel line while the mechanical fuel valve is in the second position, as called for in claim 1 of U.S. Patent No. 10,221,780.

b. Dependent claim 2 by specifically including all the aforementioned elements of claim 1 and, in addition, the fuel lockout apparatus prevents actuation of the mechanical fuel valve to the first position when the second fuel source communicates with the dual fuel engine, as called for in claim 2 of U.S. Patent No. 10,221,780.

c. Dependent claim 6 by specifically including all the aforementioned elements of claim 1 and, in addition, the mechanical fuel valve and the fuel lockout

apparatus operate together to ensure that fuel from the first fuel source and fuel from the second fuel source are not simultaneously delivered to the dual fuel engine, as called for in claim 6 of U.S. Patent No. 10,221,780.

d. Dependent claim 7 by specifically including all the aforementioned elements of claim 6 and, in addition, the first fuel source provides liquid fuel from a liquid fuel tank to the dual fuel engine and the second fuel source provides gaseous fuel from a pressurized fuel container to the dual fuel engine, as called for in claim 7 of U.S. Patent No. 10,221,780.

e. Independent claim 8 by specifically including a mechanical fuel lockout switch for an internal combustion engine, the mechanical fuel lockout being assembled by providing an internal combustion engine configured to operate on a fuel from a first fuel source and a different fuel from a second fuel source, coupling a mechanical fuel valve to the internal combustion engine actuateable between a first position and a second position to selectively control fuel flow to the internal combustion engine from the first fuel source through a first fuel line and the second fuel source through a second fuel line, and coupling a fuel lockout apparatus to the mechanical fuel valve, wherein the fuel lockout apparatus prevents actuation of the mechanical fuel valve to the first position when the second fuel source is coupled to the internal combustion engine, as called for in claim 8 of U.S. Patent No. 10,221,780.

f. Dependent claim 9 by specifically including all the aforementioned elements of claim 8 and, in addition, the fuel lockout apparatus is further configured to prevent coupling of the second fuel source to the second fuel line while the mechanical fuel valve is in the first position and to permit coupling of the second fuel source to the second fuel line while the mechanical fuel valve is in the second position, as called for in claim 9 of U.S. Patent No. 10,221,780.

g. Dependent claim 11 by specifically including all the aforementioned elements of claim 8 and, in addition, the mechanical fuel lockout switch is assembled

by coupling a fuel regulator system to the second fuel source to reduce fuel pressure therefrom and deliver fuel to the second fuel line at a pressure required for operation of the internal combustion engine, as called for in claim 11 of U.S. Patent No. 10,221,780.

h. Dependent claim 14 by specifically including all the aforementioned elements of claim 8 and, in addition, the mechanical fuel lockout switch is assembled by providing gasoline in a liquid fuel tank as the first fuel source and a liquefied petroleum gas (LPG) in a pressurized fuel container as the second fuel source, as called for in claim 14 of U.S. Patent No. 10,221,780.

i. Independent claim 15 by specifically including a mechanical fuel lockout switch for a dual fuel engine having a mechanical fuel valve actuateable between a first position and a second position to selectively control fuel flow to the dual fuel engine from a first fuel source through a first fuel line and a second fuel source through a second fuel line and a fuel lockout apparatus coupled to the mechanical fuel valve, wherein the mechanical fuel lockout switch communicates the first fuel source to the dual fuel engine and prevents communication between the second fuel source and the dual fuel engine when the mechanical fuel valve is in the first position and communicates the second fuel source to the dual fuel engine and interrupts the first fuel source communication with the dual fuel engine when in the second position and wherein the fuel lockout apparatus prevents actuation of the mechanical fuel valve to the first position when the second fuel source communicates with the dual fuel engine.

Therefore, Generac's Powermate Model DF7500E generator listed in Paragraph 15 infringes at least claims 1, 2, 6-9, 11, 14 and 15 of U.S. Patent No. 10,221,780.

17. Champion has no adequate remedy at law against Generac's acts of infringement and will suffer irreparable harm unless Generac is preliminarily and permanently enjoined from its infringement of U.S. Patent No. 10,221,780.

18. Upon information and belief, Generac's infringement has been willful, deliberate, and with knowledge of Champion's rights under U.S. Patent No. 10,221,780.

19. Upon information and belief, at least as of July 7, 2020, and again on April 4, 2024, the dates Champion sent Generac cease and desist letters demanding the cessation of infringement by Generac of Champion's patents, Generac has monitored Champion's patents and published patent applications and had actual notice of all of Champion's patents and published patent applications as of their publication dates.

20. Generac, by way of its infringing activity, has caused and continues to cause Champion to suffer damages in an amount to be determined at trial.

COUNT II: INFRINGEMENT OF U.S. PATENT NO. 10,598,101

21. Paragraphs 1 through 20 are incorporated by reference as if fully set forth herein.

22. U.S. Patent No. 10,598,101 is titled "DUAL FUEL SELECTOR SWITCH." U.S. Patent No. 10,598,101 was duly and legally issued on March 24, 2020. A true and correct copy of U.S. Patent No. 10,598,101 is attached as Exhibit B.

23. Champion is the lawful assignee of the entire right, title, and interest in and to U.S. Patent No. 10,598,101 and possesses all rights of recovery under the patent, including the right to recover damages for past infringement.

24. Champion has acquired and inspected the following Generac generator models that Generac has been and is making, using, selling, or offering for sale within the United States, or importing into the United States, and that infringe one or more claims of U.S. Patent No. 10,598,101:

a. Powermate Model PM4500DF, a multi-fuel portable generator;

b. Powermate Model PM7500DF, a multi-fuel portable generator;

c. Generac Model GP7500E, a multi-fuel portable generator; and

d. Powermate Model DF3500E, a multi-fuel portable generator.

25. Upon acquisition, disassembly as needed, review of owner's manuals and electrical schematics, and inspection, it was determined that each of the foregoing Generac generator models

includes all of the elements of at least claims 1, 2, 8, 9, 18, and 19 of U.S. Patent No. 10,598,101. Each of the foregoing Generac generator models infringes:

a. Independent claim 1 by specifically including a fuel selector for use with a dual fuel generator, the fuel selector comprising: a valve assembly fluidly connected to each of a first fuel source and a second fuel source, the valve assembly being operable to selectively control a first fuel flow and a second fuel flow from the first fuel source and the second fuel source, respectively, to an engine of the dual fuel generator; and a selector switch positioned on the valve assembly to allow a user to manually select one of the first fuel flow and the second fuel flow; wherein the valve assembly comprises: a first fuel valve having open and closed positions to selectively control the first fuel flow to the engine; and a second fuel valve having open and closed positions to selectively control the second fuel flow to the engine; and wherein the first fuel valve and the second fuel valve are mechanical valves, as called for in claim 1 of U.S. Patent No. 10,598,101.

b. Dependent claim 2 by specifically including all the aforementioned elements of claim 1 and, in addition, wherein the selector switch provides for manual actuation of the first fuel valve and the second fuel valve between the open and closed positions, as called for in claim 2 of U.S. Patent No. 10,598,101.

c. Dependent claim 8 by specifically including all the aforementioned elements of claim 1 and, in addition, wherein the first fuel valve is attached to a liquefied petroleum gas (LPG) fuel source and wherein the second fuel valve is attached to a gasoline source, as called for in claim 8 of U.S. Patent No. 10,598,101.

d. Dependent claim 9 by specifically including all the aforementioned elements of claim 1 and, in addition, wherein the mechanical valve of each of the first fuel valve and the second fuel valve is a non-solenoid valve, as called for in claim 9 of U.S. Patent No. 10,598,101.

e. Independent claim 18 by specifically including a fuel selector for use with a dual fuel generator, the fuel selector comprising: a valve assembly fluidly connected to each of a first fuel source and a second fuel source, the valve assembly being operable to selectively control a first fuel flow and a second fuel flow from the first fuel source and the second fuel source, respectively, to an engine of the dual fuel generator; and a selector switch positioned on the valve assembly to allow a user to manually select one of the first fuel flow and the second fuel flow; wherein the valve assembly comprises: two fuel inputs, with a first fuel input connected to the first fuel source and a second fuel input connected to the second fuel source; and two fuel outputs supplying fuel from only one of the first fuel source or the second fuel source, wherein the valve assembly comprises a first fuel valve having open and closed positions to selectively control the first fuel flow to the engine; and a second fuel valve having open and closed positions to selectively control the second fuel flow to the engine, as called for in claim 18 of U.S. Patent No. 10,598,101.

f. Dependent claim 19 by specifically including all the aforementioned elements of claim 18 and, in addition, wherein the first fuel valve and the second fuel valve are non-solenoid, mechanical valves, as called for in claim 19 of U.S. Patent No. 10,598,101.

Therefore, each of the foregoing Generac generator models listed in Paragraph 24(a)-(d) infringes at least claims 1, 2, 8, 9, 18, and 19 of U.S. Patent No. 10,598,101.

26. Upon information and belief, Generac has been and is now making, using, selling, or offering for sale within the United States, or importing into the United States, the following additional generator model: Powermate Model DF7500E, a multi-fuel portable generator.

27. Upon review of the owner's manual of the Powermate Model DF7500E generator shared with the Powermate Model DF3500E generator, review of images and electrical schematics of the Powermate Model DF7500E generator, and comparison of the images and electrical

schematics of the Powermate Model DF7500E generator to images and electrical schematics of the Powermate Model DF3500E generator listed in Paragraph 24(d), it was determined that the Powermate Model DF7500E generator includes all of the elements of at least claims 1, 2, 8, 9, 18, and 19 of U.S. Patent No. 10,598,101. The Powermate Model DF7500E generator infringes:

a. Independent claim 1 by specifically including a fuel selector for use with a dual fuel generator, the fuel selector comprising: a valve assembly fluidly connected to each of a first fuel source and a second fuel source, the valve assembly being operable to selectively control a first fuel flow and a second fuel flow from the first fuel source and the second fuel source, respectively, to an engine of the dual fuel generator; and a selector switch positioned on the valve assembly to allow a user to manually select one of the first fuel flow and the second fuel flow; wherein the valve assembly comprises: a first fuel valve having open and closed positions to selectively control the first fuel flow to the engine; and a second fuel valve having open and closed positions to selectively control the second fuel flow to the engine; and wherein the first fuel valve and the second fuel valve are mechanical valves, as called for in claim 1 of U.S. Patent No. 10,598,101.

b. Dependent claim 2 by specifically including all the aforementioned elements of claim 1 and, in addition, wherein the selector switch provides for manual actuation of the first fuel valve and the second fuel valve between the open and closed positions, as called for in claim 2 of U.S. Patent No. 10,598,101.

c. Dependent claim 8 by specifically including all the aforementioned elements of claim 1 and, in addition, wherein the first fuel valve is attached to a liquefied petroleum gas (LPG) fuel source and wherein the second fuel valve is attached to a gasoline source, as called for in claim 8 of U.S. Patent No. 10,598,101.

d. Dependent claim 9 by specifically including all the aforementioned elements of claim 1 and, in addition, wherein the mechanical valve of each of the first fuel

valve and the second fuel valve is a non-solenoid valve, as called for in claim 9 of U.S. Patent No. 10,598,101.

e. Independent claim 18 by specifically including a fuel selector for use with a dual fuel generator, the fuel selector comprising: a valve assembly fluidly connected to each of a first fuel source and a second fuel source, the valve assembly being operable to selectively control a first fuel flow and a second fuel flow from the first fuel source and the second fuel source, respectively, to an engine of the dual fuel generator; and a selector switch positioned on the valve assembly to allow a user to manually select one of the first fuel flow and the second fuel flow; wherein the valve assembly comprises: two fuel inputs, with a first fuel input connected to the first fuel source and a second fuel input connected to the second fuel source; and two fuel outputs supplying fuel from only one of the first fuel source or the second fuel source, wherein the valve assembly comprises a first fuel valve having open and closed positions to selectively control the first fuel flow to the engine; and a second fuel valve having open and closed positions to selectively control the second fuel flow to the engine, as called for in claim 18 of U.S. Patent No. 10,598,101.

f. Dependent claim 19 by specifically including all the aforementioned elements of claim 18 and, in addition, wherein the first fuel valve and the second fuel valve are non-solenoid, mechanical valves, as called for in claim 19 of U.S. Patent No. 10,598,101.

Therefore, the Powermate Model DF7500E generator listed in Paragraph 26 infringes at least claims 1, 2, 8, 9, 18, and 19 of U.S. Patent No. 10,598,101.

28. Champion has no adequate remedy at law against Generac's acts of infringement and will suffer irreparable harm unless Generac is preliminarily and permanently enjoined from its infringement of U.S. Patent No. 10,598,101.

29. Upon information and belief, Generac's infringement has been willful, deliberate, and with knowledge of Champion's rights under U.S. Patent No. 10,598,101.

30. Upon information and belief, at least as of July 7, 2020, and again on April 4, 2024, the dates Champion sent Generac cease and desist letters demanding the cessation of infringement by Generac of Champion's patents, Generac has monitored Champion's patents and published patent applications and had actual notice of all of Champion's patents and published patent applications as of their publication dates.

31. Generac, by way of its infringing activity, has caused and continues to cause Champion to suffer damages in an amount to be determined at trial.

COUNT III: INFRINGEMENT OF U.S. PATENT NO. 10,697,398

32. Paragraphs 1 through 31 are incorporated by reference as if fully set forth herein.

33. U.S. Patent No. 10,697,398 is titled "BATTERYLESS DUAL FUEL ENGINE WITH LIQUID FUEL CUT-OFF." U.S. Patent No. 10,697,398 was duly and legally issued on June 30, 2020. A true and correct copy of U.S. Patent No. 10,697,398 is attached as Exhibit C.

34. Champion is the lawful assignee of the entire right, title, and interest in and to U.S. Patent No. 10,697,398 and possesses all rights of recovery under the patent, including the right to recover damages for past infringement.

35. Champion has acquired and inspected the following Generac generator models that Generac has been and is making, using, selling, or offering for sale within the United States, or importing into the United States, and that infringe one or more claims of U.S. Patent No. 10,697,398:

a. Powermate Model PM4500DF, a multi-fuel portable generator;

b. Powermate Model PM7500DF, a multi-fuel portable generator; and

c. Generac Model GP7500E, a multi-fuel portable generator.

36. Upon acquisition, disassembly as needed, review of owner's manuals and electrical schematics, and inspection, it was determined that each of the foregoing Generac generator models

includes all of the elements of at least claims 43, 44, and 56-58 of U.S. Patent No. 10,697,398. Each of the foregoing Generac generator models infringes:

a. Independent claim 43 by specifically including a dual fuel engine having an engine operable on a gaseous fuel and a liquid fuel, a switch to change operation of an engine between gaseous fuel and liquid fuel, a carburetor attached to an intake of the engine to mix air and fuel and connect to a gaseous fuel source and a liquid fuel source, a liquid fuel valve positioned along a liquid fuel line coupling a liquid fuel source to a carburetor, a gaseous fuel valve positioned along a gaseous fuel line coupling a gaseous fuel source to the carburetor, and a liquid fuel cut-off incorporated into the carburetor to interrupt liquid fuel upon actuation of the switch from liquid to gaseous fuel, as called for in claim 43 of U.S. Patent No. 10,697,398.

b. Dependent claim 44 by specifically including all the aforementioned elements of claim 43 and, in addition, wherein the fuel shutoff is a manually actuated fuel shutoff, as called for in claim 44 of U.S. Patent No. 10,697,398.

c. Dependent claim 56 by specifically including all the aforementioned elements of claim 43 and, in addition, wherein the fuel shutoff extends through an opening into the float bowl such that the first end actuates in the float bowl to close the fuel passage, as called for in claim 44 of U.S. Patent No. 10,697,398.

d. Independent claim 57 by specifically including a method of assembling a dual fuel engine comprising: providing an engine operable on a gaseous fuel and a liquid fuel; attaching a carburetor to an intake of the engine, the carburetor comprising: a throat to mix gaseous fuel with air and liquid fuel with air, a float bowl, and a fuel passage extending from the float bowl to the throat to provide liquid fuel; coupling a switch to the engine to change operation of the engine between gaseous fuel and liquid fuel; and attaching a liquid fuel cut-off to the

carburetor to close the fuel passage upon actuation of the switch from liquid fuel to gaseous fuel, as called for in claim 57 of U.S. Patent No. 10,697,398.

e. Dependent claim 58 by specifically including all the aforementioned elements of claim 57 and, in addition, coupling a manually operated control operatively to the liquid fuel cut-off, as called for in claim 58 of U.S. Patent No. 10,697,398.

Therefore, each of the foregoing Generac generator models listed in Paragraph 35(a)-(c) infringes at least claims 43, 44, and 56-58 of U.S. Patent No. 10,697,398.

37. Champion has acquired and inspected the following Generac generator model that Generac has been and is making, using, selling, or offering for sale within the United States, or importing into the United States, and that infringe one or more claims of U.S. Patent No. 10,697,398: Powermate Model DF3500E, a multi-fuel portable generator.

38. Upon acquisition, disassembly as needed, review of owner's manuals and electrical schematics, and inspection, it was determined that the Powermate Model DF3500E generator includes all of the elements of at least claims 1, 3-7, 19, 20, 22, and 57 of U.S. Patent No. 10,697,398. The Powermate Model DF3500E generator model infringes:

a. Independent claim 1 by specifically including a dual fuel engine comprising: an engine operable on a gaseous fuel and a liquid fuel; a switch to change operation of the engine between gaseous fuel and liquid fuel; a carburetor attached to an intake of the engine to mix air and fuel and connect to a gaseous fuel source and a liquid fuel source; a liquid fuel valve positioned along a liquid fuel line coupling the liquid fuel source to the carburetor; a gaseous fuel valve positioned along a gaseous fuel line coupling the gaseous fuel source to the carburetor; and a liquid fuel cut-off incorporated into the carburetor to interrupt liquid fuel upon actuation of the switch from liquid fuel to gaseous fuel, as called for in claim 1 of U.S. Patent No. 10,697,398.

b. Dependent claim 3 by specifically including all the aforementioned elements of claim 1 and, in addition, wherein the gaseous fuel is LPG and the liquid fuel is gasoline, as called for in claim 3 of U.S. Patent No. 10,697,398.

c. Dependent claim 4 by specifically including all the aforementioned elements of claim 1 and, in addition, wherein the engine is a pull-start engine having an electrical power generator to supply electrical power, as called for in claim 4 of U.S. Patent No. 10,697,398.

d. Dependent claim 5 by specifically including all the aforementioned elements of claim 4 and, in addition, wherein the switch is an electro-mechanical switch connecting one fuel source to the carburetor and connected to the electrical power generator; and wherein the liquid fuel cut-off is a solenoid connected to open and close a fuel path to the pull-start engine in response to reception of electrical power from the switch, as called for in claim 5 of U.S. Patent No. 10,697,398.

e. Dependent claim 6 by specifically including all the aforementioned elements of claim 4 and, in addition, wherein the liquid fuel cut-off is a solenoid valve that operates within the carburetor to control liquid fuel flow to the engine and is powered by the electrical power generator, as called for in claim 6 of U.S. Patent No. 10,697,398.

f. Dependent claim 7 by specifically including all the aforementioned elements of claim 6 and, in addition, wherein the switch selectively powers the solenoid valve by controlling electrical connection between the solenoid valve and the electrical power generator, as called for in claim 7 of U.S. Patent No. 10,697,398.

g. Dependent claim 19 by specifically including all the aforementioned elements of claim 1 and, in addition, wherein the liquid fuel cut-off is magnetically actuated to selectively interrupt liquid fuel, as called for in claim 19 of U.S. Patent No. 10,697,398.

h. Dependent claim 20 by specifically including all the aforementioned elements of claim 1 and, in addition, a spring pushing the liquid fuel cut-off to interrupt liquid fuel; and an actuating magnet coupled to the carburetor to selectively pull the liquid fuel cut-off against the spring away from a position interrupting liquid fuel, as called for in claim 20 of U.S. Patent No. 10,697,398.

i. Dependent claim 22 by specifically including all the aforementioned elements of claim 1 and, in addition, wherein the liquid fuel cut-off is physically attached to an outer surface of the carburetor, as called for in claim 22 of U.S. Patent No. 10,697,398.

j. Independent claim 57 by specifically including a method of assembling a dual fuel engine comprising: providing an engine operable on a gaseous fuel and a liquid fuel; attaching a carburetor to an intake of the engine, the carburetor comprising: a throat to mix gaseous fuel with air and liquid fuel with air, a float bowl, and a fuel passage extending from the float bowl to the throat to provide liquid fuel; coupling a switch to the engine to change operation of the engine between gaseous fuel and liquid fuel; and attaching a liquid fuel cut-off to the carburetor to close the fuel passage upon actuation of the switch from liquid fuel to gaseous fuel, as called for in claim 57 of U.S. Patent No. 10,697,398.

Therefore, the Powermate Model DF3500E generator model listed in Paragraph 37 infringes at least claims 1, 3-7, 19, 20, 22, and 57 of U.S. Patent No. 10,697,398.

39. Upon information and belief, Generac has been and is now making, using, selling, or offering for sale within the United States, or importing into the United States, the following additional generator model: Powermate Model DF7500E, a multi-fuel portable generator.

40. Upon review of the owner's manual of the Powermate Model DF7500E generator shared with the Powermate Model DF3500E generator, review of images and electrical schematics of the Powermate Model DF7500E generator, and comparison of the images and electrical schematics of the Powermate Model DF7500E generator to images and electrical schematics of

the Powermate Model DF3500E generator listed in Paragraph 37, it was determined that the Powermate Model DF7500E generator includes all of the elements of at least claims 1, 3-7, 19, 20, 22, and 57 of U.S. Patent No. 10,697,398. The Powermate Model DF7500E generator infringes:

a. Independent claim 1 by specifically including a dual fuel engine comprising: an engine operable on a gaseous fuel and a liquid fuel; a switch to change operation of the engine between gaseous fuel and liquid fuel; a carburetor attached to an intake of the engine to mix air and fuel and connect to a gaseous fuel source and a liquid fuel source; a liquid fuel valve positioned along a liquid fuel line coupling the liquid fuel source to the carburetor; a gaseous fuel valve positioned along a gaseous fuel line coupling the gaseous fuel source to the carburetor; and a liquid fuel cut-off incorporated into the carburetor to interrupt liquid fuel upon actuation of the switch from liquid fuel to gaseous fuel, as called for in claim 1 of U.S. Patent No. 10,697,398.

b. Dependent claim 3 by specifically including all the aforementioned elements of claim 1 and, in addition, wherein the gaseous fuel is LPG and the liquid fuel is gasoline, as called for in claim 3 of U.S. Patent No. 10,697,398.

c. Dependent claim 4 by specifically including all the aforementioned elements of claim 1 and, in addition, wherein the engine is a pull-start engine having an electrical power generator to supply electrical power, as called for in claim 4 of U.S. Patent No. 10,697,398.

d. Dependent claim 5 by specifically including all the aforementioned elements of claim 4 and, in addition, wherein the switch is an electro-mechanical switch connecting one fuel source to the carburetor and connected to the electrical power generator; and wherein the liquid fuel cut-off is a solenoid connected to open and close a fuel path to the pull-start engine in response to reception of electrical power from the switch, as called for in claim 5 of U.S. Patent No. 10,697,398.

e. Dependent claim 6 by specifically including all the aforementioned elements of claim 4 and, in addition, wherein the liquid fuel cut-off is a solenoid valve that operates within the carburetor to control liquid fuel flow to the engine and is powered by the electrical power generator, as called for in claim 6 of U.S. Patent No. 10,697,398.

f. Dependent claim 7 by specifically including all the aforementioned elements of claim 6 and, in addition, wherein the switch selectively powers the solenoid valve by controlling electrical connection between the solenoid valve and the electrical power generator, as called for in claim 7 of U.S. Patent No. 10,697,398.

g. Dependent claim 19 by specifically including all the aforementioned elements of claim 1 and, in addition, wherein the liquid fuel cut-off is magnetically actuated to selectively interrupt liquid fuel, as called for in claim 19 of U.S. Patent No. 10,697,398.

h. Dependent claim 20 by specifically including all the aforementioned elements of claim 1 and, in addition, a spring pushing the liquid fuel cut-off to interrupt liquid fuel; and an actuating magnet coupled to the carburetor to selectively pull the liquid fuel cut-off against the spring away from a position interrupting liquid fuel, as called for in claim 20 of U.S. Patent No. 10,697,398.

i. Dependent claim 22 by specifically including all the aforementioned elements of claim 1 and, in addition, wherein the liquid fuel cut-off is physically attached to an outer surface of the carburetor, as called for in claim 22 of U.S. Patent No. 10,697,398.

j. Independent claim 57 by specifically including a method of assembling a dual fuel engine comprising: providing an engine operable on a gaseous fuel and a liquid fuel; attaching a carburetor to an intake of the engine, the carburetor comprising: a throat to mix gaseous fuel with air and liquid fuel with air, a float bowl, and a fuel passage extending from the float bowl to the throat to provide

liquid fuel; coupling a switch to the engine to change operation of the engine between gaseous fuel and liquid fuel; and attaching a liquid fuel cut-off to the carburetor to close the fuel passage upon actuation of the switch from liquid fuel to gaseous fuel, as called for in claim 57 of U.S. Patent No. 10,697,398.

Therefore, Powermate Model DF7500E generator listed in Paragraph 39 infringes at least claims 1, 3-7, 19, 20, 22, and 57 of U.S. Patent No. 10,697,398.

41. Champion has no adequate remedy at law against Generac's acts of infringement and will suffer irreparable harm unless Generac is preliminarily and permanently enjoined from its infringement of U.S. Patent No. 10,697,398.

42. Upon information and belief, Generac's infringement has been willful, deliberate, and with knowledge of Champion's rights under U.S. Patent No. 10,697,398.

43. Upon information and belief, at least as of July 7, 2020, and again on April 4, 2024, the dates Champion sent Generac cease and desist letters demanding the cessation of infringement by Generac of Champion's patents, Generac has monitored Champion's patents and published patent applications and had actual notice of all of Champion's patents and published patent applications as of their publication dates.

44. Generac, by way of its infringing activity, has caused and continues to cause Champion to suffer damages in an amount to be determined at trial.

COUNT IV: INFRINGEMENT OF U.S. PATENT NO. 11,143,120

45. Paragraphs 1 through 44 are incorporated by reference as if fully set forth herein.

46. U.S. Patent No. 11,143,120 is titled "FUEL SYSTEM FOR A MULTI-FUEL INTERNAL COMBUSTION ENGINE." U.S. Patent No. 11,143,120 was duly and legally issued on October 12, 2021. A true and correct copy of U.S. Patent No. 11,143,120 is attached as Exhibit D.

47. Champion is the lawful assignee of the entire right, title, and interest in and to U.S. Patent No. 11,143,120 and possesses all rights of recovery under the patent, including the right to recover damages for past infringement.

48. Champion has acquired and inspected the following Generac generator models that Generac has been and is making, using, selling, or offering for sale within the United States, or importing into the United States, and that infringe one or more claims of U.S. Patent No. 11,143,120:

a. Powermate Model PM4500DF, a multi-fuel portable generator;

b. Powermate Model PM7500DF, a multi-fuel portable generator; and

c. Generac Model GP7500E, a dual multi-portable generator.

49. Upon acquisition, disassembly as needed, review of owner's manuals and electrical schematics, and inspection, it was determined that each of the foregoing Generac generator models includes all of the elements of at least claims 12 and 17 of U.S. Patent No. 11,143,120. Each of the foregoing Generac generator models infringes:

a. Independent claim 12 by specifically including a multi-fuel generator and fuel delivery system having a multi-fuel internal combustion engine configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line, an alternator driven by the multi-fuel internal combustion engine, and a fuel regulator system including a primary pressure regulator coupled to a service valve of a pressurized fuel source to regulate fuel supplied from the pressurized fuel source to a reduced pressure and a secondary pressure regulator coupled to the primary pressure regulator to regulate fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the engine, as called for in claim 12 of U.S. Patent No. 11,143,120.

b. Dependent claim 17 by specifically including all the aforementioned elements of claim 12 and, in addition, wherein a dual stage pressure regulator comprises the primary pressure regulator and the secondary pressure regulator, as called for in claim 17 of U.S. Patent No. 11,143,120.

Therefore, each of the foregoing Generac generator models listed in Paragraph 48(a)-(c) infringes at least claims 12 and 17 of U.S. Patent No. 11,143,120.

50. Champion has acquired and inspected the following Generac generator models that Generac has been and is making, using, selling, or offering for sale within the United States, or importing into the United States, and that infringe one or more claims of U.S. Patent No. 11,143,120: Powermate Model DF3500E, a multi-fuel portable generator.

51. Upon acquisition, disassembly as needed, review of owner's manuals and electrical schematics, and inspection, it was determined that the Powermate Model DF3500E generator includes all of the elements of at least claims 12-15, 18, and 19 of U.S. Patent No. 11,143,120. The Powermate Model DF3500E generator infringes:

a. Independent claim 12 by specifically including a multi-fuel generator and fuel delivery system having a multi-fuel internal combustion engine configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line, an alternator driven by the multi-fuel internal combustion engine, and a fuel regulator system including a primary pressure regulator coupled to a service valve of a pressurized fuel source to regulate fuel supplied from the pressurized fuel source to a reduced pressure and a secondary pressure regulator coupled to the primary pressure regulator to regulate fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the engine, as called for in claim 12 of U.S. Patent No. 11,143,120.

b. Dependent claim 13 by specifically including all the aforementioned elements of claim 12 and, in addition, an electro-mechanical valve system coupled to the engine and operated by an electrical switch powered by one of the alternator, a battery, and a magneto that controls fuel flow to the engine from the liquid fuel source and the pressurized fuel source, as called for in claim 13 of U.S. Patent No. 11,143,120.

c. Dependent claim 14 by specifically including all the aforementioned elements of claim 13 and, in addition, wherein the electro-mechanical valve system is configured to switch operation of the generator from multiple fuel sources while the generator is running, as called for in claim 14 of U.S. Patent No. 11,143,120.

d. Dependent claim 15 by specifically including all the aforementioned elements of claim 13 and, in addition, wherein the electro-mechanical valve system is configured to prevent simultaneous delivery of the liquid fuel and the gaseous fuel to the engine, as called for in claim 15 of U.S. Patent No. 11,143,120.

e. Independent claim 18 by specifically including a carburetor for use in a multi-fuel internal combustion engine, the carburetor comprising: a throat in which fuel and air are mixed in throat to provide an air-fuel mixture for the multi-fuel internal combustion engine; a valve located in the throat to provide a choke and throttle for the multi-fuel internal combustion engine; a float bowl to hold liquid fuel; a main fuel circuit positioned downstream from the float bowl and extending from the float bowl to the throat; an idle fuel circuit that provides a flow path to the throat downstream of the throttle to run the engine at idle; and a carburetor cutoff solenoid configured to selectively control fuel flow through the main fuel circuit and the idle fuel circuit, as called for in claim 18 of U.S. Patent No. 11,143,120.

f. Dependent claim 19 by specifically including all the aforementioned elements of claim 18 and, in addition, wherein the carburetor cutoff solenoid is operatively coupled to a switch that changes operation of the engine from liquid fuel to gaseous fuel and from gaseous fuel to liquid fuel while the engine is running, and wherein the carburetor cutoff solenoid is closed to stop liquid fuel flow through the main fuel circuit and the idle fuel circuit when the switch changes operation of the engine from liquid fuel to gaseous fuel, as called for in claim 19 of U.S. Patent No. 11,143,120.

Therefore, the Powermate Model DF3500E generator listed in Paragraph 50 infringes at least claims 12-15, 18, and 19 of U.S. Patent No. 11,143,120.

52. Upon information and belief, Generac has been and is now making, using, selling, or offering for sale within the United States, or importing into the United States, the following additional generator model: Powermate Model DF7500E, a multi-fuel portable generator.

53. Upon review of the owner's manual of the Powermate Model DF7500E generator shared with the Powermate Model DF3500E generator, review of images and electrical schematics of the Powermate Model DF7500E generator, and comparison of the images and electrical schematics of the Powermate Model DF7500E generator to images and electrical schematics of the Powermate Model DF3500E generator listed in Paragraph 50, it was determined that the Powermate Model DF7500E generator includes all of the elements of at least claims 12-15, 18, and 19 of U.S. Patent No. 11,143,120. The Powermate Model DF7500E generator infringes:

a. Independent claim 12 by specifically including a multi-fuel generator and fuel delivery system having a multi-fuel internal combustion engine configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line, an alternator driven by the multi-fuel internal combustion engine, and a fuel regulator system including a primary pressure regulator coupled to a service valve of a pressurized fuel source to regulate fuel supplied from the pressurized fuel source to a reduced pressure and a secondary pressure regulator coupled to the primary pressure regulator to regulate fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the engine, as called for in claim 12 of U.S. Patent No. 11,143,120.

b. Dependent claim 13 by specifically including all the aforementioned elements of claim 12 and, in addition, an electro-mechanical valve system coupled to the engine and operated by an electrical switch powered by one of the alternator, a battery, and a magneto that controls fuel flow to the engine from the liquid fuel

source and the pressurized fuel source, as called for in claim 13 of U.S. Patent No. 11,143,120.

c. Dependent claim 14 by specifically including all the aforementioned elements of claim 13 and, in addition, wherein the electro-mechanical valve system is configured to switch operation of the generator from multiple fuel sources while the generator is running, as called for in claim 14 of U.S. Patent No. 11,143,120.

d. Dependent claim 15 by specifically including all the aforementioned elements of claim 13 and, in addition, wherein the electro-mechanical valve system is configured to prevent simultaneous delivery of the liquid fuel and the gaseous fuel to the engine, as called for in claim 15 of U.S. Patent No. 11,143,120.

e. Independent claim 18 by specifically including a carburetor for use in a multi-fuel internal combustion engine, the carburetor comprising: a throat in which fuel and air are mixed in throat to provide an air-fuel mixture for the multi-fuel internal combustion engine; a valve located in the throat to provide a choke and throttle for the multi-fuel internal combustion engine; a float bowl to hold liquid fuel; a main fuel circuit positioned downstream from the float bowl and extending from the float bowl to the throat; an idle fuel circuit that provides a flow path to the throat downstream of the throttle to run the engine at idle; and a carburetor cutoff solenoid configured to selectively control fuel flow through the main fuel circuit and the idle fuel circuit, as called for in claim 18 of U.S. Patent No. 11,143,120.

f. Dependent claim 19 by specifically including all the aforementioned elements of claim 18 and, in addition, wherein the carburetor cutoff solenoid is operatively coupled to a switch that changes operation of the engine from liquid fuel to gaseous fuel and from gaseous fuel to liquid fuel while the engine is running, and wherein the carburetor cutoff solenoid is closed to stop liquid fuel flow through the main fuel circuit and the idle fuel circuit when the switch changes operation

of the engine from liquid fuel to gaseous fuel, as called for in claim 19 of U.S. Patent No. 11,143,120.

Therefore, the Powermate Model DF7500E generator listed in Paragraph 52 infringes at least claims 12-15, 18, and 19 of U.S. Patent No. 11,143,120.

54. Champion has no adequate remedy at law against Generac's acts of infringement and will suffer irreparable harm unless Generac is preliminarily and permanently enjoined from its infringement of U.S. Patent No. 11,143,120.

55. Upon information and belief, Generac's infringement has been willful, deliberate, and with knowledge of Champion's rights under U.S. Patent No. 11,143,120.

56. Upon information and belief, at least as of July 7, 2020, and again on April 4, 2024, the dates Champion sent Generac cease and desist letters demanding the cessation of infringement by Generac of Champion's patents, Generac has monitored Champion's patents and published patent applications and had actual notice of all of Champion's patents and published patent applications as of their publication dates.

57. Generac, by way of its infringing activity, has caused and continues to cause Champion to suffer damages in an amount to be determined at trial.

COUNT V: INFRINGEMENT OF U.S. PATENT NO. 11,143,145

58. Paragraphs 1 through 57 are incorporated by reference as if fully set forth herein.

59. U.S. Patent No. 11,143,145 is titled "BATTERYLESS DUAL FUEL ENGINE WITH LIQUID FUEL CUT-OFF." U.S. Patent No. 11,143,145 was duly and legally issued on October 12, 2021. A true and correct copy of U.S. Patent No. 11,143,145 is attached as Exhibit E.

60. Champion is the lawful assignee of the entire right, title, and interest in and to U.S. Patent No. 11,143,145 and possesses all rights of recovery under the patent, including the right to recover damages for past infringement.

61. Champion has acquired and inspected the following Generac generator models that Generac has been and is making, using, selling, or offering for sale within the United States, or importing into the United States:

a. Powermate Model PM4500DF, a multi-fuel portable generator;

b. Powermate Model PM7500DF, a multi-fuel portable generator; and

c. Generac Model GP7500E, a multi-fuel portable generator.

62. Upon acquisition, disassembly as needed, review of owner's manuals and electrical schematics, and inspection, it was determined that each of the foregoing Generac generator models includes all of the elements of at least claims 11, 13, and 14 of U.S. Patent No. 11,143,145. Each of the foregoing Generac generator models infringes:

a. Independent claim 11 by specifically including a dual fuel generator comprising: an engine operable on a gaseous fuel and a liquid fuel; a carburetor attached to an intake of the engine to mix air and fuel and connect to a gaseous fuel source and a liquid fuel source; and a manually actuated fuel shutoff coupled to the carburetor, the manually actuated fuel shutoff comprising: a first end in the carburetor that actuates to selectively allow or block a flow of fuel through the carburetor; and a second end external to the carburetor to actuate the first end, as called for in claim 11 of U.S. Patent No. 11,143,145.

b. Dependent claim 13 by specifically including all the aforementioned elements of claim 11 and, in addition, wherein the gaseous fuel is LPG and the liquid fuel is gasoline, as called for in claim 13 of U.S. Patent No. 11,143,145.

c. Dependent claim 14 by specifically including all the aforementioned elements of claim 11 and, in addition, wherein the manually actuated fuel shutoff comprises a rotating mechanical valve, as called for in claim 14 of U.S. Patent No. 11,143,145.

Therefore, each of the foregoing Generac generator models listed in Paragraph 61(a)-(c) infringes at least claims 11, 13, and 14 of U.S. Patent No. 11,143,145.

63. Champion has acquired and inspected the following Generac generator models that Generac has been and is making, using, selling, or offering for sale within the United States, or importing into the United States, and that infringe one or more claims of U.S. Patent No. 11,143,145: Powermate Model DF3500E, a multi-fuel portable generator.

64. Upon acquisition, disassembly as needed, review of owner's manuals and electrical schematics, and inspection, it was determined that the Powermate Model DF3500E generator includes all of the elements of at least claims 1-7 and 10 of U.S. Patent No. 11,143,145. The Powermate Model DF3500E generator infringes:

a. Independent claim 1 by specifically including a dual fuel generator comprising: an engine operable on a gaseous fuel and a liquid fuel; an electrical power generator driven by the engine and comprising a charging coil; a switch to change operation of the engine between gaseous fuel and liquid fuel; a carburetor attached to an intake of the engine to mix air and fuel and connect to a gaseous fuel source and a liquid fuel source; a liquid fuel cut-off solenoid to interrupt liquid fuel flow to the engine upon actuation of the switch from liquid fuel to gaseous fuel; and a voltage regulator coupled to the charging coil to receive power therefrom and that operates to provide a regulated voltage to the liquid fuel cut-off solenoid, as called for in claim 1 of U.S. Patent No. 11,143,145.

b. Dependent claim 2 by specifically including all the aforementioned elements of claim 1 and, in addition, a liquid fuel valve along a liquid fuel line coupling the liquid fuel source to the carburetor; and a gaseous fuel valve along a gaseous fuel line coupling the gaseous fuel source to the carburetor, as called for in claim 2 of U.S. Patent No. 11,143,145.

c. Dependent claim 3 by specifically including all the aforementioned elements of claim 2 and, in addition, wherein each of the liquid fuel valve and the gaseous fuel valve comprises a mechanical valve, as called for in claim 3 of U.S. Patent No. 11,143,145.

d. Dependent claim 4 by specifically including all the aforementioned elements of claim 2 and, in addition, wherein the liquid fuel cut-off solenoid is attached to the carburetor, as called for in claim 4 of U.S. Patent No. 11,143,145.

e. Dependent claim 5 by specifically including all the aforementioned elements of claim 1 and, in addition, wherein the gaseous fuel is LPG and the liquid fuel is gasoline, as called for in claim 5 of U.S. Patent No. 11,143,145.

f. Dependent claim 6 by specifically including all the aforementioned elements of claim 1 and, in addition, wherein the switch is an electro-mechanical switch connecting one fuel source to the carburetor and connected to the electrical power generator, and wherein the liquid fuel cut-off solenoid is connected to open and close a fuel path to the engine in response to reception of electrical power from the switch, as called for in claim 6 of U.S. Patent No. 11,143,145.

g. Dependent claim 7 by specifically including all the aforementioned elements of claim 6 and, in addition, wherein the switch selectively powers the solenoid valve by controlling electrical connection between the solenoid valve and the electrical power generator, as called for in claim 7 of U.S. Patent No. 11,143,145.

h. Dependent claim 10 by specifically including all the aforementioned elements of claim 1 and, in addition, wherein the electrical power generator comprises a magneto or an alternator, as called for in claim 10 of U.S. Patent No. 11,143,145.

Therefore, Powermate Model DF3500E generator listed in Paragraph 64 infringes at least claims 1-7 and 10 of U.S. Patent No. 11,143,145.

65. Upon information and belief, Generac has been and is now making, using, selling, or offering for sale within the United States, or importing into the United States, the following additional generator model: Powermate Model DF7500E, a multi-fuel portable generator.

66. Upon review of the owner's manual of the Powermate Model DF7500E generator shared with the Powermate Model DF3500E generator, review of images and electrical schematics of the Powermate Model DF7500E generator, and comparison of the images and electrical schematics of the Powermate Model DF7500E generator to images and electrical schematics of the Powermate Model DF3500E generator listed in Paragraph 64, it was determined that the

Powermate Model DF7500E generator includes all of the elements of at least claims 1-7 and 10 of U.S. Patent No. 11,143,145. The Powermate Model DF7500E generator infringes:

a. Independent claim 1 by specifically including a dual fuel generator comprising: an engine operable on a gaseous fuel and a liquid fuel; an electrical power generator driven by the engine and comprising a charging coil; a switch to change operation of the engine between gaseous fuel and liquid fuel; a carburetor attached to an intake of the engine to mix air and fuel and connect to a gaseous fuel source and a liquid fuel source; a liquid fuel cut-off solenoid to interrupt liquid fuel flow to the engine upon actuation of the switch from liquid fuel to gaseous fuel; and a voltage regulator coupled to the charging coil to receive power therefrom and that operates to provide a regulated voltage to the liquid fuel cut-off solenoid, as called for in claim 1 of U.S. Patent No. 11,143,145.

b. Dependent claim 2 by specifically including all the aforementioned elements of claim 1 and, in addition, a liquid fuel valve along a liquid fuel line coupling the liquid fuel source to the carburetor; and a gaseous fuel valve along a gaseous fuel line coupling the gaseous fuel source to the carburetor, as called for in claim 2 of U.S. Patent No. 11,143,145.

c. Dependent claim 3 by specifically including all the aforementioned elements of claim 2 and, in addition, wherein each of the liquid fuel valve and the gaseous fuel valve comprises a mechanical valve, as called for in claim 3 of U.S. Patent No. 11,143,145.

d. Dependent claim 4 by specifically including all the aforementioned elements of claim 2 and, in addition, wherein the liquid fuel cut-off solenoid is attached to the carburetor, as called for in claim 4 of U.S. Patent No. 11,143,145.

e. Dependent claim 5 by specifically including all the aforementioned elements of claim 1 and, in addition, wherein the gaseous fuel is LPG and the liquid fuel is gasoline, as called for in claim 5 of U.S. Patent No. 11,143,145.

f. Dependent claim 6 by specifically including all the aforementioned elements of claim 1 and, in addition, wherein the switch is an electro-mechanical switch connecting one fuel source to the carburetor and connected to the electrical power generator, and wherein the liquid fuel cut-off solenoid is connected to open and close a fuel path to the engine in response to reception of electrical power from the switch, as called for in claim 6 of U.S. Patent No. 11,143,145.

g. Dependent claim 7 by specifically including all the aforementioned elements of claim 6 and, in addition, wherein the switch selectively powers the solenoid valve by controlling electrical connection between the solenoid valve and the electrical power generator, as called for in claim 7 of U.S. Patent No. 11,143,145.

h. Dependent claim 10 by specifically including all the aforementioned elements of claim 1 and, in addition, wherein the electrical power generator comprises a magneto or an alternator, as called for in claim 10 of U.S. Patent No. 11,143,145.

Therefore, the Powermate Model DF7500E generator listed in Paragraph 65 infringes at least claims 1-7 and 10 of U.S. Patent No. 11,143,145.

67. Champion has no adequate remedy at law against Generac's acts of infringement and will suffer irreparable harm unless Generac is preliminarily and permanently enjoined from its infringement of U.S. Patent No. 11,143,145.

68. Upon information and belief, Generac's infringement has been willful, deliberate, and with knowledge of Champion's rights under U.S. Patent No. 11,143,145.

69. Upon information and belief, at least as of July 7, 2020, and again on April 4, 2024, the dates Champion sent Generac cease and desist letters demanding the cessation of infringement by Generac of Champion's patents, Generac has monitored Champion's patents and published patent applications and had actual notice of all of Champion's patents and published patent applications as of their publication dates.

70. Generac, by way of its infringing activity, has caused and continues to cause Champion to suffer damages in an amount to be determined at trial.

COUNT VI: INFRINGEMENT OF U.S. PATENT NO. 11,306,667

71. Paragraphs 1 through 70 are incorporated by reference as if fully set forth herein.

72. U.S. Patent No. 11,306,667 is titled "DUAL FUEL SELECTOR SWITCH." U.S. Patent No. 11,306,667 was duly and legally issued on April 19, 2022. A true and correct copy of U.S. Patent No. 11,306,667 is attached as Exhibit F.

73. Champion is the lawful assignee of the entire right, title, and interest in and to U.S. Patent No. 11,306,667 and possesses all rights of recovery under the patent, including the right to recover damages for past infringement.

74. Champion has acquired and inspected the following Generac generator models that Generac has been and is making, using, selling, or offering for sale within the United States, or importing into the United States, and that infringe one or more claims of U.S. Patent No. 11,306,667:

a. Powermate Model PM4500DF, a multi-fuel portable generator;

b. Powermate Model PM7500DF, a multi-fuel portable generator; and

c. Generac Model GP7500E, a multi-fuel portable generator.

75. Upon acquisition, disassembly as needed, review of owner's manuals and electrical schematics, and inspection, it was determined that each of the foregoing Generac generator models includes all of the elements of at least claims 1-5 and 9 of U.S. Patent No. 11,306,667. Each of the foregoing Generac generator models infringes:

a. Independent claim 1 by specifically including a fuel selector for use with a dual fuel generator, the fuel selector a selector having a valve assembly fluidly connected to each of a first fuel source and a second fuel source, being operable to selectively control a first fuel flow and a second fuel flow from the first fuel source and the second fuel source, respectively, to an engine of the dual fuel generator, and including two fuel inputs, with a first fuel input connected to the first fuel source and a second fuel input connected to the second fuel source, and two fuel outputs for selectively supplying fuel to an engine from the first fuel

source or the second fuel source; and a selector switch positioned on the valve assembly to allow a user to manually select one of the first fuel flow and the second fuel flow, as called for in claim 1 of U.S. Patent No. 11,306,667.

b. Dependent claim 2 by specifically including all the aforementioned elements of claim 1 and, in addition, the two fuel outputs selectively supply fuel to the engine from only one of the first fuel source or the second fuel source, responsive to selection of the first fuel flow or the second fuel flow via the selector switch, and a corresponding operation of the valve assembly, as called for in claim 2 of U.S. Patent No. 11,306,667.

c. Dependent claim 3 by specifically including all the aforementioned elements of claim 1 and, in addition, the valve assembly has a first fuel valve having open and closed positions to selectively control the first fuel flow to the engine and a second fuel valve having open and closed positions to selectively control the second fuel flow to the engine, as called for in claim 3 of U.S. Patent No. 11,306,667.

d. Dependent claim 5 by specifically including all the aforementioned elements of claim 3 and, in addition, wherein the selector switch provides for manual actuation of the first fuel valve and the second fuel valve between the open and closed positions, as called for in claim 5 of U.S. Patent No. 11,306,667.

e. Dependent claim 9 by specifically including all the aforementioned elements of claim 1 and, in addition, the first fuel source is an LPG fuel source and wherein the second fuel source is a gasoline source, as called for in claim 9 of U.S. Patent No. 11,306,667.

Therefore, each of the foregoing Generac generator models listed in Paragraph 74(a)-(c) infringes at least claims 1-5 and 9 of U.S. Patent No. 11,306,667.

76. Champion has acquired and inspected the following Generac generator models that Generac has been and is making, using, selling, or offering for sale within the United States, or

importing into the United States, and that infringe one or more claims of U.S. Patent No. 11,143,145: Powermate Model DF3500E, a multi-fuel portable generator.

77. Upon acquisition, disassembly as needed, review of owner's manuals and electrical schematics, and inspection, it was determined that the Powermate Model DF3500E generator includes all of the elements of at least claims 1-9 of U.S. Patent No. 11,306,667. The Powermate Model DF3500E generator infringes:

a. Independent claim 1 by specifically including a fuel selector for use with a dual fuel generator, the fuel selector a selector having a valve assembly fluidly connected to each of a first fuel source and a second fuel source, being operable to selectively control a first fuel flow and a second fuel flow from the first fuel source and the second fuel source, respectively, to an engine of the dual fuel generator, and including two fuel inputs, with a first fuel input connected to the first fuel source and a second fuel input connected to the second fuel source, and two fuel outputs for selectively supplying fuel to an engine from the first fuel source or the second fuel source; and a selector switch positioned on the valve assembly to allow a user to manually select one of the first fuel flow and the second fuel flow, as called for in claim 1 of U.S. Patent No. 11,306,667.

b. Dependent claim 2 by specifically including all the aforementioned elements of claim 1 and, in addition, the two fuel outputs selectively supply fuel to the engine from only one of the first fuel source or the second fuel source, responsive to selection of the first fuel flow or the second fuel flow via the selector switch, and a corresponding operation of the valve assembly, as called for in claim 2 of U.S. Patent No. 11,306,667.

c. Dependent claim 3 by specifically including all the aforementioned elements of claim 1 and, in addition, the valve assembly has a first fuel valve having open and closed positions to selectively control the first fuel flow to the engine and a second

fuel valve having open and closed positions to selectively control the second fuel flow to the engine, as called for in claim 3 of U.S. Patent No. 11,306,667.

d. Dependent claim 5 by specifically including all the aforementioned elements of claim 3 and, in addition, wherein the selector switch provides for manual actuation of the first fuel valve and the second fuel valve between the open and closed positions, as called for in claim 5 of U.S. Patent No. 11,306,667.

e. Dependent claim 6 by specifically including all the aforementioned elements of claim 1 and, in addition, a carburetor solenoid switch configured to activate an associated carburetor solenoid when actuated, as called for in claim 6 of U.S. Patent No. 11,306,667.

f. Dependent claim 7 by specifically including all the aforementioned elements of claim 6 and, in addition, wherein, when the selector switch is in a first position, the selector switch actuates the carburetor solenoid switch, so as to activate the carburetor solenoid and stop the second fuel flow to the engine, as called for in claim 7 of U.S. Patent No. 11,306,667.

g. Dependent claim 8 by specifically including all the aforementioned elements of claim 7 and, in addition, wherein, when the selector switch is in a second position, the carburetor solenoid allows the second fuel flow to the engine, as called for in claim 8 of U.S. Patent No. 11,306,667.

h. Dependent claim 9 by specifically including all the aforementioned elements of claim 1 and, in addition, the first fuel source is an LPG fuel source and wherein the second fuel source is a gasoline source, as called for in claim 9 of U.S. Patent No. 11,306,667.

Therefore, the Powermate Model DF3500E generator listed in Paragraph 76 infringes at least claims 1-9 of U.S. Patent No. 11,306,667.

78. Upon information and belief, Generac has been and is now making, using, selling, or offering for sale within the United States, or importing into the United States, the following additional generator model: Powermate Model DF7500E, a multi-fuel portable generator.

79. Upon review of the owner's manual of the Powermate Model DF7500E generator shared with the Powermate Model DF3500E generator, review of images and electrical schematics of the Powermate Model DF7500E generator, and comparison of the images and electrical schematics of the Powermate Model DF7500E generator to images and electrical schematics of the Powermate Model DF3500E generator listed in Paragraph 76, it was determined that the Powermate Model DF7500E generator includes all of the elements of at least claims 1-9 of U.S. Patent No. 11,306,667. The Powermate Model DF7500E generator infringes:

a. Independent claim 1 by specifically including a fuel selector for use with a dual fuel generator, the fuel selector a selector having a valve assembly fluidly connected to each of a first fuel source and a second fuel source, being operable to selectively control a first fuel flow and a second fuel flow from the first fuel source and the second fuel source, respectively, to an engine of the dual fuel generator, and including two fuel inputs, with a first fuel input connected to the first fuel source and a second fuel input connected to the second fuel source, and two fuel outputs for selectively supplying fuel to an engine from the first fuel source or the second fuel source; and a selector switch positioned on the valve assembly to allow a user to manually select one of the first fuel flow and the second fuel flow, as called for in claim 1 of U.S. Patent No. 11,306,667.

b. Dependent claim 2 by specifically including all the aforementioned elements of claim 1 and, in addition, the two fuel outputs selectively supply fuel to the engine from only one of the first fuel source or the second fuel source, responsive to selection of the first fuel flow or the second fuel flow via the selector switch, and a corresponding operation of the valve assembly, as called for in claim 2 of U.S. Patent No. 11,306,667.

c. Dependent claim 3 by specifically including all the aforementioned elements of claim 1 and, in addition, the valve assembly has a first fuel valve having open and closed positions to selectively control the first fuel flow to the engine and a second fuel valve having open and closed positions to selectively control the second fuel flow to the engine, as called for in claim 3 of U.S. Patent No. 11,306,667.

d. Dependent claim 5 by specifically including all the aforementioned elements of claim 3 and, in addition, wherein the selector switch provides for manual actuation of the first fuel valve and the second fuel valve between the open and closed positions, as called for in claim 5 of U.S. Patent No. 11,306,667.

e. Dependent claim 6 by specifically including all the aforementioned elements of claim 1 and, in addition, a carburetor solenoid switch configured to activate an associated carburetor solenoid when actuated, as called for in claim 6 of U.S. Patent No. 11,306,667.

f. Dependent claim 7 by specifically including all the aforementioned elements of claim 6 and, in addition, wherein, when the selector switch is in a first position, the selector switch actuates the carburetor solenoid switch, so as to activate the carburetor solenoid and stop the second fuel flow to the engine, as called for in claim 7 of U.S. Patent No. 11,306,667.

g. Dependent claim 8 by specifically including all the aforementioned elements of claim 7 and, in addition, wherein, when the selector switch is in a second position, the carburetor solenoid allows the second fuel flow to the engine, as called for in claim 8 of U.S. Patent No. 11,306,667.

h. Dependent claim 9 by specifically including all the aforementioned elements of claim 1 and, in addition, the first fuel source is an LPG fuel source and wherein the second fuel source is a gasoline source, as called for in claim 9 of U.S. Patent No. 11,306,667.

Therefore, the Powermate Model DF7500E generator listed in Paragraph 78 infringes at least claims 1-9 of U.S. Patent No. 11,306,667.

80. Champion has no adequate remedy at law against Generac's acts of infringement and will suffer irreparable harm unless Generac is preliminarily and permanently enjoined from its infringement of U.S. Patent No. 11,306,667.

81. Upon information and belief, Generac's infringement has been willful, deliberate, and with knowledge of Champion's rights under U.S. Patent No. 11,306,667.

82. Upon information and belief, at least as of July 7, 2020, and again on April 4, 2024, the dates Champion sent Generac cease and desist letters demanding the cessation of infringement by Generac of Champion's patents, Generac has monitored Champion's patents and published patent applications and had actual notice of all of Champion's patents and published patent applications as of their publication dates.

83. Generac, by way of its infringing activity, has caused and continues to cause Champion to suffer damages in an amount to be determined at trial.

COUNT VII: INFRINGEMENT OF U.S. PATENT NO. 11,492,985

84. Paragraphs 1 through 83 are incorporated by reference as if fully set forth herein.

85. U.S. Patent No. 11,492,985 is titled "OFF-BOARD FUEL REGULATOR FOR GENERATOR ENGINE." U.S. Patent No. 11,492,985 was duly and legally issued on November 8, 2022. A true and correct copy of U.S. Patent No. 11,492,985 is attached as Exhibit G.

86. Champion is the lawful assignee of the entire right, title, and interest in and to U.S. Patent No. 11,492,985 and possesses all rights of recovery under the patent, including the right to recover damages for past infringement.

87. Champion has acquired and inspected the following Generac generator models that Generac has been and is making, using, selling, or offering for sale within the United States, or importing into the United States, and that infringe one or more claims of U.S. Patent No. 11,492,985:

a. Powermate Model PM4500DF, a multi-fuel portable generator;

b. Powermate Model PM7500DF, a multi-fuel portable generator;

c. Generac Model GP7500E, a multi-fuel portable generator; and

d. Powermate Model DF3500E, a multi-fuel portable generator.

88. Upon acquisition, disassembly as needed, review of owner's manuals and electrical schematics, and inspection, it was determined that each of the foregoing Generac generator models includes all of the elements of at least claims 16 and 17 of U.S. Patent No. 11,492,985. Each of the foregoing Generac generator models infringes:

a. Independent claim 16 by specifically including a dual fuel generator and fuel delivery system having a dual fuel generator configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line; and a fuel regulator system located off board a dual fuel generator, including a primary pressure regulator coupled to a service valve of a pressurized fuel source, configured to regulate the gaseous fuel supplied from the pressurized fuel source in the first stage, the gaseous fuel regulated down to a first reduced pressure in the first stage and regulate the gaseous fuel output from the first stage in the second stage, the first reduced pressure gaseous fuel from the first stage being regulated down to a second reduced pressure in the second stage for delivery through the gaseous fuel line to operate the generator, wherein the fuel regulator system outputs gaseous fuel to the generator for operation of the engine at the second reduced pressure, as called for in claim 16 of U.S. Patent No. 11,492,985.

b. Dependent claim 17 by specifically including all the aforementioned elements of claim 16 and, in addition, wherein the primary and secondary pressure regulators are integral components of a dual stage pressure regulator, as called for in claim 17 of U.S. Patent No. 11,492,985.

Therefore, each of the foregoing Generac generator models listed in Paragraph 87(a)-(d) infringes at least claims 16 and 17 of U.S. Patent No. 11,492,985.

89. Upon information and belief, Generac has been and is now making, using, selling, or offering for sale within the United States, or importing into the United States, the following additional generator model: Powermate Model DF7500E, a multi-fuel portable generator.

90. Upon review of the owner's manual of the Powermate Model DF7500E generator shared with the Powermate Model DF3500E generator, review of images and electrical schematics of the Powermate Model DF7500E generator, and comparison of the images and electrical schematics of the Powermate Model DF7500E generator to images and electrical schematics of the Powermate Model DF3500E generator listed in Paragraph 87(d), it was determined that the Powermate Model DF7500E generator includes all of the elements of at least claims 16 and 17 of U.S. Patent No. 11,492,985. The Powermate Model DF7500E generator infringes:

a. Independent claim 16 by specifically including a dual fuel generator and fuel delivery system having a dual fuel generator configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line; and a fuel regulator system located off board a dual fuel generator, including a primary pressure regulator coupled to a service valve of a pressurized fuel source, configured to regulate the gaseous fuel supplied from the pressurized fuel source in the first stage, the gaseous fuel regulated down to a first reduced pressure in the first stage and regulate the gaseous fuel output from the first stage in the second stage, the first reduced pressure gaseous fuel from the first stage being regulated down to a second reduced pressure in the second stage for delivery through the gaseous fuel line to operate the generator, wherein the fuel regulator system outputs gaseous fuel to the generator for operation of the engine at the second reduced pressure, as called for in claim 16 of U.S. Patent No. 11,492,985.

b. Dependent claim 17 by specifically including all the aforementioned elements of claim 16 and, in addition, wherein the primary and secondary pressure regulators

are integral components of a dual stage pressure regulator, as called for in claim 17 of U.S. Patent No. 11,492,985.

Therefore, the Powermate Model DF7500E generator listed in Paragraph 89 infringes at least claims 16 and 17 of U.S. Patent No. 11,492,985.

91. Champion has no adequate remedy at law against Generac's acts of infringement and will suffer irreparable harm unless Generac is preliminarily and permanently enjoined from its infringement of U.S. Patent No. 11,492,985.

92. Upon information and belief, Generac's infringement has been willful, deliberate, and with knowledge of Champion's rights under U.S. Patent No. 11,492,985.

93. Upon information and belief, at least as of July 7, 2020, and again on April 4, 2024, the dates Champion sent Generac cease and desist letters demanding the cessation of infringement by Generac of Champion's patents, Generac has monitored Champion's patents and published patent applications and had actual notice of all of Champion's patents and published patent applications as of their publication dates.

94. Generac, by way of its infringing activity, has caused and continues to cause Champion to suffer damages in an amount to be determined at trial.

COUNT VIII: INFRINGEMENT OF U.S. PATENT NO. 11,530,654

95. Paragraphs 1 through 94 are incorporated by reference as if fully set forth herein.

96. U.S. Patent No. 11,530,654 is titled "OFF-BOARD FUEL REGULATOR FOR GENERATOR ENGINE." U.S. Patent No. 11,530,654 was duly and legally issued on December 20, 2022. A true and correct copy of U.S. Patent No. 11,530,654 is attached as Exhibit H.

97. Champion is the lawful assignee of the entire right, title, and interest in and to U.S. Patent No. 11,530,654 and possesses all rights of recovery under the patent, including the right to recover damages for past infringement.

98. Champion has acquired and inspected the following Generac generator models that Generac has been and is making, using, selling, or offering for sale within the United States, or

importing into the United States, and that infringe one or more claims of U.S. Patent No. 11,530,654:

a. Powermate Model PM4500DF, a multi-fuel portable generator;

b. Powermate Model PM7500DF, a multi-fuel portable generator;

c. Generac Model GP7500E, a multi-fuel portable generator; and

d. Powermate Model DF3500E, a multi-fuel portable generator.

99. Upon acquisition, disassembly as needed, review of owner's manuals and electrical schematics, and inspection, it was determined that each of the foregoing Generac generator models includes all of the elements of at least claims 6, 7, and 9 of U.S. Patent No. 11,530,654. Each of the foregoing Generac generator models infringes:

a. Independent claim 6 by specifically including a dual fuel generator and fuel delivery system having a dual fuel generator configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line, a fuel regulator system located off board the dual fuel generator and having a primary pressure regulator coupled to a service valve of a pressurized fuel source and configured to regulate a gaseous fuel supplied from the pressurized fuel source to a first reduced pressure and a secondary pressure regulator coupled to the primary pressure regulator and configured to regulate the gaseous fuel supplied from the primary pressure regulator down from the first reduced pressure to a second reduced pressure for delivery through a gaseous fuel line to operate the dual fuel generator, a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel generator from a liquid fuel source through a liquid fuel line and the pressurized fuel source through the gaseous fuel line and that opens and closes the liquid fuel line to selectively control fuel flow from the liquid fuel source to the dual fuel generator, and a fuel lockout apparatus coupled to the mechanical fuel valve and configured to prevent

the pressurized fuel source from coupling to the gaseous fuel line while the mechanical fuel valve opens the liquid fuel line and permit the pressurized fuel source to couple to the gaseous fuel line while the mechanical fuel valve closes the liquid fuel line, as called for in claim 6 of U.S. Patent No. 11,530,654.

b. Dependent claim 7 by specifically including all the aforementioned elements of claim 6 and, in addition, the fuel lockout apparatus is further configured to prevent the mechanical fuel valve from opening the liquid fuel line while the dual fuel generator receives fuel from the pressurized fuel source, as called for in claim 7 of U.S. Patent No. 11,530,654.

c. Dependent claim 9 by specifically including all the aforementioned elements of claim 6 and, in addition, wherein the primary and secondary pressure regulators are integral components of a dual stage pressure regulator, as called for in claim 7 of U.S. Patent No. 11,530,654.

Therefore, each of the foregoing Generac generator models listed in Paragraph 98(a)-(d) infringes at least claims 6, 7, and 9 of U.S. Patent No. 11,530,654.

100. Upon information and belief, Generac has been and is now making, using, selling, or offering for sale within the United States, or importing into the United States, the following additional generator model: Powermate Model DF7500E, a multi-fuel portable generator.

101. Upon review of the owner's manual of the Powermate Model DF7500E generator shared with the Powermate Model DF3500E generator, review of images and electrical schematics of the Powermate Model DF7500E generator, and comparison of the images and electrical schematics of the Powermate Model DF7500E generator to images and electrical schematics of the Powermate Model DF3500E generator listed in Paragraph 98(d), it was determined that the Powermate Model DF7500E generator includes all of the elements of at least claims 6, 7, and 9 of U.S. Patent No. 11,530,654. The Powermate Model DF7500E generator infringes:

a. Independent claim 6 by specifically including a dual fuel generator and fuel delivery system having a dual fuel generator configured to operate on a liquid fuel

supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line, a fuel regulator system located off board the dual fuel generator and having a primary pressure regulator coupled to a service valve of a pressurized fuel source and configured to regulate a gaseous fuel supplied from the pressurized fuel source to a first reduced pressure and a secondary pressure regulator coupled to the primary pressure regulator and configured to regulate the gaseous fuel supplied from the primary pressure regulator down from the first reduced pressure to a second reduced pressure for delivery through a gaseous fuel line to operate the dual fuel generator, a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel generator from a liquid fuel source through a liquid fuel line and the pressurized fuel source through the gaseous fuel line and that opens and closes the liquid fuel line to selectively control fuel flow from the liquid fuel source to the dual fuel generator, and a fuel lockout apparatus coupled to the mechanical fuel valve and configured to prevent the pressurized fuel source from coupling to the gaseous fuel line while the mechanical fuel valve opens the liquid fuel line and permit the pressurized fuel source to couple to the gaseous fuel line while the mechanical fuel valve closes the liquid fuel line, as called for in claim 6 of U.S. Patent No. 11,530,654.

b. Dependent claim 7 by specifically including all the aforementioned elements of claim 6 and, in addition, the fuel lockout apparatus is further configured to prevent the mechanical fuel valve from opening the liquid fuel line while the dual fuel generator receives fuel from the pressurized fuel source, as called for in claim 7 of U.S. Patent No. 11,530,654.

c. Dependent claim 9 by specifically including all the aforementioned elements of claim 6 and, in addition, wherein the primary and secondary pressure regulators

are integral components of a dual stage pressure regulator, as called for in claim 7 of U.S. Patent No. 11,530,654.

Therefore, the Powermate Model DF7500E generator listed in Paragraph 100 infringes at least claims 6, 7, and 9 of U.S. Patent No. 11,530,654.

102. Champion has no adequate remedy at law against Generac's acts of infringement and will suffer irreparable harm unless Generac is preliminarily and permanently enjoined from its infringement of U.S. Patent No. 11,530,654.

103. Upon information and belief, Generac's infringement has been willful, deliberate, and with knowledge of Champion's rights under U.S. Patent No. 11,530,654.

104. Upon information and belief, at least as of July 7, 2020, and again on April 4, 2024, the dates Champion sent Generac cease and desist letters demanding the cessation of infringement by Generac of Champion's patents, Generac has monitored Champion's patents and published patent applications and had actual notice of all of Champion's patents and published patent applications as of their publication dates.

105. Generac, by way of its infringing activity, has caused and continues to cause Champion to suffer damages in an amount to be determined at trial.

COUNT IX: INFRINGEMENT OF U.S. PATENT NO. 11,840,970

106. Paragraphs 1 through 105 are incorporated by reference as if fully set forth herein.

107. U.S. Patent No. 11,840,970 is titled "DUAL FUEL GENERATOR WITH REMOTE REGULATOR." U.S. Patent No. 11,840,970 was duly and legally issued on December 12, 2023. A true and correct copy of U.S. Patent No. 11,840,970 is attached as Exhibit I.

108. Champion is the lawful assignee of the entire right, title, and interest in and to U.S. Patent No. 11,840,970 and possesses all rights of recovery under the patent, including the right to recover damages for past infringement.

109. Champion has acquired and inspected the following Generac generator models that Generac has been and is making, using, selling, or offering for sale within the United States, or

importing into the United States, and that infringe one or more claims of U.S. Patent No. 11,840,970:

a. Powermate Model PM4500DF, a multi-fuel portable generator;

b. Powermate Model PM7500DF, a multi-fuel portable generator;

c. Generac Model GP7500E, a multi-fuel portable generator; and

d. Powermate Model DF3500E, a multi-fuel portable generator.

110. Upon acquisition, disassembly as needed, review of owner's manuals and electrical schematics, and inspection, it was determined that each of the foregoing Generac generator models includes all of the elements of at least claims 1-5, 11, 20-23, 25-27, and 33 of U.S. Patent No. 11,840,970. Each of the foregoing Generac generator models infringes:

a. Independent claim 1 by specifically including a dual fuel generator and fuel delivery system including a dual fuel generator having an engine configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line and a carburetor attached to an intake of the engine to mix air and fuel and connect the liquid fuel line to the intake; a fuel regulator system located off board the dual fuel generator, the fuel regulator system including a primary pressure regulator coupled to a service valve of the pressurized fuel source and configured to regulate the fuel supplied from the pressurized fuel source to a reduced pressure and a secondary pressure regulator coupled to the primary pressure regulator and configured to regulate the gaseous fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the dual fuel generator; and a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the engine from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line, as called for in claim 1 of U.S. Patent No. 11,840,970.

b. Dependent claim 2 by specifically including all the aforementioned elements of claim 1 and, in addition, the carburetor connects the gaseous fuel line to the intake, as called for in claim 2 of U.S. Patent No. 11,840,970.

c. Dependent claim 3 by specifically including all the aforementioned elements of claim 1 and, in addition, a fuel lockout apparatus coupled to the mechanical fuel valve; and wherein when the mechanical fuel valve is in the first position, the fuel lockout apparatus communicates the liquid fuel source to the dual fuel generator and prevents the pressurized fuel source from coupling to the dual fuel generator, and actuation of the mechanical fuel valve to the second position causes the fuel lockout apparatus to permit the pressurized fuel source to couple to the dual fuel generator, and interrupts the liquid fuel source communication with the dual fuel generator, as called for in claim 3 of U.S. Patent No. 11,840,970.

d. Dependent claim 4 by specifically including all the aforementioned elements of claim 1 and, in addition, the mechanical fuel valve opens and closes the liquid fuel line to selectively control fuel flow from the liquid fuel source to the dual fuel generator and a fuel lockout apparatus is coupled to the mechanical fuel valve and is configured to prevent the pressurized fuel source from coupling to the gaseous fuel line while the mechanical fuel valve opens the liquid fuel line and to permit the pressurized fuel source to couple to the gaseous fuel line while the mechanical fuel valve closes the liquid fuel line, as called for in claim 4 of U.S. Patent No. 11,840,970.

e. Dependent claim 5 by specifically including all the aforementioned elements of claim 4 and, in addition, the fuel lockout apparatus is further configured to prevent the mechanical fuel valve from opening the liquid fuel line while the dual fuel generator receives fuel from the pressurized fuel source, as called for in claim 5 of U.S. Patent No. 11,840,970.

f. Dependent claim 11 by specifically including all the aforementioned elements of claim 1 and, in addition, wherein the primary and secondary pressure regulators are integral components of a dual stage pressure regulator, as called for in claim 11 of U.S. Patent No. 11,840,970.

g. Independent claim 20 by specifically including a dual fuel generator and fuel delivery system comprising: a dual fuel generator configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line, the dual fuel generator comprising: a gaseous fuel valve coupled to an inlet of the gaseous fuel line and connectable to the pressurized fuel source, and a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel generator from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line; and a fuel regulator system located off board the dual fuel generator, the fuel regulator system comprising: a primary pressure regulator connectable to a service valve of the pressurized fuel source and configured to regulate the fuel supplied from the pressurized fuel source to a reduced pressure, and a secondary pressure regulator coupled to the primary pressure regulator and connectable to the gaseous fuel valve, the secondary pressure regulator configured to regulate the gaseous fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the dual fuel generator, as called for in claim 20 of U.S. Patent No. 11,840,970.

h. Dependent claim 21 by specifically including all the aforementioned elements of claim 20 and, in addition, wherein the pressurized fuel source is independent and disconnected from the dual fuel generator, as called for in claim 21 of U.S. Patent No. 11,840,970.

i. Dependent claim 22 by specifically including all the aforementioned elements of claim 21 and, in addition, wherein the fuel regulator system is disconnected from the dual fuel generator, as called for in claim 22 of U.S. Patent No. 11,840,970.

j. Dependent claim 23 by specifically including all the aforementioned elements of claim 21 and, in addition, wherein the primary pressure regulator is disconnected from the pressurized fuel source, as called for in claim 23 of U.S. Patent No. 11,840,970.

k. Dependent claim 25 by specifically including all the aforementioned elements of claim 20 and, in addition, a fuel lockout apparatus coupled to the mechanical fuel valve; and wherein when the mechanical fuel valve is in the first position, the fuel lockout apparatus communicates the liquid fuel source to the dual fuel generator and prevents the pressurized fuel source from coupling to the dual fuel generator, and actuation of the mechanical fuel valve to the second position causes the fuel lockout apparatus to permit the pressurized fuel source to couple to the dual fuel generator, and interrupts the liquid fuel source communication with the dual fuel generator, as called for in claim 25 of U.S. Patent No. 11,840,970.

l. Dependent claim 26 by specifically including all the aforementioned elements of claim 20 and, in addition, wherein the mechanical fuel valve opens and closes the liquid fuel line to selectively control fuel flow from the liquid fuel source to the dual fuel generator; and further comprises: a fuel lockout apparatus coupled to the mechanical fuel valve and configured to prevent the pressurize fuel source from coupling to the gaseous fuel line while the mechanical fuel valve opens the liquid fuel line, and permit the pressurized fuel source to couple to the gaseous fuel line while the mechanical fuel valve closes the liquid fuel line, as called for in claim 26 of U.S. Patent No. 11,840,970.

m. Dependent claim 27 by specifically including all the aforementioned elements of claim 26 and, in addition, wherein the fuel lockout apparatus is further configured

to prevent the mechanical fuel valve from opening the liquid fuel line while the dual fuel generator receives fuel from the pressurized fuel source, as called for in claim 27 of U.S. Patent No. 11,840,970.

n. Dependent claim 33 by specifically including all the aforementioned elements of claim 20 and, in addition, wherein the primary and secondary pressure regulators are integral components of a dual stage pressure regulator, as called for in claim 33 of U.S. Patent No. 11,840,970.

Therefore, each of the foregoing Generac generator models listed in Paragraph 109(a)-(d) infringes at least claims 1-5, 11, 20-23, 25-27, and 33 of U.S. Patent No. 11,840,970.

111. Upon information and belief, Generac has been and is now making, using, selling, or offering for sale within the United States, or importing into the United States, the following additional generator model: Powermate Model DF7500E, a multi-fuel portable generator.

112. Upon review of the owner's manual of the Powermate Model DF7500E generator shared with the Powermate Model DF3500E generator, review of images and electrical schematics of the Powermate Model DF7500E generator, and comparison of the images and electrical schematics of the Powermate Model DF7500E generator to images and electrical schematics of the Powermate Model DF3500E generator listed in Paragraph 109(d), it was determined that the Powermate Model DF7500E generator includes all of the elements of at least claims 1-5, 11, 20-23, 25-27, and 33 of U.S. Patent No. 11,840,970. The Powermate Model DF7500E generator infringes:

a. Independent claim 1 by specifically including a dual fuel generator and fuel delivery system including a dual fuel generator having an engine configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line and a carburetor attached to an intake of the engine to mix air and fuel and connect the liquid fuel line to the intake; a fuel regulator system located off board the dual fuel generator, the fuel regulator system including a primary

pressure regulator coupled to a service valve of the pressurized fuel source and configured to regulate the fuel supplied from the pressurized fuel source to a reduced pressure and a secondary pressure regulator coupled to the primary pressure regulator and configured to regulate the gaseous fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the dual fuel generator; and a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the engine from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line, as called for in claim 1 of U.S. Patent No. 11,840,970.

b. Dependent claim 2 by specifically including all the aforementioned elements of claim 1 and, in addition, the carburetor connects the gaseous fuel line to the intake, as called for in claim 2 of U.S. Patent No. 11,840,970.

c. Dependent claim 3 by specifically including all the aforementioned elements of claim 1 and, in addition, a fuel lockout apparatus coupled to the mechanical fuel valve; and wherein when the mechanical fuel valve is in the first position, the fuel lockout apparatus communicates the liquid fuel source to the dual fuel generator and prevents the pressurized fuel source from coupling to the dual fuel generator, and actuation of the mechanical fuel valve to the second position causes the fuel lockout apparatus to permit the pressurized fuel source to couple to the dual fuel generator, and interrupts the liquid fuel source communication with the dual fuel generator, as called for in claim 3 of U.S. Patent No. 11,840,970.

d. Dependent claim 4 by specifically including all the aforementioned elements of claim 1 and, in addition, the mechanical fuel valve opens and closes the liquid fuel line to selectively control fuel flow from the liquid fuel source to the dual fuel generator and a fuel lockout apparatus is coupled to the mechanical fuel valve and is configured to prevent the pressurized fuel source from coupling to the gaseous

fuel line while the mechanical fuel valve opens the liquid fuel line and to permit the pressurized fuel source to couple to the gaseous fuel line while the mechanical fuel valve closes the liquid fuel line, as called for in claim 4 of U.S. Patent No. 11,840,970.

e. Dependent claim 5 by specifically including all the aforementioned elements of claim 4 and, in addition, the fuel lockout apparatus is further configured to prevent the mechanical fuel valve from opening the liquid fuel line while the dual fuel generator receives fuel from the pressurized fuel source, as called for in claim 5 of U.S. Patent No. 11,840,970.

f. Dependent claim 11 by specifically including all the aforementioned elements of claim 1 and, in addition, wherein the primary and secondary pressure regulators are integral components of a dual stage pressure regulator, as called for in claim 11 of U.S. Patent No. 11,840,970.

g. Independent claim 20 by specifically including a dual fuel generator and fuel delivery system comprising: a dual fuel generator configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line, the dual fuel generator comprising: a gaseous fuel valve coupled to an inlet of the gaseous fuel line and connectable to the pressurized fuel source, and a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel generator from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line; and a fuel regulator system located off board the dual fuel generator, the fuel regulator system comprising: a primary pressure regulator connectable to a service valve of the pressurized fuel source and configured to regulate the fuel supplied from the pressurized fuel source to a reduced pressure, and a secondary pressure regulator coupled to the primary pressure regulator and connectable to the gaseous fuel

valve, the secondary pressure regulator configured to regulate the gaseous fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the dual fuel generator, as called for in claim 20 of U.S. Patent No. 11,840,970.

h. Dependent claim 21 by specifically including all the aforementioned elements of claim 20 and, in addition, wherein the pressurized fuel source is independent and disconnected from the dual fuel generator, as called for in claim 21 of U.S. Patent No. 11,840,970.

i. Dependent claim 22 by specifically including all the aforementioned elements of claim 21 and, in addition, wherein the fuel regulator system is disconnected from the dual fuel generator, as called for in claim 22 of U.S. Patent No. 11,840,970.

j. Dependent claim 23 by specifically including all the aforementioned elements of claim 21 and, in addition, wherein the primary pressure regulator is disconnected from the pressurized fuel source, as called for in claim 23 of U.S. Patent No. 11,840,970.

k. Dependent claim 25 by specifically including all the aforementioned elements of claim 20 and, in addition, a fuel lockout apparatus coupled to the mechanical fuel valve; and wherein when the mechanical fuel valve is in the first position, the fuel lockout apparatus communicates the liquid fuel source to the dual fuel generator and prevents the pressurized fuel source from coupling to the dual fuel generator, and actuation of the mechanical fuel valve to the second position causes the fuel lockout apparatus to permit the pressurized fuel source to couple to the dual fuel generator, and interrupts the liquid fuel source communication with the dual fuel generator, as called for in claim 25 of U.S. Patent No. 11,840,970.

l. Dependent claim 26 by specifically including all the aforementioned elements of claim 20 and, in addition, wherein the mechanical fuel valve opens and closes the liquid fuel line to selectively control fuel flow from the liquid fuel source to the

dual fuel generator; and further comprises: a fuel lockout apparatus coupled to the mechanical fuel valve and configured to prevent the pressurize fuel source from coupling to the gaseous fuel line while the mechanical fuel valve opens the liquid fuel line, and permit the pressurized fuel source to couple to the gaseous fuel line while the mechanical fuel valve closes the liquid fuel line, as called for in claim 26 of U.S. Patent No. 11,840,970.

m. Dependent claim 27 by specifically including all the aforementioned elements of claim 26 and, in addition, wherein the fuel lockout apparatus is further configured to prevent the mechanical fuel valve from opening the liquid fuel line while the dual fuel generator receives fuel from the pressurized fuel source, as called for in claim 27 of U.S. Patent No. 11,840,970.

n. Dependent claim 33 by specifically including all the aforementioned elements of claim 20 and, in addition, wherein the primary and secondary pressure regulators are integral components of a dual stage pressure regulator, as called for in claim 33 of U.S. Patent No. 11,840,970.

Therefore, the Powermate Model DF7500E generator listed in Paragraph 111 infringes at least claims 1-5, 11, 20-23, 25-27, and 33 of U.S. Patent No. 11,840,970.

113. Champion has no adequate remedy at law against Generac's acts of infringement and will suffer irreparable harm unless Generac is preliminarily and permanently enjoined from its infringement of U.S. Patent No. 11,840,970.

114. Upon information and belief, Generac's infringement has been willful, deliberate, and with knowledge of Champion's rights under U.S. Patent No. 11,840,970.

115. Upon information and belief, at least as of July 7, 2020, and again on April 4, 2024, the dates Champion sent Generac cease and desist letters demanding the cessation of infringement by Generac of Champion's patents, Generac has monitored Champion's patents and published patent applications and had actual notice of all of Champion's patents and published patent applications as of their publication dates.

116. Generac, by way of its infringing activity, has caused and continues to cause Champion to suffer damages in an amount to be determined at trial.

COUNT X: INFRINGEMENT OF U.S. PATENT NO. 11,905,895

117. Paragraphs 1 through 116 are incorporated by reference as if fully set forth herein.

118. U.S. Patent No. 11,905,895 is titled "DUAL FUEL LOCKOUT SWITCH FOR GENERATOR ENGINE." U.S. Patent No. 11,905,895 was duly and legally issued on February 20, 2024. A true and correct copy of U.S. Patent No. 11,905,895 is attached as Exhibit J.

119. Champion is the lawful assignee of the entire right, title, and interest in and to U.S. Patent No. 11,905,895 and possesses all rights of recovery under the patent, including the right to recover damages for past infringement.

120. Champion has acquired and inspected the following Generac generator models that Generac has been and is making, using, selling, or offering for sale within the United States, or importing into the United States, and that infringe one or more claims of U.S. Patent No. 11,905,895:

a. Powermate Model PM4500DF, a multi-fuel portable generator;

b. Powermate Model PM7500DF, a multi-fuel portable generator;

c. Generac Model GP7500E, a multi-fuel portable generator; and

d. Powermate Model DF3500E, a multi-fuel portable generator.

121. Upon acquisition, disassembly as needed, review of owner's manuals and electrical schematics, and inspection, it was determined that each of the foregoing Generac generator models includes all of the elements of at least claims 1, 2, 6-8, 12-15, and 21 of U.S. Patent No. 11,905,895. Each of the foregoing Generac generator models infringes:

a. Independent claim 1 by specifically including a mechanical fuel lockout switch for a dual fuel engine having a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel engine from a first fuel source through a first fuel line and a second fuel source through a second fuel line, the mechanical fuel valve configured to allow

communication between the first fuel source and the dual fuel engine and prevent communication between the second fuel source and the dual fuel engine while in the first position and prevent communication between the first fuel source and the dual fuel engine while in the second position; and a fuel lockout apparatus coupled to the mechanical fuel valve and configured to prevent the second fuel source from coupling to the second fuel line while the mechanical fuel valve is in the first position and permit the second fuel source to couple to the second fuel line while the mechanical fuel valve is in the second position, as called for in claim 1 of U.S. Patent No. 11,905,895.

b. Dependent claim 2 by specifically including all the aforementioned elements of claim 1 and, in addition, the fuel lockout apparatus prevents actuation of the mechanical fuel valve to the first position when the second fuel source is in communication with the dual fuel engine, as called for in claim 2 of U.S. Patent No. 11,905,895.

c. Dependent claim 6 by specifically including all the aforementioned elements of claim 1 and, in addition, the mechanical fuel valve and the fuel lockout apparatus operate together to ensure that fuel from the first fuel source and fuel from the second fuel source are not simultaneously delivered to the dual fuel engine, as called for in claim 6 of U.S. Patent No. 11,905,895.

d. Dependent claim 7 by specifically including all the aforementioned elements of claim 6 and, in addition, wherein the mechanical fuel valve is configured to: provide liquid fuel from a liquid fuel tank of the first fuel source to the dual fuel engine while in the first position, and provide gaseous fuel from a pressurized fuel container of the second fuel source to the dual fuel engine while in the second position, as called for in claim 7 of U.S. Patent No. 11,905,895.

e. Independent claim 8 by specifically including a mechanical fuel lockout switch for a dual fuel engine having a mechanical fuel valve actuatable between a first

position and a second position to selectively control fuel flow to the dual fuel engine from a first fuel source through a first fuel line and a second fuel source through a second fuel line, the mechanical fuel valve configured to allow communication between the first fuel source and the dual fuel engine and prevent communication between the second fuel source and the dual fuel engine while the first position and prevent communication between the first fuel source and the dual fuel engine while in the second position; and a fuel lockout apparatus coupled to the mechanical fuel valve and configured to prevent actuation of the mechanical fuel valve to the first position when the second fuel source is in communication with the dual fuel engine, as called for in claim 8 of U.S. Patent No. 11,905,895.

f. Dependent claim 12 by specifically including all the aforementioned elements of claim 8 and, in addition, the mechanical fuel valve and the fuel lockout apparatus operate together to ensure that fuel from the first fuel source and fuel from the second fuel source are not simultaneously delivered to the dual fuel engine, as called for in claim 12 of U.S. Patent No. 11,905,895.

g. Dependent claim 13 by specifically including all the aforementioned elements of claim 12 and, in addition, wherein the mechanical fuel valve is configured to: provide liquid fuel from a liquid fuel tank of the first fuel source to the dual fuel engine while in the first position, and provide gaseous fuel from a pressurized fuel container of the second fuel source to the dual fuel engine while in the second position, as called for in claim 13 of U.S. Patent No. 11,905,895.

h. Independent claim 14 by specifically including a dual fuel generator and fuel delivery system having a dual fuel generator configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line; a fuel regulator system located off board the dual fuel generator, the fuel regulator system including a primary pressure regulator couplable to a service valve of the

pressurized fuel source and configured to regulate the gaseous fuel supplied from the pressurized fuel source to a reduced pressure and a secondary pressure regulator couplable to the primary pressure regulator and configured to regulate the gaseous fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the dual fuel generator; a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel generator from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line, the mechanical fuel valve configured to open and close the liquid fuel line to selectively control fuel flow from the liquid fuel source to the dual fuel generator; and a fuel lockout apparatus coupled to the mechanical fuel valve and configured to prevent the pressurized fuel source from coupling to the gaseous fuel line while the liquid fuel line is open and permit the pressurized fuel source to couple to the gaseous fuel line while the liquid fuel line is closed by the mechanical fuel valve, as called for in claim 14 of U.S. Patent No. 11,905,895.

i. Dependent claim 15 by specifically including all the aforementioned elements of claim 14 and, in addition, the fuel lockout apparatus is further configured to prevent the mechanical fuel valve from opening the liquid fuel line while the fuel regulator system is coupled to the gaseous fuel line, as called for in claim 15 of U.S. Patent No. 11,905,895.

j. Dependent claim 21 by specifically including all the aforementioned elements of claim 14 and, in addition, wherein: the fuel regulator system comprises a dual stage pressure regulator; and the primary and secondary pressure regulators are integral components of the dual stage pressure regulator, as called for in claim 21 of U.S. Patent No. 11,905,895.

Therefore, each of the foregoing Generac generator models listed in Paragraph 120(a)-(d) infringes at least claims 1, 2, 6-8, 12-15 and 21 of U.S. Patent No. 11,905,895.

122. Upon information and belief, Generac has been and is now making, using, selling, or offering for sale within the United States, or importing into the United States, the following additional generator model: Powermate Model DF7500E, a multi-fuel portable generator.

123. Upon review of the owner's manual of the Powermate Model DF7500E generator shared with the Powermate Model DF3500E generator, review of images and electrical schematics of the Powermate Model DF7500E generator, and comparison of the images and electrical schematics of the Powermate Model DF7500E generator to images and electrical schematics of the Powermate Model DF3500E generator listed in Paragraph 120(d), it was determined that the Powermate Model DF7500E generator includes all of the elements of at least claims 1, 2, 6-8, 12-15 and 21 of U.S. Patent No. 11,905,895. The Powermate Model DF7500E generator infringes:

a. Independent claim 1 by specifically including a mechanical fuel lockout switch for a dual fuel engine having a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel engine from a first fuel source through a first fuel line and a second fuel source through a second fuel line, the mechanical fuel valve configured to allow communication between the first fuel source and the dual fuel engine and prevent communication between the second fuel source and the dual fuel engine while in the first position and prevent communication between the first fuel source and the dual fuel engine while in the second position; and a fuel lockout apparatus coupled to the mechanical fuel valve and configured to prevent the second fuel source from coupling to the second fuel line while the mechanical fuel valve is in the first position and permit the second fuel source to couple to the second fuel line while the mechanical fuel valve is in the second position, as called for in claim 1 of U.S. Patent No. 11,905,895.

b. Dependent claim 2 by specifically including all the aforementioned elements of claim 1 and, in addition, the fuel lockout apparatus prevents actuation of the mechanical fuel valve to the first position when the second fuel source is in

communication with the dual fuel engine, as called for in claim 2 of U.S. Patent No. 11,905,895.

c. Dependent claim 6 by specifically including all the aforementioned elements of claim 1 and, in addition, the mechanical fuel valve and the fuel lockout apparatus operate together to ensure that fuel from the first fuel source and fuel from the second fuel source are not simultaneously delivered to the dual fuel engine, as called for in claim 6 of U.S. Patent No. 11,905,895.

d. Dependent claim 7 by specifically including all the aforementioned elements of claim 6 and, in addition, wherein the mechanical fuel valve is configured to: provide liquid fuel from a liquid fuel tank of the first fuel source to the dual fuel engine while in the first position, and provide gaseous fuel from a pressurized fuel container of the second fuel source to the dual fuel engine while in the second position, as called for in claim 7 of U.S. Patent No. 11,905,895.

e. Independent claim 8 by specifically including a mechanical fuel lockout switch for a dual fuel engine having a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel engine from a first fuel source through a first fuel line and a second fuel source through a second fuel line, the mechanical fuel valve configured to allow communication between the first fuel source and the dual fuel engine and prevent communication between the second fuel source and the dual fuel engine while the first position and prevent communication between the first fuel source and the dual fuel engine while in the second position; and a fuel lockout apparatus coupled to the mechanical fuel valve and configured to prevent actuation of the mechanical fuel valve to the first position when the second fuel source is in communication with the dual fuel engine, as called for in claim 8 of U.S. Patent No. 11,905,895.

f. Dependent claim 12 by specifically including all the aforementioned elements of claim 8 and, in addition, the mechanical fuel valve and the fuel lockout apparatus

operate together to ensure that fuel from the first fuel source and fuel from the second fuel source are not simultaneously delivered to the dual fuel engine, as called for in claim 12 of U.S. Patent No. 11,905,895.

g. Dependent claim 13 by specifically including all the aforementioned elements of claim 12 and, in addition, wherein the mechanical fuel valve is configured to: provide liquid fuel from a liquid fuel tank of the first fuel source to the dual fuel engine while in the first position, and provide gaseous fuel from a pressurized fuel container of the second fuel source to the dual fuel engine while in the second position, as called for in claim 13 of U.S. Patent No. 11,905,895.

h. Independent claim 14 by specifically including a dual fuel generator and fuel delivery system having a dual fuel generator configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line; a fuel regulator system located off board the dual fuel generator, the fuel regulator system including a primary pressure regulator couplable to a service valve of the pressurized fuel source and configured to regulate the gaseous fuel supplied from the pressurized fuel source to a reduced pressure and a secondary pressure regulator couplable to the primary pressure regulator and configured to regulate the gaseous fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the dual fuel generator; a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel generator from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line, the mechanical fuel valve configured to open and close the liquid fuel line to selectively control fuel flow from the liquid fuel source to the dual fuel generator; and a fuel lockout apparatus coupled to the mechanical fuel valve and configured to prevent the pressurized fuel source from coupling to the gaseous

fuel line while the liquid fuel line is open and permit the pressurized fuel source to couple to the gaseous fuel line while the liquid fuel line is closed by the mechanical fuel valve, as called for in claim 14 of U.S. Patent No. 11,905,895.

i. Dependent claim 15 by specifically including all the aforementioned elements of claim 14 and, in addition, the fuel lockout apparatus is further configured to prevent the mechanical fuel valve from opening the liquid fuel line while the fuel regulator system is coupled to the gaseous fuel line, as called for in claim 15 of U.S. Patent No. 11,905,895.

j. Dependent claim 21 by specifically including all the aforementioned elements of claim 14 and, in addition, wherein: the fuel regulator system comprises a dual stage pressure regulator; and the primary and secondary pressure regulators are integral components of the dual stage pressure regulator, as called for in claim 21 of U.S. Patent No. 11,905,895.

Therefore, the Powermate Model DF7500E generator listed in Paragraph 122 infringes at least claims 1, 2, 6-8, 12-15 and 21 of U.S. Patent No. 11,905,895.

124. Champion has no adequate remedy at law against Generac's acts of infringement and will suffer irreparable harm unless Generac is preliminarily and permanently enjoined from its infringement of U.S. Patent No. 11,905,895.

125. Upon information and belief, Generac's infringement has been willful, deliberate, and with knowledge of Champion's rights under U.S. Patent No. 11,905,895.

126. Upon information and belief, at least as of July 7, 2020, and again on April 4, 2024, the dates Champion sent Generac cease and desist letters demanding the cessation of infringement by Generac of Champion's patents, Generac has monitored Champion's patents and published patent applications and had actual notice of all of Champion's patents and published patent applications as of their publication dates.

127. Generac, by way of its infringing activity, has caused and continues to cause Champion to suffer damages in an amount to be determined at trial.

COUNT XI: INFRINGEMENT OF U.S. PATENT NO. 11,905,896

128. Paragraphs 1 through 127 are incorporated by reference as if fully set forth herein.

129. U.S. Patent No. 11,905,896 is titled "DUAL FUEL SELECTOR SWITCH." U.S. Patent No. 11,905,896 was duly and legally issued on February 20, 2024. A true and correct copy of U.S. Patent No. 11,905,896 is attached as Exhibit K.

130. Champion is the lawful assignee of the entire right, title, and interest in and to U.S. Patent No. 11,905,896 and possesses all rights of recovery under the patent, including the right to recover damages for past infringement.

131. Champion has acquired and inspected the following Generac generator models that Generac has been and is making, using, selling, or offering for sale within the United States, or importing into the United States, and that infringe one or more claims of U.S. Patent No. 11,905,896:

a. Powermate Model PM4500DF, a multi-fuel portable generator;

b. Powermate Model PM7500DF, a multi-fuel portable generator; and

c. Generac Model GP7500E, a multi-fuel portable generator.

132. Upon acquisition, disassembly as needed, review of owner's manuals and electrical schematics, and inspection, it was determined that each of the foregoing Generac generator models includes all of the elements of at least claims 7, 8, 14-16, 30-32, 34, and 35 of U.S. Patent No. 11,905,896. Each of the foregoing Generac generator models infringes:

a. Independent claim 7 by specifically including a fuel selector for use with a dual fuel generator, the fuel selector comprising: a valve assembly fluidly couplable to each of a first fuel source and a second fuel source and operable to selectively control a first fuel flow and a second fuel flow from the first fuel source and the second fuel source, respectively, to an engine of the dual fuel generator, the valve assembly comprising: a first mechanical fuel valve having open and closed positions to selectively control the first fuel flow to the engine; and a second mechanical fuel valve having open and closed positions to selectively control the

second fuel flow to the engine; and a selector switch movable with respect to the valve assembly to allow a user to manually select the first fuel flow or the second fuel flow, as called for in claim 7 of U.S. Patent No. 11,905,896.

b. Dependent claim 8 by specifically including all the aforementioned elements of claim 7 and, in addition, wherein the selector switch provides for manual actuation of the first fuel valve and the second fuel valve between the open and closed positions, as called for in claim 8 of U.S. Patent No. 11,905,896.

c. Dependent claim 14 by specifically including all the aforementioned elements of claim 7 and, in addition, wherein: the first fuel valve is couplable to a liquefied petroleum gas (LPG) fuel source; and the second fuel valve is couplable to a gasoline source, as called for in claim 14 of U.S. Patent No. 11,905,896.

d. Independent claim 15 by specifically including a fuel selector for use with a dual fuel generator, the fuel selector comprising: a valve assembly fluidly couplable to each of a first fuel source and a second fuel source and operable to selectively control a first fuel flow and a second fuel flow from the first fuel source and the second fuel source, respectively, to an engine of the dual fuel generator, the valve assembly comprising: a first fuel valve having open and closed positions to selectively control the first fuel flow to the engine; and a second fuel valve having open and closed positions to selectively control the second fuel flow to the engine; and at least one valve handle mechanically coupled to the first fuel valve and the second fuel valve to selectively open and close the first fuel valve and the second fuel valve responsive to actuation thereof so as to enable the first fuel flow to the engine or the second fuel flow to the engine, as called for in claim 15 of U.S. Patent No. 11,905,896.

e. Dependent claim 16 by specifically including the all the aforementioned elements of claim 15 and, in addition, wherein the at least one valve handle enables only

one of the first and second fuel flows to the engine at a given time, as called for in claim 36 of U.S. Patent No. 11,905,896.

f. Independent claim 30 by specifically including a fuel selector for use with a dual fuel generator, the fuel selector comprising: a valve assembly fluidly couplable to each of a first fuel source and a second fuel source and operable to selectively control a first fuel flow and a second fuel flow from the first fuel source and the second fuel source, respectively, to an engine of the dual fuel generator, the valve assembly comprising: two fuel inputs comprising: a first fuel input couplable to the first fuel source; and a second fuel input couplable to the second fuel source; and two fuel outputs configured to selectively supply fuel to the engine from the first fuel source or the second fuel source; and a selector switch positioned on the valve assembly to allow a user to manually select the first fuel flow or the second fuel flow, as called for in claim 30 of U.S. Patent No. 11,905,896.

g. Dependent claim 31 by specifically including all the aforementioned elements of claim 30 and, in addition, wherein the two fuel outputs are configured to selectively supply fuel to the engine from only one of the first and second fuel sources responsive to selection of the first fuel flow or the second fuel flow via the selector switch and a corresponding operation of the valve assembly, as called for in claim 31 of U.S. Patent No. 11,905,896.

h. Dependent claim 32 by specifically including all the aforementioned elements of claim 30 and, in addition, wherein the valve assembly comprises: a first fuel valve having open and closed positions to selectively control the first fuel flow to the engine; and a second fuel valve having open and closed positions to selectively control the second fuel flow to the engine, as called for in claim 32 of U.S. Patent No. 11,905,896.

i. Dependent claim 34 by specifically including all the aforementioned elements of claim 32 and, in addition, wherein the first fuel valve and the second fuel valve

are non-solenoid, mechanical valves, as called for in claim 34 of U.S. Patent No. 11,905,896.

j. Dependent claim 35 by specifically including all the aforementioned elements of claim 32 and, in addition, wherein the selector switch provides for manual actuation of the first fuel valve and the second fuel valve between the open and closed positions, as called for in claim 35 of U.S. Patent No. 11,905,896.

Therefore, each of the Generac generator models listed in Paragraph 131(a)-(c) infringes at least claims 7, 8, 14-16, 30-32, 34, and 35 of U.S. Patent No. 11,905,896.

133. Champion has acquired and inspected the following Generac generator models that Generac has been and is making, using, selling, or offering for sale within the United States, or importing into the United States, and that infringe one or more claims of U.S. Patent No. 11,905,896: Powermate Model DF3500E, a multi-fuel portable generator.

134. Upon acquisition, disassembly as needed, review of owner's manuals and electrical schematics, and inspection, it was determined that the Powermate Model DF3500E generator includes all of the elements of at least claims 7, 8, 14-16, and 34-38 of U.S. Patent No. 11,905,896. The Powermate Model DF3500E generator infringes:

a. Independent claim 7 by specifically including a fuel selector for use with a dual fuel generator, the fuel selector comprising: a valve assembly fluidly couplable to each of a first fuel source and a second fuel source and operable to selectively control a first fuel flow and a second fuel flow from the first fuel source and the second fuel source, respectively, to an engine of the dual fuel generator, the valve assembly comprising: a first mechanical fuel valve having open and closed positions to selectively control the first fuel flow to the engine; and a second mechanical fuel valve having open and closed positions to selectively control the second fuel flow to the engine; and a selector switch movable with respect to the valve assembly to allow a user to manually select the first fuel flow or the second fuel flow, as called for in claim 7 of U.S. Patent No. 11,905,896.

b. Dependent claim 8 by specifically including all the aforementioned elements of claim 7 and, in addition, wherein the selector switch provides for manual actuation of the first fuel valve and the second fuel valve between the open and closed positions, as called for in claim 8 of U.S. Patent No. 11,905,896.

c. Dependent claim 14 by specifically including all the aforementioned elements of claim 7 and, in addition, wherein: the first fuel valve is couplable to a liquefied petroleum gas (LPG) fuel source; and the second fuel valve is couplable to a gasoline source, as called for in claim 14 of U.S. Patent No. 11,905,896.

d. Independent claim 15 by specifically including a fuel selector for use with a dual fuel generator, the fuel selector comprising: a valve assembly fluidly couplable to each of a first fuel source and a second fuel source and operable to selectively control a first fuel flow and a second fuel flow from the first fuel source and the second fuel source, respectively, to an engine of the dual fuel generator, the valve assembly comprising: a first fuel valve having open and closed positions to selectively control the first fuel flow to the engine; and a second fuel valve having open and closed positions to selectively control the second fuel flow to the engine; and at least one valve handle mechanically coupled to the first fuel valve and the second fuel valve to selectively open and close the first fuel valve and the second fuel valve responsive to actuation thereof so as to enable the first fuel flow to the engine or the second fuel flow to the engine, as called for in claim 15 of U.S. Patent No. 11,905,896.

e. Dependent claim 16 by specifically including the all the aforementioned elements of claim 15 and, in addition, wherein the at least one valve handle enables only one of the first and second fuel flows to the engine at a given time, as called for in claim 36 of U.S. Patent No. 11,905,896.

f. Independent claim 30 by specifically including a fuel selector for use with a dual fuel generator, the fuel selector comprising: a valve assembly fluidly couplable to

each of a first fuel source and a second fuel source and operable to selectively control a first fuel flow and a second fuel flow from the first fuel source and the second fuel source, respectively, to an engine of the dual fuel generator, the valve assembly comprising: two fuel inputs comprising: a first fuel input couplable to the first fuel source; and a second fuel input couplable to the second fuel source; and two fuel outputs configured to selectively supply fuel to the engine from the first fuel source or the second fuel source; and a selector switch positioned on the valve assembly to allow a user to manually select the first fuel flow or the second fuel flow, as called for in claim 30 of U.S. Patent No. 11,905,896.

g. Dependent claim 31 by specifically including all the aforementioned elements of claim 30 and, in addition, wherein the two fuel outputs are configured to selectively supply fuel to the engine from only one of the first and second fuel sources responsive to selection of the first fuel flow or the second fuel flow via the selector switch and a corresponding operation of the valve assembly, as called for in claim 31 of U.S. Patent No. 11,905,896.

h. Dependent claim 32 by specifically including all the aforementioned elements of claim 30 and, in addition, wherein the valve assembly comprises: a first fuel valve having open and closed positions to selectively control the first fuel flow to the engine; and a second fuel valve having open and closed positions to selectively control the second fuel flow to the engine, as called for in claim 32 of U.S. Patent No. 11,905,896.

i. Dependent claim 34 by specifically including all the aforementioned elements of claim 32 and, in addition, wherein the first fuel valve and the second fuel valve are non-solenoid, mechanical valves, as called for in claim 34 of U.S. Patent No. 11,905,896.

j. Dependent claim 35 by specifically including all the aforementioned elements of claim 32 and, in addition, wherein the selector switch provides for manual

actuation of the first fuel valve and the second fuel valve between the open and closed positions, as called for in claim 35 of U.S. Patent No. 11,905,896.

k. Dependent claim 36 by specifically including all the aforementioned elements of claim 30 and, in addition, a carburetor solenoid switch configured to activate an associated carburetor solenoid when actuated, as called for in claim 36 of U.S. Patent No. 11,905,896.

l. Dependent claim 37 by specifically including all the aforementioned elements of claim 36 and, in addition, wherein, when the selector switch is in a first position, the selector switch actuates the carburetor solenoid switch so as to activate the carburetor solenoid and prohibit the second fuel flow to the engine, as called for in claim 37 of U.S. Patent No. 11,905,896.

m. Dependent claim 38 by specifically including all the aforementioned elements of claim 37 and, in addition, wherein, when the selector switch is in a second position, the carburetor solenoid allows the second fuel flow to the engine, as called for in claim 38 of U.S. Patent No. 11,905,896.

Therefore, the Powermate Model DF3500E generator listed in Paragraph 133 infringes at least claims 7, 8, 14-16, 30-32, and 34-38 of U.S. Patent No. 11,905,896.

135. Upon information and belief, Generac has been and is now making, using, selling, or offering for sale within the United States, or importing into the United States, the following additional generator model: Powermate Model DF7500E, a multi-fuel portable generator.

136. Upon review of the owner's manual of the Powermate Model DF7500E generator shared with the Powermate Model DF3500E generator, review of images and electrical schematics of the Powermate Model DF7500E generator, and comparison of the images and electrical schematics of the Powermate Model DF7500E generator to images and electrical schematics of the Powermate Model DF3500E generator listed in Paragraph 133, it was determined that the Powermate Model DF7500E generator includes all of the elements of at least claims 7, 8, 14-16,

30-32, and 34-38 of U.S. Patent No. 11,905,896. The Powermate Model DF7500E generator infringes:

a. Independent claim 7 by specifically including a fuel selector for use with a dual fuel generator, the fuel selector comprising: a valve assembly fluidly couplable to each of a first fuel source and a second fuel source and operable to selectively control a first fuel flow and a second fuel flow from the first fuel source and the second fuel source, respectively, to an engine of the dual fuel generator, the valve assembly comprising: a first mechanical fuel valve having open and closed positions to selectively control the first fuel flow to the engine; and a second mechanical fuel valve having open and closed positions to selectively control the second fuel flow to the engine; and a selector switch movable with respect to the valve assembly to allow a user to manually select the first fuel flow or the second fuel flow, as called for in claim 7 of U.S. Patent No. 11,905,896.

b. Dependent claim 8 by specifically including all the aforementioned elements of claim 7 and, in addition, wherein the selector switch provides for manual actuation of the first fuel valve and the second fuel valve between the open and closed positions, as called for in claim 8 of U.S. Patent No. 11,905,896.

c. Dependent claim 14 by specifically including all the aforementioned elements of claim 7 and, in addition, wherein: the first fuel valve is couplable to a liquefied petroleum gas (LPG) fuel source; and the second fuel valve is couplable to a gasoline source, as called for in claim 14 of U.S. Patent No. 11,905,896.

d. Independent claim 15 by specifically including a fuel selector for use with a dual fuel generator, the fuel selector comprising: a valve assembly fluidly couplable to each of a first fuel source and a second fuel source and operable to selectively control a first fuel flow and a second fuel flow from the first fuel source and the second fuel source, respectively, to an engine of the dual fuel generator, the valve assembly comprising: a first fuel valve having open and closed positions to

selectively control the first fuel flow to the engine; and a second fuel valve having open and closed positions to selectively control the second fuel flow to the engine; and at least one valve handle mechanically coupled to the first fuel valve and the second fuel valve to selectively open and close the first fuel valve and the second fuel valve responsive to actuation thereof so as to enable the first fuel flow to the engine or the second fuel flow to the engine, as called for in claim 15 of U.S. Patent No. 11,905,896.

e. Dependent claim 16 by specifically including the all the aforementioned elements of claim 15 and, in addition, wherein the at least one valve handle enables only one of the first and second fuel flows to the engine at a given time, as called for in claim 36 of U.S. Patent No. 11,905,896.

f. Independent claim 30 by specifically including a fuel selector for use with a dual fuel generator, the fuel selector comprising: a valve assembly fluidly couplable to each of a first fuel source and a second fuel source and operable to selectively control a first fuel flow and a second fuel flow from the first fuel source and the second fuel source, respectively, to an engine of the dual fuel generator, the valve assembly comprising: two fuel inputs comprising: a first fuel input couplable to the first fuel source; and a second fuel input couplable to the second fuel source; and two fuel outputs configured to selectively supply fuel to the engine from the first fuel source or the second fuel source; and a selector switch positioned on the valve assembly to allow a user to manually select the first fuel flow or the second fuel flow, as called for in claim 30 of U.S. Patent No. 11,905,896.

g. Dependent claim 31 by specifically including all the aforementioned elements of claim 30 and, in addition, wherein the two fuel outputs are configured to selectively supply fuel to the engine from only one of the first and second fuel sources responsive to selection of the first fuel flow or the second fuel flow via

the selector switch and a corresponding operation of the valve assembly, as called for in claim 31 of U.S. Patent No. 11,905,896.

h. Dependent claim 32 by specifically including all the aforementioned elements of claim 30 and, in addition, wherein the valve assembly comprises: a first fuel valve having open and closed positions to selectively control the first fuel flow to the engine; and a second fuel valve having open and closed positions to selectively control the second fuel flow to the engine, as called for in claim 32 of U.S. Patent No. 11,905,896.

i. Dependent claim 34 by specifically including all the aforementioned elements of claim 32 and, in addition, wherein the first fuel valve and the second fuel valve are non-solenoid, mechanical valves, as called for in claim 34 of U.S. Patent No. 11,905,896.

j. Dependent claim 35 by specifically including all the aforementioned elements of claim 32 and, in addition, wherein the selector switch provides for manual actuation of the first fuel valve and the second fuel valve between the open and closed positions, as called for in claim 35 of U.S. Patent No. 11,905,896.

k. Dependent claim 36 by specifically including all the aforementioned elements of claim 30 and, in addition, a carburetor solenoid switch configured to activate an associated carburetor solenoid when actuated, as called for in claim 36 of U.S. Patent No. 11,905,896.

l. Dependent claim 37 by specifically including all the aforementioned elements of claim 36 and, in addition, wherein, when the selector switch is in a first position, the selector switch actuates the carburetor solenoid switch so as to activate the carburetor solenoid and prohibit the second fuel flow to the engine, as called for in claim 37 of U.S. Patent No. 11,905,896.

m. Dependent claim 38 by specifically including all the aforementioned elements of claim 37 and, in addition, wherein, when the selector switch is in a second

position, the carburetor solenoid allows the second fuel flow to the engine, as called for in claim 38 of U.S. Patent No. 11,905,896.

Therefore, the Powermate Model DF7500E generator listed in Paragraph 135 infringes at least claims 7, 8, 14-16, 30-32, and 34-38 of U.S. Patent No. 11,905,896.

137. Champion has no adequate remedy at law against Generac's acts of infringement and will suffer irreparable harm unless Generac is preliminarily and permanently enjoined from its infringement of U.S. Patent No. 11,905,896.

138. Upon information and belief, Generac's infringement has been willful, deliberate, and with knowledge of Champion's rights under U.S. Patent No. 11,905,896.

139. Upon information and belief, at least as of July 7, 2020, and again on April 4, 2024, the dates Champion sent Generac cease and desist letters demanding the cessation of infringement by Generac of Champion's patents, Generac has monitored Champion's patents and published patent applications and had actual notice of all of Champion's patents and published patent applications as of their publication dates.

140. Generac, by way of its infringing activity, has caused and continues to cause Champion to suffer damages in an amount to be determined at trial.

PRAYER FOR RELIEF

Wherefore, Champion prays for judgment against Generac, granting Champion the following relief:

A. That this Court adjudge and decree that U.S. Patent No. 10,221,780 is valid and enforceable against Generac and that Generac has infringed and continues to infringe the patent;

B. That this Court adjudge and decree that U.S. Patent No. 10,598,101 is valid and enforceable against Generac and that Generac has infringed and continues to infringe the patent;

C. That this Court adjudge and decree that U.S. Patent No. 10,697,398 is valid and enforceable against Generac and that Generac has infringed and continues to infringe the patent;

D. That this Court adjudge and decree that U.S. Patent No. 11,143,120 is valid and enforceable against Generac and that Generac has infringed and continues to infringe the patent;

E. That this Court adjudge and decree that U.S. Patent No. 11,143,145 is valid and enforceable against Generac and that Generac has infringed and continues to infringe the patent;

F. That this Court adjudge and decree that U.S. Patent No. 11,306,667 is valid and enforceable against Generac and that Generac has infringed and continues to infringe the patent;

G. That this Court adjudge and decree that U.S. Patent No. 11,492,985 is valid and enforceable against Generac and that Generac has infringed and continues to infringe the patent;

H. That this Court adjudge and decree that U.S. Patent No. 11,530,654 is valid and enforceable against Generac and that Generac has infringed and continues to infringe the patent;

I. That this Court adjudge and decree that U.S. Patent No. 11,840,970 is valid and enforceable against Generac and that Generac has infringed and continues to infringe the patent;

J. That this Court adjudge and decree that U.S. Patent No. 11,905,895 is valid and enforceable against Generac and that Generac has infringed and continues to infringe the patent;

K. That this Court adjudge and decree that U.S. Patent No. 11,905,896 is valid and enforceable against Generac and that Generac has infringed and continues to infringe the patent;

L. That this Court grant injunctions enjoining the aforesaid acts of infringement by Generac, its officers, agents, servants, employees, subsidiaries, and attorneys, and those acting in concert with them, including related individuals and entities, customers, representatives, original equipment manufacturers ("OEMs"), dealers, and distributors;

M. That this Court enter an award to Champion of such damages as it shall prove at trial against Generac that are adequate to compensate Champion for said infringement as permitted under the Patent Act;

N. That this Court order an award to Champion of up to three times the amount of compensatory damages because of Generac's willful infringement and any enhanced damages as provided by 35 U.S.C. § 284;

O. That this Court render a finding that this case is "exceptional" and award Champion its costs and reasonable attorneys' fees, as provided by 35 U.S.C. § 285;

P. That this Court award Champion pre-judgment and post-judgment interests on damages to the maximum extent allowed under the law; and

Q. That this Court grant to Champion such other, further, and different relief as may be just and proper.

JURY TRIAL DEMAND

Pursuant to Rule 38(b) of the Federal Rules of Civil Procedure, Champion respectfully demands a trial by jury of any and all issues triable of right before a jury.

Dated this 9th day of October, 2024.

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EXHIBIT A

US010221780B2

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

(10) **Patent No.: US 10,221,780 B2**
(45) **Date of Patent: Mar. 5, 2019**

(54) **DUAL FUEL LOCKOUT SWITCH FOR GENERATOR ENGINE**

(71) Applicant: **Chmapion Engine Technology, LLC**, Sussex, WI (US)

(72) Inventors: **Mark J. Sarder**, Waukesha, WI (US); **Aleko D. Sotiriades**, Cedarburg, WI (US); **James J. Dehn**, Brookfield, WI (US); **Leigh Jenison**, Hartland, WI (US)

(73) Assignee: **Champion Power Equipment, Inc.**, Santa Fe Springs, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 605 days.

(21) Appl. No.: **14/738,060**

(22) Filed: **Jun. 12, 2015**

(65) **Prior Publication Data**

US 2016/0363058 A1 Dec. 15, 2016

(51) **Int. Cl.**
F02D 19/06 (2006.01)

(52) **U.S. Cl.**
CPC ***F02D 19/0613*** (2013.01); ***F02D 19/0605*** (2013.01); ***F02D 19/0647*** (2013.01); ***F02D 19/0673*** (2013.01); *Y02T 10/36* (2013.01)

(58) **Field of Classification Search**
CPC F02D 19/0613; F02D 16/0605; F02D 19/0647; Y02T 10/36
See application file for complete search history.

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Primary Examiner — Kevin A Lathers
(74) *Attorney, Agent, or Firm* — Ziolkowski Patent Solutions Group, SC

(57) **ABSTRACT**

A mechanical fuel lockout switch for a dual fuel engine includes a mechanical fuel valve actuateable between a first position and a second position to selectively control fuel flow to the dual fuel engine from a first fuel source through a first fuel line and a second fuel source through a second fuel line. The mechanical fuel lockout switch also includes a fuel lockout apparatus coupled to the mechanical fuel valve. The mechanical fuel lockout switch communicates the first fuel source to the dual fuel engine and prevents communication between the second fuel source and the dual fuel engine when the mechanical fuel valve is in the first position, and communicates the second fuel source to the dual fuel engine and interrupts the first fuel source communication with the dual fuel engine when in the second position.

15 Claims, 5 Drawing Sheets

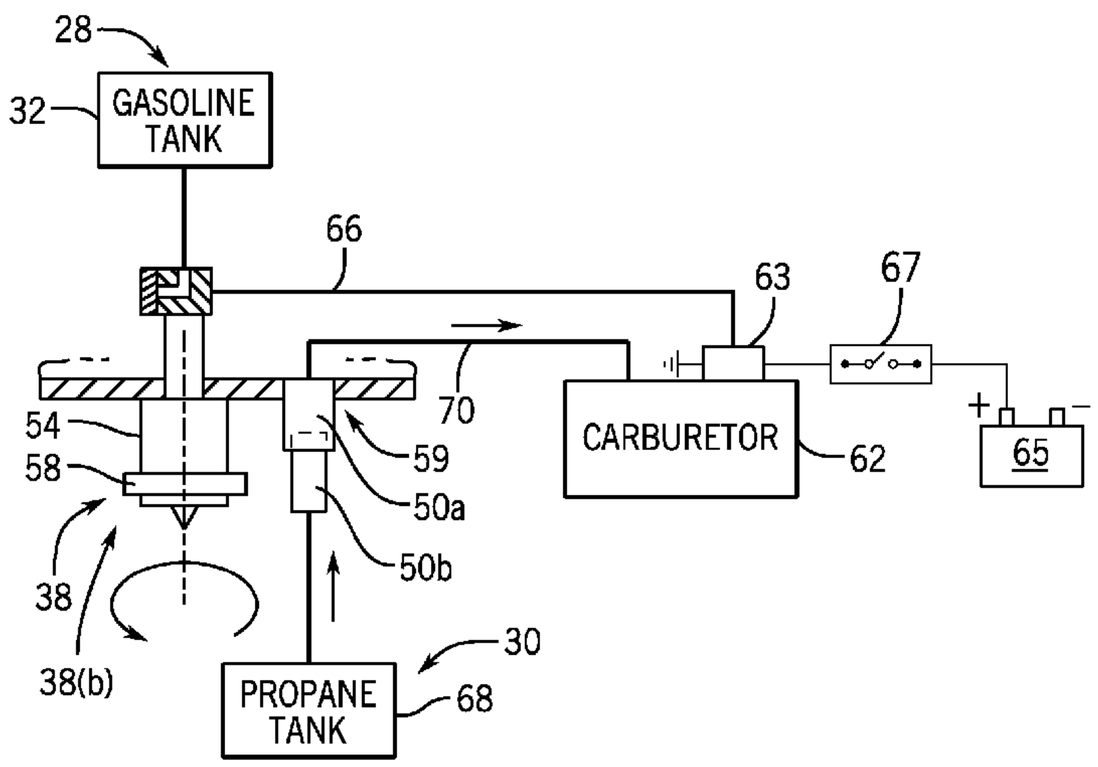

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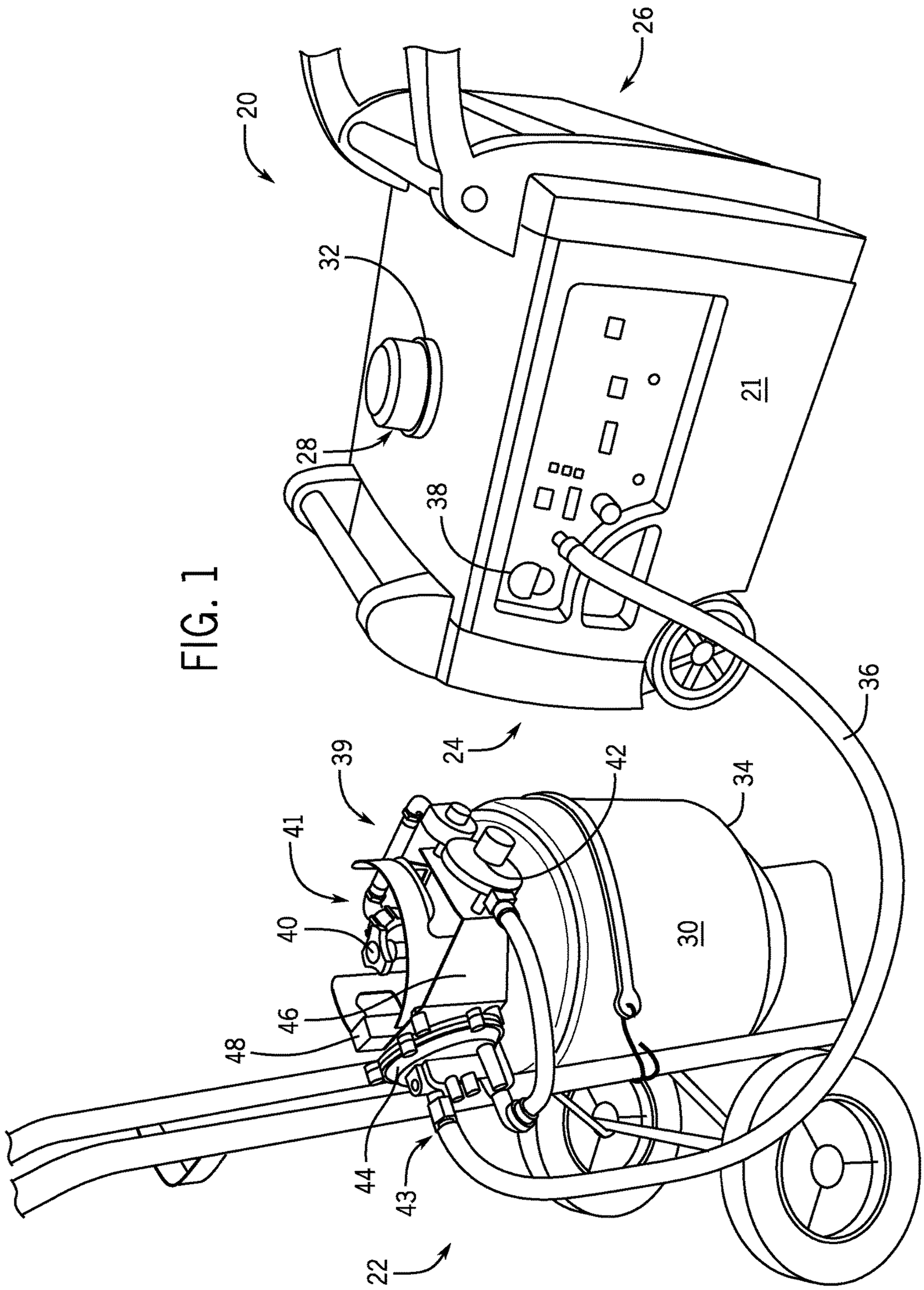
FIG. 1



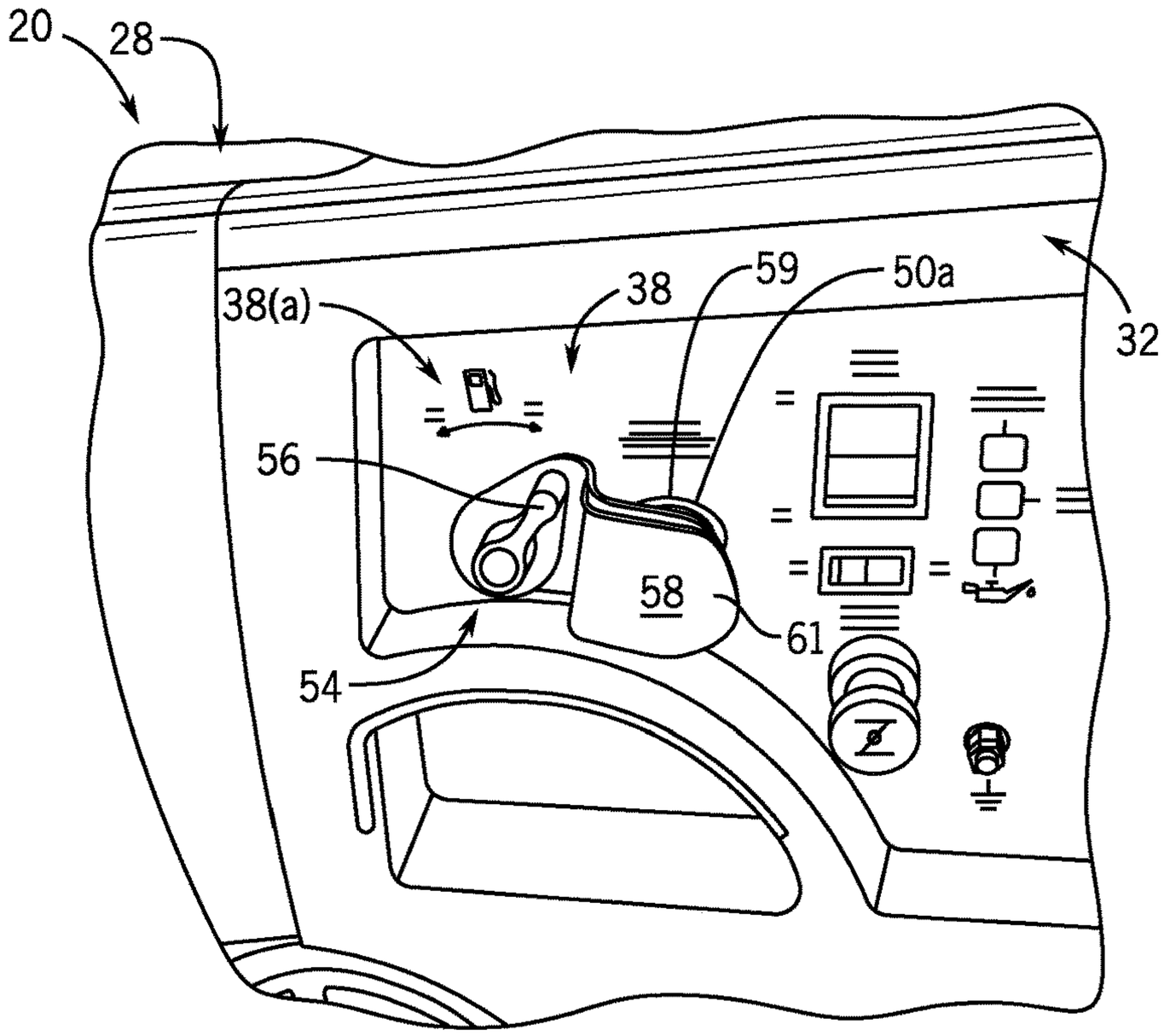


FIG. 2

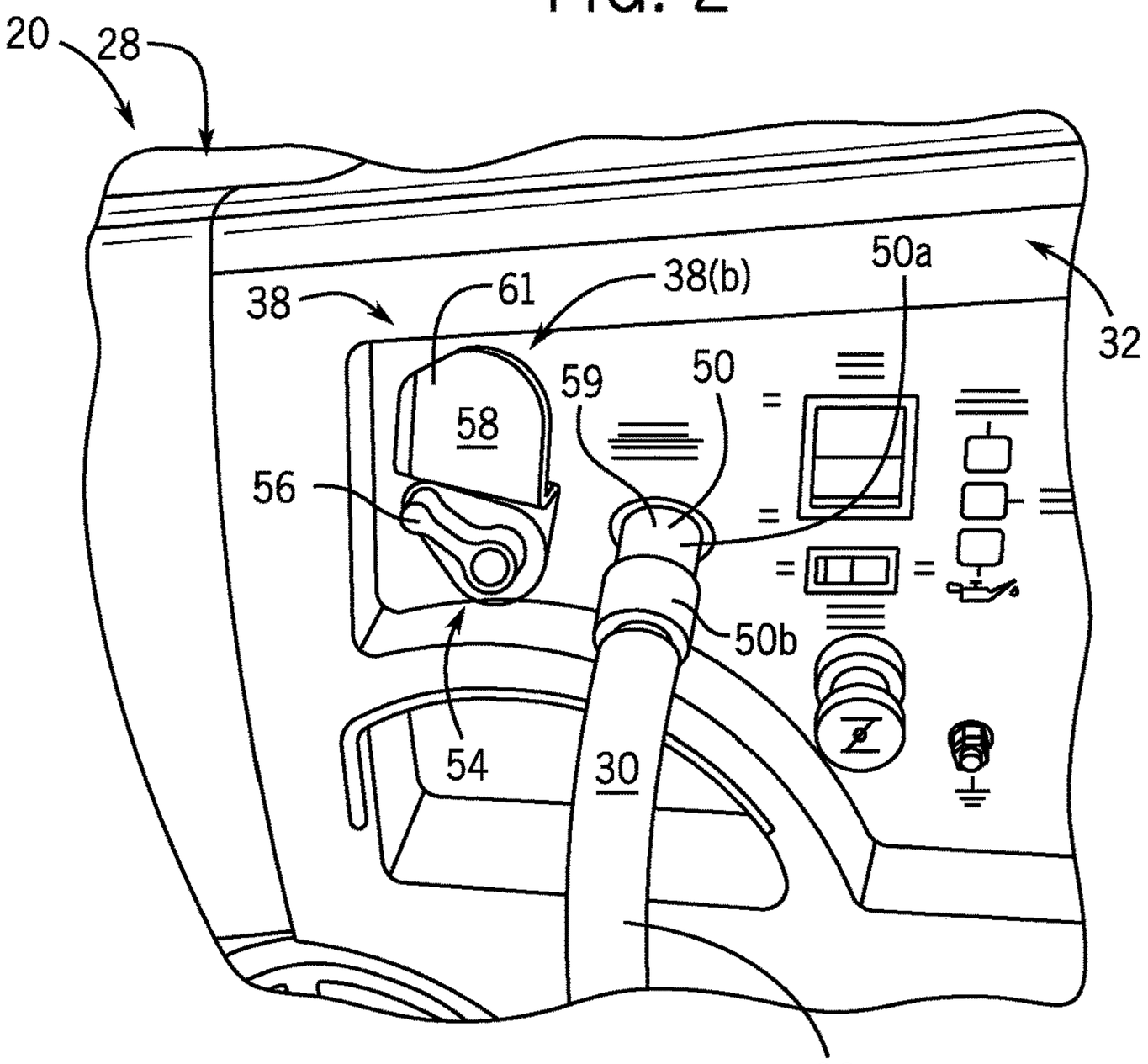


FIG. 3

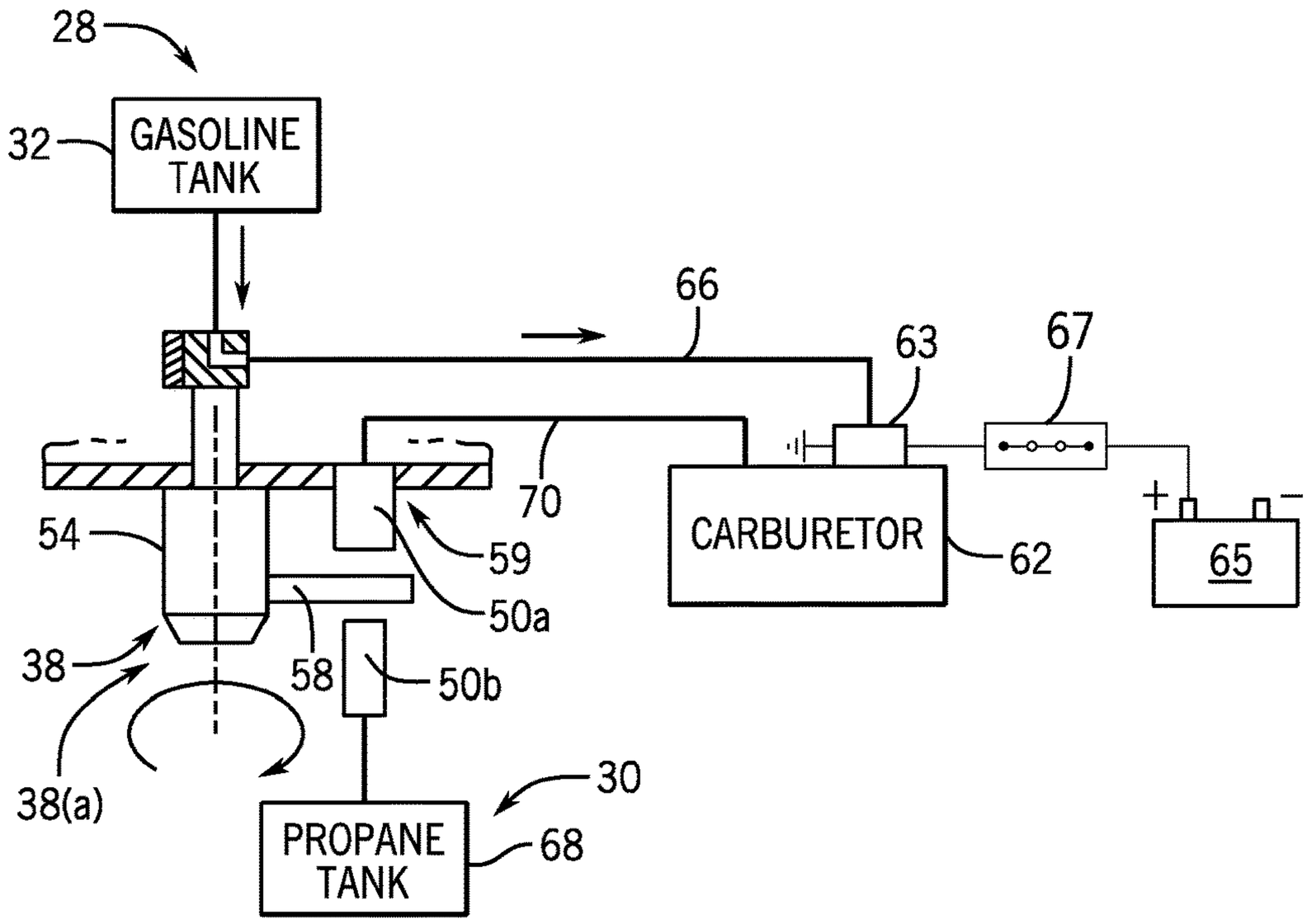


FIG. 4A

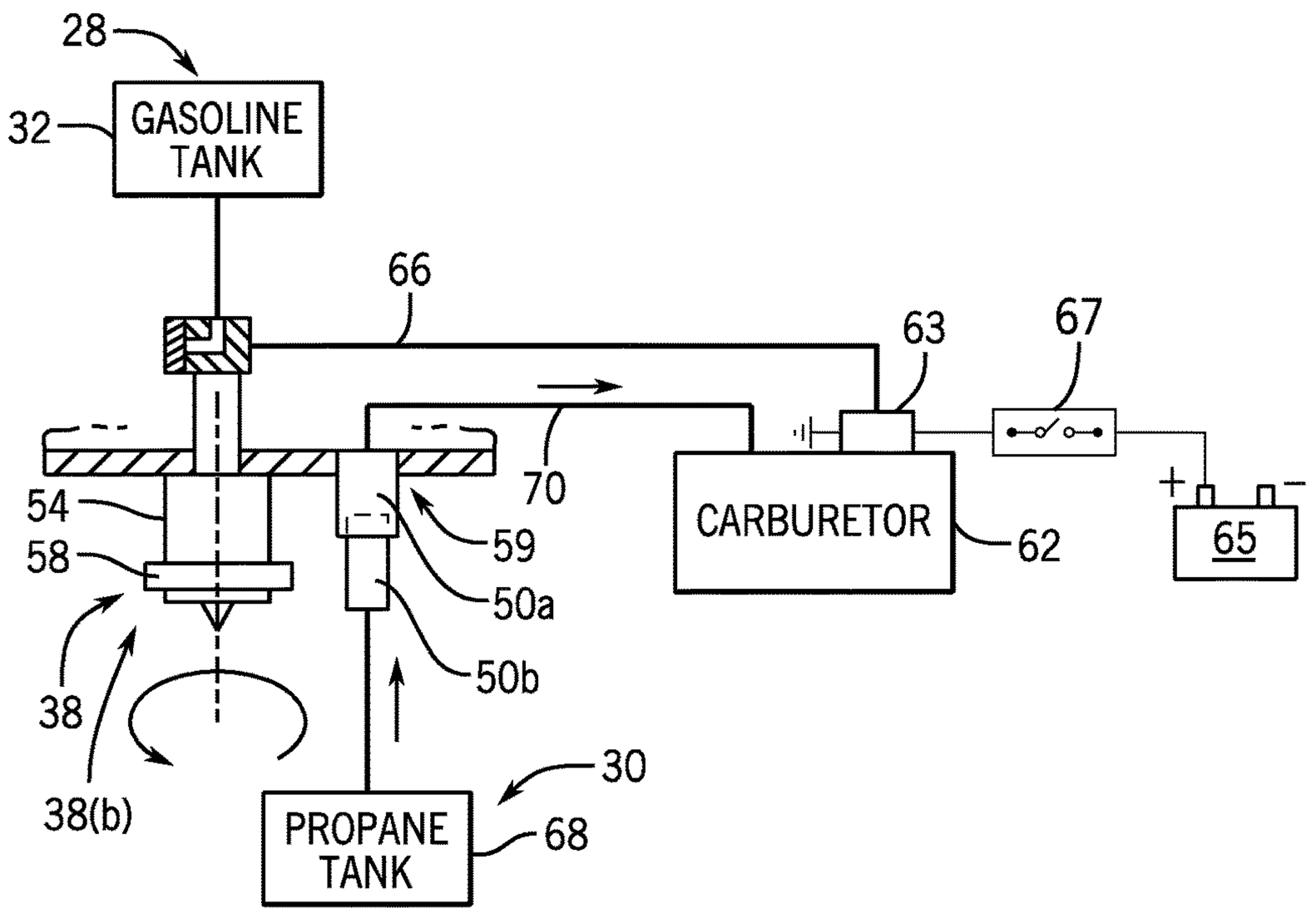


FIG. 4B

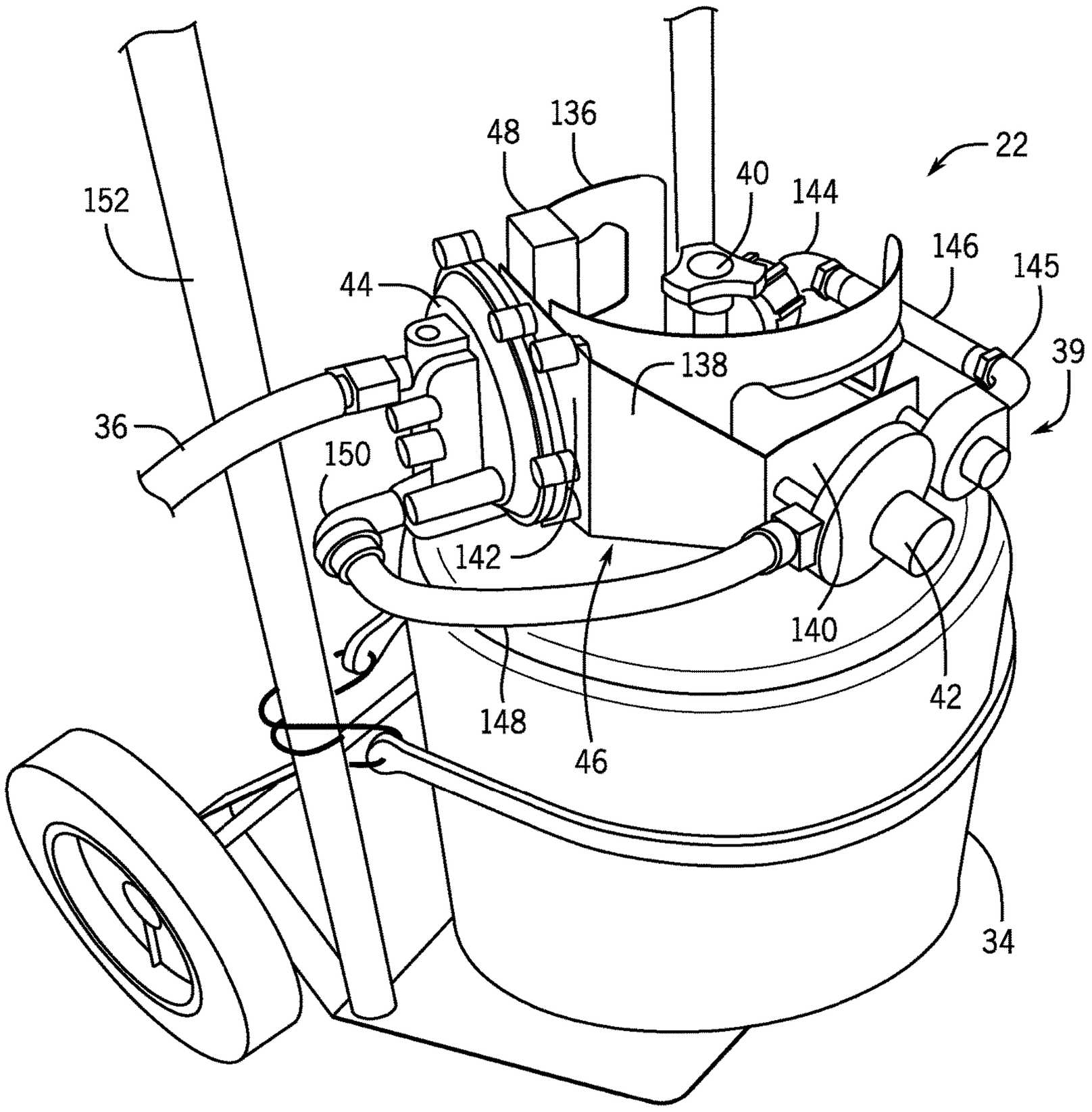


FIG. 5

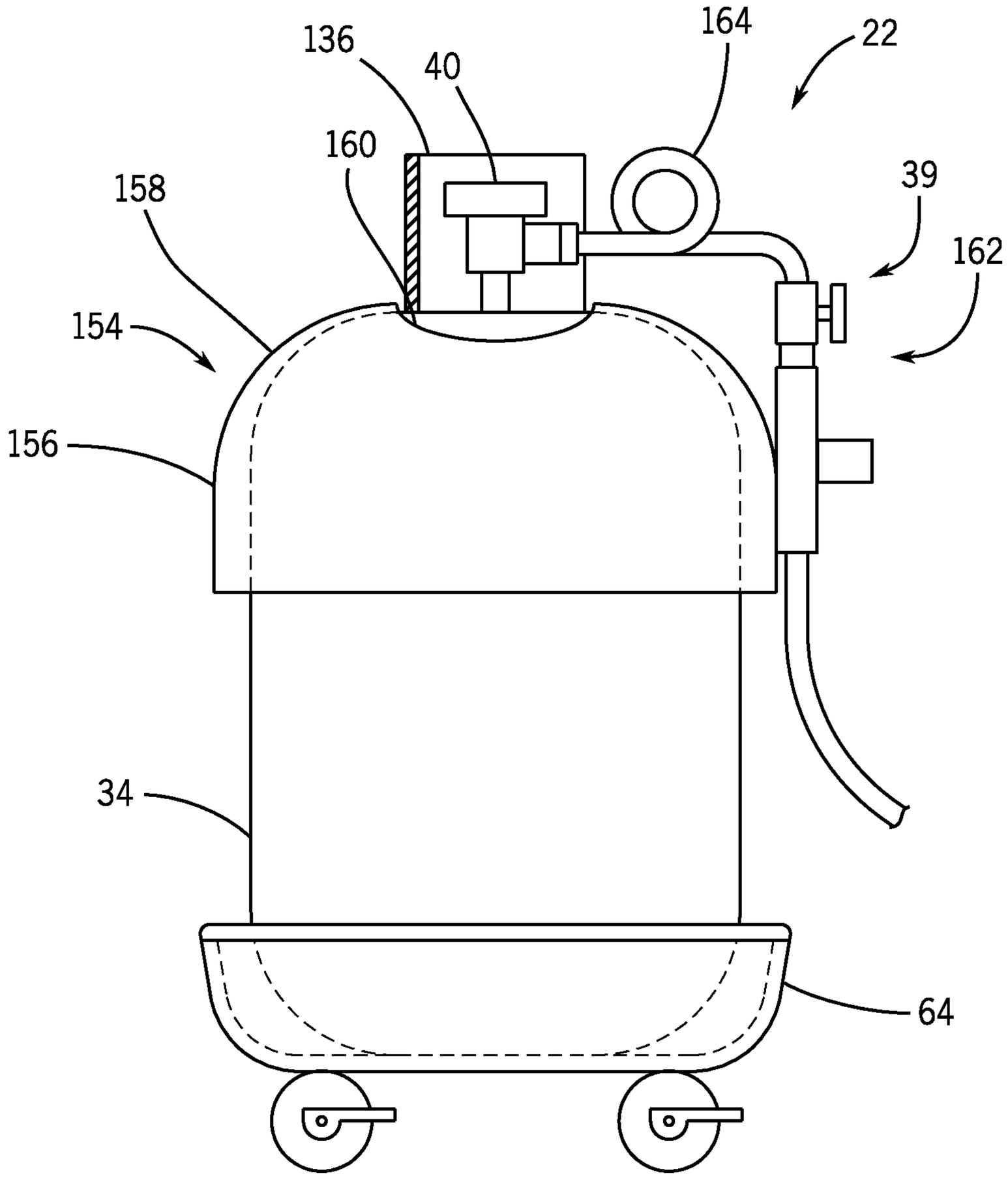


FIG. 6

DUAL FUEL LOCKOUT SWITCH FOR GENERATOR ENGINE

BACKGROUND OF THE INVENTION

Embodiments of the invention relate generally to dual fuel generators, and more particularly, to an apparatus and method for delivering liquid fuel and gaseous fuel to a dual fuel generator.

Electric generators are frequently driven by internal combustion engines that use gasoline as a fuel source. Gasoline is a common fuel source for generators in a variety of applications. However, alternative fuel sources also provide a desirable fuel source. For instance, alternative fuels may provide a clean burning fuel that limits hazardous emissions. Alternative fuels may also be stored for long periods of time without degradation, whereas gasoline can degrade over a period of months leading to hard starting, rough running, and also lead to gum and varnish deposit left in the fuel system. In addition, generators that operate on alternative fuels may generate electricity when gasoline is not readily available. For instance, generators are frequently used when power outages in the utility grid result from severe weather. Unfortunately, gas stations may also be closed as a result of the power outage. Such a circumstance presents just one example where it would be advantageous to operate electrical generators on alternative fuels.

Certain generators are configured to operate as "dual fuel" generators, otherwise known as bi-fuel generators. These generators are driven by an internal combustion engine that is configured to operate on a liquid fuel for a period of operation and an alternative fuel for another period of operation. The alternative fuel source may exist in a gaseous state at normal temperature and pressure and can be any one of liquefied petroleum gas, compressed natural gas, hydrogen, or the like. Liquefied petroleum gas (LPG), often referred to as propane, exists in a gaseous state at normal temperature and pressure but can be conveniently stored under pressure in a liquid state. LPG may be a desirable fuel source for internal combustion engines because it can be stored for longer periods of time and contains fewer impurities than gasoline, resulting in smoother and cleaner operation, and often resulting in a longer lasting engine.

In order to provide the liquid and gaseous fuel to the engine, the dual fuel engine may have a first fuel line for liquid fuel and a second fuel line for gaseous fuel. A liquid fuel source and a gaseous fuel source may be coupled to the respective lines to provide fuel to the engine. However, a common problem with such configurations that couple two fuel sources to a single engine is the engine can experience overly rich air-fuel ratio when both fuels are simultaneously engaged during cross-over switching between the fuel sources. Further, such simultaneous delivery of fuel from the first fuel line and the second fuel line may make the engine hard to start or lead to unstable operating conditions.

Therefore, it would be desirable to design a dual fuel generator having a liquid fuel and gaseous fuel delivery system that overcomes the aforementioned detriments without substantially increasing the overall cost of the system.

BRIEF DESCRIPTION OF THE INVENTION

In accordance with one aspect of the invention, a mechanical fuel lockout switch for a dual fuel engine provides for the selection of a desired fuel to operate the engine. The mechanical fuel lockout switch includes a mechanical fuel valve and a fuel lockout apparatus. The

mechanical fuel valve actuates between a first position and a second position to selectively control fuel flow to the dual fuel engine from a first fuel source through a first fuel line and a second fuel source through a second fuel line. The fuel lockout apparatus couples to the mechanical fuel valve ensuring individual communication of the fuel sources to the engine. The mechanical fuel lockout switch communicates the first fuel source to the dual fuel engine and prevents communication between the second fuel source and the dual fuel engine when the mechanical fuel valve is in the first position, and communicates the second fuel source to the dual fuel engine and interrupts the first fuel source communication with the dual fuel engine when in the second position.

In accordance with another aspect of the invention, a dual fuel generator and fuel delivery system includes a dual fuel generator configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line. The dual fuel generator and fuel delivery system also includes a fuel regulator system located off board the dual fuel generator to control the pressure of fuel from the pressurized fuel source and deliver the fuel at a desired pressure for operation of the generator. The fuel regulator system includes a primary pressure regulator coupled to a service valve of the pressurized fuel source and configured to regulate the fuel supplied from the pressurized fuel source to a reduced pressure. The fuel regulator system also includes a secondary pressure regulator coupled to the primary pressure regulator and configured to regulate the gaseous fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the dual fuel generator. The dual fuel generator and fuel delivery system further includes a mechanical fuel valve actuateable between a first position and a second position to selectively control fuel flow to the dual fuel generator from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line.

In accordance with yet another aspect of the invention, a method of assembling a mechanical fuel lockout switch for an internal combustion engine includes providing an internal combustion engine configured to operate on a fuel from a first fuel source and a different fuel from a second fuel source. The method also includes coupling a mechanical fuel valve to the internal combustion engine actuateable between a first position and a second position to selectively control fuel flow to the internal combustion engine from the first fuel source through a first fuel line and the second fuel source through a second fuel line. The method further includes coupling a fuel lockout apparatus to the mechanical fuel valve. When the mechanical fuel valve is in the first position, the fuel lockout apparatus communicates the first fuel source to the internal combustion engine and prevents the second fuel source from coupling to the internal combustion engine, and actuation of the mechanical fuel valve to the second position causes the fuel lockout apparatus to permit the second fuel source to couple to the internal combustion engine, and interrupts the first fuel source communication with the internal combustion engine.

Various other features and advantages will be made apparent from the following detailed description and the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings illustrate preferred embodiments presently contemplated for carrying out the invention.

In the drawings:

FIG. **1** is a perspective view of a dual fuel generator coupled to a fuel delivery system, according to an embodiment of the invention.

FIG. **2** is a detail view of a portion of the generator of FIG. **1** about a mechanical fuel lockout switch with the switch in a first position, according to an embodiment of the invention.

FIG. **3** is a detail view similar to FIG. **2** and showing the mechanical fuel lockout switch in a second position, with an LPG supply line connected thereto, according to an embodiment of the invention.

FIG. **4**A is a schematic diagram of a fuel system for the dual fuel generator of FIG. **1** showing a liquid fuel source in communication with a carburetor of the generator consistent with the first position of the switch as shown in FIG. **2**, according to an embodiment of the invention.

FIG. **4**B is a schematic diagram of the fuel system of FIG. **4**A showing a gaseous fuel source in communication with a carburetor of the generator of FIG. **1** consistent with the second position of the switch as shown in FIG. **3**, according to an embodiment of the invention.

FIG. **5** is a perspective view of a fuel delivery system for the dual fuel generator of FIG. **1**, according to an embodiment of the invention.

FIG. **6** is a side view of a fuel delivery system for the dual fuel generator of FIG. **1**, according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The operating environment of the invention is described with respect to a dual fuel generator. However, it will be appreciated by those skilled in the art that the invention is equally applicable for use with any dual fuel internal combustion engine. Moreover, the invention will be described with respect to a dual fuel generator configured to operate on a liquid fuel and a gaseous fuel. However, one skilled in the art will further appreciate that the invention is equally applicable for use with other fuel combinations for dual fuel generators and internal combustion engines.

Referring to FIG. **1**, a dual fuel generator **20** is coupled to a fuel delivery system **22**, in accordance with an embodiment of the invention. Dual fuel generator **20** includes an internal combustion engine (not shown) within housing **21** at one end **24**, operatively connected to an alternator also enclosed in housing **21** at another end **26**, by conventional means. Dual fuel generator **20** is configured to operate on different fuels via either a first fuel source **28** or a second fuel source **30**. In an exemplary embodiment of the invention, first fuel source **28** is a liquid fuel and second fuel source **30** is a gaseous fuel. The liquid fuel may be gasoline and the gaseous fuel may be liquid petroleum gas (LPG). Each can selectively operate the generator as desired and controlled by an operator. For instance, generator **20** may operate on gasoline for a first period of operation and then switch to LPG for a second period of operation. However, it is contemplated that dual fuel generator **20** is configured to operate on fuels other than gasoline and LPG (e.g., natural gas, biodiesel, etc.), and thus the scope of the invention is not meant to be limited strictly to a dual fuel arrangement where first fuel source **28** provides gasoline and second fuel source **30** provides LPG.

In one embodiment of the invention, dual fuel generator **20** includes a gasoline tank **32** or, generally, a liquid fuel tank, located inside cover **21** onboard generator **20** to provide gasoline to the engine as first fuel source **28**. Gasoline tank **32** connects to a first fuel line to provide gasoline to the carburetor to run the engine, as will later be described with reference to FIGS. **4**A and **4**B. Generator **20** is also coupled to a pressurized fuel container **34**, or a pressurized fuel source, located off board generator **20** to provide LPG to the engine as second fuel source **30**. Pressurized fuel container **34** is coupled to generator **20** with an LPG supply hose **36**. LPG supply hose **36** is coupled to a second fuel line within generator **20** to provide LPG to the carburetor to run the engine. Dual fuel generator **20** includes a mechanical fuel lockout switch **38** for selecting a desired fuel to be provided to the engine. The mechanical fuel lockout switch **38** is actuated to select first fuel source **28** when in a first position, as shown in FIG. **2**, and alternately to select second fuel source **30** when in a second position, as shown in FIG. **3**.

Referring back to FIG. **1**, in an exemplary embodiment, fuel **30** from pressurized fuel container **34** is regulated using a fuel regulator system **39** for delivery to the engine. Fuel regulator system **39** includes one or more pressure regulators that reduce and control the pressure of the fuel from pressurized fuel container **34** and delivers fuel at a desired pressure for operation of the engine. Fuel regulator system **39** has an inlet **41** operatively coupled to a service valve **40** of pressurized fuel container **34** and an outlet **43** coupled to LPG supply hose **36**. Fuel regulator system **39** includes a primary pressure regulator **42** coupled to pressurized fuel container **34** and a secondary pressure regulator **44**. Primary pressure regulator **42** protects downstream components from high pressure of pressurized fuel container **34**. Primary pressure regulator **42** receives LPG through service valve **40** of pressurized fuel container **34** and reduces the pressure of the LPG to a first stage. In one embodiment of the invention, the first stage may be delivered directly to generator **20** at a pressure required for operation of the engine.

In an exemplary embodiment of the invention, fuel regulator system **39** includes secondary pressure regulator **44** coupled to the outlet of primary pressure regulator **42** in order to use standard "off-the-shelf" components. Typically, the primary pressure regulator is mounted on the LPG tank, while the secondary pressure regulator is mounted on the component using the fuel, such as an engine or grill. Here, since generator **20** can be used as a gasoline only generator, secondary pressure regulator **44** is mounted off-board the generator to reduce size and cost of the generator. Secondary pressure regulator **44** receives LPG from primary pressure regulator **42** and further reduces the pressure of LPG to a second stage to be delivered to generator **20**. In a system with two regulators, primary pressure regulator **42** regulates fuel received from pressurized fuel container **34** and reduces the pressure of the fuel to a level required for operation of secondary pressure regulator **44**. Secondary pressure regulator **44** regulates fuel received from primary pressure regulator **42** and further reduces the pressure of the fuel to a level required for operation of generator **20**. In addition, primary pressure regulator **42** may compensate for varying tank pressure as fuel is depleted while secondary pressure regulator **44** may compensate for varying demand from generator **20**.

In accordance with an exemplary embodiment of the invention, fuel regulator system **39** includes both the primary and secondary regulators, or a custom single regulator, but in any case is located remotely, or off-board, from dual fuel generator **20**. Fuel regulator system **39** may be directly mounted to pressurized fuel container **34** using a regulator mounting bracket **46**. Regulator mounting bracket **46** has

mounting locations for primary pressure regulator **42** and secondary pressure regulator **44**. Regulator mounting bracket **46** also has a securing mechanism **48** to secure regulator mounting bracket **46** to pressurized fuel container **34**.

In another embodiment of the invention, primary pressure regulator **42** is mounted on regulator mounting bracket **46** while secondary pressure regulator **44** could be mounted on or near generator **20**. In yet another embodiment of the invention, a dual stage regulator may regulate the fuel received from pressurized fuel container **34** and deliver fuel at a pressure required for operation of generator **20**. Such a dual stage regulator may regulate the fuel to the second stage within a single structure. The dual stage regulator may be mounted directly on fuel container **34**.

Referring to FIG. **2**, a detail view of a portion of generator **20** of FIG. **1** depicts mechanical fuel lockout switch **38** in a first position **38**(*a*), in accordance with an embodiment of the invention. In this position, mechanical fuel lockout switch **38** provides gasoline flow from gasoline tank **32** to the engine while preventing connection of an LPG supply line to fuel inlet **59** of the second fuel line, as will later be discussed in detail with reference to FIGS. **4**A and **4**B. Still referring to FIG. **2**, mechanical fuel lockout switch **38** provides a combination liquid fuel shutoff valve and a gaseous fuel supply lockout that prevents simultaneous delivery of fuel to the engine from gasoline tank **32** and pressurized fuel container **34**, FIG. **1**. As such, mechanical fuel lockout switch **38** provides a fuel selector to ensure only the selected fuel is provided to dual fuel generator **20**.

Mechanical fuel lockout switch **38**, FIG. **2**, includes mechanical fuel valve **54** actuateable between first position **38**(*a*) as shown in FIG. **2** and second position **38**(*b*) as shown in FIG. **3** to selectively control fuel flow to the dual fuel engine from first fuel source **28** through a first fuel line and second fuel source **30** through a second fuel line **36**. Mechanical fuel lockout switch **38** may also include fuel lockout apparatus **58** coupled to mechanical fuel valve **54** to communicate fuel sources individually to generator **20**. In one embodiment of the invention, fuel lockout apparatus **58** communicates first fuel source **28** to the engine by actuating mechanical fuel valve **54** to first position **38**(*a*) to open the first fuel line as shown in FIG. **2**, and communicates second fuel source **30** to the engine by actuating mechanical fuel valve **54** to second position **38**(*b*) to open communication of the second fuel source **30** to the engine as shown in FIG. **3**. Referring back to FIG. **2**, when mechanical fuel valve **54** is in first position **38**(*a*), fuel lockout apparatus **58** communicates first fuel source **28** to the dual fuel engine and prevents communication between the second fuel source and the dual fuel engine.

In an exemplary embodiment of the invention, mechanical fuel valve **54** controls the flow of LPG to the engine by actuating fuel lockout apparatus **58** to block or unblock fuel inlet **59** for the second fuel source. Mechanical fuel valve **54** is coupled to the first fuel line, as shown in FIGS. **4**A and **4**B, and therefore can control the flow of gasoline to the engine by opening and closing the first fuel line. When the mechanical fuel valve **54**, FIG. **2**, is in the first position **38**(*a*), gasoline flows from the gasoline tank to the engine and the fuel lockout apparatus **58** blocks the fuel inlet **59**. Accordingly, fuel lockout apparatus **58** prevents LPG flow to generator **20** when the mechanical fuel valve **54** is in first position **38**(*a*) wherein the engine is operated on gasoline.

Mechanical fuel valve **54** includes a fuel valve handle **56** to control the opening and closing of the valve. Fuel valve handle **56** is movable between first position **38**(*a*) as shown in FIG. **2** and second position **38**(*b*) as shown in FIG. **3**. Mechanical fuel valve **54** opens the first fuel line (to enable liquid fuel flow to the engine) when fuel valve handle **56** is in the first position, and mechanical fuel valve **54** closes the first fuel line (to prevent liquid fuel flow to the engine) when fuel valve handle **56** is in the second position. Thus, when fuel valve handle **56** is in first position **38**(*a*) as shown in FIG. **2**, mechanical fuel valve **54** opens the first fuel line and allows gasoline from gasoline tank **32** to flow to the engine.

Fuel valve handle **56** is coupled to fuel lockout apparatus **58**. Fuel valve handle **56** actuates with fuel lockout apparatus **58** to prevent LPG flow to generator **20** when gasoline flow to the generator is enabled. Fuel lockout apparatus **58** is controlled by fuel valve handle **56** so that moving fuel valve handle **56** to the first position causes fuel lockout apparatus **58** to block fuel inlet **59** for LPG, and moving fuel valve handle **56** to the second position causes fuel lockout apparatus **58** to unblock fuel inlet **59** for LPG.

In an exemplary embodiment of the invention, fuel valve handle **56** rotates between the first position and the second position and fuel lockout apparatus **58** is rigidly coupled to the rotating handle. Fuel lockout apparatus **58** may include a fuel inlet cover **61**, which may be a flange, coupled to fuel valve handle **56** so that fuel inlet cover **61** rotates with the handle. Fuel inlet cover **61** extends radially outward from fuel valve handle **56** and sweeps over fuel inlet **59** for LPG as fuel valve handle **56** rotates. That is, fuel inlet cover **61** rotates transversely across fuel inlet **59** and blocks access thereto. Accordingly, fuel inlet cover **61** prevents LPG flow to generator **20** when fuel valve handle **56** is in first position **38**(*a*) to allow gasoline to run the engine.

Referring to FIG. **3**, a detail view of a portion of generator **20** of FIG. **1** depicts mechanical fuel lockout switch **38** in a second position **38**(*b*), in accordance with an embodiment of the invention. In this position, the mechanical fuel lockout switch **38** provides a disconnect to stop gasoline flow from gasoline tank **32** to the engine while allowing connection of LPG supply hose **36** to fuel inlet **59** of the second fuel line. FIG. **3** further shows LPG supply hose **36** coupling second fuel source **30** to generator **20** to deliver LPG to run the generator.

Mechanical fuel lockout switch **38** includes mechanical fuel valve **54** coupled to fuel lockout apparatus **58** to prevent gasoline flow to generator **20** when LPG from the LPG service hose **36** is supplied to the engine. In one embodiment of the invention, actuation of mechanical fuel valve **54** to second position **38**(*b*) causes fuel lockout apparatus **58** to allow communication of second fuel source **30** to the dual fuel engine, and interrupts the first fuel source **28** communication with the dual fuel engine. The position of fuel lockout apparatus **58** prevents the fuel valve handle **56** from moving to first position **38**(*a*) (FIG. **2**) while LPG supply hose **36** is connected to generator **20**.

A quick-disconnect hose coupling **50**, also referred to as a quick-connect hose coupling, connects LPG supply hose **36** to generator **20** so that LPG supply hose **36** may be quickly attached and detached from generator **20**. Hose coupling **50** has a first end **50***a* mounted on the external surface of generator **20** and coupled to supply the second fuel to the engine. Hose coupling **50** has a second end **50***b* coupled to the outlet of LPG supply hose **36**. Hose coupling **50** has a valve that opens when the couplings are engaged and closes when the couplings are disengaged. As such, quick-disconnect hose coupling **50** automatically opens when connected to enable fuel flow from LPG supply hose **36** to the engine. Hose coupling **50** automatically disconnects fluid communication when disconnected. Accordingly,

when the supply hose is detached from generator **20**, the coupling **50** is automatically closed so that fuel does not escape and unwanted air does not enter the fuel system.

In one embodiment, fuel inlet cover **61** is coupled to fuel valve handle **56** so that it is spaced apart from the surface of generator **20** to provide clearance for first end **50***a* of the quick-disconnect hose coupling **50** that protrudes from the surface of generator **20**. As shown in FIG. **2**, fuel inlet cover **61** blocks off first end **50***a* of the quick-disconnect hose coupling when fuel valve handle **56** is rotated to first position **38**(*a*) to enable gasoline flow so that fuel inlet cover **61** prevents connection of LPG supply hose **36** (FIG. **3**) to generator **20**. As shown in FIG. **3**, fuel inlet cover **61** uncovers first end **50***a* of the quick-disconnect hose coupling **50** when fuel valve handle **56** is rotated to second position **38**(*b*) to disable gasoline flow so that fuel inlet cover **61** permits connection of LPG supply hose **36** to generator **20**.

To operate generator **20** on LPG, fuel valve handle **56** is turned to second position **38**(*b*) to disable the flow of gasoline to the engine and to expose first end **50***a* of hose coupling **50** on generator **20**. LPG supply hose **36** is then connected to generator **20** via hose coupling **50** to enable the flow of LPG to the engine. To operate generator **20** on gasoline, LPG supply hose **36** is disconnected from generator **20** via hose coupling **50** to disable the flow of LPG to the engine and to unblock fuel valve handle **56** from rotating to the first position. As shown in FIG. **2**, fuel valve handle **56** is then turned to first position **38**(*a*) to enable the flow of gasoline to generator **20**.

Referring to FIG. **4**A, a schematic diagram of a fuel system for a dual fuel engine shows mechanical fuel lockout switch **38** in first position **38**(*a*) to provide communication between the first fuel source **28** and dual fuel carburetor **62**, according to an embodiment of the invention. Mechanical fuel lockout switch **38** prevents communication between second fuel source **30** and dual fuel carburetor **62** when the switch is in first position **38**(*a*). In one embodiment of the invention, first fuel source **28** includes a gasoline tank **32** to provide gasoline to carburetor **62** through a first fuel line **66**, and second fuel source **30** includes a propane or LPG tank **68** to provide propane or LPG to carburetor **62** through a second fuel line **70**. Accordingly, first fuel line **66** may be a liquid fuel line and second fuel line **70** may be a gaseous fuel line.

Mechanical fuel lockout switch **38** includes a mechanical fuel valve **54** actuateable between first position **38**(*a*) as shown in FIG. **4**A and second position **38**(*b*) as shown in FIG. **4**B to selectively control fuel flow to the dual fuel engine from first fuel source **28** through first fuel line **66** and second fuel source **30** through second fuel line **70**. Referring back to FIG. **4**A, mechanical fuel valve **54** selectively controls fuel flow through first fuel line **66** by opening the line when the mechanical fuel lockout switch **38** actuates to first position **38**(*a*). Mechanical fuel valve **54** may be coupled to fuel lockout apparatus **58** that actuates with mechanical fuel valve **54** to block and unblock fuel inlet **59** of second fuel line **70**. First end **50***a* of the quick-disconnect hose coupling is located at fuel inlet **59** and a mating end **50***b* of the quick-disconnect hose coupling is coupled to the propane or LPG tank **68**. Actuation of mechanical fuel valve **54** to first position **38**(*a*) causes fuel lockout apparatus **58** to block fuel inlet **59** to prevent coupling the first end **50***a* and second end **50***b* of the quick-disconnect hose coupling together, and actuation of mechanical fuel valve **54** to another position causes fuel lockout apparatus **58** to unblock fuel inlet **59** to permit attaching first end **50***a* and second end **50***b* together.

In one embodiment of the invention, a fuel cut solenoid **63** couples to carburetor **62** to regulate liquid fuel flow into a main nozzle within the carburetor. Fuel cut solenoid **63** is advantageous to control liquid fuel flow downstream of a float bowl in the carburetor and can stop fuel flow to the engine immediately after ignition shutdown. As such, fuel cut solenoid **63** prevents the engine from drawing in fuel from the float bowl while the engine shuts off. Fuel cut solenoid **63** also traps fuel in the float bowl to eliminate delay in filling the bowl when starting the engine on liquid fuel, and prevents liquid fuel flow from the float bowl to the engine when starting on gaseous fuel.

Fuel cut solenoid **63** may regulate fuel flow through multiple fuel lines in carburetor **62** that provide fuel from the float bowl to the engine. For instance, carburetor **62** may have a main fuel line and an idle fuel line that receive fuel from the float bowl. Fuel cut solenoid **63** may control fuel flow through all of the fuel lines that receive fuel from the float bowl or may regulate only some of the fuel lines. As such, fuel cut solenoid **63** may block fuel flow through the main fuel line while small amounts of fuel can flow through the idle fuel line.

Fuel cut solenoid **63** preferably operates as a normally closed valve that opens when powered by a 12 volt battery **65**, although fuel cut solenoid **63** may also be operated as a normally open valve. The normally closed valve is opened for gasoline mode to allow gasoline flow to the engine and closed for LPG mode to prevent gasoline flow to the engine. Fuel cut solenoid **63** is operated by an electrical switch **67** which may be mechanically actuated and controlled by mechanical fuel lockout switch **38**. As such, actuation of mechanical fuel lockout switch **38** to first position **38**(*a*) closes electrical switch **67** to power and open fuel cut solenoid **63** as represented in FIG. **4**A, and actuation of mechanical fuel lockout switch **38** to second position **38**(*b*) opens electrical switch **67** to interrupt power and close fuel cut solenoid **63** as represented in FIG. **4**B.

Referring to FIG. **4**B, a schematic diagram of a fuel system for a dual fuel engine shows mechanical fuel lockout switch **38** in second position **38**(*b*) to provide communication between second fuel source **30** and dual fuel carburetor **62**, according to an embodiment of the invention. Mechanical fuel lockout switch **38** prevents communication between first fuel source **28** and dual fuel carburetor **62** when the switch is in second position **38**(*b*). The dual fuel engine has a first fuel line **66** to provide fuel from first fuel source **28** to carburetor **62** and a second fuel line **70** to provide fuel from second fuel source **30** to carburetor **62**.

Mechanical fuel lockout switch **38** includes mechanical fuel valve **54** that selectively controls fuel flow through first fuel line **66** by closing the line when mechanical fuel lockout switch **38** actuates to second position **38**(*b*). Mechanical fuel lockout switch **38** may also include a mechanical lockout apparatus **58** to block and unblock fuel inlet **59** of the second fuel line **70**. Fuel inlet **59** may include first end **50***a* of the quick-connect hose coupling mounted on the generator and coupled to second fuel line **70**. Second end **50***b* of the quick-connect hose coupling is coupled to the outlet of second fuel source **30**, and the first end **50***a* mates with second end **50***b* to quickly attach propane or LPG tank **68** to second fuel line **70**. Fuel lockout apparatus **58** may also hold mechanical fuel lockout switch **38** in second position **38**(*b*) when the propane or LPG tank **68** is coupled to the engine via the ends **50***a*, **50***b* of the quick-connect hose coupling.

Fuel cut solenoid **63** couples to carburetor **62** to regulate liquid fuel flow through the carburetor as described with respect to FIG. **4**A. FIG. **4**B shows electrical switch **67**

opened to interrupt power and close fuel cut solenoid **63** for LPG mode when mechanical fuel lockout switch **38** is in second position **38**(*b*).

FIGS. **4**A and **4**B depict an embodiment where mechanical fuel valve **54** operates along first fuel line **66** to provide a flow path for first fuel source **28** to carburetor **62** when the valve is in first position **38**(*a*). That is, mechanical fuel valve **54** may control a single fuel line that runs through the valve while operating fuel lockout apparatus **58** to control fuel flow through second fuel line **70**. Embodiments of the invention also contemplate mechanical fuel valve **54** configured to operate along second fuel line **70** to provide a flow path for second fuel source **30** to carburetor **62** when the valve is in second position **38**(*b*). Mechanical fuel valve **54** may be configured to control multiple fuel lines that run through the valve according to embodiments of the invention.

Referring now to FIG. **5**, a perspective view of fuel delivery system **22** for dual fuel generator **20** of FIG. **1** is shown, in accordance with an embodiment of the invention. Fuel delivery system **22** includes a mounting arrangement for fuel regulator system **39**. The mounting arrangement includes regulator mounting bracket **46** for mounting fuel regulator system **39**. Regulator mounting bracket **46** extends around the outer periphery of collar **136** on pressurized fuel container **34**. Regulator mounting bracket **46** has securing mechanism **48** to secure to collar **136**. In one embodiment, securing mechanism **48** is a rigid component that extends inward from regulator mounting bracket **46** with a slot for receiving collar **136** to hold regulator mounting bracket **46** to collar **136**.

Regulator mounting bracket **46** provides mounting locations for pressure regulators. In one embodiment, regulator mounting bracket **46** is made of sheet metal bent in two locations to provide a central panel **138**, a first outer panel **140**, and a second outer panel **142** for mounting the regulators. The panels may be angled from each other such that regulator mounting bracket **46** fits around collar **136**. Primary pressure regulator **42** mounts on first outer panel **140** and secondary pressure regulator **44** mounts on second outer panel **142**. The panels are sized according to their respective regulators. Accordingly, second outer panel **142** is larger than first outer panel **140** if secondary pressure regulator **44** is larger than primary pressure regulator **42**. Panels **140**, **142** have fasteners or openings to receive fasteners to couple respective regulators **42**, **44** to the panels. Regulator mounting bracket **46** rests on top of pressurized fuel container **34** and engages the periphery of collar **136** to support fuel regulator system **39** on the container.

In one embodiment of the invention, primary pressure regulator **42** couples to two ninety degree elbows **144**, **145** to reach around collar **136** in order to couple to service valve **40**. The two elbows **144**, **145** are joined by a hose or pipe **146** that leads from elbow **144** at service valve **40** to elbow **145** at the outer periphery of collar **136**. The outlet of primary pressure regulator **42** couples to a hose **148** that extends to another ninety degree elbow **150** coupled to the inlet of secondary pressure regulator **44**. Secondary pressure regulator **44** couples to LPG supply hose **36**. Pressurized fuel container **34** may be strapped to a dolly **152**.

Referring now to FIG. **6**, a side view of another fuel delivery system **22** for dual fuel generator **20** of FIG. **1** is shown, in accordance with an embodiment of the invention. Fuel delivery system **22** includes a mounting arrangement for fuel regulator system **39**. The mounting arrangement includes a regulator mounting structure **154** for mounting fuel regulator system **39** to pressurized fuel container **34**. Regulator mounting structure **154** includes a cylinder **156** that surrounds the circumference of pressurized fuel container **34** to secure regulator mounting structure **154** radially along the circumference of pressurized fuel container **34**. Cylinder **156** couples to a dome **158** to support cylinder **156** relative to the top of pressurized fuel container **34**. Dome **158** has a central opening **160** through which collar **136** of pressurized fuel container **34** extends. Collar **136** of pressurized fuel container **34** extends through dome **158** so that service valve **40** is easily accessible from above regulator mounting structure **154** and so that dome **158** sits on pressurized fuel container **34** around collar **136**.

Regulator mounting structure **154** supports pressure regulators around the outer circumference of cylinder **156**. In some embodiments of the invention, a dual stage pressure regulator **162** functions as both a primary pressure regulator and a secondary pressure regulator in a single integral component, and dual stage pressure regulator **162** may be mounted on regulator mounting structure **154**. In other embodiments in of the invention, primary pressure regulator **42** (FIG. **5**) is mounted to service valve **40** while secondary pressure regulator **44** (FIG. **5**) is mounted on regulator mounting structure **154**. Alternatively, both primary pressure regulator **42** (FIG. **5**) and secondary pressure regulator **44** (FIG. **5**) may be mounted on regulator mounting structure **154**.

Fuel regulator system **39** may be coupled to service valve **40** by a flexible connector called a pigtail **164**. Pigtail **164** absorbs shock in the system from pressure surges and from movement of downstream components. Pigtail **164** can be looped to conserve space and therefore pressurized fuel container **34** is referred to as an LPG pig. Accordingly, regulator mounting structure **154** is referred to as a pig hat because it fits on the LPG pig. Pressurized fuel container **34** may be secured to a platform or mobile cart **64** for stability or transportation. In another embodiment, a regulator mounting device, including regulator mounting structure **154** or regulator mounting bracket **46** (FIG. **5**), is secured directly to a platform or a mobile cart.

Beneficially, embodiments of the invention provide for a mechanical fuel lockout switch to ensure that two fuels are not simultaneously delivered to a dual fuel internal combustion engine. Embodiments of the invention also provide for a dual fuel generator with a remotely mounted gaseous fuel regulator system.

Therefore, according to one embodiment of the invention, a mechanical fuel lockout switch for a dual fuel engine includes a mechanical fuel valve actuateable between a first position and a second position to selectively control fuel flow to the dual fuel engine from a first fuel source through a first fuel line and a second fuel source through a second fuel line. The mechanical fuel lockout switch also includes a fuel lockout apparatus coupled to the mechanical fuel valve. The mechanical fuel lockout switch communicates the first fuel source to the dual fuel engine and prevents communication between the second fuel source and the dual fuel engine when the mechanical fuel valve is in the first position, and communicates the second fuel source to the dual fuel engine and interrupts the first fuel source communication with the dual fuel engine when in the second position.

According to another embodiment of the invention, a dual fuel generator and fuel delivery system includes a dual fuel generator configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line. The dual fuel generator and fuel delivery

system also includes a fuel regulator system located off board the dual fuel generator. The fuel regulator system includes a primary pressure regulator coupled to a service valve of the pressurized fuel source and configured to regulate the fuel supplied from the pressurized fuel source to a reduced pressure. The fuel regulator system also includes a secondary pressure regulator coupled to the primary pressure regulator and configured to regulate the gaseous fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the dual fuel generator. The dual fuel generator and fuel delivery system further includes a mechanical fuel valve actuateable between a first position and a second position to selectively control fuel flow to the dual fuel generator from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line.

According to yet another embodiment of the invention, a method of assembling a mechanical fuel lockout switch for an internal combustion engine includes providing an internal combustion engine configured to operate on a fuel from a first fuel source and a different fuel from a second fuel source. The method also includes coupling a mechanical fuel valve to the internal combustion engine actuateable between a first position and a second position to selectively control fuel flow to the internal combustion engine from the first fuel source through a first fuel line and the second fuel source through a second fuel line. The method further includes coupling a fuel lockout apparatus to the mechanical fuel valve. When the mechanical fuel valve is in the first position, the fuel lockout apparatus communicates the first fuel source to the internal combustion engine and prevents the second fuel source from coupling to the internal combustion engine, and actuation of the mechanical fuel valve to the second position causes the fuel lockout apparatus to permit the second fuel source to couple to the internal combustion engine, and interrupts the first fuel source communication with the internal combustion engine.

This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

What is claimed is:

1. A mechanical fuel lockout switch for a dual fuel engine comprising:

a mechanical fuel valve actuateable between a first position and a second position to selectively control fuel flow to the dual fuel engine from a first fuel source through a first fuel line and a second fuel source through a second fuel line; and

a fuel lockout apparatus coupled to the mechanical fuel valve;

wherein the mechanical fuel lockout switch:

communicates the first fuel source to the dual fuel engine and prevents communication between the second fuel source and the dual fuel engine when the mechanical fuel valve is in the first position, and

communicates the second fuel source to the dual fuel engine and interrupts the first fuel source communication with the dual fuel engine when in the second position; and

wherein the fuel lockout apparatus is configured to:

prevent the second fuel source from coupling to the second fuel line while the mechanical fuel valve is in the first position; and

permit the second fuel source to couple to the second fuel line while the mechanical fuel valve is in the second position.

2. The mechanical fuel lockout switch for a dual fuel engine of claim **1**, wherein the fuel lockout apparatus prevents actuation of the mechanical fuel valve to the first position when the second fuel source communicates with the dual fuel engine.

3. The mechanical fuel lockout switch for a dual fuel engine of claim **1**, wherein the fuel lockout apparatus comprises a flange rigidly coupled to the mechanical fuel valve that covers an inlet of the second fuel line while the mechanical fuel valve is in the first position and uncovers the inlet of the second fuel line while the mechanical fuel valve is in the second position.

4. The mechanical fuel lockout switch for a dual fuel engine of claim **3**, wherein the mechanical fuel valve rotates between the first position and the second position and the flange rotates transversely across the inlet of the second fuel line.

5. The mechanical fuel lockout switch for a dual fuel engine of claim **3**, further comprising;

a first end of a quick-disconnect hose coupling attached to the inlet of the second fuel line; and

a second end of the quick-disconnect hose coupling attached to the second fuel source to mate with the first end of the quick-disconnect hose coupling to couple the second fuel source to the second fuel line.

6. The mechanical fuel lockout switch for a dual fuel engine of claim **1**, wherein the mechanical fuel valve and the fuel lockout apparatus operate together to ensure that fuel from the first fuel source and fuel from the second fuel source are not simultaneously delivered to the dual fuel engine.

7. The mechanical fuel lockout switch for a dual fuel engine of claim **6**, wherein the first fuel source provides liquid fuel from a liquid fuel tank to the dual fuel engine and the second fuel source provides gaseous fuel from a pressurized fuel container to the dual fuel engine.

8. A method of assembling a mechanical fuel lockout switch for an internal combustion engine comprising:

providing an internal combustion engine configured to operate on a fuel from a first fuel source and a different fuel from a second fuel source;

coupling a mechanical fuel valve to the internal combustion engine actuateable between a first position and a second position to selectively control fuel flow to the internal combustion engine from the first fuel source through a first fuel line and the second fuel source through a second fuel line; and

coupling a fuel lockout apparatus to the mechanical fuel valve;

wherein when the mechanical fuel valve is in the first position, the fuel lockout apparatus communicates the first fuel source to the internal combustion engine and prevents the second fuel source from coupling to the internal combustion engine, and actuation of the mechanical fuel valve to the second position causes the fuel lockout apparatus to permit the second fuel source

to couple to the internal combustion engine, and interrupts the first fuel source communication with the internal combustion engine; and

wherein the fuel lockout apparatus prevents actuation of the mechanical fuel valve to the first position when the second fuel source is coupled to the internal combustion engine.

9. The method of claim **8**, wherein the fuel lockout apparatus is further configured to:

prevent coupling of the second fuel source to the second fuel line while the mechanical fuel valve is in the first position; and

permit coupling of the second fuel source to the second fuel line while the mechanical fuel valve is in the second position.

10. The method of claim **8**, wherein the fuel lockout apparatus comprises a fuel inlet cover configured to actuate in unison with the mechanical fuel valve to cover a fuel inlet on the internal combustion engine for the second fuel source when the mechanical fuel valve is in the first position and uncover the fuel inlet when the mechanical fuel valve is in the second position.

11. The method of claim **8**, further comprising coupling a fuel regulator system to the second fuel source to reduce fuel pressure therefrom and deliver fuel to the second fuel line at a pressure required for operation of the internal combustion engine.

12. The method of claim **11**, further comprising mounting the fuel regulator system to the second fuel source located off-board the internal combustion engine.

13. The method of claim **11**, further comprising:

coupling one end of a quick-disconnect hose coupling to an inlet on the internal combustion engine for the second fuel source; and

coupling a mating end of the quick-disconnect hose coupling to an outlet of the fuel regulator system.

14. The method of claim **8**, further comprising providing gasoline in a liquid fuel tank as the first fuel source and LPG in a pressurized fuel container as the second fuel source.

15. A mechanical fuel lockout switch for a dual fuel engine comprising:

a mechanical fuel valve actuateable between a first position and a second position to selectively control fuel flow to the dual fuel engine from a first fuel source through a first fuel line and a second fuel source through a second fuel line; and

a fuel lockout apparatus coupled to the mechanical fuel valve;

wherein the mechanical fuel lockout switch:

communicates the first fuel source to the dual fuel engine and prevents communication between the second fuel source and the dual fuel engine when the mechanical fuel valve is in the first position, and

communicates the second fuel source to the dual fuel engine and interrupts the first fuel source communication with the dual fuel engine when in the second position; and

wherein the fuel lockout apparatus prevents actuation of the mechanical fuel valve to the first position when the second fuel source communicates with the dual fuel engine.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 10,221,780 B2
APPLICATION NO. : 14/738060
DATED : March 5, 2019
INVENTOR(S) : Sarder et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the Title Page

Item (71) Applicant: delete "Chmapion" and substitute therefore -- Champion --.

Signed and Sealed this
Eleventh Day of June, 2024

Katherine Kelly Vidal

Katherine Kelly Vidal
Director of the United States Patent and Trademark Office

EXHIBIT B

US010598101B2

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

(10) **Patent No.: US 10,598,101 B2**
(45) **Date of Patent: Mar. 24, 2020**

(54) **DUAL FUEL SELECTOR SWITCH**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 584 days.

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(65) **Prior Publication Data**

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(51) **Int. Cl.**

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F02M 13/08	(2006.01)
F02D 29/06	(2006.01)

(52) **U.S. Cl.**

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(58) **Field of Classification Search**

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Primary Examiner — Syed O Hasan

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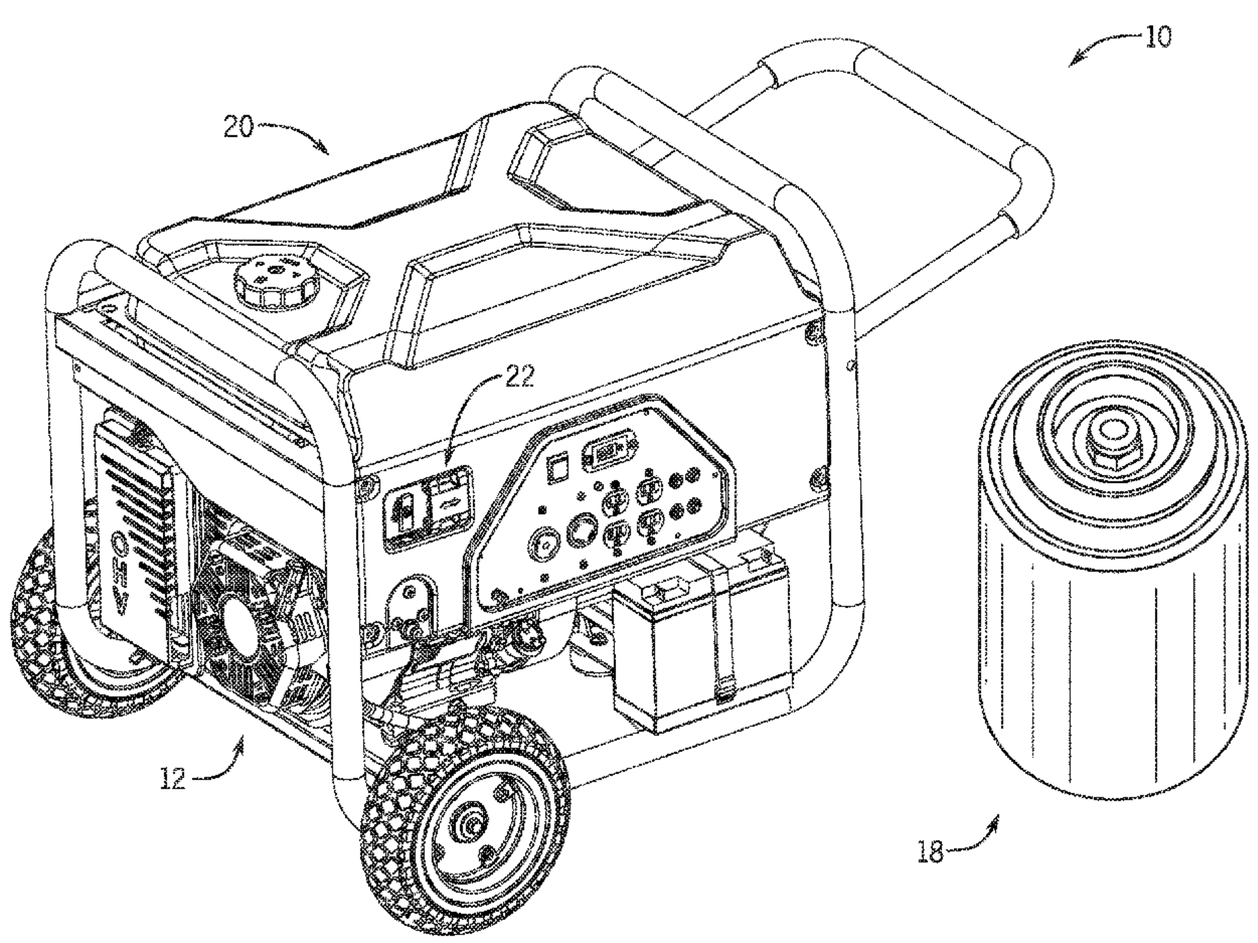
(57) **ABSTRACT**

A fuel selector for use with a dual fuel generator includes a selector plate, a first fuel valve assembly positioned adjacent the selector plate and actuatable between an ON position and an OFF position to selectively control a first fuel flow to an engine of the dual fuel generator, and a second fuel valve assembly positioned adjacent the selector plate and actuatable between an ON position and an OFF position to selectively control a second fuel flow to the engine of the dual fuel generator. A selector switch coupled to the selector plate is linearly translatable from a first position to a second position, so as to enable positioning of only one of the first fuel valve assembly and the second fuel valve assembly in the ON position at a given time, such that the first and second fuel valve assemblies cannot be in the ON position concurrently.

19 Claims, 6 Drawing Sheets



(52) **U.S. Cl.**
CPC ***F02D 29/06*** (2013.01); ***F02M 13/08*** (2013.01); *Y02T 10/36* (2013.01); *Y10T 137/0318* (2015.04); *Y10T 137/0491* (2015.04); *Y10T 137/87684* (2015.04)

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CPC F02M 21/0293; F02M 21/0236; F02M 21/0233; F02M 13/08; F02M 21/21; F02B 53/00; F02B 63/00; H02K 1/22
USPC ..... 123/525, 2, 3; 290/1 A; 137/383
See application file for complete search history.

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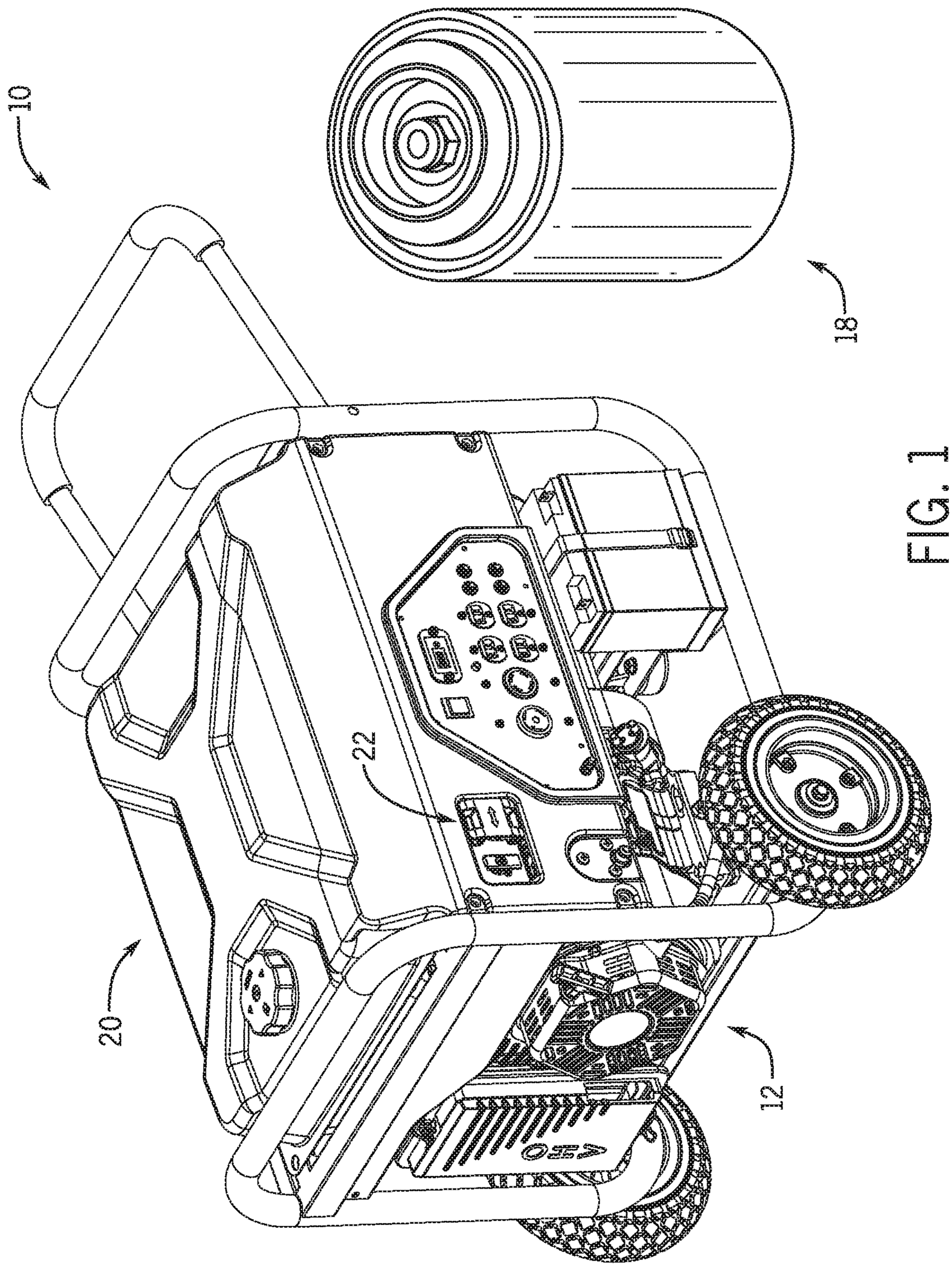

FIG. 1

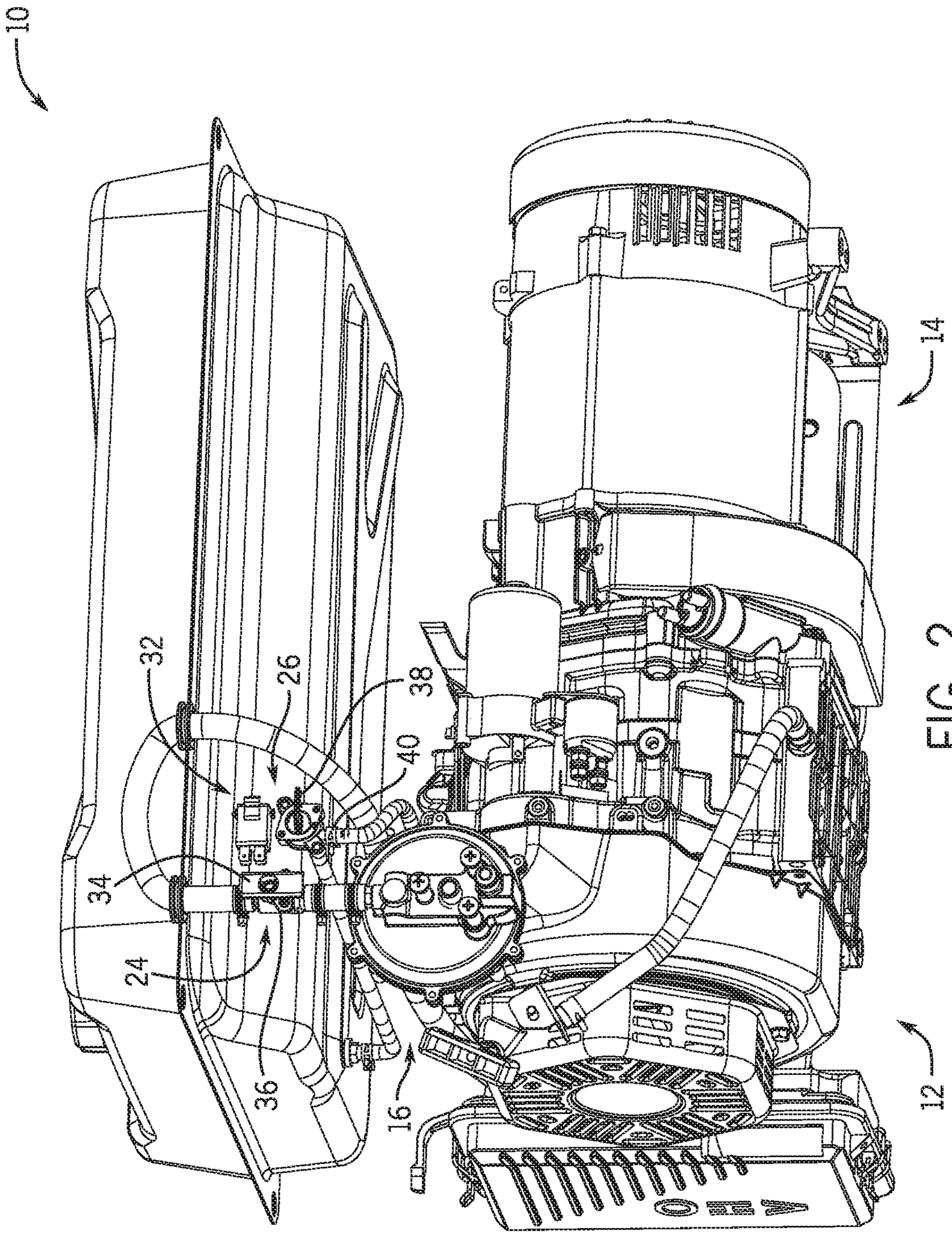

FIG. 2

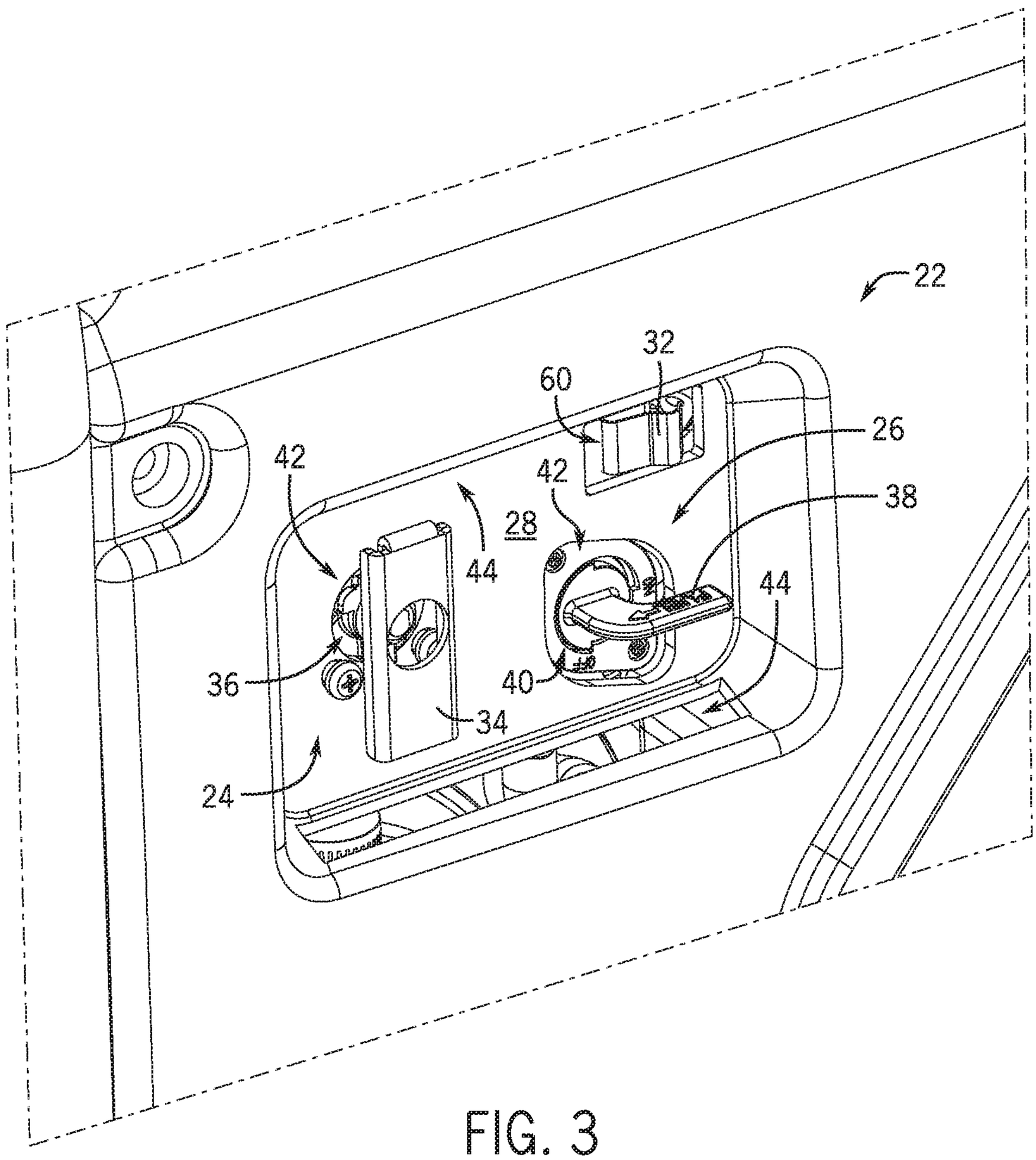

FIG. 3

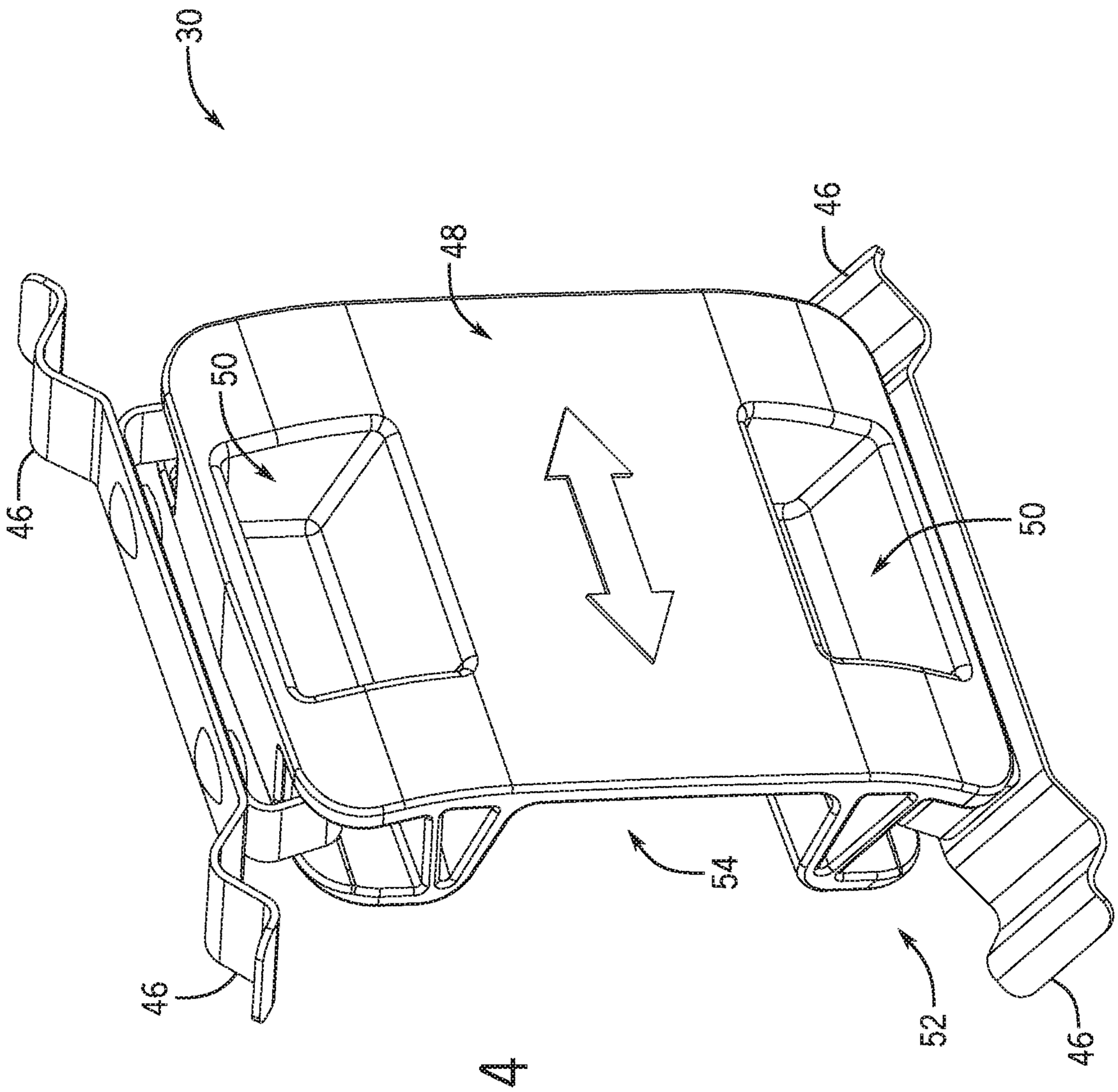

FIG. 4

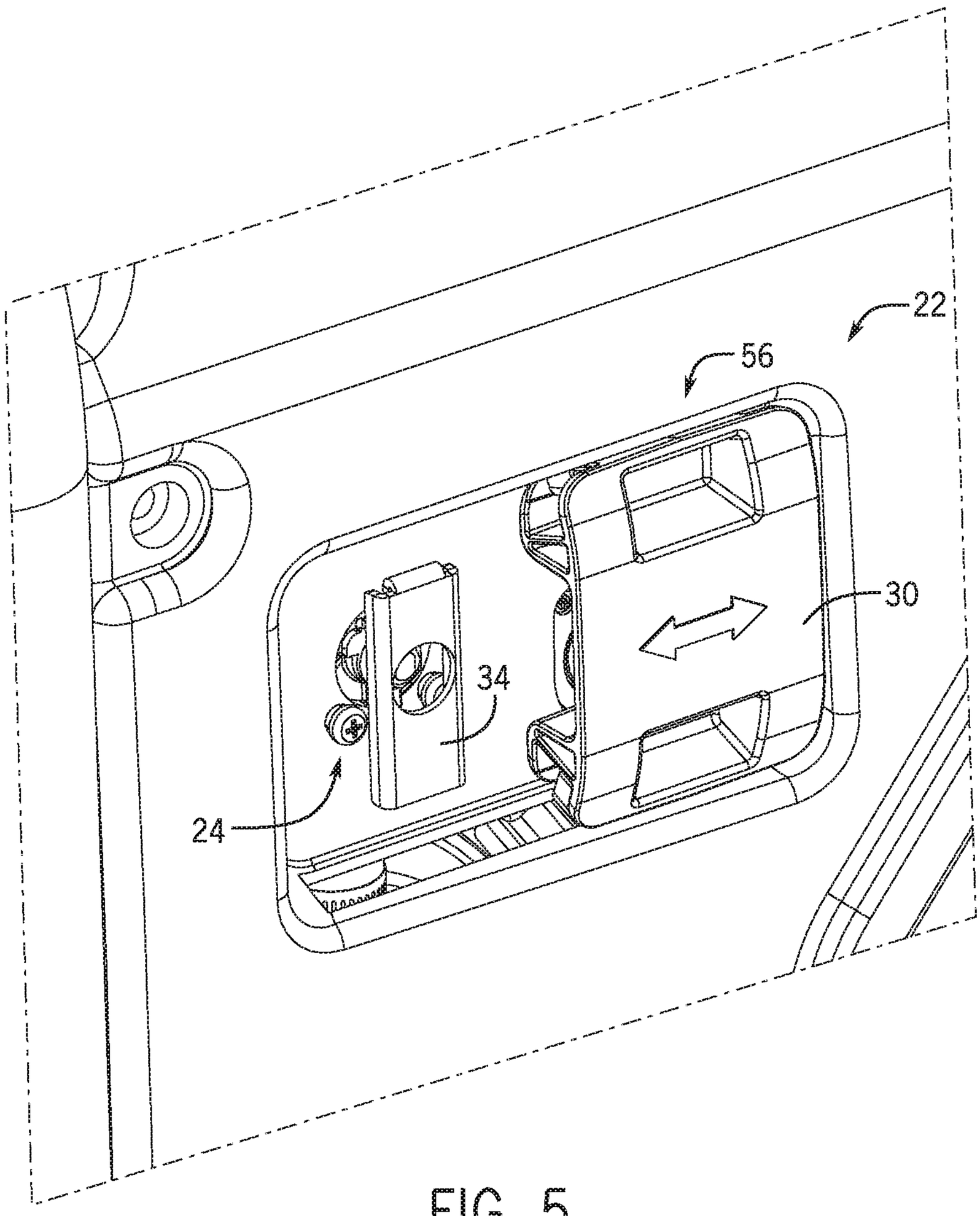

FIG. 5

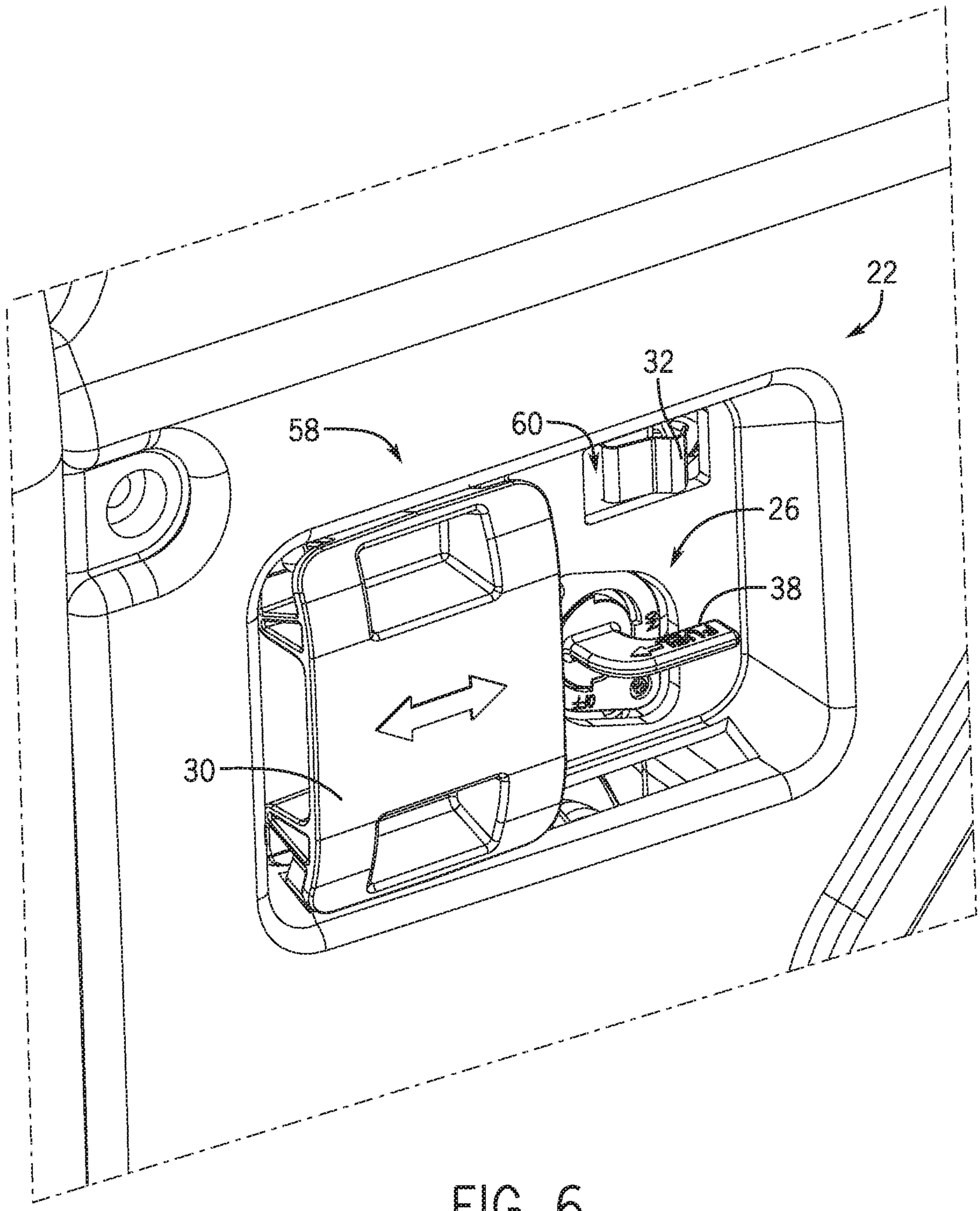

FIG. 6

DUAL FUEL SELECTOR SWITCH

CROSS-REFERENCE TO RELATED APPLICATION

The present invention is a continuation of and claims the benefit of U.S. Ser. No. 14/069,747, filed on Nov. 1, 2013, the disclosure of which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

Embodiments of the invention relate generally to dual fuel generators and, more particularly, to a selector switch for use on a dual fuel generator that is configured to ensure that only one type of fuel may be in use at a given time in the generator.

Engine-driven, electrical generators are used in a wide variety of applications. Typically, an electrical generator utilizes a single driving engine directly coupled to a generator or alternator through a common shaft. Upon activation of the generator, a fuel and air mixture is provided to the combustion chambers of corresponding cylinders of the engine. The fuel mixture in each combustion chamber is ignited causing an explosion within the cylinders. The explosive forces within the combustion chambers in the cylinders cause linear motion of the pistons within their corresponding cylinders. The linear motion of the pistons is converted into rotational motion by a crankshaft that, in turn, drives the alternator. As is conventional, the driven alternator generates electrical power.

Certain generators are defined as "dual fuel" generators that include an engine having the ability to be fueled with either of two fuels, such as either gasoline or liquefied petroleum gas (LPG), for example. These "dual fuel" engines may selectively operate on gasoline or LPG as desired and controlled by an operator, such as being operated on LPG/gasoline for a first period of operation and selectively switching over to the other of LPG/gasoline for another period of operation, with such a switching of fuels being controlled as desired by an operator. Typical dual fuel generators utilize separate valves for each fuel type, such as an LPG valve and a gasoline valve, to control flow of the respective fuels to the engine. While the existence of two separate valves allows one fuel type to have its valve "on" while the other has its valve "off," there is nothing to prevent both valves from being "on" at the same time. As such, it is possible for both valves to be in the "on" position, which can lead to a potentially unsafe condition resulting from the mixture of the fuels.

Therefore, it would be desirable to provide a dual fuel generator with a selector switch that would prohibit the mixing of two differing types of fuels. It would further be desirable for such a selector switch to inhibit positioning/actuation of the valves in such a manner that the valve for a first fuel source is prevented from being "on" when the valve for a second fuel source is "on", and vice versa.

BRIEF DESCRIPTION OF THE INVENTION

In accordance with one aspect of the invention, a fuel selector for use with a dual fuel generator includes a selector plate, a first fuel valve assembly positioned adjacent the selector plate and actuatable between an ON position and an OFF position to selectively control a first fuel flow to an engine of the dual fuel generator, and a second fuel valve assembly positioned adjacent the selector plate and actuatable between an ON position and an OFF position to selectively control a second fuel flow to the engine of the dual fuel generator. The fuel selector also includes a selector switch coupled to the selector plate so as to be linearly translatable from a first position to a second position, wherein translation of the selector switch between the first and second positions enables positioning of only one of the first fuel valve assembly and the second fuel valve assembly in the ON position at a given time, such that the first and second fuel valve assemblies cannot be in the ON position concurrently.

In accordance with another aspect of the invention, a method of controlling fuel flow in a dual fuel generator includes providing a first fuel valve assembly to control fuel flow from a first fuel source to an internal combustion engine of the dual fuel generator, the first fuel valve assembly including a first fuel valve handle movable between an ON position and an OFF position to control fuel flow from the first fuel source to the internal combustion engine. The method also includes providing a second fuel valve assembly to control fuel flow from a second fuel source to the internal combustion engine of the dual fuel generator, the second fuel valve assembly including a second fuel valve handle movable between an ON position and an OFF position to control fuel flow from the second fuel source to the internal combustion engine. The method further includes providing a fuel selector switch adjacent the first fuel valve assembly and the second fuel valve assembly such that the fuel selector switch is translatable to a first position and a section position, wherein the fuel selector switch is translatable between the first position and the section position to selectively inhibit actuation of the first fuel valve handle and the second fuel valve handle, so as to prevent a simultaneous flow of fuels from the first and second fuel sources to the internal combustion engine.

In accordance with yet another aspect of the invention, a dual fuel generator includes a first fuel source, a second fuel source, and an internal combustion engine coupled to the first fuel source and the second fuel source to selectively receive fuel therefrom. The dual fuel generator also includes a fuel selector configured to control a flow of fuel from the first and second fuel sources to the internal combustion engine, with the fuel selector comprising a first fuel valve assembly including a first fuel valve and a first fuel valve handle that is actuatable between an open position and a closed position to selectively open and close the first fuel valve, a second fuel valve assembly including a second fuel valve and a second fuel valve handle that is actuatable between an open position and a closed position to selectively open and close the second fuel valve, a selector plate having the first fuel valve assembly and the second fuel valve assembly coupled to a front side thereof, and a selector switch slideably coupled to the selector plate so as to be movable from a first position to a second position. Positioning of the selector switch in the first position causes the selector switch to cover the second fuel valve handle so as to prevent the second fuel valve handle from moving to the open position and positioning of the selector switch in the second position causes the selector switch to cover the first fuel valve handle so as to prevent the first fuel valve handle from moving to the open position.

These and other advantages and features will be more readily understood from the following detailed description of preferred embodiments of the invention that is provided in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings illustrate embodiments presently contemplated for carrying out the invention.

In the drawings:

FIG. **1** is a perspective view of a dual fuel generator, according to an embodiment of the invention.

FIG. **2** is a partial view of the dual fuel generator of FIG. **1**, according to an embodiment of the invention

FIG. **3** is a front perspective view of a fuel selector for use with the dual fuel generator of FIG. **1**, according to an embodiment of the invention.

FIG. **4** is a front perspective view of a selector switch for use with the fuel selector of FIG. **3**, according to an embodiment of the invention.

FIG. **5** is a front perspective view of the fuel selector of FIG. **3** with the selector switch in a first position, according to an embodiment of the invention.

FIG. **6** is a front perspective view of the fuel selector of FIG. **3** with the selector switch in a second position, according to an embodiment of the invention.

DETAILED DESCRIPTION

Referring first to FIGS. **1** and **2**, a dual fuel generator **10** is illustrated, according to an embodiment of the invention—with a perspective view of the generator **10** being shown in FIG. **1** and a more detailed partial view of the generator **10** being shown in FIG. **2** to further illustrate features thereof. Dual fuel generator **10** includes an internal combustible engine **12** operatively connected to an alternator **14** in a conventional manner. The engine **12** includes pistons (not shown) that are slideably received within corresponding cylinders (not shown) thereof, with each cylinder further including an intake valve for admitting a fuel-air mixture and an exhaust valve for venting exhaust gases following combustion. The fuel-air mixture is provided by a carburetor **16** that includes a movable throttle, with a position of the throttle regulating the amount of fuel and air admitted into the cylinders and thus the speed and power developed by the engine **12** when the air-fuel mixture is ignited to generate reciprocal movement of the pistons. The reciprocal movement of the pistons of engine **12** is translated to rotational movement by a crankshaft (not shown) that, in turn, drives the alternator **14**, so as to generate an electrical output power from the generator **10**.

As the generator **10** is a dual fuel generator, the engine **12** is designed to use different fuels from either a first fuel source **18** or a second fuel source **20**. In an exemplary embodiment of the invention, first fuel source **18** supplies a liquefied petroleum gas (LPG) to the engine **12** and second fuel source **20** supplies gasoline to the engine **12**, with the generator **10** selectively operating on LPG or gasoline as desired and controlled by an operator, such as for example operating on LPG for a first period of operation and then switching over to gasoline for another period of operation. However, it is contemplated that the first fuel source **18** and/or second fuel source **20** may be other types of fuel sources (e.g., natural gas, biodiesel, etc.), according to additional embodiments of the invention—and thus the scope of the invention is not meant to be limited strictly to a gasoline-LPG dual fuel embodiment.

For selectively controlling the flow of gasoline and LPG to the engine **12**, dual fuel generator **10** includes a fuel selector **22** constructed to provide for selection of a desired fuel source **18**, **20** for supplying fuel to engine **12**. The fuel selector **22** not only provides for selection of a desired fuel source **18**, **20** for supplying fuel to engine **12**, but also selectively restricts the selection of a fuel source so as to enable the use of only one fuel at a time. As a result, fuel from first fuel source **18** cannot flow to engine **12** while fuel from second fuel source **20** is flowing to engine **12**, and vice versa.

The fuel selector **22** of generator **10** is shown in greater detail in FIGS. **3-6** according to an embodiment of the invention. In general, the fuel selector **22** includes a first valve assembly **24**, a second valve assembly **26**, a selector plate **28**, a selector switch **30**, and a carburetor solenoid switch **32**. These elements of the fuel selector **22** collectively function to provide for selective control of a fuel flow (of gasoline or LPG) to the engine **12**, with the fuel selector **22** enabling selection of a desired fuel source **18**, **20** to provide a fuel flow therefrom while also inhibiting the selection of the other fuel source **18**, **20** so as to prevent a fuel flow therefrom, thereby enabling only a single fuel to flow to the engine **12** at one time.

Referring first to FIG. **3**, a front view of fuel selector **22** is shown with selector switch **30** removed therefrom, so as to best illustrate the construction of the first valve assembly **24** and the second valve assembly **26**. The first valve assembly **24** and the second valve assembly **26** are attached, respectively, to first fuel source **18** and second fuel source **20** to selectively control a flow of fuel from the fuel sources to the engine **12**. First valve assembly **24** includes a first fuel valve handle **34** that is operatively connected to a first fuel valve **36** to control an opening and closing of the first fuel valve. Similarly, second valve assembly **26** includes a second fuel valve handle **38** that is operatively connected to a second fuel valve **40** to control an opening and closing of the second fuel valve.

Each of the first valve assembly **24** and the second valve assembly **26** are movable between an ON position and an OFF position to control opening and closing of their respective fuel valve. More specifically, first and second fuel valve handles **34**, **38** are movable between an ON position and an OFF position, with the fuel valves **36**, **40** being open (to enable fuel flow to the engine **12**) when their respective fuel valve handle **34**, **38** is in the ON position and being closed (to prevent fuel flow to the engine **12**) when their respective fuel valve handle **34**, **38** is in the OFF position. Thus, when first fuel valve handle **34** is in an ON position, first fuel valve **36** is open and allows the fuel from first fuel source **18** to flow to the engine **12**, and when second fuel valve handle **38** is in an ON position, second fuel valve **40** is open and allows the fuel from second fuel source **20** to flow to the engine **12**.

In the preferred embodiments of the invention, first valve assembly **24** and second valve assembly **26** are located adjacent to each other on the same horizontal plane or parallel horizontal planes. In such an embodiment, first valve assembly **24** is in the ON position when first fuel valve handle **34** is moved to a vertical orientation/position and first valve assembly **24** is in an OFF position when first fuel valve handle **34** is moved to a horizontal orientation/position. Similarly, second valve assembly **26** is in the ON position when second fuel valve handle **38** is moved to a vertical orientation/position second valve assembly **26** is in an OFF position when second fuel valve handle **38** is moved to a horizontal orientation/position. It is recognized, however, that an alternative embodiment of the invention may have first valve assembly **24** and second valve assembly **26** located adjacent to each other on the same vertical plane or parallel vertical planes. One having ordinary skill in the art would recognize that in such an alternative embodiment of the invention, first and second valve assemblies **24** would be in the ON position when their respective fuel valve handles **34**, **38** are horizontal, and would be in the OFF position when their respective fuel valve handles **34**, **38** are vertical.

As shown in FIG. **3**, first valve assembly **24** and second valve assembly **26** are positioned adjacent to the selector plate **28** of fuel selector **22**. The selector plate **28** may be integrally formed as part of a larger outer frame assembly of generator **10** or may be an insert attachable to such a frame assembly. Openings **42** are formed in selector plate **28** so as to accommodate positioning of the first valve assembly **24** and second valve assembly **26**—with the openings **42** enabling positioning of first and second fuel valve handles **34**, **38** in front of selector plate **28**, such that they may be actuated by an operator of the generator **10** in order to open/close their respective valves **36**, **40**. Selector plate **28** also includes slots or grooves **44** formed therein that are positioned both above and below the first and second fuel valve handles **34**, **38**, with the slots **44** extending generally in a lengthwise fashion along a length of the selector plate **28**. Each of the slots **44** is configured to receive a protrusion or flange formed on selector switch **30**, such that the selector switch **30** can be slideably coupled to the selector plate **28**—with the selector switch **30** being translatable in a linear fashion by way of its mating with the slots **44**.

Detailed views of the selector switch **30** and of its mating with the selector plate **28** are shown in FIGS. **4-6**. Referring first to FIG. **4**, the general structure of selector switch **30** is shown according to an exemplary embodiment. Protrusions or flanges **46** are formed on each of top and bottom surfaces of the selector switch **30** that are configured to mate with the corresponding slots **44** formed in selector plate **28** (FIG. **3**). The protrusions **46** may be flexible so as to accommodate coupling of the selector switch **30** to the selector plate **28**. A front surface **48** of selector switch **30** includes finger-hold depressions **50** formed therein that accommodate the fingers of an operator, with the finger-holds providing a convenient feature by which the operator can operate (i.e., slide) the selector switch **30**. A back surface **52** of the selector switch **30** includes a groove or channel **54** formed therein having a width and depth sufficient to receive the first and second fuel valve handles **34**, **38** therein when in their horizontal position (i.e., the OFF position). The groove **54** is further sized and configured such that the first and second fuel valve handles **34**, **38** will not fit therein when in their vertical position (i.e., the ON position).

Positioning of the selector switch **30** relative to the selector plate **28** and first and second valve assemblies **24**, **26** is shown in FIGS. **5** and **6**. As shown therein, positioning of the first valve assembly **24** and second valve assembly **26** adjacent selector plate **28**—and on the same horizontal plane—provides for selective positioning of the selector switch **30** relative to the fuel valve handles **34**, **38** in what are generally referred to hereafter as a first position and a second position **56**, **58**. The selector switch **30** is translatable in a horizontal motion—via a sliding motion within slots **44** of the selector plate **28**—from the first position **56** (FIG. **5**) to the second position **58** (FIG. **6**) to selectively restrict actuation of the first and second fuel valve handles **34**, **38**. As the groove **54** formed in selector switch **30** is configured such that the first and second fuel valve handles **34**, **38** will not fit therein when in their vertical position (i.e., the ON position), it is recognized that in order to translate the selector switch **30** back and forth between the first and second positions **56**, **58**, both of the fuel valve handles **34**, **38** must be in their horizontal OFF position.

In FIG. **5**, selector switch **30** is illustrated in the first position **56**. When selector switch **30** is in first position **56**, selector switch **30** covers second fuel valve handle **38**, and groove **54** formed on the back surface **52** of the fuel selector switch **30** locks second fuel valve handle **38** in an OFF position, so as to prohibit the second valve assembly **26** from moving to the ON position. Further, when selector switch **30** is in first position **56**, first valve assembly **24** is able to move freely between the ON position and the OFF position, with the first fuel valve handle **34** being actuatable by the operator. In one embodiment of the invention, when first valve assembly **24** is in the ON position, first fuel valve handle **34** is in a vertical position and prevents selector switch **30** from moving horizontally from first position **56** to second position **58**.

In operation, when selector switch **30** is moved from second position **58** into first position **56**, second fuel valve handle **38** slides into the groove **54** formed in selector switch **30**. As a result, when selector switch **30** is in first position **56**, second fuel valve handle **38** is unable to move, as it is locked in place by groove **54**, and second valve assembly **26** is locked in the OFF position, with movement from the OFF position to the ON position being prohibited.

IN FIG. **6**, selector switch **30** is illustrated in the second position **58**. When selector switch **30** is in second position **58**, selector switch **30** covers first fuel valve handle **34**, and groove **54** formed on the back surface **52** of the fuel selector switch **30** locks first fuel valve handle **34** in an OFF position, so as to prohibit the first valve assembly **24** from moving to the ON position. In addition, when selector switch **30** is in second position **58**, second valve assembly **26** is able to freely move between the ON position and the OFF position, with the second fuel valve handle **38** being actuatable by the operator. In one embodiment of the invention, when second valve assembly **26** is in the ON position, second fuel valve handle **38** is in a vertical position and prevents selector switch **30** from moving horizontally from second position **58** to first position **56**.

In operation, when selector switch **30** is moved from first position **56** into second position **58**, first fuel valve handle **34** slides into groove **54** formed in selector switch **30**. Therefore, when selector switch **30** is in second position **58**, first fuel valve handle **34** is unable to move, as it is locked in place by groove **54**, and first valve assembly **24** is locked in the OFF position, with movement from the OFF position to the ON position being prohibited.

Referring still now to FIG. **6**, according to an exemplary embodiment of the invention, the fuel selector **22** of generator **10** further comprises a carburetor solenoid switch **32** that is positioned within an opening **60** formed in selector plate **28** so as to extend therethrough and is further positioned adjacent second valve assembly **26** (i.e., second fuel valve handle **38**. As solenoid switch **32** is located adjacent to the second valve assembly **26**—which is in turn connected to the gasoline fuel source **20**—selector switch **30** covers and triggers solenoid switch **32** when slid from the second position **58** to the first position **56**—by depressing the solenoid switch **32** as it comes in contact therewith. When solenoid switch **32** is triggered, a carburetor shutoff solenoid operatively connected to the solenoid switch **32** is activated and shuts off the flow of gasoline to the carburetor **16** (FIG. **2**). In the preferred embodiment of the invention, solenoid switch **32** is a depressible switch, but it is contemplated that solenoid switch **32** may be another type of switch that can be activated via interaction with selector switch **30** or via interaction with either valve handle **34**, **38**, so as to activate the carburetor shutoff solenoid.

Beneficially, the design of the fuel selector **22** and of the selector switch **30** described herein prevents differing fuels from two separate fuel sources from flowing to the engine of a dual fuel generator at the same time. The interaction of the selector switch **30** with the first and second fuel valve

assemblies **24**, **26**—with the selector switch **30** sliding back and forth to selectively cover/engage first and second fuel valve assemblies **24**, **26**—prohibits both valve assemblies from being in the "ON" position at the same time. The selector switch **30** is thus a foolproof device that prevents the mixing of fuels so as to provide additional safety to the usage of dual fuel generators.

Therefore, according to one embodiment of the invention, a fuel selector for use with a dual fuel generator includes a selector plate, a first fuel valve assembly positioned adjacent the selector plate and actuatable between an ON position and an OFF position to selectively control a first fuel flow to an engine of the dual fuel generator, and a second fuel valve assembly positioned adjacent the selector plate and actuatable between an ON position and an OFF position to selectively control a second fuel flow to the engine of the dual fuel generator. The fuel selector also includes a selector switch coupled to the selector plate so as to be linearly translatable from a first position to a second position, wherein translation of the selector switch between the first and second positions enables positioning of only one of the first fuel valve assembly and the second fuel valve assembly in the ON position at a given time, such that the first and second fuel valve assemblies cannot be in the ON position concurrently.

According to another embodiment of the invention, a method of controlling fuel flow in a dual fuel generator includes providing a first fuel valve assembly to control fuel flow from a first fuel source to an internal combustion engine of the dual fuel generator, the first fuel valve assembly including a first fuel valve handle movable between an ON position and an OFF position to control fuel flow from the first fuel source to the internal combustion engine. The method also includes providing a second fuel valve assembly to control fuel flow from a second fuel source to the internal combustion engine of the dual fuel generator, the second fuel valve assembly including a second fuel valve handle movable between an ON position and an OFF position to control fuel flow from the second fuel source to the internal combustion engine. The method further includes providing a fuel selector switch adjacent the first fuel valve assembly and the second fuel valve assembly such that the fuel selector switch is translatable to a first position and a section position, wherein the fuel selector switch is translatable between the first position and the section position to selectively inhibit actuation of the first fuel valve handle and the second fuel valve handle, so as to prevent a simultaneous flow of fuels from the first and second fuel sources to the internal combustion engine.

According to yet another embodiment of the invention, a dual fuel generator includes a first fuel source, a second fuel source, and an internal combustion engine coupled to the first fuel source and the second fuel source to selectively receive fuel therefrom. The dual fuel generator also includes a fuel selector configured to control a flow of fuel from the first and second fuel sources to the internal combustion engine, with the fuel selector comprising a first fuel valve assembly including a first fuel valve and a first fuel valve handle that is actuatable between an open position and a closed position to selectively open and close the first fuel valve, a second fuel valve assembly including a second fuel valve and a second fuel valve handle that is actuatable between an open position and a closed position to selectively open and close the second fuel valve, a selector plate having the first fuel valve assembly and the second fuel valve assembly coupled to a front side thereof, and a selector switch slideably coupled to the selector plate so as to be movable from a first position to a second position. Positioning of the selector switch in the first position causes the selector switch to cover the second fuel valve handle so as to prevent the second fuel valve handle from moving to the open position and positioning of the selector switch in the second position causes the selector switch to cover the first fuel valve handle so as to prevent the first fuel valve handle from moving to the open position.

While the invention has been described in connection with only a limited number of embodiments, it should be readily understood that the invention is not limited to such disclosed embodiments. Rather, the invention can be modified to incorporate any number of variations, alterations, substitutions or equivalent arrangements not heretofore described, but which are commensurate with the spirit and scope of the invention. Additionally, while various embodiments of the invention have been described, it is to be understood that aspects of the invention may include only some of the described embodiments. Accordingly, the invention is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

What is claimed is:

1. A fuel selector for use with a dual fuel generator, the fuel selector comprising:

a valve assembly fluidly connected to each of a first fuel source and a second fuel source, the valve assembly being operable to selectively control a first fuel flow and a second fuel flow from the first fuel source and the second fuel source, respectively, to an engine of the dual fuel generator; and

a selector switch positioned on the valve assembly to allow a user to manually select one of the first fuel flow and the second fuel flow;

wherein the valve assembly comprises:

a first fuel valve having open and closed positions to selectively control the first fuel flow to the engine; and

a second fuel valve having open and closed positions to selectively control the second fuel flow to the engine; and

wherein the first fuel valve and the second fuel valve are mechanical valves.

2. The fuel selector of claim **1** wherein the selector switch provides for manual actuation of the first fuel valve and the second fuel valve between the open and closed positions.

3. The fuel selector of claim **2** further comprising:

a first valve handle coupled to the first fuel valve and actuatable between an ON position and an OFF position to selectively open and close the first fuel valve, respectively;

a second valve handle coupled to the second fuel valve and actuatable between an ON position and an OFF position to selectively open and close the second fuel valve, respectively;

wherein the selector switch is positioned relative to the first and second valve handles so as to provide for only one of the first and second valve handles to be in the ON position at a given time.

4. The fuel selector of claim **3** further comprising a selector plate positioned adjacent the first and second valve handles, wherein the selector switch is coupled to the selector plate so as to be movable from a first position to a second position, with movement of the selector switch between the first and second positions enabling positioning of only one of the first valve handle and the second valve handle in the ON position at a given time.

5. The fuel selector of claim 4 wherein, when the selector switch is in the first position, the first valve handle is actuatable between the ON position and the OFF position and the second valve handle is prohibited from being in the ON position; and

wherein, when the selector switch is in the second position, the first valve handle is prohibited from being in the ON position and the second valve handle is actuatable between the ON position and the OFF position.

6. The fuel selector of claim 4 further comprising a carburetor solenoid switch coupled to the selector plate adjacent and extending out of a front surface thereof, the carburetor solenoid switch comprising a depressible switch configured to activate an associated solenoid when depressed.

7. The fuel selector of claim 6 wherein when the selector switch is in the first position so as to prohibit the second valve handle from being in the ON position, the selector switch depresses the carburetor solenoid switch, so as to activate the carburetor solenoid and stop the flow of the gasoline fuel source.

8. The fuel selector of claim 1 wherein the first fuel valve is attached to a liquefied petroleum gas (LPG) fuel source and wherein the second fuel valve is attached to a gasoline source.

9. The fuel selector of claim 1 wherein the mechanical valve of each of the first fuel valve and the second fuel valve is a non-solenoid valve.

10. A fuel selector for use with a dual fuel generator, the fuel selector comprising:

a valve assembly fluidly connected to each of a first fuel source and a second fuel source, the valve assembly being operable to selectively control a first fuel flow and a second fuel flow from the first fuel source and the second fuel source, respectively, to an engine of the dual fuel generator; and

at least one valve handle positioned on and operably connected to the valve assembly to actuate the valve assembly to enable one of the first fuel flow and the second fuel flow to the engine;

wherein the valve assembly comprises:

a first fuel valve having open and closed positions to selectively control the first fuel flow to the engine; and

a second fuel valve having open and closed positions to selectively control the second fuel flow to the engine; and

wherein the at least one valve handle is mechanically coupled to the first fuel valve and the second fuel valve to selectively open and close the first fuel valve and the second fuel valve responsive to actuation thereof.

11. The fuel selector of claim 10 wherein the at least one valve handle enables only one of the first fuel flow and the second fuel flow to the engine at a given time.

12. The fuel selector of claim 10 wherein the at least one valve handle comprises:

a first valve handle coupled to the first fuel valve and actuatable between an ON position and an OFF position to selectively open and close the first fuel valve, respectively;

a second valve handle coupled to the second fuel valve and actuatable between an ON position and an OFF position to selectively open and close the second fuel valve, respectively.

13. The fuel selector of claim 12 further comprising a selector switch positioned relative to the first and second valve handles so as to provide for only one of the first and second valve handles to be in the ON position at a given time.

14. The fuel selector of claim 13 further comprising a selector plate positioned adjacent the first and second valve handles, wherein the selector switch is coupled to the selector plate so as to be movable from a first position to a second position, with movement of the selector switch between the first and second positions enabling positioning of only one of the first valve handle and the second valve handle in the ON position at a given time.

15. The fuel selector of claim 14 wherein, when the selector switch is in the first position, the first valve handle is actuatable between the ON position and the OFF position and the second valve handle is prohibited from being in the ON position; and

wherein, when the selector switch is in the second position, the first valve handle is prohibited from being in the ON position and the second valve handle is actuatable between the ON position and the OFF position.

16. The fuel selector of claim 10 wherein the first fuel source comprises liquefied petroleum gas (LPG) and the second fuel source comprises gasoline.

17. A fuel selector of a dual fuel generator comprising: a selector switch having a first fuel mode and a second fuel mode; a solenoid switch having open and closed positions; and a fuel solenoid having open and closed positions; wherein, when the selector switch is in the first fuel mode, the solenoid switch and the fuel solenoid are in the closed positions and when the selector switch is in the second fuel mode, the solenoid switch and the fuel solenoid are in the open positions, wherein the selector switch triggers the solenoid switch when changed from the second fuel mode to the first fuel mode, so as to cause the solenoid switch and the fuel solenoid to operate in the closed positions, and a valve assembly positioned on or adjacent the selector switch and fluidly connected to each of a first fuel source and a second fuel source, the valve assembly being operable to selectively control a first fuel flow and a second fuel flow from the first fuel source and the second fuel source, respectively, to an engine of the dual fuel generator; and wherein positioning of the selector switch in the first fuel mode and the second fuel mode enables a selection of one of the first fuel flow and the second fuel flow.

18. A fuel selector for use with a dual fuel generator, the fuel selector comprising: a valve assembly fluidly connected to each of a first fuel source and a second fuel source, the valve assembly being operable to selectively control a first fuel flow and a second fuel flow from the first fuel source and the second fuel source, respectively, to an engine of the dual fuel generator; and a selector switch positioned on the valve assembly to allow a user to manually select one of the first fuel flow and the second fuel flow; wherein the valve assembly comprises: two fuel inputs, with a first fuel input connected to the first fuel source and a second fuel input connected to the second fuel source; and two fuel outputs supplying fuel from only one of the first fuel source or the second fuel source, wherein the valve assembly comprises a first fuel valve having open and closed positions to selectively control the first fuel flow to the engine; and a second fuel valve having open and closed positions to selectively control the second fuel flow to the engine.

19. The fuel selector of claim 18, wherein the first fuel valve and the second fuel valve are non-solenoid, mechanical valves.

* * * * *

EXHIBIT C

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

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(45) **Date of Patent: Jun. 30, 2020**

(54) **BATTERYLESS DUAL FUEL ENGINE WITH LIQUID FUEL CUT-OFF**

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(58) **Field of Classification Search**
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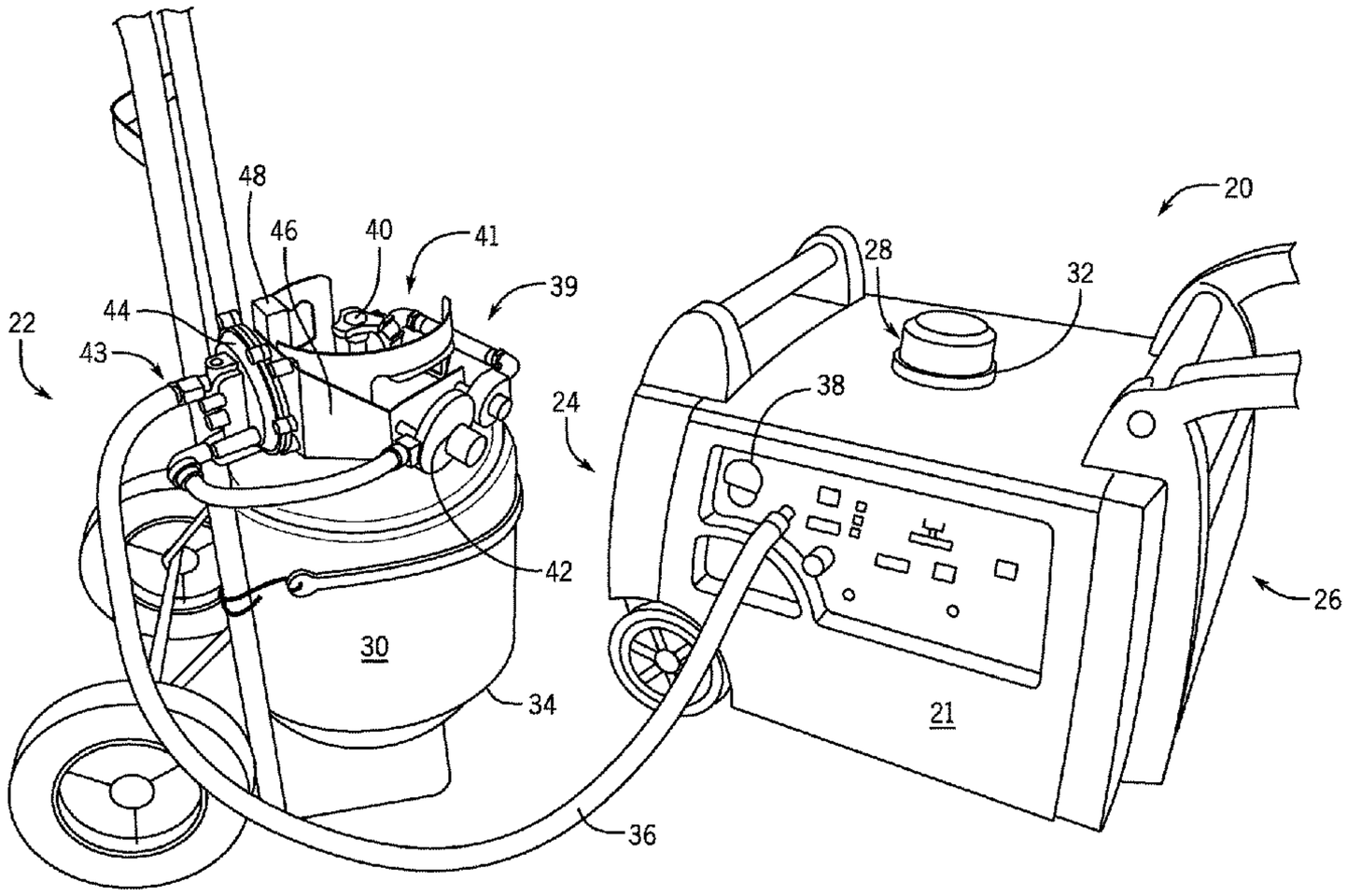
(74) *Attorney, Agent, or Firm* — Ziolkowski Patent Solutions Group, SC

(57) **ABSTRACT**

A dual fuel engine includes an engine operable on a gaseous fuel and a liquid fuel and a switch to change operation of the engine between gaseous fuel and liquid fuel. The dual fuel engine also includes a carburetor attached to an intake of the engine to mix air and fuel and connect to a gaseous fuel source and a liquid fuel source. A liquid fuel cut-off attaches to the carburetor to interrupt liquid fuel upon actuation of the switch from liquid fuel to gaseous fuel.

64 Claims, 12 Drawing Sheets



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F02M 43/00	(2006.01)
F02M 17/10	(2006.01)
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F02B 63/04	(2006.01)
F02D 41/06	(2006.01)
F02M 21/04	(2006.01)
F02D 41/00	(2006.01)
F02M 19/08	(2006.01)
F02N 3/02	(2006.01)

(52) **U.S. Cl.**
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See application file for complete search history.

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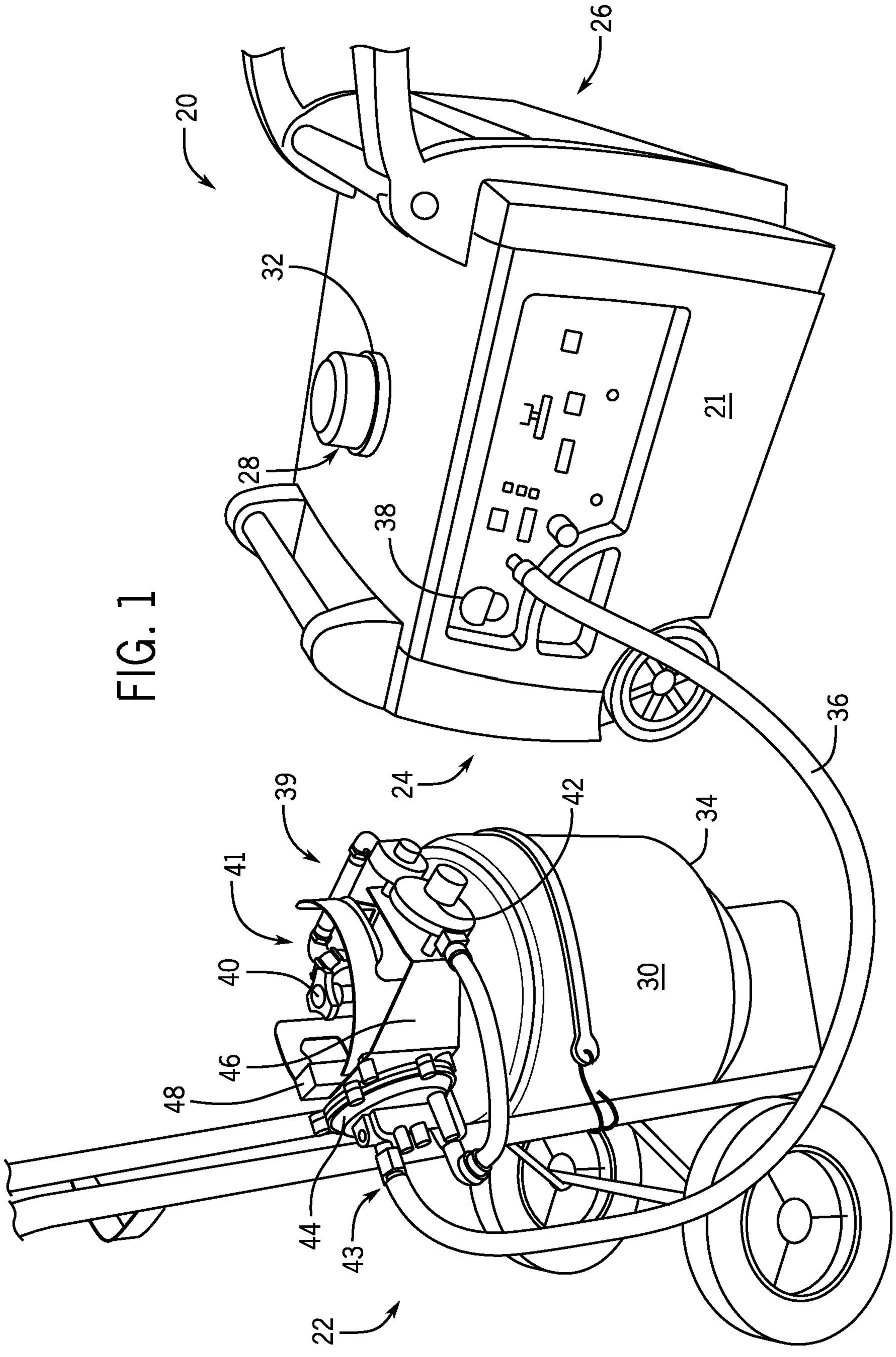
FIG. 1



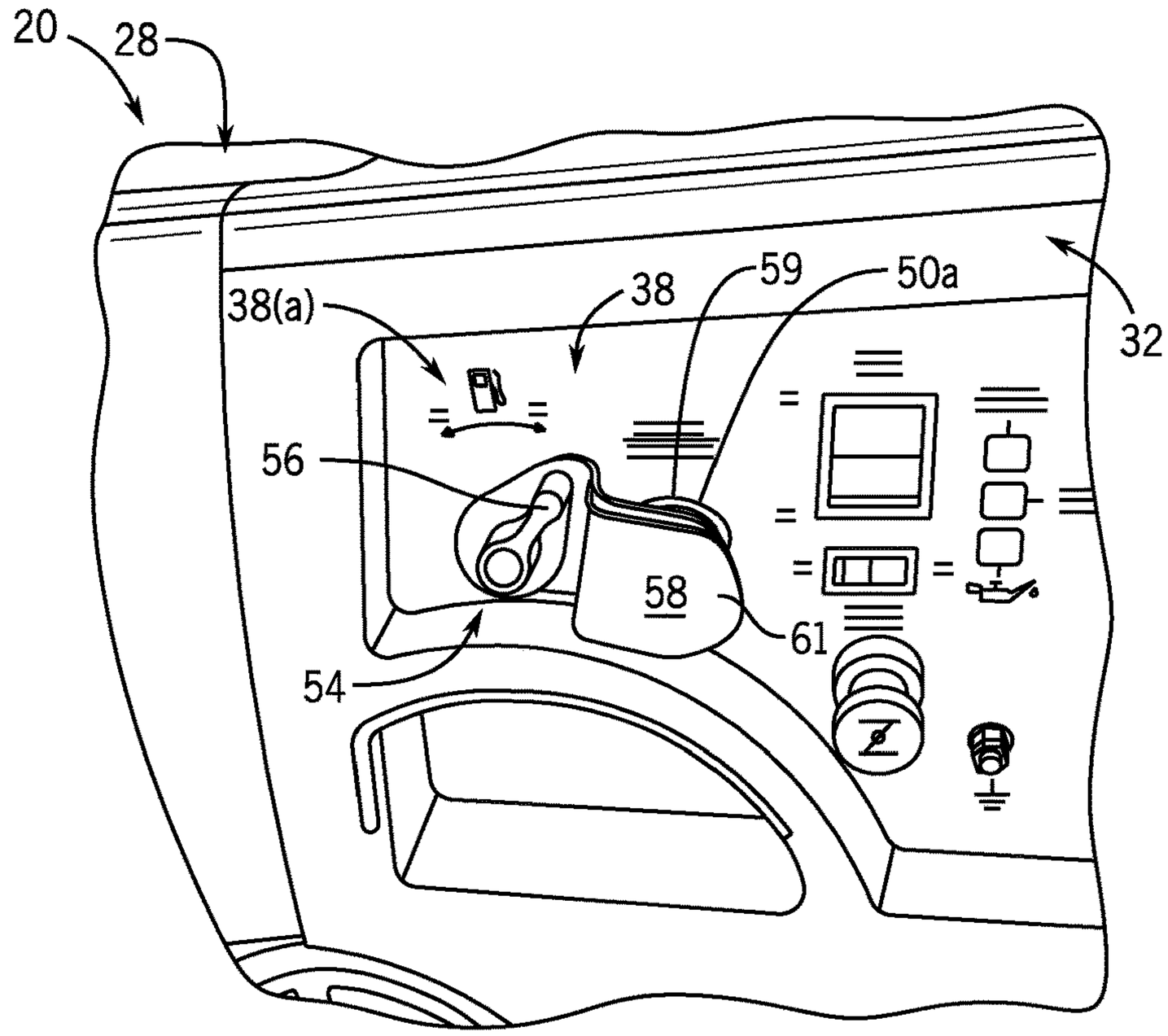

20
28
38(a)
38
59
50a
32
56
58
61
54

FIG. 2

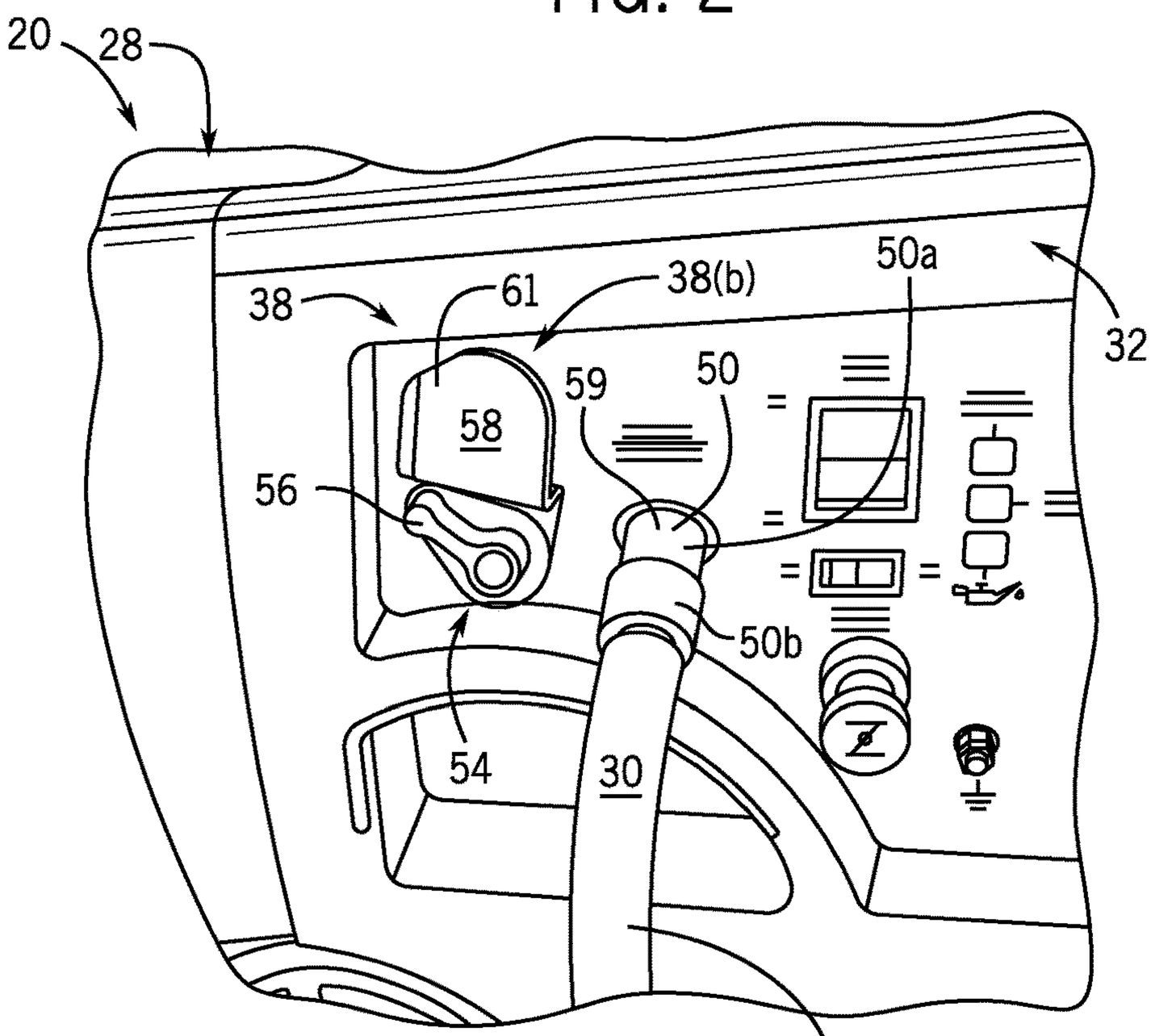

20
28
38
61
38(b)
50a
32
59
50
58
56
50b
54
30
36

FIG. 3

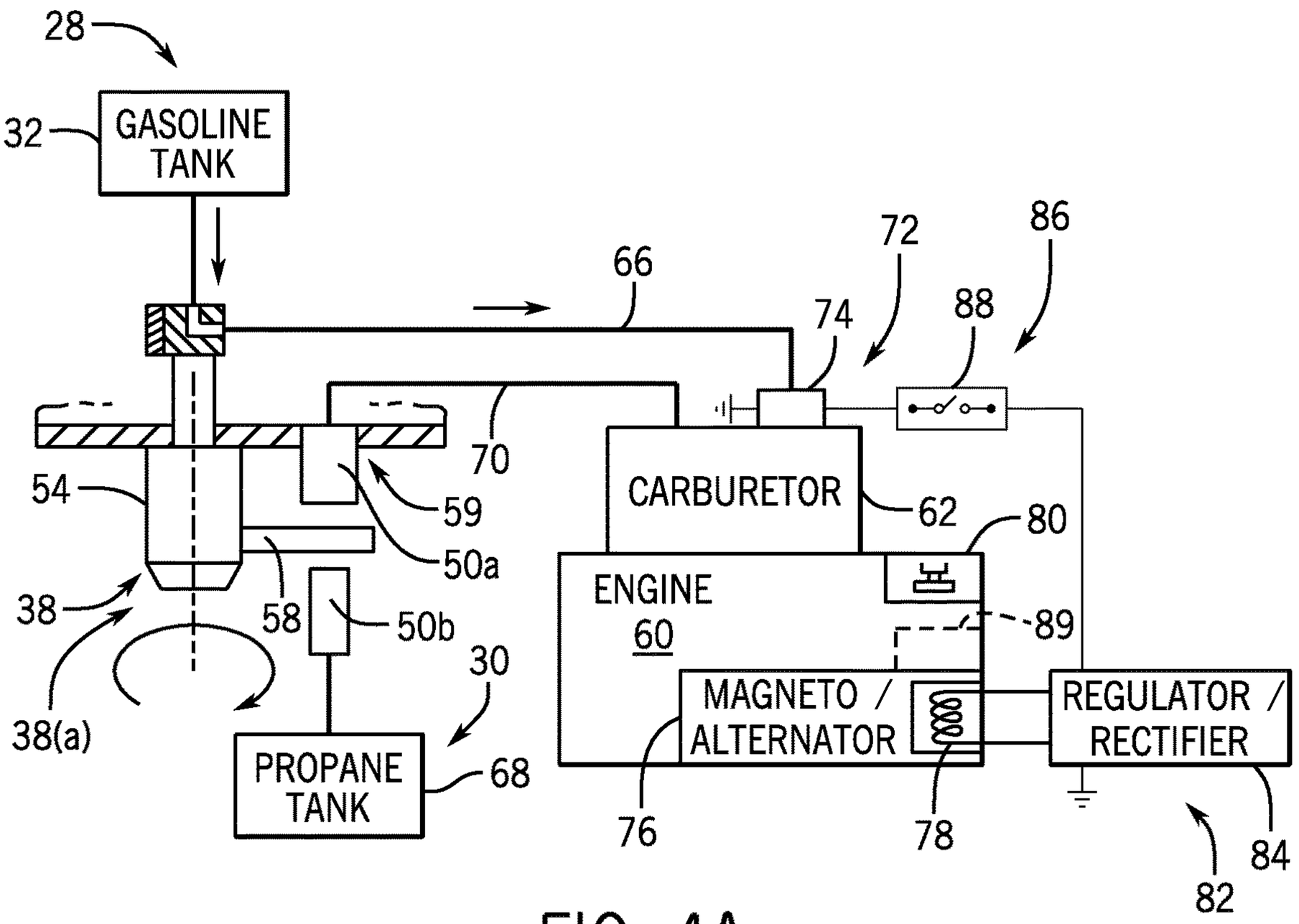


FIG. 4A

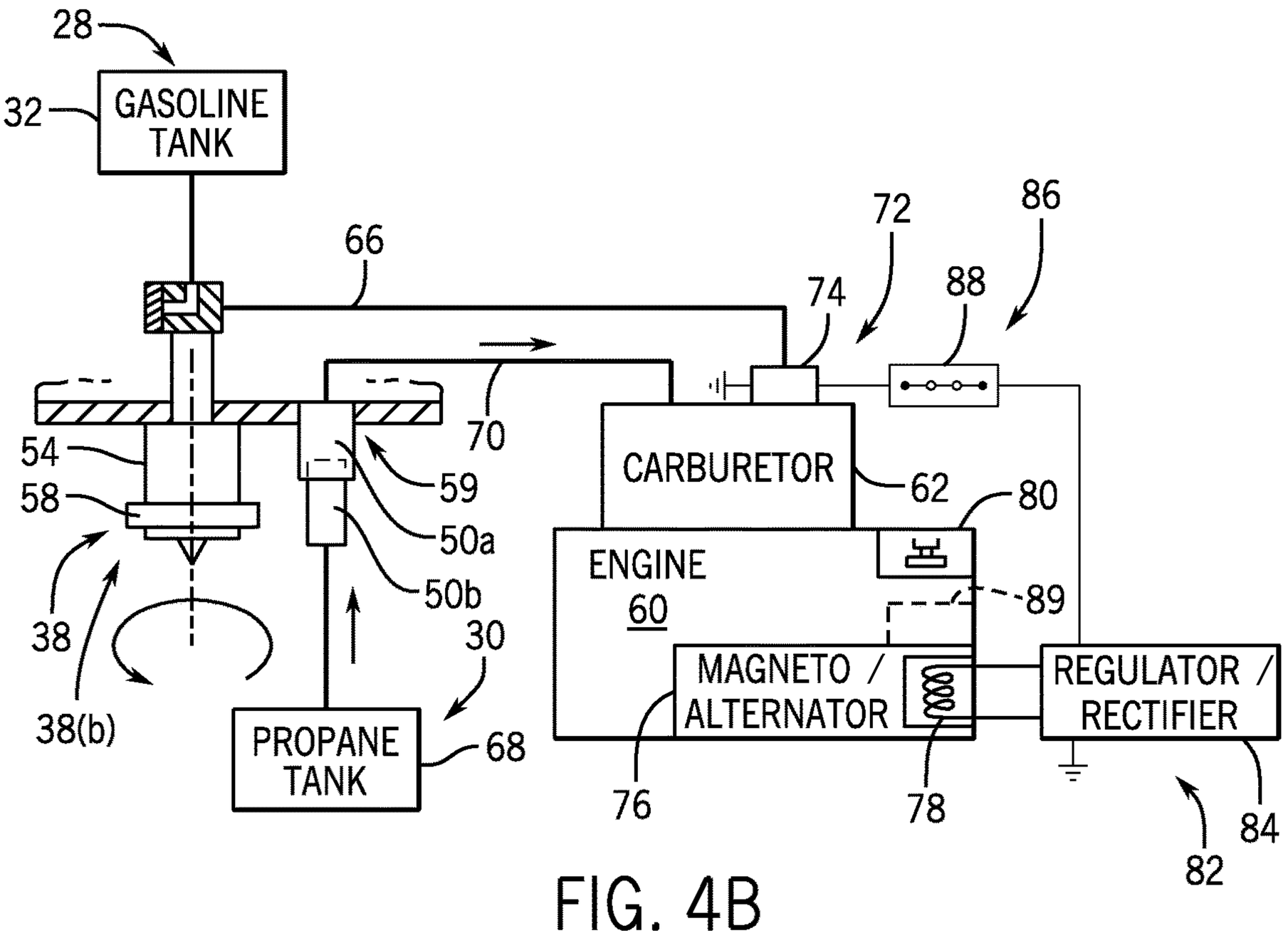


FIG. 4B

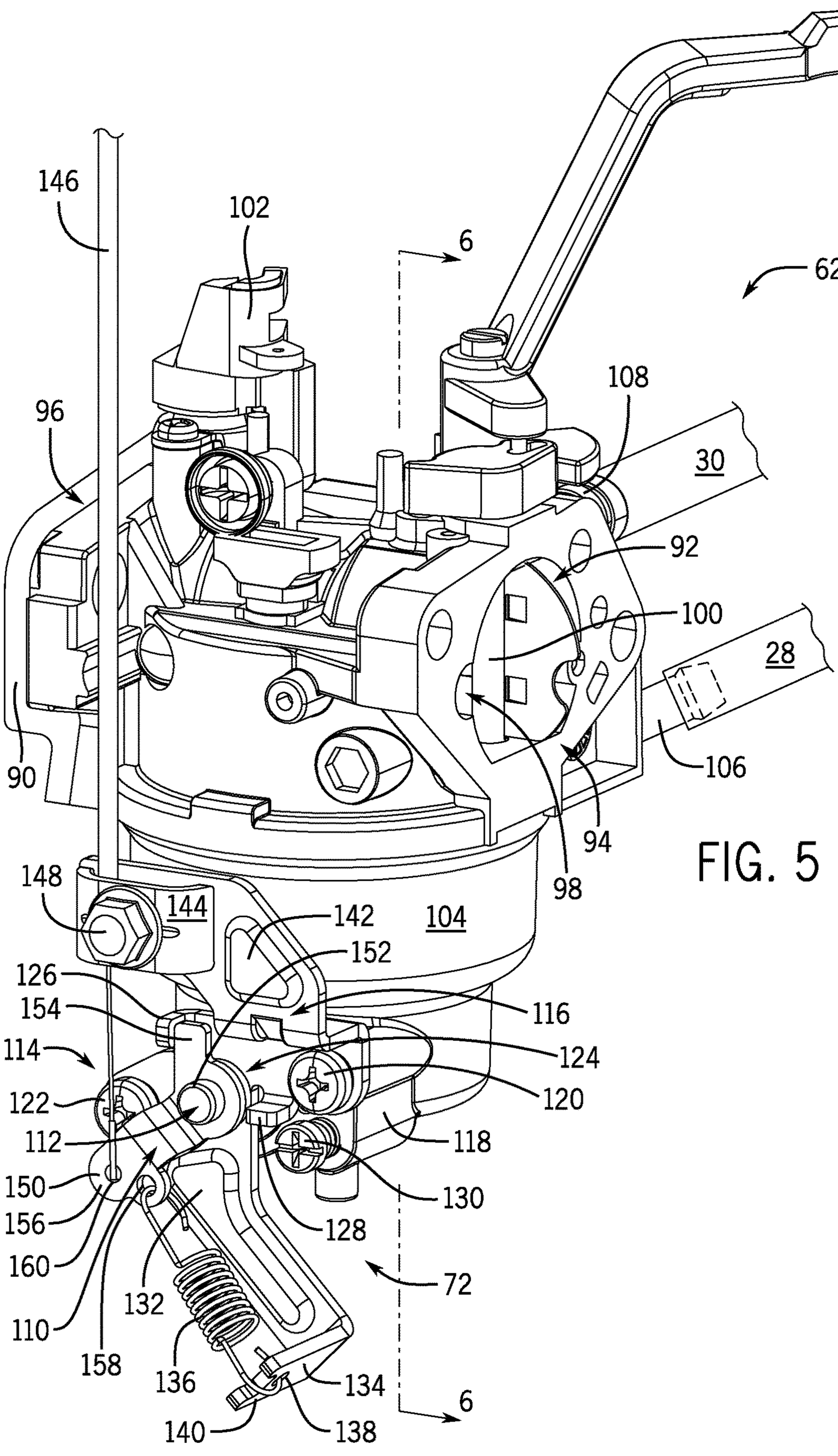
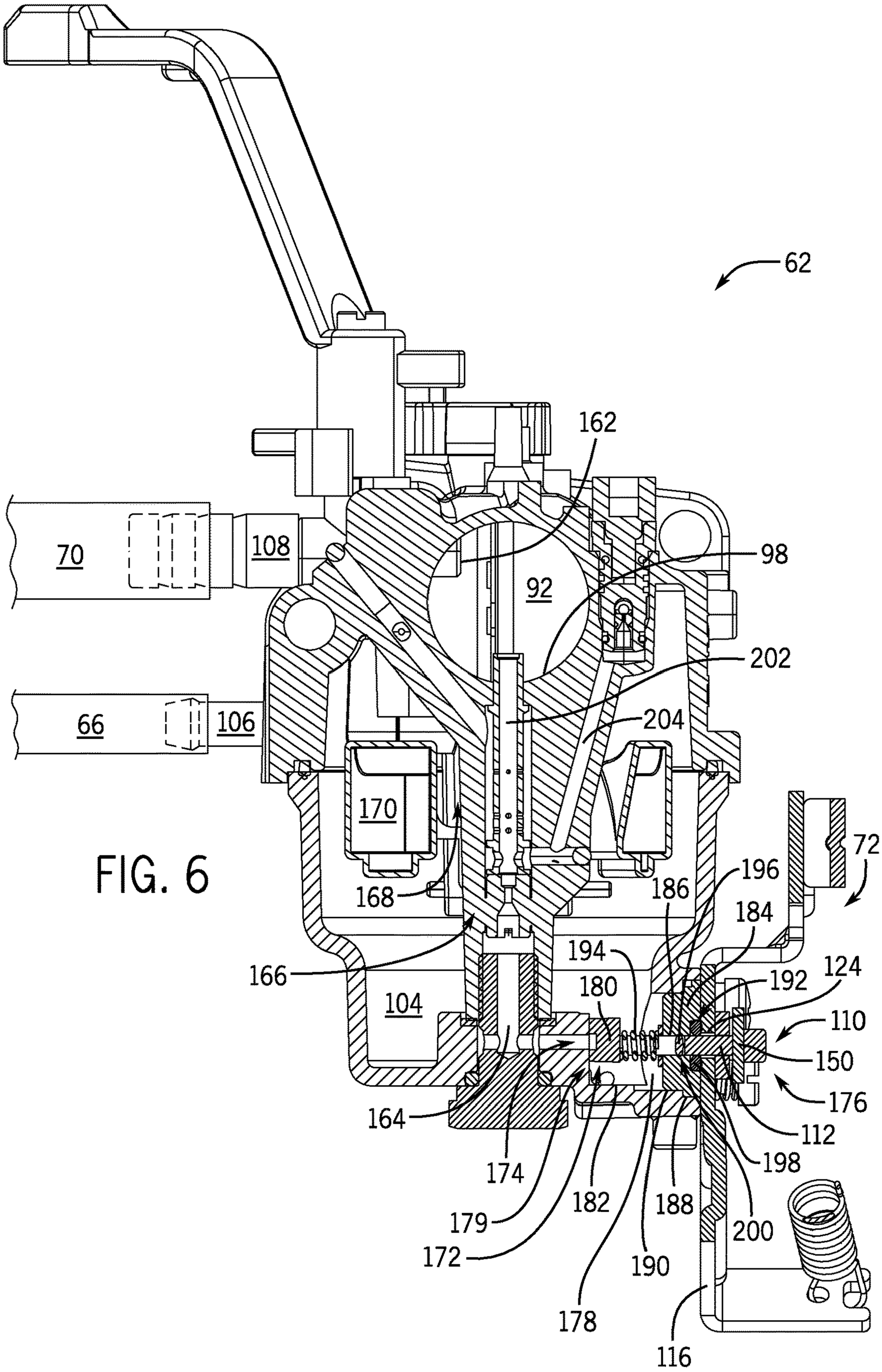


FIG. 5


62
162
70
108
98
92
202
66
106
204
170
72
196
168
186
184
194
124
192
180
110
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150
166
176
164
112
198
174
182
188
179
200
172
190
178
116

FIG. 6

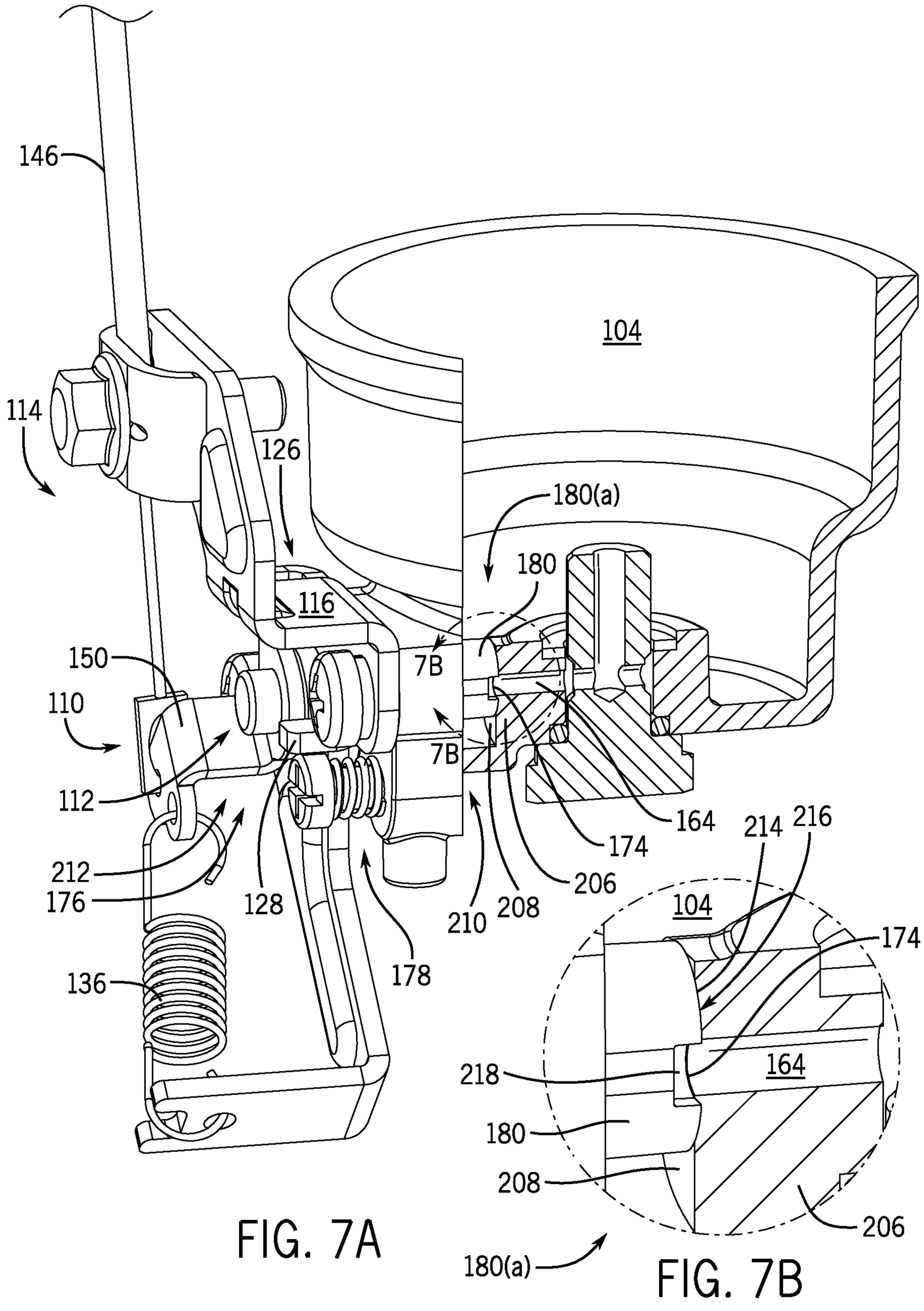

FIG. 7A

FIG. 7B

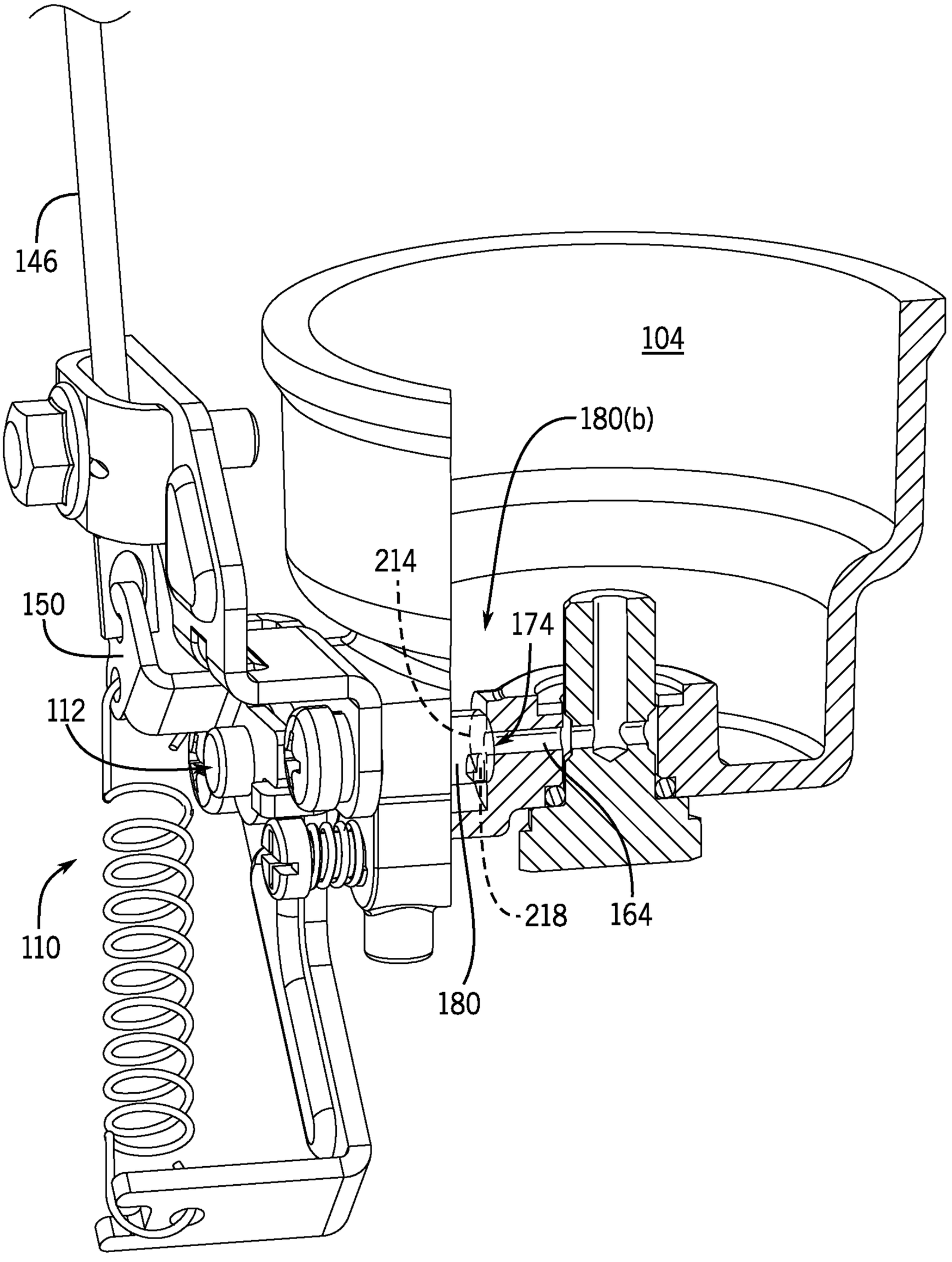

FIG. 8

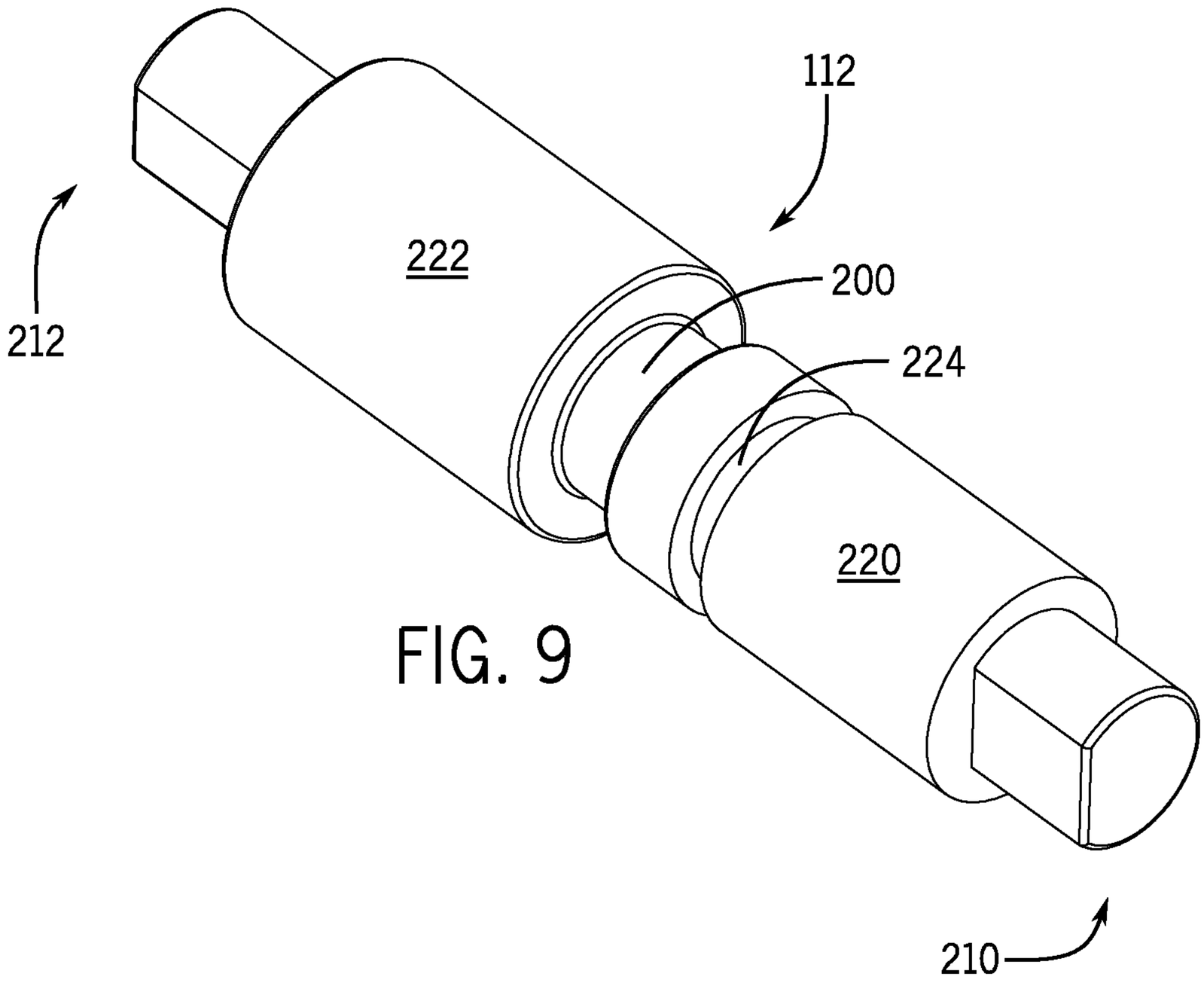

FIG. 9

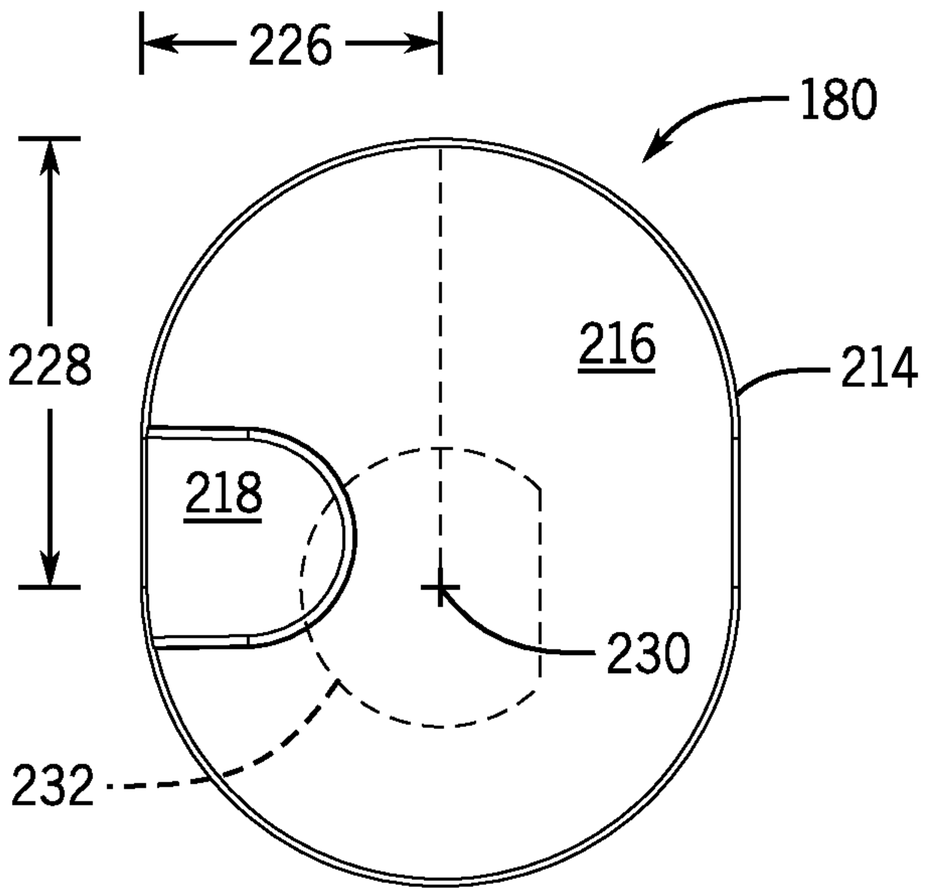

FIG. 10

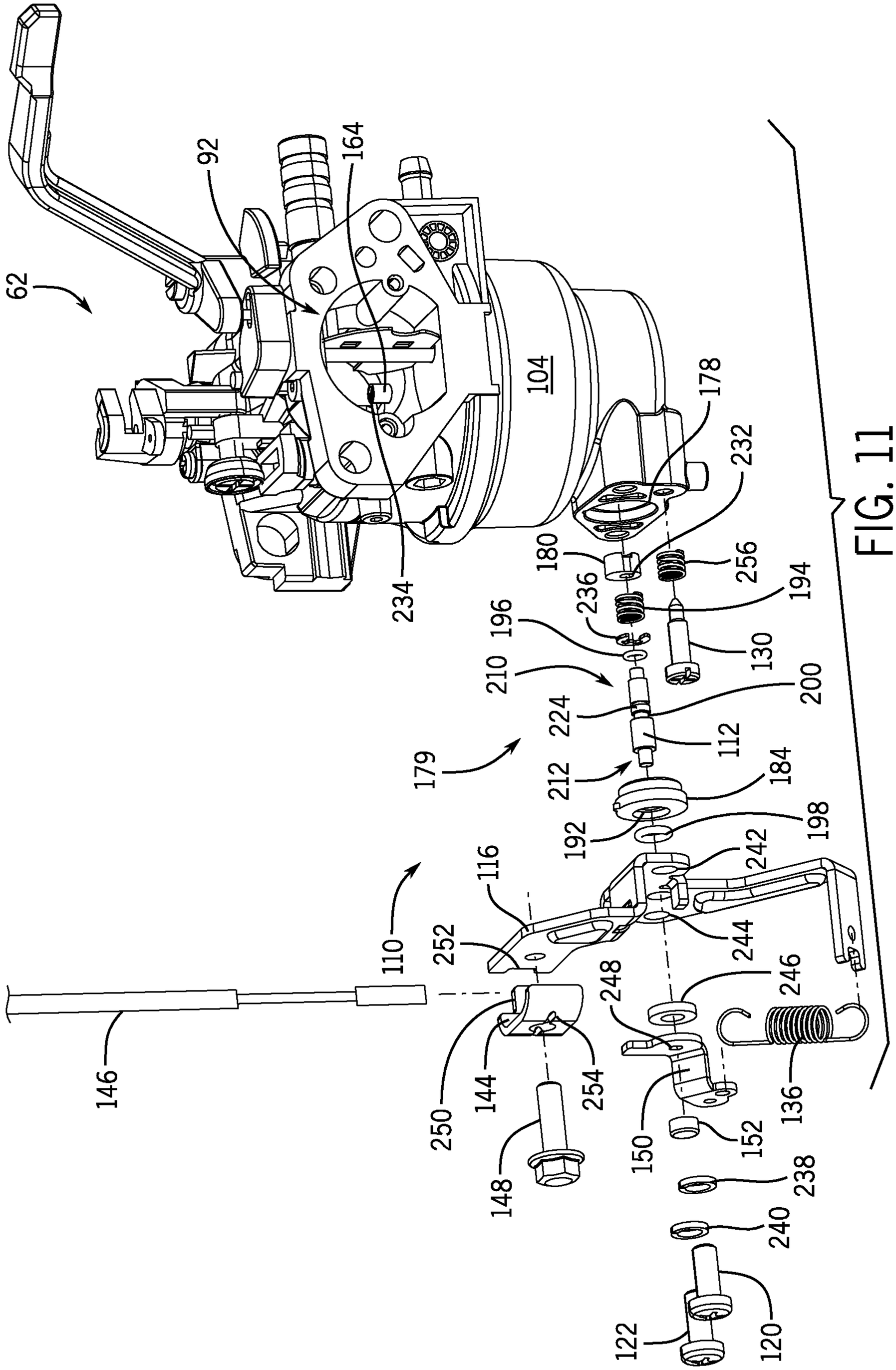
62
92
164
104
178
232
180
256
234
236
194
196
210
130
200
224
112
179
212
184
192
198
242
116
110
252
244
248
246
146
144
254
250
148
150
152
136
238
240
122
120

FIG. 11

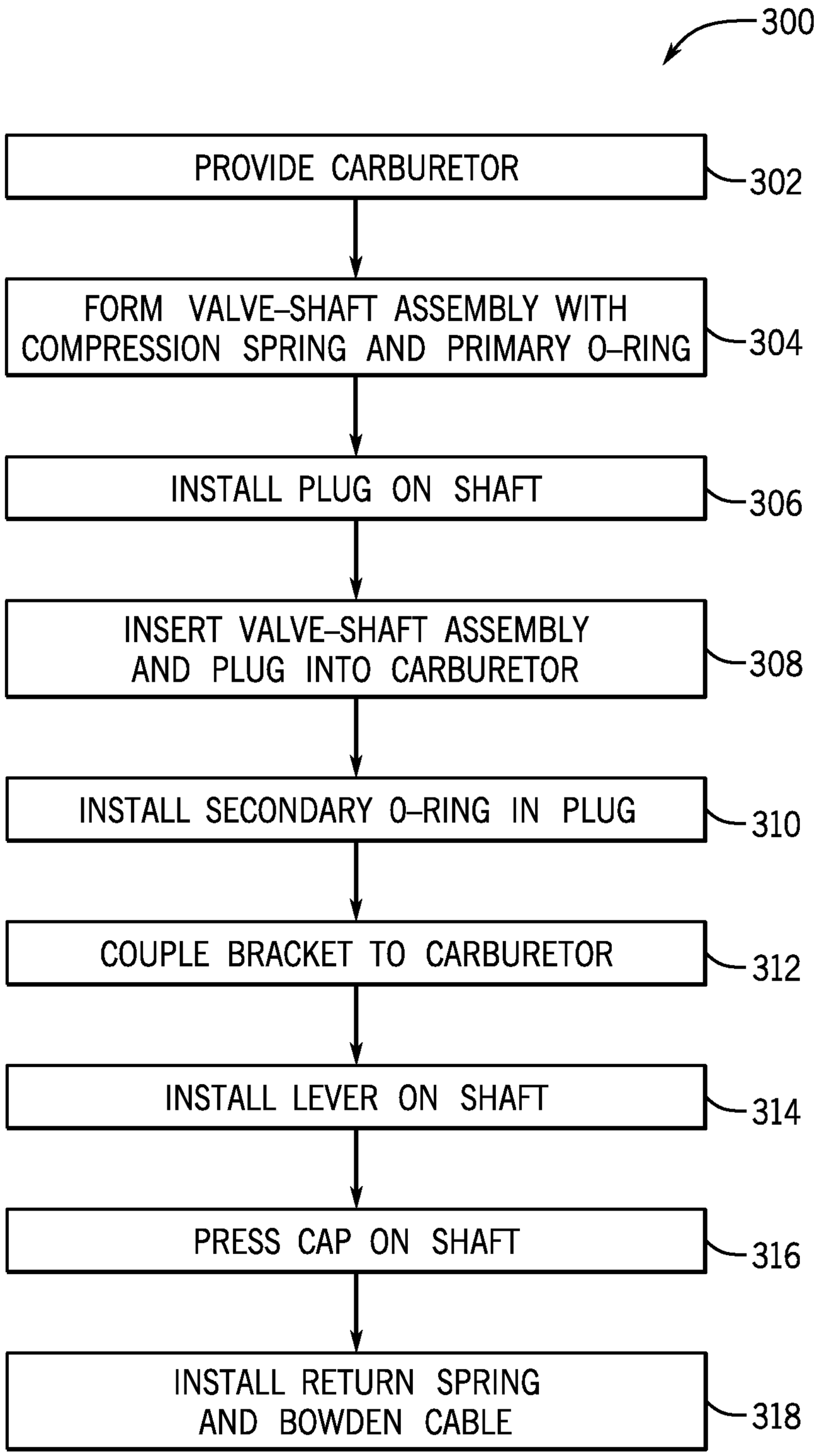

FIG. 12

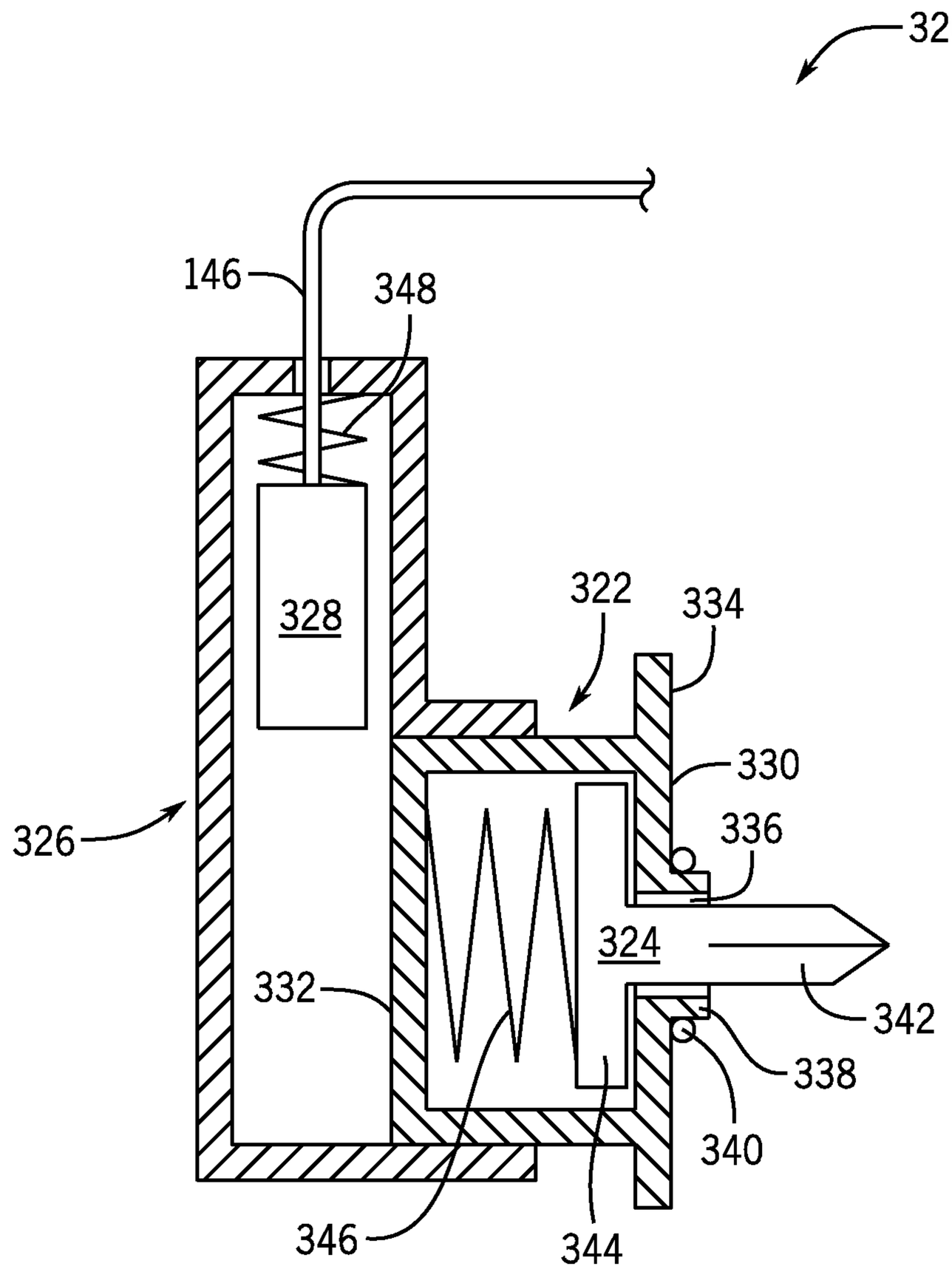

FIG. 13

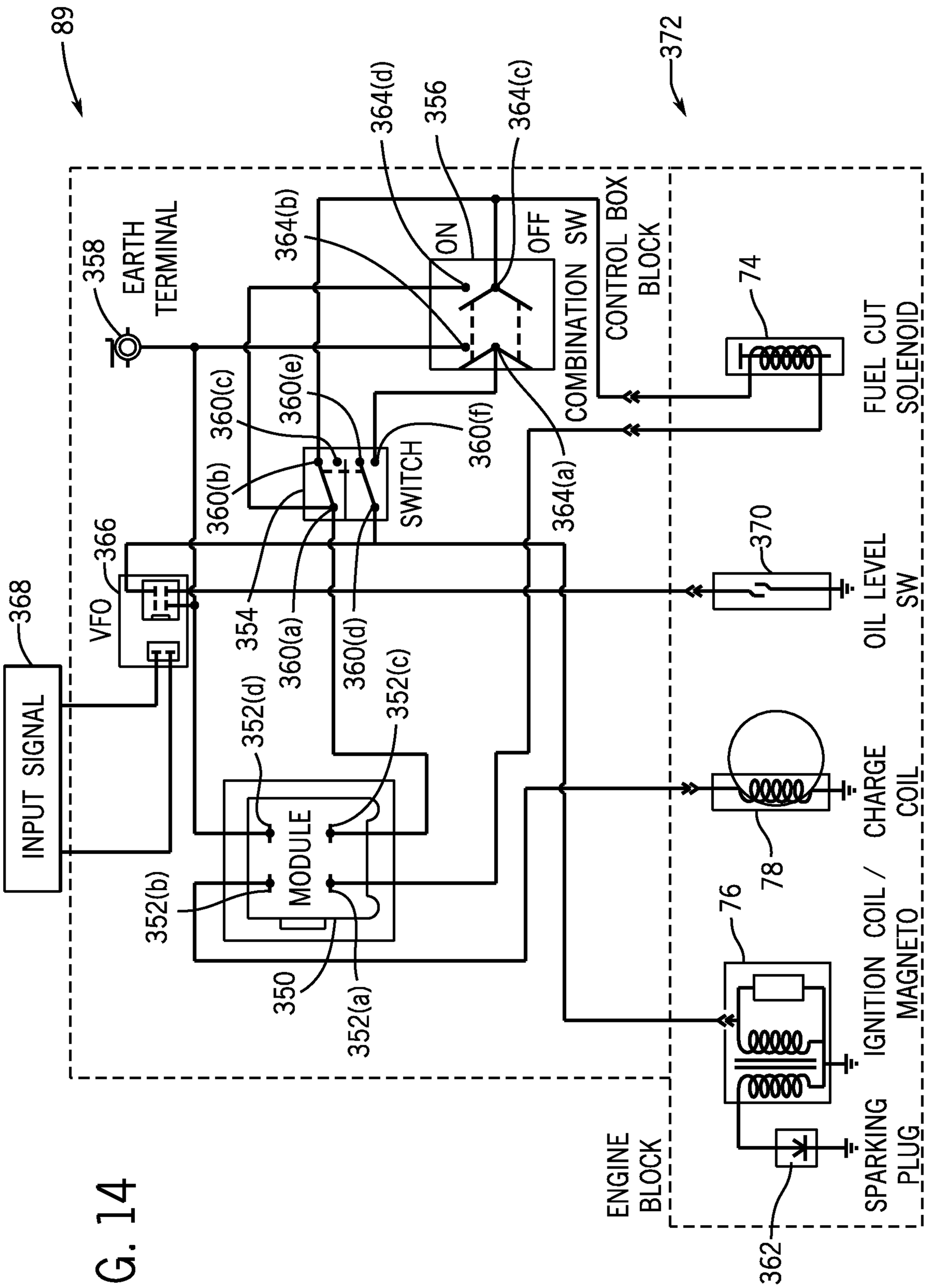
89
372
364(d)
356
364(c)
364(b)
358
EARTH TERMINAL
ON
OFF
COMBINATION SW
CONTROL BOX
BLOCK
74
FUEL CUT SOLENOID
360(c)
360(e)
360(f)
360(b)
SWITCH
364(a)
366
VFO
370
OIL LEVEL SW
368
INPUT SIGNAL
354
360(a)
360(d)
352(d)
352(c)
MODULE
352(b)
CHARGE COIL
78
76
IGNITION COIL / MAGNETO
350
352(a)
SPARKING PLUG
ENGINE BLOCK
362

FIG. 14

BATTERYLESS DUAL FUEL ENGINE WITH LIQUID FUEL CUT-OFF

CROSS-REFERENCE TO RELATED APPLICATION

The present application is a continuation-in-part of, and claims priority to, U.S. patent application Ser. No. 14/738,060, filed Jun. 12, 2015, the disclosure of which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

Embodiments of the invention relate generally to dual fuel generators, and more particularly, to an apparatus and method for delivering liquid fuel or gaseous fuel to a dual fuel generator.

Electric generators are frequently driven by internal combustion engines that use gasoline as a fuel source. Gasoline is a common fuel source for generators in a variety of applications. However, alternative fuel sources also provide a desirable fuel source. For instance, alternative fuels may provide a clean burning fuel that limits hazardous emissions. Alternative fuels may also be stored for long periods of time without degradation, whereas gasoline can degrade over a period of months leading to hard starting, rough running, and also lead to gum and varnish deposit left in the fuel system. In addition, generators that operate on alternative fuels may generate electricity when gasoline is not readily available. For instance, generators are frequently used when power outages in the utility grid result from severe weather. Unfortunately, gas stations may also be closed as a result of the power outage. Such a circumstance presents just one example where it would be advantageous to operate electrical generators on alternative fuels.

Certain generators are configured to operate as "dual fuel" generators, otherwise known as bi-fuel generators. These generators are driven by an internal combustion engine that is configured to operate on a liquid fuel for a period of operation and an alternative fuel for another period of operation. The alternative fuel source is generally a gaseous fuel that may exist in a gaseous state at normal temperature and pressure and can be any one of liquefied petroleum gas, compressed natural gas, hydrogen, or the like. Liquefied petroleum gas (LPG), often referred to as propane, exists in a gaseous state at normal temperature and pressure but can be conveniently stored under pressure in a liquid state. LPG may be a desirable fuel source for internal combustion engines because it can be stored for longer periods of time and contains fewer impurities than gasoline, resulting in smoother and cleaner operation, and often resulting in a longer lasting engine.

In order to provide the liquid and gaseous fuel to the engine, the dual fuel engine may have a first fuel line for liquid fuel and a second fuel line for gaseous fuel. A liquid fuel source and a gaseous fuel source may be coupled to the respective lines to provide fuel to the engine. However, a common problem with such configurations that couple two fuel sources to a single engine is the engine can experience overly rich air-fuel ratio when both fuels are simultaneously engaged during cross-over switching between the fuel sources. Such simultaneous delivery of fuel from the first fuel line and the second fuel line may make the engine hard to start or lead to unstable operating conditions. Further, a float bowl in the carburetor that must first fill or empty prior to changeover causes delay in cross-over switching between the fuel sources.

Therefore, it would be desirable to design a dual fuel generator having a liquid fuel and gaseous fuel delivery system that overcomes the aforementioned detriments without substantially increasing the overall cost of the system.

BRIEF DESCRIPTION OF THE INVENTION

In accordance with one aspect of the invention, a dual fuel engine includes an engine operable on a gaseous fuel and a liquid fuel. A carburetor attaches to an intake of the engine to mix air and fuel and connect to a gaseous fuel source and a liquid fuel source. The dual fuel engine also includes a switch to change operation of the engine between gaseous fuel and liquid fuel, and a liquid fuel cut-off attaches to the carburetor to interrupt liquid fuel upon actuation of the switch from liquid fuel to gaseous fuel.

In accordance with another aspect of the invention, a batteryless dual fuel generator includes a housing containing a pull start engine coupled to drive an alternator. The engine is operable on a gaseous fuel and a liquid fuel and includes a carburetor attached to an intake of the engine. The carburetor has a throat to mix fuel with air, a float bowl, and a fuel passage to provide liquid fuel from the float bowl to the throat. The generator may also include a switch to select engine operation on either the liquid fuel or the gaseous fuel and a fuel shutoff attached to the carburetor to close the fuel passage upon selection of engine operation to gaseous fuel.

In accordance with yet another aspect of the invention, a carburetor having a fuel shutoff includes a carburetor with a float bowl, a throat, and a fuel passage to provide fuel from the float bowl to the throat. A fuel shutoff couples to the carburetor which may have a first end in the carburetor that actuates to close the fuel passage and a second end external to the carburetor to actuate the first end. The fuel shutoff may operate within the carburetor such that the fuel shutoff actuates free from linear motion when opening and closing the fuel passage.

In accordance with yet another aspect of the invention, a method of assembling a dual fuel engine includes providing an engine operable on a gaseous fuel and a liquid fuel and attaching a carburetor to an intake of the engine to supply the fuels to the engine. The carburetor includes a throat to mix gaseous fuel with air and liquid fuel with air, a float bowl, and a fuel passage to provide liquid fuel from the float bowl to the throat. The fuels may be supplied to the carburetor by a gaseous fuel source coupled to the throat and a liquid fuel source coupled to the float bowl. The method also includes coupling a switch to the engine to change operation of the engine between gaseous fuel and liquid fuel, and attaching a liquid fuel cut-off to the carburetor to close the fuel passage upon actuation of the switch from liquid fuel to gaseous fuel.

Various other features and advantages will be made apparent from the following detailed description and the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings illustrate preferred embodiments presently contemplated for carrying out the invention.

In the drawings:

FIG. **1** is a perspective view of a dual fuel generator coupled to a fuel delivery system, according to an embodiment of the invention.

FIG. **2** is a detail view of a portion of the generator of FIG. **1** about a mechanical fuel lockout switch with the switch in a first position, according to an embodiment of the invention.

FIG. **3** is a detail view similar to FIG. **2** and showing the mechanical fuel lockout switch in a second position, with an LPG supply line connected thereto, according to an embodiment of the invention.

FIG. **4**A is a schematic diagram of a fuel system for the dual fuel generator of FIG. **1** showing a liquid fuel source in communication with a carburetor of the generator consistent with the first position of the switch as shown in FIG. **2**, according to an electro-mechanical embodiment of the invention.

FIG. **4**B is a schematic diagram of the fuel system of FIG. **4**A showing a gaseous fuel source in communication with a carburetor of the generator of FIG. **1** consistent with the second position of the switch as shown in FIG. **3**, according to an electro-mechanical embodiment of the invention.

FIG. **5** is a perspective view of a dual fuel carburetor having a manual fuel shutoff system and coupled to a first fuel line and a second fuel line, according to a mechanical embodiment of the invention.

FIG. **6** is cross-sectional view of the carburetor of FIG. **5** taken along line **6**-**6** of FIG. **5** through a fuel passage that provides fuel from a float bowl to a throat of the carburetor, according to an embodiment of the invention.

FIG. **7**A is a partial sectional view of the float bowl of FIG. **6** with a manual fuel shutoff system in an open position, according to an embodiment of the invention.

FIG. **7**B is a detailed partial sectional view of the float bowl with a manual fuel shutoff of FIG. **7**A taken along line **7**B-**7**B of FIG. **7**A, according to an embodiment of the invention.

FIG. **8** is a partial sectional view similar to FIG. **7**A and showing the manual fuel shutoff system in a closed position, according to an embodiment of the invention.

FIG. **9** is a perspective view of a shaft for the manual fuel shutoff system of FIG. **5**, according to an embodiment of the invention.

FIG. **10** is a side view of a valve member for the manual fuel shutoff system of FIG. **5**, according to an embodiment of the invention.

FIG. **11** is a perspective view of the carburetor of FIG. **5** with the manual fuel shutoff system exploded from a float bowl of the carburetor.

FIG. **12** is a flow chart showing steps in fabricating a manual fuel shutoff system for a carburetor, according to an embodiment of the invention.

FIG. **13** is a magnetic fuel shutoff system for a carburetor, according to a magnetic-mechanical embodiment of the invention.

FIG. **14** is a wiring diagram of a microcontroller receiving input signals and operating engine components, according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The operating environment of the invention is described with respect to a dual fuel generator. However, it will be appreciated by those skilled in the art that the invention is equally applicable for use with any dual fuel internal combustion engine. Moreover, the invention will be described with respect to a dual fuel generator configured to operate on a liquid fuel and a gaseous fuel. However, one skilled in the art will further appreciate that the invention is equally applicable for use with other fuel combinations for dual fuel generators and internal combustion engines.

Referring to FIG. **1**, a dual fuel generator **20** is coupled to a fuel delivery system **22**, in accordance with an embodiment of the invention. Dual fuel generator **20** includes an internal combustion engine (not shown) within housing **21** at one end **24**, operatively connected to an alternator also enclosed in housing **21** at another end **26**, by conventional means. Dual fuel generator **20** is configured to operate on different fuels via either a first fuel source **28** or a second fuel source **30**. In an exemplary embodiment of the invention, first fuel source **28** is a liquid fuel and second fuel source **30** is a gaseous fuel. The liquid fuel may be gasoline and the gaseous fuel may be liquid petroleum gas (LPG). Each can selectively operate the generator as desired and controlled by an operator. For instance, generator **20** may operate on gasoline for a first period of operation and then switch to LPG for a second period of operation. However, it is contemplated that dual fuel generator **20** is configured to operate on fuels other than gasoline and LPG (e.g., natural gas, biodiesel, etc.), and thus the scope of the invention is not meant to be limited strictly to a dual fuel arrangement where first fuel source **28** provides gasoline and second fuel source **30** provides LPG.

In one embodiment of the invention, dual fuel generator **20** includes a gasoline tank **32** or, generally, a liquid fuel tank, located inside cover **21** onboard generator **20** to provide gasoline to the engine as first fuel source **28**. Gasoline tank **32** connects to a first fuel line to provide gasoline to the carburetor to run the engine, as will later be described with reference to FIGS. **4**A and **4**B. Generator **20** is also coupled to a pressurized fuel container **34**, or a pressurized fuel source, located off board generator **20** to provide LPG to the engine as second fuel source **30**. Pressurized fuel container **34** is coupled to generator **20** with an LPG supply hose **36**. LPG supply hose **36** is coupled to a second fuel line within generator **20** to provide LPG to the carburetor to run the engine. Dual fuel generator **20** includes a mechanical fuel lockout switch **38** for selecting a desired fuel to be provided to the engine. The mechanical fuel lockout switch **38** is actuated to select first fuel source **28** when in a first position, as shown in FIG. **2**, and alternately to select second fuel source **30** when in a second position, as shown in FIG. **3**.

Referring back to FIG. **1**, in an exemplary embodiment, fuel **30** from pressurized fuel container **34** is regulated using a fuel regulator system **39** for delivery to the engine. Fuel regulator system **39** includes one or more pressure regulators that reduce and control the pressure of the fuel from pressurized fuel container **34** and delivers fuel at a desired pressure for operation of the engine. Fuel regulator system **39** has an inlet **41** operatively coupled to a service valve **40** of pressurized fuel container **34** and an outlet **43** coupled to LPG supply hose **36**. Fuel regulator system **39** includes a primary pressure regulator **42** coupled to pressurized fuel container **34** and a secondary pressure regulator **44**. Primary pressure regulator **42** protects downstream components from high pressure of pressurized fuel container **34**. Primary pressure regulator **42** receives LPG through service valve **40** of pressurized fuel container **34** and reduces the pressure of the LPG to a first stage. In one embodiment of the invention, the first stage may be delivered directly to generator **20** at a pressure required for operation of the engine.

In an exemplary embodiment of the invention, fuel regulator system **39** includes secondary pressure regulator **44** coupled to the outlet of primary pressure regulator **42** in order to use standard "off-the-shelf" components. Typically, the primary pressure regulator is mounted on the LPG tank, while the secondary pressure regulator is mounted on the component using the fuel, such as an engine or grill. Here, since generator **20** can be used as a gasoline only generator,

secondary pressure regulator **44** is mounted off-board the generator to reduce size and cost of the generator. Secondary pressure regulator **44** receives LPG from primary pressure regulator **42** and further reduces the pressure of LPG to a second stage to be delivered to generator **20**. In a system with two regulators, primary pressure regulator **42** regulates fuel received from pressurized fuel container **34** and reduces the pressure of the fuel to a level required for operation of secondary pressure regulator **44**. Secondary pressure regulator **44** regulates fuel received from primary pressure regulator **42** and further reduces the pressure of the fuel to a level required for operation of generator **20**. In addition, primary pressure regulator **42** may compensate for varying tank pressure as fuel is depleted while secondary pressure regulator **44** may compensate for varying demand from generator **20**.

In accordance with an exemplary embodiment of the invention, fuel regulator system **39** includes both the primary and secondary regulators, or a custom single regulator, but in any case is located remotely, or off-board, from dual fuel generator **20**. Fuel regulator system **39** may be directly mounted to pressurized fuel container **34** using a regulator mounting bracket **46**. Regulator mounting bracket **46** has mounting locations for primary pressure regulator **42** and secondary pressure regulator **44**. Regulator mounting bracket **46** also has a securing mechanism **48** to secure regulator mounting bracket **46** to pressurized fuel container **34**.

In another embodiment of the invention, primary pressure regulator **42** is mounted on regulator mounting bracket **46** while secondary pressure regulator **44** could be mounted on or near generator **20**. In yet another embodiment of the invention, a dual stage regulator may regulate the fuel received from pressurized fuel container **34** and deliver fuel at a pressure required for operation of generator **20**. Such a dual stage regulator may regulate the fuel to the second stage within a single structure. The dual stage regulator may be mounted directly on fuel container **34**.

Referring to FIG. **2**, a detail view of a portion of generator **20** of FIG. **1** depicts mechanical fuel lockout switch **38** in a first position **38**(*a*), in accordance with an embodiment of the invention. In this position, mechanical fuel lockout switch **38** provides gasoline flow from gasoline tank **32** to the engine while preventing connection of an LPG supply line to fuel inlet **59** of the second fuel line, as will later be discussed in detail with reference to FIGS. **4**A and **4**B. Still referring to FIG. **2**, mechanical fuel lockout switch **38** provides a combination liquid fuel shutoff valve and a gaseous fuel supply lockout that prevents simultaneous delivery of fuel to the engine from gasoline tank **32** and pressurized fuel container **34**, FIG. **1**. As such, mechanical fuel lockout switch **38** provides a fuel selector to ensure only the selected fuel is provided to dual fuel generator **20**.

Mechanical fuel lockout switch **38**, FIG. **2**, includes mechanical fuel valve **54** actuateable between first position **38**(*a*) as shown in FIG. **2** and second position **38**(*b*) as shown in FIG. **3** to selectively control fuel flow to the dual fuel engine from first fuel source **28** through a first fuel line and second fuel source **30** through a second fuel line **36**. Mechanical fuel lockout switch **38** may also include fuel lockout apparatus **58** coupled to mechanical fuel valve **54** to communicate fuel sources individually to generator **20**. In one embodiment of the invention, fuel lockout apparatus **58** communicates first fuel source **28** to the engine by actuating mechanical fuel valve **54** to first position **38**(*a*) to open the first fuel line as shown in FIG. **2**, and communicates second fuel source **30** to the engine by actuating mechanical fuel valve **54** to second position **38**(*b*) to open communication of the second fuel source **30** to the engine as shown in FIG. **3**. Referring back to FIG. **2**, when mechanical fuel valve **54** is in first position **38**(*a*), fuel lockout apparatus **58** communicates first fuel source **28** to the dual fuel engine and prevents communication between the second fuel source and the dual fuel engine.

In an exemplary embodiment of the invention, mechanical fuel valve **54** controls the flow of LPG to the engine by actuating fuel lockout apparatus **58** to block or unblock fuel inlet **59** for the second fuel source. Mechanical fuel valve **54** is coupled to the first fuel line as a liquid fuel valve, as shown in FIGS. **4**A and **4**B, and therefore can control the flow of gasoline to the engine by opening and closing the first fuel line. When the mechanical fuel valve **54**, FIG. **2**, is in the first position **38**(*a*), gasoline flows from the gasoline tank to the engine and the fuel lockout apparatus **58** blocks the fuel inlet **59**. Accordingly, fuel lockout apparatus **58** prevents LPG flow to generator **20** when the mechanical fuel valve **54** is in first position **38**(*a*) wherein the engine is operated on gasoline.

Mechanical fuel valve **54** includes a fuel valve handle **56** to control the opening and closing of the valve. Fuel valve handle **56** is movable between first position **38**(*a*) as shown in FIG. **2** and second position **38**(*b*) as shown in FIG. **3**. Mechanical fuel valve **54** opens the first fuel line (to enable liquid fuel flow to the engine) when fuel valve handle **56** is in the first position, and mechanical fuel valve **54** closes the first fuel line (to prevent liquid fuel flow to the engine) when fuel valve handle **56** is in the second position. Thus, when fuel valve handle **56** is in first position **38**(*a*) as shown in FIG. **2**, mechanical fuel valve **54** opens the first fuel line and allows gasoline from gasoline tank **32** to flow to the engine.

Fuel valve handle **56** is coupled to fuel lockout apparatus **58**. Fuel valve handle **56** actuates with fuel lockout apparatus **58** to prevent LPG flow to generator **20** when gasoline flow to the generator is enabled. Fuel lockout apparatus **58** is controlled by fuel valve handle **56** so that moving fuel valve handle **56** to the first position causes fuel lockout apparatus **58** to block fuel inlet **59** for LPG, and moving fuel valve handle **56** to the second position causes fuel lockout apparatus **58** to unblock fuel inlet **59** for LPG.

In an exemplary embodiment of the invention, fuel valve handle **56** rotates between the first position and the second position and fuel lockout apparatus **58** is rigidly coupled to the rotating handle. Fuel lockout apparatus **58** may include a fuel inlet cover **61**, which may be a flange, coupled to fuel valve handle **56** so that fuel inlet cover **61** rotates with the handle. Fuel inlet cover **61** extends radially outward from fuel valve handle **56** and sweeps over fuel inlet **59** for LPG as fuel valve handle **56** rotates. That is, fuel inlet cover **61** rotates transversely across fuel inlet **59** and blocks access thereto. Accordingly, fuel inlet cover **61** prevents LPG flow to generator **20** when fuel valve handle **56** is in first position **38**(*a*) to allow gasoline to run the engine.

Referring to FIG. **3**, a detail view of a portion of generator **20** of FIG. **1** depicts mechanical fuel lockout switch **38** in a second position **38**(*b*), in accordance with an embodiment of the invention. In this position, mechanical fuel lockout switch **38** provides a disconnect to stop gasoline flow from gasoline tank **32** to the engine while allowing connection of LPG supply hose **36** to fuel inlet **59** of the second fuel line. FIG. **3** further shows LPG supply hose **36** coupling second fuel source **30** to generator **20** to deliver LPG to run the generator.

Mechanical fuel lockout switch **38** includes mechanical fuel valve **54** coupled to fuel lockout apparatus **58** to prevent

gasoline flow to generator **20** when LPG from the LPG supply hose **36** is supplied to the engine. In one embodiment of the invention, actuation of mechanical fuel valve **54** to second position **38**(*b*) causes fuel lockout apparatus **58** to allow communication of second fuel source **30** to the dual fuel engine, and interrupts the first fuel source **28** communication with the dual fuel engine. The position of fuel lockout apparatus **58** prevents the fuel valve handle **56** from moving to first position **38**(*a*) (FIG. **2**) while LPG supply hose **36** is connected to generator **20**.

A quick-disconnect hose coupling **50**, also referred to as a quick-connect hose coupling, connects LPG supply hose **36** to generator **20** so that LPG supply hose **36** may be quickly attached and detached from generator **20**. Hose coupling **50** has a first end **50***a* mounted on the external surface of generator **20** and coupled to supply the second fuel to the engine. Hose coupling **50** has a second end **50***b* coupled to the outlet of LPG supply hose **36**. Each end **50***a*, **50***b* has a gaseous fuel valve that opens when the couplings are engaged and closes when the couplings are disengaged. As such, quick-disconnect hose coupling **50** automatically opens when connected to enable fuel flow from LPG supply hose **36** to the engine. Hose coupling **50** automatically disconnects fluid communication when disconnected. Accordingly, when the supply hose is detached from generator **20**, the coupling **50** is automatically closed so that fuel does not escape and unwanted air does not enter the fuel system.

In one embodiment, fuel inlet cover **61** is coupled to fuel valve handle **56** so that it is spaced apart from the surface of generator **20** to provide clearance for first end **50***a* of the quick-disconnect hose coupling **50** that protrudes from the surface of generator **20**. As shown in FIG. **2**, fuel inlet cover **61** blocks off first end **50***a* of the quick-disconnect hose coupling when fuel valve handle **56** is rotated to first position **38**(*a*) to enable gasoline flow so that fuel inlet cover **61** prevents connection of LPG supply hose **36** (FIG. **3**) to generator **20**. As shown in FIG. **3**, fuel inlet cover **61** uncovers first end **50***a* of the quick-disconnect hose coupling **50** when fuel valve handle **56** is rotated to second position **38**(*b*) to disable gasoline flow so that fuel inlet cover **61** permits connection of LPG supply hose **36** to generator **20**.

To operate generator **20** on LPG, fuel valve handle **56** is turned to second position **38**(*b*) to disable the flow of gasoline to the engine and to expose first end **50***a* of hose coupling **50** on generator **20**. LPG supply hose **36** is then connected to generator **20** via hose coupling **50** to enable the flow of LPG to the engine. To operate generator **20** on gasoline, LPG supply hose **36** is disconnected from generator **20** via hose coupling **50** to disable the flow of LPG to the engine and to unblock fuel valve handle **56** from rotating to the first position. As shown in FIG. **2**, fuel valve handle **56** is then turned to first position **38**(*a*) to enable the flow of gasoline to generator **20**.

Referring to FIG. **4**A, a schematic diagram of a fuel system for a dual fuel engine **60** shows mechanical fuel lockout switch **38** in first position **38**(*a*) to provide communication between the first fuel source **28** and dual fuel carburetor **62**, according to an embodiment of the invention. Mechanical fuel lockout switch **38** prevents communication between second fuel source **30** and dual fuel carburetor **62** when the switch is in first position **38**(*a*). In one embodiment of the invention, first fuel source **28** includes a gasoline tank **32** to provide gasoline to carburetor **62** through a first fuel line **66**, and second fuel source **30** can include a propane or LPG tank **68** to provide propane or LPG to carburetor **62** through a second fuel line **70**. Accordingly, first fuel line **66** may be a liquid fuel line and second fuel line **70** may be a gaseous fuel line.

Mechanical fuel lockout switch **38** changes the fuel source for engine **60** between liquid fuel and gaseous fuel. Mechanical fuel lockout switch **38** includes a mechanical fuel valve **54** actuateable between first position **38**(*a*) as shown in FIG. **4**A and second position **38**(*b*) as shown in FIG. **4**B to selectively control fuel flow to the dual fuel engine **60** from first fuel source **28** through first fuel line **66** and second fuel source **30** through second fuel line **70**. Referring back to FIG. **4**A, mechanical fuel valve **54** selectively controls fuel flow through first fuel line **66** by opening the line when the mechanical fuel lockout switch **38** actuates to first position **38**(*a*). Mechanical fuel valve **54** may be coupled to fuel lockout apparatus **58** that actuates with mechanical fuel valve **54** to block and unblock fuel inlet **59** of second fuel line **70**. First end **50***a* of the quick-disconnect hose coupling is located at fuel inlet **59** and a mating end **50***b* of the quick-disconnect hose coupling is coupled to the propane or LPG tank **68**. Actuation of mechanical fuel valve **54** to first position **38**(*a*) causes fuel lockout apparatus **58** to block fuel inlet **59** to prevent coupling the first end **50***a* and second end **50***b* of the quick-disconnect hose coupling together, and actuation of mechanical fuel valve **54** to another position causes fuel lockout apparatus **58** to unblock fuel inlet **59** to permit attaching first end **50***a* and second end **50***b* together.

A liquid fuel cut-off **72** couples to carburetor **62** to regulate liquid fuel flow through the carburetor. Liquid fuel cut-off **72** can stop liquid fuel flow to engine **60** to prevent an overly rich air-fuel ratio when operating engine **60** on gaseous fuel. Liquid fuel cut-off **72** may attach to carburetor **62** to interrupt liquid fuel upon actuation of mechanical fuel lockout switch **38** from liquid fuel to gaseous fuel. As such, liquid fuel cut-off **72** can prevent engine flooding by stopping liquid fuel flow when starting on gaseous fuel. Liquid fuel cut-off **72** is manually operated in some embodiments of the invention and electrically operated in other embodiments of the invention.

In one embodiment of the invention, liquid fuel cut-off **72** comprises a fuel cut solenoid **74**, also referred to as a carburetor cutoff solenoid, that operates within carburetor **62** as a solenoid valve to control liquid fuel flow to engine **60**. Fuel cut solenoid **74** actuates between an open position to provide liquid fuel to engine **60** and a closed position to stop liquid fuel to the engine. Fuel cut solenoid **74** can operate as a normally open solenoid valve so that power is not required to open the solenoid during liquid fuel operation. As such, fuel cut solenoid **74** is powered and moved to a closed position to stop liquid fuel flow to engine **60** during gaseous fuel operation. Alternatively, fuel cut solenoid **74** may be operated as a normally closed valve that is powered to open for liquid fuel operation.

Fuel cut solenoid **74** is preferably powered by a magneto **76**, alternator, engine flywheel with a charge winding, or other electrical power generator having a charge winding or coil **78**. Charging coil **78** allows operation of fuel cut solenoid **74** in a batteryless engine. In a batteryless dual fuel generator, the charging coil **78** may be integral to an alternator driven by the batteryless engine. Engine **60** may be a pull-start engine having a recoil starter **80**. During engine startup, recoil starter **80** cranks the engine with a manual pull by a user that causes magneto **76** to supply electrical power to fuel cut solenoid **74**. While a fuel cut solenoid **74** in a normally open mode does not require any initial electrical power for starting engine **60** on liquid fuel,

charging coil **78** powers the solenoid to stop liquid fuel flow during startup on gaseous fuel. Alternatively, charging coil **78** can power a fuel cut solenoid **74** operating in a normally closed mode to open and provide liquid fuel to engine **60** during startup on liquid fuel.

Charging coil **78** has an output voltage generally proportional to engine speed and therefore charge coil **78** will produce a range of voltages over the range of engine operating speeds. For example, if charging coil **78** produces 12 VAC at 3600 rpm, it may only produce 1 VAC at 300 rpm which would be insufficient voltage during startup to power a solenoid that requires 12 volts. An alternator typically used to power 12 volt accessories, such as a battery, at engine speeds will need increased output voltage to provide sufficient voltage for operation of fuel cut solenoid **74** at low recoil start speeds. In addition, the output voltage of a charging coil may vary if the alternator or magneto **76** also powers accessories. Accordingly, the output voltage of a charging coil should be verified by running engine **60** through the full range of operating speeds before increasing the output voltage.

Additional turns can be added to a charging coil in the alternator or magneto **76** to increase the output voltage and provide sufficient voltage to activate fuel cut solenoid **74** at manual start speeds. Typical alternators or magnetos may have limited room within stator laminations for additional turns, but low current requirements of fuel cut solenoid **74** allows substitution of smaller gage wire. Alternatively, solenoid windings on fuel cut solenoid **74** can be modified to operate at lower voltages for recoil starting. However, adding coil turns to a charge winding provides an inexpensive modification and allows use of standard 12 volt solenoids.

To protect electrical systems, a voltage regulator **82** couples to charging coil **78** to provide a fixed output voltage for a varying input voltage. If charge winding **78** is wound to supply 12 VAC at 300 rpm, it could supply 144 VAC at 3600 rpm. Applying 144 volts could quickly destroy a solenoid designed to operate at 12 volts. Accordingly, voltage regulator **82** may comprise a switching power supply circuit **84** that regulates a rectified DC power output from magneto **76** and provides a fixed voltage to fuel cut solenoid **74**. Switching circuits are very efficient, dissipate very little power, and can be made small and inexpensive. Switching power supply circuit **84** allows for low rpm, recoil starter electrical power generation with charge coil **78** voltage control over engine speed range.

In the embodiment shown in FIGS. **4**A and **4**B, fuel cut solenoid **74** is operated by an electro-mechanical switch **86**. Electro-mechanical switch **86** connects one fuel source to carburetor **62** and is connected to magneto **76** for a power source. Electro-mechanical switch **86** may comprise an electrical switch **88** that provides electrical connection between fuel cut solenoid **74** and magneto **76**. Electro-mechanical switch **86** may also comprise mechanical fuel lockout switch **38**, and electrical switch **88** can be mechanically actuated and controlled by mechanical fuel lockout switch **38**. Fuel cut solenoid **74** connects to open and close a fuel path to pull-start engine **60** in response to reception of electrical power from electro-mechanical switch **86**.

Fuel cut solenoid **74** can operate as a normally open valve that closes when powered by alternator or magneto **76**. The normally open valve is activated to close and prevent gasoline flow to engine **60** for LPG mode, and deactivated to open and allow gasoline flow to engine **60** for gasoline mode. As such, actuation of mechanical fuel lockout switch **38** to first position **38**(*a*) opens electrical switch **88** to interrupt power and open fuel cut solenoid **74** as represented in FIG. **4**A, and actuation of mechanical fuel lockout switch **38** to second position **38**(*b*) closes electrical switch **88** to power and close fuel cut solenoid **74** as represented in FIG. **4**B. Alternatively, fuel cut solenoid **74** can operate as a normally closed valve where actuation of mechanical fuel lockout switch **38** to first position **38**(*a*) closes electrical switch **88** to power and open fuel cut solenoid **74**, and actuation of mechanical fuel lockout switch **38** to second position **38**(*b*) opens electrical switch **88** to interrupt power and close fuel cut solenoid **74**.

In an alternative embodiment of the invention, a microcontroller **89** operates fuel cut solenoid **74** so that fuel cut solenoid **74** opens to operate engine **60** on gasoline and is closed when the engine operates on LPG. While engine **60** is running, charging coil **78** provides power available to microcontroller **89** for operation of fuel cut solenoid **74**. Fuel cut solenoid **74** may operate in a normally open mode to allow gasoline flow to engine **60** without power from microcontroller **89**, and microcontroller **89** may operate fuel cut solenoid **74** to operate as an after-fire solenoid when shutting down engine **60** from gasoline operation. That is, microcontroller **89** powers fuel cut solenoid **74** to a closed position preventing fuel being drawn into engine **60** and muffler during engine shutdown from operation on gasoline. When engine **60** runs on LPG, microcontroller **89** switches on power to close fuel cut solenoid **74** to prevent engine **60** from drawing in gasoline from the float bowl of carburetor **62** and first fuel line **66**. Microcontroller **89** may also operate fuel cut solenoid **74** configured to be normally closed. Implementation of microcontroller **89** is further described with respect to FIG. **14**.

Referring to FIG. **4**B, a schematic diagram of a fuel system for a dual fuel engine shows mechanical fuel lockout switch **38** in second position **38**(*b*) to provide communication between second fuel source **30** and dual fuel carburetor **62**, according to an embodiment of the invention. Mechanical fuel lockout switch **38** prevents communication between first fuel source **28** and dual fuel carburetor **62** when the switch is in second position **38**(*b*). The dual fuel engine has a first fuel line **66** to provide fuel from first fuel source **28** to carburetor **62** and a second fuel line **70** to provide fuel from second fuel source **30** to carburetor **62**.

Mechanical fuel lockout switch **38** includes mechanical fuel valve **54** that selectively controls fuel flow through first fuel line **66** by closing the line when mechanical fuel lockout switch **38** actuates to second position **38**(*b*). Mechanical fuel lockout switch **38** may also include a mechanical lockout apparatus **58** to block and unblock fuel inlet **59** of the second fuel line **70**. Fuel inlet **59** may include first end **50***a* of the quick-connect hose coupling mounted on the generator and coupled to second fuel line **70**. Second end **50***b* of the quick-connect hose coupling is coupled to the outlet of second fuel source **30**, and the first end **50***a* mates with second end **50***b* to quickly attach propane or LPG tank **68** to second fuel line **70**. Fuel lockout apparatus **58** may also hold mechanical fuel lockout switch **38** in second position **38**(*b*) when the propane or LPG tank **68** is coupled to the engine via the ends **50***a*, **50***b* of the quick-connect hose coupling.

Liquid fuel cut-off **72** couples to carburetor **62** to regulate liquid fuel flow through the carburetor as described with respect to FIG. **4**A. Liquid fuel cut-off **72** may comprise a fuel cut solenoid **74** powered by magneto **76**. Engine **60** has recoil starter **80** that cranks the engine and drives magneto **76** to power fuel cut solenoid **74** when starting the engine. Voltage regulator **82** reduces the voltage delivered to fuel cut solenoid **74** at higher engine operating speeds. Fuel cut

solenoid **74** is activated by electro-mechanical switch **86** providing electrical connection to magneto **76** via electrical switch **88**. Electrical switch **88** can be manually actuated and controlled by mechanical fuel lockout switch **38**. FIG. **4**B shows electrical switch **88** closed to power a normally open configured fuel cut solenoid **74** to a closed position for LPG mode when mechanical fuel lockout switch **38** is in second position **38**(*b*).

FIG. **4**A and FIG. **4**B depict an embodiment where mechanical fuel valve **54** operates along first fuel line **66** to provide a flow path for first fuel source **28** to carburetor **62** when the valve is in first position **38**(*a*). That is, mechanical fuel valve **54** may control a single fuel line that runs through the valve while operating fuel lockout apparatus **58** to control fuel flow through second fuel line **70**. Embodiments of the invention also contemplate mechanical fuel valve **54** configured to operate along second fuel line **70** to provide a flow path for second fuel source **30** to carburetor **62** when the valve is in second position **38**(*b*). Mechanical fuel valve **54** may be configured to control multiple fuel lines that run through the valve according to embodiments of the invention. In another embodiment of the invention, a manual fuel petcock is coupled along second fuel line **70** to provide an independent shut-off from second fuel source **30** to the engine.

Referring to FIG. **5**, a dual fuel carburetor having a manual fuel shutoff system is shown, in accordance with a mechanical embodiment of the invention. Carburetor **62** attaches to an intake **90** of the engine to mix air and fuel and connect to a liquid fuel source and a gaseous fuel source. Carburetor **62** has a mixing passage or throat **92** having an inlet **94** for air and an outlet **96** for an air-fuel mixture. A venturi **98** is located in throat **92** with a choke valve **100** located upstream from the venturi and a throttle valve **102** located downstream from the venturi. Carburetor **62** has a float bowl **104** that provides fuel through a fuel passage into a narrow portion of venturi **98**. Float bowl **104** has a liquid fuel inlet **106** to receive liquid fuel from first fuel source **28**. Throat **92** has a gaseous fuel inlet **108** to receive gaseous fuel from second fuel source **30**. Dual fuel carburetor **62** mixes air with fuel from first fuel source **28** and second fuel source **30** and provides the respective air-fuel mixtures for operation of the dual fuel generator.

Liquid fuel cut-off **72** couples to carburetor **62** to control liquid fuel flow downstream of float bowl **104** in the carburetor. Liquid fuel cut-off **72** can close off float bowl **104** to stop liquid fuel flow to the engine and prevent an overly rich air-fuel ratio during gaseous fuel operation. As such, liquid fuel cut-off **72** prevents engine flooding when starting on gaseous fuel. Liquid fuel cut-off **72** also traps fuel in float bowl **104** to eliminate delay in filling the bowl when starting the engine on liquid fuel, and can stop liquid fuel flow to the engine immediately after ignition shutdown. As such, liquid fuel cut-off **72** reduces emissions and prevents afterfire by stopping the engine from continuing to draw in fuel from float bowl **104** during shutdown.

In the embodiment of FIG. **5**, liquid fuel cut-off **72** comprises a manually operated fuel shutoff **110** coupled to carburetor **62** to control liquid fuel flow downstream of float bowl **104**. Manual fuel shutoff **110** can be cable actuated for use on engines without battery power, for instance engines with recoil starters. Manual fuel shutoff **110** actuates between a first position to allow gasoline flow to the engine, as shown in FIG. **7**A, and a second position to prevent gasoline flow to the engine, as shown in FIG. **8**. Referring back to FIG. **5**, manual fuel shutoff **110** may comprise a shaft **112** extending into carburetor **62** that actuates between the first position and second position. A manually operated control system **114** couples to shaft **112** external to carburetor **62** to control manual fuel shutoff **110**.

A bracket **116** couples to the outer surface of carburetor **62** to support manual control system **114**. Bracket **116** mounts to a boss **118** extending outwards from float bowl **104**. Boss **118** has a flat vertical surface with a pair of tapped holes for mounting bracket **116** to float bowl **104**. Screws **120**, **122** extend through respective holes in bracket **116** and into the tapped holes to mount the bracket to carburetor **62**. Manual fuel shutoff **110** extends out of carburetor **62** and through an opening **124** in bracket **116**. Bracket **116** has a first stopping tab **126** and a second stopping tab **128** extending away from float bowl **104** to hold manual fuel shutoff **110** in a respective open or closed position. A fuel drain screw **130** extends into an opening in carburetor **62** adjacent bracket **116**.

Bracket **116** has a lower arm **132** extending downward and to the air inlet side of carburetor **62**. Lower arm **132** has a bottom portion **134** bent outward from carburetor **62** to couple to a control system spring **136**. Bottom portion **134** has a hole **138** for control system spring **136** adjacent a positioning groove **140** for the spring. Control system spring **136** is held in position by groove **140** as it hooks through hole **138**. Bracket **116** also has an upper arm **142** extending first outward from carburetor **62** and then vertically and to the outlet side of the carburetor. Upper arm **142** has a cable clamp **144** for holding a Bowden cable **146**. Cable clamp **144** has a flat midsection and two curved ends contacting bracket **116** to hold the midsection slightly apart from the bracket. Cable clamp **144** is coupled to bracket **116** by a bolt **148** extending through a hole in the midsection and through upper arm **142** of the bracket.

A lever **150** couples to shaft **112** to actuate manual fuel shutoff **110**. A cap **152** holds lever **150** on shaft **112**. Alternatively, lever **150** may be coupled to the shaft **112** by welding or staking. Lever **150** has a first lever arm **154** to contact and hold lever **150** against first and second stopping tabs **126**, **128** of the bracket. Lever **150** has a second lever arm **156** to actuate shaft **112**. First lever arm **154** is in plane with an opening in the lever for shaft **112** and second lever arm **156** extends first outward from carburetor **62** and then parallel to first lever arm **154**. Second lever arm **156** extends outward from carburetor **62** to provide clearance between bracket **116** and the second lever arm for control system spring **136** and screw **122**. Second lever arm **156** has two holes **158**, **160** for coupling control system spring **136** and Bowden cable **146** to lever **150**.

Manual fuel shutoff **110** operates as a valve within carburetor **62** to selectively interrupt liquid fuel flow to the engine. Control system spring **136** preferably pulls on lever **150** to hold manual fuel shutoff **110** in an open valve position, and Bowden cable **146** pulls lever **150** against control system spring **136** to rotate manual fuel shutoff **110** to a closed valve position. As such, control system spring **136** holds manual fuel shutoff **110** open for gasoline mode until Bowden cable **146** is pulled to close the valve for LPG mode. Alternatively, control system spring **136** can hold manual fuel shutoff **110** in a closed valve position until Bowden cable **146** is pulled to open the valve. Therefore, actuation of the Bowden cable **146** acts as a switch to assist in changeover between the dual fuels. Manual fuel shutoff **110** may rotate 90 degrees between the open and closed positions with stopping tabs **126**, **128** positioned about bracket **116** accordingly. Lever **150** can be positioned on shaft **112** so that second lever arm **156** is pulled upward by a generally vertical Bowden cable **146**. Second lever arm **156** may actuate between a position 45 degrees below

horizontal for an open valve and a position 45 degrees above horizontal for a closed valve. When holding the valve open, control system spring **136** may be oriented at a right angle to second lever arm **156** for increased leverage.

Referring to FIG. **6**, a cross-sectional view of the carburetor taken generally about line **6-6** of FIG. **5** is shown, in accordance with an embodiment of the invention. Carburetor **62** includes a throat **92** to mix gaseous fuel with air and liquid fuel with air. Throat **92** includes a gaseous fuel inlet port **162** in communication with gaseous fuel inlet **108** coupled to a second fuel line **70**. Carburetor **62** also includes float bowl **104** and a fuel passage **164** to provide a liquid fuel path from float bowl **104** through a main nozzle **166** into venturi **98**. Float bowl **104** has a liquid fuel inlet port **168** and a float valve **170** to regulate liquid fuel flow through liquid fuel inlet port **168**. Liquid fuel inlet port **168** is in communication with the liquid fuel inlet **106** coupled to first fuel line **66**.

Manual fuel shutoff **110** couples to carburetor **62** to regulate liquid fuel flow downstream of float bowl **104**. Manual fuel shutoff **110** attaches to carburetor **62** to close fuel passage **164** upon selection of engine operation to gaseous fuel. Manual fuel shutoff **110** may have a first end **172** positioned in carburetor **62** adjacent an inlet port **174** to fuel passage **164**, and the first end **172** actuates to close fuel passage **164**. That is, first end **172** actuates between a first position to permit fuel flow into fuel passage **164**, as shown in FIG. **7**A, and a second position to prevent fuel flow into fuel passage **164**, as shown in FIG. **8**.

Referring back to FIG. **6**, manual fuel shutoff **110** has a second end **176** positioned external to carburetor **62** that is manually actuated to operate manual fuel shutoff **110**. Manual fuel shutoff **110** may have a rotating shaft **112** that extends through an opening **178** in carburetor **62**. A blocking member or valve tip **180** couples to shaft **112** in carburetor **62** to create a valve-shaft assembly **179**. Valve tip **180** rotates parallel to inlet **174** of fuel passage **164** between a blocking position and non-blocking position to selectively block fuel flow into fuel passage **164**. Lever **150** couples to shaft **112** external to carburetor **62** and actuates to rotate shaft **112** and valve tip **180**.

Shaft **112** may be horizontal or substantially horizontal to allow valve tip **180** to be positioned directly in float bowl **104** adjacent inlet port **174** of fuel passage **164**. That is, manual fuel shutoff **110** may be coupled to carburetor **62** such that second end **176** is horizontal from first end **172**. Inlet **174** of fuel passage **164** can face horizontal or substantially horizontal to accommodate valve tip **180** in float bowl **104**. As such, fuel passage **164** may have a horizontal component that receives fuel from float bowl **104** leading to a vertical component to provide fuel to venturi **98**. The interior surface of the float bowl **104** may also have a recess or cavity **182** to provide room for valve member **180** in the bowl.

Opening **178** in carburetor **62** has a plug **184** to hold shaft **112** and prevent fuel flow out of the carburetor. Shaft **112** extends through a hole **186** in plug **184** and hole **186** is positioned to align valve tip **180** with fuel passage **164**. Plug **184** has a larger outer diameter **188** toward the external side of carburetor **62** and a smaller outer diameter **190** toward the internal side. Larger outer diameter **188** and smaller outer diameter **190** mate with corresponding diameters of opening **178**. Plug **184** has a counterbore **192** to hole **186** on the external side of the plug. A compression spring **194** is positioned around shaft **112** in float bowl **104** to push valve tip **180** against plug **184**. Compression spring **194** holds valve tip **180** against inlet **174** of fuel passage **164** in order to seal the fuel passage.

A primary o-ring **196** and a secondary o-ring **198** are positioned around shaft **112** to provide a respective first and second fuel seal between the shaft and plug **184** and to seal first end **172** of manual fuel shutoff **110** in carburetor **62**. Primary o-ring **196** may be positioned in an o-ring groove **200** in shaft **112** and secondary o-ring **198** may be positioned in counterbore **192** of plug **184**. A bracket **116** or other support member mounts over counterbore **192** and around shaft **112** to hold secondary o-ring **198** in counterbore **192**. Bracket **116** has an opening **124** large enough for shaft **112** but small enough to hold secondary o-ring **198** in counterbore **192**. Manual fuel shutoff **110** actuates in a rotative motion free from linear motion in part to ensure fuel will not leak through primary o-ring **196** or secondary o-ring **198**. Compared to a sliding valve, a rotating valve, such as manual fuel shutoff **110**, reduces the likelihood that fuel will leak from carburetor **62**.

Liquid fuel cut-off **72** may regulate fuel flow through multiple fuel passages in carburetor **62** that provide fuel from float bowl **104** to the engine. For instance, carburetor **62** may have a main fuel circuit **202** and an idle fuel circuit **204**. Main fuel circuit **202** provides fuel through main nozzle **166** into a narrow portion of venturi **98**. Idle fuel circuit **204** provides fuel to throat **92** downstream from the throttle valve. Liquid fuel cut-off **72** may regulate fuel flow through some or all of the fuel circuits that provide fuel from float bowl **104** to the engine. FIG. **6** shows an embodiment where idle fuel circuit **204** branches off from main fuel circuit **202** and liquid fuel cut-off **72** actuates to block fuel flow into both main fuel circuit **202** and idle fuel circuit **204**. In other embodiments, liquid fuel cut-off **72** closes main fuel circuit **202** while small amounts of liquid fuel pass through idle fuel circuit **204**. Fuel passing through idle fuel circuit **204** may not negatively affect engine performance during LPG operation but will eventually drain the gasoline tank.

Referring to FIG. **7**A, a partial sectional view of a float bowl shows a manual fuel shutoff system in an open position for gasoline mode, in accordance with an embodiment of the invention. The partial sectional view is taken through a portion of float bowl **104** along fuel passage **164** while showing another portion of float bowl **104** in front of fuel passage **164** and coupled to manual fuel shutoff **110**. Inlet **174** to fuel passage **164** is in a boss **206** extending outward from a central region of float bowl **104**. Boss **206** has an oval top with sides that extend to the floor of float bowl **104**. Inlet **174** to fuel passage **164** extends through boss **206** and has a substantially flat perimeter edge **208** around inlet port **174** on the surface of the boss. Manual fuel shutoff **110** presses against substantially flat perimeter edge **208** surrounding fuel passage **164** to block fuel flow into fuel passage **164**.

Manual fuel shutoff **110** may have a rotating shaft **112** extending through an aperture **178** in float bowl **104**. Shaft **112** has a first end **210** coupled to valve tip **180** and located in float bowl **104** that is held against inlet port **174** to fuel passage **164**. Shaft **112** rotates valve tip **180** against inlet port **174** between a first position **180**(*a*) allowing fuel flow through the inlet port **174**, as shown in FIG. **7**A, and a second position **180**(*b*) blocking fuel flow through the inlet port **174**, as shown in FIG. **8**. That is, valve tip **180** uncovers the inlet **174** of fuel passage **164** to permit fuel flow into the inlet **174** when rotated to first position **180**(*a*), FIG. **7**A, and covers inlet **174** of fuel passage **164** to prevent fuel flow into inlet **174** when rotated to second position **180**(*b*), FIG. **8**.

Referring back to FIG. **7**A, the manual fuel shutoff system further includes bracket **116** to support shaft **112** in float bowl **104** and provide mounting locations for manually operated control system **114**. Bracket **116** also has a pair of stopping tabs **126**, **128** to hold the manual fuel shutoff **110** in an open or closed position. Shaft **112** extends through bracket **116** and lever **150** couples to a second end **212** of shaft **112** located outside of float bowl **104**. Control system spring **136** couples lever **150** to bracket **116** to hold lever **150** against stopping tab **126** and hold manual fuel shutoff **110** in the open position for gasoline mode. Bowden cable **146** couples to lever **150** to pull against control system spring **136** and rotate manual fuel shutoff **110** to the closed position for LPG mode. As such, second end **176** of manual fuel shutoff **110** is positioned external to float bowl **104** and coupled to manually operated control system **114** to operate manual fuel shutoff **110**.

Referring to FIG. **7**B, a detailed partial sectional view of the float bowl of FIG. **7**A taken along line **7**B-**7**B shows a manual fuel shutoff in an open position for gasoline mode, in accordance with an embodiment of the invention. Float bowl **104** includes boss **206** through which fuel passage **164** extends and having a substantially flat perimeter edge **208** surrounding inlet **174** to fuel passage **164**. Substantially flat perimeter edge **208** preferably has a flat finished surface for improved sealing against valve tip **180**. Valve tip **180** maintains planar contact with substantially flat perimeter edge **208** while rotating between an open position permitting fuel flow into inlet **174** and a closed position blocking fuel flow into inlet **174**. As such, valve tip **180** rotates parallel to inlet **174** of fuel passage **164** between the open or first position **180**(*a*) and closed or second position **180**(*b*), FIG. **8**.

Referring again to FIG. **7**B, valve tip **180** may comprise an oval or stadium **214** having a flat surface **216** that contacts perimeter edge **208** around inlet **174** of fuel passage **164**. Valve tip **180** may have a recessed portion or cutout **218** in the flat surface **216** to provide a flow passage through the valve tip. Fuel flows through the cutout **218** into the inlet **174** of fuel passage **164** when cutout **218** is aligned with inlet **174**. That is, cutout **218** in valve tip **180** aligns with inlet port **174** when valve tip **180** is rotated to the open position such that fuel can pass from float bowl **104** through cutout **218** into fuel passage **164**. Cutout **218** in valve tip **180** is strategically positioned in a narrow portion of stadium **214** so a long portion of stadium **214** can be rotated to cover and block inlet **174**. Valve tip **180** may comprise one of many shapes including a stadium, an oval, a disk, a rectangle, an irregular shape, among others.

Referring to FIG. **8**, a partial sectional view of a float bowl shows a manual fuel shutoff system in a closed position for LPG mode, in accordance with an embodiment of the invention. Valve tip **180** pushes against inlet **174** to fuel passage **164** to seal the inlet when in second position **180**(*b*). Valve tip **180** may have a stadium shape **214** with a cutout **218** in the narrow portion of the stadium to provide a flow passage. Valve tip **180** blocks fuel flow into fuel passage **164** when the cutout **218** in valve tip **180** is rotated away from inlet **174** of fuel passage **164**. Cutout **218** may face downward when in the closed position and horizontal when in the open position. Lever **150** couples to shaft **112** outside of float bowl **104** and is actuated by Bowden cable **146** to operate manual fuel shutoff **110**.

Bowden cable **146** may be coupled to mechanical fuel lockout switch **38**, FIG. **1**, to automatically open and close manual fuel shutoff **110** upon selection of a corresponding fuel source. Mechanical fuel lockout switch **38** may have a lever arm inside of the generator housing for actuating Bowden cable **146**, FIG. **8**. Alternatively, Bowden cable **146** may have a push-pull knob located on an external surface of the generator housing to independently actuate manual fuel shutoff **110**. In either case, manual fuel shutoff **110** can attach to the carburetor to close fuel passage **164** downstream from float bowl **104** upon actuation of the mechanical fuel lockout switch **38**, FIG. **1**, from liquid fuel to gaseous fuel.

Referring to FIG. **9**, a perspective view of a shaft for the manual fuel shutoff system of FIGS. **5**-**8** is shown, in accordance with an embodiment of the invention. Shaft **112** has two "D" shaped ends each located at a respective first end **210** and second end **212** of the shaft. Shaft **112** also has a first diameter **220** and a larger second diameter **222** each extending radially from shaft **112** outward beyond the two "D" shaped ends. First diameter **220** and second diameter **222** are separated by o-ring groove **200** with first diameter **220** toward first end **210** of shaft **112** and second diameter **222** toward second end **212** of shaft **112**. First diameter **220** also has a groove **224** for a retaining ring. Lever **150**, FIG. **8**, has a "D" shaped opening to fit on the second end **212** of shaft **112** and held against the second diameter **222**.

Referring to FIG. **10**, a side view of a valve member for the manual fuel shutoff system of FIG. **5**-**8** is shown, in accordance with an embodiment of the invention. Valve tip **180** has a flat surface **216** to seal and rotate against a mating surface in the carburetor. Valve tip **180** is preferably made from polyoxymethylene (POM) or other thermoplastic material to provide a surface suitable for sealing. Valve tip **180** may be shaped as a stadium **214** with a short direction **226** and a long direction **228** extending from a center of rotation **230**. The long direction **228** rotates over inlet **174**, FIG. **8**, to selectively block fuel passage **164**. As such, valve tip **180** may rotate less than 360 degrees between the open and closed positions, and valve tip **180** rotates substantially 90 degrees between the positions in an exemplary embodiment of the invention.

Referring back to FIG. **10**, cutout **218** may be located along a straight side of stadium **214** to create a flow passage through valve tip **180**. Cutout **218** may have a depth less than the thickness of stadium **214** or may extend through the thickness of the stadium. Cutout **218** may be a half circle with tangent side components extending perpendicular to a straight edge of stadium **214**, through a side of valve tip **180**. Cutout **218** may extend into valve tip **180** short of the center of stadium **214** and positioned slightly offset along the length of the stadium from the stadium center.

Valve tip **180** may have a "D" shaped opening **232** to press onto shaft **112** of FIG. **9**, defining center of rotation **230**, FIG. **10**. Center of rotation **230** may be equal distance from straight edges of stadium **214** and positioned between cutout **218** and a rounded end of the stadium that is the closest rounded end to the cutout. Cutout **218** is askew from center of rotation **230** along the length of stadium **214** in part to cover more distance when rotated away from inlet port **174**, FIG. **8**. In addition, valve tip **180** is positioned off center on shaft **112** to increase the length of long direction **228** from center of rotation **230** that is rotated to cover inlet port **174**.

Referring to FIG. **11**, a perspective view of the carburetor of FIG. **5** with the manual fuel shutoff system exploded from a float bowl of the carburetor is shown, in accordance with an embodiment of the invention. Carburetor **62** has a throat **92**, a float bowl **104**, and a fuel passage **164** from float bowl **104** to an outlet port **234** in throat **92**. Manual fuel shutoff **110** includes shaft **112** having first end **210** to be positioned

in float bowl **104** and a second end **212** to be positioned external to float bowl **104**. A primary o-ring **196** installs on shaft **112** and positioned in an o-ring groove **200** in shaft **112**. A retaining ring **236** installs on shaft **112** in a groove **224** toward first end **210** from o-ring groove **200**. Compression spring **194** installs on shaft **112** followed by valve tip **180** pressed onto first end **210** of shaft **112** creating a valve-shaft assembly **179**. Orientation of valve tip **180** is controlled by a "D" shaped hole **232** in valve tip **180** mating with a "D" shaped end of shaft **112**.

Plug **184** installs on shaft **112** pushing compression spring **194** against valve tip **180**. Primary o-ring **196** seals between shaft **112** and plug **184**. Valve-shaft assembly **179** inserts through opening **178** in float bowl **104** and plug **184** presses into the opening. Plug **184** anchors in opening **178** so that compression spring **194** holds valve tip **180** against fuel passage **164**. Secondary o-ring **198** installs around shaft **112** to seal between the shaft and plug **184**. Secondary o-ring **198** may be positioned in a counterbore **192** in plug **184**. Bracket **116** couples to float bowl **104** and holds secondary o-ring **198** positioned in counterbore **192**. Bracket **116** may be 2.0 mm thick and stamped from Q235 grade steel. A pair of screws **120**, **122** each having a spring lock washer **238**, **240** extend through a respective hole **242**, **244** in bracket **116** to mount bracket **116** to carburetor **62**. Screws **120**, **122** may be M5 screws. A spacer **246** installs on shaft **112** and against bracket **116**.

Lever **150** couples to shaft **112** and held apart from bracket **116** by spacer **246**. Shaft **112** has a "D" shape at second end **212** that is inserted into a corresponding "D" shaped opening **248** in lever **150**. The orientation of lever **150** is controlled by "D" shape hole **248** in lever **150** mating with a "D" shape end of shaft **112**. Lever **150** may be 1.5 mm thick and stamped from Q235 grade steel. Cap **152** presses onto shaft **112** to hold lever **150** on shaft **112**. Control system spring **136** attaches to lever **150** and bracket **116** to hold manual fuel shutoff **110** open. Cable clamp **144** couples to bracket **116** by bolt **148**. Cable clamp **144** has a tab **250** at one or both ends that fits into a corresponding slot or recess **252** in bracket **116**. Cable clamp **144** also has a midsection with a notch **254** to pinch and hold Bowden cable **146** to bracket **116**. Bowden cable **146** is held by cable clamp **144** and attaches to lever **150** to actuate manual fuel shutoff **110** to the closed position. Fuel drain screw **130** and drain screw spring **256** insert into carburetor **62**. In one embodiment, drain screw spring **256** is the same type of spring used for compression spring **194**.

Referring to FIG. **12**, and with continued reference back to FIG. **11**, a method of fabricating a manual fuel shutoff system for a carburetor is shown, in accordance with an embodiment of the invention. Process **300** begins by providing carburetor **62** at STEP **302**. Process **300** continues with making a valve-shaft assembly **179** at STEP **304**, with valve tip **180** pressed onto shaft **112**. Also in STEP **304**, a compression spring **194** is stalled on shaft **112** and primary o-ring **196** is installed around shaft **112**. Process **300** continues by installing plug **184** on valve-shaft assembly **179** at STEP **306**. Next, valve-shaft assembly **179** is inserted through opening **178** in float bowl **104** and plug **184** is pressed into the opening at STEP **308**. Process **300** continues at STEP **310** by installing secondary o-ring **198** in a groove on plug **184**. Next, bracket **116** is coupled to float bowl **104** of carburetor **62** in STEP **312**. Process **300** continues at STEP **314** by installing lever **150** on shaft **112**. Next, cap **152** is pressed onto shaft **112** to hold lever **150** to shaft **112** in STEP **316**. In STEP **318**, control system spring **136** is installed on lever **150** and bracket **116**. Also, in STEP **318**, Bowden cable **146** is attached to lever **150** to actuate shaft **112**.

Referring to FIG. **13**, a magnetic fuel shutoff system for a carburetor is shown, in accordance with an embodiment of the invention. Magnetic fuel shutoff system **320** couples to the carburetor to provide a magnetically actuated liquid fuel cut-off for the internal combustion engine. Magnetic fuel shutoff system **320** controls liquid fuel flow through a fuel passage leading from the float bowl to the throat in the carburetor. Magnetic fuel shutoff system **320** can be manually actuated between an open position to allow gasoline flow to the engine for gasoline operation and a closed position to prevent gasoline flow to the engine for LPG operation.

Magnetic fuel shutoff system **320** includes a housing at least partially enclosing the liquid fuel cut-off. That is, magnetic fuel shutoff system **320** has a first section **322** housing magnetic fuel shutoff **324** and a second section **326** housing a manually actuated magnet **328** to operate the magnetic fuel shutoff. First section **322** has a forward wall **330** and a back wall **332** with the forward wall facing internal to the carburetor. Forward wall **330** has a flange **334** around an outer perimeter for coupling to the carburetor. Forward wall **330** also has an opening **336** through which a plunger **342** of the magnetic fuel shutoff **324** extends into the carburetor. A lip **338** extends forward from forward wall **330** around opening **336** and an o-ring **340** is installed around lip **338**. Flange **334** may be mounted to a plug in an opening of the carburetor with magnetic fuel shutoff **324** entering the carburetor through a hole in the plug.

First section **322** provides a sealing member enclosing plunger **342** of magnetic fuel shutoff **324** to the carburetor and holding fuel in the carburetor. The plunger **342** extends through opening **336** in forward wall **330** with a pointed end that is selectively inserted into a fuel supply path in the carburetor to block fuel flow downstream from the float bowl. Magnetic fuel shutoff **324** has a back plate **344** coupled to plunger **342** in first section **322**. Plunger **342** extends perpendicular from a forward face of back plate **344**. A spring **346** pushes a back face of back plate **344** against back wall **332** to push plunger **342** through opening **336** in forward wall **330** to block the fuel supply path in the carburetor. Accordingly, the first section **322** holds the spring **346** against the plunger **342**. Magnetic fuel shutoff **324** is guided through its actuation by back plate **344** sliding through first section **322** and plunger **342** through opening **336** in forward wall **330**.

Second section **326** couples to first section **322** and is located behind back wall **332**. Second section **326** encloses an actuating magnet **328** to selectively pull magnetic fuel shutoff **324** against spring **346**. Second section **326** preferably guides actuating magnet **328** along a path perpendicular to that of magnetic fuel shutoff **324**. As such, the magnetic force to pull magnetic fuel shutoff **324** to an open valve position is the strongest when actuating magnet **328** is aligned with the path of magnetic fuel shutoff **324**. Actuating magnet **328** pulls magnetic fuel shutoff **324** against spring **346** when actuating magnet **328** approaches magnetic fuel shutoff **324** and releases magnetic fuel shutoff **324** while traveling away from magnetic fuel shutoff **324**. Actuating magnet **328** may comprise a rare-earth or other permanent magnet.

In an exemplary embodiment of the invention, magnetic fuel shutoff **324** actuates horizontally between an open position to permit fuel flow into a fuel passage in the carburetor and a closed positioned to prevent fuel flow into

the fuel passage. Actuating magnet **328** preferably follows a vertical path and a spring **348** couples to a top of second section **326** pushing downward on actuating magnet **328**. Bowden cable **146** couples to the top of second section **326** and to actuating magnet **328** to pull the magnet vertically against spring **348** and operate magnetic fuel shutoff system **320**.

Referring now to FIG. **14**, a wiring diagram of a microcontroller **89** receiving input signals and operating engine components is shown, according to an embodiment of the invention. Microcontroller **89** closes fuel cut solenoid **74** when the engine operates on LPG and opens the fuel cut solenoid to operate the engine on gasoline. For LPG mode, microcontroller **89** switches on power to fuel cut solenoid **74** to close the solenoid preventing the engine from drawing in gasoline from the float bowl of the carburetor. During shutdown from gasoline operation, microcontroller **89** can also power fuel cut solenoid **74** to a closed position preventing additional gasoline being drawn into the engine. While microcontroller **89** can operate fuel cut solenoid **74** operating in a normally open configuration, microcontroller **89** can also operate a fuel cut solenoid operating in a normally closed configuration.

Microcontroller **89** may include a module **350** to connect fuel cut solenoid **74**, charging coil **78**, switches and a ground terminal. Module **350** has a first connection **352**(*a*) to couple fuel cut solenoid **74** and a second connection **352**(*b*) to couple charging coil **78** to power the fuel cut solenoid. Fuel cut solenoid **74** may be coupled to a fuel switch **354** and a combination switch **356** that are also connected to module **350** via a third connection **352**(*c*). Fuel switch **354** changes operation of the engine between LPG and gasoline, and combination switch **356** can operate to kill the engine. A ground terminal **358** connects to module **350** via a fourth connection **352**(*d*) in order to ground fuel cut solenoid **74** via fuel switch **354** or combination switch **356**.

In LPG mode, fuel switch **354** connects a first contact **360**(*a*) to a second contact **360**(*b*), instead of third contact **360**(*c*), to complete an electrical circuit for fuel cut solenoid **74** by connecting the fuel cut solenoid to ground terminal **358**. A fuel cut solenoid **74** operating in a normally open configuration is therefore powered and closed to prevent gasoline flow from the fuel bowl of the carburetor to the engine. Fuel switch **354** also connects a fourth contact **360**(*d*) to a fifth contact **360**(*e*), instead of sixth contact **360**(*f*), to prevent combination switch **356** from grounding magneto **76** thereby maintaining power to spark plug **362**.

In gasoline mode, fuel switch **354** connects first contact **360**(*a*) to third contact **360**(*c*) to interrupt an electrical circuit for fuel cut solenoid **74** by disconnecting the fuel cut solenoid from ground terminal **358**. A fuel cut solenoid **74** operating in a normally open configuration is therefore unpowered and opened to allow gasoline flow from the fuel bowl of the carburetor to the engine. Fuel switch **354** also connects fourth contact **360**(*d*) to sixth contact **360**(*f*) to allow combination switch **356** to ground magneto **76** upon shutdown thereby interrupting power to spark plug **362**.

Combination switch **356** can actuate fuel cut solenoid **74** upon engine shutdown from gasoline operation to prevent after-fire. That is, combination switch **356** connects a first point **364**(*a*) to a second point **364**(*b*) to kill the engine by connecting magneto **76** to ground terminal **358**. At the same time, combination switch **356** connects a third point **364**(*c*) to a fourth point **364**(*d*) completing an electrical circuit for fuel cut solenoid **74** by connecting the solenoid to ground terminal **358**. Fuel cut solenoid **74** is then powered and closed to prevent continued gasoline flow to the engine after combination switch **356** stops power supply to spark plug **362**.

In one embodiment of the invention, combination switch **356** can operate as a kill switch only for gasoline operation. That is, combination switch **356** can be decoupled from magneto **76** by fuel switch **354** so that combination switch **356** cannot be actuated to shut down the engine during LPG operation. In another embodiment of the invention, combination switch **356** can operate as a kill switch for both gasoline operation and LPG operation. During LPG operation, combination switch **356** may actuate fuel switch **354** with actuation of combination switch **356** to ground magneto **76** and kill the engine. That is, combination switch **356** connects first point **364**(*a*) to second point **364**(*b*) and also actuates fuel switch **354** to connect fourth contact **360**(*d*) to sixth contact **360**(*f*) so that magneto **76** is coupled to ground terminal **358** killing the engine. At the same time, combination switch **356** connects third point **364**(*c*) to fourth point **364**(*d*) so that fuel cut solenoid **74** maintains connection to ground terminal **358** to remain closed even though fuel switch **354** interrupts connection between first contact **360**(*a*) and second contact **360**(*b*).

Microcontroller **89** may also include a Voltage Frequency and Low Oil Shutdown (VFO) module **366**. VFO module **366** can measure parameters of an alternator driven by an engine in a generator. VFO module **366** monitors alternator voltage and frequency by receiving an input signal **368** from the alternator. Input signal **368** is 120 VAC and 60 Hz from the alternator as a monitoring point for VFO module **366**. VFO module **366** allows the engine to run if alternator parameters are within preset limits and shuts down the engine if the parameters are outside the limits. VFO module **366** can also monitor oil volume within the engine by receiving an input signal from an oil level switch **370** shown in the wiring diagram engine block **372**. VFO module **366** may allow the engine to operate only if the oil volume is greater than a preset lower limit and can shutdown the engine by initiating connection between the ignition coil or magneto **76** and ground terminal **358**.

Beneficially, embodiments of the invention provide for a fuel lockout switch to ensure that two fuels are not simultaneously delivered to a dual fuel internal combustion engine and to efficiently convert operation of the engine between the fuel sources. Embodiments of the invention also provide for a dual fuel generator with a remotely mounted gaseous fuel regulator system. Embodiments of the invention also provide for a batteryless dual fuel internal combustion engine having a liquid fuel cut-off coupled to a carburetor to selectively interrupt liquid fuel.

Therefore, according to one embodiment of the invention, a dual fuel engine includes an engine operable on a gaseous fuel and a liquid fuel and a switch to change operation of the engine between gaseous fuel and liquid fuel. The dual fuel engine also includes a carburetor attached to an intake of the engine to mix air and fuel and connect to a gaseous fuel source and a liquid fuel source. A liquid fuel cut-off attaches to the carburetor to interrupt liquid fuel upon actuation of the switch from liquid fuel to gaseous fuel.

According to another embodiment of the invention, a batteryless dual fuel generator includes a housing containing a pull start engine coupled to drive an alternator, the engine operable on a gaseous fuel and a liquid fuel. A carburetor attaches to an intake of the engine and includes a throat to mix fuel with air, a float bowl, and a fuel passage to provide liquid fuel from the float bowl to the throat. The generator

also includes a fuel shutoff attached to the carburetor to close the fuel passage upon selection of engine operation to gaseous fuel.

According to yet another embodiment of the invention, a carburetor having a fuel shutoff includes a carburetor with a float bowl, a throat, and a fuel passage to provide fuel from the float bowl to the throat. The carburetor further includes a fuel shutoff coupled to the carburetor having a first end in the carburetor that actuates to close the fuel passage and a second end external to the carburetor to actuate the first end, and the fuel shutoff can actuate free from linear motion.

According to yet another embodiment of the invention, a method of assembling a dual fuel engine includes providing an engine operable on a gaseous fuel and a liquid fuel. The method also includes attaching a carburetor to an intake of the engine, the carburetor includes a throat to mix gaseous fuel with air and liquid fuel with air, a float bowl, and a fuel passage to provide liquid fuel from the float bowl to the throat. The method also includes coupling a switch to the engine to change operation of the engine between gaseous fuel and liquid fuel and attaching a liquid fuel cut-off to the carburetor to close the fuel passage upon actuation of the switch from liquid fuel to gaseous fuel.

This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

What is claimed is:

1. A dual fuel engine comprising:

an engine operable on a gaseous fuel and a liquid fuel;

a switch to change operation of the engine between gaseous fuel and liquid fuel;

a carburetor attached to an intake of the engine to mix air and fuel and connect to a gaseous fuel source and a liquid fuel source;

a liquid fuel valve positioned along a liquid fuel line coupling the liquid fuel source to the carburetor;

a gaseous fuel valve positioned along a gaseous fuel line coupling the gaseous fuel source to the carburetor; and

a liquid fuel cut-off incorporated into the carburetor to interrupt liquid fuel upon actuation of the switch from liquid fuel to gaseous fuel.

2. The dual fuel engine of claim **1**, wherein the engine is a pull start, batteryless engine.

3. The dual fuel engine of claim **1**, wherein the gaseous fuel is LPG and the liquid fuel is gasoline.

4. The dual fuel engine of claim **1**, wherein the engine is a pull-start engine having an electrical power generator to supply electrical power.

5. The dual fuel engine of claim **4**, wherein the switch is an electro-mechanical switch connecting one fuel source to the carburetor and connected to the electrical power generator; and

wherein the liquid fuel cut-off is a solenoid connected to open and close a fuel path to the pull-start engine in response to reception of electrical power from the switch.

6. The dual fuel engine of claim **4**, wherein the liquid fuel cut-off is a solenoid valve that operates within the carburetor to control liquid fuel flow to the engine and is powered by the electrical power generator.

7. The dual fuel engine of claim **6**, wherein the switch selectively powers the solenoid valve by controlling electrical connection between the solenoid valve and the electrical power generator.

8. The dual fuel engine of claim **6**, wherein the solenoid valve is normally open to provide liquid fuel to the engine when the solenoid valve is unpowered.

9. The dual fuel engine of claim **8**, wherein a pull-starter drives the electrical power generator to power and close the solenoid valve while starting the engine on gaseous fuel.

10. The dual fuel engine of claim **6**, wherein the electrical power generator comprises a magneto or an alternator coupled to a voltage regulator to provide a regulated voltage to the solenoid valve.

11. The dual fuel engine of claim **6**, wherein the solenoid valve is open to provide liquid fuel to the engine when the solenoid valve is powered.

12. The dual fuel engine of claim **11**, wherein a pull-starter drives the electrical power generator to power and open the solenoid valve while starting the engine on liquid fuel.

13. The dual fuel engine of claim **6** further comprising a microcontroller to close the solenoid valve when the engine operates on gaseous fuel and open the solenoid valve to operate the engine on liquid fuel.

14. The dual fuel engine of claim **13**, wherein the microcontroller closes the solenoid valve during engine shutdown from operation on liquid fuel.

15. The dual fuel engine of claim **1**, wherein the liquid fuel cut-off is manually actuated to interrupt liquid fuel.

16. The dual fuel engine of claim **1**, wherein the liquid fuel cut-off actuates to interrupt liquid fuel free from linear motion.

17. The dual fuel engine of claim **1**, wherein the liquid fuel cut-off comprises:

a rotating shaft extending through an aperture in the carburetor;

a fuel seal around the shaft to seal the aperture; and

a blocking member coupled to the shaft in the carburetor that rotates between a blocking and a non-blocking position to selectively block a liquid fuel path to the engine.

18. The dual fuel engine of claim **17** further comprising:

a lever coupled to the shaft outside the carburetor;

a spring coupled to the lever to hold the blocking member in either the blocking or non-blocking position; and

a cable coupled to the lever to pull against the spring and rotate the blocking member to the other of the blocking or non-blocking positions.

19. The dual fuel engine of claim **1**, wherein the liquid fuel cut-off is magnetically actuated to selectively interrupt liquid fuel.

20. The dual fuel engine of claim **1** further comprising:

a spring pushing the liquid fuel cut-off to interrupt liquid fuel; and

an actuating magnet coupled to the carburetor to selectively pull the liquid fuel cut-off against the spring away from a position interrupting liquid fuel.

21. The dual fuel engine of claim **20** further comprising a housing at least partially enclosing the liquid fuel cutoff, the housing including:

a first section enclosing a plunger of the liquid fuel cut-off to the carburetor and holding the spring against the plunger; and

a second section coupled to the first section and enclosing the actuating magnet.

22. The dual fuel engine of claim **1**, wherein the liquid fuel cut-off is physically attached to an outer surface of the carburetor.

23. A batteryless dual fuel generator comprising:

a housing containing a pull start engine coupled to drive an alternator, the engine operable on a gaseous fuel and a liquid fuel;

a carburetor attached to an intake of the engine comprising:

a throat to mix fuel with air,

a float bowl, and

a fuel passage extending from the float bowl to the throat to provide liquid fuel; and

a fuel shutoff attached to the carburetor to close the fuel passage upon selection of engine operation to gaseous fuel.

24. The batteryless dual fuel generator of claim **23**, wherein the fuel shutoff actuates to close the fuel passage free from linear motion.

25. The batteryless dual fuel generator of claim **23**, wherein the fuel shutoff comprises:

a rotating shaft extending through an opening in the carburetor; and

a valve member coupled to the shaft in the carburetor that rotates to control fuel flow into the fuel passage.

26. The batteryless dual fuel generator of claim **25**, wherein the valve member is positioned in the float bowl and the shaft extends substantially horizontal through the opening.

27. The batteryless dual fuel generator of claim **25**, wherein the valve member has a flow passage that aligns with the fuel passage to control fuel flow into the fuel passage.

28. The batteryless dual fuel generator of claim **25** further comprising:

a compression spring on the shaft in the carburetor pushing the valve member to close the fuel passage; and

a plug in the opening surrounding the shaft to hold the compression spring against the valve member.

29. The batteryless dual fuel generator of claim **28** further comprising:

a lever coupled to the shaft outside the carburetor; and

a cable coupled to the lever to actuate the valve member to open and close the fuel passage.

30. The batteryless dual fuel generator of claim **28** further comprising one or more fuel seals within the plug to seal around the shaft.

31. The batteryless dual fuel generator of claim **23**, wherein the fuel shutoff is magnetically actuated to selectively close the fuel passage, controlled by a manually actuated magnet coupled to the carburetor.

32. The batteryless dual fuel generator of claim **23** further comprising:

a spring pushing the fuel shutoff to close the fuel passage; and

an actuating magnet coupled to the carburetor to selectively pull the fuel shutoff against the spring to open the fuel passage.

33. The batteryless dual fuel generator of claim **32** further comprising a housing at least partially enclosing the fuel shutoff, the housing including:

a first section enclosing a plunger of the fuel shutoff to the carburetor and holding the spring against the plunger; and

a second section coupled to the first section and enclosing the actuating magnet.

34. The batteryless dual fuel generator of claim **23**, wherein the fuel shutoff is a carburetor cutoff solenoid; and wherein the generator further comprises:

a charge winding to generate electrical power to operate the carburetor cutoff solenoid, and

a switch to selectively power the carburetor cutoff solenoid by controlling electrical connection between the carburetor cutoff solenoid and the charge winding.

35. The batteryless dual fuel generator of claim **34**, wherein the carburetor cutoff solenoid is normally open to provide liquid fuel to the engine when the carburetor cutoff solenoid is unpowered.

36. The batteryless dual fuel generator of claim **35**, wherein a pull-starter drives the engine operating the charge winding to power and close the carburetor cutoff solenoid while starting the engine on gaseous fuel.

37. The batteryless dual fuel generator of claim **34**, wherein the switch is an electro-mechanical switch connected to the charge winding and connecting at least one fuel source to the carburetor to selectively control fuel flow from the at least one fuel source to the carburetor.

38. The batteryless dual fuel generator of claim **34**, wherein the charge winding is coupled to a voltage regulator to provide a regulated voltage to the carburetor cutoff solenoid.

39. The batteryless dual fuel generator of claim **34**, wherein the carburetor cutoff solenoid is open to provide liquid fuel to the engine when the carburetor cutoff solenoid is powered.

40. The batteryless dual fuel generator of claim **39**, wherein a pull-starter drives the engine operating the charge winding to power and open the carburetor cutoff solenoid while starting the engine on liquid fuel.

41. The batteryless dual fuel generator of claim **34**, wherein the switch is a microcontroller configured to close the carburetor cutoff solenoid when the engine operates on gaseous fuel and to open the carburetor cutoff solenoid to operate the engine on liquid fuel.

42. The batteryless dual fuel generator of claim **41**, wherein the microcontroller closes the carburetor cutoff solenoid during engine shutdown from operation on liquid fuel.

43. A carburetor having a fuel shutoff comprising:

a carburetor comprising:

a float bowl,

a throat, and

a fuel passage extending from the float bowl to the throat; and

a fuel shutoff coupled to the carburetor having a first end in the carburetor that actuates to close the fuel passage and a second end external to the carburetor to actuate the first end; and

wherein the fuel shutoff actuates free from linear motion.

44. The carburetor having a fuel shutoff of claim **43**, wherein the fuel shutoff is a manually actuated fuel shutoff.

45. The carburetor having a fuel shutoff of claim **43**, wherein the fuel shutoff comprises a shaft extending into the carburetor through an aperture in the float bowl and coupled to a valve tip in the float bowl that rotates to open and close the fuel passage.

46. The carburetor having a fuel shutoff of claim **45**, wherein the valve tip rotates parallel to an inlet of the fuel passage between a first position permitting fuel flow into the inlet and a second position blocking fuel flow into the inlet.

47. The carburetor having a fuel shutoff of claim 45, wherein the fuel passage has an inlet with a substantially flat perimeter edge and the valve tip maintains planar contact with the perimeter edge while rotating to open and close the fuel passage.

48. The carburetor having a fuel shutoff of claim 47, wherein the shaft is substantially horizontal and the inlet of the fuel passage faces substantially horizontal.

49. The carburetor having a fuel shutoff of claim 47 further comprising:

a plug in the aperture around the shaft; and

a compression spring around the shaft in the float bowl pushing against the plug to hold the valve tip against the perimeter edge of the inlet.

50. The carburetor having a fuel shutoff of claim 49 further comprising a first fuel seal between the shaft and plug, the first fuel seal comprising a primary o-ring in an o-ring groove in the shaft.

51. The carburetor having a fuel shutoff of claim 50 further comprising:

a second fuel seal between the shaft and plug, the second fuel seal comprising a secondary o-ring in a counterbore in the plug; and

a support member mounted over the counterbore around the shaft to hold the secondary o-ring in the counterbore.

52. The carburetor having a fuel shutoff of claim 45 further comprising:

a lever coupled to the shaft outside of the carburetor;

a spring coupled to the lever to hold the fuel shutoff opening the fuel passage; and

a cable coupled to the lever to move the lever against the spring and rotate the fuel shutoff to close the fuel passage.

53. The carburetor having a fuel shutoff of claim 45, wherein the valve tip comprises thermoplastic.

54. The carburetor having a fuel shutoff of claim 45, wherein the valve tip comprises one of an oval and stadium shape.

55. The carburetor having a fuel shutoff of claim 45, wherein the valve tip has a cutout that aligns with the fuel passage to open the fuel passage.

56. The carburetor having a fuel shutoff of claim 43, wherein the fuel shutoff extends through an opening into the float bowl such that the first end actuates in the float bowl to close the fuel passage.

57. A method of assembling a dual fuel engine comprising:

providing an engine operable on a gaseous fuel and a liquid fuel;

attaching a carburetor to an intake of the engine, the carburetor comprising:

a throat to mix gaseous fuel with air and liquid fuel with air,

a float bowl, and

a fuel passage extending from the float bowl to the throat to provide liquid fuel;

coupling a switch to the engine to change operation of the engine between gaseous fuel and liquid fuel; and

attaching a liquid fuel cut-off to the carburetor to close the fuel passage upon actuation of the switch from liquid fuel to gaseous fuel.

58. The method of claim 57 further comprising coupling a manually operated control operatively to the liquid fuel cut-off.

59. The method of claim 57, wherein attaching the liquid fuel cut-off to the carburetor comprises:

providing a shaft having a valve tip located at an end of the shaft;

installing a compression spring on the shaft;

installing a plug on the shaft so that the compression spring is positioned between the plug and the valve tip; and

anchoring the plug in an aperture in the carburetor so that the compression spring holds the valve tip to an inlet of the fuel passage.

60. The method of claim 59, wherein providing the shaft having a valve tip located at an end of the shaft comprises pressing the valve tip onto the shaft.

61. The method of claim 59 further comprising positioning at least one fuel seal on the shaft to seal between the shaft and plug.

62. The method of claim 59, wherein the shaft rotates the valve tip between a first position allowing fuel flow into the fuel passage and a second position blocking fuel flow into the fuel passage.

63. The method of claim 62, wherein the valve tip comprises an oval or stadium shape with a cutout in the oval or stadium shape that aligns with the fuel passage when the valve tip is rotated to the first position such that fuel can pass through the cutout into the fuel passage.

64. The method of claim 62 further comprising:

coupling a lever to the shaft;

attaching a control spring to the lever to actuate the shaft to one of the first position and second position; and

attaching a cable to the lever to actuate the shaft to the other of the first position and second position.

* * * * *

EXHIBIT D

US011143120B2

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Collie et al.

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(45) **Date of Patent: Oct. 12, 2021**

(54) **FUEL SYSTEM FOR A MULTI-FUEL INTERNAL COMBUSTION ENGINE**

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(Continued)

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CPC ***F02D 19/0613*** (2013.01); ***F02B 43/00*** (2013.01); ***F02B 63/04*** (2013.01);
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(58) **Field of Classification Search**
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(Continued)

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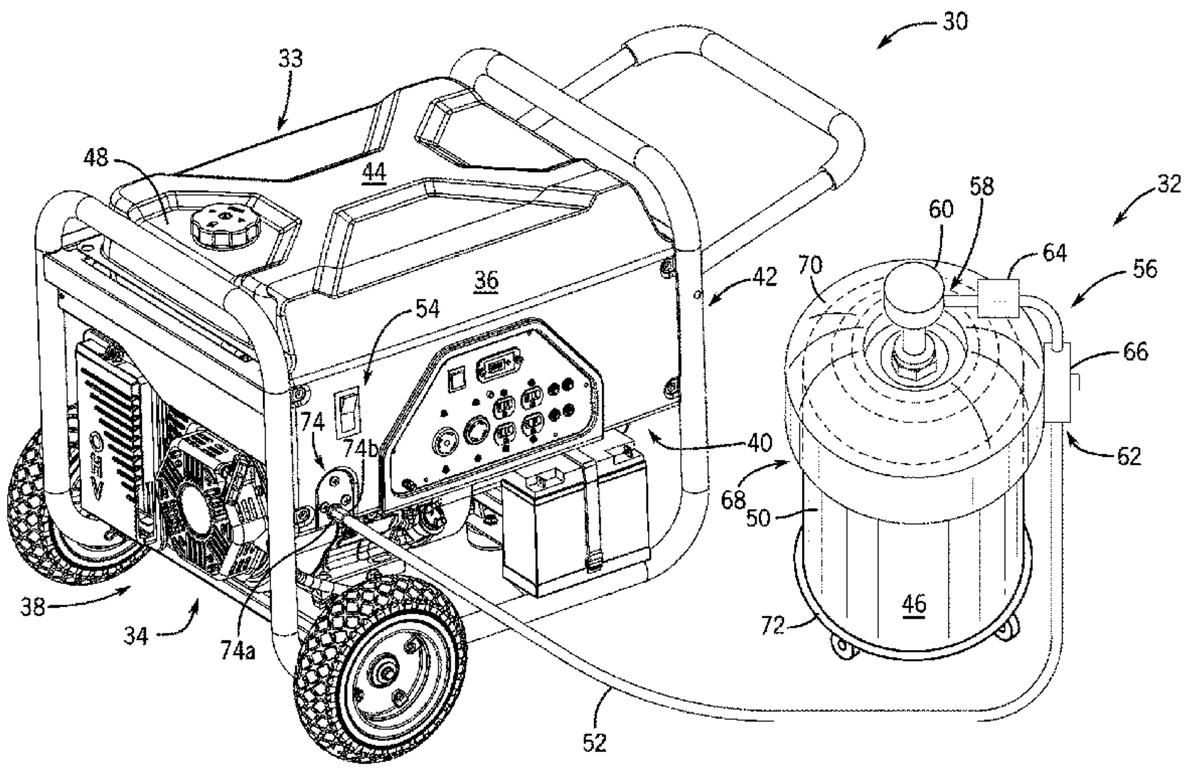
Primary Examiner — Long T Tran
(74) *Attorney, Agent, or Firm* — Ziolkowski Patent Solutions Group, SC

(57) **ABSTRACT**

A multi-fuel engine includes an engine operable on a liquid fuel and first and second gaseous fuels. The multi-fuel engine also includes a liquid cutoff solenoid selectively operable between open and closed positions to allow and inhibit a flow of the liquid fuel to the engine and at least one gaseous cutoff valve selectively operable between open and closed positions to allow and inhibit a flow of the first and second gaseous fuels to the engine. A jet block couples the first gaseous fuel source and the second gaseous fuel source to a carburetor connected to an intake of the engine, with the jet block being located downstream from the at least one gaseous cutoff valve. The jet block includes a first gaseous fuel jet to meter the first gaseous fuel to the carburetor and a second gaseous fuel jet to meter the second gaseous fuel to the carburetor.

19 Claims, 4 Drawing Sheets



Related U.S. Application Data

continuation of application No. 15/285,215, filed on Oct. 4, 2016, now Pat. No. 10,393,034, which is a continuation-in-part of application No. 14/925,441, filed on Oct. 28, 2015, now Pat. No. 10,697,398, which is a continuation-in-part of application No. 14/738,060, filed on Jun. 12, 2015, now Pat. No. 10,221,780.

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F02M 19/06	(2006.01)
F02M 19/08	(2006.01)
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F02D 29/06	(2006.01)
F02D 41/06	(2006.01)
F02N 3/02	(2006.01)
F02D 41/00	(2006.01)

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See application file for complete search history.

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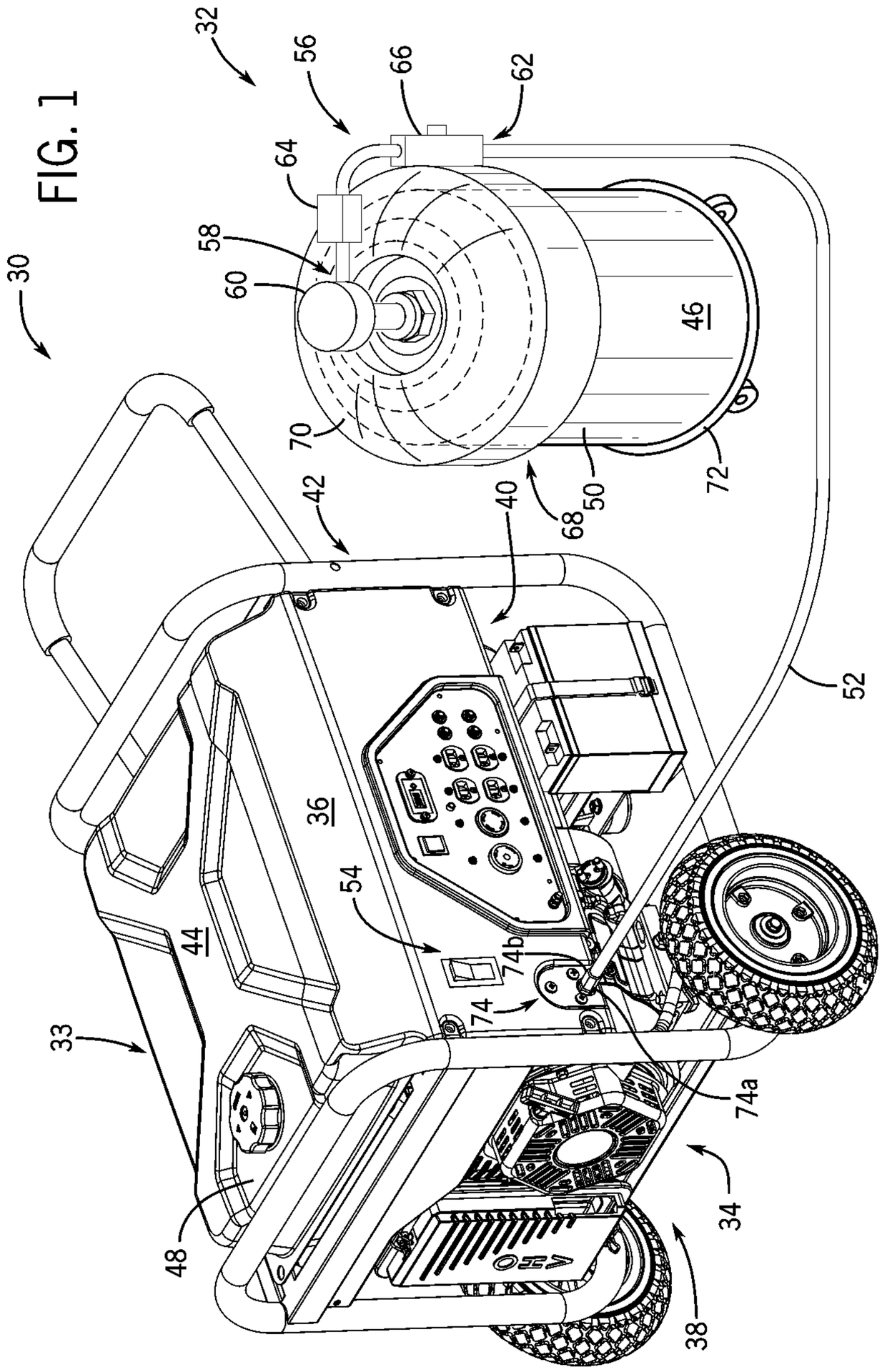
FIG. 1



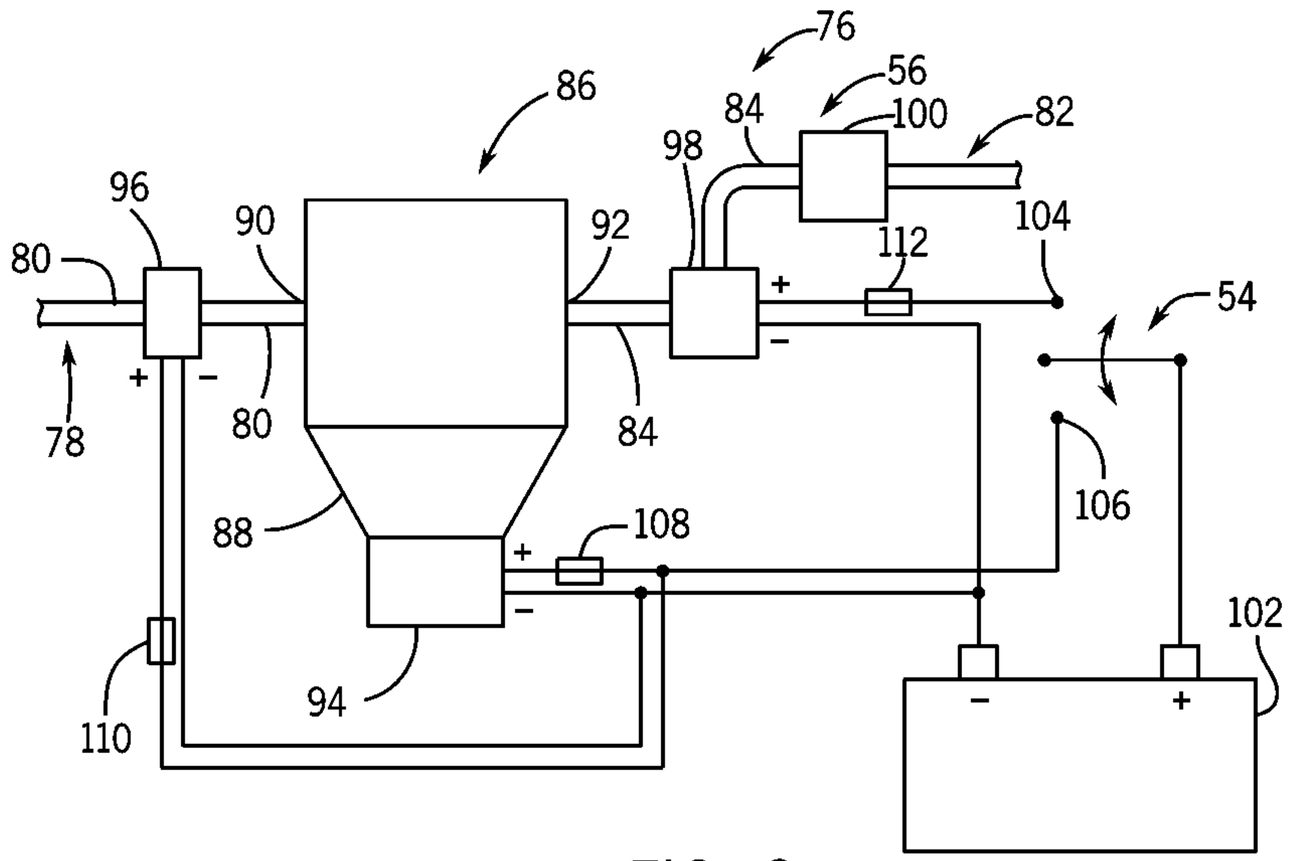


FIG. 2

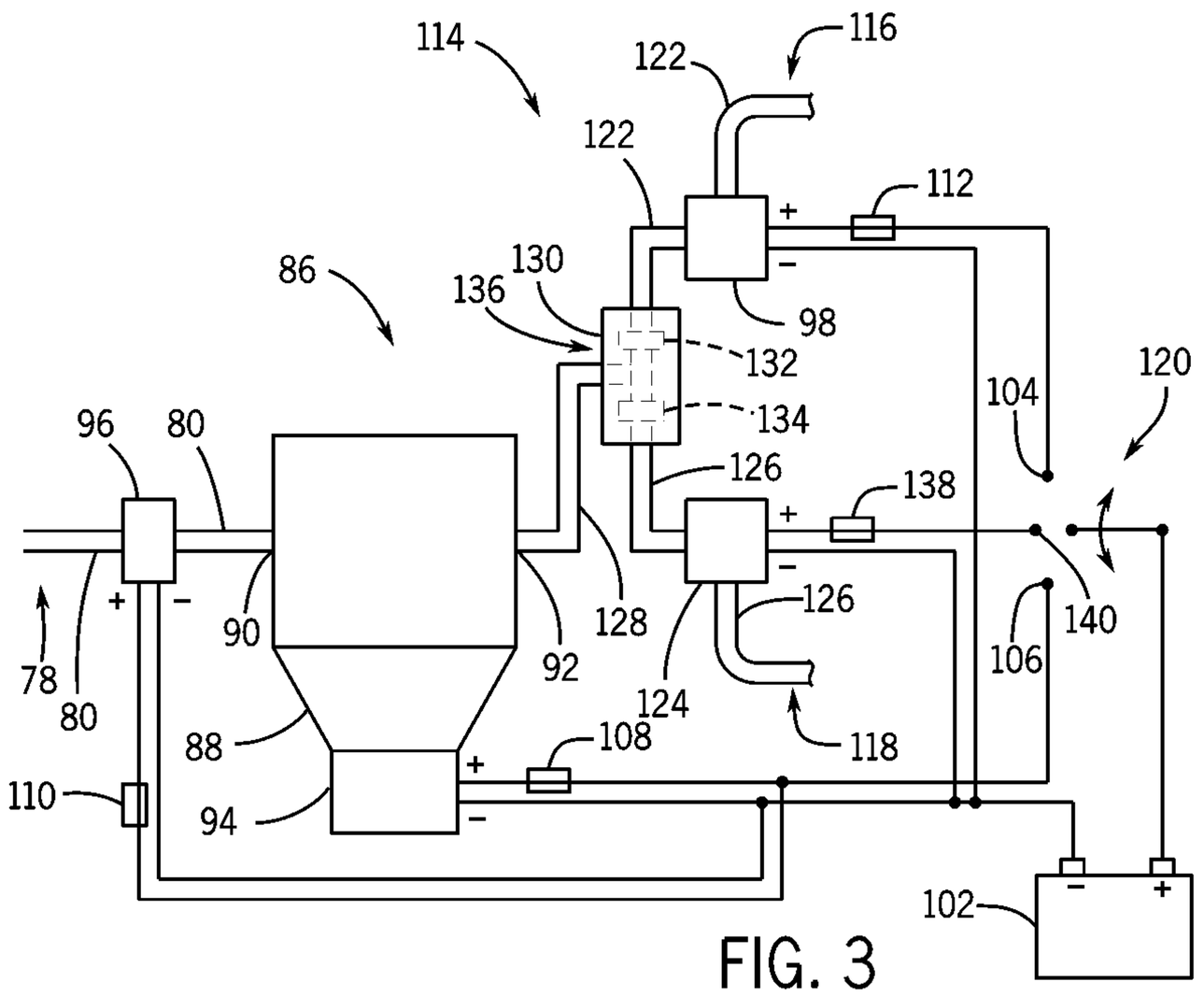


FIG. 3

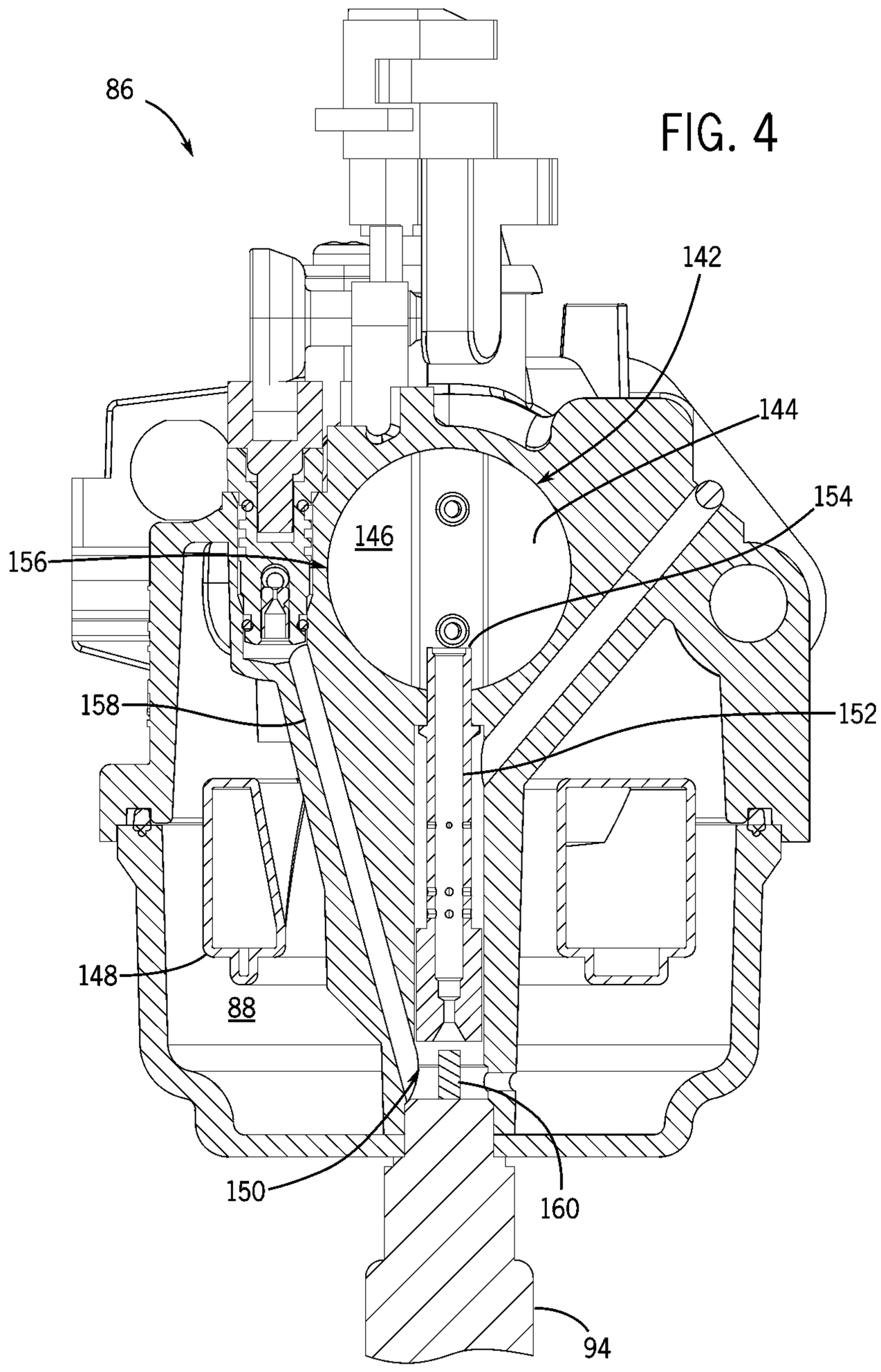
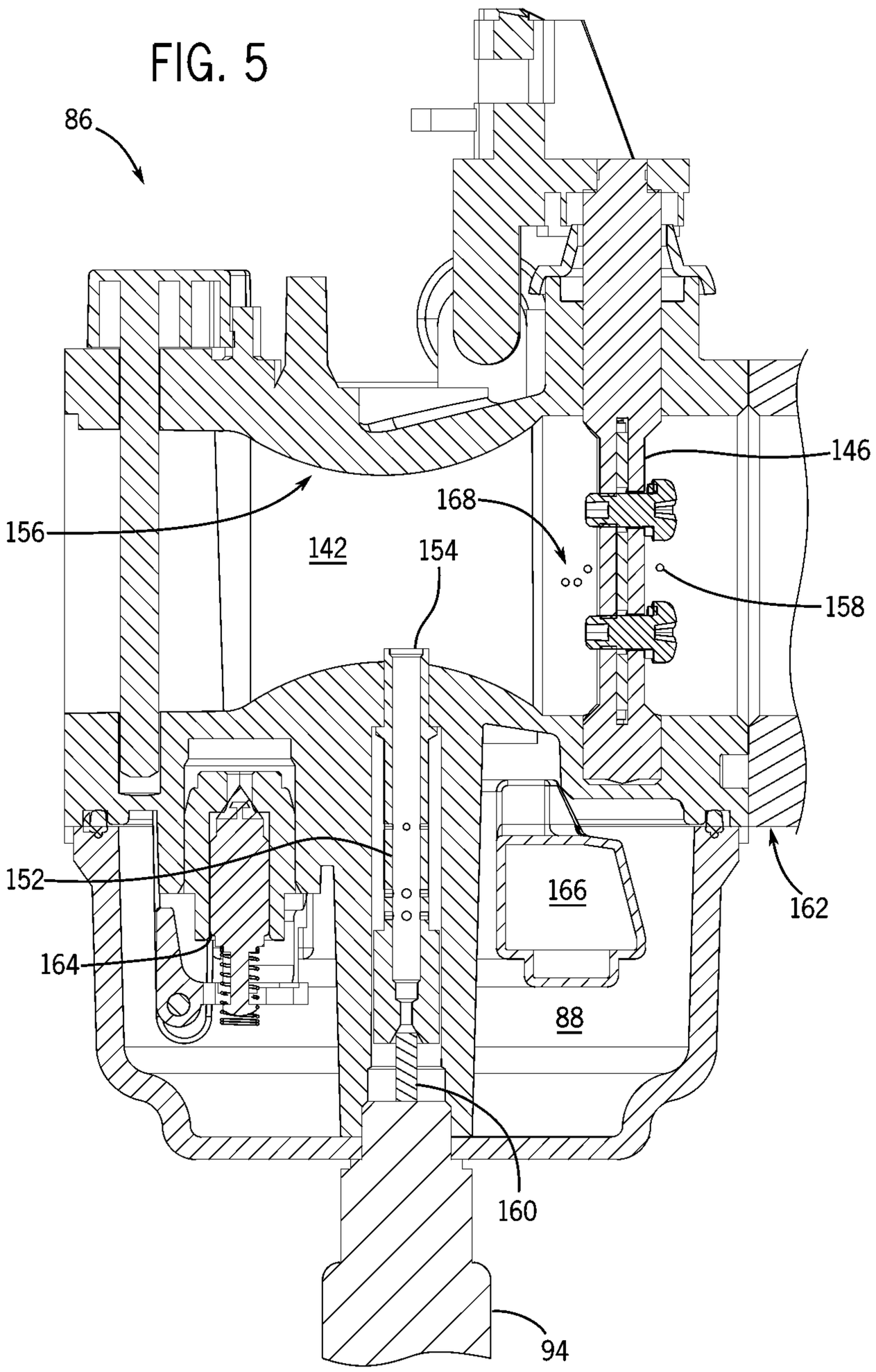


FIG. 4

FIG. 5



FUEL SYSTEM FOR A MULTI-FUEL INTERNAL COMBUSTION ENGINE

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a continuation of and claims priority to U.S. patent application Ser. No. 16/358,822, filed Mar. 20, 2019, which is a continuation of and claims priority to U.S. patent application Ser. No. 15/285,215, filed Oct. 4, 2016, now Issued U.S. Pat. No. 10,393,034, which is a continuation-in-part of and claims priority to U.S. patent application Ser. No. 14/925,441, filed Oct. 28, 2015, which is a continuation-in-part of and claims priority to U.S. patent application Ser. No. 14/738,060, filed Jun. 12, 2015, now Issued U.S. Pat. No. 10,221,780, the disclosures of which are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

Embodiments of the invention relate generally to dual fuel and other multi-fuel internal combustion engines, and more particularly, to an apparatus and method for delivering liquid fuel and gaseous fuel to a generator driven by a multi-fuel internal combustion engine.

Electric generators are frequently driven by internal combustion engines that use gasoline as a fuel source. Gasoline is a common fuel source for generators in a variety of applications. However, alternative fuel sources also provide a desirable fuel source. For instance, alternative fuels may provide a cleaner burning fuel that limits undesirable emissions. Alternative fuels may also be stored for longer periods of time without degradation, whereas gasoline can degrade over a period of months leading to hard starting, rough running, and also lead to gum and varnish deposits in the fuel system. In addition, generators that operate on alternative fuels are able to generate electricity when gasoline is not readily available. For instance, generators are frequently used when power outages in the utility grid result from severe weather. Unfortunately, gas stations may also be closed as a result of the power outage. Such a circumstance presents just one example where it would be advantageous to operate electric generators on alternative fuels.

Certain generators are configured to operate as "dual fuel" generators, otherwise known as bi-fuel generators. These generators are driven by an internal combustion engine that is configured to operate on either liquid fuel or an alternative fuel. The alternative fuel may exist in a gaseous state at normal temperature and pressure and can be any one of liquefied petroleum gas, compressed natural gas, hydrogen, or the like. Liquefied petroleum gas (LPG), often referred to as propane, exists in a gaseous state at normal temperature and pressure but can be conveniently stored under pressure in a liquid state. LPG may be a desirable fuel source for internal combustion engines because it can be stored for extended periods of time and contains fewer impurities than gasoline, resulting in smoother and cleaner operation. In addition, propane fueled engines typically have a longer life cycle due to less carbon build-up and virtually no fuel gumming or varnish accumulation.

In order to provide the liquid and gaseous fuel to the engine, the dual fuel engine may have a first fuel line for liquid fuel and a second fuel line for gaseous fuel. A liquid fuel source and a gaseous fuel source may be coupled to the respective lines to provide fuel to the engine. However, a common problem with such configurations that couple two fuel sources to a single fuel inlet, such as a carburetor, of an

engine is that during cross-over switching between the fuel sources the engine can experience overly rich air-fuel ratio. This is particularly problematic when switching from a liquid fuel to a gaseous fuel because carburetors have a fuel bowl containing fuel that is drawn into the engine even after the liquid fuel source is cut-off. Therefore, for a period of time, the engine is running on both liquid and gaseous fuels causing an overly rich fuel mixture. Further, such simultaneous delivery of fuel from the first fuel line and the second fuel line, even if for a brief time, may make the engine hard to start and lead to unstable operating conditions.

Therefore, it would be desirable to design a generator having a liquid fuel and gaseous fuel delivery system that overcomes the aforementioned detriments without substantially increasing the overall cost of the system.

BRIEF DESCRIPTION OF THE INVENTION

In accordance with one aspect of the invention, a multi-fuel engine includes an engine operable on a liquid fuel, a first gaseous fuel from a first gaseous fuel source, and a second gaseous fuel from a second gaseous fuel source. The multi-fuel engine also includes a liquid cutoff solenoid coupled to open and close a liquid fuel path to the engine, a first gaseous cutoff solenoid coupled to open and close the first gaseous fuel source to the engine, a second gaseous cutoff solenoid coupling the engine to the second gaseous fuel source to control flow of the second gaseous fuel to the engine, and a switch coupling a power source to the liquid cutoff solenoid and the first gaseous cutoff solenoid to switch between fuel sources on-the-fly during engine operation.

In accordance with another aspect of the invention, a multi-fuel engine includes an engine operable on a liquid fuel, a first gaseous fuel from a first gaseous fuel source, and a second gaseous fuel from a second gaseous fuel source. The multi-fuel engine also includes a liquid cutoff solenoid selectively operable between open and closed positions to allow and inhibit a flow of the liquid fuel to the engine, at least one gaseous cutoff valve selectively operable between open and closed positions to allow and inhibit a flow of the first gaseous fuel and the second gaseous fuel to the engine. and a jet block coupling the first gaseous fuel source and the second gaseous fuel source to a carburetor connected to an intake of the engine, wherein the jet block is located downstream from the at least one gaseous cutoff valve. The jet block further includes a first gaseous fuel jet configured to meter the first gaseous fuel to the carburetor and a second gaseous fuel jet configured to meter the second gaseous fuel to the carburetor.

Various other features and advantages will be made apparent from the following detailed description and the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings illustrate preferred embodiments presently contemplated for carrying out the invention.

In the drawings:

FIG. **1** is a perspective view of a multi-fuel generator coupled to a fuel delivery system, according to an embodiment of the invention.

FIG. **2** is a schematic diagram of a fuel system for the multi-fuel generator of FIG. **1** configured in a bi-fuel arrangement, according to an embodiment of the invention.

FIG. **3** is a schematic diagram of a fuel system for the multi-fuel generator of FIG. **1** to operate in a tri-fuel arrangement, according to an embodiment of the invention.

FIG. **4** is a cross-sectional view of a carburetor for the multi-fuel generator of FIG. **1** taken transverse to a throat of the carburetor and through a fuel passage that provides fuel from a float bowl to the throat of the carburetor, according to an embodiment of the invention.

FIG. **5** is a cross-sectional view of the carburetor of FIG. **4** coupled to an engine intake taken lengthwise to the throat and through the fuel passage, according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The operating environment of the invention is described with respect to a multi-fuel generator. However, it will be appreciated by those skilled in the art that the invention is equally applicable for use with any multi-fuel internal combustion engine. Moreover, the invention will be described with respect to a dual fuel or other multi-fuel generator configured to operate on liquid fuel and gaseous fuel. However, one skilled in the art will further appreciate that the invention is equally applicable for use with other fuel combinations for multi-fuel generators and internal combustion engines.

Referring to FIG. **1**, a dual fuel generator **30** is coupled to fuel delivery systems **32**, **33** in accordance with an embodiment of the invention. Dual fuel generator **30** includes a dual fuel internal combustion engine **34** within housing **36** at one end **38**, operatively connected to an alternator **40** also enclosed in housing **36** at another end **42** by conventional means. Dual fuel generator **30** is configured to operate on different fuels via either a first fuel source **44** or a second fuel source **46**. In an exemplary embodiment of the invention, first fuel source **44** is a liquid fuel and second fuel source **46** is a gaseous fuel. In one preferred embodiment, the liquid fuel is gasoline and the gaseous fuel is liquid petroleum gas (LPG). An operator can selectively operate the generator on either fuel as desired. For instance, generator **30** may operate on gasoline for a first period of operation and then switch to LPG for a second period of operation. However, it is contemplated that dual fuel generator **30** is configured to operate on fuels other than gasoline and LPG (e.g., natural gas, biodiesel, etc.), and thus the scope of the invention is not meant to be limited strictly to a dual fuel arrangement where first fuel source **44** provides gasoline and second fuel source **46** provides LPG. In addition, embodiments of the invention contemplate tri-fuel, quad-fuel, and other multi-fuel arrangements.

In one embodiment of the invention, dual fuel generator **30** includes a gasoline tank **48** or, generally, a liquid fuel tank, located inside cover **36** onboard generator **30** to provide gasoline to the engine as first fuel source **44**. Gasoline tank **48** connects to a first fuel line to provide gasoline to the carburetor to run the engine, as will later be described with reference to FIG. **2**. Generator **30** is also coupled to a pressurized fuel container **50**, or a pressurized fuel source, located off board generator **30** to provide LPG to the engine as second fuel source **46**. Pressurized fuel container **50** is coupled to generator **30** with an LPG supply hose **52**. LPG supply hose **52** is coupled to a second fuel line within generator **30** to provide LPG to the engine via the carburetor. Dual fuel generator **30** includes an electrical fuel switch **54** for selecting a desired fuel to the engine.

In an exemplary embodiment, fuel **46** from pressurized fuel container **50** is regulated using a fuel regulator system **56** for delivery to the engine. Fuel regulator system **56** includes one or more pressure regulators that reduce and control the pressure of the fuel from pressurized fuel container **50** and delivers fuel at a desired pressure for operation of the engine. Fuel regulator system **56** has an inlet **58** operatively coupled to a service valve **60** of pressurized fuel container **50** and an outlet **62** coupled to LPG supply hose **52**. Fuel regulator system **56** includes a primary pressure regulator **64** coupled to pressurized fuel container **50** and a secondary pressure regulator **66**. Primary pressure regulator **64** protects downstream components from high pressure of pressurized fuel container **50**. Primary pressure regulator **64** receives LPG through service valve **60** of pressurized fuel container **50** and reduces the pressure of the LPG to a first stage. In one embodiment of the invention, the first stage may be delivered directly to generator **30** at a pressure required for operation of the engine.

In an exemplary embodiment of the invention, fuel regulator system **56** includes secondary pressure regulator **66** coupled to the outlet of primary pressure regulator **64** in order to use standard "off-the-shelf" components. Typically, the primary pressure regulator is mounted on the LPG tank, while the secondary pressure regulator is mounted on the component using the fuel, such as an engine or grill. Here, since generator **30** can be used as a gasoline only generator, secondary pressure regulator **66** is mounted off-board the generator to reduce size and cost of the generator. Secondary pressure regulator **66** receives LPG from primary pressure regulator **64** and further reduces the pressure of LPG to a second stage to be delivered to generator **30**. In a system with two regulators, primary pressure regulator **64** regulates fuel received from pressurized fuel container **50** and reduces the pressure of the fuel to a level required for operation of secondary pressure regulator **66**. Secondary pressure regulator **66** regulates fuel received from primary pressure regulator **64** and further reduces the pressure of the fuel to a level required for operation of generator **30**. In addition, primary pressure regulator **64** may compensate for varying tank pressure as fuel is depleted while secondary pressure regulator **66** may compensate for varying demand from generator **30**.

In accordance with an exemplary embodiment of the invention, fuel regulator system **56** includes both the primary and secondary regulators or a customized single regulator to perform both regulator functions in one, but in any case, in this embodiment, is located remotely, or off-board, from dual fuel generator **30**. Fuel regulator system **56** may be directly mounted to pressurized fuel container **50** using a regulator mounting structure **68**. Regulator mounting structure **68** is a device having mounting locations for primary pressure regulator **64** and secondary pressure regulator **66**. Regulator mounting structure **68** also has a securing mechanism **70** to secure regulator mounting structure **68** to pressurized fuel container **50**. The securing mechanism **70** is a cover or dome that sits on the container with an opening therein that fits around service valve **60**.

In another embodiment of the invention, primary pressure regulator **64** is mounted on regulator mounting structure **68** while secondary pressure regulator **66** could be mounted on or near generator **30**. In yet another embodiment of the invention, a dual stage regulator regulates the fuel received from pressurized fuel container **50** and delivers fuel at a pressure required for operation of generator **30**. Such a dual stage regulator regulates the fuel to the second stage within a single structure and may comprise both the primary pressure regulator **64** and the secondary pressure regulator **66**. The dual stage regulator may be mounted directly on fuel container **50**. Pressurized fuel container **50** may be secured to a platform or mobile cart **72** for stability or transportation.

In another embodiment, a regulator mounting structure **68** is secured directly to a platform or a mobile cart.

A quick-disconnect hose coupling **74**, also referred to as a quick-connect hose coupling, connects LPG supply hose **52** to generator **30** so that LPG supply hose **52** may be quickly attached and detached from generator **30**. Hose coupling **74** has a first end **74***a* mounted on the external surface of generator **30** and coupled to supply the second fuel to the engine. Hose coupling **74** has a second end **74***b* coupled to the outlet of LPG supply hose **52**. Hose coupling **74** has a valve that opens when the couplings are engaged and closes when the couplings are disengaged. As such, quick-disconnect hose coupling **74** automatically opens when connected to enable fuel flow from LPG supply hose **52** to the engine. Hose coupling **74** automatically disconnects fluid communication when disconnected. Accordingly, when the supply hose is detached from generator **30**, the coupling **74** is automatically closed so that fuel does not escape and unwanted air does not enter the fuel system.

Referring now to FIG. **2**, a schematic diagram of a fuel system for the dual fuel generator is shown, in accordance with an embodiment of the invention. The fuel system includes an electro-mechanical valve system **76** that includes a carburetor cutoff solenoid **94**, gasoline cutoff solenoid **96**, and a LPG cutoff solenoid **98**. The electro-mechanical valve system **76** is coupled to a multi-fuel internal combustion engine configured to operate on a liquid fuel supplied from a liquid fuel source **78** through a liquid fuel line **80**, and a gaseous fuel supplied from a gaseous fuel source **82**, or a pressurized fuel source, through a gaseous fuel line **84**. Electro-mechanical valve system **76** is operated by electrical fuel switch **54** that controls fuel flow to the engine from liquid fuel source **78** and gaseous fuel source **82**. In an exemplary embodiment of the invention, the dual fuel engine operates on gasoline from liquid fuel source **78** and LPG from gaseous fuel source **82**.

In one embodiment of the invention, the engine has a carburetor **86** coupled to an intake of the engine to mix air and fuel and connect to liquid fuel line **80** and gaseous fuel line **84**. Carburetor **86** has a mixing passage or throat with an inlet for air and an outlet for the air-fuel mixture. Carburetor **86** also has a float bowl **88** that receives liquid fuel through a liquid fuel inlet **90** coupled to liquid fuel line **80**. Carburetor **86** may also have a gaseous fuel inlet **92** in the throat and coupled to gaseous fuel line **84**. Gaseous fuel inlet **92** is preferably located upstream from a venturi in the throat for improved fuel and air mixing. Air is mixed with either of the fuels in the throat to provide the air-fuel mixture for operation of the engine. In another embodiment of the invention, a gaseous fuel mixer couples to the engine intake to mix gaseous fuel and air separately from carburetor **86**.

In an exemplary embodiment of the invention, electro-mechanical valve system **76** includes a carburetor cutoff solenoid **94** coupled to carburetor **86** to control liquid fuel flow to the engine. Carburetor cutoff solenoid **94** operates to open and close a liquid fuel path to the engine downstream from float bowl **88** in carburetor **86**. The liquid fuel path in carburetor **86** provides fuel to the throat from float bowl **88** and will later be described with reference to FIG. **4**. The liquid fuel path may comprise a main fuel circuit within carburetor **86**, and in some cases, also includes an idle fuel circuit within carburetor **86**. Carburetor cutoff solenoid **94** cuts off liquid fuel flow through the liquid fuel path to provide a liquid fuel cutoff solenoid that controls fuel flow from liquid fuel line **80** to the engine.

Electro-mechanical valve system **76** may include a gasoline cutoff solenoid **96**, or generally a liquid fuel cutoff solenoid, coupling liquid fuel source **78** to carburetor **86** and to control flow of the liquid fuel to carburetor **86**. That is, gasoline cutoff solenoid **96** provides a liquid fuel valve coupled along liquid fuel line **80** to open and close liquid fuel source **78** to the engine. Electro-mechanical valve system **76** can operate with either or both the gasoline cutoff solenoid **96** and carburetor cutoff solenoid **94** to control liquid fuel flow to the engine. However, gasoline cutoff solenoid **96** is advantageous to quickly cut-off all liquid fuel flow to carburetor **86**, and particularly, through the idle fuel circuit if carburetor cutoff solenoid **94** is regulating fuel through the main fuel circuit only. While limited fuel flow through the idle fuel circuit may not noticeably affect gaseous fuel operation, gasoline cutoff solenoid **96** prevents drawing gasoline through the idle fuel circuit after carburetor cutoff solenoid **94** closes the main fuel circuit.

Electro-mechanical valve system **76** may include an LPG cutoff solenoid **98**, or generally a gaseous fuel cutoff solenoid, coupling gaseous fuel source **82** to the intake and to control flow of the gaseous fuel to the engine. LPG cutoff solenoid **98** provides a gaseous fuel valve coupled along gaseous fuel line **84** to open and close gaseous fuel source **82** to the engine. LPG cutoff solenoid **98** is preferably located downstream from fuel regulator system **56**, shown in FIG. **2** as dual stage regulator **100**, for a fast response in controlling gaseous fuel delivery to the engine.

Electro-mechanical valve system **76** also includes electrical switch **54** coupling a power source **102** to one or more of carburetor cutoff solenoid **94**, gasoline cutoff solenoid **96** and LPG cutoff solenoid **98** to actuate the solenoids and provide a one-touch fuel selector to switch engine operation between fuels. Power source **102** is shown as a battery in FIG. **2**, but could be from an engine driven power source, such as an alternator **40** (FIG. **1**), a magneto, or any other suitable power supply. Switch **54** selectively powers solenoids **94**, **96**, **98** to engage liquid fuel operation when actuated to a first position and gaseous fuel operation when actuated to a second position. In an exemplary embodiment of the invention, switch **54** engages gasoline operation by closing LPG cutoff solenoid **98**, opening gasoline cutoff solenoid **96**, and operating carburetor cutoff solenoid **94** to open the main fuel circuit in the carburetor, and switch **54** engages LPG operation by closing gasoline cutoff solenoid **96**, operating carburetor cutoff solenoid **94** to close the main fuel circuit, and opening LPG cutoff solenoid **98**.

In an exemplary embodiment of the invention, gasoline cutoff solenoid **96**, LPG cutoff solenoid **98**, and carburetor cutoff solenoid **94** operate as normally closed solenoid valves to ensure excess fuel is not delivered to the engine if power to the solenoids is interrupted. To engage LPG operation, electrical fuel switch **54** provides electrical connection between power source **102** and a first contact **104** to power LPG cutoff solenoid **98** to open gaseous fuel line **84** while gasoline cutoff solenoid **96** and carburetor cutoff solenoid **94** are unpowered to close liquid fuel line **80** and the main fuel circuit in carburetor **86**, respectively. To engage gasoline operation, electrical switch **54** provides electrical connection between power source **102** and a second contact **106** to power gasoline cutoff solenoid **96** and carburetor cutoff solenoid **94** to open liquid fuel line **80** and the main fuel circuit in carburetor **86**, respectively, while LPG cutoff solenoid **98** is unpowered to close gaseous fuel line **84**.

In an alternative embodiment of the invention, gasoline cutoff solenoid **96**, LPG cutoff solenoid **98**, and carburetor cutoff solenoid **94** operate as normally open solenoid valves to ensure fuel is provided to the engine if power to the

solenoids is interrupted. To engage gasoline operation, switch **54** provides electrical connection between power source **102** and first contact **104** to power LPG cutoff solenoid **98** to close gaseous fuel line **84** while gasoline cutoff solenoid **96** and carburetor cutoff solenoid **94** are unpowered to open liquid fuel line **80** and the main fuel circuit in carburetor **86**, respectively. To engage LPG operation, switch **54** provides electrical connection between power source **102** and second contact **106** to power gasoline cutoff solenoid **96** and carburetor cutoff solenoid **94** to close liquid fuel line **80** and the main fuel circuit in carburetor **86**, respectively, while LPG cutoff solenoid **98** is unpowered to open gaseous fuel line **84**.

Electro-mechanical valve system **76** can be configured to switch operation of the generator from multiple fuel sources while the generator is running, also referred to as "on-the-fly" fuel changeover. That is, switch **54** couples power source **102** to LPG cutoff solenoid **98** and one or more of the gasoline cutoff solenoid **96** and carburetor cutoff solenoid **94** to change operation of the engine from liquid fuel to gaseous fuel and from gaseous fuel to liquid fuel while the engine is running. Electro-mechanical valve system **76** provides for precisely timed fuel changeover between the fuel sources to switch engine operation with minimal or no interruption in the performance of the engine, and it can be timed to prevent or substantially prevent fuel overlap between the fuel sources.

To quickly start and stop liquid fuel delivery to the engine, carburetor cutoff solenoid **94** regulates fuel flow through a liquid fuel path downstream of float bowl **88**. Carburetor cutoff solenoid **94** also traps enough gasoline in float bowl **88** to provide quick delivery of gasoline to the engine during changeover from LPG to gasoline to prevent any lag or hesitation in engine performance. During changeover from gasoline to LPG, carburetor cutoff solenoid **94** blocks fuel flow from float bowl **88** to the engine, thereby preventing an over-rich condition. That is, carburetor cutoff solenoid **94** can block gasoline remaining in float bowl **88** after gasoline cutoff solenoid **96** closes liquid fuel line **80** to prevent mixing gasoline with the LPG. Accordingly, carburetor cutoff solenoid **94** responds quickly upon actuation of switch **54** to limit fuel overlap and prevent overly rich fuel conditions that could adversely affect engine performance.

In addition, gasoline cutoff solenoid **96** may be opened to fill float bowl **88** with liquid fuel prior to switching engine operation to liquid fuel. That is, float bowl **88** will empty through the idle fuel circuit if carburetor cutoff solenoid **94** only blocks the main fuel circuit. Gasoline delivery to the engine during changeover is delayed if float bowl **88** must first be filled, and such delay could cause the engine to lose power or stall. Therefore, switch **54** may be configured to actuate gasoline cutoff solenoid **96** prior to actuating carburetor cutoff solenoid **94** to ensure adequate fuel in float bowl **88** for a smooth transition from LPG to gasoline.

In one embodiment of the invention, switch **54** actuates carburetor cutoff solenoid **94** and LPG cutoff solenoid **98** to change engine operation between the liquid fuel and the gaseous fuel so as to prevent fuel flow from liquid fuel source **78** and gaseous fuel source **82** simultaneously. In such an embodiment, electro-mechanical valve system **76** operates as a dual fuel lockout to ensure only one fuel is delivered to the engine. Switch **54** may simultaneously actuate carburetor cutoff solenoid **94** and LPG cutoff solenoid **98** to prevent or substantially prevent simultaneous fuel delivery of the liquid fuel and the gaseous fuel to the engine. In other embodiments, switch **54** actuates any of solenoids **94**, **96**, **98** in succession to prevent or substantially prevent simultaneous fuel delivery of the liquid fuel and the gaseous fuel to the engine. As such, switch **54** can operate the electro-mechanical valve system **76** to prevent an overly rich air-fuel ratio during cross-over switching between fuel sources, even while operating at full load.

In another embodiment of the invention, electro-mechanical valve system **76** provides a slight overlap in fuel delivery to the engine to ensure a smooth transition during changeover. Carburetor cutoff solenoid **94** may close the liquid fuel path in carburetor **86** after LPG cutoff solenoid **98** opens to ensure fuel flow to the engine is not interrupted during changeover from gasoline to LPG. LPG cutoff solenoid **98** may close after carburetor cutoff solenoid **94** opens the liquid fuel path in carburetor **86** to ensure fuel flow to the engine is not interrupted during changeover from LPG to gasoline. Accordingly, switch **54** may actuate LPG cutoff solenoid **98** and carburetor cutoff solenoid **94** in succession to provide fuel overlap when changing engine operation between the liquid fuel and the gaseous fuel. Electro-mechanical valve system **76** can also be configured to provide blended fuel operation, if so desired.

Switch **54** can institute a predefined delay between actuating any of gasoline cutoff solenoid **96**, carburetor cutoff solenoid **94**, and LPG cutoff solenoid **98**. Adjustable rheostats or predefined electronic delay circuits **108**, **110**, **112** can be coupled to the electrical connections of any of solenoids **94**, **96**, **98** to delay their actuation. As such, any of solenoids **96**, **94**, **98** may be configured to operate according to a user adjustable preset delay to actuate one or more of the solenoids in succession. In some embodiments of the invention, electronic delay circuits **108**, **110**, **112** provide simultaneous delivery of fuels to the engine for any fraction of a second or for up to several seconds.

Electro-mechanical valve system **76** can also change engine operation between fuel sources on-the-fly without gasoline cutoff solenoid **96** regulating fuel through liquid fuel line **80**. In such an embodiment, upon actuation of switch **54** from gaseous fuel to liquid fuel, carburetor cutoff solenoid **94** can open a liquid fuel path in the carburetor to engage engine operation on liquid fuel and LPG cutoff solenoid **98** can actuate to stop engine operation on gaseous fuel. Also, upon actuation of switch **54** from liquid fuel to gaseous fuel, LPG cutoff solenoid **98** can open the gaseous fuel line **84** to engage engine operation on gaseous fuel and carburetor cutoff solenoid **94** can actuate to stop engine operation on liquid fuel.

Alternatively, electro-mechanical valve system **76** can change engine operation between fuel sources on-the-fly without carburetor cutoff solenoid **94**. In such an embodiment, gasoline cutoff solenoid **96** can open the liquid fuel line **80** to engage engine operation on liquid fuel upon actuation of switch **54** from gaseous fuel to liquid fuel, and gasoline cutoff solenoid **96** can stop engine operation on liquid fuel upon actuation of switch **54** from liquid fuel to gaseous fuel. Further, gasoline cutoff solenoid **96** and LPG cutoff solenoid **98** can be precisely timed to limit or prevent fuel overlap during changeover without interrupting engine performance. For instance, gasoline cutoff solenoid **96** may be opened prior to closing LPG cutoff solenoid **98** to ensure adequate fuel in float bowl **88** for on-the-fly changeover. Also, gasoline cutoff solenoid **96** may be closed before LPG cutoff solenoid **98** is opened to reduce fuel in float bowl **88** and limit fuel overlap during on-the-fly changeover. Accordingly, switch **54** may be precisely timed to operate gasoline cutoff solenoid **96** and LPG cutoff solenoid **98** to prevent, or substantially prevent, simultaneous fuel delivery of the liquid fuel and the gaseous fuel to the engine.

Referring now to FIG. **3**, a schematic diagram of a fuel system to operate the generator in a tri-fuel arrangement is shown, in accordance with an embodiment of the invention. The fuel system includes an electro-mechanical valve system **114** coupled to a multi-fuel internal combustion engine configured to operate on a liquid fuel supplied from a liquid fuel source **78** and first and second gaseous fuels supplied from a respective first gaseous fuel source **116** and second gaseous fuel source **118**. Electro-mechanical valve system **114** is operated by a tri-fuel electrical switch **120** that controls fuel flow to the engine from liquid fuel source **78** and gaseous fuel sources **116**, **118**. In an exemplary embodiment of the invention, the multi-fuel engine operates on gasoline from liquid fuel source **78**, liquid petroleum gas (LPG) from first gaseous fuel source **116**, and natural gas (NG) from second gaseous fuel source **118**.

Electro-mechanical valve system **114** may include gasoline cutoff solenoid **96** to open and close a liquid fuel path through liquid fuel line **80** to carburetor **86**, a carburetor cutoff solenoid **94** to control liquid fuel flow through the carburetor, and LPG cutoff solenoid **98** to open and close a gaseous fuel path for the first gaseous fuel through LPG line **122** to the engine. Electro-mechanical valve system **114** may also include an NG cutoff solenoid **124**, or generally a gaseous fuel cutoff solenoid, to couple the engine intake to second gaseous fuel source **118** and to control flow of the second gaseous fuel to the engine. NG cutoff solenoid **124** provides a gaseous fuel valve coupled along an NG line **126** to open and close second gaseous fuel source **118** to the engine. That is, NG cutoff solenoid **124** operates to open and close a gaseous fuel path for the second gaseous fuel through NG line **126** to the engine.

In an exemplary embodiment of the invention, a gaseous fuel line **128** provides NG and LPG to the engine by coupling to carburetor **86** and to both gaseous fuel sources **116**, **118**. A jet block **80** may be used to couple gaseous fuel line **128** to LPG line **122** and NG line **126**. In one embodiment of the invention, jet block **80** is a 2-way branched fitting coupling first gaseous fuel source **116** and second gaseous fuel source **118** to carburetor **86** and located downstream from LPG cutoff solenoid **98** and NG cutoff solenoid **124**. Jet block **80** may also comprise a first gaseous fuel jet **82** sized for the first gaseous fuel coupled to the first gaseous fuel source **116**, and a second gaseous fuel jet **84** sized for the second gaseous fuel coupled to the second gaseous fuel source **118**. The gaseous fuel jets **82**, **84** comprise gaseous fuel main jets sized to meter the respective fuels as desired for a particular engine, or based on desired performance for each fuel in a given application. Jet block **80** has an outlet port **86** coupled to gaseous fuel line **128** to provide fuel from first gaseous fuel jet **82** and second gaseous fuel jet **84** to the engine.

Jet block **80** may be used to modify a dual fuel internal combustion engine into a tri-fuel engine by coupling a second gaseous fuel source to the engine intake. Jet block **80** can incorporate more than two gaseous fuel jets to couple additional gaseous fuel lines to carburetor **86**. Each fuel line has a gaseous fuel valve to open and close the line. A fuel switch is wired appropriately to operate the additional solenoids. As such, jet block **80** allows a dual fuel engine to operate as a tri-fuel engine, quad-fuel engine or to operate with additional fuel sources.

Electro-mechanical valve system **114** includes a tri-fuel switch **120** coupling power source **102** to any of gasoline cutoff solenoid **96**, LPG cutoff solenoid **98**, NG cutoff solenoid **124**, and carburetor cutoff solenoid **94** to selectively operate the solenoids and engage gasoline operation when actuated to a first position, engage LPG operation when actuated to a second position, and engage NG operation when actuated to a third position. When tri-fuel switch **120** engages engine operation on one of the fuels, it may also stop delivery of the remaining fuels to the engine. As such, solenoids **94**, **96**, **98**, **124** engage engine operation on their respective fuel source upon selection of the tri-fuel switch **120** to the respective fuel source, and the solenoids **94**, **96**, **98**, **124** stop engine operation on their respective fuel source upon selection of the switch to another fuel source.

Electro-mechanical valve system **114** can be configured to switch operation of the generator from any single fuel to any other single fuel from first gaseous fuel source **116**, second gaseous fuel source **118**, and liquid fuel source **78** on-the-fly while the engine is running. For instance, tri-fuel switch **120** can actuate any combination of the carburetor cutoff solenoid **94**, LPG cutoff solenoid **98**, NG cutoff solenoid **124** and gasoline cutoff solenoid **96** to change operation of the engine among the liquid fuel, the first gaseous fuel, and the second gaseous fuel while the engine remains running. Electro-mechanical valve system **114** provides for precisely timed fuel changeover to switch engine operation among fuel sources with minimal or no interruption in the performance of the engine, and it can be timed to prevent or substantially prevent fuel overlap between the fuel sources.

To change between gaseous fuel and liquid fuel, tri-fuel switch **120** may operate NG cutoff solenoid **124** for NG and LPG cutoff solenoid **98** for LPG corresponding to the description of switch **54** operating LPG cutoff solenoid **98** with respect to FIG. **2**. Referring back to FIG. **3**, to switch between first gaseous fuel source **116** and second gaseous fuel source **118**, tri-fuel switch **120** may simultaneously actuate LPG cutoff solenoid **98** and NG cutoff solenoid **124** to prevent or substantially prevent simultaneous fuel delivery of first gaseous fuel source **116** and second gaseous fuel source **118** to the engine. As such, electro-mechanical valve system **114** can operate as a tri-fuel lockout to ensure only one fuel is delivered to the engine. In other embodiments, tri-fuel switch **120** actuates the NG cutoff solenoid **124** and LPG cutoff solenoid **98** in succession to ensure appropriately timed on-the-fly fuel changeover between the two gaseous fuels. Adjustable rheostats or predefined electronic delay circuits **108**, **110**, **112**, **88**, may be coupled to the electrical connections of any of solenoids **94**, **96**, **98**, **124**, to delay their actuation.

In one embodiment of the invention, solenoids **98**, **124**, **94**, **96** operate as normally closed solenoid valves to ensure excess fuel is not provided to the engine if power to the solenoids is interrupted. To engage LPG operation, tri-fuel switch **120** provides electrical connection between power source **102** and first contact **104** to power LPG cutoff solenoid **98** to open LPG line **122** while gasoline cutoff solenoid **96**, carburetor cutoff solenoid **94**, and NG cutoff solenoid **124** are unpowered to close liquid fuel line **80**, the main fuel circuit in carburetor **86**, and NG line **126**, respectively. To engage gasoline operation, tri-fuel switch **120** provides electrical connection between power source **102** and second contact **106** to power gasoline cutoff solenoid **96** and carburetor cutoff solenoid **94** to open liquid fuel line **80** and the main fuel circuit in carburetor **86** while LPG cutoff solenoid **98** and NG cutoff solenoid **124** are unpowered to close LPG line **122** and NG line **126**, respectively. To engage NG operation, tri-fuel switch **120** provides electrical connection between power source **102** and a third contact **140** to power NG cutoff solenoid **124** to open NG line **126** while gasoline cutoff solenoid **96**, carburetor cutoff solenoid **94**

and LPG cutoff solenoid **98** are unpowered to close liquid fuel line **80**, the main fuel circuit in carburetor **86**, and LPG line **122**, respectively.

In an alternative embodiment of the invention, solenoids **98**, **124**, **94**, **96** operate as normally open solenoid valves to ensure fuel is provided to the engine if power to the solenoids is interrupted. To engage LPG operation, tri-fuel switch **120** provides electrical connection between power source **102** and both second contact **106** and third contact **140** to power gasoline cutoff solenoid **96**, carburetor cutoff solenoid **94**, and NG cutoff solenoid **124** to close liquid fuel line **80**, main fuel circuit in carburetor **86**, and NG line **126**, respectively, while LPG cutoff solenoid **98** is unpowered to open LPG line **122**. To engage gasoline operation, tri-fuel switch **120** provides electrical connection between power source **102** and both first contact **104** and third contact **140** to power LPG cutoff solenoid **98** and NG cutoff solenoid **124** to close LPG line **122** and NG line **126** while gasoline cutoff solenoid **96** and carburetor cutoff solenoid **94** are unpowered to open liquid fuel line **80** and the main fuel circuit in carburetor **86**, respectively. To engage NG operation, tri-fuel switch **120** provides electrical connection between power source **102** and both first contact **104** and second contact **106** to power gasoline cutoff solenoid **96**, carburetor cutoff solenoid **94**, and LPG cutoff solenoid **98** to close liquid fuel line **80**, main fuel circuit in carburetor **86**, and LPG line **122**, respectively, while NG cutoff solenoid **124** is unpowered to open NG line **126**.

Referring now to FIG. **4**, a cross-sectional view of carburetor **86** taken transverse to a barrel or throat **142** of the carburetor is shown, in accordance with an embodiment of the invention. Fuel and air are mixed in throat **142** to provide an air-fuel mixture for the multi-fuel internal combustion engine. A butterfly valve **144** is located in throat **142** to provide a choke and throttle **146** for the engine. Carburetor **86** has a float bowl **88** to hold liquid fuel with a float valve **148** to control the fuel level in the bowl. Carburetor **86** has a liquid fuel path **150** from float bowl **88** to throat **142**. Liquid fuel path **150** is shown in FIG. **4** referring to main fuel circuit **152** in carburetor **86**, but may also include other fuel circuits in the carburetor. Main fuel circuit **152** provides a flow path from float bowl **88** to a nozzle **154** in a venturi **156** upstream from throttle **146**. An idle fuel circuit **158** provides a flow path to the throat **142** downstream of throttle **146** to run the engine at idle.

In one embodiment of the invention, carburetor **86** has a carburetor cutoff solenoid **94** coupled to carburetor **86** to regulate liquid fuel flow to the engine. Carburetor cutoff solenoid **94** actuates to open and close liquid fuel path **150** to the engine downstream from float bowl **88**. Carburetor cutoff solenoid **94** has an actuating member **160** that moves to selectively block fuel flow through liquid fuel path **150**, comprising main fuel circuit **152**, and may be positioned to selectively block fuel flow into the inlet of main fuel circuit **152**. Gasoline cutoff solenoid **96** (FIG. **2**) closes off the liquid fuel line to carburetor **86** and fuel flowing through idle fuel circuit **158** stops when float bowl **88** empties. In another embodiment of the invention, carburetor cutoff solenoid **94** is configured to control fuel flow through both main fuel circuit **152** and idle fuel circuit **158**. For instance, idle fuel circuit **158** may branch off from main fuel circuit **152** with carburetor cutoff solenoid **94** actuating to block fuel flow into both circuits.

Referring now to FIG. **5**, a cross-sectional view of carburetor **86** is shown taken lengthwise to throat **142**, in accordance with an embodiment of the invention. Carburetor **86** is attached to the engine at engine intake **162** to supply a metered mixture of air and fuel and connect a liquid fuel source to the intake. Throat **142** includes venturi **156** and throttle **146** located downstream from venturi **156**. A float bowl **88** and a float **166** control and maintain the fuel level in the bowl from an inlet valve **164**. Main fuel circuit **152** provides a flow path from float bowl **88** to nozzle **154** in a narrow portion of venturi **156**. Idle fuel circuit **158** provides a flow path from float bowl **88** to throat **142** downstream of throttle **146**. Transition fuel circuit **168** provides a flow path to throat **142** upstream from throttle **146** and branches off from idle fuel circuit **158**. Transition fuel circuit **168** is opened to vacuum conditions as the throttle **146** moves slightly from a closed position to provide additional fuel as the engine transitions from idle.

Carburetor cutoff solenoid **94** couples to float bowl **88** to selectively control liquid fuel flow through main fuel circuit **152**. Carburetor cutoff solenoid **94** includes actuating member **160** capable of blocking fuel flow through main fuel circuit **152** when actuated. FIG. **5** shows actuating member **160** in an extended or blocking position, while FIG. **4** shows actuating member **160** in a retracted or open position. Carburetor cutoff solenoid **94** actuates to quickly start and stop liquid fuel flow from float bowl **88** to the engine through main fuel circuit **152** to provide precisely timed engine changeover between liquid and gaseous fuel sources.

Beneficially, embodiments of the invention thus provide for a multi-fuel internal combustion engine capable of switching between liquid fuel and gaseous fuel sources while the engine is running. Embodiments of the invention also provide for a multi-fuel internal combustion engine having a fuel system to prevent an overly rich air-fuel ratio during cross-over switching between fuel sources. Embodiments of the invention also provide for a multi-fuel generator with a remotely mounted gaseous fuel pressure regulator system.

Therefore, according to one embodiment of the invention, a multi-fuel engine includes an engine operable on a liquid fuel, a first gaseous fuel from a first gaseous fuel source, and a second gaseous fuel from a second gaseous fuel source. The multi-fuel engine also includes a liquid cutoff solenoid coupled to open and close a liquid fuel path to the engine, a first gaseous cutoff solenoid coupled to open and close the first gaseous fuel source to the engine, a second gaseous cutoff solenoid coupling the engine to the second gaseous fuel source to control flow of the second gaseous fuel to the engine, and a switch coupling a power source to the liquid cutoff solenoid and the first gaseous cutoff solenoid to switch between fuel sources on-the-fly during engine operation.

According to another embodiment of the invention, a multi-fuel engine includes an engine operable on a liquid fuel, a first gaseous fuel from a first gaseous fuel source, and a second gaseous fuel from a second gaseous fuel source. The multi-fuel engine also includes a liquid cutoff solenoid selectively operable between open and closed positions to allow and inhibit a flow of the liquid fuel to the engine, at least one gaseous cutoff valve selectively operable between open and closed positions to allow and inhibit a flow of the first gaseous fuel and the second gaseous fuel to the engine. and a jet block coupling the first gaseous fuel source and the second gaseous fuel source to a carburetor connected to an intake of the engine, wherein the jet block is located downstream from the at least one gaseous cutoff valve. The jet block further includes a first gaseous fuel jet configured to meter the first gaseous fuel to the carburetor and a second gaseous fuel jet configured to meter the second gaseous fuel to the carburetor.

This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

What is claimed is:

1. A multi-fuel engine comprising:

an engine operable on a liquid fuel and a gaseous fuel;

a carburetor attached to an intake of the engine to mix air and fuel and connect a liquid fuel source to the intake, the carburetor comprising a float bowl;

a liquid cutoff solenoid coupled to open and close a liquid fuel path to the engine;

a gaseous cutoff solenoid coupled to open and close a gaseous fuel source to the engine;

a switch selectively coupling a power source to the liquid cutoff solenoid and the gaseous cutoff solenoid to open and close the liquid fuel path and the gaseous fuel path; and

one or more timing circuits electrically coupled to the liquid cutoff solenoid and the gaseous cutoff solenoid that operate to control an actuation time of the liquid cutoff solenoid and the gaseous cutoff solenoid.

2. The multi-fuel engine of claim **1** wherein the one or more timing circuits comprise one or more delay circuits configured to institute a predefined delay before actuating the liquid cutoff solenoid and the gaseous fuel cutoff solenoid.

3. The multi-fuel engine of claim **1** wherein the one or more timing circuits comprise one or more rheostats configured to institute a delay before actuating the liquid cutoff solenoid and the gaseous fuel cutoff solenoid.

4. The multi-fuel engine of claim **1** wherein the one or more timing circuits provide a user adjustable preset delay before actuating the liquid cutoff solenoid and the gaseous cutoff solenoid.

5. The multi-fuel engine of claim **1** wherein the one or more timing circuits control the actuation time of the liquid cutoff solenoid and the gaseous cutoff solenoid to provide simultaneous delivery of fuels to the engine for any fraction of a second or for up to several seconds.

6. The multi-fuel engine of claim **1** wherein the switch and the one or more timing circuits control actuation of the liquid cutoff solenoid and the gaseous cutoff solenoid to enable changing engine operation between the liquid fuel and the gaseous fuel, so as to prevent fuel flow from the liquid fuel source and the gaseous fuel source simultaneously and allow switching between fuel sources on-the-fly during engine operation.

7. The multi-fuel engine of claim **1** wherein the liquid cutoff solenoid comprises a first liquid cutoff solenoid coupled to the carburetor to control flow of liquid fuel within the carburetor, and wherein the multi-fuel engine further comprises a second liquid cutoff solenoid positioned on a liquid fuel line coupling the liquid fuel source to the carburetor to open and close the liquid fuel source to the engine.

8. The multi-fuel engine of claim **7** wherein one of the one or more timing circuits is electrically coupled to the second liquid cutoff solenoid to control an actuation time of the second liquid cutoff solenoid, such that the actuation time of the second liquid cutoff solenoid is controlled along with the actuation time of the first liquid cutoff solenoid and the gaseous cutoff solenoid.

9. The multi-fuel engine of claim **1** wherein the engine is a dual fuel engine that operates on gasoline from the liquid fuel source and LPG from the gaseous fuel source.

10. The multi-fuel engine of claim **1** wherein the carburetor connects the gaseous fuel source to the intake.

11. The multi-fuel engine of claim **1** further comprising:

an alternator driven by the engine to form a generator; and

a fuel regulator system located off-board the generator and comprising:

a primary pressure regulator coupled to a service valve of the pressurized fuel source to regulate the fuel supplied from the pressurized fuel source to a reduced pressure, and

a secondary pressure regulator coupled to the primary pressure regulator to regulate the gaseous fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the engine.

12. A multi-fuel generator and fuel delivery system comprising:

a multi-fuel internal combustion engine configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line;

an alternator driven by the multi-fuel internal combustion engine; and

a fuel regulator system comprising:

a primary pressure regulator coupled to a service valve of the pressurized fuel source to regulate fuel supplied from the pressurized fuel source to a reduced pressure, and

a secondary pressure regulator coupled to the primary pressure regulator to regulate fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the engine.

13. The multi-fuel generator and fuel delivery system of claim **12** an electro-mechanical valve system coupled to the engine and operated by an electrical switch powered by one of the alternator, a battery, and a magneto that controls fuel flow to the engine from the liquid fuel source and the pressurized fuel source.

14. The multi-fuel generator and fuel delivery system of claim **13** wherein the electro-mechanical valve system is configured to switch operation of the generator from multiple fuel sources while the generator is running.

15. The multi-fuel generator and fuel delivery system of claim **13** wherein the electro-mechanical valve system is configured to prevent simultaneous delivery of the liquid fuel and the gaseous fuel to the engine.

16. The multi-fuel generator and fuel delivery system of claim **12** wherein the pressurized fuel source comprises a pressurized fuel container located off-board the generator having a regulator mounting device to secure at least the secondary pressure regulator thereto.

17. The multi-fuel generator and fuel delivery system of claim **12** wherein a dual stage pressure regulator comprises the primary pressure regulator and the secondary pressure regulator.

18. A carburetor for use in a multi-fuel internal combustion engine, the carburetor comprising:

a throat in which fuel and air are mixed in throat to provide an air-fuel mixture for the multi-fuel internal combustion engine;

a valve located in the throat to provide a choke and throttle for the multi-fuel internal combustion engine;

a float bowl to hold liquid fuel;

a main fuel circuit positioned downstream from the float bowl and extending from the float bowl to the throat;

an idle fuel circuit that provides a flow path to the throat downstream of the throttle to run the engine at idle; and

a carburetor cutoff solenoid configured to selectively control fuel flow through the main fuel circuit and the idle fuel circuit.

19. The carburetor of claim **18** wherein the carburetor cutoff solenoid is operatively coupled to a switch that changes operation of the engine from liquid fuel to gaseous fuel and from gaseous fuel to liquid fuel while the engine is running, and wherein the carburetor cutoff solenoid is closed to stop liquid fuel flow through the main fuel circuit and the idle fuel circuit when the switch changes operation of the engine from liquid fuel to gaseous fuel.

* * * * *

EXHIBIT E

US011143145B2

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

(10) **Patent No.: US 11,143,145 B2**
(45) **Date of Patent: Oct. 12, 2021**

(54) **BATTERYLESS DUAL FUEL ENGINE WITH LIQUID FUEL CUT-OFF**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/946,438**

(22) Filed: **Jun. 22, 2020**

(65) **Prior Publication Data**

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(51) **Int. Cl.**
F02M 43/00 (2006.01)
F02D 19/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***F02M 17/38*** (2013.01); ***F02B 43/00*** (2013.01); ***F02B 63/04*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC F02M 13/08; F02M 57/06; F02M 43/00; F02M 19/06; F02M 7/10; F02M 21/0215;
(Continued)

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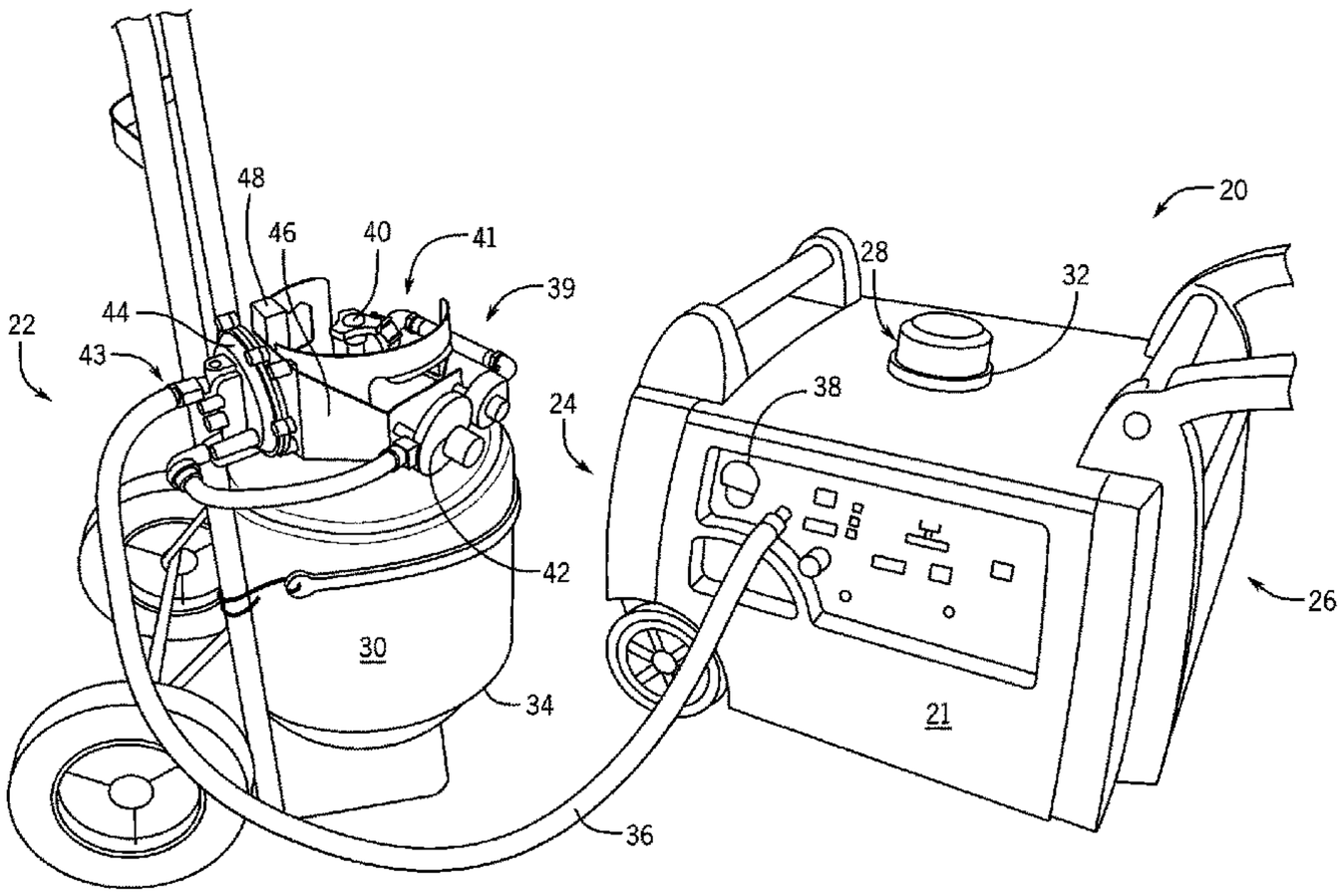
Primary Examiner — Long T Tran
(74) *Attorney, Agent, or Firm* — Ziolkowski Patent Solutions Group, SC

(57) **ABSTRACT**

A dual fuel engine includes an engine operable on a gaseous fuel and a liquid fuel and a switch to change operation of the engine between gaseous fuel and liquid fuel. The dual fuel engine also includes a carburetor attached to an intake of the engine to mix air and fuel and connect to a gaseous fuel source and a liquid fuel source. A liquid fuel cut-off attaches to the carburetor to interrupt liquid fuel upon actuation of the switch from liquid fuel to gaseous fuel.

19 Claims, 12 Drawing Sheets



Related U.S. Application Data

continuation-in-part of application No. 14/738,060, filed on Jun. 12, 2015, now Pat. No. 10,221,781.

(51) **Int. Cl.**

F02D 41/00	(2006.01)
F02M 17/38	(2006.01)
F02M 13/08	(2006.01)
F02D 19/06	(2006.01)
F02B 43/00	(2006.01)
F02M 17/10	(2006.01)
F02M 21/02	(2006.01)
F02B 63/04	(2006.01)
F02D 41/06	(2006.01)
F02M 21/04	(2006.01)
F02M 19/08	(2006.01)
F02N 3/02	(2006.01)

(52) **U.S. Cl.**

CPC ***F02D 19/0613*** (2013.01); ***F02M 13/08*** (2013.01); ***F02M 17/10*** (2013.01); ***F02M 21/0212*** (2013.01); ***F02M 43/00*** (2013.01); *F02D 41/0025* (2013.01); *F02D 41/062* (2013.01); *F02M 19/08* (2013.01); *F02M 21/047* (2013.01); *F02N 3/02* (2013.01); *Y02T 10/30* (2013.01)

(58) **Field of Classification Search**

CPC F02M 35/10196; F02D 19/0647; F02D 19/0613; F02D 29/06; F02D 41/0025

See application file for complete search history.

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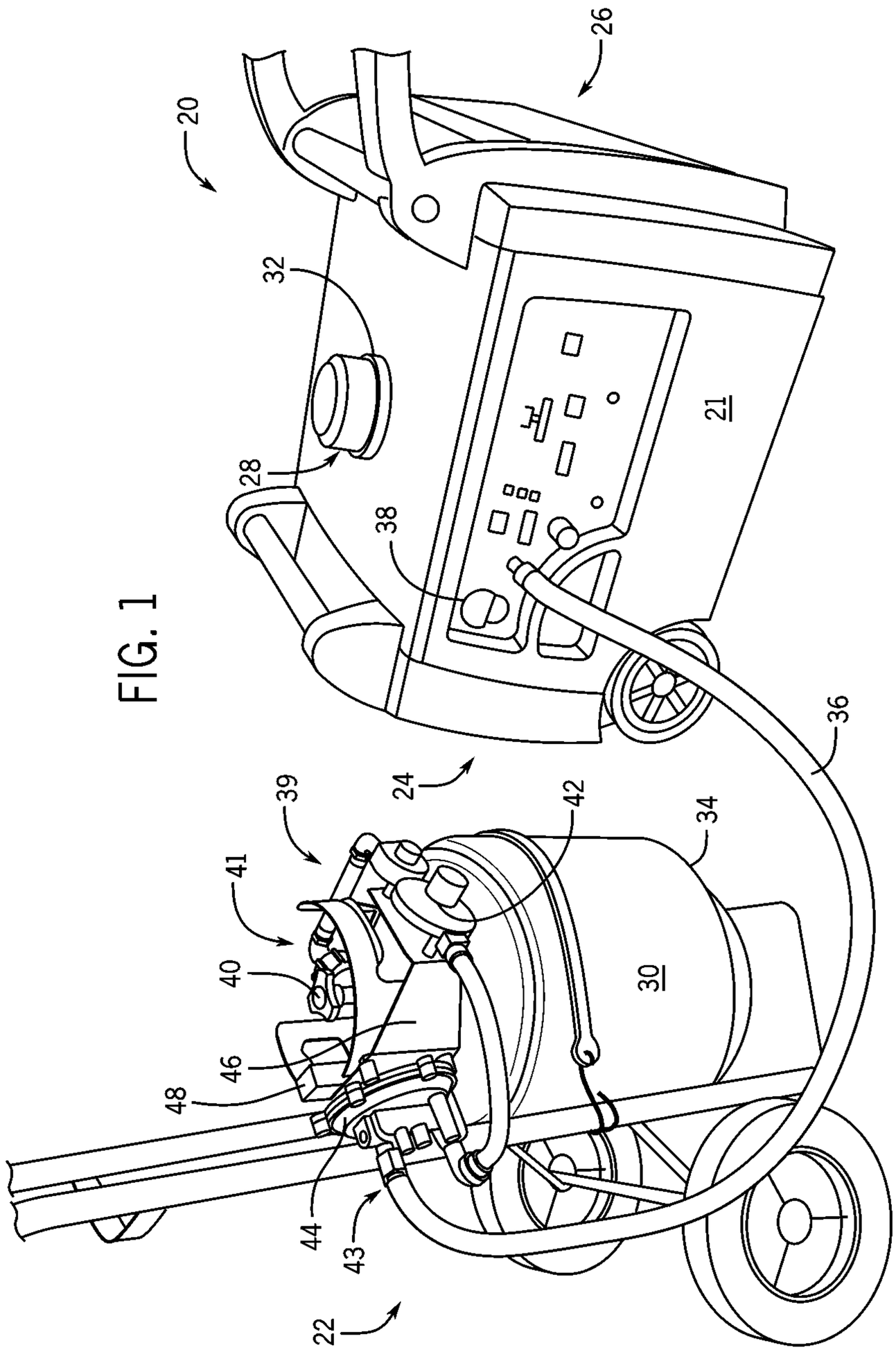
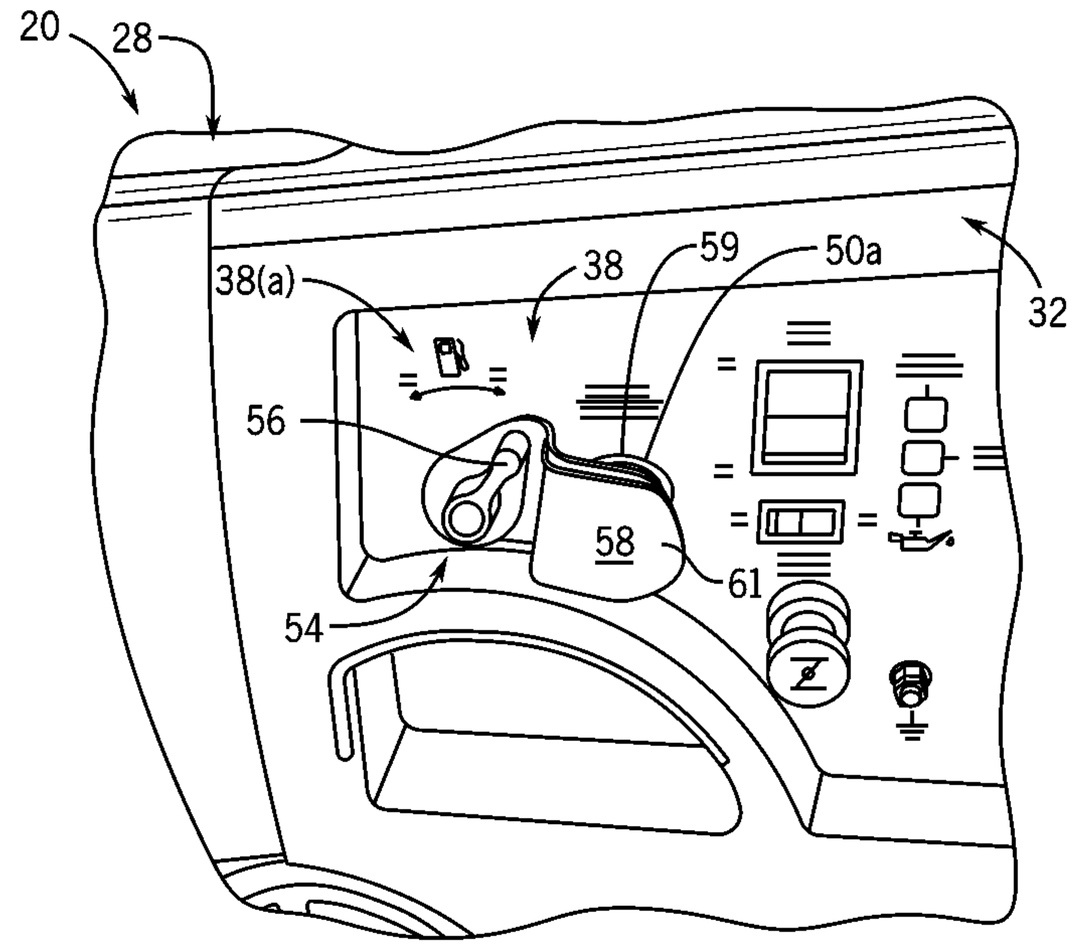
FIG. 1

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28
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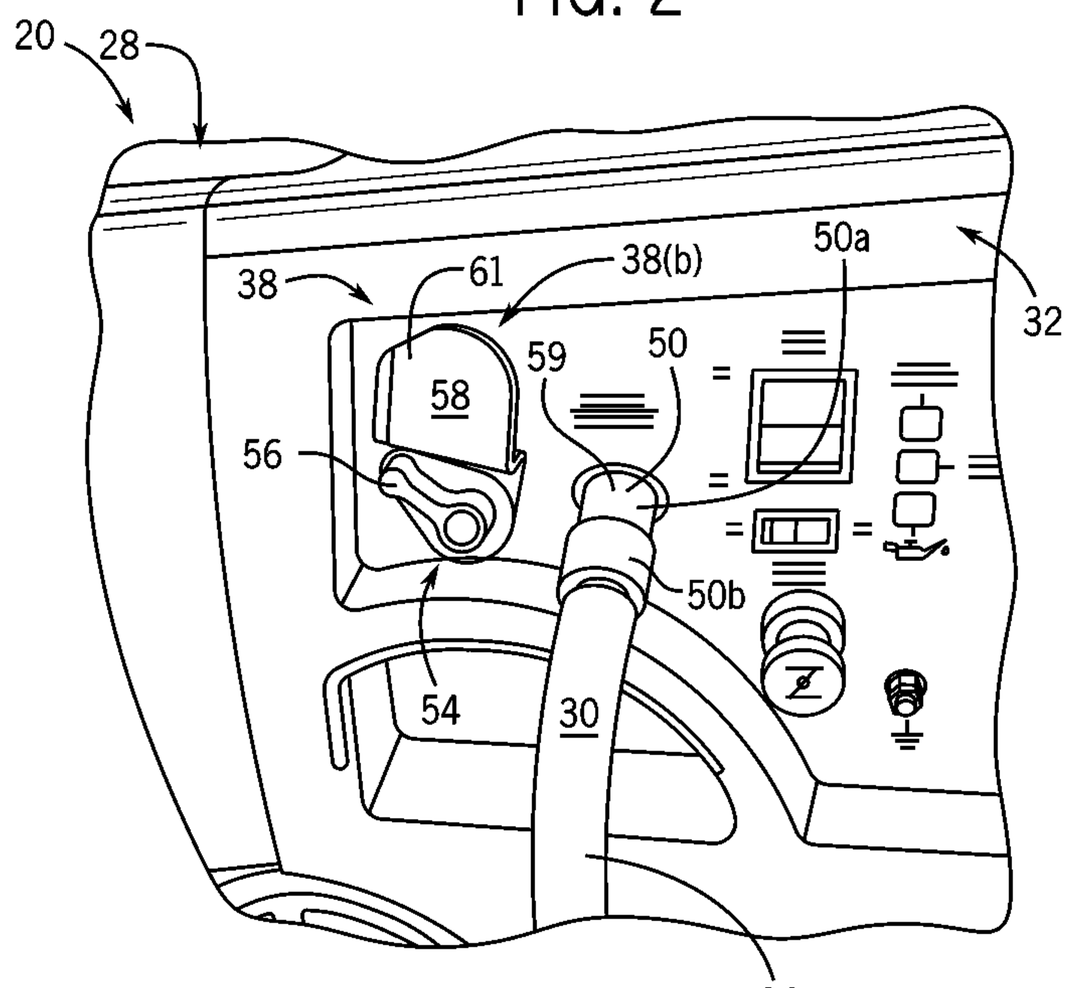
38
59
50a
32
56
58
61
54

FIG. 2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38(b)
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50
58
56
50b
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30
36

FIG. 3

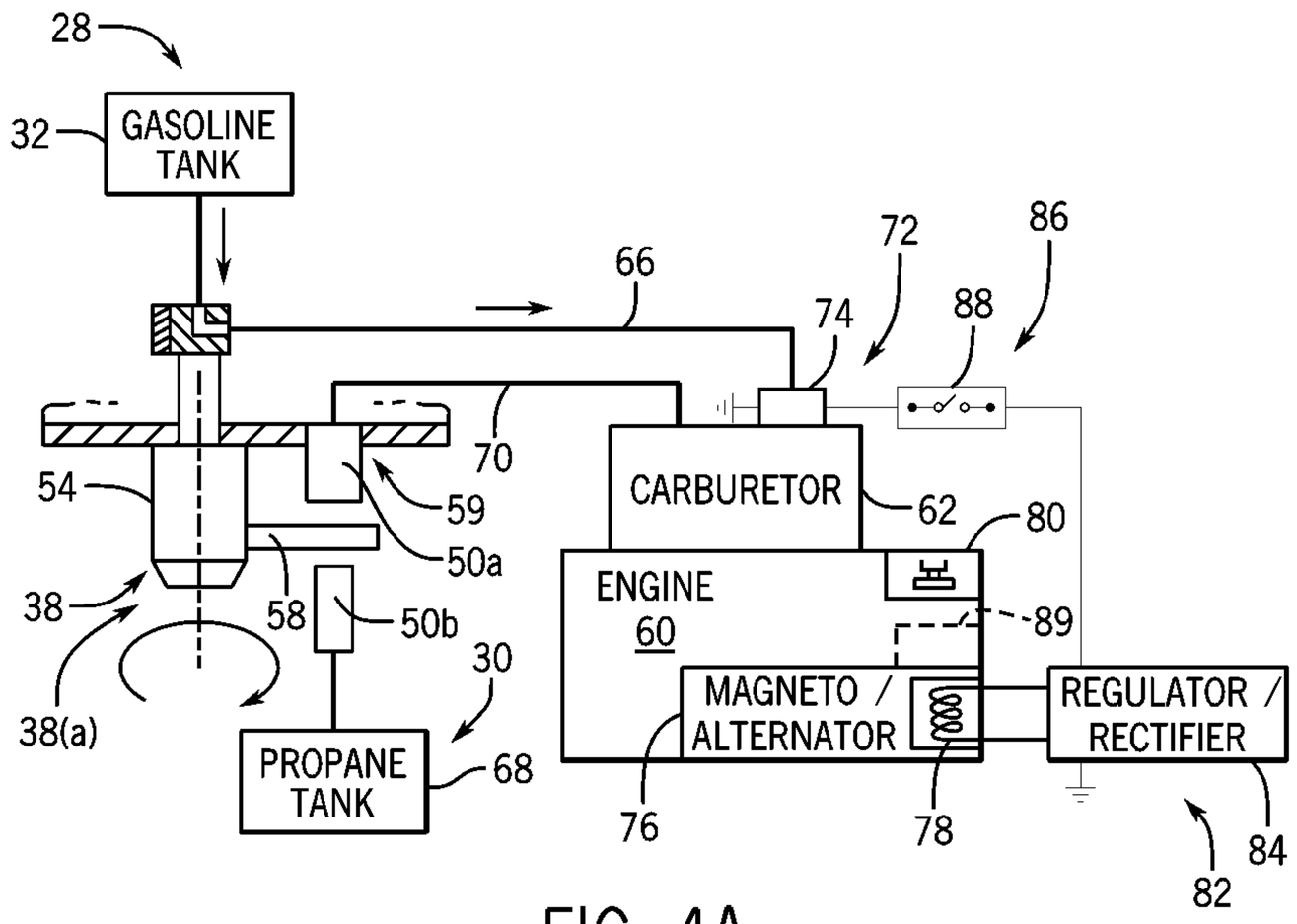


FIG. 4A

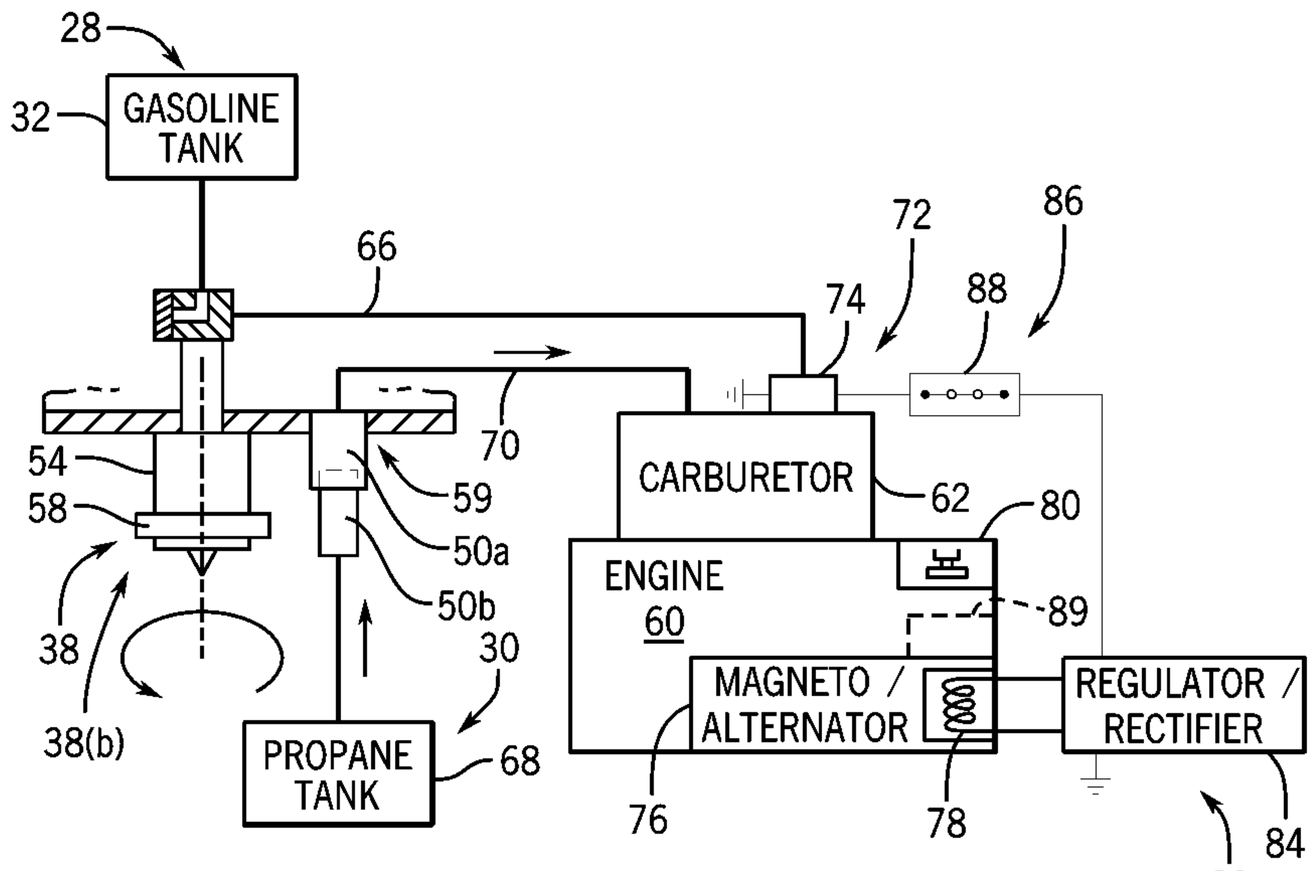
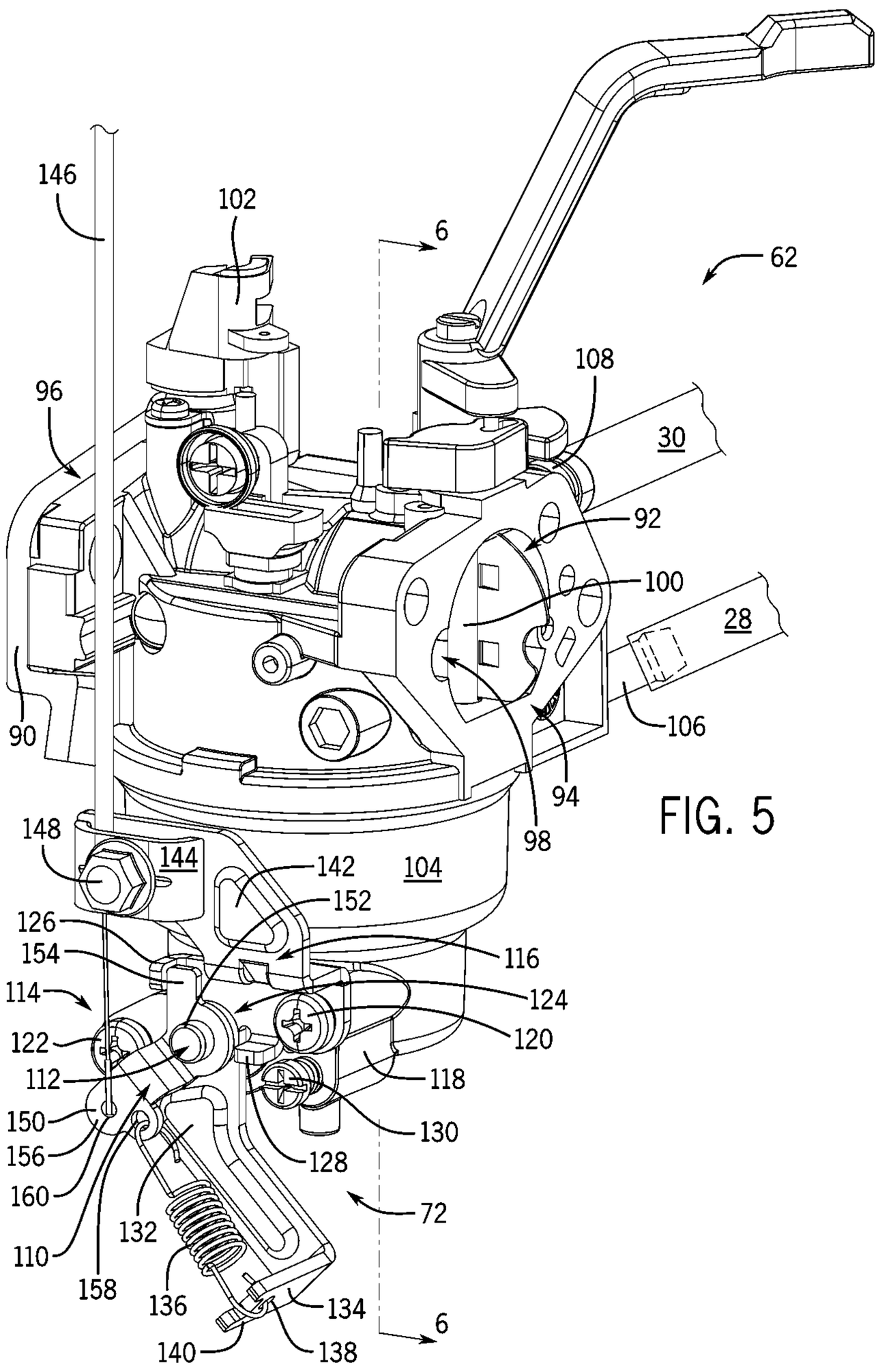


FIG. 4B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116
114
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130
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72
160
132
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158
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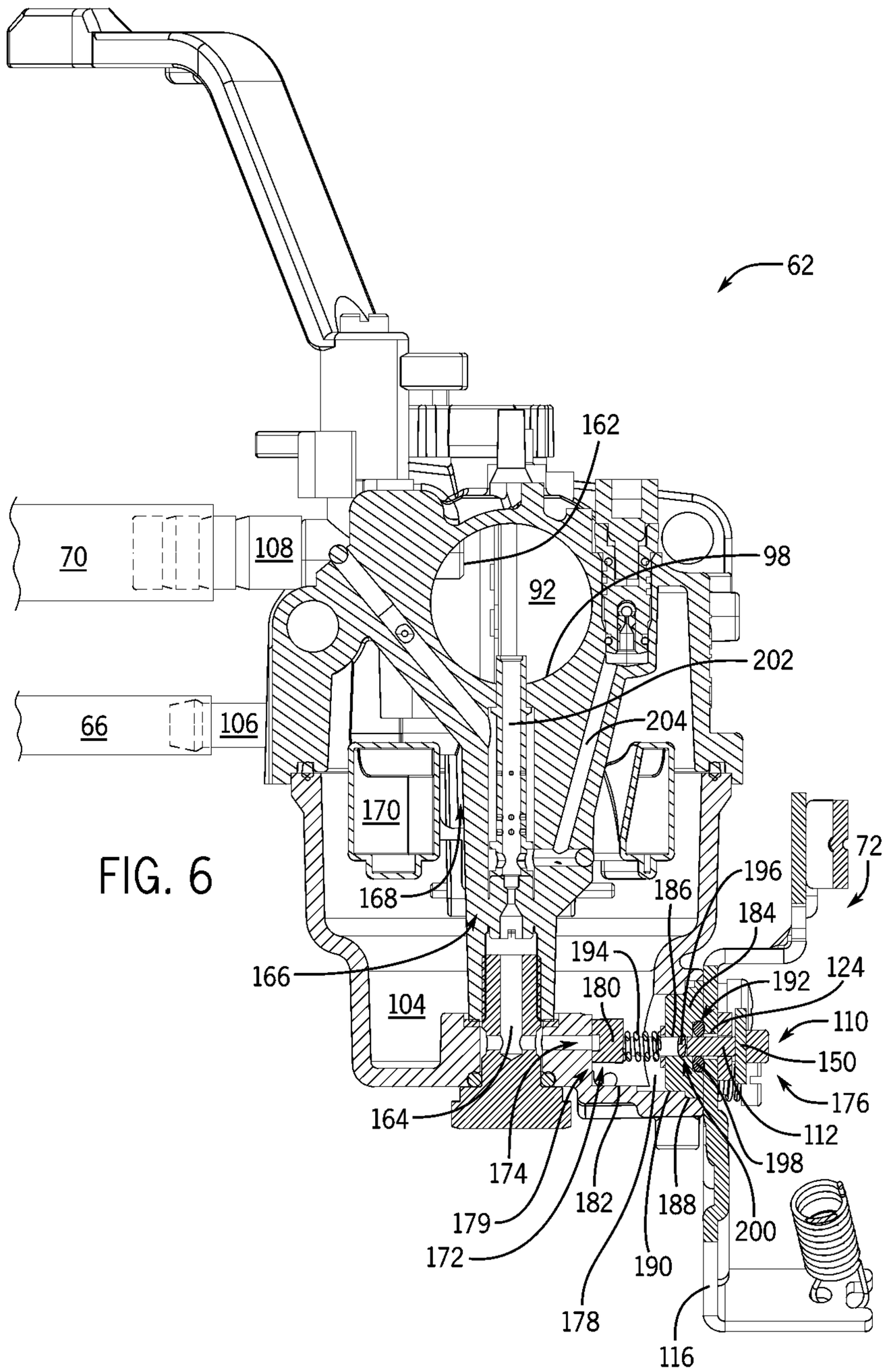
6
140
138

FIG. 5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179
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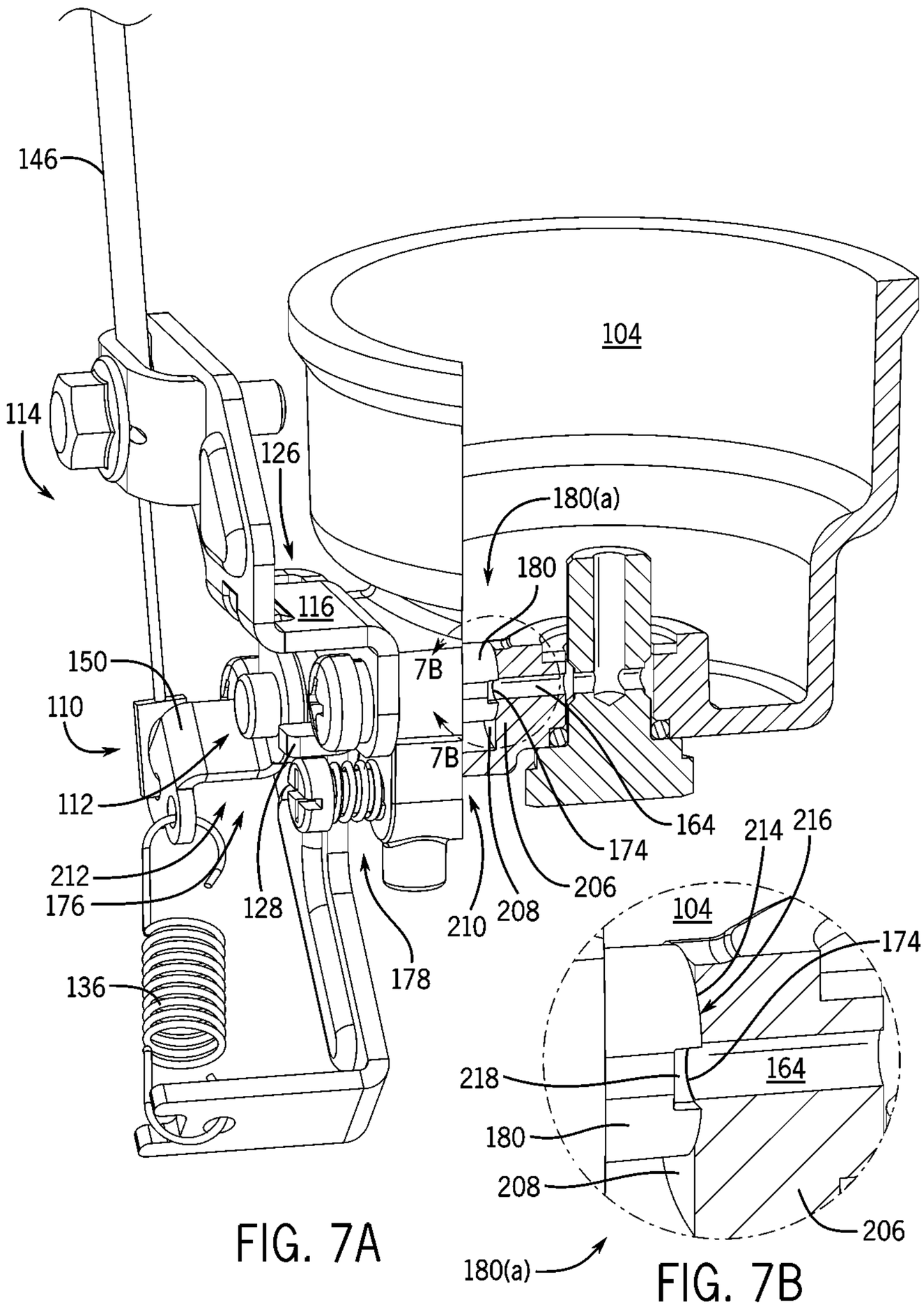
172
190
178
116

FIG. 6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104
114
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180(a)
180
116
150
7B
110
7B
112
164
174
214
216
212
176
206
128
210
208
104
174
178
136
218
164
180
208
206
180(a)

FIG. 7A

FIG. 7B

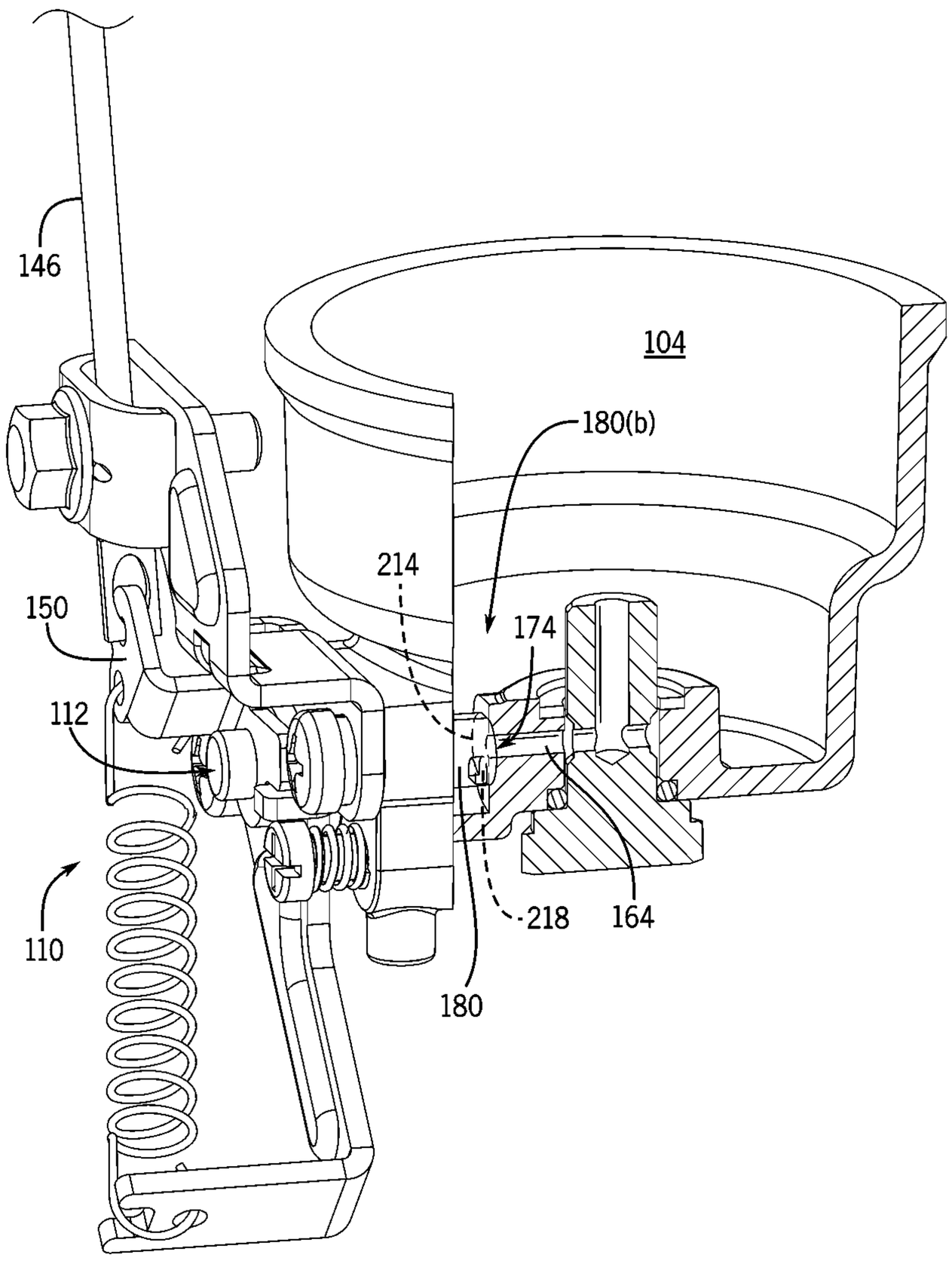


FIG. 8

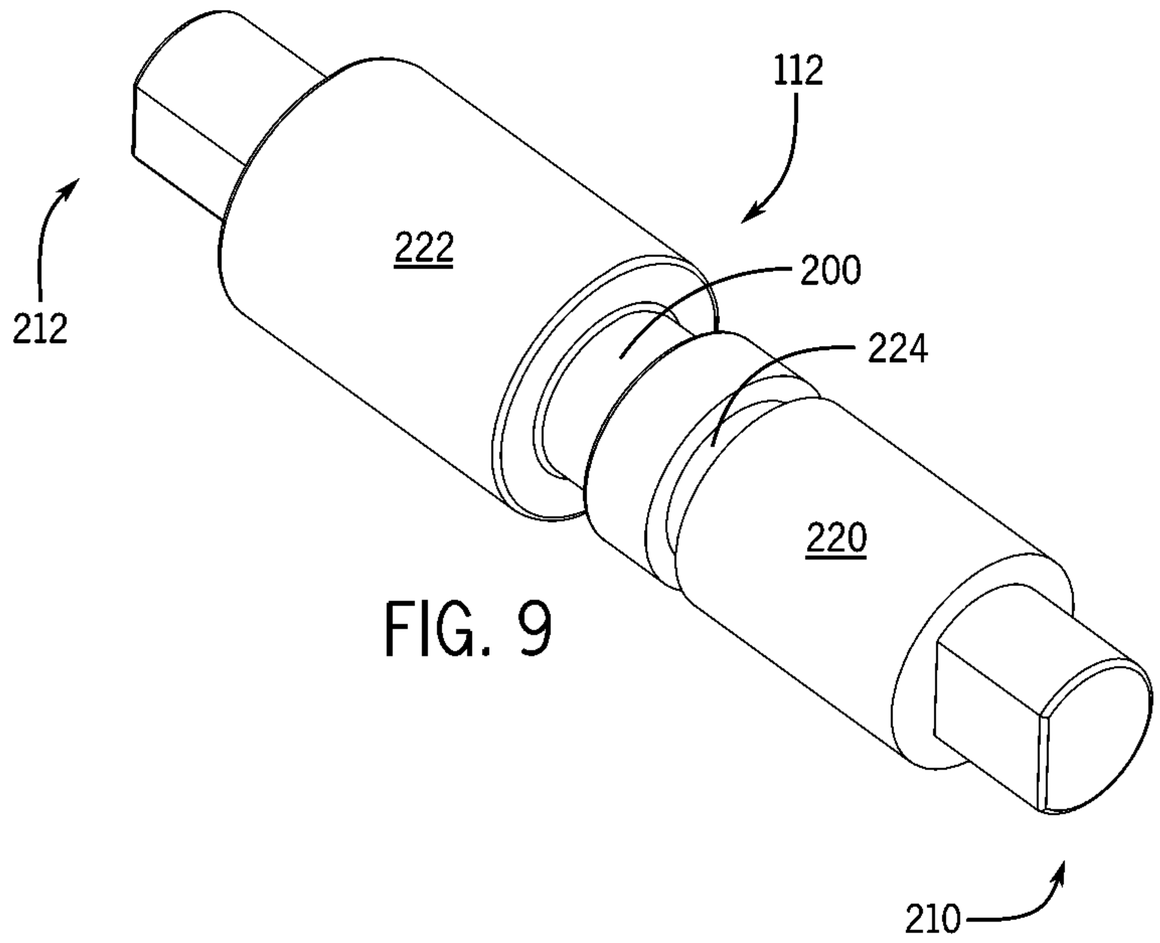


FIG. 9

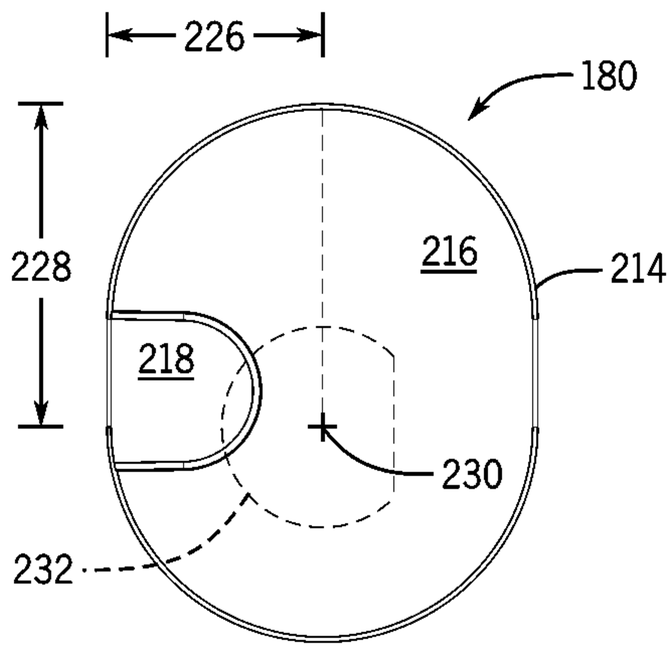
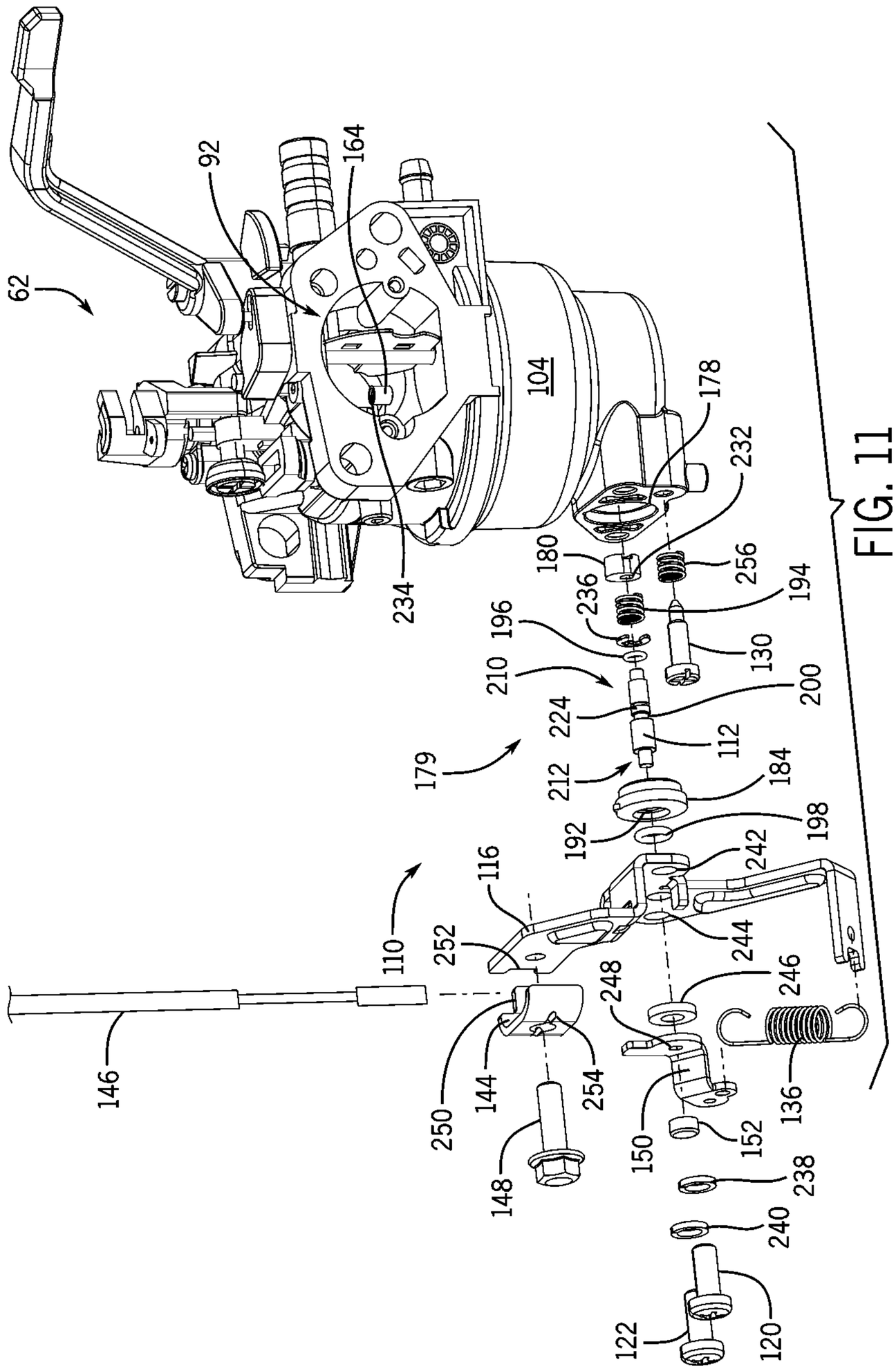


FIG. 10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198
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120

FIG. 11

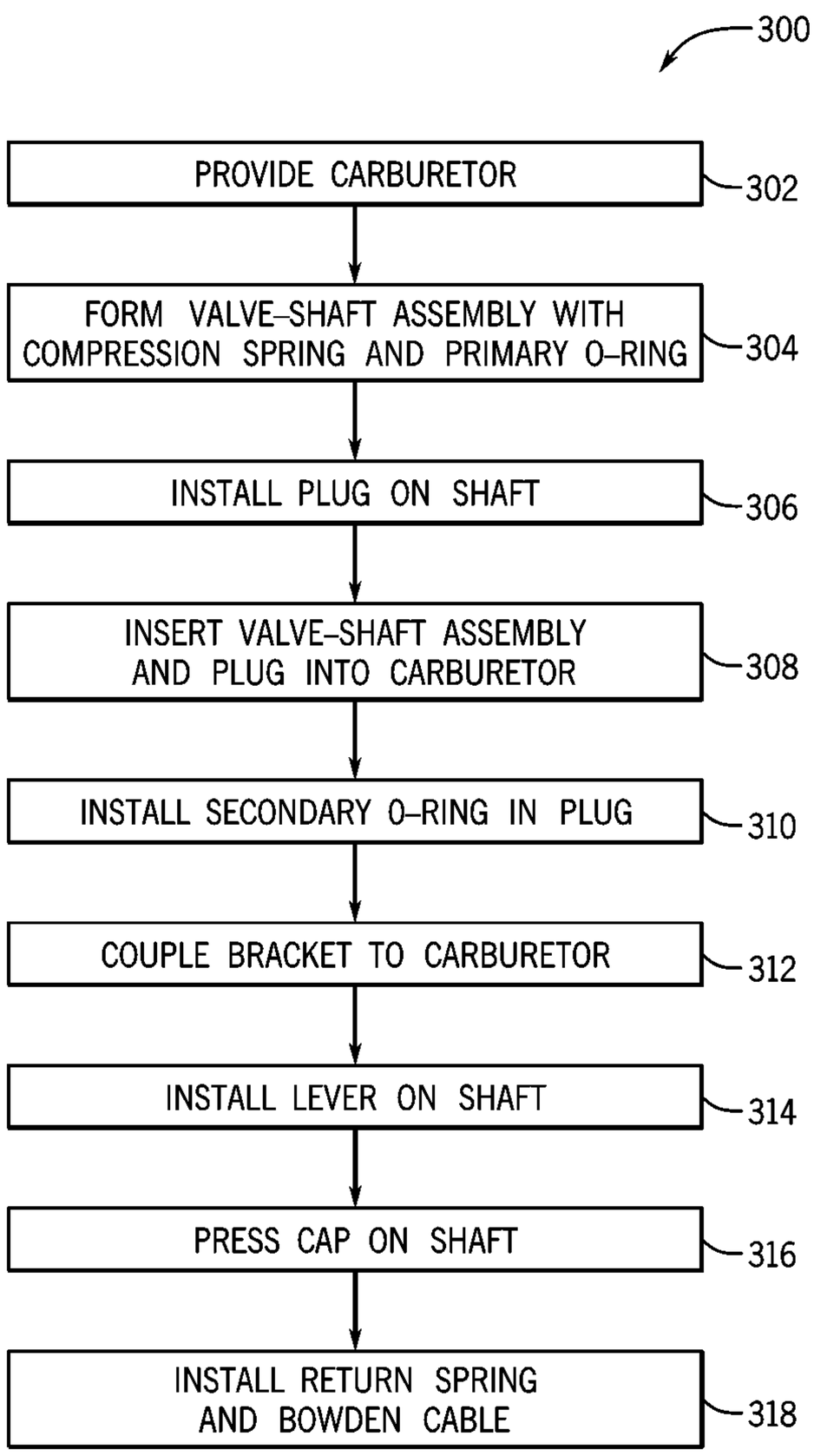
300
PROVIDE CARBURETOR
302
FORM VALVE-SHAFT ASSEMBLY WITH COMPRESSION SPRING AND PRIMARY O-RING
304
INSTALL PLUG ON SHAFT
306
INSERT VALVE-SHAFT ASSEMBLY AND PLUG INTO CARBURETOR
308
INSTALL SECONDARY O-RING IN PLUG
310
COUPLE BRACKET TO CARBURETOR
312
INSTALL LEVER ON SHAFT
314
PRESS CAP ON SHAFT
316
INSTALL RETURN SPRING AND BOWDEN CABLE
318

FIG. 12

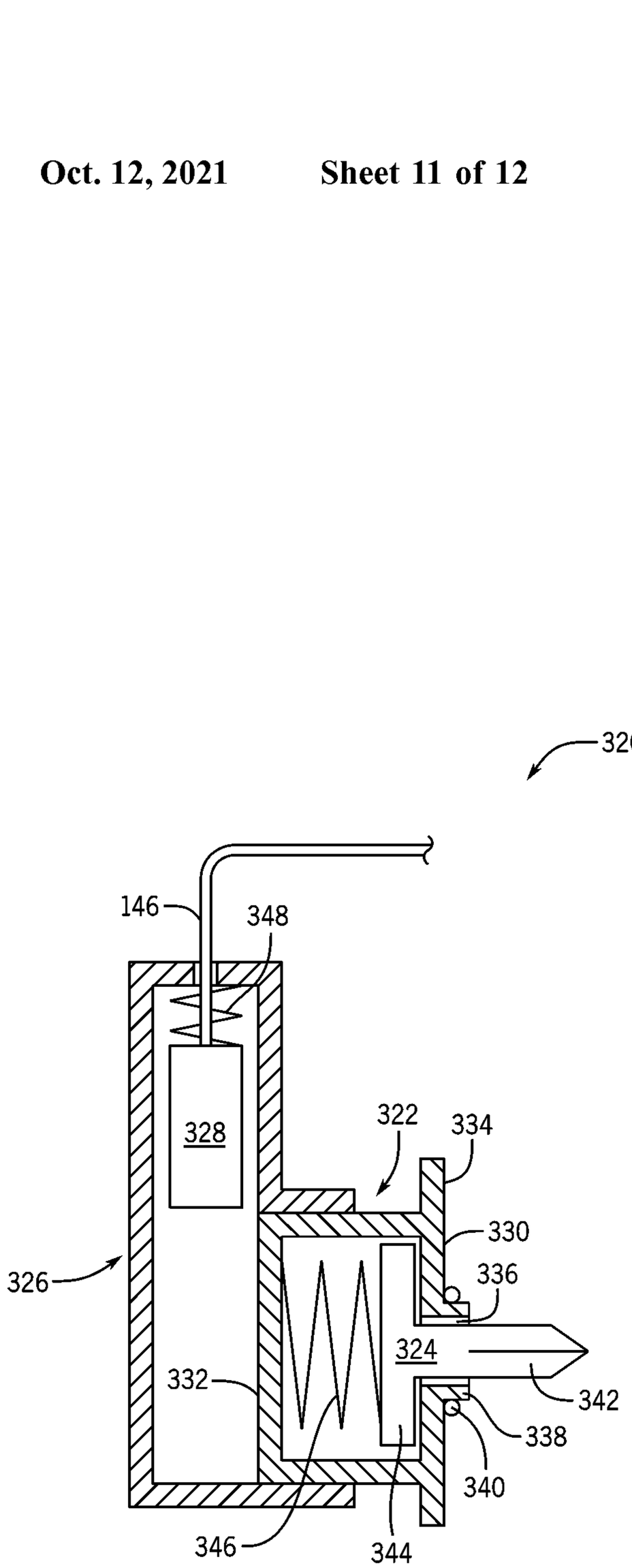

FIG. 13

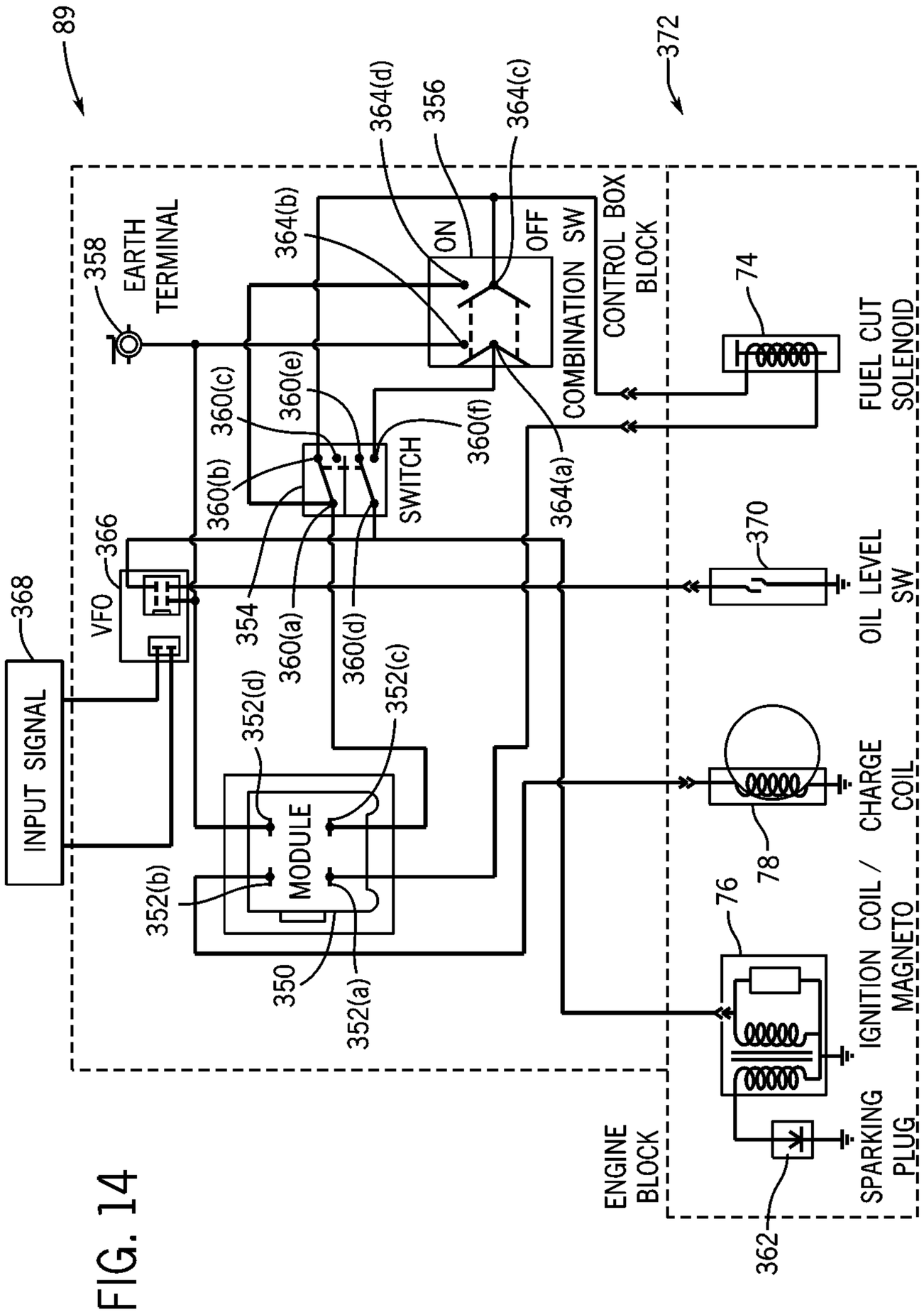
89
372
364(d)
356
364(c)
358
EARTH TERMINAL
364(b)
ON
OFF
COMBINATION SW
CONTROL BOX BLOCK
74
FUEL CUT SOLENOID
360(c)
360(e)
360(f)
360(b)
SWITCH
364(a)
366
VFO
370
OIL LEVEL SW
368
INPUT SIGNAL
354
360(a)
360(d)
352(d)
352(c)
MODULE
352(b)
78
CHARGE COIL
76
IGNITION COIL / MAGNETO
350
352(a)
SPARKING PLUG
ENGINE BLOCK
362

FIG. 14

BATTERYLESS DUAL FUEL ENGINE WITH LIQUID FUEL CUT-OFF

CROSS-REFERENCE TO RELATED APPLICATION

The present application is a continuation of, and claims priority to U.S. patent application Ser. No. 14/925,441, filed Oct. 28, 2015, which is a continuation-in-part of, and claims priority to, U.S. patent application Ser. No. 14/738,060, filed Jun. 12, 2015, now Issued U.S. Pat. No. 10,221,780, issued Mar. 5, 2019, the disclosures of which are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

Embodiments of the invention relate generally to dual fuel generators, and more particularly, to an apparatus and method for delivering liquid fuel or gaseous fuel to a dual fuel generator.

Electric generators are frequently driven by internal combustion engines that use gasoline as a fuel source. Gasoline is a common fuel source for generators in a variety of applications. However, alternative fuel sources also provide a desirable fuel source. For instance, alternative fuels may provide a clean burning fuel that limits hazardous emissions. Alternative fuels may also be stored for long periods of time without degradation, whereas gasoline can degrade over a period of months leading to hard starting, rough running, and also lead to gum and varnish deposit left in the fuel system. In addition, generators that operate on alternative fuels may generate electricity when gasoline is not readily available. For instance, generators are frequently used when power outages in the utility grid result from severe weather. Unfortunately, gas stations may also be closed as a result of the power outage. Such a circumstance presents just one example where it would be advantageous to operate electrical generators on alternative fuels.

Certain generators are configured to operate as "dual fuel" generators, otherwise known as bi-fuel generators. These generators are driven by an internal combustion engine that is configured to operate on a liquid fuel for a period of operation and an alternative fuel for another period of operation. The alternative fuel source is generally a gaseous fuel that may exist in a gaseous state at normal temperature and pressure and can be any one of liquefied petroleum gas, compressed natural gas, hydrogen, or the like. Liquefied petroleum gas (LPG), often referred to as propane, exists in a gaseous state at normal temperature and pressure but can be conveniently stored under pressure in a liquid state. LPG may be a desirable fuel source for internal combustion engines because it can be stored for longer periods of time and contains fewer impurities than gasoline, resulting in smoother and cleaner operation, and often resulting in a longer lasting engine.

In order to provide the liquid and gaseous fuel to the engine, the dual fuel engine may have a first fuel line for liquid fuel and a second fuel line for gaseous fuel. A liquid fuel source and a gaseous fuel source may be coupled to the respective lines to provide fuel to the engine. However, a common problem with such configurations that couple two fuel sources to a single engine is the engine can experience overly rich air-fuel ratio when both fuels are simultaneously engaged during cross-over switching between the fuel sources. Such simultaneous delivery of fuel from the first fuel line and the second fuel line may make the engine hard to start or lead to unstable operating conditions. Further, a

float bowl in the carburetor that must first fill or empty prior to changeover causes delay in cross-over switching between the fuel sources.

Therefore, it would be desirable to design a dual fuel generator having a liquid fuel and gaseous fuel delivery system that overcomes the aforementioned detriments without substantially increasing the overall cost of the system.

BRIEF DESCRIPTION OF THE INVENTION

In accordance with one aspect of the invention, a dual fuel engine includes an engine operable on a gaseous fuel and a liquid fuel. A carburetor attaches to an intake of the engine to mix air and fuel and connect to a gaseous fuel source and a liquid fuel source. The dual fuel engine also includes a switch to change operation of the engine between gaseous fuel and liquid fuel, and a liquid fuel cut-off attaches to the carburetor to interrupt liquid fuel upon actuation of the switch from liquid fuel to gaseous fuel.

In accordance with another aspect of the invention, a batteryless dual fuel generator includes a housing containing a pull start engine coupled to drive an alternator. The engine is operable on a gaseous fuel and a liquid fuel and includes a carburetor attached to an intake of the engine. The carburetor has a throat to mix fuel with air, a float bowl, and a fuel passage to provide liquid fuel from the float bowl to the throat. The generator may also include a switch to select engine operation on either the liquid fuel or the gaseous fuel and a fuel shutoff attached to the carburetor to close the fuel passage upon selection of engine operation to gaseous fuel.

In accordance with yet another aspect of the invention, a carburetor having a fuel shutoff includes a carburetor with a float bowl, a throat, and a fuel passage to provide fuel from the float bowl to the throat. A fuel shutoff couples to the carburetor which may have a first end in the carburetor that actuates to close the fuel passage and a second end external to the carburetor to actuate the first end. The fuel shutoff may operate within the carburetor such that the fuel shutoff actuates free from linear motion when opening and closing the fuel passage.

In accordance with yet another aspect of the invention, a method of assembling a dual fuel engine includes providing an engine operable on a gaseous fuel and a liquid fuel and attaching a carburetor to an intake of the engine to supply the fuels to the engine. The carburetor includes a throat to mix gaseous fuel with air and liquid fuel with air, a float bowl, and a fuel passage to provide liquid fuel from the float bowl to the throat. The fuels may be supplied to the carburetor by a gaseous fuel source coupled to the throat and a liquid fuel source coupled to the float bowl. The method also includes coupling a switch to the engine to change operation of the engine between gaseous fuel and liquid fuel, and attaching a liquid fuel cut-off to the carburetor to close the fuel passage upon actuation of the switch from liquid fuel to gaseous fuel.

Various other features and advantages will be made apparent from the following detailed description and the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings illustrate preferred embodiments presently contemplated for carrying out the invention.

In the drawings:

FIG. **1** is a perspective view of a dual fuel generator coupled to a fuel delivery system, according to an embodiment of the invention.

FIG. **2** is a detail view of a portion of the generator of FIG. **1** about a mechanical fuel lockout switch with the switch in a first position, according to an embodiment of the invention.

FIG. **3** is a detail view similar to FIG. **2** and showing the mechanical fuel lockout switch in a second position, with an LPG supply line connected thereto, according to an embodiment of the invention.

FIG. **4**A is a schematic diagram of a fuel system for the dual fuel generator of FIG. **1** showing a liquid fuel source in communication with a carburetor of the generator consistent with the first position of the switch as shown in FIG. **2**, according to an electro-mechanical embodiment of the invention.

FIG. **4**B is a schematic diagram of the fuel system of FIG. **4**A showing a gaseous fuel source in communication with a carburetor of the generator of FIG. **1** consistent with the second position of the switch as shown in FIG. **3**, according to an electro-mechanical embodiment of the invention.

FIG. **5** is a perspective view of a dual fuel carburetor having a manual fuel shutoff system and coupled to a first fuel line and a second fuel line, according to a mechanical embodiment of the invention.

FIG. **6** is cross-sectional view of the carburetor of FIG. **5** taken along line **6**-**6** of FIG. **5** through a fuel passage that provides fuel from a float bowl to a throat of the carburetor, according to an embodiment of the invention.

FIG. **7**A is a partial sectional view of the float bowl of FIG. **6** with a manual fuel shutoff system in an open position, according to an embodiment of the invention.

FIG. **7**B is a detailed partial sectional view of the float bowl with a manual fuel shutoff of FIG. **7**A taken along line **7**B-**7**B of FIG. **7**A, according to an embodiment of the invention.

FIG. **8** is a partial sectional view similar to FIG. **7**A and showing the manual fuel shutoff system in a closed position, according to an embodiment of the invention.

FIG. **9** is a perspective view of a shaft for the manual fuel shutoff system of FIG. **5**, according to an embodiment of the invention.

FIG. **10** is a side view of a valve member for the manual fuel shutoff system of FIG. **5**, according to an embodiment of the invention.

FIG. **11** is a perspective view of the carburetor of FIG. **5** with the manual fuel shutoff system exploded from a float bowl of the carburetor.

FIG. **12** is a flow chart showing steps in fabricating a manual fuel shutoff system for a carburetor, according to an embodiment of the invention.

FIG. **13** is a magnetic fuel shutoff system for a carburetor, according to a magnetic-mechanical embodiment of the invention.

FIG. **14** is a wiring diagram of a microcontroller receiving input signals and operating engine components, according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The operating environment of the invention is described with respect to a dual fuel generator. However, it will be appreciated by those skilled in the art that the invention is equally applicable for use with any dual fuel internal combustion engine. Moreover, the invention will be described with respect to a dual fuel generator configured to operate on a liquid fuel and a gaseous fuel. However, one skilled in the art will further appreciate that the invention is equally applicable for use with other fuel combinations for dual fuel generators and internal combustion engines.

Referring to FIG. **1**, a dual fuel generator **20** is coupled to a fuel delivery system **22**, in accordance with an embodiment of the invention. Dual fuel generator **20** includes an internal combustion engine (not shown) within housing **21** at one end **24**, operatively connected to an alternator also enclosed in housing **21** at another end **26**, by conventional means. Dual fuel generator **20** is configured to operate on different fuels via either a first fuel source **28** or a second fuel source **30**. In an exemplary embodiment of the invention, first fuel source **28** is a liquid fuel and second fuel source **30** is a gaseous fuel. The liquid fuel may be gasoline and the gaseous fuel may be liquid petroleum gas (LPG). Each can selectively operate the generator as desired and controlled by an operator. For instance, generator **20** may operate on gasoline for a first period of operation and then switch to LPG for a second period of operation. However, it is contemplated that dual fuel generator **20** is configured to operate on fuels other than gasoline and LPG (e.g., natural gas, biodiesel, etc.), and thus the scope of the invention is not meant to be limited strictly to a dual fuel arrangement where first fuel source **28** provides gasoline and second fuel source **30** provides LPG.

In one embodiment of the invention, dual fuel generator **20** includes a gasoline tank **32** or, generally, a liquid fuel tank, located inside cover **21** onboard generator **20** to provide gasoline to the engine as first fuel source **28**. Gasoline tank **32** connects to a first fuel line to provide gasoline to the carburetor to run the engine, as will later be described with reference to FIGS. **4**A and **4**B. Generator **20** is also coupled to a pressurized fuel container **34**, or a pressurized fuel source, located off board generator **20** to provide LPG to the engine as second fuel source **30**. Pressurized fuel container **34** is coupled to generator **20** with an LPG supply hose **36**. LPG supply hose **36** is coupled to a second fuel line within generator **20** to provide LPG to the carburetor to run the engine. Dual fuel generator **20** includes a mechanical fuel lockout switch **38** for selecting a desired fuel to be provided to the engine. The mechanical fuel lockout switch **38** is actuated to select first fuel source **28** when in a first position, as shown in FIG. **2**, and alternately to select second fuel source **30** when in a second position, as shown in FIG. **3**.

Referring back to FIG. **1**, in an exemplary embodiment, fuel **30** from pressurized fuel container **34** is regulated using a fuel regulator system **39** for delivery to the engine. Fuel regulator system **39** includes one or more pressure regulators that reduce and control the pressure of the fuel from pressurized fuel container **34** and delivers fuel at a desired pressure for operation of the engine. Fuel regulator system **39** has an inlet **41** operatively coupled to a service valve **40** of pressurized fuel container **34** and an outlet **43** coupled to LPG supply hose **36**. Fuel regulator system **39** includes a primary pressure regulator **42** coupled to pressurized fuel container **34** and a secondary pressure regulator **44**. Primary pressure regulator **42** protects downstream components from high pressure of pressurized fuel container **34**. Primary pressure regulator **42** receives LPG through service valve **40** of pressurized fuel container **34** and reduces the pressure of the LPG to a first stage. In one embodiment of the invention, the first stage may be delivered directly to generator **20** at a pressure required for operation of the engine.

In an exemplary embodiment of the invention, fuel regulator system **39** includes secondary pressure regulator **44** coupled to the outlet of primary pressure regulator **42** in order to use standard "off-the-shelf" components. Typically,

the primary pressure regulator is mounted on the LPG tank, while the secondary pressure regulator is mounted on the component using the fuel, such as an engine or grill. Here, since generator **20** can be used as a gasoline only generator, secondary pressure regulator **44** is mounted off-board the generator to reduce size and cost of the generator. Secondary pressure regulator **44** receives LPG from primary pressure regulator **42** and further reduces the pressure of LPG to a second stage to be delivered to generator **20**. In a system with two regulators, primary pressure regulator **42** regulates fuel received from pressurized fuel container **34** and reduces the pressure of the fuel to a level required for operation of secondary pressure regulator **44**. Secondary pressure regulator **44** regulates fuel received from primary pressure regulator **42** and further reduces the pressure of the fuel to a level required for operation of generator **20**. In addition, primary pressure regulator **42** may compensate for varying tank pressure as fuel is depleted while secondary pressure regulator **44** may compensate for varying demand from generator **20**.

In accordance with an exemplary embodiment of the invention, fuel regulator system **39** includes both the primary and secondary regulators, or a custom single regulator, but in any case is located remotely, or off-board, from dual fuel generator **20**. Fuel regulator system **39** may be directly mounted to pressurized fuel container **34** using a regulator mounting bracket **46**. Regulator mounting bracket **46** has mounting locations for primary pressure regulator **42** and secondary pressure regulator **44**. Regulator mounting bracket **46** also has a securing mechanism **48** to secure regulator mounting bracket **46** to pressurized fuel container **34**.

In another embodiment of the invention, primary pressure regulator **42** is mounted on regulator mounting bracket **46** while secondary pressure regulator **44** could be mounted on or near generator **20**. In yet another embodiment of the invention, a dual stage regulator may regulate the fuel received from pressurized fuel container **34** and deliver fuel at a pressure required for operation of generator **20**. Such a dual stage regulator may regulate the fuel to the second stage within a single structure. The dual stage regulator may be mounted directly on fuel container **34**.

Referring to FIG. **2**, a detail view of a portion of generator **20** of FIG. **1** depicts mechanical fuel lockout switch **38** in a first position **38**(*a*), in accordance with an embodiment of the invention. In this position, mechanical fuel lockout switch **38** provides gasoline flow from gasoline tank **32** to the engine while preventing connection of an LPG supply line to fuel inlet **59** of the second fuel line, as will later be discussed in detail with reference to FIGS. **4**A and **4**B. Still referring to FIG. **2**, mechanical fuel lockout switch **38** provides a combination liquid fuel shutoff valve and a gaseous fuel supply lockout that prevents simultaneous delivery of fuel to the engine from gasoline tank **32** and pressurized fuel container **34**, FIG. **1**. As such, mechanical fuel lockout switch **38** provides a fuel selector to ensure only the selected fuel is provided to dual fuel generator **20**.

Mechanical fuel lockout switch **38**, FIG. **2**, includes mechanical fuel valve **54** actuateable between first position **38**(*a*) as shown in FIG. **2** and second position **38**(*b*) as shown in FIG. **3** to selectively control fuel flow to the dual fuel engine from first fuel source **28** through a first fuel line and second fuel source **30** through a second fuel line **36**. Mechanical fuel lockout switch **38** may also include fuel lockout apparatus **58** coupled to mechanical fuel valve **54** to communicate fuel sources individually to generator **20**. In one embodiment of the invention, fuel lockout apparatus **58** communicates first fuel source **28** to the engine by actuating mechanical fuel valve **54** to first position **38**(*a*) to open the first fuel line as shown in FIG. **2**, and communicates second fuel source **30** to the engine by actuating mechanical fuel valve **54** to second position **38**(*b*) to open communication of the second fuel source **30** to the engine as shown in FIG. **3**. Referring back to FIG. **2**, when mechanical fuel valve **54** is in first position **38**(*a*), fuel lockout apparatus **58** communicates first fuel source **28** to the dual fuel engine and prevents communication between the second fuel source and the dual fuel engine.

In an exemplary embodiment of the invention, mechanical fuel valve **54** controls the flow of LPG to the engine by actuating fuel lockout apparatus **58** to block or unblock fuel inlet **59** for the second fuel source. Mechanical fuel valve **54** is coupled to the first fuel line as a liquid fuel valve, as shown in FIGS. **4**A and **4**B, and therefore can control the flow of gasoline to the engine by opening and closing the first fuel line. When the mechanical fuel valve **54**, FIG. **2**, is in the first position **38**(*a*), gasoline flows from the gasoline tank to the engine and the fuel lockout apparatus **58** blocks the fuel inlet **59**. Accordingly, fuel lockout apparatus **58** prevents LPG flow to generator **20** when the mechanical fuel valve **54** is in first position **38**(*a*) wherein the engine is operated on gasoline.

Mechanical fuel valve **54** includes a fuel valve handle **56** to control the opening and closing of the valve. Fuel valve handle **56** is movable between first position **38**(*a*) as shown in FIG. **2** and second position **38**(*b*) as shown in FIG. **3**. Mechanical fuel valve **54** opens the first fuel line (to enable liquid fuel flow to the engine) when fuel valve handle **56** is in the first position, and mechanical fuel valve **54** closes the first fuel line (to prevent liquid fuel flow to the engine) when fuel valve handle **56** is in the second position. Thus, when fuel valve handle **56** is in first position **38**(*a*) as shown in FIG. **2**, mechanical fuel valve **54** opens the first fuel line and allows gasoline from gasoline tank **32** to flow to the engine.

Fuel valve handle **56** is coupled to fuel lockout apparatus **58**. Fuel valve handle **56** actuates with fuel lockout apparatus **58** to prevent LPG flow to generator **20** when gasoline flow to the generator is enabled. Fuel lockout apparatus **58** is controlled by fuel valve handle **56** so that moving fuel valve handle **56** to the first position causes fuel lockout apparatus **58** to block fuel inlet **59** for LPG, and moving fuel valve handle **56** to the second position causes fuel lockout apparatus **58** to unblock fuel inlet **59** for LPG.

In an exemplary embodiment of the invention, fuel valve handle **56** rotates between the first position and the second position and fuel lockout apparatus **58** is rigidly coupled to the rotating handle. Fuel lockout apparatus **58** may include a fuel inlet cover **61**, which may be a flange, coupled to fuel valve handle **56** so that fuel inlet cover **61** rotates with the handle. Fuel inlet cover **61** extends radially outward from fuel valve handle **56** and sweeps over fuel inlet **59** for LPG as fuel valve handle **56** rotates. That is, fuel inlet cover **61** rotates transversely across fuel inlet **59** and blocks access thereto. Accordingly, fuel inlet cover **61** prevents LPG flow to generator **20** when fuel valve handle **56** is in first position **38**(*a*) to allow gasoline to run the engine.

Referring to FIG. **3**, a detail view of a portion of generator **20** of FIG. **1** depicts mechanical fuel lockout switch **38** in a second position **38**(*b*), in accordance with an embodiment of the invention. In this position, mechanical fuel lockout switch **38** provides a disconnect to stop gasoline flow from gasoline tank **32** to the engine while allowing connection of LPG supply hose **36** to fuel inlet **59** of the second fuel line.

FIG. **3** further shows LPG supply hose **36** coupling second fuel source **30** to generator **20** to deliver LPG to run the generator.

Mechanical fuel lockout switch **38** includes mechanical fuel valve **54** coupled to fuel lockout apparatus **58** to prevent gasoline flow to generator **20** when LPG from the LPG supply hose **36** is supplied to the engine. In one embodiment of the invention, actuation of mechanical fuel valve **54** to second position **38**(*b*) causes fuel lockout apparatus **58** to allow communication of second fuel source **30** to the dual fuel engine, and interrupts the first fuel source **28** communication with the dual fuel engine. The position of fuel lockout apparatus **58** prevents the fuel valve handle **56** from moving to first position **38**(*a*) (FIG. **2**) while LPG supply hose **36** is connected to generator **20**.

A quick-disconnect hose coupling **50**, also referred to as a quick-connect hose coupling, connects LPG supply hose **36** to generator **20** so that LPG supply hose **36** may be quickly attached and detached from generator **20**. Hose coupling **50** has a first end **50***a* mounted on the external surface of generator **20** and coupled to supply the second fuel to the engine. Hose coupling **50** has a second end **50***b* coupled to the outlet of LPG supply hose **36**. Each end **50***a*, **50***b* has a gaseous fuel valve that opens when the couplings are engaged and closes when the couplings are disengaged. As such, quick-disconnect hose coupling **50** automatically opens when connected to enable fuel flow from LPG supply hose **36** to the engine. Hose coupling **50** automatically disconnects fluid communication when disconnected. Accordingly, when the supply hose is detached from generator **20**, the coupling **50** is automatically closed so that fuel does not escape and unwanted air does not enter the fuel system.

In one embodiment, fuel inlet cover **61** is coupled to fuel valve handle **56** so that it is spaced apart from the surface of generator **20** to provide clearance for first end **50***a* of the quick-disconnect hose coupling **50** that protrudes from the surface of generator **20**. As shown in FIG. **2**, fuel inlet cover **61** blocks off first end **50***a* of the quick-disconnect hose coupling when fuel valve handle **56** is rotated to first position **38**(*a*) to enable gasoline flow so that fuel inlet cover **61** prevents connection of LPG supply hose **36** (FIG. **3**) to generator **20**. As shown in FIG. **3**, fuel inlet cover **61** uncovers first end **50***a* of the quick-disconnect hose coupling **50** when fuel valve handle **56** is rotated to second position **38**(*b*) to disable gasoline flow so that fuel inlet cover **61** permits connection of LPG supply hose **36** to generator **20**.

To operate generator **20** on LPG, fuel valve handle **56** is turned to second position **38**(*b*) to disable the flow of gasoline to the engine and to expose first end **50***a* of hose coupling **50** on generator **20**. LPG supply hose **36** is then connected to generator **20** via hose coupling **50** to enable the flow of LPG to the engine. To operate generator **20** on gasoline, LPG supply hose **36** is disconnected from generator **20** via hose coupling **50** to disable the flow of LPG to the engine and to unblock fuel valve handle **56** from rotating to the first position. As shown in FIG. **2**, fuel valve handle **56** is then turned to first position **38**(*a*) to enable the flow of gasoline to generator **20**.

Referring to FIG. **4**A, a schematic diagram of a fuel system for a dual fuel engine **60** shows mechanical fuel lockout switch **38** in first position **38**(*a*) to provide communication between the first fuel source **28** and dual fuel carburetor **62**, according to an embodiment of the invention. Mechanical fuel lockout switch **38** prevents communication between second fuel source **30** and dual fuel carburetor **62** when the switch is in first position **38**(*a*). In one embodiment of the invention, first fuel source **28** includes a gasoline tank **32** to provide gasoline to carburetor **62** through a first fuel line **66**, and second fuel source **30** can include a propane or LPG tank **68** to provide propane or LPG to carburetor **62** through a second fuel line **70**. Accordingly, first fuel line **66** may be a liquid fuel line and second fuel line **70** may be a gaseous fuel line.

Mechanical fuel lockout switch **38** changes the fuel source for engine **60** between liquid fuel and gaseous fuel. Mechanical fuel lockout switch **38** includes a mechanical fuel valve **54** actuateable between first position **38**(*a*) as shown in FIG. **4**A and second position **38**(*b*) as shown in FIG. **4**B to selectively control fuel flow to the dual fuel engine **60** from first fuel source **28** through first fuel line **66** and second fuel source **30** through second fuel line **70**. Referring back to FIG. **4**A, mechanical fuel valve **54** selectively controls fuel flow through first fuel line **66** by opening the line when the mechanical fuel lockout switch **38** actuates to first position **38**(*a*). Mechanical fuel valve **54** may be coupled to fuel lockout apparatus **58** that actuates with mechanical fuel valve **54** to block and unblock fuel inlet **59** of second fuel line **70**. First end **50***a* of the quick-disconnect hose coupling is located at fuel inlet **59** and a mating end **50***b* of the quick-disconnect hose coupling is coupled to the propane or LPG tank **68**. Actuation of mechanical fuel valve **54** to first position **38**(*a*) causes fuel lockout apparatus **58** to block fuel inlet **59** to prevent coupling the first end **50***a* and second end **50***b* of the quick-disconnect hose coupling together, and actuation of mechanical fuel valve **54** to another position causes fuel lockout apparatus **58** to unblock fuel inlet **59** to permit attaching first end **50***a* and second end **50***b* together.

A liquid fuel cut-off **72** couples to carburetor **62** to regulate liquid fuel flow through the carburetor. Liquid fuel cut-off **72** can stop liquid fuel flow to engine **60** to prevent an overly rich air-fuel ratio when operating engine **60** on gaseous fuel. Liquid fuel cut-off **72** may attach to carburetor **62** to interrupt liquid fuel upon actuation of mechanical fuel lockout switch **38** from liquid fuel to gaseous fuel. As such, liquid fuel cut-off **72** can prevent engine flooding by stopping liquid fuel flow when starting on gaseous fuel. Liquid fuel cut-off **72** is manually operated in some embodiments of the invention and electrically operated in other embodiments of the invention.

In one embodiment of the invention, liquid fuel cut-off **72** comprises a fuel cut solenoid **74**, also referred to as a carburetor cutoff solenoid, that operates within carburetor **62** as a solenoid valve to control liquid fuel flow to engine **60**. Fuel cut solenoid **74** actuates between an open position to provide liquid fuel to engine **60** and a closed position to stop liquid fuel to the engine. Fuel cut solenoid **74** can operate as a normally open solenoid valve so that power is not required to open the solenoid during liquid fuel operation. As such, fuel cut solenoid **74** is powered and moved to a closed position to stop liquid fuel flow to engine **60** during gaseous fuel operation. Alternatively, fuel cut solenoid **74** may be operated as a normally closed valve that is powered to open for liquid fuel operation.

Fuel cut solenoid **74** is preferably powered by a magneto **76**, alternator, engine flywheel with a charge winding, or other electrical power generator having a charge winding or coil **78**. Charging coil **78** allows operation of fuel cut solenoid **74** in a batteryless engine. In a batteryless dual fuel generator, the charging coil **78** may be integral to an alternator driven by the batteryless engine. Engine **60** may be a pull-start engine having a recoil starter **80**. During engine startup, recoil starter **80** cranks the engine with a

manual pull by a user that causes magneto **76** to supply electrical power to fuel cut solenoid **74**. While a fuel cut solenoid **74** in a normally open mode does not require any initial electrical power for starting engine **60** on liquid fuel, charging coil **78** powers the solenoid to stop liquid fuel flow during startup on gaseous fuel. Alternatively, charging coil **78** can power a fuel cut solenoid **74** operating in a normally closed mode to open and provide liquid fuel to engine **60** during startup on liquid fuel.

Charging coil **78** has an output voltage generally proportional to engine speed and therefore charge coil **78** will produce a range of voltages over the range of engine operating speeds. For example, if charging coil **78** produces 12 VAC at 3600 rpm, it may only produce 1 VAC at 300 rpm which would be insufficient voltage during startup to power a solenoid that requires 12 volts. An alternator typically used to power 12 volt accessories, such as a battery, at engine speeds will need increased output voltage to provide sufficient voltage for operation of fuel cut solenoid **74** at low recoil start speeds. In addition, the output voltage of a charging coil may vary if the alternator or magneto **76** also powers accessories. Accordingly, the output voltage of a charging coil should be verified by running engine **60** through the full range of operating speeds before increasing the output voltage.

Additional turns can be added to a charging coil in the alternator or magneto **76** to increase the output voltage and provide sufficient voltage to activate fuel cut solenoid **74** at manual start speeds. Typical alternators or magnetos may have limited room within stator laminations for additional turns, but low current requirements of fuel cut solenoid **74** allows substitution of smaller gage wire. Alternatively, solenoid windings on fuel cut solenoid **74** can be modified to operate at lower voltages for recoil starting. However, adding coil turns to a charge winding provides an inexpensive modification and allows use of standard 12 volt solenoids.

To protect electrical systems, a voltage regulator **82** couples to charging coil **78** to provide a fixed output voltage for a varying input voltage. If charge winding **78** is wound to supply 12 VAC at 300 rpm, it could supply 144 VAC at 3600 rpm. Applying 144 volts could quickly destroy a solenoid designed to operate at 12 volts. Accordingly, voltage regulator **82** may comprise a switching power supply circuit **84** that regulates a rectified DC power output from magneto **76** and provides a fixed voltage to fuel cut solenoid **74**. Switching circuits are very efficient, dissipate very little power, and can be made small and inexpensive. Switching power supply circuit **84** allows for low rpm, recoil starter electrical power generation with charge coil **78** voltage control over engine speed range.

In the embodiment shown in FIGS. **4**A and **4**B, fuel cut solenoid **74** is operated by an electro-mechanical switch **86**. Electro-mechanical switch **86** connects one fuel source to carburetor **62** and is connected to magneto **76** for a power source. Electro-mechanical switch **86** may comprise an electrical switch **88** that provides electrical connection between fuel cut solenoid **74** and magneto **76**. Electro-mechanical switch **86** may also comprise mechanical fuel lockout switch **38**, and electrical switch **88** can be mechanically actuated and controlled by mechanical fuel lockout switch **38**. Fuel cut solenoid **74** connects to open and close a fuel path to pull-start engine **60** in response to reception of electrical power from electro-mechanical switch **86**.

Fuel cut solenoid **74** can operate as a normally open valve that closes when powered by alternator or magneto **76**. The normally open valve is activated to close and prevent gasoline flow to engine **60** for LPG mode, and deactivated to open and allow gasoline flow to engine **60** for gasoline mode. As such, actuation of mechanical fuel lockout switch **38** to first position **38**(*a*) opens electrical switch **88** to interrupt power and open fuel cut solenoid **74** as represented in FIG. **4**A, and actuation of mechanical fuel lockout switch **38** to second position **38**(*b*) closes electrical switch **88** to power and close fuel cut solenoid **74** as represented in FIG. **4**B. Alternatively, fuel cut solenoid **74** can operate as a normally closed valve where actuation of mechanical fuel lockout switch **38** to first position **38**(*a*) closes electrical switch **88** to power and open fuel cut solenoid **74**, and actuation of mechanical fuel lockout switch **38** to second position **38**(*b*) opens electrical switch **88** to interrupt power and close fuel cut solenoid **74**.

In an alternative embodiment of the invention, a microcontroller **89** operates fuel cut solenoid **74** so that fuel cut solenoid **74** opens to operate engine **60** on gasoline and is closed when the engine operates on LPG. While engine **60** is running, charging coil **78** provides power available to microcontroller **89** for operation of fuel cut solenoid **74**. Fuel cut solenoid **74** may operate in a normally open mode to allow gasoline flow to engine **60** without power from microcontroller **89**, and microcontroller **89** may operate fuel cut solenoid **74** to operate as an after-fire solenoid when shutting down engine **60** from gasoline operation. That is, microcontroller **89** powers fuel cut solenoid **74** to a closed position preventing fuel being drawn into engine **60** and muffler during engine shutdown from operation on gasoline. When engine **60** runs on LPG, microcontroller **89** switches on power to close fuel cut solenoid **74** to prevent engine **60** from drawing in gasoline from the float bowl of carburetor **62** and first fuel line **66**. Microcontroller **89** may also operate fuel cut solenoid **74** configured to be normally closed. Implementation of microcontroller **89** is further described with respect to FIG. **14**.

Referring to FIG. **4**B, a schematic diagram of a fuel system for a dual fuel engine shows mechanical fuel lockout switch **38** in second position **38**(*b*) to provide communication between second fuel source **30** and dual fuel carburetor **62**, according to an embodiment of the invention. Mechanical fuel lockout switch **38** prevents communication between first fuel source **28** and dual fuel carburetor **62** when the switch is in second position **38**(*b*). The dual fuel engine has a first fuel line **66** to provide fuel from first fuel source **28** to carburetor **62** and a second fuel line **70** to provide fuel from second fuel source **30** to carburetor **62**.

Mechanical fuel lockout switch **38** includes mechanical fuel valve **54** that selectively controls fuel flow through first fuel line **66** by closing the line when mechanical fuel lockout switch **38** actuates to second position **38**(*b*). Mechanical fuel lockout switch **38** may also include a mechanical lockout apparatus **58** to block and unblock fuel inlet **59** of the second fuel line **70**. Fuel inlet **59** may include first end **50***a* of the quick-connect hose coupling mounted on the generator and coupled to second fuel line **70**. Second end **50***b* of the quick-connect hose coupling is coupled to the outlet of second fuel source **30**, and the first end **50***a* mates with second end **50***b* to quickly attach propane or LPG tank **68** to second fuel line **70**. Fuel lockout apparatus **58** may also hold mechanical fuel lockout switch **38** in second position **38**(*b*) when the propane or LPG tank **68** is coupled to the engine via the ends **50***a*, **50***b* of the quick-connect hose coupling.

Liquid fuel cut-off **72** couples to carburetor **62** to regulate liquid fuel flow through the carburetor as described with respect to FIG. **4**A. Liquid fuel cut-off **72** may comprise a fuel cut solenoid **74** powered by magneto **76**. Engine **60** has

recoil starter **80** that cranks the engine and drives magneto **76** to power fuel cut solenoid **74** when starting the engine. Voltage regulator **82** reduces the voltage delivered to fuel cut solenoid **74** at higher engine operating speeds. Fuel cut solenoid **74** is activated by electro-mechanical switch **86** providing electrical connection to magneto **76** via electrical switch **88**. Electrical switch **88** can be manually actuated and controlled by mechanical fuel lockout switch **38**. FIG. **4**B shows electrical switch **88** closed to power a normally open configured fuel cut solenoid **74** to a closed position for LPG mode when mechanical fuel lockout switch **38** is in second position **38**(*b*).

FIG. **4**A and FIG. **4**B depict an embodiment where mechanical fuel valve **54** operates along first fuel line **66** to provide a flow path for first fuel source **28** to carburetor **62** when the valve is in first position **38**(*a*). That is, mechanical fuel valve **54** may control a single fuel line that runs through the valve while operating fuel lockout apparatus **58** to control fuel flow through second fuel line **70**. Embodiments of the invention also contemplate mechanical fuel valve **54** configured to operate along second fuel line **70** to provide a flow path for second fuel source **30** to carburetor **62** when the valve is in second position **38**(*b*). Mechanical fuel valve **54** may be configured to control multiple fuel lines that run through the valve according to embodiments of the invention. In another embodiment of the invention, a manual fuel petcock is coupled along second fuel line **70** to provide an independent shut-off from second fuel source **30** to the engine.

Referring to FIG. **5**, a dual fuel carburetor having a manual fuel shutoff system is shown, in accordance with a mechanical embodiment of the invention. Carburetor **62** attaches to an intake **90** of the engine to mix air and fuel and connect to a liquid fuel source and a gaseous fuel source. Carburetor **62** has a mixing passage or throat **92** having an inlet **94** for air and an outlet **96** for an air-fuel mixture. A venturi **98** is located in throat **92** with a choke valve **100** located upstream from the venturi and a throttle valve **102** located downstream from the venturi. Carburetor **62** has a float bowl **104** that provides fuel through a fuel passage into a narrow portion of venturi **98**. Float bowl **104** has a liquid fuel inlet **106** to receive liquid fuel from first fuel source **28**. Throat **92** has a gaseous fuel inlet **108** to receive gaseous fuel from second fuel source **30**. Dual fuel carburetor **62** mixes air with fuel from first fuel source **28** and second fuel source **30** and provides the respective air-fuel mixtures for operation of the dual fuel generator.

Liquid fuel cut-off **72** couples to carburetor **62** to control liquid fuel flow downstream of float bowl **104** in the carburetor. Liquid fuel cut-off **72** can close off float bowl **104** to stop liquid fuel flow to the engine and prevent an overly rich air-fuel ratio during gaseous fuel operation. As such, liquid fuel cut-off **72** prevents engine flooding when starting on gaseous fuel. Liquid fuel cut-off **72** also traps fuel in float bowl **104** to eliminate delay in filling the bowl when starting the engine on liquid fuel, and can stop liquid fuel flow to the engine immediately after ignition shutdown. As such, liquid fuel cut-off **72** reduces emissions and prevents afterfire by stopping the engine from continuing to draw in fuel from float bowl **104** during shutdown.

In the embodiment of FIG. **5**, liquid fuel cut-off **72** comprises a manually operated fuel shutoff **110** coupled to carburetor **62** to control liquid fuel flow downstream of float bowl **104**. Manual fuel shutoff **110** can be cable actuated for use on engines without battery power, for instance engines with recoil starters. Manual fuel shutoff **110** actuates between a first position to allow gasoline flow to the engine, as shown in FIG. **7**A, and a second position to prevent gasoline flow to the engine, as shown in FIG. **8**. Referring back to FIG. **5**, manual fuel shutoff **110** may comprise a shaft **112** extending into carburetor **62** that actuates between the first position and second position. A manually operated control system **114** couples to shaft **112** external to carburetor **62** to control manual fuel shutoff **110**.

A bracket **116** couples to the outer surface of carburetor **62** to support manual control system **114**. Bracket **116** mounts to a boss **118** extending outwards from float bowl **104**. Boss **118** has a flat vertical surface with a pair of tapped holes for mounting bracket **116** to float bowl **104**. Screws **120**, **122** extend through respective holes in bracket **116** and into the tapped holes to mount the bracket to carburetor **62**. Manual fuel shutoff **110** extends out of carburetor **62** and through an opening **124** in bracket **116**. Bracket **116** has a first stopping tab **126** and a second stopping tab **128** extending away from float bowl **104** to hold manual fuel shutoff **110** in a respective open or closed position. A fuel drain screw **130** extends into an opening in carburetor **62** adjacent bracket **116**.

Bracket **116** has a lower arm **132** extending downward and to the air inlet side of carburetor **62**. Lower arm **132** has a bottom portion **134** bent outward from carburetor **62** to couple to a control system spring **136**. Bottom portion **134** has a hole **138** for control system spring **136** adjacent a positioning groove **140** for the spring. Control system spring **136** is held in position by groove **140** as it hooks through hole **138**. Bracket **116** also has an upper arm **142** extending first outward from carburetor **62** and then vertically and to the outlet side of the carburetor. Upper arm **142** has a cable clamp **144** for holding a Bowden cable **146**. Cable clamp **144** has a flat midsection and two curved ends contacting bracket **116** to hold the midsection slightly apart from the bracket. Cable clamp **144** is coupled to bracket **116** by a bolt **148** extending through a hole in the midsection and through upper arm **142** of the bracket.

A lever **150** couples to shaft **112** to actuate manual fuel shutoff **110**. A cap **152** holds lever **150** on shaft **112**. Alternatively, lever **150** may be coupled to the shaft **112** by welding or staking. Lever **150** has a first lever arm **154** to contact and hold lever **150** against first and second stopping tabs **126**, **128** of the bracket. Lever **150** has a second lever arm **156** to actuate shaft **112**. First lever arm **154** is in plane with an opening in the lever for shaft **112** and second lever arm **156** extends first outward from carburetor **62** and then parallel to first lever arm **154**. Second lever arm **156** extends outward from carburetor **62** to provide clearance between bracket **116** and the second lever arm for control system spring **136** and screw **122**. Second lever arm **156** has two holes **158**, **160** for coupling control system spring **136** and Bowden cable **146** to lever **150**.

Manual fuel shutoff **110** operates as a valve within carburetor **62** to selectively interrupt liquid fuel flow to the engine. Control system spring **136** preferably pulls on lever **150** to hold manual fuel shutoff **110** in an open valve position, and Bowden cable **146** pulls lever **150** against control system spring **136** to rotate manual fuel shutoff **110** to a closed valve position. As such, control system spring **136** holds manual fuel shutoff **110** open for gasoline mode until Bowden cable **146** is pulled to close the valve for LPG mode. Alternatively, control system spring **136** can hold manual fuel shutoff **110** in a closed valve position until Bowden cable **146** is pulled to open the valve. Therefore, actuation of the Bowden cable **146** acts as a switch to assist in changeover between the dual fuels. Manual fuel shutoff **110** may rotate 90 degrees between the open and closed positions with stopping tabs **126**, **128** positioned about

bracket **116** accordingly. Lever **150** can be positioned on shaft **112** so that second lever arm **156** is pulled upward by a generally vertical Bowden cable **146**. Second lever arm **156** may actuate between a position 45 degrees below horizontal for an open valve and a position 45 degrees above horizontal for a closed valve. When holding the valve open, control system spring **136** may be oriented at a right angle to second lever arm **156** for increased leverage.

Referring to FIG. **6**, a cross-sectional view of the carburetor taken generally about line **6-6** of FIG. **5** is shown, in accordance with an embodiment of the invention. Carburetor **62** includes a throat **92** to mix gaseous fuel with air and liquid fuel with air. Throat **92** includes a gaseous fuel inlet port **162** in communication with gaseous fuel inlet **108** coupled to a second fuel line **70**. Carburetor **62** also includes float bowl **104** and a fuel passage **164** to provide a liquid fuel path from float bowl **104** through a main nozzle **166** into venturi **98**. Float bowl **104** has a liquid fuel inlet port **168** and a float valve **170** to regulate liquid fuel flow through liquid fuel inlet port **168**. Liquid fuel inlet port **168** is in communication with the liquid fuel inlet **106** coupled to first fuel line **66**.

Manual fuel shutoff **110** couples to carburetor **62** to regulate liquid fuel flow downstream of float bowl **104**. Manual fuel shutoff **110** attaches to carburetor **62** to close fuel passage **164** upon selection of engine operation to gaseous fuel. Manual fuel shutoff **110** may have a first end **172** positioned in carburetor **62** adjacent an inlet port **174** to fuel passage **164**, and the first end **172** actuates to close fuel passage **164**. That is, first end **172** actuates between a first position to permit fuel flow into fuel passage **164**, as shown in FIG. **7**A, and a second position to prevent fuel flow into fuel passage **164**, as shown in FIG. **8**.

Referring back to FIG. **6**, manual fuel shutoff **110** has a second end **176** positioned external to carburetor **62** that is manually actuated to operate manual fuel shutoff **110**. Manual fuel shutoff **110** may have a rotating shaft **112** that extends through an opening **178** in carburetor **62**. A blocking member or valve tip **180** couples to shaft **112** in carburetor **62** to create a valve-shaft assembly **179**. Valve tip **180** rotates parallel to inlet **174** of fuel passage **164** between a blocking position and non-blocking position to selectively block fuel flow into fuel passage **164**. Lever **150** couples to shaft **112** external to carburetor **62** and actuates to rotate shaft **112** and valve tip **180**.

Shaft **112** may be horizontal or substantially horizontal to allow valve tip **180** to be positioned directly in float bowl **104** adjacent inlet port **174** of fuel passage **164**. That is, manual fuel shutoff **110** may be coupled to carburetor **62** such that second end **176** is horizontal from first end **172**. Inlet **174** of fuel passage **164** can face horizontal or substantially horizontal to accommodate valve tip **180** in float bowl **104**. As such, fuel passage **164** may have a horizontal component that receives fuel from float bowl **104** leading to a vertical component to provide fuel to venturi **98**. The interior surface of the float bowl **104** may also have a recess or cavity **182** to provide room for valve member **180** in the bowl.

Opening **178** in carburetor **62** has a plug **184** to hold shaft **112** and prevent fuel flow out of the carburetor. Shaft **112** extends through a hole **186** in plug **184** and hole **186** is positioned to align valve tip **180** with fuel passage **164**. Plug **184** has a larger outer diameter **188** toward the external side of carburetor **62** and a smaller outer diameter **190** toward the internal side. Larger outer diameter **188** and smaller outer diameter **190** mate with corresponding diameters of opening **178**. Plug **184** has a counterbore **192** to hole **186** on the external side of the plug. A compression spring **194** is positioned around shaft **112** in float bowl **104** to push valve tip **180** against plug **184**. Compression spring **194** holds valve tip **180** against inlet **174** of fuel passage **164** in order to seal the fuel passage.

A primary o-ring **196** and a secondary o-ring **198** are positioned around shaft **112** to provide a respective first and second fuel seal between the shaft and plug **184** and to seal first end **172** of manual fuel shutoff **110** in carburetor **62**. Primary o-ring **196** may be positioned in an o-ring groove **200** in shaft **112** and secondary o-ring **198** may be positioned in counterbore **192** of plug **184**. A bracket **116** or other support member mounts over counterbore **192** and around shaft **112** to hold secondary o-ring **198** in counterbore **192**. Bracket **116** has an opening **124** large enough for shaft **112** but small enough to hold secondary o-ring **198** in counterbore **192**. Manual fuel shutoff **110** actuates in a rotative motion free from linear motion in part to ensure fuel will not leak through primary o-ring **196** or secondary o-ring **198**. Compared to a sliding valve, a rotating valve, such as manual fuel shutoff **110**, reduces the likelihood that fuel will leak from carburetor **62**.

Liquid fuel cut-off **72** may regulate fuel flow through multiple fuel passages in carburetor **62** that provide fuel from float bowl **104** to the engine. For instance, carburetor **62** may have a main fuel circuit **202** and an idle fuel circuit **204**. Main fuel circuit **202** provides fuel through main nozzle **166** into a narrow portion of venturi **98**. Idle fuel circuit **204** provides fuel to throat **92** downstream from the throttle valve. Liquid fuel cut-off **72** may regulate fuel flow through some or all of the fuel circuits that provide fuel from float bowl **104** to the engine. FIG. **6** shows an embodiment where idle fuel circuit **204** branches off from main fuel circuit **202** and liquid fuel cut-off **72** actuates to block fuel flow into both main fuel circuit **202** and idle fuel circuit **204**. In other embodiments, liquid fuel cut-off **72** closes main fuel circuit **202** while small amounts of liquid fuel pass through idle fuel circuit **204**. Fuel passing through idle fuel circuit **204** may not negatively affect engine performance during LPG operation but will eventually drain the gasoline tank.

Referring to FIG. **7**A, a partial sectional view of a float bowl shows a manual fuel shutoff system in an open position for gasoline mode, in accordance with an embodiment of the invention. The partial sectional view is taken through a portion of float bowl **104** along fuel passage **164** while showing another portion of float bowl **104** in front of fuel passage **164** and coupled to manual fuel shutoff **110**. Inlet **174** to fuel passage **164** is in a boss **206** extending outward from a central region of float bowl **104**. Boss **206** has an oval top with sides that extend to the floor of float bowl **104**. Inlet **174** to fuel passage **164** extends through boss **206** and has a substantially flat perimeter edge **208** around inlet port **174** on the surface of the boss. Manual fuel shutoff **110** presses against substantially flat perimeter edge **208** surrounding fuel passage **164** to block fuel flow into fuel passage **164**.

Manual fuel shutoff **110** may have a rotating shaft **112** extending through an aperture **178** in float bowl **104**. Shaft **112** has a first end **210** coupled to valve tip **180** and located in float bowl **104** that is held against inlet port **174** to fuel passage **164**. Shaft **112** rotates valve tip **180** against inlet port **174** between a first position **180**(*a*) allowing fuel flow through the inlet port **174**, as shown in FIG. **7**A, and a second position **180**(*b*) blocking fuel flow through the inlet port **174**, as shown in FIG. **8**. That is, valve tip **180** uncovers the inlet **174** of fuel passage **164** to permit fuel flow into the inlet **174** when rotated to first position **180**(*a*), FIG. **7**A, and

covers inlet **174** of fuel passage **164** to prevent fuel flow into inlet **174** when rotated to second position **180**(*b*), FIG. **8**.

Referring back to FIG. **7**A, the manual fuel shutoff system further includes bracket **116** to support shaft **112** in float bowl **104** and provide mounting locations for manually operated control system **114**. Bracket **116** also has a pair of stopping tabs **126**, **128** to hold the manual fuel shutoff **110** in an open or closed position. Shaft **112** extends through bracket **116** and lever **150** couples to a second end **212** of shaft **112** located outside of float bowl **104**. Control system spring **136** couples lever **150** to bracket **116** to hold lever **150** against stopping tab **126** and hold manual fuel shutoff **110** in the open position for gasoline mode. Bowden cable **146** couples to lever **150** to pull against control system spring **136** and rotate manual fuel shutoff **110** to the closed position for LPG mode. As such, second end **176** of manual fuel shutoff **110** is positioned external to float bowl **104** and coupled to manually operated control system **114** to operate manual fuel shutoff **110**.

Referring to FIG. **7**B, a detailed partial sectional view of the float bowl of FIG. **7**A taken along line **7**B-**7**B shows a manual fuel shutoff in an open position for gasoline mode, in accordance with an embodiment of the invention. Float bowl **104** includes boss **206** through which fuel passage **164** extends and having a substantially flat perimeter edge **208** surrounding inlet **174** to fuel passage **164**. Substantially flat perimeter edge **208** preferably has a flat finished surface for improved sealing against valve tip **180**. Valve tip **180** maintains planar contact with substantially flat perimeter edge **208** while rotating between an open position permitting fuel flow into inlet **174** and a closed position blocking fuel flow into inlet **174**. As such, valve tip **180** rotates parallel to inlet **174** of fuel passage **164** between the open or first position **180**(*a*) and closed or second position **180**(*b*), FIG. **8**.

Referring again to FIG. **7**B, valve tip **180** may comprise an oval or stadium **214** having a flat surface **216** that contacts perimeter edge **208** around inlet **174** of fuel passage **164**. Valve tip **180** may have a recessed portion or cutout **218** in the flat surface **216** to provide a flow passage through the valve tip. Fuel flows through the cutout **218** into the inlet **174** of fuel passage **164** when cutout **218** is aligned with inlet **174**. That is, cutout **218** in valve tip **180** aligns with inlet port **174** when valve tip **180** is rotated to the open position such that fuel can pass from float bowl **104** through cutout **218** into fuel passage **164**. Cutout **218** in valve tip **180** is strategically positioned in a narrow portion of stadium **214** so a long portion of stadium **214** can be rotated to cover and block inlet **174**. Valve tip **180** may comprise one of many shapes including a stadium, an oval, a disk, a rectangle, an irregular shape, among others.

Referring to FIG. **8**, a partial sectional view of a float bowl shows a manual fuel shutoff system in a closed position for LPG mode, in accordance with an embodiment of the invention. Valve tip **180** pushes against inlet **174** to fuel passage **164** to seal the inlet when in second position **180**(*b*). Valve tip **180** may have a stadium shape **214** with a cutout **218** in the narrow portion of the stadium to provide a flow passage. Valve tip **180** blocks fuel flow into fuel passage **164** when the cutout **218** in valve tip **180** is rotated away from inlet **174** of fuel passage **164**. Cutout **218** may face downward when in the closed position and horizontal when in the open position. Lever **150** couples to shaft **112** outside of float bowl **104** and is actuated by Bowden cable **146** to operate manual fuel shutoff **110**.

Bowden cable **146** may be coupled to mechanical fuel lockout switch **38**, FIG. **1**, to automatically open and close manual fuel shutoff **110** upon selection of a corresponding fuel source. Mechanical fuel lockout switch **38** may have a lever arm inside of the generator housing for actuating Bowden cable **146**, FIG. **8**. Alternatively, Bowden cable **146** may have a push-pull knob located on an external surface of the generator housing to independently actuate manual fuel shutoff **110**. In either case, manual fuel shutoff **110** can attach to the carburetor to close fuel passage **164** downstream from float bowl **104** upon actuation of the mechanical fuel lockout switch **38**, FIG. **1**, from liquid fuel to gaseous fuel.

Referring to FIG. **9**, a perspective view of a shaft for the manual fuel shutoff system of FIGS. **5**-**8** is shown, in accordance with an embodiment of the invention. Shaft **112** has two "D" shaped ends each located at a respective first end **210** and second end **212** of the shaft. Shaft **112** also has a first diameter **220** and a larger second diameter **222** each extending radially from shaft **112** outward beyond the two "D" shaped ends. First diameter **220** and second diameter **222** are separated by o-ring groove **200** with first diameter **220** toward first end **210** of shaft **112** and second diameter **222** toward second end **212** of shaft **112**. First diameter **220** also has a groove **224** for a retaining ring. Lever **150**, FIG. **8**, has a "D" shaped opening to fit on the second end **212** of shaft **112** and held against the second diameter **222**.

Referring to FIG. **10**, a side view of a valve member for the manual fuel shutoff system of FIG. **5**-**8** is shown, in accordance with an embodiment of the invention. Valve tip **180** has a flat surface **216** to seal and rotate against a mating surface in the carburetor. Valve tip **180** is preferably made from polyoxymethylene (POM) or other thermoplastic material to provide a surface suitable for sealing. Valve tip **180** may be shaped as a stadium **214** with a short direction **226** and a long direction **228** extending from a center of rotation **230**. The long direction **228** rotates over inlet **174**, FIG. **8**, to selectively block fuel passage **164**. As such, valve tip **180** may rotate less than 360 degrees between the open and closed positions, and valve tip **180** rotates substantially 90 degrees between the positions in an exemplary embodiment of the invention.

Referring back to FIG. **10**, cutout **218** may be located along a straight side of stadium **214** to create a flow passage through valve tip **180**. Cutout **218** may have a depth less than the thickness of stadium **214** or may extend through the thickness of the stadium. Cutout **218** may be a half circle with tangent side components extending perpendicular to a straight edge of stadium **214**, through a side of valve tip **180**. Cutout **218** may extend into valve tip **180** short of the center of stadium **214** and positioned slightly offset along the length of the stadium from the stadium center.

Valve tip **180** may have a "D" shaped opening **232** to press onto shaft **112** of FIG. **9**, defining center of rotation **230**, FIG. **10**. Center of rotation **230** may be equal distance from straight edges of stadium **214** and positioned between cutout **218** and a rounded end of the stadium that is the closest rounded end to the cutout. Cutout **218** is askew from center of rotation **230** along the length of stadium **214** in part to cover more distance when rotated away from inlet port **174**, FIG. **8**. In addition, valve tip **180** is positioned off center on shaft **112** to increase the length of long direction **228** from center of rotation **230** that is rotated to cover inlet port **174**.

Referring to FIG. **11**, a perspective view of the carburetor of FIG. **5** with the manual fuel shutoff system exploded from a float bowl of the carburetor is shown, in accordance with an embodiment of the invention. Carburetor **62** has a throat **92**, a float bowl **104**, and a fuel passage **164** from float bowl

104 to an outlet port 234 in throat 92. Manual fuel shutoff 110 includes shaft 112 having first end 210 to be positioned in float bowl 104 and a second end 212 to be positioned external to float bowl 104. A primary o-ring 196 installs on shaft 112 and positioned in an o-ring groove 200 in shaft 112. A retaining ring 236 installs on shaft 112 in a groove 224 toward first end 210 from o-ring groove 200. Compression spring 194 installs on shaft 112 followed by valve tip 180 pressed onto first end 210 of shaft 112 creating a valve-shaft assembly 179. Orientation of valve tip 180 is controlled by a "D" shaped hole 232 in valve tip 180 mating with a "D" shaped end of shaft 112.

Plug 184 installs on shaft 112 pushing compression spring 194 against valve tip 180. Primary o-ring 196 seals between shaft 112 and plug 184. Valve-shaft assembly 179 inserts through opening 178 in float bowl 104 and plug 184 presses into the opening. Plug 184 anchors in opening 178 so that compression spring 194 holds valve tip 180 against fuel passage 164. Secondary o-ring 198 installs around shaft 112 to seal between the shaft and plug 184. Secondary o-ring 198 may be positioned in a counterbore 192 in plug 184. Bracket 116 couples to float bowl 104 and holds secondary o-ring 198 positioned in counterbore 192. Bracket 116 may be 2.0 mm thick and stamped from Q235 grade steel. A pair of screws 120, 122 each having a spring lock washer 238, 240 extend through a respective hole 242, 244 in bracket 116 to mount bracket 116 to carburetor 62. Screws 120, 122 may be M5 screws. A spacer 246 installs on shaft 112 and against bracket 116.

Lever 150 couples to shaft 112 and held apart from bracket 116 by spacer 246. Shaft 112 has a "D" shape at second end 212 that is inserted into a corresponding "D" shaped opening 248 in lever 150. The orientation of lever 150 is controlled by "D" shape hole 248 in lever 150 mating with a "D" shape end of shaft 112. Lever 150 may be 1.5 mm thick and stamped from Q235 grade steel. Cap 152 presses onto shaft 112 to hold lever 150 on shaft 112. Control system spring 136 attaches to lever 150 and bracket 116 to hold manual fuel shutoff 110 open. Cable clamp 144 couples to bracket 116 by bolt 148. Cable clamp 144 has a tab 250 at one or both ends that fits into a corresponding slot or recess 252 in bracket 116. Cable clamp 144 also has a midsection with a notch 254 to pinch and hold Bowden cable 146 to bracket 116. Bowden cable 146 is held by cable clamp 144 and attaches to lever 150 to actuate manual fuel shutoff 110 to the closed position. Fuel drain screw 130 and drain screw spring 256 insert into carburetor 62. In one embodiment, drain screw spring 256 is the same type of spring used for compression spring 194.

Referring to FIG. 12, and with continued reference back to FIG. 11, a method of fabricating a manual fuel shutoff system for a carburetor is shown, in accordance with an embodiment of the invention. Process 300 begins by providing carburetor 62 at STEP 302. Process 300 continues with making a valve-shaft assembly 179 at STEP 304, with valve tip 180 pressed onto shaft 112. Also in STEP 304, a compression spring 194 is stalled on shaft 112 and primary o-ring 196 is installed around shaft 112. Process 300 continues by installing plug 184 on valve-shaft assembly 179 at STEP 306. Next, valve-shaft assembly 179 is inserted through opening 178 in float bowl 104 and plug 184 is pressed into the opening at STEP 308. Process 300 continues at STEP 310 by installing secondary o-ring 198 in a groove on plug 184. Next, bracket 116 is coupled to float bowl 104 of carburetor 62 in STEP 312. Process 300 continues at STEP 314 by installing lever 150 on shaft 112. Next, cap 152 is pressed onto shaft 112 to hold lever 150 to shaft 112 in STEP 316. In STEP 318, control system spring 136 is installed on lever 150 and bracket 116. Also, in STEP 318, Bowden cable 146 is attached to lever 150 to actuate shaft 112.

Referring to FIG. 13, a magnetic fuel shutoff system for a carburetor is shown, in accordance with an embodiment of the invention. Magnetic fuel shutoff system 320 couples to the carburetor to provide a magnetically actuated liquid fuel cut-off for the internal combustion engine. Magnetic fuel shutoff system 320 controls liquid fuel flow through a fuel passage leading from the float bowl to the throat in the carburetor. Magnetic fuel shutoff system 320 can be manually actuated between an open position to allow gasoline flow to the engine for gasoline operation and a closed position to prevent gasoline flow to the engine for LPG operation.

Magnetic fuel shutoff system 320 includes a housing at least partially enclosing the liquid fuel cut-off. That is, magnetic fuel shutoff system 320 has a first section 322 housing magnetic fuel shutoff 324 and a second section 326 housing a manually actuated magnet 328 to operate the magnetic fuel shutoff. First section 322 has a forward wall 330 and a back wall 332 with the forward wall facing internal to the carburetor. Forward wall 330 has a flange 334 around an outer perimeter for coupling to the carburetor. Forward wall 330 also has an opening 336 through which a plunger 342 of the magnetic fuel shutoff 324 extends into the carburetor. A lip 338 extends forward from forward wall 330 around opening 336 and an o-ring 340 is installed around lip 338. Flange 334 may be mounted to a plug in an opening of the carburetor with magnetic fuel shutoff 324 entering the carburetor through a hole in the plug.

First section 322 provides a sealing member enclosing plunger 342 of magnetic fuel shutoff 324 to the carburetor and holding fuel in the carburetor. The plunger 342 extends through opening 336 in forward wall 330 with a pointed end that is selectively inserted into a fuel supply path in the carburetor to block fuel flow downstream from the float bowl. Magnetic fuel shutoff 324 has a back plate 344 coupled to plunger 342 in first section 322. Plunger 342 extends perpendicular from a forward face of back plate 344. A spring 346 pushes a back face of back plate 344 against back wall 332 to push plunger 342 through opening 336 in forward wall 330 to block the fuel supply path in the carburetor. Accordingly, the first section 322 holds the spring 346 against the plunger 342. Magnetic fuel shutoff 324 is guided through its actuation by back plate 344 sliding through first section 322 and plunger 342 through opening 336 in forward wall 330.

Second section 326 couples to first section 322 and is located behind back wall 332. Second section 326 encloses an actuating magnet 328 to selectively pull magnetic fuel shutoff 324 against spring 346. Second section 326 preferably guides actuating magnet 328 along a path perpendicular to that of magnetic fuel shutoff 324. As such, the magnetic force to pull magnetic fuel shutoff 324 to an open valve position is the strongest when actuating magnet 328 is aligned with the path of magnetic fuel shutoff 324. Actuating magnet 328 pulls magnetic fuel shutoff 324 against spring 346 when actuating magnet 328 approaches magnetic fuel shutoff 324 and releases magnetic fuel shutoff 324 while traveling away from magnetic fuel shutoff 324. Actuating magnet 328 may comprise a rare-earth or other permanent magnet.

In an exemplary embodiment of the invention, magnetic fuel shutoff 324 actuates horizontally between an open position to permit fuel flow into a fuel passage in the

carburetor and a closed positioned to prevent fuel flow into the fuel passage. Actuating magnet **328** preferably follows a vertical path and a spring **348** couples to a top of second section **326** pushing downward on actuating magnet **328**. Bowden cable **146** couples to the top of second section **326** and to actuating magnet **328** to pull the magnet vertically against spring **348** and operate magnetic fuel shutoff system **320**.

Referring now to FIG. **14**, a wiring diagram of a microcontroller **89** receiving input signals and operating engine components is shown, according to an embodiment of the invention. Microcontroller **89** closes fuel cut solenoid **74** when the engine operates on LPG and opens the fuel cut solenoid to operate the engine on gasoline. For LPG mode, microcontroller **89** switches on power to fuel cut solenoid **74** to close the solenoid preventing the engine from drawing in gasoline from the float bowl of the carburetor. During shutdown from gasoline operation, microcontroller **89** can also power fuel cut solenoid **74** to a closed position preventing additional gasoline being drawn into the engine. While microcontroller **89** can operate fuel cut solenoid **74** operating in a normally open configuration, microcontroller **89** can also operate a fuel cut solenoid operating in a normally closed configuration.

Microcontroller **89** may include a module **350** to connect fuel cut solenoid **74**, charging coil **78**, switches and a ground terminal. Module **350** has a first connection **352**(*a*) to couple fuel cut solenoid **74** and a second connection **352**(*b*) to couple charging coil **78** to power the fuel cut solenoid. Fuel cut solenoid **74** may be coupled to a fuel switch **354** and a combination switch **356** that are also connected to module **350** via a third connection **352**(*c*). Fuel switch **354** changes operation of the engine between LPG and gasoline, and combination switch **356** can operate to kill the engine. A ground terminal **358** connects to module **350** via a fourth connection **352**(*d*) in order to ground fuel cut solenoid **74** via fuel switch **354** or combination switch **356**.

In LPG mode, fuel switch **354** connects a first contact **360**(*a*) to a second contact **360**(*b*), instead of third contact **360**(*c*), to complete an electrical circuit for fuel cut solenoid **74** by connecting the fuel cut solenoid to ground terminal **358**. A fuel cut solenoid **74** operating in a normally open configuration is therefore powered and closed to prevent gasoline flow from the fuel bowl of the carburetor to the engine. Fuel switch **354** also connects a fourth contact **360**(*d*) to a fifth contact **360**(*e*), instead of sixth contact **360**(*f*), to prevent combination switch **356** from grounding magneto **76** thereby maintaining power to spark plug **362**.

In gasoline mode, fuel switch **354** connects first contact **360**(*a*) to third contact **360**(*c*) to interrupt an electrical circuit for fuel cut solenoid **74** by disconnecting the fuel cut solenoid from ground terminal **358**. A fuel cut solenoid **74** operating in a normally open configuration is therefore unpowered and opened to allow gasoline flow from the fuel bowl of the carburetor to the engine. Fuel switch **354** also connects fourth contact **360**(*d*) to sixth contact **360**(*f*) to allow combination switch **356** to ground magneto **76** upon shutdown thereby interrupting power to spark plug **362**.

Combination switch **356** can actuate fuel cut solenoid **74** upon engine shutdown from gasoline operation to prevent after-fire. That is, combination switch **356** connects a first point **364**(*a*) to a second point **364**(*b*) to kill the engine by connecting magneto **76** to ground terminal **358**. At the same time, combination switch **356** connects a third point **364**(*c*) to a fourth point **364**(*d*) completing an electrical circuit for fuel cut solenoid **74** by connecting the solenoid to ground terminal **358**. Fuel cut solenoid **74** is then powered and closed to prevent continued gasoline flow to the engine after combination switch **356** stops power supply to spark plug **362**.

In one embodiment of the invention, combination switch **356** can operate as a kill switch only for gasoline operation. That is, combination switch **356** can be decoupled from magneto **76** by fuel switch **354** so that combination switch **356** cannot be actuated to shut down the engine during LPG operation. In another embodiment of the invention, combination switch **356** can operate as a kill switch for both gasoline operation and LPG operation. During LPG operation, combination switch **356** may actuate fuel switch **354** with actuation of combination switch **356** to ground magneto **76** and kill the engine. That is, combination switch **356** connects first point **364**(*a*) to second point **364**(*b*) and also actuates fuel switch **354** to connect fourth contact **360**(*d*) to sixth contact **360**(*f*) so that magneto **76** is coupled to ground terminal **358** killing the engine. At the same time, combination switch **356** connects third point **364**(*c*) to fourth point **364**(*d*) so that fuel cut solenoid **74** maintains connection to ground terminal **358** to remain closed even though fuel switch **354** interrupts connection between first contact **360**(*a*) and second contact **360**(*b*).

Microcontroller **89** may also include a Voltage Frequency and Low Oil Shutdown (VFO) module **366**. VFO module **366** can measure parameters of an alternator driven by an engine in a generator. VFO module **366** monitors alternator voltage and frequency by receiving an input signal **368** from the alternator. Input signal **368** is 120 VAC and 60 Hz from the alternator as a monitoring point for VFO module **366**. VFO module **366** allows the engine to run if alternator parameters are within preset limits and shuts down the engine if the parameters are outside the limits. VFO module **366** can also monitor oil volume within the engine by receiving an input signal from an oil level switch **370** shown in the wiring diagram engine block **372**. VFO module **366** may allow the engine to operate only if the oil volume is greater than a preset lower limit and can shutdown the engine by initiating connection between the ignition coil or magneto **76** and ground terminal **358**.

Beneficially, embodiments of the invention provide for a fuel lockout switch to ensure that two fuels are not simultaneously delivered to a dual fuel internal combustion engine and to efficiently convert operation of the engine between the fuel sources. Embodiments of the invention also provide for a dual fuel generator with a remotely mounted gaseous fuel regulator system. Embodiments of the invention also provide for a batteryless dual fuel internal combustion engine having a liquid fuel cut-off coupled to a carburetor to selectively interrupt liquid fuel.

Therefore, according to one embodiment of the invention, a dual fuel engine includes an engine operable on a gaseous fuel and a liquid fuel and a switch to change operation of the engine between gaseous fuel and liquid fuel. The dual fuel engine also includes a carburetor attached to an intake of the engine to mix air and fuel and connect to a gaseous fuel source and a liquid fuel source. A liquid fuel cut-off attaches to the carburetor to interrupt liquid fuel upon actuation of the switch from liquid fuel to gaseous fuel.

According to another embodiment of the invention, a batteryless dual fuel generator includes a housing containing a pull start engine coupled to drive an alternator, the engine operable on a gaseous fuel and a liquid fuel. A carburetor attaches to an intake of the engine and includes a throat to mix fuel with air, a float bowl, and a fuel passage to provide liquid fuel from the float bowl to the throat. The generator

also includes a fuel shutoff attached to the carburetor to close the fuel passage upon selection of engine operation to gaseous fuel.

According to yet another embodiment of the invention, a carburetor having a fuel shutoff includes a carburetor with a float bowl, a throat, and a fuel passage to provide fuel from the float bowl to the throat. The carburetor further includes a fuel shutoff coupled to the carburetor having a first end in the carburetor that actuates to close the fuel passage and a second end external to the carburetor to actuate the first end, and the fuel shutoff can actuate free from linear motion.

According to yet another embodiment of the invention, a method of assembling a dual fuel engine includes providing an engine operable on a gaseous fuel and a liquid fuel. The method also includes attaching a carburetor to an intake of the engine, the carburetor includes a throat to mix gaseous fuel with air and liquid fuel with air, a float bowl, and a fuel passage to provide liquid fuel from the float bowl to the throat. The method also includes coupling a switch to the engine to change operation of the engine between gaseous fuel and liquid fuel and attaching a liquid fuel cut-off to the carburetor to close the fuel passage upon actuation of the switch from liquid fuel to gaseous fuel.

This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

What is claimed is:

1. A dual fuel generator comprising:

an engine operable on a gaseous fuel and a liquid fuel;

an electrical power generator driven by the engine and comprising a charging coil;

a switch to change operation of the engine between gaseous fuel and liquid fuel;

a carburetor attached to an intake of the engine to mix air and fuel and connect to a gaseous fuel source and a liquid fuel source;

a liquid fuel cut-off solenoid to interrupt liquid fuel flow to the engine upon actuation of the switch from liquid fuel to gaseous fuel; and

a voltage regulator coupled to the charging coil to receive power therefrom and that operates to provide a regulated voltage to the liquid fuel cut-off solenoid.

2. The dual fuel generator of claim **1** further comprising:

a liquid fuel valve along a liquid fuel line coupling the liquid fuel source to the carburetor; and

a gaseous fuel valve along a gaseous fuel line coupling the gaseous fuel source to the carburetor.

3. The dual fuel generator of claim **2**, wherein each of the liquid fuel valve and the gaseous fuel valve comprises a mechanical valve.

4. The dual fuel generator of claim **2**, wherein the liquid fuel cut-off solenoid is attached to the carburetor.

5. The dual fuel generator of claim **1**, wherein the gaseous fuel is LPG and the liquid fuel is gasoline.

6. The dual fuel generator of claim **1**, wherein the switch is an electro-mechanical switch connecting one fuel source to the carburetor and connected to the electrical power generator, and wherein the liquid fuel cut-off solenoid is connected to open and close a fuel path to the engine in response to reception of electrical power from the switch.

7. The dual fuel generator of claim **6**, wherein the switch selectively powers the solenoid valve by controlling electrical connection between the solenoid valve and the electrical power generator.

8. The dual fuel generator of claim **1**, wherein the liquid fuel cut-off solenoid is normally open to provide liquid fuel to the engine when the liquid fuel cut-off solenoid is unpowered.

9. The dual fuel generator of claim **8**, wherein the dual fuel generator is a batteryless dual fuel generator and the engine is a pull-start engine, the batteryless dual fuel generator further comprising a pull-starter that drives the electrical power generator to power and close the liquid fuel cut-off solenoid while starting the engine on gaseous fuel.

10. The dual fuel generator of claim **1**, wherein the electrical power generator comprises a magneto or an alternator.

11. A dual fuel generator comprising:

an engine operable on a gaseous fuel and a liquid fuel;

a carburetor attached to an intake of the engine to mix air and fuel and connect to a gaseous fuel source and a liquid fuel source; and

a manually actuated fuel shutoff coupled to the carburetor, the manually actuated fuel shutoff comprising:

a first end in the carburetor that actuates to selectively allow or block a flow of fuel through the carburetor; and

and a second end external to the carburetor to actuate the first end.

12. The dual fuel generator of claim **11**, wherein the engine is a pull start, batteryless engine.

13. The dual fuel generator of claim **11**, wherein the gaseous fuel is LPG and the liquid fuel is gasoline.

14. The dual fuel generator of claim **11** wherein the manually actuated fuel shutoff comprises a rotating mechanical valve.

15. The dual fuel generator of claim **14** wherein the carburetor comprises:

a float bowl;

a throat; and

a fuel passage to provide fuel from the float bowl to the throat;

wherein the manually actuated fuel shutoff comprises a shaft extending into the carburetor through an aperture in the float bowl, the shaft being coupled to a valve tip in the float bowl that rotates to open and close the fuel passage.

16. The dual fuel generator of claim **15** wherein the valve tip rotates parallel to an inlet of the fuel passage between a first position permitting fuel flow into the inlet and a second position blocking fuel flow into the inlet.

17. The dual fuel generator of claim **15**, wherein the fuel passage has an inlet with a substantially flat perimeter edge and the valve tip maintains planar contact with the perimeter edge while rotating to open and close the fuel passage.

18. The dual fuel generator of claim **17** further comprising:

a plug in the aperture around the shaft; and

a compression spring around the shaft in the float bowl pushing against the plug to hold the valve tip against the perimeter edge of the inlet.

19. The dual fuel generator of claim **15** further comprising:

a lever coupled to the shaft outside of the carburetor;

a spring coupled to the lever to hold the fuel shutoff opening the fuel passage; and

a cable coupled to the lever to move the lever against the spring and rotate the fuel shutoff to close the fuel passage.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 11,143,145 B2
APPLICATION NO. : 16/946438
DATED : October 12, 2021
INVENTOR(S) : Collie et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the Title Page

Page 2 item (63) Related U.S. Application Data: delete "10,221,781" and substitute therefore --10,221,780--.

Signed and Sealed this
Twenty-eighth Day of December, 2021

Drew Hirshfeld
Performing the Functions and Duties of the
Under Secretary of Commerce for Intellectual Property and
Director of the United States Patent and Trademark Office

EXHIBIT F

US011306667B2

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

(10) **Patent No.: US 11,306,667 B2**
(45) **Date of Patent: *Apr. 19, 2022**

(54) **DUAL FUEL SELECTOR SWITCH**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

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F02M 13/08 (2006.01)
F02D 29/06 (2006.01)

(52) **U.S. Cl.**
CPC ***F02D 19/0676*** (2013.01); ***F02D 19/0613*** (2013.01); ***F02D 19/0647*** (2013.01);
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(Continued)

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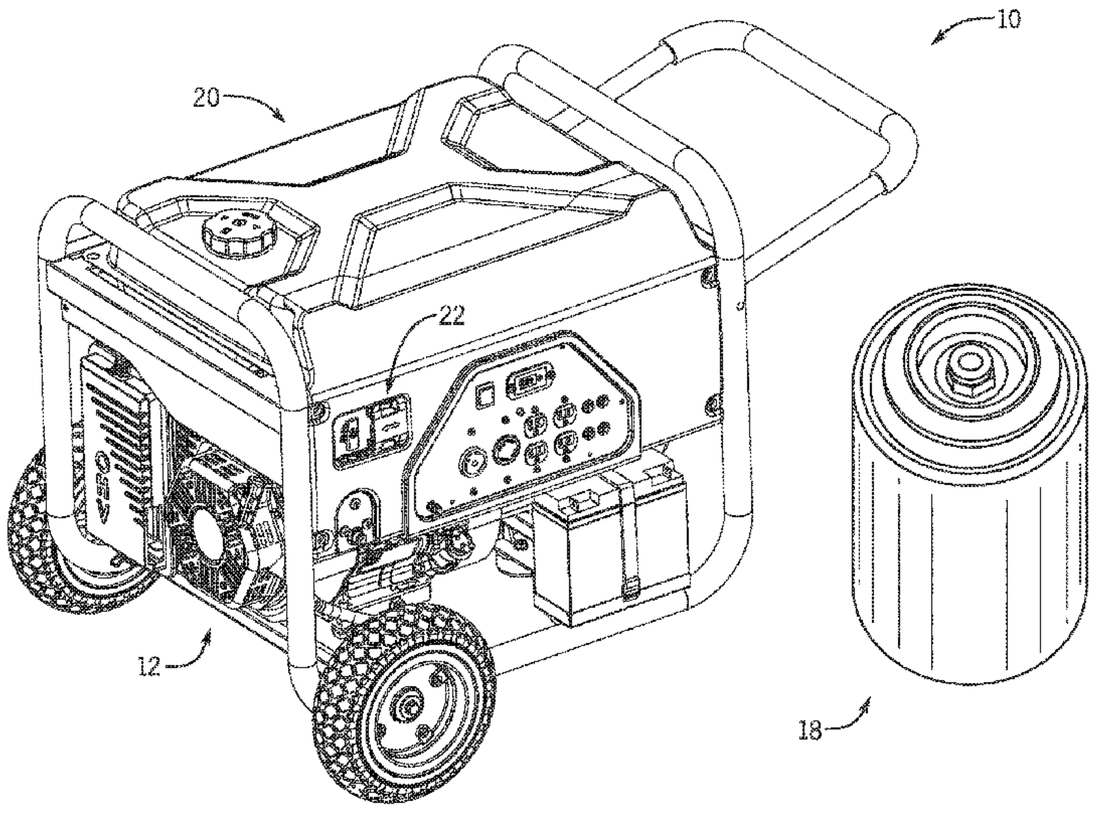
Primary Examiner — Syed O Hasan
(74) *Attorney, Agent, or Firm* — Ziolkowski Patent Solutions Group, SC

(57) **ABSTRACT**

A fuel selector for use with a dual fuel generator includes a selector plate, a first fuel valve assembly positioned adjacent the selector plate and actuatable between an ON position and an OFF position to selectively control a first fuel flow to an engine of the dual fuel generator, and a second fuel valve assembly positioned adjacent the selector plate and actuatable between an ON position and an OFF position to selectively control a second fuel flow to the engine of the dual fuel generator. A selector switch coupled to the selector plate is linearly translatable from a first position to a second position, so as to enable positioning of only one of the first fuel valve assembly and the second fuel valve assembly in the ON position at a given time, such that the first and second fuel valve assemblies cannot be in the ON position concurrently.

18 Claims, 6 Drawing Sheets



Related U.S. Application Data

continuation of application No. 14/069,747, filed on Nov. 1, 2013, now Pat. No. 9,435,273.

(52) **U.S. Cl.**
CPC ***F02D 29/06*** (2013.01); ***F02M 13/08*** (2013.01); *Y02T 10/30* (2013.01); *Y10T 137/0318* (2015.04); *Y10T 137/0491* (2015.04); *Y10T 137/87684* (2015.04)

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CPC F02M 21/0293; F02M 21/0236; F02M 13/08; F02B 53/00; F02B 63/00; H02K 1/22
See application file for complete search history.

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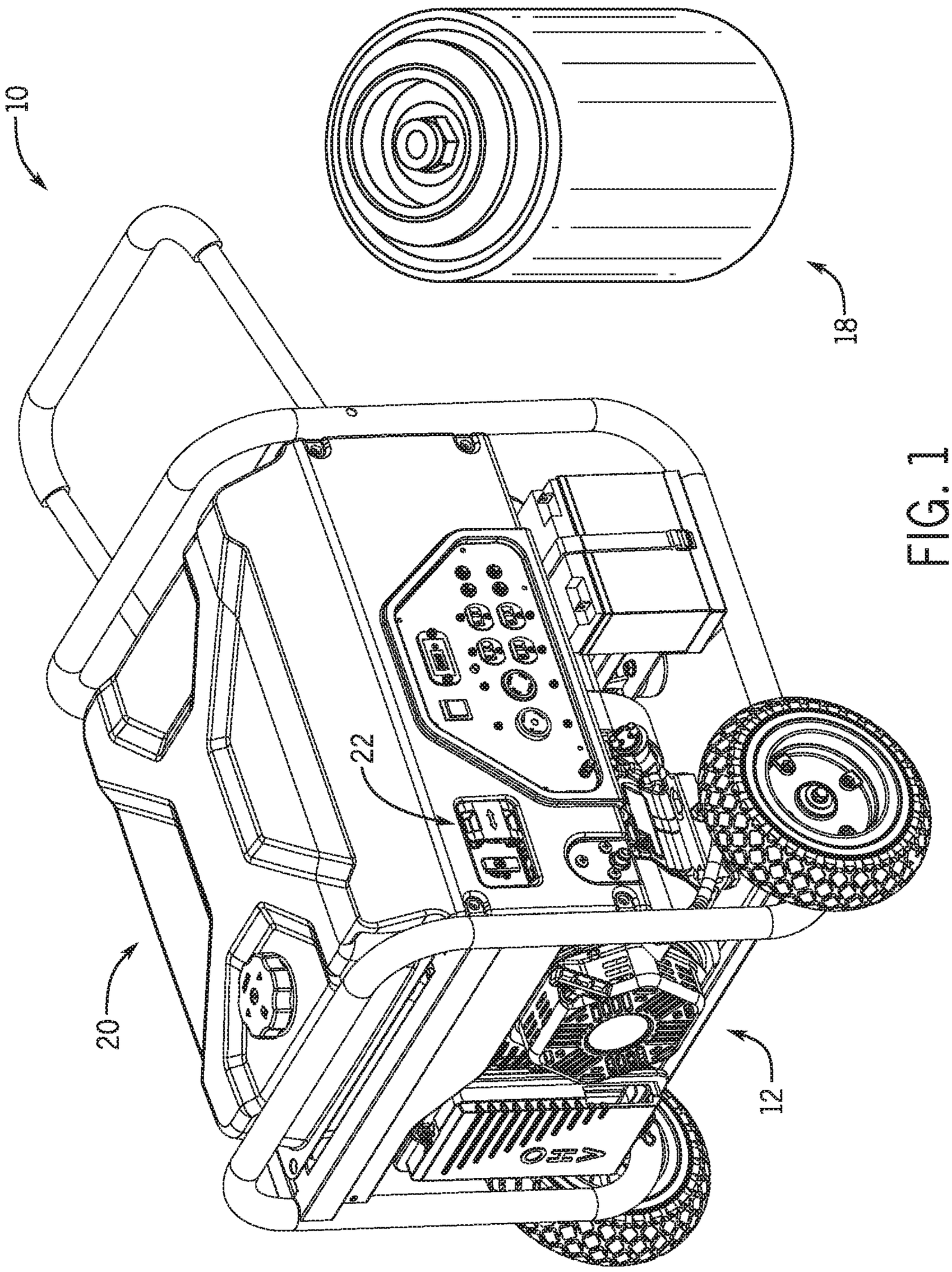

FIG. 1

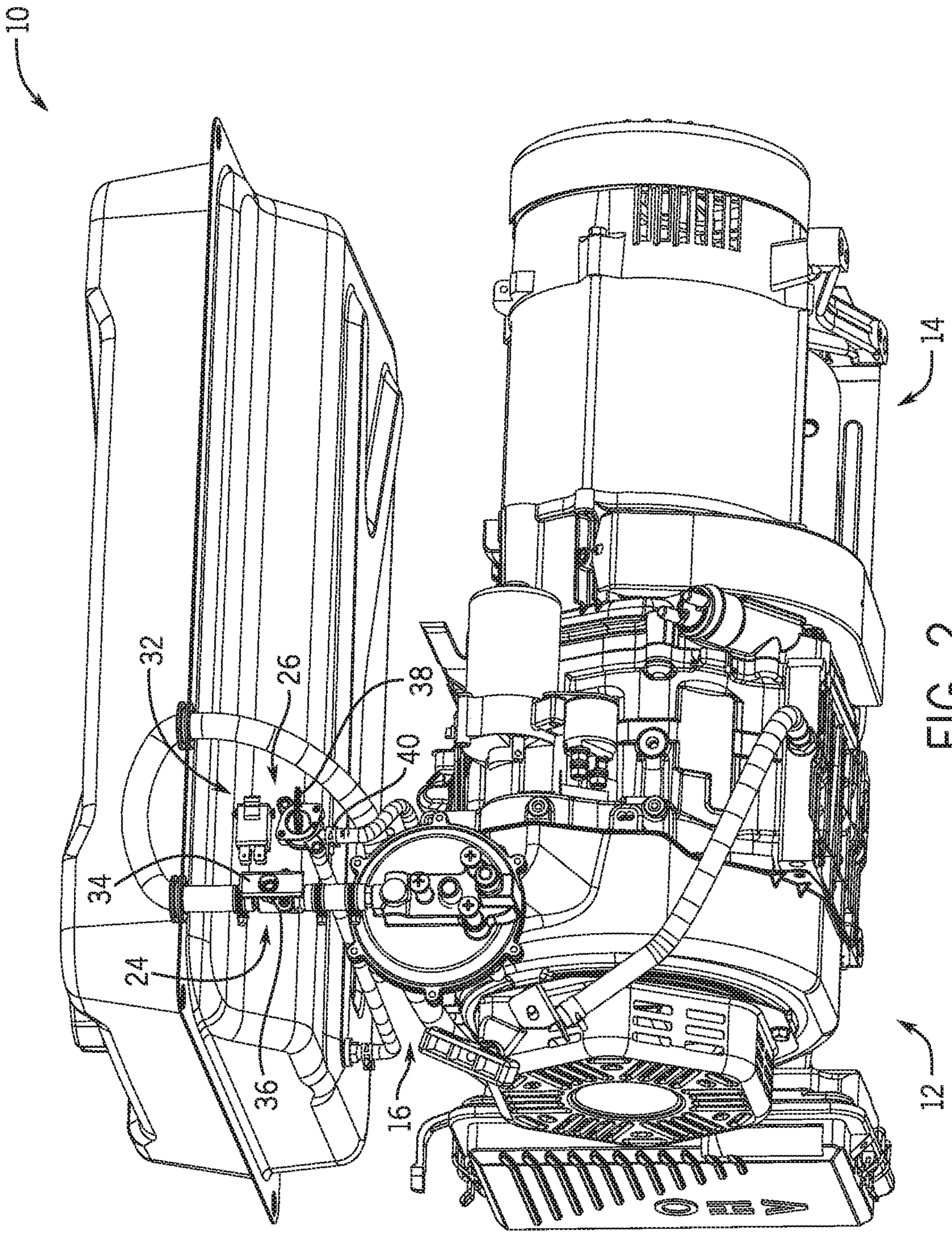

FIG. 2

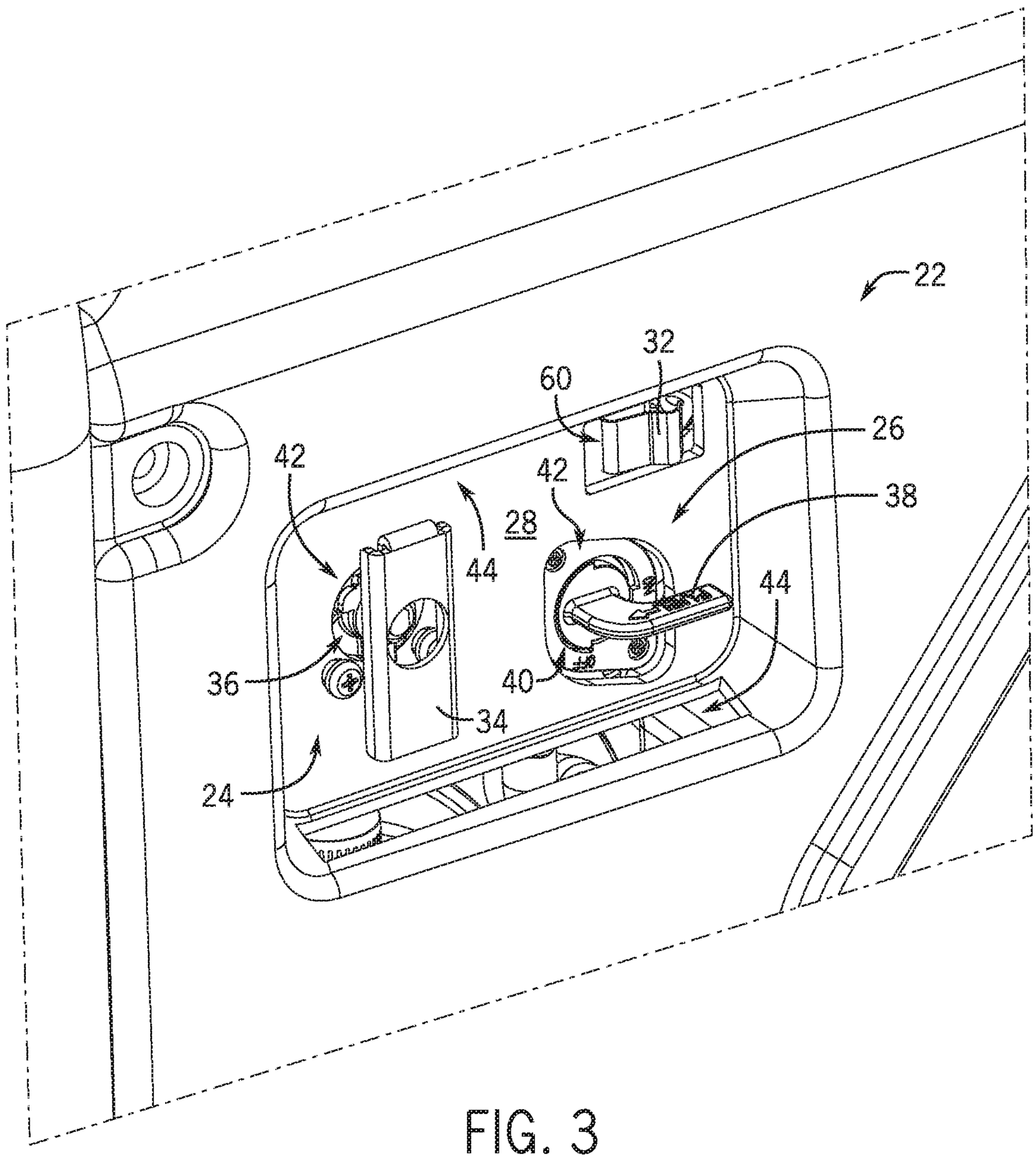

FIG. 3

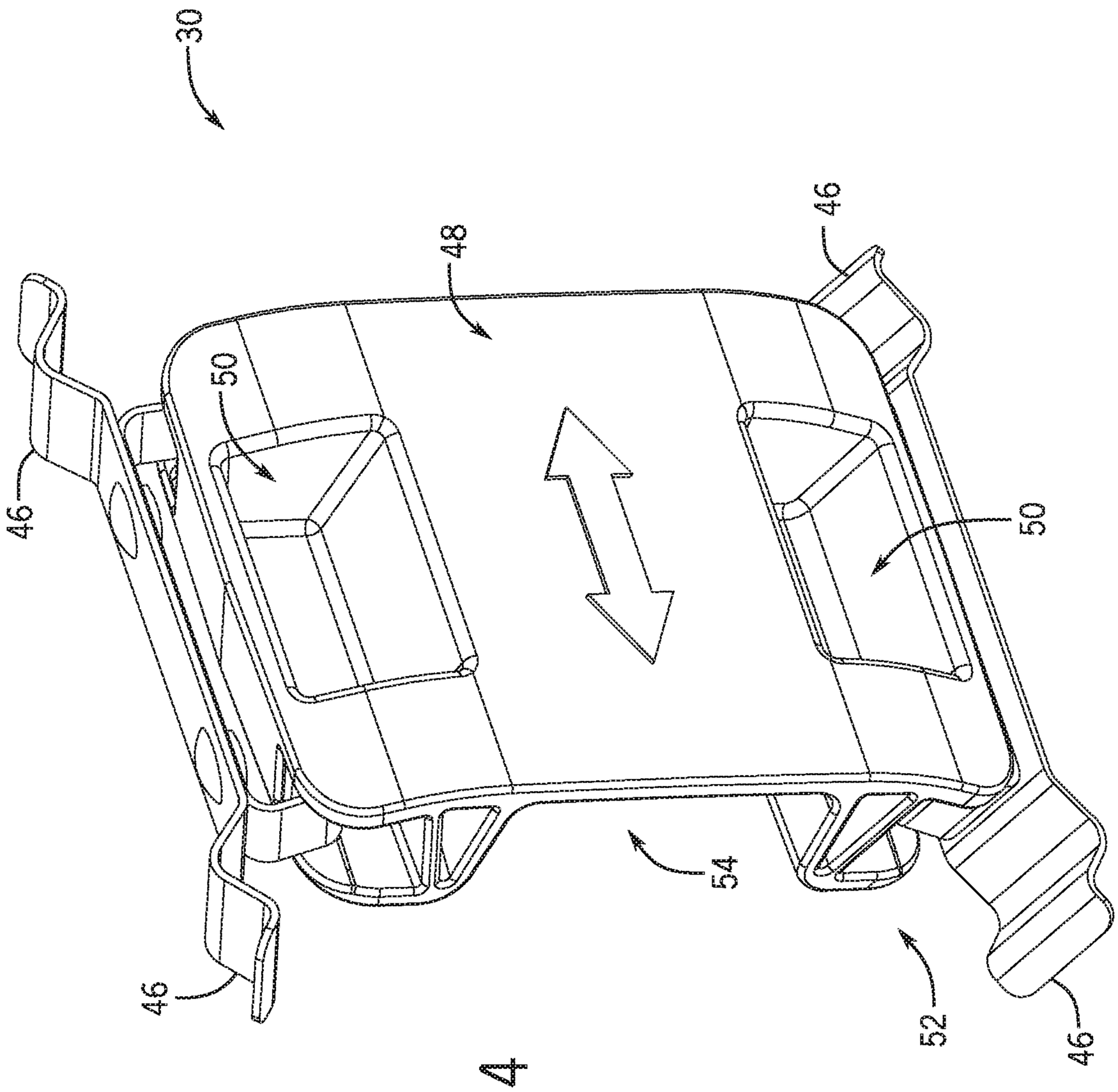

FIG. 4

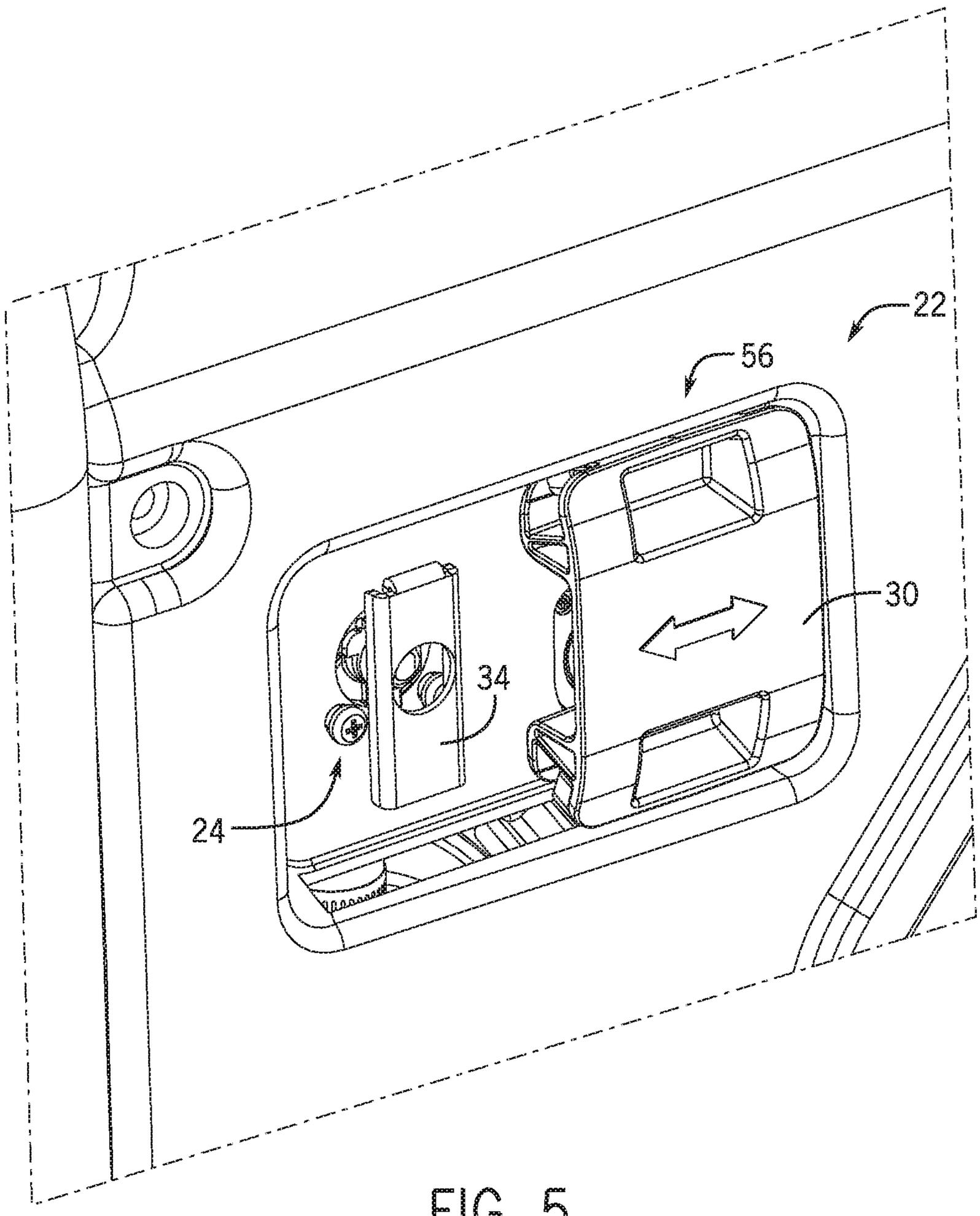

FIG. 5

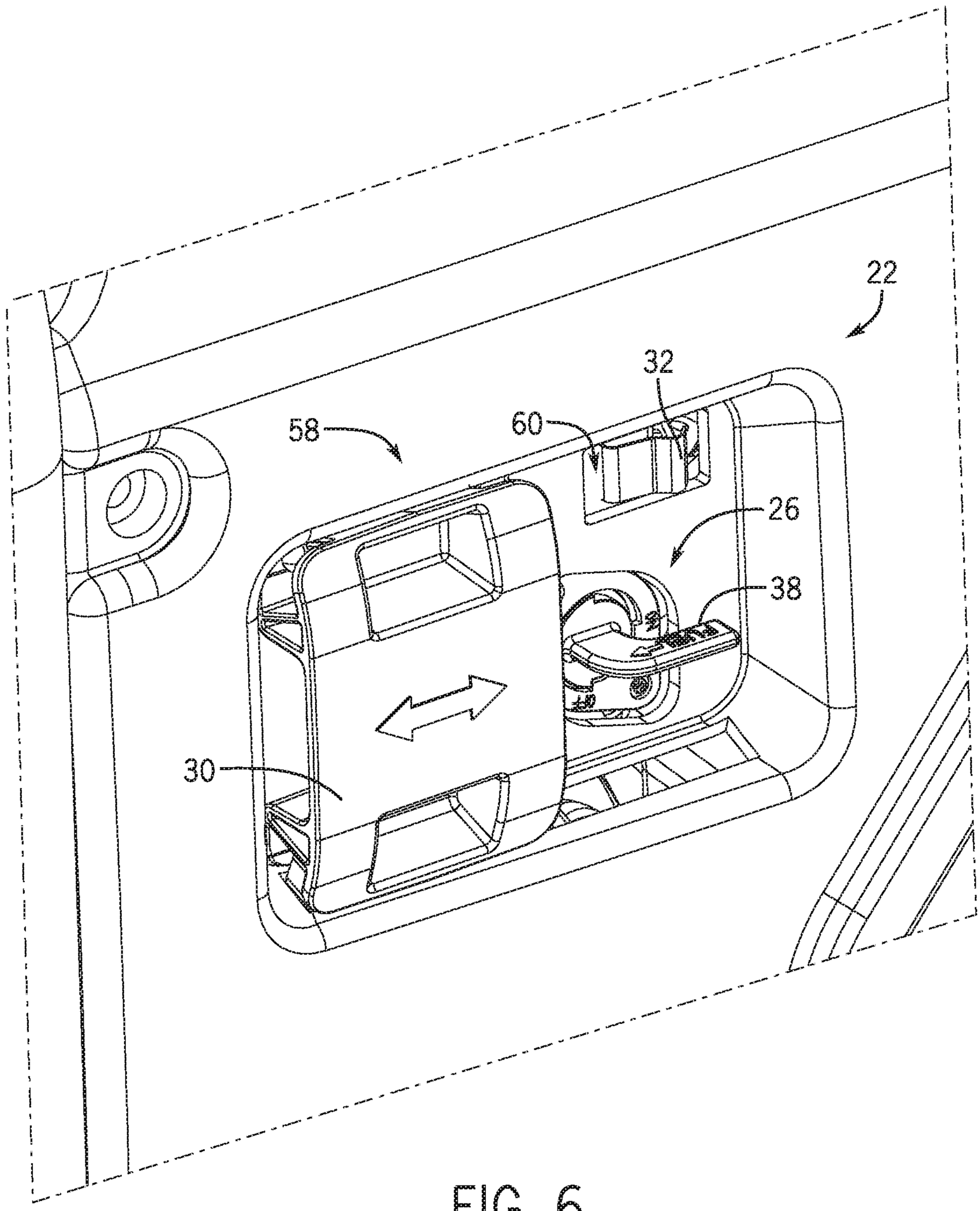

FIG. 6

DUAL FUEL SELECTOR SWITCH

CROSS-REFERENCE TO RELATED APPLICATION

The present application is a continuation of, and claims priority to, U.S. patent application Ser. No. 15/015,205, filed on Feb. 4, 2016, which is a continuation of, and claims priority to, U.S. patent application Ser. No. 14/069,747, filed on Nov. 1, 2013, now U.S. Pat. No. 9,435,273, issued Sep. 6, 2016, the disclosures of which are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

Embodiments of the invention relate generally to dual fuel generators and, more particularly, to a selector switch for use on a dual fuel generator that is configured to ensure that only one type of fuel may be in use at a given time in the generator.

Engine-driven, electrical generators are used in a wide variety of applications. Typically, an electrical generator utilizes a single driving engine directly coupled to a generator or alternator through a common shaft. Upon activation of the generator, a fuel and air mixture is provided to the combustion chambers of corresponding cylinders of the engine. The fuel mixture in each combustion chamber is ignited causing an explosion within the cylinders. The explosive forces within the combustion chambers in the cylinders cause linear motion of the pistons within their corresponding cylinders. The linear motion of the pistons is converted into rotational motion by a crankshaft that, in turn, drives the alternator. As is conventional, the driven alternator generates electrical power.

Certain generators are defined as "dual fuel" generators that include an engine having the ability to be fueled with either of two fuels, such as either gasoline or liquefied petroleum gas (LPG), for example. These "dual fuel" engines may selectively operate on gasoline or LPG as desired and controlled by an operator, such as being operated on LPG/gasoline for a first period of operation and selectively switching over to the other of LPG/gasoline for another period of operation, with such a switching of fuels being controlled as desired by an operator. Typical dual fuel generators utilize separate valves for each fuel type, such as an LPG valve and a gasoline valve, to control flow of the respective fuels to the engine. While the existence of two separate valves allows one fuel type to have its valve "on" while the other has its valve "off," there is nothing to prevent both valves from being "on" at the same time. As such, it is possible for both valves to be in the "on" position, which can lead to a potentially unsafe condition resulting from the mixture of the fuels.

Therefore, it would be desirable to provide a dual fuel generator with a selector switch that would prohibit the mixing of two differing types of fuels. It would further be desirable for such a selector switch to inhibit positioning/actuation of the valves in such a manner that the valve for a first fuel source is prevented from being "on" when the valve for a second fuel source is "on", and vice versa.

BRIEF DESCRIPTION OF THE INVENTION

In accordance with one aspect of the invention, a fuel selector for use with a dual fuel generator includes a selector plate, a first fuel valve assembly positioned adjacent the selector plate and actuatable between an ON position and an OFF position to selectively control a first fuel flow to an engine of the dual fuel generator, and a second fuel valve assembly positioned adjacent the selector plate and actuatable between an ON position and an OFF position to selectively control a second fuel flow to the engine of the dual fuel generator. The fuel selector also includes a selector switch coupled to the selector plate so as to be linearly translatable from a first position to a second position, wherein translation of the selector switch between the first and second positions enables positioning of only one of the first fuel valve assembly and the second fuel valve assembly in the ON position at a given time, such that the first and second fuel valve assemblies cannot be in the ON position concurrently.

In accordance with another aspect of the invention, a method of controlling fuel flow in a dual fuel generator includes providing a first fuel valve assembly to control fuel flow from a first fuel source to an internal combustion engine of the dual fuel generator, the first fuel valve assembly including a first fuel valve handle movable between an ON position and an OFF position to control fuel flow from the first fuel source to the internal combustion engine. The method also includes providing a second fuel valve assembly to control fuel flow from a second fuel source to the internal combustion engine of the dual fuel generator, the second fuel valve assembly including a second fuel valve handle movable between an ON position and an OFF position to control fuel flow from the second fuel source to the internal combustion engine. The method further includes providing a fuel selector switch adjacent the first fuel valve assembly and the second fuel valve assembly such that the fuel selector switch is translatable to a first position and a section position, wherein the fuel selector switch is translatable between the first position and the section position to selectively inhibit actuation of the first fuel valve handle and the second fuel valve handle, so as to prevent a simultaneous flow of fuels from the first and second fuel sources to the internal combustion engine.

In accordance with yet another aspect of the invention, a dual fuel generator includes a first fuel source, a second fuel source, and an internal combustion engine coupled to the first fuel source and the second fuel source to selectively receive fuel therefrom. The dual fuel generator also includes a fuel selector configured to control a flow of fuel from the first and second fuel sources to the internal combustion engine, with the fuel selector comprising a first fuel valve assembly including a first fuel valve and a first fuel valve handle that is actuatable between an open position and a closed position to selectively open and close the first fuel valve, a second fuel valve assembly including a second fuel valve and a second fuel valve handle that is actuatable between an open position and a closed position to selectively open and close the second fuel valve, a selector plate having the first fuel valve assembly and the second fuel valve assembly coupled to a front side thereof, and a selector switch slideably coupled to the selector plate so as to be movable from a first position to a second position. Positioning of the selector switch in the first position causes the selector switch to cover the second fuel valve handle so as to prevent the second fuel valve handle from moving to the open position and positioning of the selector switch in the second position causes the selector switch to cover the first fuel valve handle so as to prevent the first fuel valve handle from moving to the open position.

These and other advantages and features will be more readily understood from the following detailed description

of preferred embodiments of the invention that is provided in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings illustrate embodiments presently contemplated for carrying out the invention.

In the drawings:

FIG. **1** is a perspective view of a dual fuel generator, according to an embodiment of the invention.

FIG. **2** is a partial view of the dual fuel generator of FIG. **1**, according to an embodiment of the invention

FIG. **3** is a front perspective view of a fuel selector for use with the dual fuel generator of FIG. **1**, according to an embodiment of the invention.

FIG. **4** is a front perspective view of a selector switch for use with the fuel selector of FIG. **3**, according to an embodiment of the invention.

FIG. **5** is a front perspective view of the fuel selector of FIG. **3** with the selector switch in a first position, according to an embodiment of the invention.

FIG. **6** is a front perspective view of the fuel selector of FIG. **3** with the selector switch in a second position, according to an embodiment of the invention.

DETAILED DESCRIPTION

Referring first to FIGS. **1** and **2**, a dual fuel generator **10** is illustrated, according to an embodiment of the invention—with a perspective view of the generator **10** being shown in FIG. **1** and a more detailed partial view of the generator **10** being shown in FIG. **2** to further illustrate features thereof. Dual fuel generator **10** includes an internal combustible engine **12** operatively connected to an alternator **14** in a conventional manner. The engine **12** includes pistons (not shown) that are slideably received within corresponding cylinders (not shown) thereof, with each cylinder further including an intake valve for admitting a fuel-air mixture and an exhaust valve for venting exhaust gases following combustion. The fuel-air mixture is provided by a carburetor **16** that includes a movable throttle, with a position of the throttle regulating the amount of fuel and air admitted into the cylinders and thus the speed and power developed by the engine **12** when the air-fuel mixture is ignited to generate reciprocal movement of the pistons. The reciprocal movement of the pistons of engine **12** is translated to rotational movement by a crankshaft (not shown) that, in turn, drives the alternator **14**, so as to generate an electrical output power from the generator **10**.

As the generator **10** is a dual fuel generator, the engine **12** is designed to use different fuels from either a first fuel source **18** or a second fuel source **20**. In an exemplary embodiment of the invention, first fuel source **18** supplies a liquefied petroleum gas (LPG) to the engine **12** and second fuel source **20** supplies gasoline to the engine **12**, with the generator **10** selectively operating on LPG or gasoline as desired and controlled by an operator, such as for example operating on LPG for a first period of operation and then switching over to gasoline for another period of operation. However, it is contemplated that the first fuel source **18** and/or second fuel source **20** may be other types of fuel sources (e.g., natural gas, biodiesel, etc.), according to additional embodiments of the invention—and thus the scope of the invention is not meant to be limited strictly to a gasoline-LPG dual fuel embodiment.

For selectively controlling the flow of gasoline and LPG to the engine **12**, dual fuel generator **10** includes a fuel selector **22** constructed to provide for selection of a desired fuel source **18**, **20** for supplying fuel to engine **12**. The fuel selector **22** not only provides for selection of a desired fuel source **18**, **20** for supplying fuel to engine **12**, but also selectively restricts the selection of a fuel source so as to enable the use of only one fuel at a time. As a result, fuel from first fuel source **18** cannot flow to engine **12** while fuel from second fuel source **20** is flowing to engine **12**, and vice versa.

The fuel selector **22** of generator **10** is shown in greater detail in FIGS. **3-6** according to an embodiment of the invention. In general, the fuel selector **22** includes a first valve assembly **24**, a second valve assembly **26**, a selector plate **28**, a selector switch **30**, and a carburetor solenoid switch **32**. These elements of the fuel selector **22** collectively function to provide for selective control of a fuel flow (of gasoline or LPG) to the engine **12**, with the fuel selector **22** enabling selection of a desired fuel source **18**, **20** to provide a fuel flow therefrom while also inhibiting the selection of the other fuel source **18**, **20** so as to prevent a fuel flow therefrom, thereby enabling only a single fuel to flow to the engine **12** at one time.

Referring first to FIG. **3**, a front view of fuel selector **22** is shown with selector switch **30** removed therefrom, so as to best illustrate the construction of the first valve assembly **24** and the second valve assembly **26**. The first valve assembly **24** and the second valve assembly **26** are attached, respectively, to first fuel source **18** and second fuel source **20** to selectively control a flow of fuel from the fuel sources to the engine **12**. First valve assembly **24** includes a first fuel valve handle **34** that is operatively connected to a first fuel valve **36** to control an opening and closing of the first fuel valve. Similarly, second valve assembly **26** includes a second fuel valve handle **38** that is operatively connected to a second fuel valve **40** to control an opening and closing of the second fuel valve.

Each of the first valve assembly **24** and the second valve assembly **26** are movable between an ON position and an OFF position to control opening and closing of their respective fuel valve. More specifically, first and second fuel valve handles **34**, **38** are movable between an ON position and an OFF position, with the fuel valves **36**, **40** being open (to enable fuel flow to the engine **12**) when their respective fuel valve handle **34**, **38** is in the ON position and being closed (to prevent fuel flow to the engine **12**) when their respective fuel valve handle **34**, **38** is in the OFF position. Thus, when first fuel valve handle **34** is in an ON position, first fuel valve **36** is open and allows the fuel from first fuel source **18** to flow to the engine **12**, and when second fuel valve handle **38** is in an ON position, second fuel valve **40** is open and allows the fuel from second fuel source **20** to flow to the engine **12**.

In the preferred embodiments of the invention, first valve assembly **24** and second valve assembly **26** are located adjacent to each other on the same horizontal plane or parallel horizontal planes. In such an embodiment, first valve assembly **24** is in the ON position when first fuel valve handle **34** is moved to a vertical orientation/position and first valve assembly **24** is in an OFF position when first fuel valve handle **34** is moved to a horizontal orientation/position. Similarly, second valve assembly **26** is in the ON position when second fuel valve handle **38** is moved to a vertical orientation/position second valve assembly **26** is in an OFF position when second fuel valve handle **38** is moved to a horizontal orientation/position. It is recognized, however, that an alternative embodiment of the invention may have first valve assembly **24** and second valve assembly **26** located adjacent to each other on the same vertical plane or

parallel vertical planes. One having ordinary skill in the art would recognize that in such an alternative embodiment of the invention, first and second valve assemblies **24** would be in the ON position when their respective fuel valve handles **34**, **38** are horizontal, and would be in the OFF position when their respective fuel valve handles **34**, **38** are vertical.

As shown in FIG. **3**, first valve assembly **24** and second valve assembly **26** are positioned adjacent to the selector plate **28** of fuel selector **22**. The selector plate **28** may be integrally formed as part of a larger outer frame assembly of generator **10** or may be an insert attachable to such a frame assembly. Openings **42** are formed in selector plate **28** so as to accommodate positioning of the first valve assembly **24** and second valve assembly **26**—with the openings **42** enabling positioning of first and second fuel valve handles **34**, **38** in front of selector plate **28**, such that they may be actuated by an operator of the generator **10** in order to open/close their respective valves **36**, **40**. Selector plate **28** also includes slots or grooves **44** formed therein that are positioned both above and below the first and second fuel valve handles **34**, **38**, with the slots **44** extending generally in a lengthwise fashion along a length of the selector plate **28**. Each of the slots **44** is configured to receive a protrusion or flange formed on selector switch **30**, such that the selector switch **30** can be slideably coupled to the selector plate **28**—with the selector switch **30** being translatable in a linear fashion by way of its mating with the slots **44**.

Detailed views of the selector switch **30** and of its mating with the selector plate **28** are shown in FIGS. **4-6**. Referring first to FIG. **4**, the general structure of selector switch **30** is shown according to an exemplary embodiment. Protrusions or flanges **46** are formed on each of top and bottom surfaces of the selector switch **30** that are configured to mate with the corresponding slots **44** formed in selector plate **28** (FIG. **3**). The protrusions **46** may be flexible so as to accommodate coupling of the selector switch **30** to the selector plate **28**. A front surface **48** of selector switch **30** includes finger-hold depressions **50** formed therein that accommodate the fingers of an operator, with the finger-holds providing a convenient feature by which the operator can operate (i.e., slide) the selector switch **30**. A back surface **52** of the selector switch **30** includes a groove or channel **54** formed therein having a width and depth sufficient to receive the first and second fuel valve handles **34**, **38** therein when in their horizontal position (i.e., the OFF position). The groove **54** is further sized and configured such that the first and second fuel valve handles **34**, **38** will not fit therein when in their vertical position (i.e., the ON position).

Positioning of the selector switch **30** relative to the selector plate **28** and first and second valve assemblies **24**, **26** is shown in FIGS. **5** and **6**. As shown therein, positioning of the first valve assembly **24** and second valve assembly **26** adjacent selector plate **28**—and on the same horizontal plane—provides for selective positioning of the selector switch **30** relative to the fuel valve handles **34**, **38** in what are generally referred to hereafter as a first position and a second position **56**, **58**. The selector switch **30** is translatable in a horizontal motion—via a sliding motion within slots **44** of the selector plate **28**—from the first position **56** (FIG. **5**) to the second position **58** (FIG. **6**) to selectively restrict actuation of the first and second fuel valve handles **34**, **38**. As the groove **54** formed in selector switch **30** is configured such that the first and second fuel valve handles **34**, **38** will not fit therein when in their vertical position (i.e., the ON position), it is recognized that in order to translate the selector switch **30** back and forth between the first and second positions **56**, **58**, both of the fuel valve handles **34**, **38** must be in their horizontal OFF position.

In FIG. **5**, selector switch **30** is illustrated in the first position **56**. When selector switch **30** is in first position **56**, selector switch **30** covers second fuel valve handle **38**, and groove **54** formed on the back surface **52** of the fuel selector switch **30** locks second fuel valve handle **38** in an OFF position, so as to prohibit the second valve assembly **26** from moving to the ON position. Further, when selector switch **30** is in first position **56**, first valve assembly **24** is able to move freely between the ON position and the OFF position, with the first fuel valve handle **34** being actuatable by the operator. In one embodiment of the invention, when first valve assembly **24** is in the ON position, first fuel valve handle **34** is in a vertical position and prevents selector switch **30** from moving horizontally from first position **56** to second position **58**.

In operation, when selector switch **30** is moved from second position **58** into first position **56**, second fuel valve handle **38** slides into the groove **54** formed in selector switch **30**. As a result, when selector switch **30** is in first position **56**, second fuel valve handle **38** is unable to move, as it is locked in place by groove **54**, and second valve assembly **26** is locked in the OFF position, with movement from the OFF position to the ON position being prohibited.

IN FIG. **6**, selector switch **30** is illustrated in the second position **58**. When selector switch **30** is in second position **58**, selector switch **30** covers first fuel valve handle **34**, and groove **54** formed on the back surface **52** of the fuel selector switch **30** locks first fuel valve handle **34** in an OFF position, so as to prohibit the first valve assembly **24** from moving to the ON position. In addition, when selector switch **30** is in second position **58**, second valve assembly **26** is able to freely move between the ON position and the OFF position, with the second fuel valve handle **38** being actuatable by the operator. In one embodiment of the invention, when second valve assembly **26** is in the ON position, second fuel valve handle **38** is in a vertical position and prevents selector switch **30** from moving horizontally from second position **58** to first position **56**.

In operation, when selector switch **30** is moved from first position **56** into second position **58**, first fuel valve handle **34** slides into groove **54** formed in selector switch **30**. Therefore, when selector switch **30** is in second position **58**, first fuel valve handle **34** is unable to move, as it is locked in place by groove **54**, and first valve assembly **24** is locked in the OFF position, with movement from the OFF position to the ON position being prohibited.

Referring still now to FIG. **6**, according to an exemplary embodiment of the invention, the fuel selector **22** of generator **10** further comprises a carburetor solenoid switch **32** that is positioned within an opening **60** formed in selector plate **28** so as to extend therethrough and is further positioned adjacent second valve assembly **26** (i.e., second fuel valve handle **38**. As solenoid switch **32** is located adjacent to the second valve assembly **26**—which is in turn connected to the gasoline fuel source **20**—selector switch **30** covers and triggers solenoid switch **32** when slid from the second position **58** to the first position **56**—by depressing the solenoid switch **32** as it comes in contact therewith. When solenoid switch **32** is triggered, a carburetor shutoff solenoid operatively connected to the solenoid switch **32** is activated and shuts off the flow of gasoline to the carburetor **16** (FIG. **2**). In the preferred embodiment of the invention, solenoid switch **32** is a depressible switch, but it is contemplated that solenoid switch **32** may be another type of switch that can be activated via interaction with selector switch **30**

or via interaction with either valve handle **34**, **38**, so as to activate the carburetor shutoff solenoid.

Beneficially, the design of the fuel selector **22** and of the selector switch **30** described herein prevents differing fuels from two separate fuel sources from flowing to the engine of a dual fuel generator at the same time. The interaction of the selector switch **30** with the first and second fuel valve assemblies **24**, **26**—with the selector switch **30** sliding back and forth to selectively cover/engage first and second fuel valve assemblies **24**, **26**—prohibits both valve assemblies from being in the "ON" position at the same time. The selector switch **30** is thus a foolproof device that prevents the mixing of fuels so as to provide additional safety to the usage of dual fuel generators.

Therefore, according to one embodiment of the invention, a fuel selector for use with a dual fuel generator includes a selector plate, a first fuel valve assembly positioned adjacent the selector plate and actuatable between an ON position and an OFF position to selectively control a first fuel flow to an engine of the dual fuel generator, and a second fuel valve assembly positioned adjacent the selector plate and actuatable between an ON position and an OFF position to selectively control a second fuel flow to the engine of the dual fuel generator. The fuel selector also includes a selector switch coupled to the selector plate so as to be linearly translatable from a first position to a second position, wherein translation of the selector switch between the first and second positions enables positioning of only one of the first fuel valve assembly and the second fuel valve assembly in the ON position at a given time, such that the first and second fuel valve assemblies cannot be in the ON position concurrently.

According to another embodiment of the invention, a method of controlling fuel flow in a dual fuel generator includes providing a first fuel valve assembly to control fuel flow from a first fuel source to an internal combustion engine of the dual fuel generator, the first fuel valve assembly including a first fuel valve handle movable between an ON position and an OFF position to control fuel flow from the first fuel source to the internal combustion engine. The method also includes providing a second fuel valve assembly to control fuel flow from a second fuel source to the internal combustion engine of the dual fuel generator, the second fuel valve assembly including a second fuel valve handle movable between an ON position and an OFF position to control fuel flow from the second fuel source to the internal combustion engine. The method further includes providing a fuel selector switch adjacent the first fuel valve assembly and the second fuel valve assembly such that the fuel selector switch is translatable to a first position and a section position, wherein the fuel selector switch is translatable between the first position and the section position to selectively inhibit actuation of the first fuel valve handle and the second fuel valve handle, so as to prevent a simultaneous flow of fuels from the first and second fuel sources to the internal combustion engine.

According to yet another embodiment of the invention, a dual fuel generator includes a first fuel source, a second fuel source, and an internal combustion engine coupled to the first fuel source and the second fuel source to selectively receive fuel therefrom. The dual fuel generator also includes a fuel selector configured to control a flow of fuel from the first and second fuel sources to the internal combustion engine, with the fuel selector comprising a first fuel valve assembly including a first fuel valve and a first fuel valve handle that is actuatable between an open position and a closed position to selectively open and close the first fuel valve, a second fuel valve assembly including a second fuel valve and a second fuel valve handle that is actuatable between an open position and a closed position to selectively open and close the second fuel valve, a selector plate having the first fuel valve assembly and the second fuel valve assembly coupled to a front side thereof, and a selector switch slideably coupled to the selector plate so as to be movable from a first position to a second position. Positioning of the selector switch in the first position causes the selector switch to cover the second fuel valve handle so as to prevent the second fuel valve handle from moving to the open position and positioning of the selector switch in the second position causes the selector switch to cover the first fuel valve handle so as to prevent the first fuel valve handle from moving to the open position.

While the invention has been described in connection with only a limited number of embodiments, it should be readily understood that the invention is not limited to such disclosed embodiments. Rather, the invention can be modified to incorporate any number of variations, alterations, substitutions or equivalent arrangements not heretofore described, but which are commensurate with the spirit and scope of the invention. Additionally, while various embodiments of the invention have been described, it is to be understood that aspects of the invention may include only some of the described embodiments. Accordingly, the invention is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

What is claimed is:

1. A fuel selector for use with a dual fuel generator, the fuel selector comprising:

a valve assembly fluidly connected to each of a first fuel source and a second fuel source, the valve assembly being operable to selectively control a first fuel flow and a second fuel flow from the first fuel source and the second fuel source, respectively, to an engine of the dual fuel generator; and

a selector switch positioned on the valve assembly to allow a user to manually select one of the first fuel flow and the second fuel flow;

wherein the valve assembly comprises:

two fuel inputs, with a first fuel input connected to the first fuel source and a second fuel input connected to the second fuel source; and

two fuel outputs for selectively supplying fuel to the engine from the first fuel source or the second fuel source.

2. The fuel selector of claim **1** wherein the two fuel outputs selectively supply fuel to the engine from only one of the first fuel source or the second fuel source, responsive to selection of the first fuel flow or the second fuel flow via the selector switch, and a corresponding operation of the valve assembly.

3. The fuel selector of claim **1** wherein the valve assembly comprises:

a first fuel valve having open and closed positions to selectively control the first fuel flow to the engine; and

a second fuel valve having open and closed positions to selectively control the second fuel flow to the engine.

4. The fuel selector of claim **3** wherein the first fuel valve and the second fuel valve are non-solenoid, mechanical valves.

5. The fuel selector of claim **3** wherein the selector switch provides for manual actuation of the first fuel valve and the second fuel valve between the open and closed positions.

6. The fuel selector of claim 1 further comprising a carburetor solenoid switch configured to activate an associated carburetor solenoid when actuated.

7. The fuel selector of claim 6 wherein, when the selector switch is in a first position, the selector switch actuates the carburetor solenoid switch, so as to activate the carburetor solenoid and stop the second fuel flow to the engine.

8. The fuel selector of claim 7 wherein, when the selector switch is in a second position, the carburetor solenoid allows the second fuel flow to the engine.

9. The fuel selector of claim 1 wherein the first fuel source is a liquefied petroleum gas (LPG) fuel source and wherein the second fuel source is a gasoline source.

10. A fuel selector of a dual fuel generator comprising: a selector switch having a first fuel mode and a second fuel mode; a fuel solenoid having open and closed positions; and a solenoid switch having open and closed positions to activate and deactivate the fuel solenoid; wherein, when the selector switch is in the first fuel mode, the solenoid switch and the fuel solenoid are in the closed positions and, when the selector switch is in the second fuel mode, the solenoid switch and the fuel solenoid are in the open positions; and further comprising: a valve assembly fluidly connected to each of a first fuel source and a second fuel source, the valve assembly being operable to selectively control a first fuel flow and a second fuel flow from the first fuel source and the second fuel source, respectively, to an engine of the dual fuel generator; and wherein positioning of the selector switch in the first fuel mode and the second fuel mode enables a selection of one of the first fuel flow and the second fuel flow.

11. The fuel selector of claim 10 wherein the selector switch triggers the solenoid switch when changed from the second fuel mode to the first fuel mode, so as to cause the solenoid switch and the fuel solenoid to operate in the closed positions.

12. The fuel selector of claim 10 wherein the valve assembly is positioned on or adjacent the selector switch.

13. The fuel selector of claim 10 wherein the valve assembly comprises: two fuel inputs, with a first fuel input connected to the first fuel source and a second fuel input connected to the second fuel source; and two fuel outputs for selectively supplying fuel to the engine from the first fuel source or the second fuel source.

14. The fuel selector of claim 13 wherein the two fuel outputs selectively supply fuel to the engine from only one of the first fuel source or the second fuel source, responsive to selection of the first fuel flow or the second fuel flow via the selector switch and a corresponding operation of the valve assembly.

15. The fuel selector of claim 13 wherein the valve assembly comprises:

a first fuel valve having open and closed positions to selectively control the first fuel flow to the engine; and

a second fuel valve having open and closed positions to selectively control the second fuel flow to the engine.

16. The fuel selector of claim 10 wherein the first fuel source is a liquefied petroleum gas (LPG) fuel source and wherein the second fuel source is a gasoline source.

17. The fuel selector of claim 10 wherein the fuel solenoid is a carburetor shutoff solenoid.

18. The fuel selector of claim 10 wherein positioning the selector switch in the first fuel mode enables the selection of the first fuel source to the generator, and positioning the selector switch in the second fuel mode enables the selection of the second fuel source to the generator.

* * * * *

EXHIBIT G

US011492985B2

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

(10) **Patent No.: US 11,492,985 B2**
(45) **Date of Patent: Nov. 8, 2022**

(54) **OFF-BOARD FUEL REGULATOR FOR GENERATOR ENGINE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 6 days.

(21) Appl. No.: **16/783,455**

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F02D 19/06 (2006.01)

(52) **U.S. Cl.**
CPC ***F02D 19/0613*** (2013.01); ***F02D 19/0605*** (2013.01); ***F02D 19/0647*** (2013.01); ***F02D 19/0673*** (2013.01); *Y02T 10/30* (2013.01)

(58) **Field of Classification Search**
CPC F02D 19/0613; F02D 19/0605; F02D 19/0647; Y02Y 10/36
See application file for complete search history.

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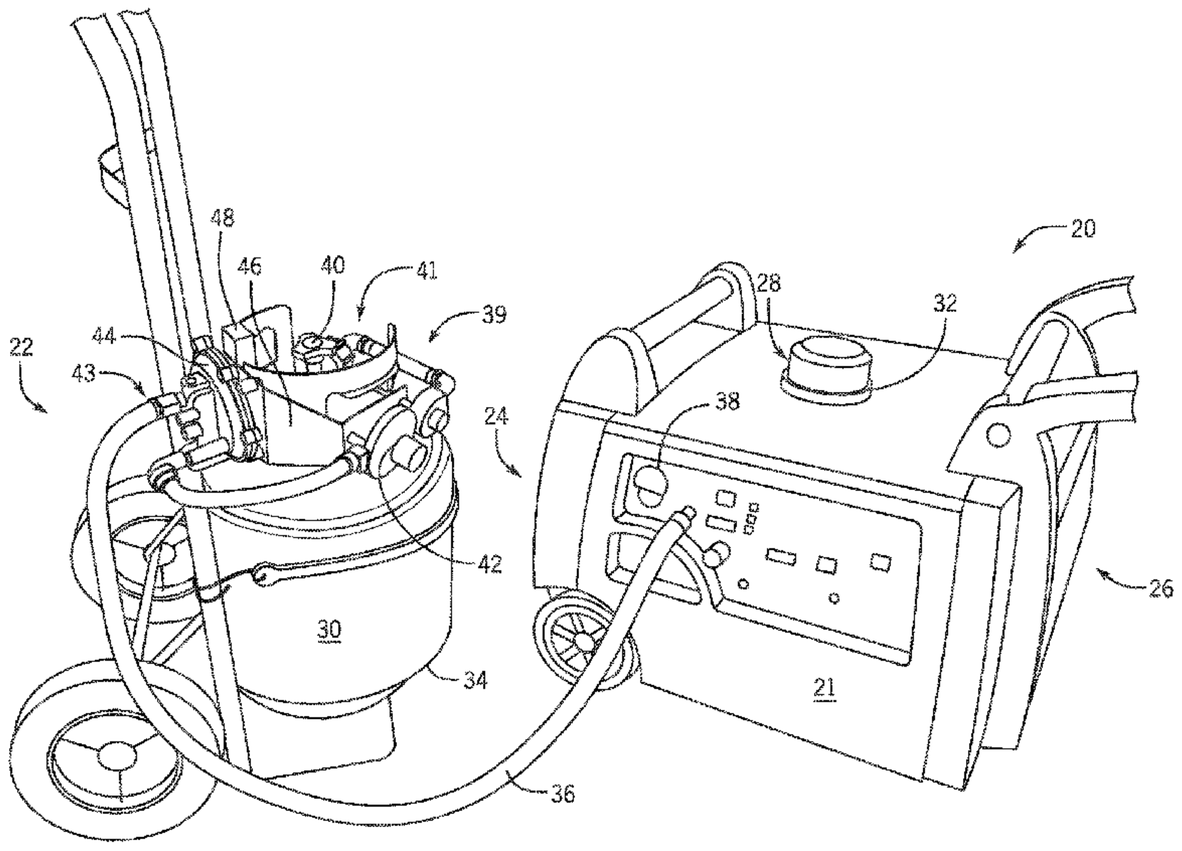
Primary Examiner — Kevin A Lathers
(74) *Attorney, Agent, or Firm* — Ziolkowski Patent Solutions Group, SC

(57) **ABSTRACT**

A generator and off-board fuel delivery system is disclosed. The generator is configured to operate on one or more fuels, including on a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line. A fuel regulator system is located off board the generator and is configured to regulate the gaseous fuel supplied from the pressurized fuel source in a first stage, with the gaseous fuel regulated down to a reduced pressure in the first stage. A second stage of the fuel regulator system regulates the reduced pressure gaseous fuel, with the reduced pressure gaseous fuel from the first stage regulated down to a desired pressure in the second stage for delivery through the gaseous fuel line to operate the generator.

19 Claims, 5 Drawing Sheets



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No. 14/738,060, filed on Jun. 12, 2015, now Pat. No. 10,221,780.

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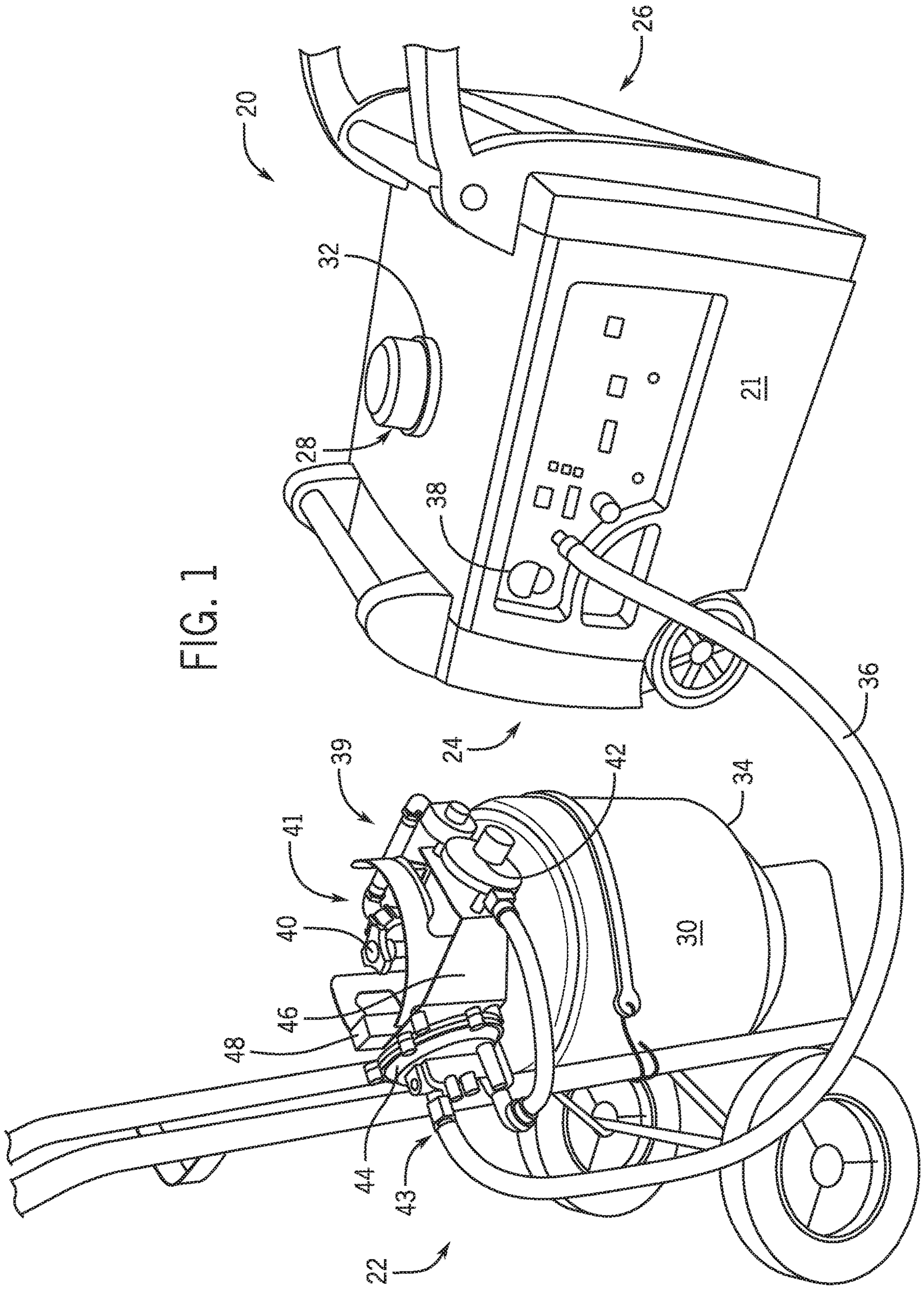
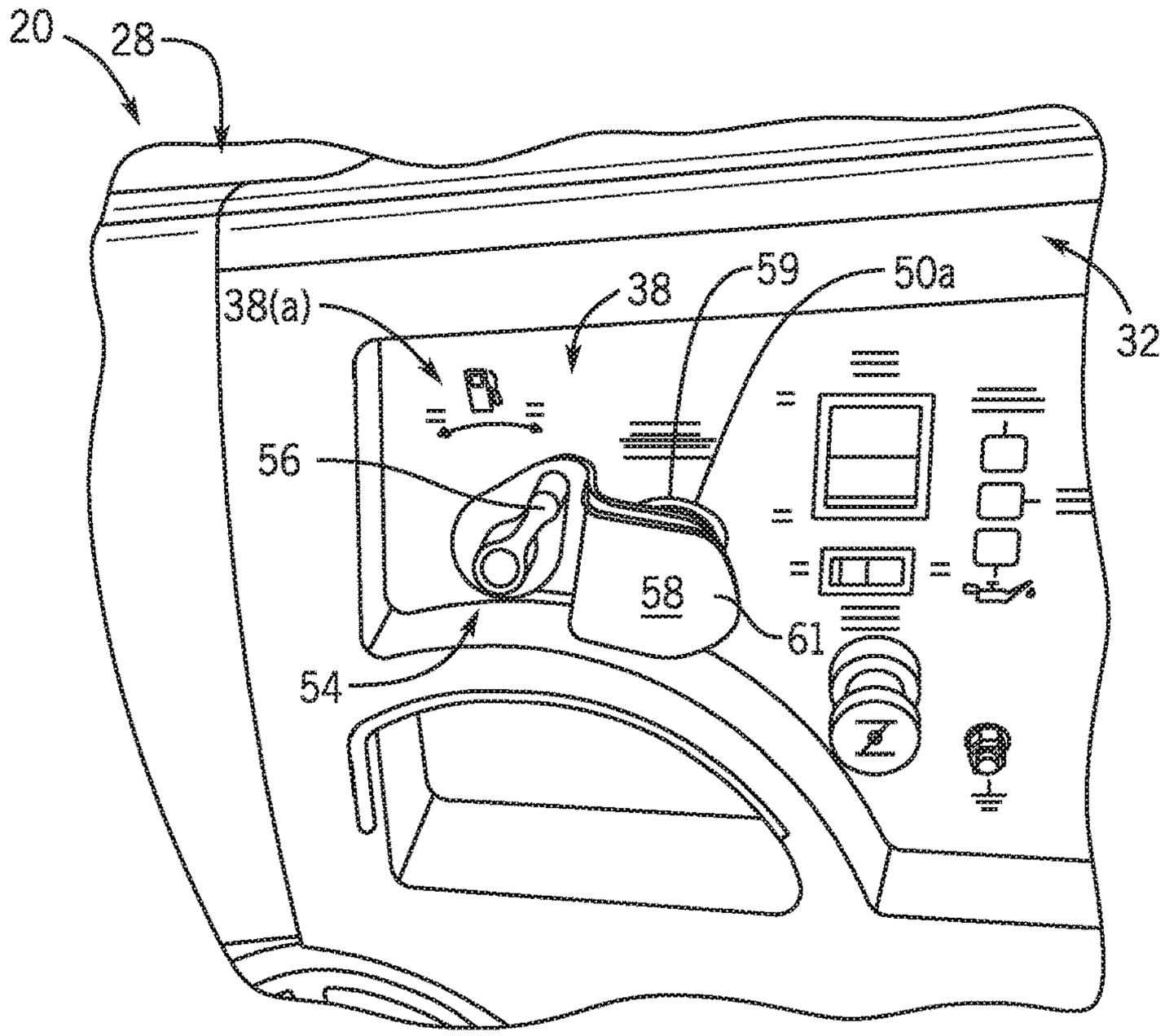
FIG. 1




20
28
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38
59
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32
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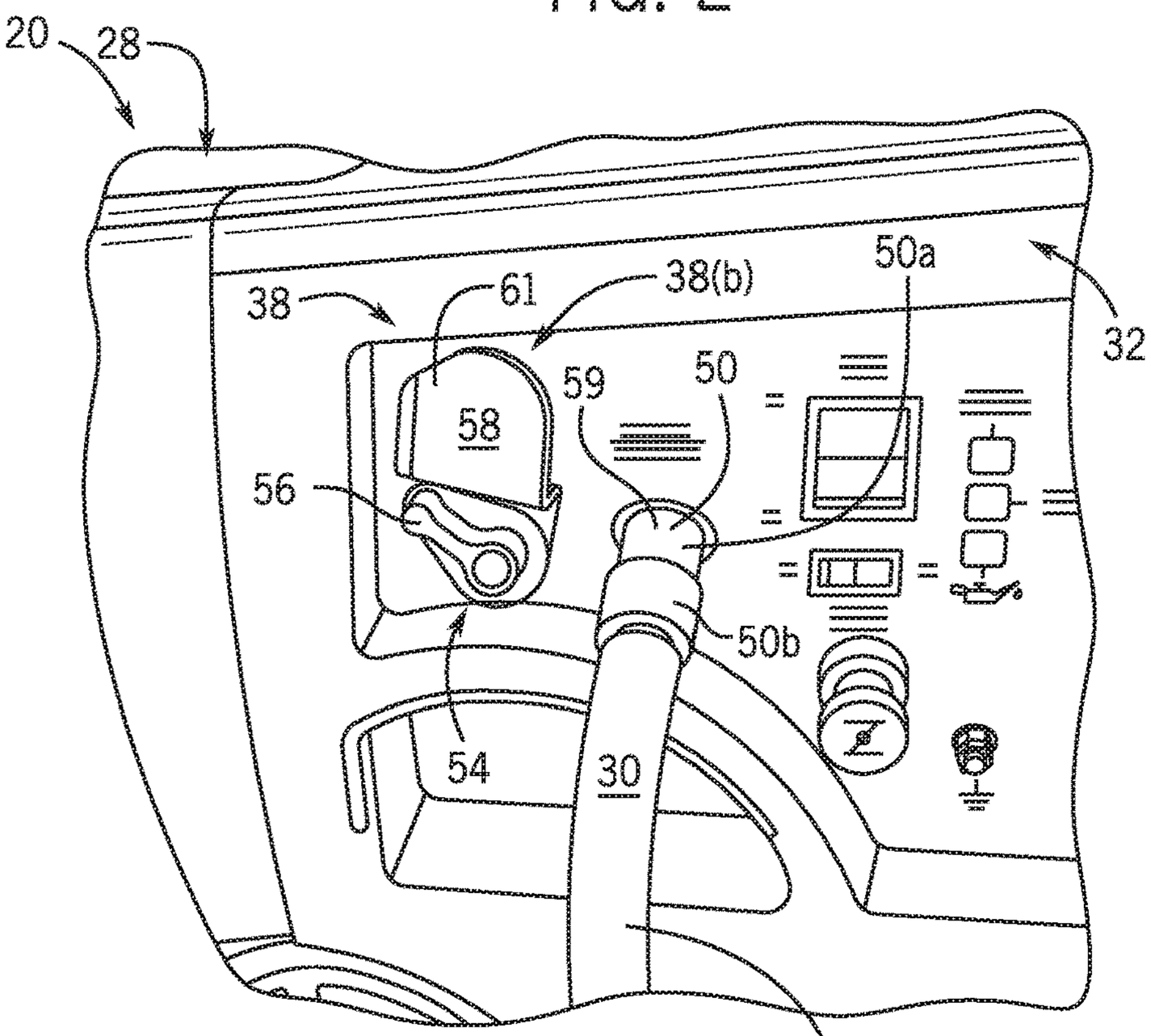
54

FIG. 2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50b
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30
36

FIG. 3

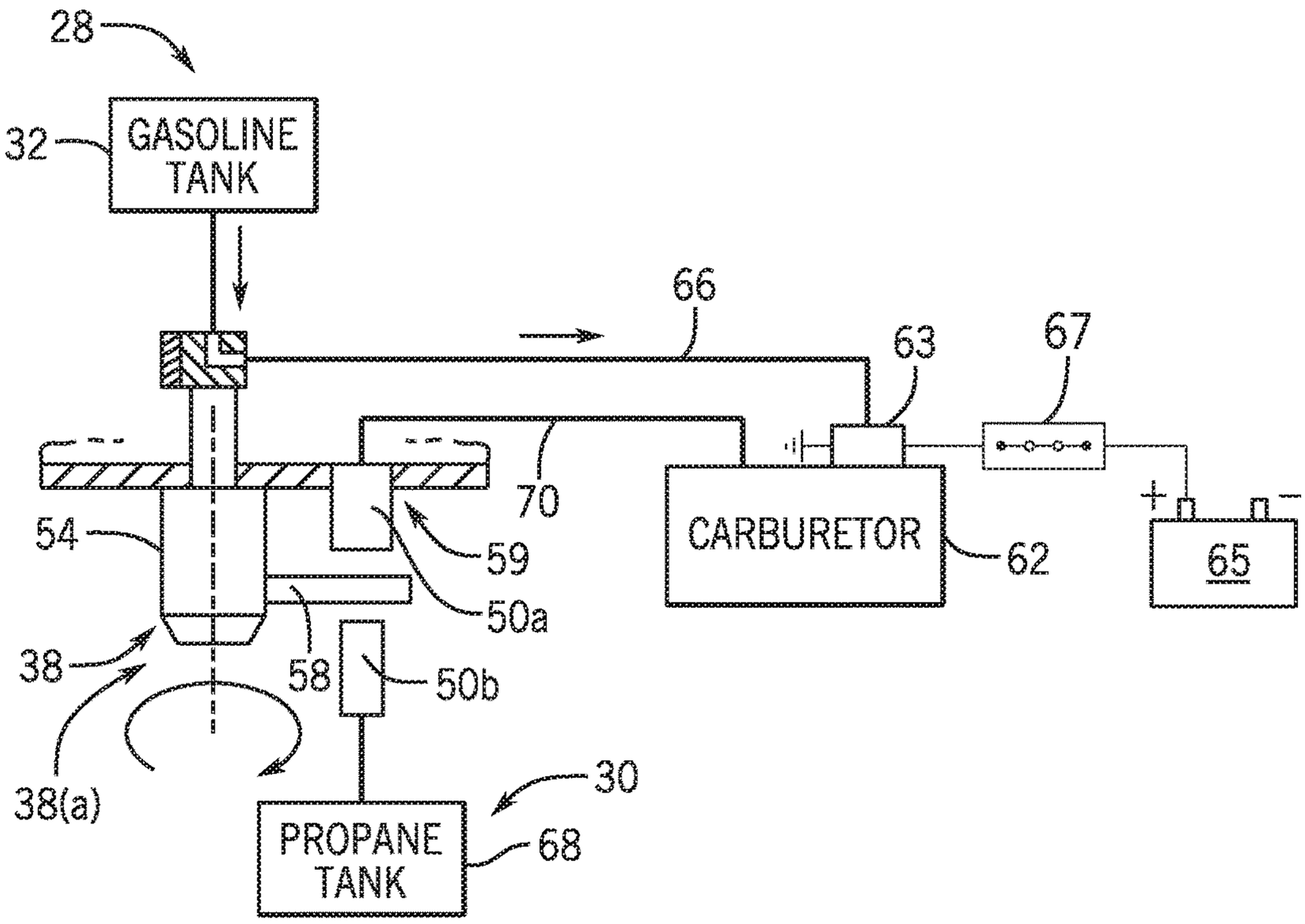

FIG. 4A

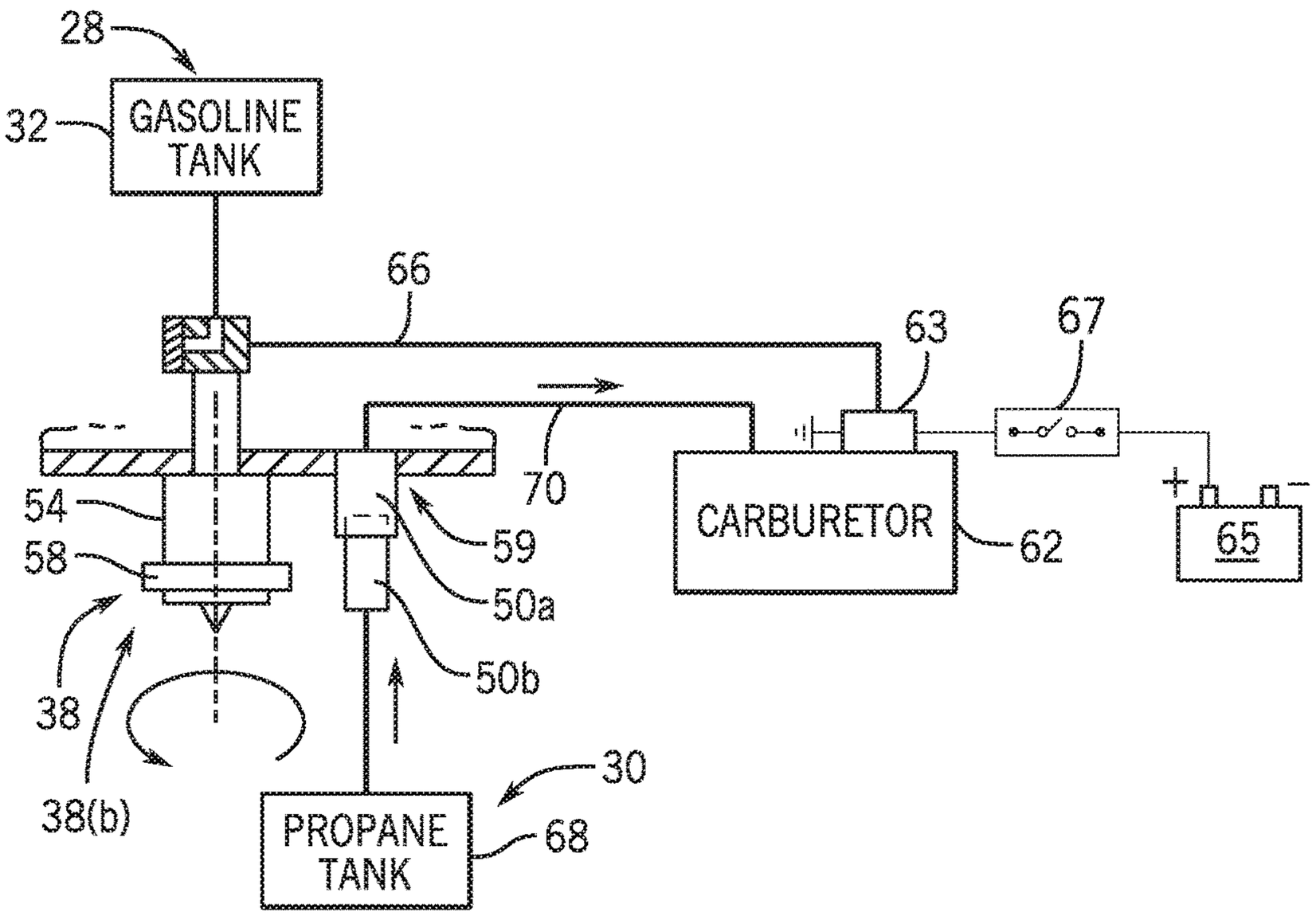

FIG. 4B

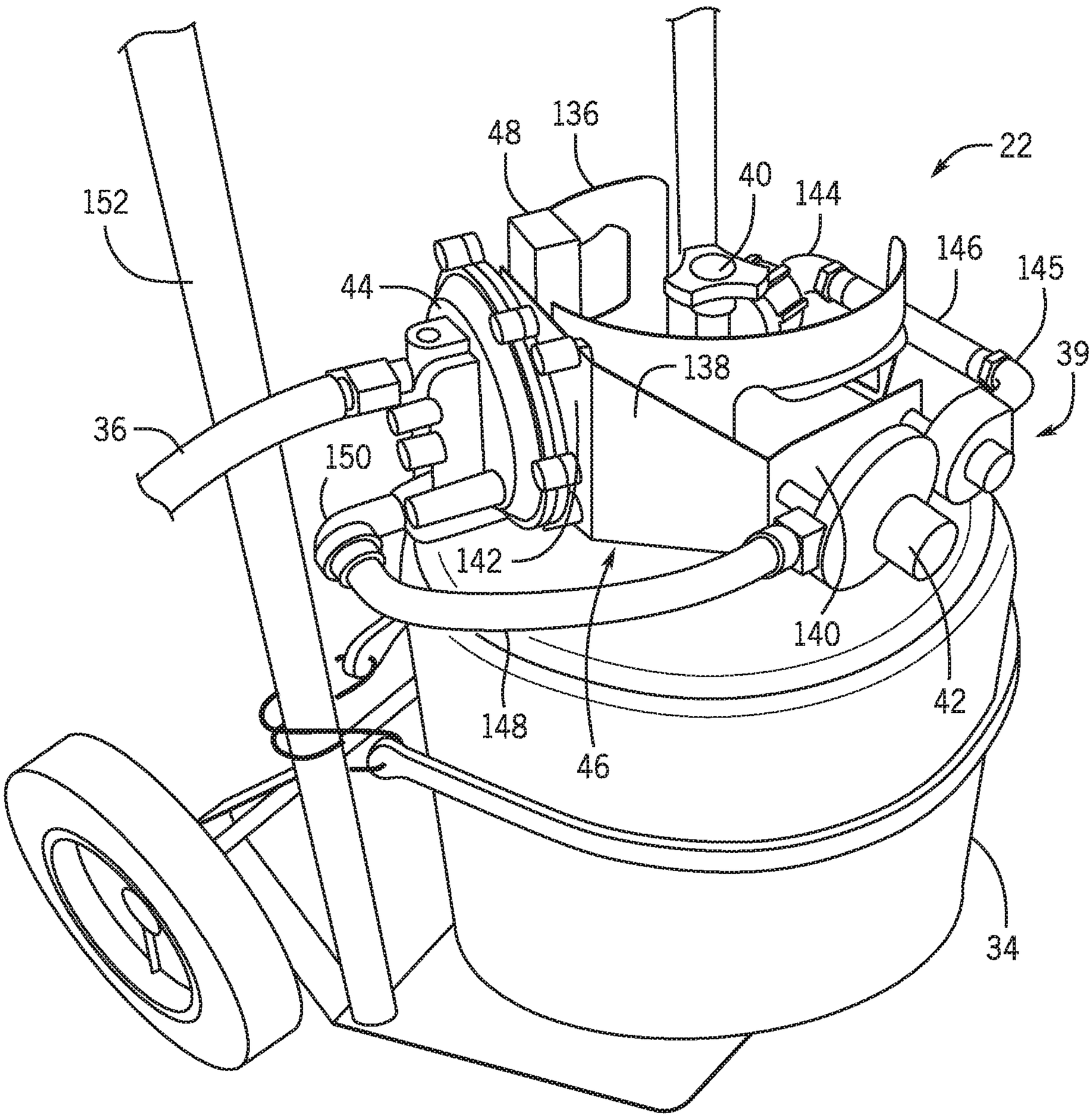

FIG. 5

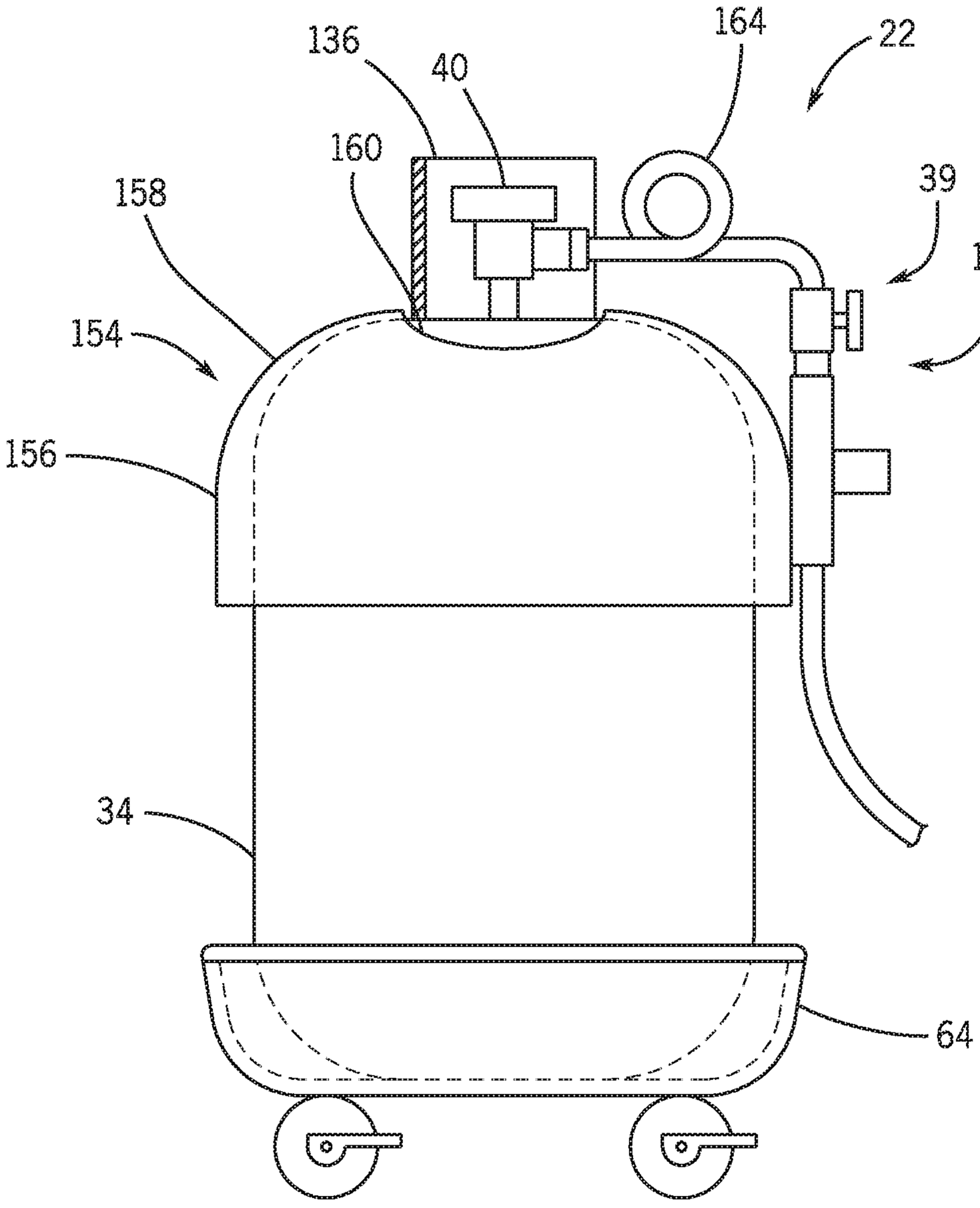

FIG. 6

OFF-BOARD FUEL REGULATOR FOR GENERATOR ENGINE

CROSS-REFERENCE TO RELATED APPLICATION

The present application is a continuation of, and claims priority to, U.S. patent application Ser. No. 16/191,503, filed on Nov. 15, 2018, which is a continuation of, and claims priority to, U.S. patent application Ser. No. 14/738,060, filed on Jun. 12, 2015, now U.S. Pat. No. 10,221,780, issued Mar. 5, 2019, the disclosures of which are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

Embodiments of the invention relate generally to dual fuel generators, and more particularly, to an apparatus and method for delivering liquid fuel and gaseous fuel to a dual fuel generator.

Electric generators are frequently driven by internal combustion engines that use gasoline as a fuel source. Gasoline is a common fuel source for generators in a variety of applications. However, alternative fuel sources also provide a desirable fuel source. For instance, alternative fuels may provide a clean burning fuel that limits hazardous emissions. Alternative fuels may also be stored for long periods of time without degradation, whereas gasoline can degrade over a period of months leading to hard starting, rough running, and also lead to gum and varnish deposit left in the fuel system. In addition, generators that operate on alternative fuels may generate electricity when gasoline is not readily available. For instance, generators are frequently used when power outages in the utility grid result from severe weather. Unfortunately, gas stations may also be closed as a result of the power outage. Such a circumstance presents just one example where it would be advantageous to operate electrical generators on alternative fuels.

Certain generators are configured to operate as "dual fuel" generators, otherwise known as bi-fuel generators. These generators are driven by an internal combustion engine that is configured to operate on a liquid fuel for a period of operation and an alternative fuel for another period of operation. The alternative fuel source may exist in a gaseous state at normal temperature and pressure and can be any one of liquefied petroleum gas, compressed natural gas, hydrogen, or the like. Liquefied petroleum gas (LPG), often referred to as propane, exists in a gaseous state at normal temperature and pressure but can be conveniently stored under pressure in a liquid state. LPG may be a desirable fuel source for internal combustion engines because it can be stored for longer periods of time and contains fewer impurities than gasoline, resulting in smoother and cleaner operation, and often resulting in a longer lasting engine.

In order to provide the liquid and gaseous fuel to the engine, the dual fuel engine may have a first fuel line for liquid fuel and a second fuel line for gaseous fuel. A liquid fuel source and a gaseous fuel source may be coupled to the respective lines to provide fuel to the engine. However, a common problem with such configurations that couple two fuel sources to a single engine is the engine can experience overly rich air-fuel ratio when both fuels are simultaneously engaged during cross-over switching between the fuel sources. Further, such simultaneous delivery of fuel from the first fuel line and the second fuel line may make the engine hard to start or lead to unstable operating conditions.

Therefore, it would be desirable to design a dual fuel generator having a liquid fuel and gaseous fuel delivery system that overcomes the aforementioned detriments without substantially increasing the overall cost of the system.

BRIEF DESCRIPTION OF THE INVENTION

In accordance with one aspect of the invention, a mechanical fuel lockout switch for a dual fuel engine provides for the selection of a desired fuel to operate the engine. The mechanical fuel lockout switch includes a mechanical fuel valve and a fuel lockout apparatus. The mechanical fuel valve actuates between a first position and a second position to selectively control fuel flow to the dual fuel engine from a first fuel source through a first fuel line and a second fuel source through a second fuel line. The fuel lockout apparatus couples to the mechanical fuel valve ensuring individual communication of the fuel sources to the engine. The mechanical fuel lockout switch communicates the first fuel source to the dual fuel engine and prevents communication between the second fuel source and the dual fuel engine when the mechanical fuel valve is in the first position, and communicates the second fuel source to the dual fuel engine and interrupts the first fuel source communication with the dual fuel engine when in the second position.

In accordance with another aspect of the invention, a dual fuel generator and fuel delivery system includes a dual fuel generator configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line. The dual fuel generator and fuel delivery system also includes a fuel regulator system located off board the dual fuel generator to control the pressure of fuel from the pressurized fuel source and deliver the fuel at a desired pressure for operation of the generator. The fuel regulator system includes a primary pressure regulator coupled to a service valve of the pressurized fuel source and configured to regulate the fuel supplied from the pressurized fuel source to a reduced pressure. The fuel regulator system also includes a secondary pressure regulator coupled to the primary pressure regulator and configured to regulate the gaseous fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the dual fuel generator. The dual fuel generator and fuel delivery system further includes a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel generator from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line.

In accordance with yet another aspect of the invention, a method of assembling a mechanical fuel lockout switch for an internal combustion engine includes providing an internal combustion engine configured to operate on a fuel from a first fuel source and a different fuel from a second fuel source. The method also includes coupling a mechanical fuel valve to the internal combustion engine actuatable between a first position and a second position to selectively control fuel flow to the internal combustion engine from the first fuel source through a first fuel line and the second fuel source through a second fuel line. The method further includes coupling a fuel lockout apparatus to the mechanical fuel valve. When the mechanical fuel valve is in the first position, the fuel lockout apparatus communicates the first fuel source to the internal combustion engine and prevents the second fuel source from coupling to the internal combustion engine,

and actuation of the mechanical fuel valve to the second position causes the fuel lockout apparatus to permit the second fuel source to couple to the internal combustion engine, and interrupts the first fuel source communication with the internal combustion engine.

Various other features and advantages will be made apparent from the following detailed description and the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings illustrate preferred embodiments presently contemplated for carrying out the invention.

In the drawings:

FIG. **1** is a perspective view of a dual fuel generator coupled to a fuel delivery system, according to an embodiment of the invention.

FIG. **2** is a detail view of a portion of the generator of FIG. **1** about a mechanical fuel lockout switch with the switch in a first position, according to an embodiment of the invention.

FIG. **3** is a detail view similar to FIG. **2** and showing the mechanical fuel lockout switch in a second position, with an LPG supply line connected thereto, according to an embodiment of the invention.

FIG. **4**A is a schematic diagram of a fuel system for the dual fuel generator of FIG. **1** showing a liquid fuel source in communication with a carburetor of the generator consistent with the first position of the switch as shown in FIG. **2**, according to an embodiment of the invention.

FIG. **4**B is a schematic diagram of the fuel system of FIG. **4**A showing a gaseous fuel source in communication with a carburetor of the generator of FIG. **1** consistent with the second position of the switch as shown in FIG. **3**, according to an embodiment of the invention.

FIG. **5** is a perspective view of a fuel delivery system for the dual fuel generator of FIG. **1**, according to an embodiment of the invention.

FIG. **6** is a side view of a fuel delivery system for the dual fuel generator of FIG. **1**, according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The operating environment of the invention is described with respect to a dual fuel generator. However, it will be appreciated by those skilled in the art that the invention is equally applicable for use with any dual fuel internal combustion engine. Moreover, the invention will be described with respect to a dual fuel generator configured to operate on a liquid fuel and a gaseous fuel. However, one skilled in the art will further appreciate that the invention is equally applicable for use with other fuel combinations for dual fuel generators and internal combustion engines.

Referring to FIG. **1**, a dual fuel generator **20** is coupled to a fuel delivery system **22**, in accordance with an embodiment of the invention. Dual fuel generator **20** includes an internal combustion engine (not shown) within housing **21** at one end **24**, operatively connected to an alternator also enclosed in housing **21** at another end **26**, by conventional means. Dual fuel generator **20** is configured to operate on different fuels via either a first fuel source **28** or a second fuel source **30**. In an exemplary embodiment of the invention, first fuel source **28** is a liquid fuel and second fuel source **30** is a gaseous fuel. The liquid fuel may be gasoline and the gaseous fuel may be liquid petroleum gas (LPG). Each can selectively operate the generator as desired and controlled by an operator. For instance, generator **20** may operate on gasoline for a first period of operation and then switch to LPG for a second period of operation. However, it is contemplated that dual fuel generator **20** is configured to operate on fuels other than gasoline and LPG (e.g., natural gas, biodiesel, etc.), and thus the scope of the invention is not meant to be limited strictly to a dual fuel arrangement where first fuel source **28** provides gasoline and second fuel source **30** provides LPG.

In one embodiment of the invention, dual fuel generator **20** includes a gasoline tank **32** or, generally, a liquid fuel tank, located inside cover **21** onboard generator **20** to provide gasoline to the engine as first fuel source **28**. Gasoline tank **32** connects to a first fuel line to provide gasoline to the carburetor to run the engine, as will later be described with reference to FIGS. **4**A and **4**B. Generator **20** is also coupled to a pressurized fuel container **34**, or a pressurized fuel source, located off board generator **20** to provide LPG to the engine as second fuel source **30**. Pressurized fuel container **34** is coupled to generator **20** with an LPG supply hose **36**. LPG supply hose **36** is coupled to a second fuel line within generator **20** to provide LPG to the carburetor to run the engine. Dual fuel generator **20** includes a mechanical fuel lockout switch **38** for selecting a desired fuel to be provided to the engine. The mechanical fuel lockout switch **38** is actuated to select first fuel source **28** when in a first position, as shown in FIG. **2**, and alternately to select second fuel source **30** when in a second position, as shown in FIG. **3**.

Referring back to FIG. **1**, in an exemplary embodiment, fuel **30** from pressurized fuel container **34** is regulated using a fuel regulator system **39** for delivery to the engine. Fuel regulator system **39** includes one or more pressure regulators that reduce and control the pressure of the fuel from pressurized fuel container **34** and delivers fuel at a desired pressure for operation of the engine. Fuel regulator system **39** has an inlet **41** operatively coupled to a service valve **40** of pressurized fuel container **34** and an outlet **43** coupled to LPG supply hose **36**. Fuel regulator system **39** includes a primary pressure regulator **42** coupled to pressurized fuel container **34** and a secondary pressure regulator **44**. Primary pressure regulator **42** protects downstream components from high pressure of pressurized fuel container **34**. Primary pressure regulator **42** receives LPG through service valve **40** of pressurized fuel container **34** and reduces the pressure of the LPG to a first stage. In one embodiment of the invention, the first stage may be delivered directly to generator **20** at a pressure required for operation of the engine.

In an exemplary embodiment of the invention, fuel regulator system **39** includes secondary pressure regulator **44** coupled to the outlet of primary pressure regulator **42** in order to use standard "off-the-shelf" components. Typically, the primary pressure regulator is mounted on the LPG tank, while the secondary pressure regulator is mounted on the component using the fuel, such as an engine or grill. Here, since generator **20** can be used as a gasoline only generator, secondary pressure regulator **44** is mounted off-board the generator to reduce size and cost of the generator. Secondary pressure regulator **44** receives LPG from primary pressure regulator **42** and further reduces the pressure of LPG to a second stage to be delivered to generator **20**. In a system with two regulators, primary pressure regulator **42** regulates fuel received from pressurized fuel container **34** and reduces the pressure of the fuel to a level required for operation of secondary pressure regulator **44**. Secondary pressure regulator **44** regulates fuel received from primary pressure

regulator **42** and further reduces the pressure of the fuel to a level required for operation of generator **20**. In addition, primary pressure regulator **42** may compensate for varying tank pressure as fuel is depleted while secondary pressure regulator **44** may compensate for varying demand from generator **20**.

In accordance with an exemplary embodiment of the invention, fuel regulator system **39** includes both the primary and secondary regulators, or a custom single regulator, but in any case is located remotely, or off-board, from dual fuel generator **20**. Fuel regulator system **39** may be directly mounted to pressurized fuel container **34** using a regulator mounting bracket **46**. Regulator mounting bracket **46** has mounting locations for primary pressure regulator **42** and secondary pressure regulator **44**. Regulator mounting bracket **46** also has a securing mechanism **48** to secure regulator mounting bracket **46** to pressurized fuel container **34**.

In another embodiment of the invention, primary pressure regulator **42** is mounted on regulator mounting bracket **46** while secondary pressure regulator **44** could be mounted on or near generator **20**. In yet another embodiment of the invention, a dual stage regulator may regulate the fuel received from pressurized fuel container **34** and deliver fuel at a pressure required for operation of generator **20**. Such a dual stage regulator may regulate the fuel to the second stage within a single structure. The dual stage regulator may be mounted directly on fuel container **34**.

Referring to FIG. **2**, a detail view of a portion of generator **20** of FIG. **1** depicts mechanical fuel lockout switch **38** in a first position **38**(*a*), in accordance with an embodiment of the invention. In this position, mechanical fuel lockout switch **38** provides gasoline flow from gasoline tank **32** to the engine while preventing connection of an LPG supply line to fuel inlet **59** of the second fuel line, as will later be discussed in detail with reference to FIGS. **4**A and **4**B. Still referring to FIG. **2**, mechanical fuel lockout switch **38** provides a combination liquid fuel shutoff valve and a gaseous fuel supply lockout that prevents simultaneous delivery of fuel to the engine from gasoline tank **32** and pressurized fuel container **34**, FIG. **1**. As such, mechanical fuel lockout switch **38** provides a fuel selector to ensure only the selected fuel is provided to dual fuel generator **20**.

Mechanical fuel lockout switch **38**, FIG. **2**, includes mechanical fuel valve **54** actuatable between first position **38**(*a*) as shown in FIG. **2** and second position **38**(*b*) as shown in FIG. **3** to selectively control fuel flow to the dual fuel engine from first fuel source **28** through a first fuel line and second fuel source **30** through a second fuel line **36**. Mechanical fuel lockout switch **38** may also include fuel lockout apparatus **58** coupled to mechanical fuel valve **54** to communicate fuel sources individually to generator **20**. In one embodiment of the invention, fuel lockout apparatus **58** communicates first fuel source **28** to the engine by actuating mechanical fuel valve **54** to first position **38**(*a*) to open the first fuel line as shown in FIG. **2**, and communicates second fuel source **30** to the engine by actuating mechanical fuel valve **54** to second position **38**(*b*) to open communication of the second fuel source **30** to the engine as shown in FIG. **3**. Referring back to FIG. **2**, when mechanical fuel valve **54** is in first position **38**(*a*), fuel lockout apparatus **58** communicates first fuel source **28** to the dual fuel engine and prevents communication between the second fuel source and the dual fuel engine.

In an exemplary embodiment of the invention, mechanical fuel valve **54** controls the flow of LPG to the engine by actuating fuel lockout apparatus **58** to block or unblock fuel inlet **59** for the second fuel source. Mechanical fuel valve **54** is coupled to the first fuel line, as shown in FIGS. **4**A and **4**B, and therefore can control the flow of gasoline to the engine by opening and closing the first fuel line. When the mechanical fuel valve **54**, FIG. **2**, is in the first position **38**(*a*), gasoline flows from the gasoline tank to the engine and the fuel lockout apparatus **58** blocks the fuel inlet **59**. Accordingly, fuel lockout apparatus **58** prevents LPG flow to generator **20** when the mechanical fuel valve **54** is in first position **38**(*a*) wherein the engine is operated on gasoline.

Mechanical fuel valve **54** includes a fuel valve handle **56** to control the opening and closing of the valve. Fuel valve handle **56** is movable between first position **38**(*a*) as shown in FIG. **2** and second position **38**(*b*) as shown in FIG. **3**. Mechanical fuel valve **54** opens the first fuel line (to enable liquid fuel flow to the engine) when fuel valve handle **56** is in the first position, and mechanical fuel valve **54** closes the first fuel line (to prevent liquid fuel flow to the engine) when fuel valve handle **56** is in the second position. Thus, when fuel valve handle **56** is in first position **38**(*a*) as shown in FIG. **2**, mechanical fuel valve **54** opens the first fuel line and allows gasoline from gasoline tank **32** to flow to the engine.

Fuel valve handle **56** is coupled to fuel lockout apparatus **58**. Fuel valve handle **56** actuates with fuel lockout apparatus **58** to prevent LPG flow to generator **20** when gasoline flow to the generator is enabled. Fuel lockout apparatus **58** is controlled by fuel valve handle **56** so that moving fuel valve handle **56** to the first position causes fuel lockout apparatus **58** to block fuel inlet **59** for LPG, and moving fuel valve handle **56** to the second position causes fuel lockout apparatus **58** to unblock fuel inlet **59** for LPG.

In an exemplary embodiment of the invention, fuel valve handle **56** rotates between the first position and the second position and fuel lockout apparatus **58** is rigidly coupled to the rotating handle. Fuel lockout apparatus **58** may include a fuel inlet cover **61**, which may be a flange, coupled to fuel valve handle **56** so that fuel inlet cover **61** rotates with the handle. Fuel inlet cover **61** extends radially outward from fuel valve handle **56** and sweeps over fuel inlet **59** for LPG as fuel valve handle **56** rotates. That is, fuel inlet cover **61** rotates transversely across fuel inlet **59** and blocks access thereto. Accordingly, fuel inlet cover **61** prevents LPG flow to generator **20** when fuel valve handle **56** is in first position **38**(*a*) to allow gasoline to run the engine.

Referring to FIG. **3**, a detail view of a portion of generator **20** of FIG. **1** depicts mechanical fuel lockout switch **38** in a second position **38**(*b*), in accordance with an embodiment of the invention. In this position, the mechanical fuel lockout switch **38** provides a disconnect to stop gasoline flow from gasoline tank **32** to the engine while allowing connection of LPG supply hose **36** to fuel inlet **59** of the second fuel line. FIG. **3** further shows LPG supply hose **36** coupling second fuel source **30** to generator **20** to deliver LPG to run the generator.

Mechanical fuel lockout switch **38** includes mechanical fuel valve **54** coupled to fuel lockout apparatus **58** to prevent gasoline flow to generator **20** when LPG from the LPG service hose **36** is supplied to the engine. In one embodiment of the invention, actuation of mechanical fuel valve **54** to second position **38**(*b*) causes fuel lockout apparatus **58** to allow communication of second fuel source **30** to the dual fuel engine, and interrupts the first fuel source **28** communication with the dual fuel engine. The position of fuel lockout apparatus **58** prevents the fuel valve handle **56** from moving to first position **38**(*a*) (FIG. **2**) while LPG supply hose **36** is connected to generator **20**.

A quick-disconnect hose coupling **50**, also referred to as a quick-connect hose coupling, connects LPG supply hose **36** to generator **20** so that LPG supply hose **36** may be quickly attached and detached from generator **20**. Hose coupling **50** has a first end **50***a* mounted on the external surface of generator **20** and coupled to supply the second fuel to the engine. Hose coupling **50** has a second end **50***b* coupled to the outlet of LPG supply hose **36**. Hose coupling **50** has a valve that opens when the couplings are engaged and closes when the couplings are disengaged. As such, quick-disconnect hose coupling **50** automatically opens when connected to enable fuel flow from LPG supply hose **36** to the engine. Hose coupling **50** automatically disconnects fluid communication when disconnected. Accordingly, when the supply hose is detached from generator **20**, the coupling **50** is automatically closed so that fuel does not escape and unwanted air does not enter the fuel system.

In one embodiment, fuel inlet cover **61** is coupled to fuel valve handle **56** so that it is spaced apart from the surface of generator **20** to provide clearance for first end **50***a* of the quick-disconnect hose coupling **50** that protrudes from the surface of generator **20**. As shown in FIG. **2**, fuel inlet cover **61** blocks off first end **50***a* of the quick-disconnect hose coupling when fuel valve handle **56** is rotated to first position **38**(*a*) to enable gasoline flow so that fuel inlet cover **61** prevents connection of LPG supply hose **36** (FIG. **3**) to generator **20**. As shown in FIG. **3**, fuel inlet cover **61** uncovers first end **50***a* of the quick-disconnect hose coupling **50** when fuel valve handle **56** is rotated to second position **38**(*b*) to disable gasoline flow so that fuel inlet cover **61** permits connection of LPG supply hose **36** to generator **20**.

To operate generator **20** on LPG, fuel valve handle **56** is turned to second position **38**(*b*) to disable the flow of gasoline to the engine and to expose first end **50***a* of hose coupling **50** on generator **20**. LPG supply hose **36** is then connected to generator **20** via hose coupling **50** to enable the flow of LPG to the engine. To operate generator **20** on gasoline, LPG supply hose **36** is disconnected from generator **20** via hose coupling **50** to disable the flow of LPG to the engine and to unblock fuel valve handle **56** from rotating to the first position. As shown in FIG. **2**, fuel valve handle **56** is then turned to first position **38**(*a*) to enable the flow of gasoline to generator **20**.

Referring to FIG. **4**A, a schematic diagram of a fuel system for a dual fuel engine shows mechanical fuel lockout switch **38** in first position **38**(*a*) to provide communication between the first fuel source **28** and dual fuel carburetor **62**, according to an embodiment of the invention. Mechanical fuel lockout switch **38** prevents communication between second fuel source **30** and dual fuel carburetor **62** when the switch is in first position **38**(*a*). In one embodiment of the invention, first fuel source **28** includes a gasoline tank **32** to provide gasoline to carburetor **62** through a first fuel line **66**, and second fuel source **30** includes a propane or LPG tank **68** to provide propane or LPG to carburetor **62** through a second fuel line **70**. Accordingly, first fuel line **66** may be a liquid fuel line and second fuel line **70** may be a gaseous fuel line.

Mechanical fuel lockout switch **38** includes a mechanical fuel valve **54** actuatable between first position **38**(*a*) as shown in FIG. **4**A and second position **38**(*b*) as shown in FIG. **4**B to selectively control fuel flow to the dual fuel engine from first fuel source **28** through first fuel line **66** and second fuel source **30** through second fuel line **70**. Referring back to FIG. **4**A, mechanical fuel valve **54** selectively controls fuel flow through first fuel line **66** by opening the line when the mechanical fuel lockout switch **38** actuates to first position **38**(*a*). Mechanical fuel valve **54** may be coupled to fuel lockout apparatus **58** that actuates with mechanical fuel valve **54** to block and unblock fuel inlet **59** of second fuel line **70**. First end **50***a* of the quick-disconnect hose coupling is located at fuel inlet **59** and a mating end **50***b* of the quick-disconnect hose coupling is coupled to the propane or LPG tank **68**. Actuation of mechanical fuel valve **54** to first position **38**(*a*) causes fuel lockout apparatus **58** to block fuel inlet **59** to prevent coupling the first end **50***a* and second end **50***b* of the quick-disconnect hose coupling together, and actuation of mechanical fuel valve **54** to another position causes fuel lockout apparatus **58** to unblock fuel inlet **59** to permit attaching first end **50***a* and second end **50***b* together.

In one embodiment of the invention, a fuel cut solenoid **63** couples to carburetor **62** to regulate liquid fuel flow into a main nozzle within the carburetor. Fuel cut solenoid **63** is advantageous to control liquid fuel flow downstream of a float bowl in the carburetor and can stop fuel flow to the engine immediately after ignition shutdown. As such, fuel cut solenoid **63** prevents the engine from drawing in fuel from the float bowl while the engine shuts off. Fuel cut solenoid **63** also traps fuel in the float bowl to eliminate delay in filling the bowl when starting the engine on liquid fuel, and prevents liquid fuel flow from the float bowl to the engine when starting on gaseous fuel.

Fuel cut solenoid **63** may regulate fuel flow through multiple fuel lines in carburetor **62** that provide fuel from the float bowl to the engine. For instance, carburetor **62** may have a main fuel line and an idle fuel line that receive fuel from the float bowl. Fuel cut solenoid **63** may control fuel flow through all of the fuel lines that receive fuel from the float bowl or may regulate only some of the fuel lines. As such, fuel cut solenoid **63** may block fuel flow through the main fuel line while small amounts of fuel can flow through the idle fuel line.

Fuel cut solenoid **63** preferably operates as a normally closed valve that opens when powered by a 12 volt battery **65**, although fuel cut solenoid **63** may also be operated as a normally open valve. The normally closed valve is opened for gasoline mode to allow gasoline flow to the engine and closed for LPG mode to prevent gasoline flow to the engine. Fuel cut solenoid **63** is operated by an electrical switch **67** which may be mechanically actuated and controlled by mechanical fuel lockout switch **38**. As such, actuation of mechanical fuel lockout switch **38** to first position **38**(*a*) closes electrical switch **67** to power and open fuel cut solenoid **63** as represented in FIG. **4**A, and actuation of mechanical fuel lockout switch **38** to second position **38**(*b*) opens electrical switch **67** to interrupt power and close fuel cut solenoid **63** as represented in FIG. **4**B.

Referring to FIG. **4**B, a schematic diagram of a fuel system for a dual fuel engine shows mechanical fuel lockout switch **38** in second position **38**(*b*) to provide communication between second fuel source **30** and dual fuel carburetor **62**, according to an embodiment of the invention. Mechanical fuel lockout switch **38** prevents communication between first fuel source **28** and dual fuel carburetor **62** when the switch is in second position **38**(*b*). The dual fuel engine has a first fuel line **66** to provide fuel from first fuel source **28** to carburetor **62** and a second fuel line **70** to provide fuel from second fuel source **30** to carburetor **62**.

Mechanical fuel lockout switch **38** includes mechanical fuel valve **54** that selectively controls fuel flow through first fuel line **66** by closing the line when mechanical fuel lockout switch **38** actuates to second position **38**(*b*). Mechanical fuel lockout switch **38** may also include a mechanical lockout

apparatus **58** to block and unblock fuel inlet **59** of the second fuel line **70**. Fuel inlet **59** may include first end **50***a* of the quick-connect hose coupling mounted on the generator and coupled to second fuel line **70**. Second end **50***b* of the quick-connect hose coupling is coupled to the outlet of second fuel source **30**, and the first end **50***a* mates with second end **50***b* to quickly attach propane or LPG tank **68** to second fuel line **70**. Fuel lockout apparatus **58** may also hold mechanical fuel lockout switch **38** in second position **38**(*b*) when the propane or LPG tank **68** is coupled to the engine via the ends **50***a*, **50***b* of the quick-connect hose coupling.

Fuel cut solenoid **63** couples to carburetor **62** to regulate liquid fuel flow through the carburetor as described with respect to FIG. **4**A. FIG. **4**B shows electrical switch **67** opened to interrupt power and close fuel cut solenoid **63** for LPG mode when mechanical fuel lockout switch **38** is in second position **38**(*b*).

FIGS. **4**A and **4**B depict an embodiment where mechanical fuel valve **54** operates along first fuel line **66** to provide a flow path for first fuel source **28** to carburetor **62** when the valve is in first position **38**(*a*). That is, mechanical fuel valve **54** may control a single fuel line that runs through the valve while operating fuel lockout apparatus **58** to control fuel flow through second fuel line **70**. Embodiments of the invention also contemplate mechanical fuel valve **54** configured to operate along second fuel line **70** to provide a flow path for second fuel source **30** to carburetor **62** when the valve is in second position **38**(*b*). Mechanical fuel valve **54** may be configured to control multiple fuel lines that run through the valve according to embodiments of the invention.

Referring now to FIG. **5**, a perspective view of fuel delivery system **22** for dual fuel generator **20** of FIG. **1** is shown, in accordance with an embodiment of the invention. Fuel delivery system **22** includes a mounting arrangement for fuel regulator system **39**. The mounting arrangement includes regulator mounting bracket **46** for mounting fuel regulator system **39**. Regulator mounting bracket **46** extends around the outer periphery of collar **136** on pressurized fuel container **34**. Regulator mounting bracket **46** has securing mechanism **48** to secure to collar **136**. In one embodiment, securing mechanism **48** is a rigid component that extends inward from regulator mounting bracket **46** with a slot for receiving collar **136** to hold regulator mounting bracket **46** to collar **136**.

Regulator mounting bracket **46** provides mounting locations for pressure regulators. In one embodiment, regulator mounting bracket **46** is made of sheet metal bent in two locations to provide a central panel **138**, a first outer panel **140**, and a second outer panel **142** for mounting the regulators. The panels may be angled from each other such that regulator mounting bracket **46** fits around collar **136**. Primary pressure regulator **42** mounts on first outer panel **140** and secondary pressure regulator **44** mounts on second outer panel **142**. The panels are sized according to their respective regulators. Accordingly, second outer panel **142** is larger than first outer panel **140** if secondary pressure regulator **44** is larger than primary pressure regulator **42**. Panels **140**, **142** have fasteners or openings to receive fasteners to couple respective regulators **42**, **44** to the panels. Regulator mounting bracket **46** rests on top of pressurized fuel container **34** and engages the periphery of collar **136** to support fuel regulator system **39** on the container.

In one embodiment of the invention, primary pressure regulator **42** couples to two ninety degree elbows **144**, **145** to reach around collar **136** in order to couple to service valve **40**. The two elbows **144**, **145** are joined by a hose or pipe **146** that leads from elbow **144** at service valve **40** to elbow **145** at the outer periphery of collar **136**. The outlet of primary pressure regulator **42** couples to a hose **148** that extends to another ninety degree elbow **150** coupled to the inlet of secondary pressure regulator **44**. Secondary pressure regulator **44** couples to LPG supply hose **36**. Pressurized fuel container **34** may be strapped to a dolly **152**.

Referring now to FIG. **6**, a side view of another fuel delivery system **22** for dual fuel generator **20** of FIG. **1** is shown, in accordance with an embodiment of the invention. Fuel delivery system **22** includes a mounting arrangement for fuel regulator system **39**. The mounting arrangement includes a regulator mounting structure **154** for mounting fuel regulator system **39** to pressurized fuel container **34**. Regulator mounting structure **154** includes a cylinder **156** that surrounds the circumference of pressurized fuel container **34** to secure regulator mounting structure **154** radially along the circumference of pressurized fuel container **34**. Cylinder **156** couples to a dome **158** to support cylinder **156** relative to the top of pressurized fuel container **34**. Dome **158** has a central opening **160** through which collar **136** of pressurized fuel container **34** extends. Collar **136** of pressurized fuel container **34** extends through dome **158** so that service valve **40** is easily accessible from above regulator mounting structure **154** and so that dome **158** sits on pressurized fuel container **34** around collar **136**.

Regulator mounting structure **154** supports pressure regulators around the outer circumference of cylinder **156**. In some embodiments of the invention, a dual stage pressure regulator **162** functions as both a primary pressure regulator and a secondary pressure regulator in a single integral component, and dual stage pressure regulator **162** may be mounted on regulator mounting structure **154**. In other embodiments in of the invention, primary pressure regulator **42** (FIG. **5**) is mounted to service valve **40** while secondary pressure regulator **44** (FIG. **5**) is mounted on regulator mounting structure **154**. Alternatively, both primary pressure regulator **42** (FIG. **5**) and secondary pressure regulator **44** (FIG. **5**) may be mounted on regulator mounting structure **154**.

Fuel regulator system **39** may be coupled to service valve **40** by a flexible connector called a pigtail **164**. Pigtail **164** absorbs shock in the system from pressure surges and from movement of downstream components. Pigtail **164** can be looped to conserve space and therefore pressurized fuel container **34** is referred to as an LPG pig. Accordingly, regulator mounting structure **154** is referred to as a pig hat because it fits on the LPG pig. Pressurized fuel container **34** may be secured to a platform or mobile cart **64** for stability or transportation. In another embodiment, a regulator mounting device, including regulator mounting structure **154** or regulator mounting bracket **46** (FIG. **5**), is secured directly to a platform or a mobile cart.

Beneficially, embodiments of the invention provide for a mechanical fuel lockout switch to ensure that two fuels are not simultaneously delivered to a dual fuel internal combustion engine. Embodiments of the invention also provide for a dual fuel generator with a remotely mounted gaseous fuel regulator system.

Therefore, according to one embodiment of the invention, a mechanical fuel lockout switch for a dual fuel engine includes a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel engine from a first fuel source through a first fuel line and a second fuel source through a second fuel line. The mechanical fuel lockout switch also includes a fuel lockout apparatus coupled to the mechanical fuel

valve. The mechanical fuel lockout switch communicates the first fuel source to the dual fuel engine and prevents communication between the second fuel source and the dual fuel engine when the mechanical fuel valve is in the first position, and communicates the second fuel source to the dual fuel engine and interrupts the first fuel source communication with the dual fuel engine when in the second position.

According to another embodiment of the invention, a dual fuel generator and fuel delivery system includes a dual fuel generator configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line. The dual fuel generator and fuel delivery system also includes a fuel regulator system located off board the dual fuel generator. The fuel regulator system includes a primary pressure regulator coupled to a service valve of the pressurized fuel source and configured to regulate the fuel supplied from the pressurized fuel source to a reduced pressure. The fuel regulator system also includes a secondary pressure regulator coupled to the primary pressure regulator and configured to regulate the gaseous fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the dual fuel generator. The dual fuel generator and fuel delivery system further includes a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel generator from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line.

According to yet another embodiment of the invention, a method of assembling a mechanical fuel lockout switch for an internal combustion engine includes providing an internal combustion engine configured to operate on a fuel from a first fuel source and a different fuel from a second fuel source. The method also includes coupling a mechanical fuel valve to the internal combustion engine actuatable between a first position and a second position to selectively control fuel flow to the internal combustion engine from the first fuel source through a first fuel line and the second fuel source through a second fuel line. The method further includes coupling a fuel lockout apparatus to the mechanical fuel valve. When the mechanical fuel valve is in the first position, the fuel lockout apparatus communicates the first fuel source to the internal combustion engine and prevents the second fuel source from coupling to the internal combustion engine, and actuation of the mechanical fuel valve to the second position causes the fuel lockout apparatus to permit the second fuel source to couple to the internal combustion engine, and interrupts the first fuel source communication with the internal combustion engine.

This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

What is claimed is:

1. A generator and fuel delivery system comprising:

a generator free of any pressure regulator and configured to operate on a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line;

a fuel regulator system located off-board the generator and comprising a first stage and a second stage, the fuel regulator system configured to:

regulate the gaseous fuel supplied from the pressurized fuel source in the first stage, the gaseous fuel regulated down to a reduced pressure in the first stage; and

regulate the reduced pressure gaseous fuel in the second stage, the reduced pressure gaseous fuel from the first stage regulated down to a desired pressure in the second stage for delivery through the gaseous fuel line to operate the generator.

2. The generator and fuel delivery system of claim **1** wherein the first and second stages comprise a dual stage regulator configured to regulate the gaseous fuel supplied from the pressurized fuel source and regulate the reduced pressure gaseous fuel.

3. The generator and fuel delivery system of claim **2** wherein the dual stage regulator is mounted directly onto the pressurized fuel source, off-board from the generator.

4. The generator and fuel delivery system of claim **1** wherein the generator comprises a dual fuel generator configured to operate on the gaseous fuel and on a liquid fuel, the liquid fuel supplied from a liquid fuel source through a liquid fuel line.

5. The generator and fuel delivery system of claim **4** further comprising a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel generator from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line.

6. The generator and fuel delivery system of claim **5** further comprising a fuel lockout apparatus coupled to the mechanical fuel valve;

wherein, when the mechanical fuel valve is in the first position, the fuel lockout apparatus communicates the liquid fuel source to the dual fuel generator and prevents the pressurized fuel source from coupling to the dual fuel generator; and

wherein, when the mechanical fuel valve is in the second position, the fuel lockout apparatus permits the pressurized fuel source to couple to the dual fuel generator and interrupts the liquid fuel source communication with the dual fuel generator.

7. The generator and fuel delivery system of claim **1**, wherein the first stage comprises a primary pressure regulator and the second stage comprises a secondary pressure regulator; and

wherein the generator and fuel delivery system further comprises a quick-connect hose coupling including:

a first end coupled to an outlet of the secondary pressure regulator; and

a second end coupled to an inlet of the gaseous fuel line to couple the secondary pressure regulator to the gaseous fuel line.

8. The generator and fuel delivery system of claim **7**, further comprising a regulator mounting device secured to the pressurized fuel source with at least the secondary pressure regulator mounted on the regulator mounting device.

9. The generator and fuel delivery system of claim 8, wherein the primary pressure regulator is mounted on the regulator mounting device.

10. The generator and fuel delivery system of claim 9, wherein the pressurized fuel source comprises a pressurized fuel container having a collar; and

wherein the regulator mounting device secures to the collar so that the primary and secondary pressure regulators are positioned adjacent each other along an outer periphery of the collar.

11. A generator and fuel delivery system comprising:

a generator comprising an engine configured to operate on a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line;

a fuel regulator system located off-board the generator and comprising a first stage and a second stage, the fuel regulator system configured to:

regulate the gaseous fuel supplied from the pressurized fuel source in the first stage, the gaseous fuel regulated down to a first reduced pressure in the first stage; and

regulate the gaseous fuel output from the first stage in the second stage, the first reduced pressure gaseous fuel from the first stage being regulated down to a second reduced pressure in the second stage for delivery through the gaseous fuel line to operate the generator;

wherein the fuel regulator system outputs gaseous fuel to the generator for operation of the engine at the second reduced pressure.

12. The generator and fuel delivery system of claim 11 wherein the first and second stages comprise a dual stage regulator configured to regulate the gaseous fuel supplied from the pressurized fuel source and regulate the reduced pressure gaseous fuel.

13. The generator and fuel delivery system of claim 12 wherein the dual stage regulator is mounted directly onto the pressurized fuel source, off-board from the generator.

14. The generator and fuel delivery system of claim 11 wherein the generator comprises a dual fuel generator configured to operate on the gaseous fuel and on a liquid fuel, the liquid fuel supplied from a liquid fuel source through a liquid fuel line.

15. The generator and fuel delivery system of claim 14 further comprising a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel generator from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line.

16. A dual fuel generator and fuel delivery system comprising:

a dual fuel generator configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line;

a fuel regulator system located off board the dual fuel generator, the fuel regulator system comprising:

a primary pressure regulator coupled to a service valve of the pressurized fuel source and configured to regulate the fuel supplied from the pressurized fuel source to a first reduced pressure; and

a secondary pressure regulator coupled to the primary pressure regulator and configured to regulate the gaseous fuel supplied from the primary pressure regulator down from the first reduced pressure to a second reduced pressure for delivery through the gaseous fuel line to operate the dual fuel generator;

wherein the fuel regulator system outputs gaseous fuel to the dual fuel generator for operation thereof at the second reduced pressure.

17. The dual fuel generator and fuel delivery system of claim 16 wherein the primary and secondary pressure regulators are integral components of a dual stage pressure regulator.

18. The dual fuel generator and fuel delivery system of claim 16, further comprising a quick-connect hose coupling including:

a first end coupled to an outlet of the secondary pressure regulator; and

a second end coupled to an inlet of the gaseous fuel line to couple the secondary pressure regulator to the gaseous fuel line.

19. The dual fuel generator and fuel delivery system of claim 16, wherein the pressurized fuel source comprises a pressurized fuel container having a collar; and

wherein a regulator mounting device secures to the collar so that the primary and secondary pressure regulators are positioned adjacent each other along an outer periphery of the collar.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 11,492,985 B2
APPLICATION NO. : 16/783455
DATED : November 8, 2022
INVENTOR(S) : Sarder et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the Title Page:

The first or sole Notice should read --

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 130 days.

Signed and Sealed this
Fourteenth Day of May, 2024

Katherine Kelly Vidal

Katherine Kelly Vidal
Director of the United States Patent and Trademark Office

EXHIBIT H

US011492985B2

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

(10) **Patent No.: US 11,492,985 B2**
(45) **Date of Patent: Nov. 8, 2022**

(54) **OFF-BOARD FUEL REGULATOR FOR GENERATOR ENGINE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 6 days.

(21) Appl. No.: **16/783,455**

(22) Filed: **Feb. 6, 2020**

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(51) **Int. Cl.**
F02D 19/06 (2006.01)

(52) **U.S. Cl.**
CPC ***F02D 19/0613*** (2013.01); ***F02D 19/0605*** (2013.01); ***F02D 19/0647*** (2013.01); ***F02D 19/0673*** (2013.01); *Y02T 10/30* (2013.01)

(58) **Field of Classification Search**
CPC F02D 19/0613; F02D 19/0605; F02D 19/0647; Y02Y 10/36
See application file for complete search history.

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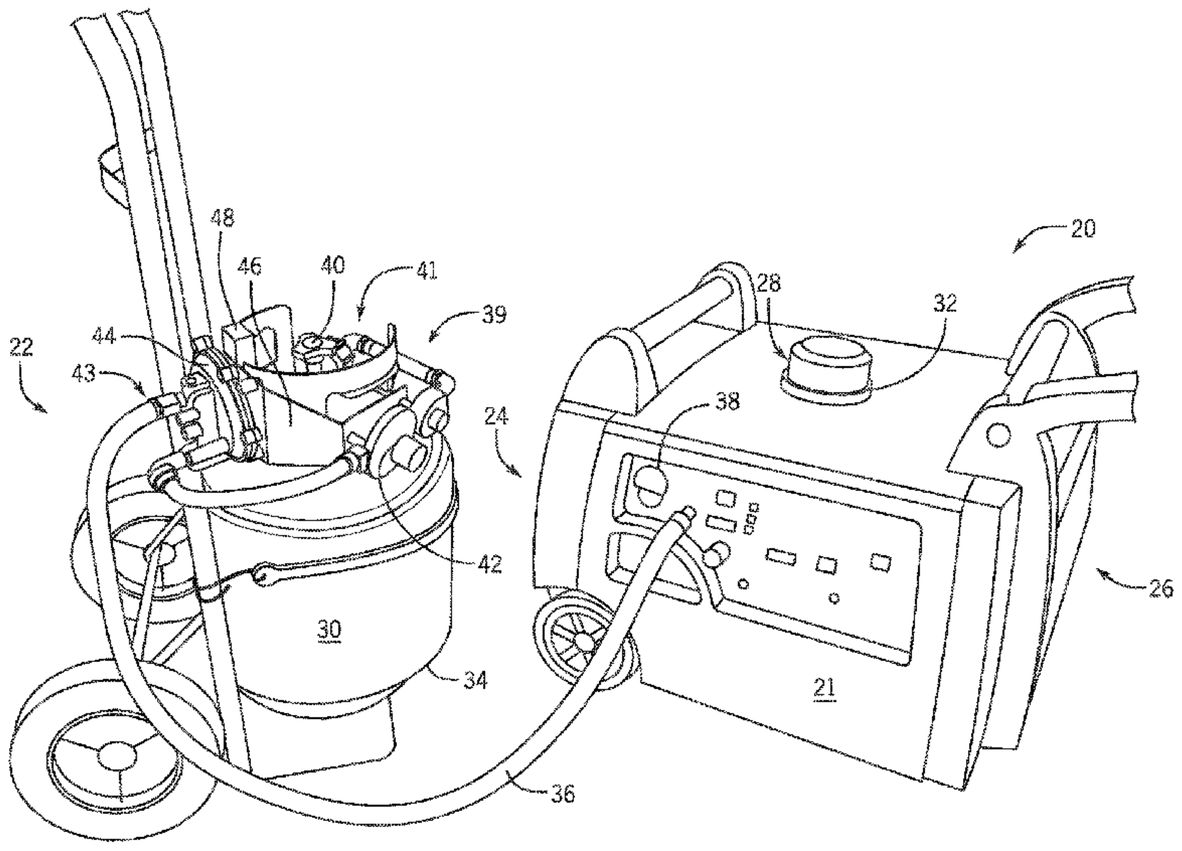
Primary Examiner — Kevin A Lathers
(74) *Attorney, Agent, or Firm* — Ziolkowski Patent Solutions Group, SC

(57) **ABSTRACT**

A generator and off-board fuel delivery system is disclosed. The generator is configured to operate on one or more fuels, including on a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line. A fuel regulator system is located off board the generator and is configured to regulate the gaseous fuel supplied from the pressurized fuel source in a first stage, with the gaseous fuel regulated down to a reduced pressure in the first stage. A second stage of the fuel regulator system regulates the reduced pressure gaseous fuel, with the reduced pressure gaseous fuel from the first stage regulated down to a desired pressure in the second stage for delivery through the gaseous fuel line to operate the generator.

19 Claims, 5 Drawing Sheets



Related U.S. Application Data

No. 14/738,060, filed on Jun. 12, 2015, now Pat. No. 10,221,780.

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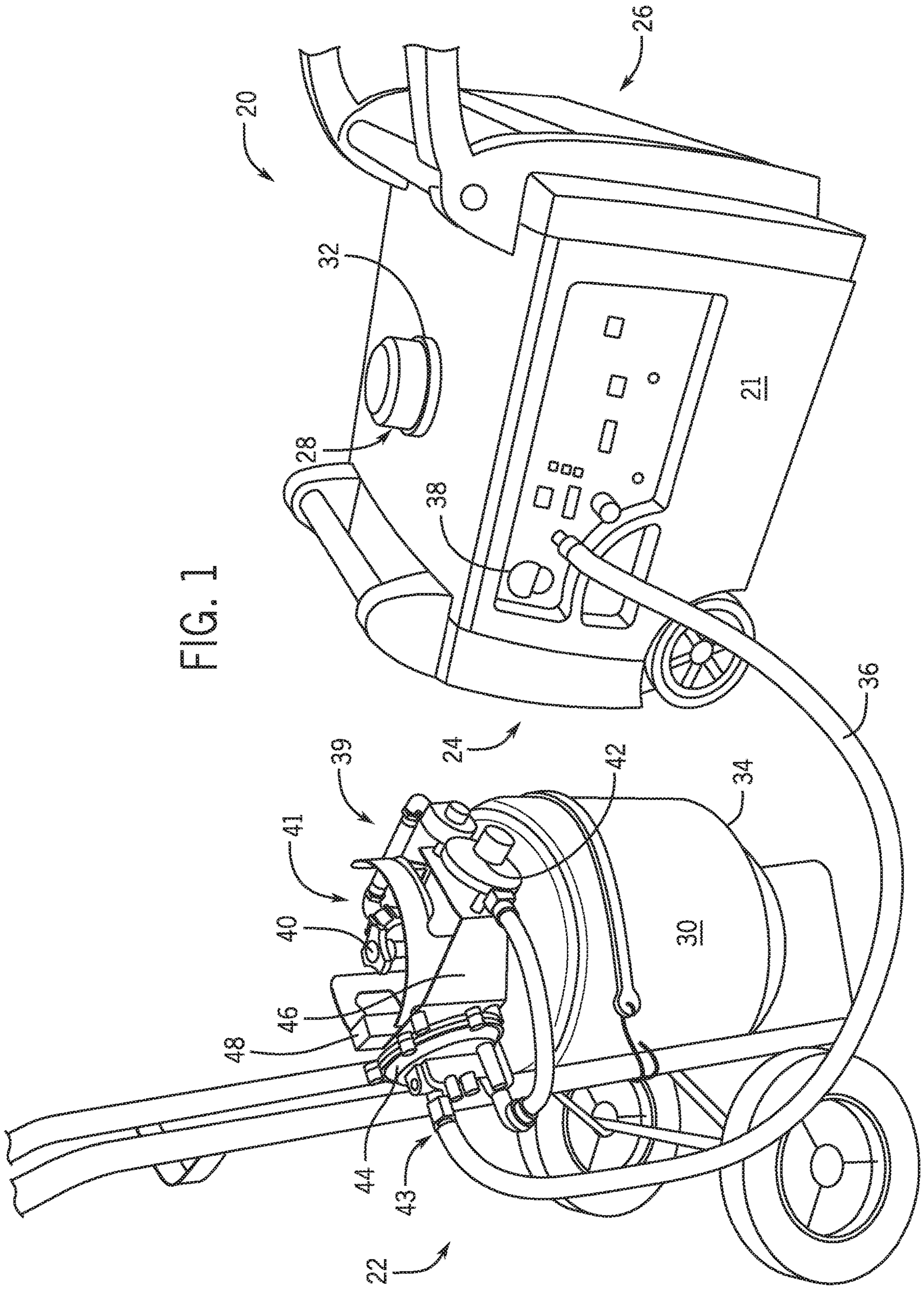
FIG. 1



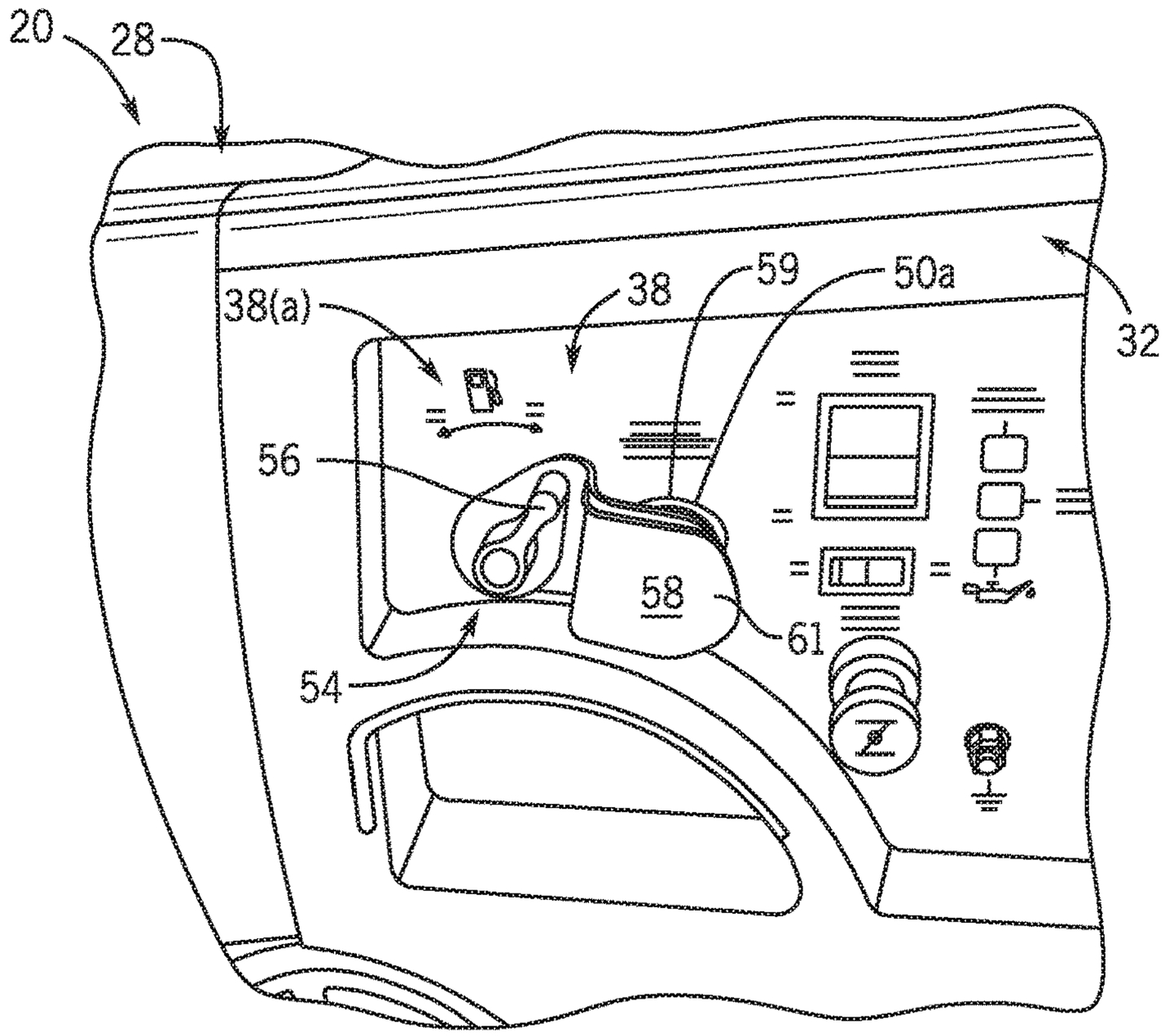

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FIG. 2

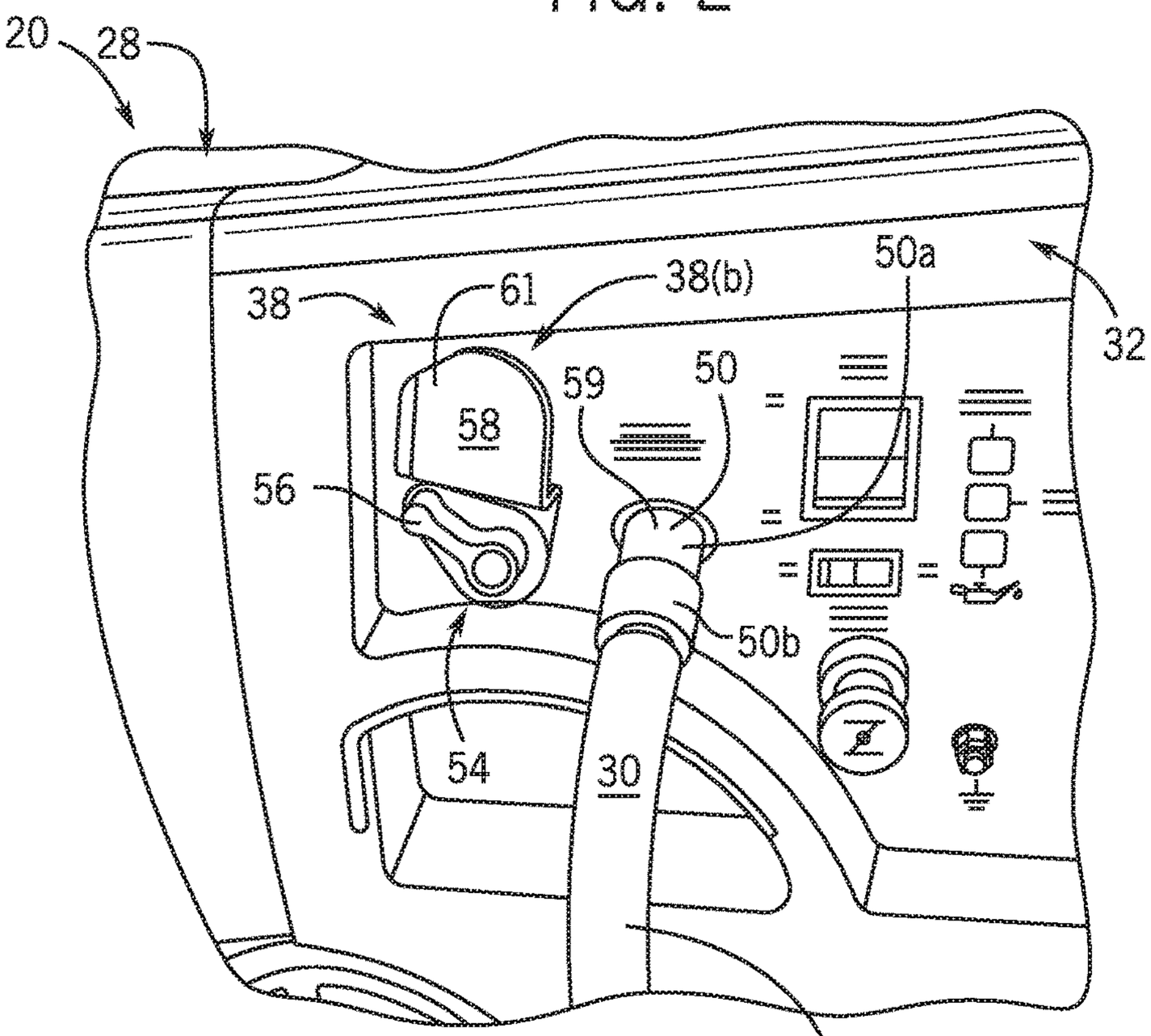
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FIG. 3

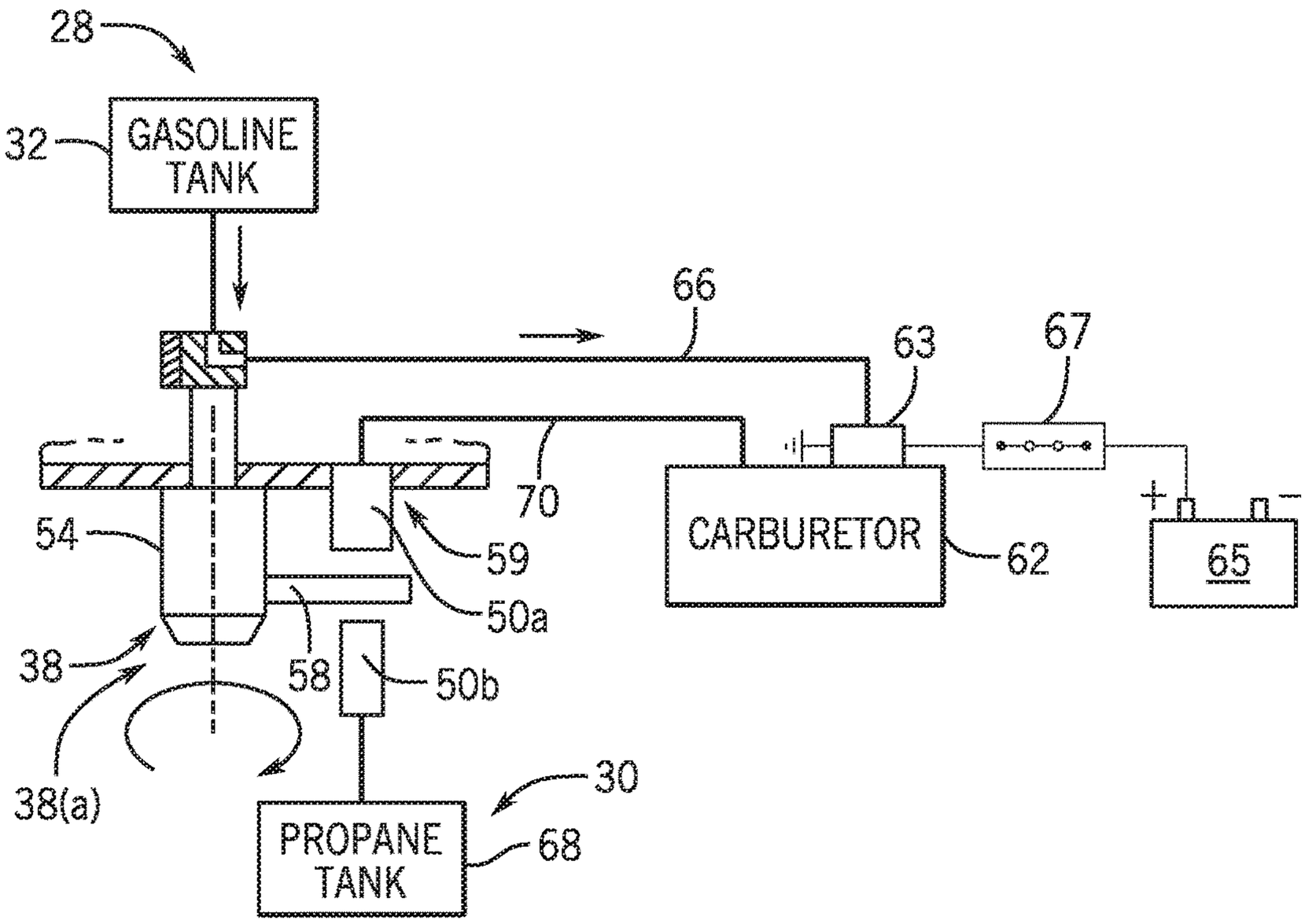

FIG. 4A

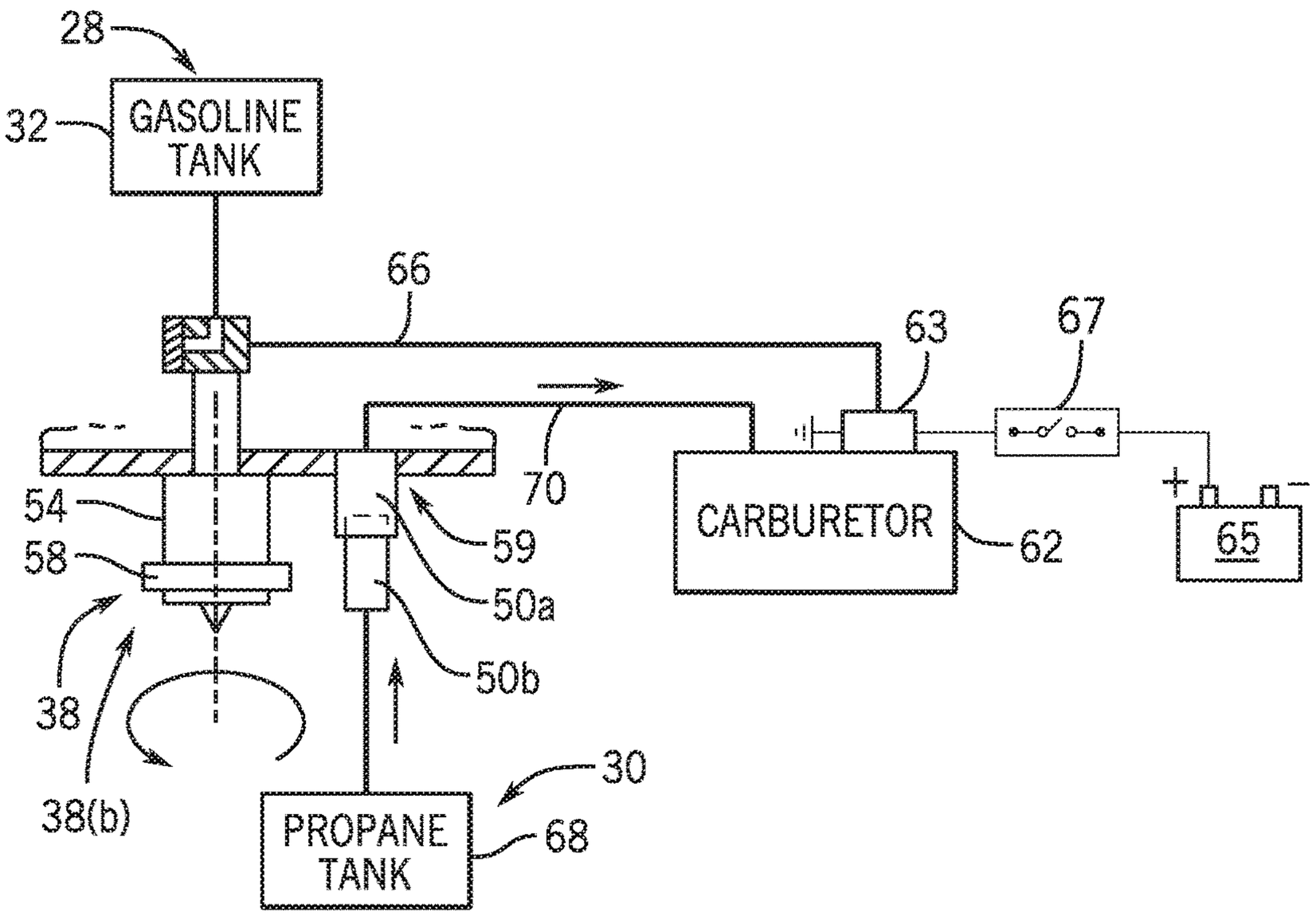

FIG. 4B

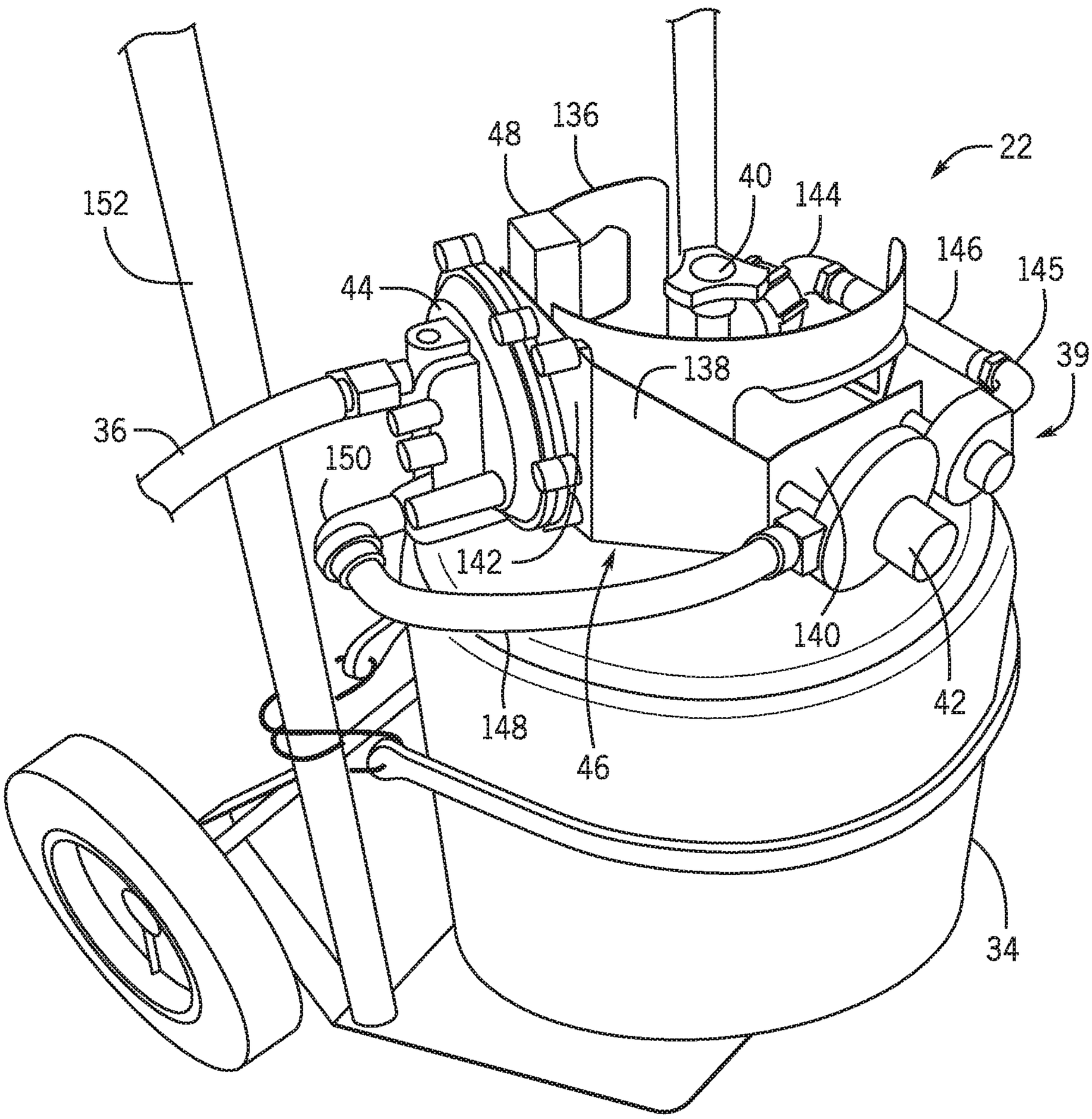

FIG. 5

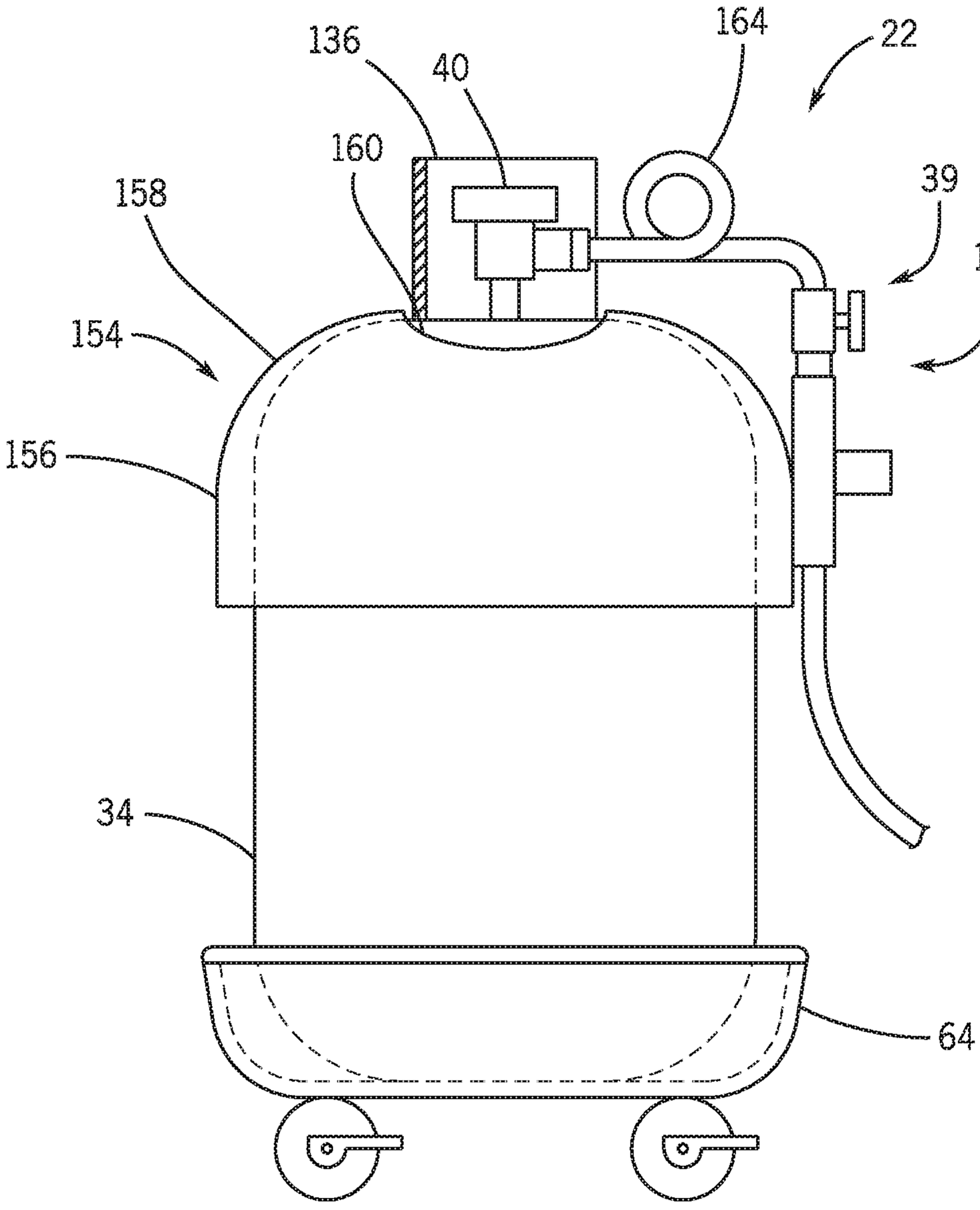

FIG. 6

OFF-BOARD FUEL REGULATOR FOR GENERATOR ENGINE

CROSS-REFERENCE TO RELATED APPLICATION

The present application is a continuation of, and claims priority to, U.S. patent application Ser. No. 16/191,503, filed on Nov. 15, 2018, which is a continuation of, and claims priority to, U.S. patent application Ser. No. 14/738,060, filed on Jun. 12, 2015, now U.S. Pat. No. 10,221,780, issued Mar. 5, 2019, the disclosures of which are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

Embodiments of the invention relate generally to dual fuel generators, and more particularly, to an apparatus and method for delivering liquid fuel and gaseous fuel to a dual fuel generator.

Electric generators are frequently driven by internal combustion engines that use gasoline as a fuel source. Gasoline is a common fuel source for generators in a variety of applications. However, alternative fuel sources also provide a desirable fuel source. For instance, alternative fuels may provide a clean burning fuel that limits hazardous emissions. Alternative fuels may also be stored for long periods of time without degradation, whereas gasoline can degrade over a period of months leading to hard starting, rough running, and also lead to gum and varnish deposit left in the fuel system. In addition, generators that operate on alternative fuels may generate electricity when gasoline is not readily available. For instance, generators are frequently used when power outages in the utility grid result from severe weather. Unfortunately, gas stations may also be closed as a result of the power outage. Such a circumstance presents just one example where it would be advantageous to operate electrical generators on alternative fuels.

Certain generators are configured to operate as "dual fuel" generators, otherwise known as bi-fuel generators. These generators are driven by an internal combustion engine that is configured to operate on a liquid fuel for a period of operation and an alternative fuel for another period of operation. The alternative fuel source may exist in a gaseous state at normal temperature and pressure and can be any one of liquefied petroleum gas, compressed natural gas, hydrogen, or the like. Liquefied petroleum gas (LPG), often referred to as propane, exists in a gaseous state at normal temperature and pressure but can be conveniently stored under pressure in a liquid state. LPG may be a desirable fuel source for internal combustion engines because it can be stored for longer periods of time and contains fewer impurities than gasoline, resulting in smoother and cleaner operation, and often resulting in a longer lasting engine.

In order to provide the liquid and gaseous fuel to the engine, the dual fuel engine may have a first fuel line for liquid fuel and a second fuel line for gaseous fuel. A liquid fuel source and a gaseous fuel source may be coupled to the respective lines to provide fuel to the engine. However, a common problem with such configurations that couple two fuel sources to a single engine is the engine can experience overly rich air-fuel ratio when both fuels are simultaneously engaged during cross-over switching between the fuel sources. Further, such simultaneous delivery of fuel from the first fuel line and the second fuel line may make the engine hard to start or lead to unstable operating conditions.

Therefore, it would be desirable to design a dual fuel generator having a liquid fuel and gaseous fuel delivery system that overcomes the aforementioned detriments without substantially increasing the overall cost of the system.

BRIEF DESCRIPTION OF THE INVENTION

In accordance with one aspect of the invention, a mechanical fuel lockout switch for a dual fuel engine provides for the selection of a desired fuel to operate the engine. The mechanical fuel lockout switch includes a mechanical fuel valve and a fuel lockout apparatus. The mechanical fuel valve actuates between a first position and a second position to selectively control fuel flow to the dual fuel engine from a first fuel source through a first fuel line and a second fuel source through a second fuel line. The fuel lockout apparatus couples to the mechanical fuel valve ensuring individual communication of the fuel sources to the engine. The mechanical fuel lockout switch communicates the first fuel source to the dual fuel engine and prevents communication between the second fuel source and the dual fuel engine when the mechanical fuel valve is in the first position, and communicates the second fuel source to the dual fuel engine and interrupts the first fuel source communication with the dual fuel engine when in the second position.

In accordance with another aspect of the invention, a dual fuel generator and fuel delivery system includes a dual fuel generator configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line. The dual fuel generator and fuel delivery system also includes a fuel regulator system located off board the dual fuel generator to control the pressure of fuel from the pressurized fuel source and deliver the fuel at a desired pressure for operation of the generator. The fuel regulator system includes a primary pressure regulator coupled to a service valve of the pressurized fuel source and configured to regulate the fuel supplied from the pressurized fuel source to a reduced pressure. The fuel regulator system also includes a secondary pressure regulator coupled to the primary pressure regulator and configured to regulate the gaseous fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the dual fuel generator. The dual fuel generator and fuel delivery system further includes a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel generator from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line.

In accordance with yet another aspect of the invention, a method of assembling a mechanical fuel lockout switch for an internal combustion engine includes providing an internal combustion engine configured to operate on a fuel from a first fuel source and a different fuel from a second fuel source. The method also includes coupling a mechanical fuel valve to the internal combustion engine actuatable between a first position and a second position to selectively control fuel flow to the internal combustion engine from the first fuel source through a first fuel line and the second fuel source through a second fuel line. The method further includes coupling a fuel lockout apparatus to the mechanical fuel valve. When the mechanical fuel valve is in the first position, the fuel lockout apparatus communicates the first fuel source to the internal combustion engine and prevents the second fuel source from coupling to the internal combustion engine,

and actuation of the mechanical fuel valve to the second position causes the fuel lockout apparatus to permit the second fuel source to couple to the internal combustion engine, and interrupts the first fuel source communication with the internal combustion engine.

Various other features and advantages will be made apparent from the following detailed description and the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings illustrate preferred embodiments presently contemplated for carrying out the invention.

In the drawings:

FIG. **1** is a perspective view of a dual fuel generator coupled to a fuel delivery system, according to an embodiment of the invention.

FIG. **2** is a detail view of a portion of the generator of FIG. **1** about a mechanical fuel lockout switch with the switch in a first position, according to an embodiment of the invention.

FIG. **3** is a detail view similar to FIG. **2** and showing the mechanical fuel lockout switch in a second position, with an LPG supply line connected thereto, according to an embodiment of the invention.

FIG. **4**A is a schematic diagram of a fuel system for the dual fuel generator of FIG. **1** showing a liquid fuel source in communication with a carburetor of the generator consistent with the first position of the switch as shown in FIG. **2**, according to an embodiment of the invention.

FIG. **4**B is a schematic diagram of the fuel system of FIG. **4**A showing a gaseous fuel source in communication with a carburetor of the generator of FIG. **1** consistent with the second position of the switch as shown in FIG. **3**, according to an embodiment of the invention.

FIG. **5** is a perspective view of a fuel delivery system for the dual fuel generator of FIG. **1**, according to an embodiment of the invention.

FIG. **6** is a side view of a fuel delivery system for the dual fuel generator of FIG. **1**, according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The operating environment of the invention is described with respect to a dual fuel generator. However, it will be appreciated by those skilled in the art that the invention is equally applicable for use with any dual fuel internal combustion engine. Moreover, the invention will be described with respect to a dual fuel generator configured to operate on a liquid fuel and a gaseous fuel. However, one skilled in the art will further appreciate that the invention is equally applicable for use with other fuel combinations for dual fuel generators and internal combustion engines.

Referring to FIG. **1**, a dual fuel generator **20** is coupled to a fuel delivery system **22**, in accordance with an embodiment of the invention. Dual fuel generator **20** includes an internal combustion engine (not shown) within housing **21** at one end **24**, operatively connected to an alternator also enclosed in housing **21** at another end **26**, by conventional means. Dual fuel generator **20** is configured to operate on different fuels via either a first fuel source **28** or a second fuel source **30**. In an exemplary embodiment of the invention, first fuel source **28** is a liquid fuel and second fuel source **30** is a gaseous fuel. The liquid fuel may be gasoline and the gaseous fuel may be liquid petroleum gas (LPG). Each can selectively operate the generator as desired and controlled by an operator. For instance, generator **20** may operate on gasoline for a first period of operation and then switch to LPG for a second period of operation. However, it is contemplated that dual fuel generator **20** is configured to operate on fuels other than gasoline and LPG (e.g., natural gas, biodiesel, etc.), and thus the scope of the invention is not meant to be limited strictly to a dual fuel arrangement where first fuel source **28** provides gasoline and second fuel source **30** provides LPG.

In one embodiment of the invention, dual fuel generator **20** includes a gasoline tank **32** or, generally, a liquid fuel tank, located inside cover **21** onboard generator **20** to provide gasoline to the engine as first fuel source **28**. Gasoline tank **32** connects to a first fuel line to provide gasoline to the carburetor to run the engine, as will later be described with reference to FIGS. **4**A and **4**B. Generator **20** is also coupled to a pressurized fuel container **34**, or a pressurized fuel source, located off board generator **20** to provide LPG to the engine as second fuel source **30**. Pressurized fuel container **34** is coupled to generator **20** with an LPG supply hose **36**. LPG supply hose **36** is coupled to a second fuel line within generator **20** to provide LPG to the carburetor to run the engine. Dual fuel generator **20** includes a mechanical fuel lockout switch **38** for selecting a desired fuel to be provided to the engine. The mechanical fuel lockout switch **38** is actuated to select first fuel source **28** when in a first position, as shown in FIG. **2**, and alternately to select second fuel source **30** when in a second position, as shown in FIG. **3**.

Referring back to FIG. **1**, in an exemplary embodiment, fuel **30** from pressurized fuel container **34** is regulated using a fuel regulator system **39** for delivery to the engine. Fuel regulator system **39** includes one or more pressure regulators that reduce and control the pressure of the fuel from pressurized fuel container **34** and delivers fuel at a desired pressure for operation of the engine. Fuel regulator system **39** has an inlet **41** operatively coupled to a service valve **40** of pressurized fuel container **34** and an outlet **43** coupled to LPG supply hose **36**. Fuel regulator system **39** includes a primary pressure regulator **42** coupled to pressurized fuel container **34** and a secondary pressure regulator **44**. Primary pressure regulator **42** protects downstream components from high pressure of pressurized fuel container **34**. Primary pressure regulator **42** receives LPG through service valve **40** of pressurized fuel container **34** and reduces the pressure of the LPG to a first stage. In one embodiment of the invention, the first stage may be delivered directly to generator **20** at a pressure required for operation of the engine.

In an exemplary embodiment of the invention, fuel regulator system **39** includes secondary pressure regulator **44** coupled to the outlet of primary pressure regulator **42** in order to use standard "off-the-shelf" components. Typically, the primary pressure regulator is mounted on the LPG tank, while the secondary pressure regulator is mounted on the component using the fuel, such as an engine or grill. Here, since generator **20** can be used as a gasoline only generator, secondary pressure regulator **44** is mounted off-board the generator to reduce size and cost of the generator. Secondary pressure regulator **44** receives LPG from primary pressure regulator **42** and further reduces the pressure of LPG to a second stage to be delivered to generator **20**. In a system with two regulators, primary pressure regulator **42** regulates fuel received from pressurized fuel container **34** and reduces the pressure of the fuel to a level required for operation of secondary pressure regulator **44**. Secondary pressure regulator **44** regulates fuel received from primary pressure

regulator **42** and further reduces the pressure of the fuel to a level required for operation of generator **20**. In addition, primary pressure regulator **42** may compensate for varying tank pressure as fuel is depleted while secondary pressure regulator **44** may compensate for varying demand from generator **20**.

In accordance with an exemplary embodiment of the invention, fuel regulator system **39** includes both the primary and secondary regulators, or a custom single regulator, but in any case is located remotely, or off-board, from dual fuel generator **20**. Fuel regulator system **39** may be directly mounted to pressurized fuel container **34** using a regulator mounting bracket **46**. Regulator mounting bracket **46** has mounting locations for primary pressure regulator **42** and secondary pressure regulator **44**. Regulator mounting bracket **46** also has a securing mechanism **48** to secure regulator mounting bracket **46** to pressurized fuel container **34**.

In another embodiment of the invention, primary pressure regulator **42** is mounted on regulator mounting bracket **46** while secondary pressure regulator **44** could be mounted on or near generator **20**. In yet another embodiment of the invention, a dual stage regulator may regulate the fuel received from pressurized fuel container **34** and deliver fuel at a pressure required for operation of generator **20**. Such a dual stage regulator may regulate the fuel to the second stage within a single structure. The dual stage regulator may be mounted directly on fuel container **34**.

Referring to FIG. **2**, a detail view of a portion of generator **20** of FIG. **1** depicts mechanical fuel lockout switch **38** in a first position **38**(*a*), in accordance with an embodiment of the invention. In this position, mechanical fuel lockout switch **38** provides gasoline flow from gasoline tank **32** to the engine while preventing connection of an LPG supply line to fuel inlet **59** of the second fuel line, as will later be discussed in detail with reference to FIGS. **4**A and **4**B. Still referring to FIG. **2**, mechanical fuel lockout switch **38** provides a combination liquid fuel shutoff valve and a gaseous fuel supply lockout that prevents simultaneous delivery of fuel to the engine from gasoline tank **32** and pressurized fuel container **34**, FIG. **1**. As such, mechanical fuel lockout switch **38** provides a fuel selector to ensure only the selected fuel is provided to dual fuel generator **20**.

Mechanical fuel lockout switch **38**, FIG. **2**, includes mechanical fuel valve **54** actuatable between first position **38**(*a*) as shown in FIG. **2** and second position **38**(*b*) as shown in FIG. **3** to selectively control fuel flow to the dual fuel engine from first fuel source **28** through a first fuel line and second fuel source **30** through a second fuel line **36**. Mechanical fuel lockout switch **38** may also include fuel lockout apparatus **58** coupled to mechanical fuel valve **54** to communicate fuel sources individually to generator **20**. In one embodiment of the invention, fuel lockout apparatus **58** communicates first fuel source **28** to the engine by actuating mechanical fuel valve **54** to first position **38**(*a*) to open the first fuel line as shown in FIG. **2**, and communicates second fuel source **30** to the engine by actuating mechanical fuel valve **54** to second position **38**(*b*) to open communication of the second fuel source **30** to the engine as shown in FIG. **3**. Referring back to FIG. **2**, when mechanical fuel valve **54** is in first position **38**(*a*), fuel lockout apparatus **58** communicates first fuel source **28** to the dual fuel engine and prevents communication between the second fuel source and the dual fuel engine.

In an exemplary embodiment of the invention, mechanical fuel valve **54** controls the flow of LPG to the engine by actuating fuel lockout apparatus **58** to block or unblock fuel inlet **59** for the second fuel source. Mechanical fuel valve **54** is coupled to the first fuel line, as shown in FIGS. **4**A and **4**B, and therefore can control the flow of gasoline to the engine by opening and closing the first fuel line. When the mechanical fuel valve **54**, FIG. **2**, is in the first position **38**(*a*), gasoline flows from the gasoline tank to the engine and the fuel lockout apparatus **58** blocks the fuel inlet **59**. Accordingly, fuel lockout apparatus **58** prevents LPG flow to generator **20** when the mechanical fuel valve **54** is in first position **38**(*a*) wherein the engine is operated on gasoline.

Mechanical fuel valve **54** includes a fuel valve handle **56** to control the opening and closing of the valve. Fuel valve handle **56** is movable between first position **38**(*a*) as shown in FIG. **2** and second position **38**(*b*) as shown in FIG. **3**. Mechanical fuel valve **54** opens the first fuel line (to enable liquid fuel flow to the engine) when fuel valve handle **56** is in the first position, and mechanical fuel valve **54** closes the first fuel line (to prevent liquid fuel flow to the engine) when fuel valve handle **56** is in the second position. Thus, when fuel valve handle **56** is in first position **38**(*a*) as shown in FIG. **2**, mechanical fuel valve **54** opens the first fuel line and allows gasoline from gasoline tank **32** to flow to the engine.

Fuel valve handle **56** is coupled to fuel lockout apparatus **58**. Fuel valve handle **56** actuates with fuel lockout apparatus **58** to prevent LPG flow to generator **20** when gasoline flow to the generator is enabled. Fuel lockout apparatus **58** is controlled by fuel valve handle **56** so that moving fuel valve handle **56** to the first position causes fuel lockout apparatus **58** to block fuel inlet **59** for LPG, and moving fuel valve handle **56** to the second position causes fuel lockout apparatus **58** to unblock fuel inlet **59** for LPG.

In an exemplary embodiment of the invention, fuel valve handle **56** rotates between the first position and the second position and fuel lockout apparatus **58** is rigidly coupled to the rotating handle. Fuel lockout apparatus **58** may include a fuel inlet cover **61**, which may be a flange, coupled to fuel valve handle **56** so that fuel inlet cover **61** rotates with the handle. Fuel inlet cover **61** extends radially outward from fuel valve handle **56** and sweeps over fuel inlet **59** for LPG as fuel valve handle **56** rotates. That is, fuel inlet cover **61** rotates transversely across fuel inlet **59** and blocks access thereto. Accordingly, fuel inlet cover **61** prevents LPG flow to generator **20** when fuel valve handle **56** is in first position **38**(*a*) to allow gasoline to run the engine.

Referring to FIG. **3**, a detail view of a portion of generator **20** of FIG. **1** depicts mechanical fuel lockout switch **38** in a second position **38**(*b*), in accordance with an embodiment of the invention. In this position, the mechanical fuel lockout switch **38** provides a disconnect to stop gasoline flow from gasoline tank **32** to the engine while allowing connection of LPG supply hose **36** to fuel inlet **59** of the second fuel line. FIG. **3** further shows LPG supply hose **36** coupling second fuel source **30** to generator **20** to deliver LPG to run the generator.

Mechanical fuel lockout switch **38** includes mechanical fuel valve **54** coupled to fuel lockout apparatus **58** to prevent gasoline flow to generator **20** when LPG from the LPG service hose **36** is supplied to the engine. In one embodiment of the invention, actuation of mechanical fuel valve **54** to second position **38**(*b*) causes fuel lockout apparatus **58** to allow communication of second fuel source **30** to the dual fuel engine, and interrupts the first fuel source **28** communication with the dual fuel engine. The position of fuel lockout apparatus **58** prevents the fuel valve handle **56** from moving to first position **38**(*a*) (FIG. **2**) while LPG supply hose **36** is connected to generator **20**.

A quick-disconnect hose coupling **50**, also referred to as a quick-connect hose coupling, connects LPG supply hose **36** to generator **20** so that LPG supply hose **36** may be quickly attached and detached from generator **20**. Hose coupling **50** has a first end **50***a* mounted on the external surface of generator **20** and coupled to supply the second fuel to the engine. Hose coupling **50** has a second end **50***b* coupled to the outlet of LPG supply hose **36**. Hose coupling **50** has a valve that opens when the couplings are engaged and closes when the couplings are disengaged. As such, quick-disconnect hose coupling **50** automatically opens when connected to enable fuel flow from LPG supply hose **36** to the engine. Hose coupling **50** automatically disconnects fluid communication when disconnected. Accordingly, when the supply hose is detached from generator **20**, the coupling **50** is automatically closed so that fuel does not escape and unwanted air does not enter the fuel system.

In one embodiment, fuel inlet cover **61** is coupled to fuel valve handle **56** so that it is spaced apart from the surface of generator **20** to provide clearance for first end **50***a* of the quick-disconnect hose coupling **50** that protrudes from the surface of generator **20**. As shown in FIG. **2**, fuel inlet cover **61** blocks off first end **50***a* of the quick-disconnect hose coupling when fuel valve handle **56** is rotated to first position **38**(*a*) to enable gasoline flow so that fuel inlet cover **61** prevents connection of LPG supply hose **36** (FIG. **3**) to generator **20**. As shown in FIG. **3**, fuel inlet cover **61** uncovers first end **50***a* of the quick-disconnect hose coupling **50** when fuel valve handle **56** is rotated to second position **38**(*b*) to disable gasoline flow so that fuel inlet cover **61** permits connection of LPG supply hose **36** to generator **20**.

To operate generator **20** on LPG, fuel valve handle **56** is turned to second position **38**(*b*) to disable the flow of gasoline to the engine and to expose first end **50***a* of hose coupling **50** on generator **20**. LPG supply hose **36** is then connected to generator **20** via hose coupling **50** to enable the flow of LPG to the engine. To operate generator **20** on gasoline, LPG supply hose **36** is disconnected from generator **20** via hose coupling **50** to disable the flow of LPG to the engine and to unblock fuel valve handle **56** from rotating to the first position. As shown in FIG. **2**, fuel valve handle **56** is then turned to first position **38**(*a*) to enable the flow of gasoline to generator **20**.

Referring to FIG. **4**A, a schematic diagram of a fuel system for a dual fuel engine shows mechanical fuel lockout switch **38** in first position **38**(*a*) to provide communication between the first fuel source **28** and dual fuel carburetor **62**, according to an embodiment of the invention. Mechanical fuel lockout switch **38** prevents communication between second fuel source **30** and dual fuel carburetor **62** when the switch is in first position **38**(*a*). In one embodiment of the invention, first fuel source **28** includes a gasoline tank **32** to provide gasoline to carburetor **62** through a first fuel line **66**, and second fuel source **30** includes a propane or LPG tank **68** to provide propane or LPG to carburetor **62** through a second fuel line **70**. Accordingly, first fuel line **66** may be a liquid fuel line and second fuel line **70** may be a gaseous fuel line.

Mechanical fuel lockout switch **38** includes a mechanical fuel valve **54** actuatable between first position **38**(*a*) as shown in FIG. **4**A and second position **38**(*b*) as shown in FIG. **4**B to selectively control fuel flow to the dual fuel engine from first fuel source **28** through first fuel line **66** and second fuel source **30** through second fuel line **70**. Referring back to FIG. **4**A, mechanical fuel valve **54** selectively controls fuel flow through first fuel line **66** by opening the line when the mechanical fuel lockout switch **38** actuates to first position **38**(*a*). Mechanical fuel valve **54** may be coupled to fuel lockout apparatus **58** that actuates with mechanical fuel valve **54** to block and unblock fuel inlet **59** of second fuel line **70**. First end **50***a* of the quick-disconnect hose coupling is located at fuel inlet **59** and a mating end **50***b* of the quick-disconnect hose coupling is coupled to the propane or LPG tank **68**. Actuation of mechanical fuel valve **54** to first position **38**(*a*) causes fuel lockout apparatus **58** to block fuel inlet **59** to prevent coupling the first end **50***a* and second end **50***b* of the quick-disconnect hose coupling together, and actuation of mechanical fuel valve **54** to another position causes fuel lockout apparatus **58** to unblock fuel inlet **59** to permit attaching first end **50***a* and second end **50***b* together.

In one embodiment of the invention, a fuel cut solenoid **63** couples to carburetor **62** to regulate liquid fuel flow into a main nozzle within the carburetor. Fuel cut solenoid **63** is advantageous to control liquid fuel flow downstream of a float bowl in the carburetor and can stop fuel flow to the engine immediately after ignition shutdown. As such, fuel cut solenoid **63** prevents the engine from drawing in fuel from the float bowl while the engine shuts off. Fuel cut solenoid **63** also traps fuel in the float bowl to eliminate delay in filling the bowl when starting the engine on liquid fuel, and prevents liquid fuel flow from the float bowl to the engine when starting on gaseous fuel.

Fuel cut solenoid **63** may regulate fuel flow through multiple fuel lines in carburetor **62** that provide fuel from the float bowl to the engine. For instance, carburetor **62** may have a main fuel line and an idle fuel line that receive fuel from the float bowl. Fuel cut solenoid **63** may control fuel flow through all of the fuel lines that receive fuel from the float bowl or may regulate only some of the fuel lines. As such, fuel cut solenoid **63** may block fuel flow through the main fuel line while small amounts of fuel can flow through the idle fuel line.

Fuel cut solenoid **63** preferably operates as a normally closed valve that opens when powered by a 12 volt battery **65**, although fuel cut solenoid **63** may also be operated as a normally open valve. The normally closed valve is opened for gasoline mode to allow gasoline flow to the engine and closed for LPG mode to prevent gasoline flow to the engine. Fuel cut solenoid **63** is operated by an electrical switch **67** which may be mechanically actuated and controlled by mechanical fuel lockout switch **38**. As such, actuation of mechanical fuel lockout switch **38** to first position **38**(*a*) closes electrical switch **67** to power and open fuel cut solenoid **63** as represented in FIG. **4**A, and actuation of mechanical fuel lockout switch **38** to second position **38**(*b*) opens electrical switch **67** to interrupt power and close fuel cut solenoid **63** as represented in FIG. **4**B.

Referring to FIG. **4**B, a schematic diagram of a fuel system for a dual fuel engine shows mechanical fuel lockout switch **38** in second position **38**(*b*) to provide communication between second fuel source **30** and dual fuel carburetor **62**, according to an embodiment of the invention. Mechanical fuel lockout switch **38** prevents communication between first fuel source **28** and dual fuel carburetor **62** when the switch is in second position **38**(*b*). The dual fuel engine has a first fuel line **66** to provide fuel from first fuel source **28** to carburetor **62** and a second fuel line **70** to provide fuel from second fuel source **30** to carburetor **62**.

Mechanical fuel lockout switch **38** includes mechanical fuel valve **54** that selectively controls fuel flow through first fuel line **66** by closing the line when mechanical fuel lockout switch **38** actuates to second position **38**(*b*). Mechanical fuel lockout switch **38** may also include a mechanical lockout

apparatus **58** to block and unblock fuel inlet **59** of the second fuel line **70**. Fuel inlet **59** may include first end **50***a* of the quick-connect hose coupling mounted on the generator and coupled to second fuel line **70**. Second end **50***b* of the quick-connect hose coupling is coupled to the outlet of second fuel source **30**, and the first end **50***a* mates with second end **50***b* to quickly attach propane or LPG tank **68** to second fuel line **70**. Fuel lockout apparatus **58** may also hold mechanical fuel lockout switch **38** in second position **38**(*b*) when the propane or LPG tank **68** is coupled to the engine via the ends **50***a*, **50***b* of the quick-connect hose coupling.

Fuel cut solenoid **63** couples to carburetor **62** to regulate liquid fuel flow through the carburetor as described with respect to FIG. **4**A. FIG. **4**B shows electrical switch **67** opened to interrupt power and close fuel cut solenoid **63** for LPG mode when mechanical fuel lockout switch **38** is in second position **38**(*b*).

FIGS. **4**A and **4**B depict an embodiment where mechanical fuel valve **54** operates along first fuel line **66** to provide a flow path for first fuel source **28** to carburetor **62** when the valve is in first position **38**(*a*). That is, mechanical fuel valve **54** may control a single fuel line that runs through the valve while operating fuel lockout apparatus **58** to control fuel flow through second fuel line **70**. Embodiments of the invention also contemplate mechanical fuel valve **54** configured to operate along second fuel line **70** to provide a flow path for second fuel source **30** to carburetor **62** when the valve is in second position **38**(*b*). Mechanical fuel valve **54** may be configured to control multiple fuel lines that run through the valve according to embodiments of the invention.

Referring now to FIG. **5**, a perspective view of fuel delivery system **22** for dual fuel generator **20** of FIG. **1** is shown, in accordance with an embodiment of the invention. Fuel delivery system **22** includes a mounting arrangement for fuel regulator system **39**. The mounting arrangement includes regulator mounting bracket **46** for mounting fuel regulator system **39**. Regulator mounting bracket **46** extends around the outer periphery of collar **136** on pressurized fuel container **34**. Regulator mounting bracket **46** has securing mechanism **48** to secure to collar **136**. In one embodiment, securing mechanism **48** is a rigid component that extends inward from regulator mounting bracket **46** with a slot for receiving collar **136** to hold regulator mounting bracket **46** to collar **136**.

Regulator mounting bracket **46** provides mounting locations for pressure regulators. In one embodiment, regulator mounting bracket **46** is made of sheet metal bent in two locations to provide a central panel **138**, a first outer panel **140**, and a second outer panel **142** for mounting the regulators. The panels may be angled from each other such that regulator mounting bracket **46** fits around collar **136**. Primary pressure regulator **42** mounts on first outer panel **140** and secondary pressure regulator **44** mounts on second outer panel **142**. The panels are sized according to their respective regulators. Accordingly, second outer panel **142** is larger than first outer panel **140** if secondary pressure regulator **44** is larger than primary pressure regulator **42**. Panels **140**, **142** have fasteners or openings to receive fasteners to couple respective regulators **42**, **44** to the panels. Regulator mounting bracket **46** rests on top of pressurized fuel container **34** and engages the periphery of collar **136** to support fuel regulator system **39** on the container.

In one embodiment of the invention, primary pressure regulator **42** couples to two ninety degree elbows **144**, **145** to reach around collar **136** in order to couple to service valve **40**. The two elbows **144**, **145** are joined by a hose or pipe **146** that leads from elbow **144** at service valve **40** to elbow **145** at the outer periphery of collar **136**. The outlet of primary pressure regulator **42** couples to a hose **148** that extends to another ninety degree elbow **150** coupled to the inlet of secondary pressure regulator **44**. Secondary pressure regulator **44** couples to LPG supply hose **36**. Pressurized fuel container **34** may be strapped to a dolly **152**.

Referring now to FIG. **6**, a side view of another fuel delivery system **22** for dual fuel generator **20** of FIG. **1** is shown, in accordance with an embodiment of the invention. Fuel delivery system **22** includes a mounting arrangement for fuel regulator system **39**. The mounting arrangement includes a regulator mounting structure **154** for mounting fuel regulator system **39** to pressurized fuel container **34**. Regulator mounting structure **154** includes a cylinder **156** that surrounds the circumference of pressurized fuel container **34** to secure regulator mounting structure **154** radially along the circumference of pressurized fuel container **34**. Cylinder **156** couples to a dome **158** to support cylinder **156** relative to the top of pressurized fuel container **34**. Dome **158** has a central opening **160** through which collar **136** of pressurized fuel container **34** extends. Collar **136** of pressurized fuel container **34** extends through dome **158** so that service valve **40** is easily accessible from above regulator mounting structure **154** and so that dome **158** sits on pressurized fuel container **34** around collar **136**.

Regulator mounting structure **154** supports pressure regulators around the outer circumference of cylinder **156**. In some embodiments of the invention, a dual stage pressure regulator **162** functions as both a primary pressure regulator and a secondary pressure regulator in a single integral component, and dual stage pressure regulator **162** may be mounted on regulator mounting structure **154**. In other embodiments in of the invention, primary pressure regulator **42** (FIG. **5**) is mounted to service valve **40** while secondary pressure regulator **44** (FIG. **5**) is mounted on regulator mounting structure **154**. Alternatively, both primary pressure regulator **42** (FIG. **5**) and secondary pressure regulator **44** (FIG. **5**) may be mounted on regulator mounting structure **154**.

Fuel regulator system **39** may be coupled to service valve **40** by a flexible connector called a pigtail **164**. Pigtail **164** absorbs shock in the system from pressure surges and from movement of downstream components. Pigtail **164** can be looped to conserve space and therefore pressurized fuel container **34** is referred to as an LPG pig. Accordingly, regulator mounting structure **154** is referred to as a pig hat because it fits on the LPG pig. Pressurized fuel container **34** may be secured to a platform or mobile cart **64** for stability or transportation. In another embodiment, a regulator mounting device, including regulator mounting structure **154** or regulator mounting bracket **46** (FIG. **5**), is secured directly to a platform or a mobile cart.

Beneficially, embodiments of the invention provide for a mechanical fuel lockout switch to ensure that two fuels are not simultaneously delivered to a dual fuel internal combustion engine. Embodiments of the invention also provide for a dual fuel generator with a remotely mounted gaseous fuel regulator system.

Therefore, according to one embodiment of the invention, a mechanical fuel lockout switch for a dual fuel engine includes a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel engine from a first fuel source through a first fuel line and a second fuel source through a second fuel line. The mechanical fuel lockout switch also includes a fuel lockout apparatus coupled to the mechanical fuel

valve. The mechanical fuel lockout switch communicates the first fuel source to the dual fuel engine and prevents communication between the second fuel source and the dual fuel engine when the mechanical fuel valve is in the first position, and communicates the second fuel source to the dual fuel engine and interrupts the first fuel source communication with the dual fuel engine when in the second position.

According to another embodiment of the invention, a dual fuel generator and fuel delivery system includes a dual fuel generator configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line. The dual fuel generator and fuel delivery system also includes a fuel regulator system located off board the dual fuel generator. The fuel regulator system includes a primary pressure regulator coupled to a service valve of the pressurized fuel source and configured to regulate the fuel supplied from the pressurized fuel source to a reduced pressure. The fuel regulator system also includes a secondary pressure regulator coupled to the primary pressure regulator and configured to regulate the gaseous fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the dual fuel generator. The dual fuel generator and fuel delivery system further includes a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel generator from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line.

According to yet another embodiment of the invention, a method of assembling a mechanical fuel lockout switch for an internal combustion engine includes providing an internal combustion engine configured to operate on a fuel from a first fuel source and a different fuel from a second fuel source. The method also includes coupling a mechanical fuel valve to the internal combustion engine actuatable between a first position and a second position to selectively control fuel flow to the internal combustion engine from the first fuel source through a first fuel line and the second fuel source through a second fuel line. The method further includes coupling a fuel lockout apparatus to the mechanical fuel valve. When the mechanical fuel valve is in the first position, the fuel lockout apparatus communicates the first fuel source to the internal combustion engine and prevents the second fuel source from coupling to the internal combustion engine, and actuation of the mechanical fuel valve to the second position causes the fuel lockout apparatus to permit the second fuel source to couple to the internal combustion engine, and interrupts the first fuel source communication with the internal combustion engine.

This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

What is claimed is:

1. A generator and fuel delivery system comprising:

a generator free of any pressure regulator and configured to operate on a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line;

a fuel regulator system located off-board the generator and comprising a first stage and a second stage, the fuel regulator system configured to:

regulate the gaseous fuel supplied from the pressurized fuel source in the first stage, the gaseous fuel regulated down to a reduced pressure in the first stage; and

regulate the reduced pressure gaseous fuel in the second stage, the reduced pressure gaseous fuel from the first stage regulated down to a desired pressure in the second stage for delivery through the gaseous fuel line to operate the generator.

2. The generator and fuel delivery system of claim **1** wherein the first and second stages comprise a dual stage regulator configured to regulate the gaseous fuel supplied from the pressurized fuel source and regulate the reduced pressure gaseous fuel.

3. The generator and fuel delivery system of claim **2** wherein the dual stage regulator is mounted directly onto the pressurized fuel source, off-board from the generator.

4. The generator and fuel delivery system of claim **1** wherein the generator comprises a dual fuel generator configured to operate on the gaseous fuel and on a liquid fuel, the liquid fuel supplied from a liquid fuel source through a liquid fuel line.

5. The generator and fuel delivery system of claim **4** further comprising a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel generator from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line.

6. The generator and fuel delivery system of claim **5** further comprising a fuel lockout apparatus coupled to the mechanical fuel valve;

wherein, when the mechanical fuel valve is in the first position, the fuel lockout apparatus communicates the liquid fuel source to the dual fuel generator and prevents the pressurized fuel source from coupling to the dual fuel generator; and

wherein, when the mechanical fuel valve is in the second position, the fuel lockout apparatus permits the pressurized fuel source to couple to the dual fuel generator and interrupts the liquid fuel source communication with the dual fuel generator.

7. The generator and fuel delivery system of claim **1**, wherein the first stage comprises a primary pressure regulator and the second stage comprises a secondary pressure regulator; and

wherein the generator and fuel delivery system further comprises a quick-connect hose coupling including:

a first end coupled to an outlet of the secondary pressure regulator; and

a second end coupled to an inlet of the gaseous fuel line to couple the secondary pressure regulator to the gaseous fuel line.

8. The generator and fuel delivery system of claim **7**, further comprising a regulator mounting device secured to the pressurized fuel source with at least the secondary pressure regulator mounted on the regulator mounting device.

9. The generator and fuel delivery system of claim 8, wherein the primary pressure regulator is mounted on the regulator mounting device.

10. The generator and fuel delivery system of claim 9, wherein the pressurized fuel source comprises a pressurized fuel container having a collar; and

wherein the regulator mounting device secures to the collar so that the primary and secondary pressure regulators are positioned adjacent each other along an outer periphery of the collar.

11. A generator and fuel delivery system comprising:

a generator comprising an engine configured to operate on a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line;

a fuel regulator system located off-board the generator and comprising a first stage and a second stage, the fuel regulator system configured to:

regulate the gaseous fuel supplied from the pressurized fuel source in the first stage, the gaseous fuel regulated down to a first reduced pressure in the first stage; and

regulate the gaseous fuel output from the first stage in the second stage, the first reduced pressure gaseous fuel from the first stage being regulated down to a second reduced pressure in the second stage for delivery through the gaseous fuel line to operate the generator;

wherein the fuel regulator system outputs gaseous fuel to the generator for operation of the engine at the second reduced pressure.

12. The generator and fuel delivery system of claim 11 wherein the first and second stages comprise a dual stage regulator configured to regulate the gaseous fuel supplied from the pressurized fuel source and regulate the reduced pressure gaseous fuel.

13. The generator and fuel delivery system of claim 12 wherein the dual stage regulator is mounted directly onto the pressurized fuel source, off-board from the generator.

14. The generator and fuel delivery system of claim 11 wherein the generator comprises a dual fuel generator configured to operate on the gaseous fuel and on a liquid fuel, the liquid fuel supplied from a liquid fuel source through a liquid fuel line.

15. The generator and fuel delivery system of claim 14 further comprising a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel generator from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line.

16. A dual fuel generator and fuel delivery system comprising:

a dual fuel generator configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line;

a fuel regulator system located off board the dual fuel generator, the fuel regulator system comprising:

a primary pressure regulator coupled to a service valve of the pressurized fuel source and configured to regulate the fuel supplied from the pressurized fuel source to a first reduced pressure; and

a secondary pressure regulator coupled to the primary pressure regulator and configured to regulate the gaseous fuel supplied from the primary pressure regulator down from the first reduced pressure to a second reduced pressure for delivery through the gaseous fuel line to operate the dual fuel generator;

wherein the fuel regulator system outputs gaseous fuel to the dual fuel generator for operation thereof at the second reduced pressure.

17. The dual fuel generator and fuel delivery system of claim 16 wherein the primary and secondary pressure regulators are integral components of a dual stage pressure regulator.

18. The dual fuel generator and fuel delivery system of claim 16, further comprising a quick-connect hose coupling including:

a first end coupled to an outlet of the secondary pressure regulator; and

a second end coupled to an inlet of the gaseous fuel line to couple the secondary pressure regulator to the gaseous fuel line.

19. The dual fuel generator and fuel delivery system of claim 16, wherein the pressurized fuel source comprises a pressurized fuel container having a collar; and

wherein a regulator mounting device secures to the collar so that the primary and secondary pressure regulators are positioned adjacent each other along an outer periphery of the collar.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 11,492,985 B2
APPLICATION NO. : 16/783455
DATED : November 8, 2022
INVENTOR(S) : Sarder et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the Title Page:

The first or sole Notice should read --

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 130 days.

Signed and Sealed this
Fourteenth Day of May, 2024

Katherine Kelly Vidal

Katherine Kelly Vidal
Director of the United States Patent and Trademark Office

EXHIBIT I

US011840970B2

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

(10) **Patent No.: US 11,840,970 B2**
(45) **Date of Patent: *Dec. 12, 2023**

(54) **DUAL FUEL GENERATOR WITH REMOTE REGULATOR**

(71) Applicant: **Champion Power Equipment, Inc.**, Santa Fe Springs, CA (US)

(72) Inventors: **Mark J. Sarder**, Waukesha, WI (US); **Aleko D. Sotiriades**, Cedarburg, WI (US); **James J. Dehn**, Brookfield, WI (US); **Leigh Jenison**, Hartland, WI (US)

(73) Assignee: **Champion Power Equipment, Inc.**, Santa Fe Springs, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **17/937,046**

(22) Filed: **Sep. 30, 2022**

(65) **Prior Publication Data**

US 2023/0023142 A1 Jan. 26, 2023

Related U.S. Application Data

(63) Continuation of application No. 16/783,455, filed on Feb. 6, 2020, now Pat. No. 11,492,985, which is a continuation of application No. 16/191,503, filed on Nov. 15, 2018, now Pat. No. 11,530,654, which is a continuation of application No. 14/738,060, filed on Jun. 12, 2015, now Pat. No. 10,221,780.

(51) **Int. Cl.**
F02D 19/06 (2006.01)

(52) **U.S. Cl.**
CPC ***F02D 19/0613*** (2013.01); ***F02D 19/0605*** (2013.01); ***F02D 19/0647*** (2013.01); ***F02D 19/0673*** (2013.01); *Y02T 10/30* (2013.01)

(58) **Field of Classification Search**
CPC F02D 19/0647; F02D 19/0605; F02D 19/0613
See application file for complete search history.

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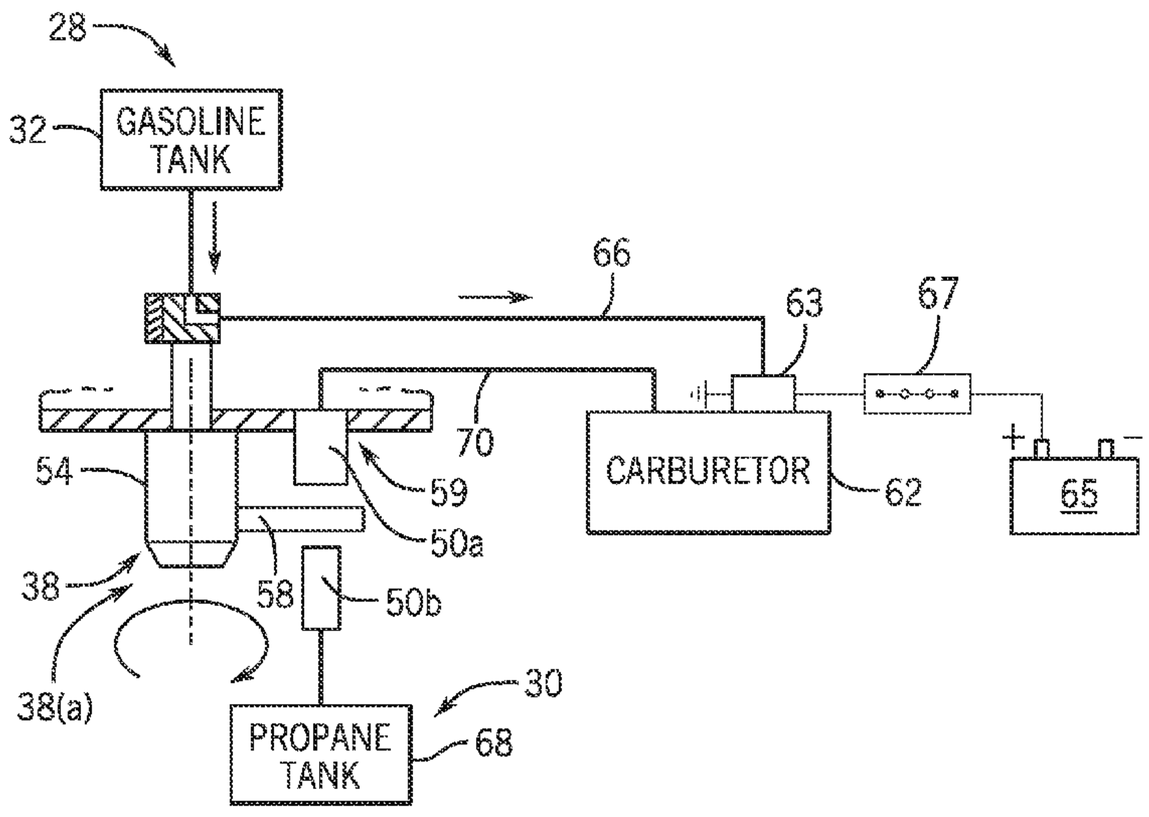
Primary Examiner — Kevin A Lathers
(74) *Attorney, Agent, or Firm* — Ziolkowski Patent Solutions Group, SC

(57) **ABSTRACT**

A generator and off-board fuel delivery system is disclosed. The generator is configured to operate on one or more fuels, including on a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line. A fuel regulator system is located off board the generator and is configured to regulate the gaseous fuel supplied from the pressurized fuel source in a first stage, with the gaseous fuel regulated down to a reduced pressure in the first stage. A second stage of the fuel regulator system regulates the reduced pressure gaseous fuel, with the reduced pressure gaseous fuel from the first stage regulated down to a desired pressure in the second stage for delivery through the gaseous fuel line to operate the generator.

52 Claims, 5 Drawing Sheets



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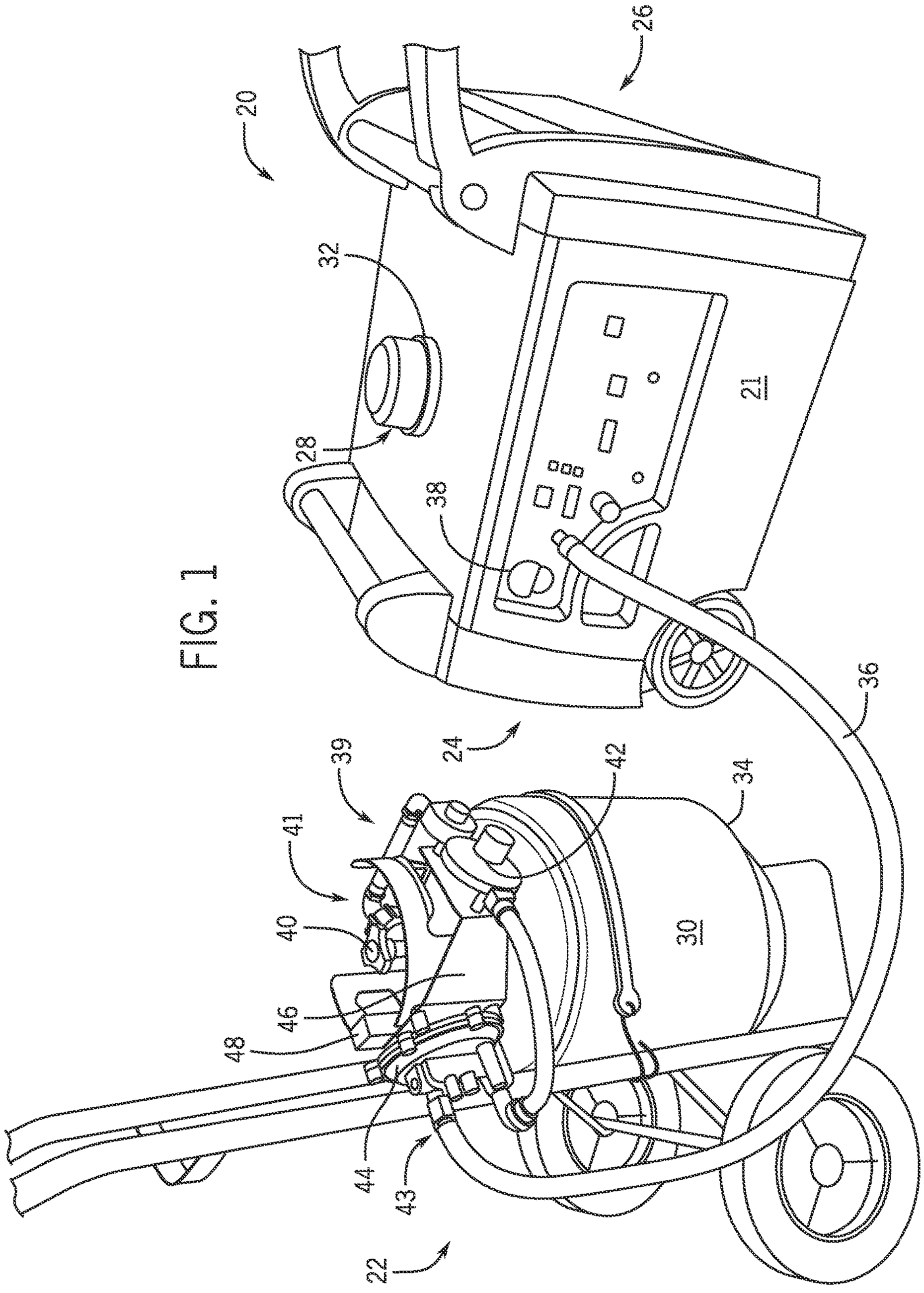


FIG. 1

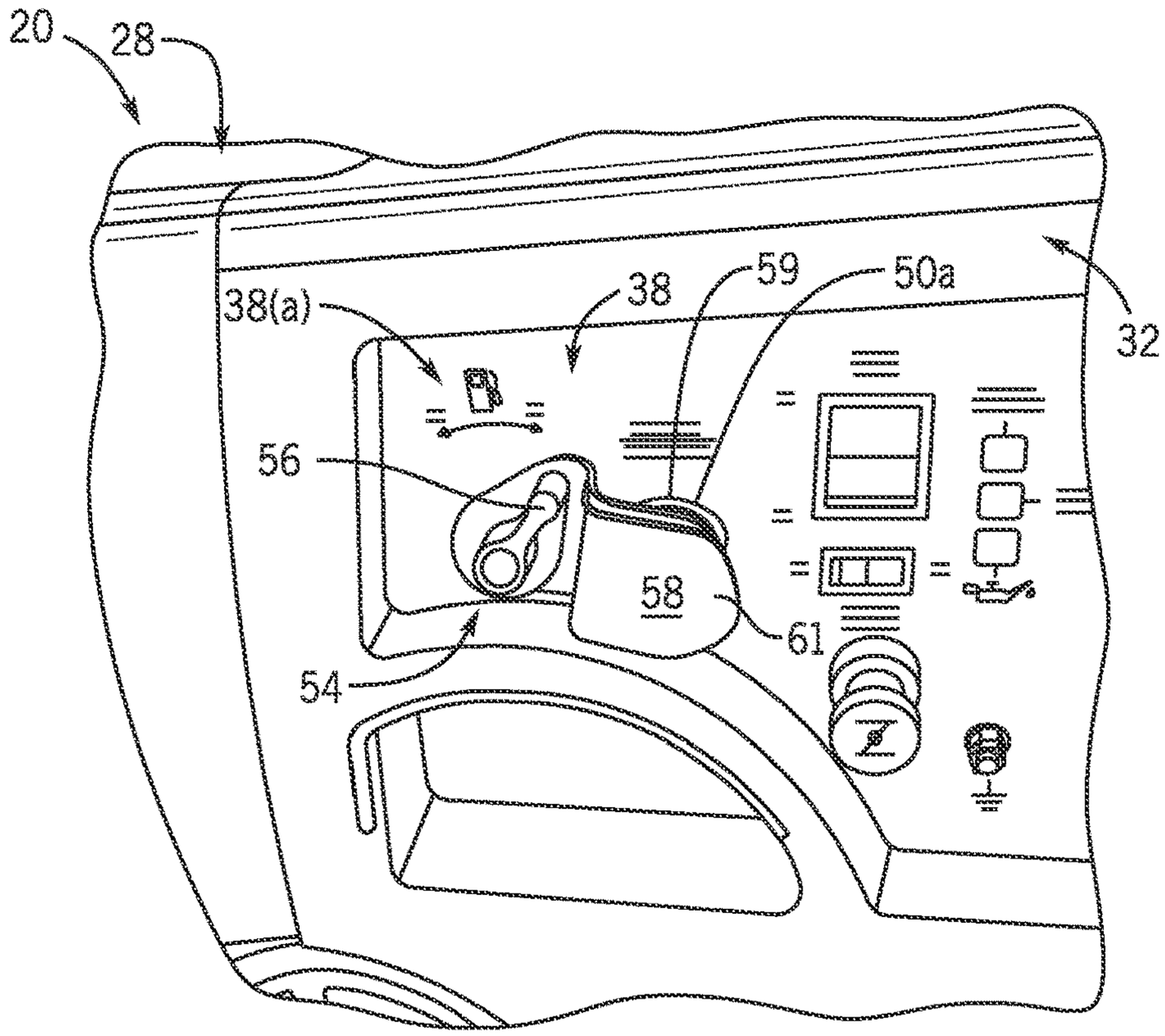
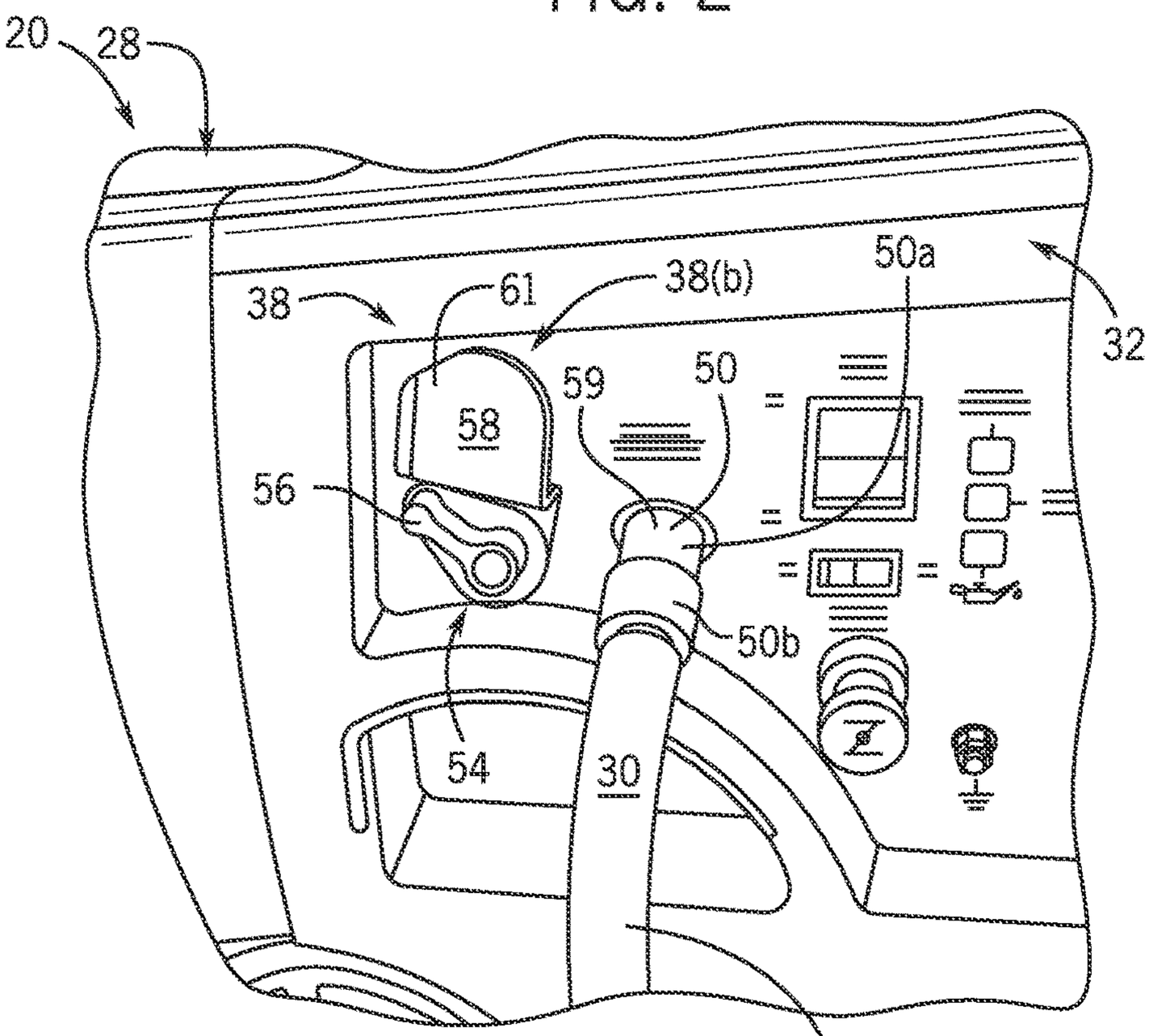

20
28
38(a)
38
59
50a
32
56
58
61
54

FIG. 2


20
28
38
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38(b)
50a
32
59
50
58
56
50b
54
30
36

FIG. 3

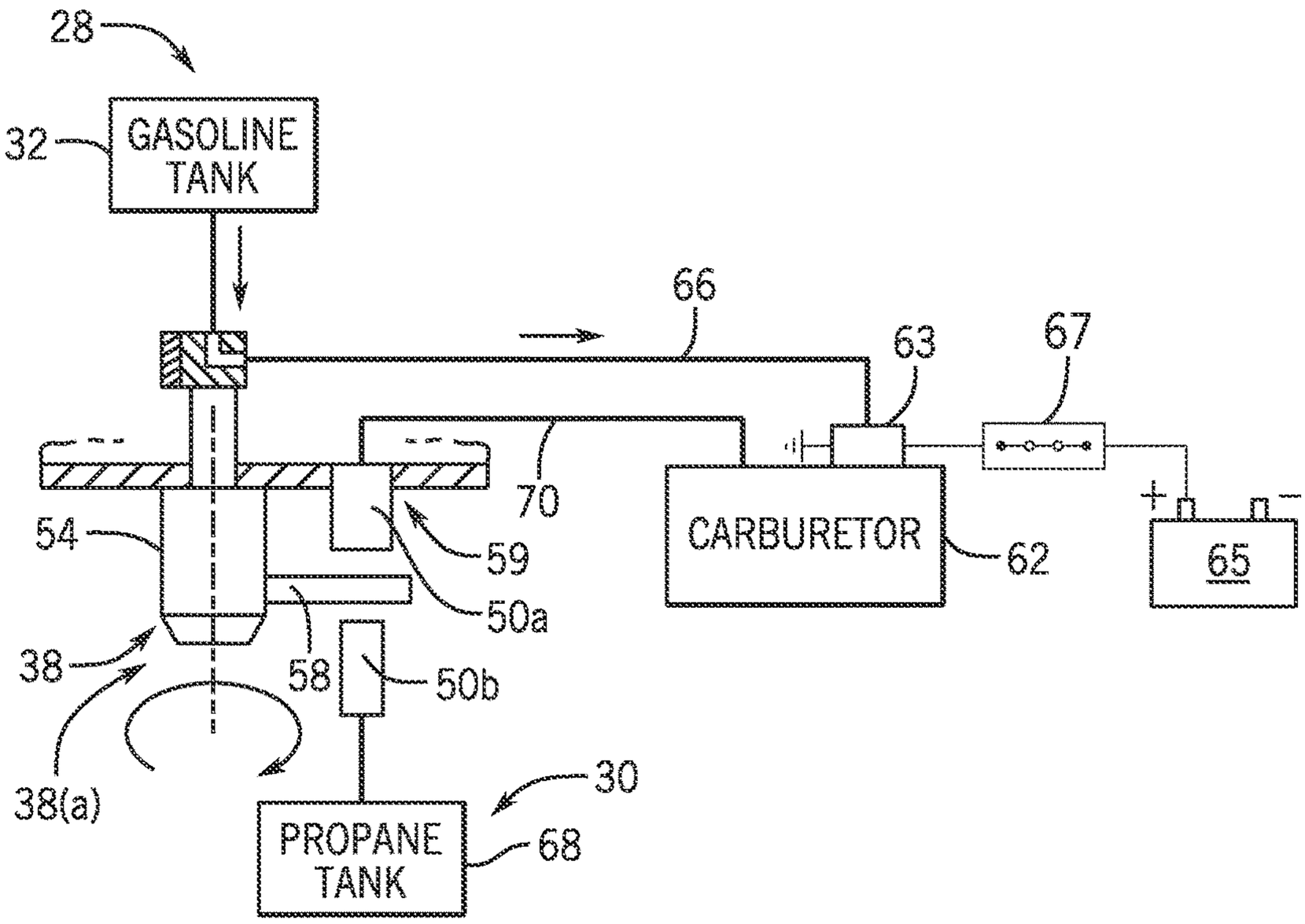

FIG. 4A

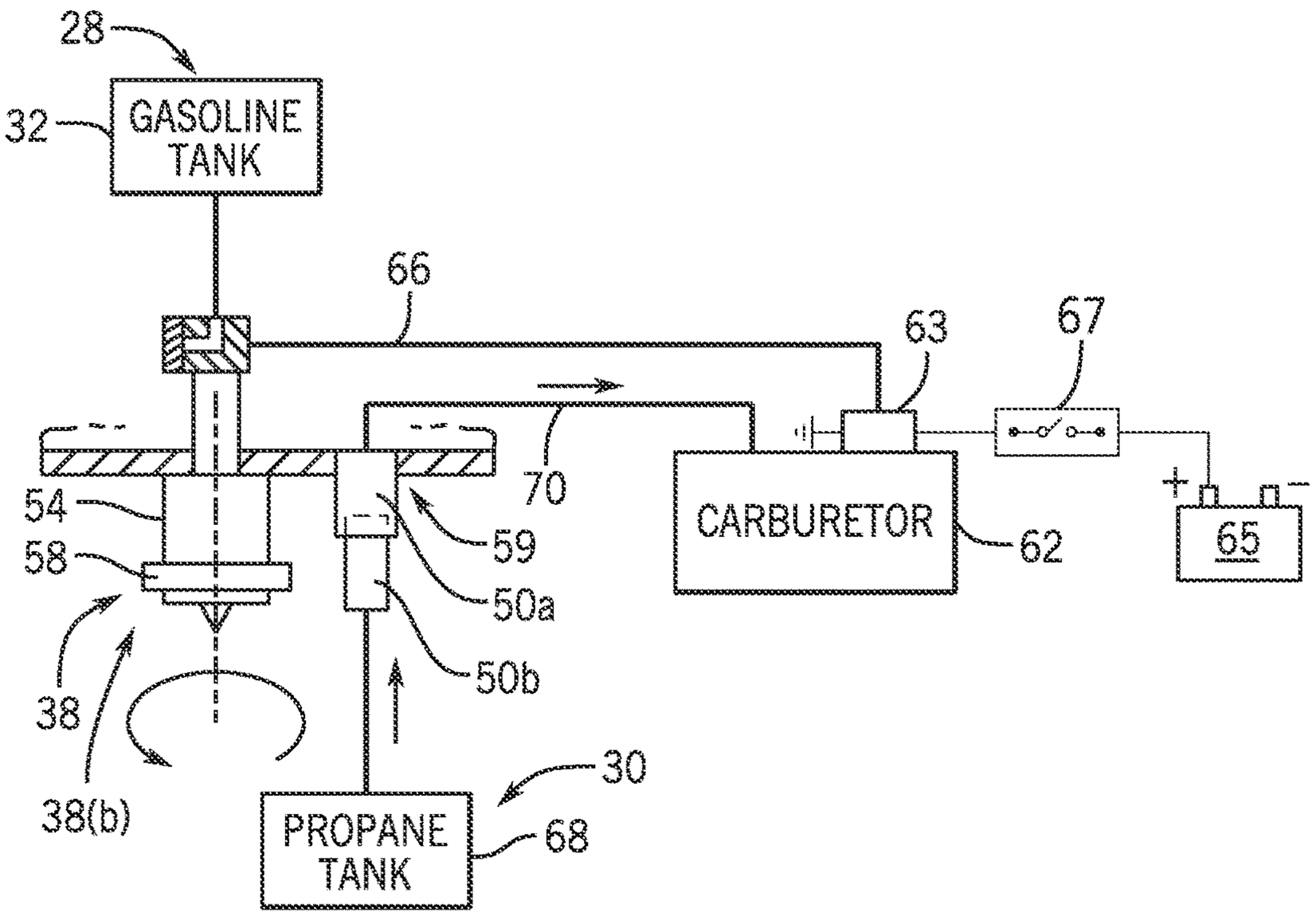

FIG. 4B

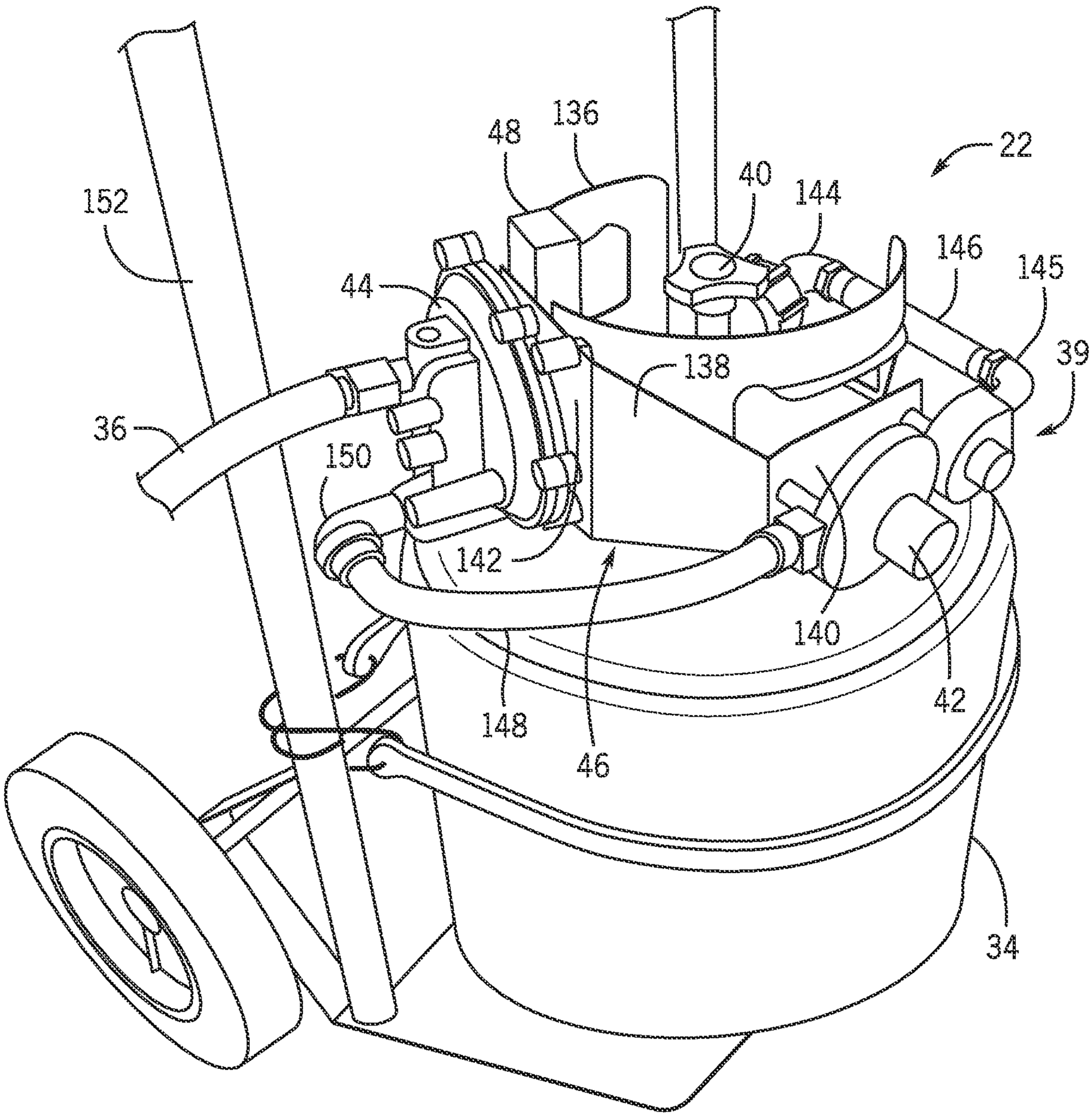

FIG. 5

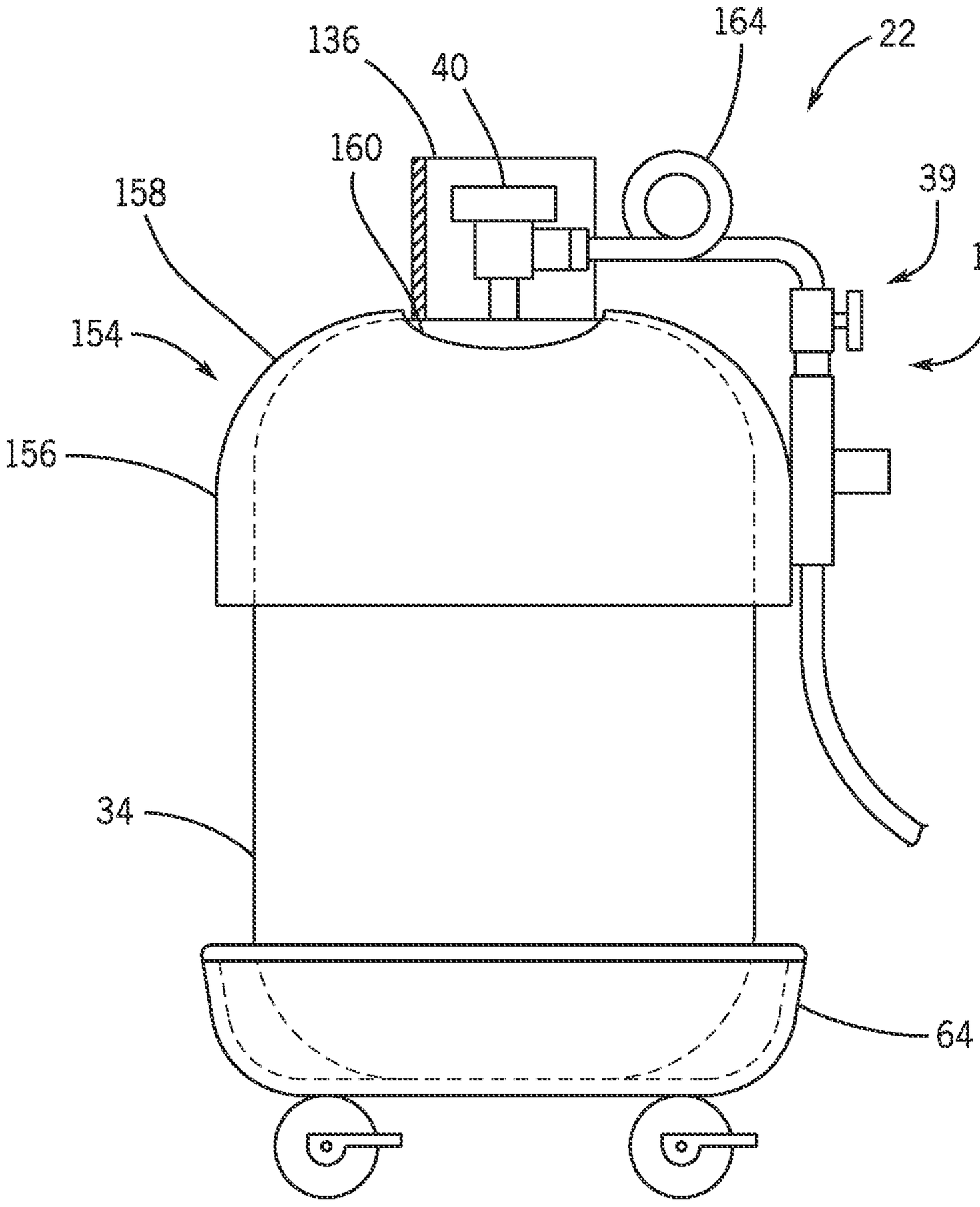

FIG. 6

DUAL FUEL GENERATOR WITH REMOTE REGULATOR

CROSS-REFERENCE TO RELATED APPLICATION

The present application is a continuation of, and claims priority to, U.S. patent application Ser. No. 16/783,455, filed on Feb. 6, 2020, which is a continuation of, and claims priority to, U.S. patent application Ser. No. 16/191,503, filed on Nov. 15, 2018, which is a continuation of, and claims priority to, U.S. patent application Ser. No. 14/738,060, filed on Jun. 12, 2015, now U.S. Pat. No. 10,221,780, the disclosures of which are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

Embodiments of the invention relate generally to dual fuel generators, and more particularly, to an apparatus and method for delivering liquid fuel and gaseous fuel to a dual fuel generator.

Electric generators are frequently driven by internal combustion engines that use gasoline as a fuel source. Gasoline is a common fuel source for generators in a variety of applications. However, alternative fuel sources also provide a desirable fuel source. For instance, alternative fuels may provide a clean burning fuel that limits hazardous emissions. Alternative fuels may also be stored for long periods of time without degradation, whereas gasoline can degrade over a period of months leading to hard starting, rough running, and also lead to gum and varnish deposit left in the fuel system. In addition, generators that operate on alternative fuels may generate electricity when gasoline is not readily available. For instance, generators are frequently used when power outages in the utility grid result from severe weather. Unfortunately, gas stations may also be closed as a result of the power outage. Such a circumstance presents just one example where it would be advantageous to operate electrical generators on alternative fuels.

Certain generators are configured to operate as "dual fuel" generators, otherwise known as bi-fuel generators. These generators are driven by an internal combustion engine that is configured to operate on a liquid fuel for a period of operation and an alternative fuel for another period of operation. The alternative fuel source may exist in a gaseous state at normal temperature and pressure and can be any one of liquefied petroleum gas, compressed natural gas, hydrogen, or the like. Liquefied petroleum gas (LPG), often referred to as propane, exists in a gaseous state at normal temperature and pressure but can be conveniently stored under pressure in a liquid state. LPG may be a desirable fuel source for internal combustion engines because it can be stored for longer periods of time and contains fewer impurities than gasoline, resulting in smoother and cleaner operation, and often resulting in a longer lasting engine.

In order to provide the liquid and gaseous fuel to the engine, the dual fuel engine may have a first fuel line for liquid fuel and a second fuel line for gaseous fuel. A liquid fuel source and a gaseous fuel source may be coupled to the respective lines to provide fuel to the engine. However, a common problem with such configurations that couple two fuel sources to a single engine is the engine can experience overly rich air-fuel ratio when both fuels are simultaneously engaged during cross-over switching between the fuel sources. Further, such simultaneous delivery of fuel from the first fuel line and the second fuel line may make the engine hard to start or lead to unstable operating conditions.

Therefore, it would be desirable to design a dual fuel generator having a liquid fuel and gaseous fuel delivery system that overcomes the aforementioned detriments without substantially increasing the overall cost of the system.

BRIEF DESCRIPTION OF THE INVENTION

In accordance with one aspect of the invention, a dual fuel generator and fuel delivery system includes a dual fuel generator including an engine configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line, and a carburetor attached to an intake of the engine to mix air and fuel and connect the liquid fuel line to the intake. A fuel regulator system may be located off board the dual fuel generator that includes a primary pressure regulator coupled to a service valve of the pressurized fuel source and configured to regulate the fuel supplied from the pressurized fuel source to a reduced pressure, and a secondary pressure regulator coupled to the primary pressure regulator and configured to regulate the gaseous fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the dual fuel generator. A mechanical fuel valve may be actuatable between a first position and a second position to selectively control fuel flow to the engine from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line.

In accordance with another aspect of the invention, a dual fuel generator and fuel delivery system includes a dual fuel generator including a generator housing, an alternator mounted within the generator housing, and an engine driving the alternator and mounted within the generator housing, the engine configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line. The dual fuel generator is preferably free of any pressure regulator mounted within the generator housing. A fuel regulator system may be located off board the dual fuel generator that is configured to regulate the gaseous fuel supplied from the pressurized fuel source in a first stage, the gaseous fuel regulated down to a reduced pressure in the first stage; and regulate the reduced pressure gaseous fuel in a second stage, the reduced pressure gaseous fuel from the first stage regulated down to a desired pressure in the second stage for delivery through the gaseous fuel line to operate the dual fuel generator. A mechanical fuel valve may be actuatable between a first position and a second position to selectively control fuel flow to the dual fuel generator from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line.

In accordance with yet another aspect of the invention, a dual fuel generator and fuel delivery system includes a dual fuel generator configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line. The dual fuel generator may include a gaseous fuel valve coupled to an inlet of the gaseous fuel line and connectible to the pressurized fuel source, and a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel generator from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous

fuel line. A fuel regulator system may be located off board the dual fuel generator that includes a primary pressure regulator connectable to a service valve of the pressurized fuel source and configured to regulate the fuel supplied from the pressurized fuel source to a reduced pressure, and a secondary pressure regulator coupled to the primary pressure regulator and connectable to the gaseous fuel valve. The secondary pressure regulator may be configured to regulate the gaseous fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the dual fuel generator.

In accordance with yet another aspect of the invention, a dual fuel generator and fuel delivery system includes a dual fuel generator configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line. A fuel regulator system may be located off board the dual fuel generator that includes a primary pressure regulator coupled to a service valve of the pressurized fuel source and configured to regulate the fuel supplied from the pressurized fuel source to a reduced pressure, and a secondary pressure regulator coupled to the primary pressure regulator and configured to regulate the gaseous fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the dual fuel generator. A mechanical fuel valve may be actuatable between a first position and a second position to selectively control fuel flow to the dual fuel generator from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line, and the mechanical fuel valve may output gaseous fuel to the dual fuel generator during operation thereof on gaseous fuel at the desired pressure from the secondary pressure regulator.

In accordance with yet another aspect of the invention, a dual fuel generator includes an alternator and a dual fuel engine coupled to drive the alternator, the dual fuel engine configured to operate on a liquid fuel supplied from a liquid fuel source and a gaseous fuel supplied from a pressurized fuel source. The dual fuel generator may also include a liquid fuel line coupled to the dual fuel engine to provide the liquid fuel from the liquid fuel source, a gaseous fuel line coupled to the dual fuel engine to provide the gaseous fuel from the pressurized fuel source, and a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel engine from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line. The dual fuel generator is preferably free from any gaseous fuel pressure regulator.

Various other features and advantages will be made apparent from the following detailed description and the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings illustrate preferred embodiments presently contemplated for carrying out the invention.

In the drawings:

FIG. **1** is a perspective view of a dual fuel generator coupled to a fuel delivery system, according to an embodiment of the invention.

FIG. **2** is a detail view of a portion of the generator of FIG. **1** about a mechanical fuel lockout switch with the switch in a first position, according to an embodiment of the invention.

FIG. **3** is a detail view similar to FIG. **2** and showing the mechanical fuel lockout switch in a second position, with an LPG supply line connected thereto, according to an embodiment of the invention.

FIG. **4**A is a schematic diagram of a fuel system for the dual fuel generator of FIG. **1** showing a liquid fuel source in communication with a carburetor of the generator consistent with the first position of the switch as shown in FIG. **2**, according to an embodiment of the invention.

FIG. **4**B is a schematic diagram of the fuel system of FIG. **4**A showing a gaseous fuel source in communication with a carburetor of the generator of FIG. **1** consistent with the second position of the switch as shown in FIG. **3**, according to an embodiment of the invention.

FIG. **5** is a perspective view of a fuel delivery system for the dual fuel generator of FIG. **1**, according to an embodiment of the invention.

FIG. **6** is a side view of a fuel delivery system for the dual fuel generator of FIG. **1**, according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The operating environment of the invention is described with respect to a dual fuel generator. However, it will be appreciated by those skilled in the art that the invention is equally applicable for use with any dual fuel internal combustion engine. Moreover, the invention will be described with respect to a dual fuel generator configured to operate on a liquid fuel and a gaseous fuel. However, one skilled in the art will further appreciate that the invention is equally applicable for use with other fuel combinations for dual fuel generators and internal combustion engines.

Referring to FIG. **1**, a dual fuel generator **20** is coupled to a fuel delivery system **22**, in accordance with an embodiment of the invention. Dual fuel generator **20** includes an internal combustion engine (not shown) within housing **21** at one end **24**, operatively connected to an alternator also enclosed in housing **21** at another end **26**, by conventional means. Dual fuel generator **20** is configured to operate on different fuels via either a first fuel source **28** or a second fuel source **30**. In an exemplary embodiment of the invention, first fuel source **28** is a liquid fuel and second fuel source **30** is a gaseous fuel. The liquid fuel may be gasoline and the gaseous fuel may be liquid petroleum gas (LPG). Each can selectively operate the generator as desired and controlled by an operator. For instance, generator **20** may operate on gasoline for a first period of operation and then switch to LPG for a second period of operation. However, it is contemplated that dual fuel generator **20** is configured to operate on fuels other than gasoline and LPG (e.g., natural gas, biodiesel, etc.), and thus the scope of the invention is not meant to be limited strictly to a dual fuel arrangement where first fuel source **28** provides gasoline and second fuel source **30** provides LPG.

In one embodiment of the invention, dual fuel generator **20** includes a gasoline tank **32** or, generally, a liquid fuel tank, located inside cover **21** onboard generator **20** to provide gasoline to the engine as first fuel source **28**. Gasoline tank **32** connects to a first fuel line to provide gasoline to the carburetor to run the engine, as will later be described with reference to FIGS. **4**A and **4**B. Generator **20** is also coupled to a pressurized fuel container **34**, or a pressurized fuel source, located off board generator **20** to provide LPG to the engine as second fuel source **30**. Pressurized fuel container **34** is coupled to generator **20** with

an LPG supply hose **36**. LPG supply hose **36** is coupled to a second fuel line within generator **20** to provide LPG to the carburetor to run the engine. Dual fuel generator **20** includes a mechanical fuel lockout switch **38** for selecting a desired fuel to be provided to the engine. The mechanical fuel lockout switch **38** is actuated to select first fuel source **28** when in a first position, as shown in FIG. **2**, and alternately to select second fuel source **30** when in a second position, as shown in FIG. **3**.

Referring back to FIG. **1**, in an exemplary embodiment, fuel **30** from pressurized fuel container **34** is regulated using a fuel regulator system **39** for delivery to the engine. Fuel regulator system **39** includes one or more pressure regulators that reduce and control the pressure of the fuel from pressurized fuel container **34** and delivers fuel at a desired pressure for operation of the engine. Fuel regulator system **39** has an inlet **41** operatively coupled to a service valve **40** of pressurized fuel container **34** and an outlet **43** coupled to LPG supply hose **36**. Fuel regulator system **39** includes a primary pressure regulator **42** coupled to pressurized fuel container **34** and a secondary pressure regulator **44**. Primary pressure regulator **42** protects downstream components from high pressure of pressurized fuel container **34**. Primary pressure regulator **42** receives LPG through service valve **40** of pressurized fuel container **34** and reduces the pressure of the LPG to a first stage. In one embodiment of the invention, the first stage may be delivered directly to generator **20** at a pressure required for operation of the engine.

In an exemplary embodiment of the invention, fuel regulator system **39** includes secondary pressure regulator **44** coupled to the outlet of primary pressure regulator **42** in order to use standard "off-the-shelf" components. Typically, the primary pressure regulator is mounted on the LPG tank, while the secondary pressure regulator is mounted on the component using the fuel, such as an engine or grill. Here, since generator **20** can be used as a gasoline only generator, secondary pressure regulator **44** is mounted off-board the generator to reduce size and cost of the generator. Secondary pressure regulator **44** receives LPG from primary pressure regulator **42** and further reduces the pressure of LPG to a second stage to be delivered to generator **20**. In a system with two regulators, primary pressure regulator **42** regulates fuel received from pressurized fuel container **34** and reduces the pressure of the fuel to a level required for operation of secondary pressure regulator **44**. Secondary pressure regulator **44** regulates fuel received from primary pressure regulator **42** and further reduces the pressure of the fuel to a level required for operation of generator **20**. In addition, primary pressure regulator **42** may compensate for varying tank pressure as fuel is depleted while secondary pressure regulator **44** may compensate for varying demand from generator **20**.

In accordance with an exemplary embodiment of the invention, fuel regulator system **39** includes both the primary and secondary regulators, or a custom single regulator, but in any case is located remotely, or off-board, from dual fuel generator **20**. Fuel regulator system **39** may be directly mounted to pressurized fuel container **34** using a regulator mounting bracket **46**. Regulator mounting bracket **46** has mounting locations for primary pressure regulator **42** and secondary pressure regulator **44**. Regulator mounting bracket **46** also has a securing mechanism **48** to secure regulator mounting bracket **46** to pressurized fuel container **34**.

In another embodiment of the invention, primary pressure regulator **42** is mounted on regulator mounting bracket **46** while secondary pressure regulator **44** could be mounted on or near generator **20**. In yet another embodiment of the invention, a dual stage regulator may regulate the fuel received from pressurized fuel container **34** and deliver fuel at a pressure required for operation of generator **20**. Such a dual stage regulator may regulate the fuel to the second stage within a single structure. The dual stage regulator may be mounted directly on fuel container **34**.

Referring to FIG. **2**, a detail view of a portion of generator **20** of FIG. **1** depicts mechanical fuel lockout switch **38** in a first position **38**(*a*), in accordance with an embodiment of the invention. In this position, mechanical fuel lockout switch **38** provides gasoline flow from gasoline tank **32** to the engine while preventing connection of an LPG supply line to fuel inlet **59** of the second fuel line, as will later be discussed in detail with reference to FIGS. **4**A and **4**B. Still referring to FIG. **2**, mechanical fuel lockout switch **38** provides a combination liquid fuel shutoff valve and a gaseous fuel supply lockout that prevents simultaneous delivery of fuel to the engine from gasoline tank **32** and pressurized fuel container **34**, FIG. **1**. As such, mechanical fuel lockout switch **38** provides a fuel selector to ensure only the selected fuel is provided to dual fuel generator **20**.

Mechanical fuel lockout switch **38**, FIG. **2**, includes mechanical fuel valve **54** actuatable between first position **38**(*a*) as shown in FIG. **2** and second position **38**(*b*) as shown in FIG. **3** to selectively control fuel flow to the dual fuel engine from first fuel source **28** through a first fuel line and second fuel source **30** through a second fuel line **36**. Mechanical fuel lockout switch **38** may also include fuel lockout apparatus **58** coupled to mechanical fuel valve **54** to communicate fuel sources individually to generator **20**. In one embodiment of the invention, fuel lockout apparatus **58** communicates first fuel source **28** to the engine by actuating mechanical fuel valve **54** to first position **38**(*a*) to open the first fuel line as shown in FIG. **2**, and communicates second fuel source **30** to the engine by actuating mechanical fuel valve **54** to second position **38**(*b*) to open communication of the second fuel source **30** to the engine as shown in FIG. **3**. Referring back to FIG. **2**, when mechanical fuel valve **54** is in first position **38**(*a*), fuel lockout apparatus **58** communicates first fuel source **28** to the dual fuel engine and prevents communication between the second fuel source and the dual fuel engine.

In an exemplary embodiment of the invention, mechanical fuel valve **54** controls the flow of LPG to the engine by actuating fuel lockout apparatus **58** to block or unblock fuel inlet **59** for the second fuel source. Mechanical fuel valve **54** is coupled to the first fuel line, as shown in FIGS. **4**A and **4**B, and therefore can control the flow of gasoline to the engine by opening and closing the first fuel line. When the mechanical fuel valve **54**, FIG. **2**, is in the first position **38**(*a*), gasoline flows from the gasoline tank to the engine and the fuel lockout apparatus **58** blocks the fuel inlet **59**. Accordingly, fuel lockout apparatus **58** prevents LPG flow to generator **20** when the mechanical fuel valve **54** is in first position **38**(*a*) wherein the engine is operated on gasoline.

Mechanical fuel valve **54** includes a fuel valve handle **56** to control the opening and closing of the valve. Fuel valve handle **56** is movable between first position **38**(*a*) as shown in FIG. **2** and second position **38**(*b*) as shown in FIG. **3**. Mechanical fuel valve **54** opens the first fuel line (to enable liquid fuel flow to the engine) when fuel valve handle **56** is in the first position, and mechanical fuel valve **54** closes the first fuel line (to prevent liquid fuel flow to the engine) when fuel valve handle **56** is in the second position. Thus, when fuel valve handle **56** is in first position **38**(*a*) as shown in

FIG. **2**, mechanical fuel valve **54** opens the first fuel line and allows gasoline from gasoline tank **32** to flow to the engine.

Fuel valve handle **56** is coupled to fuel lockout apparatus **58**. Fuel valve handle **56** actuates with fuel lockout apparatus **58** to prevent LPG flow to generator **20** when gasoline flow to the generator is enabled. Fuel lockout apparatus **58** is controlled by fuel valve handle **56** so that moving fuel valve handle **56** to the first position causes fuel lockout apparatus **58** to block fuel inlet **59** for LPG, and moving fuel valve handle **56** to the second position causes fuel lockout apparatus **58** to unblock fuel inlet **59** for LPG.

In an exemplary embodiment of the invention, fuel valve handle **56** rotates between the first position and the second position and fuel lockout apparatus **58** is rigidly coupled to the rotating handle. Fuel lockout apparatus **58** may include a fuel inlet cover **61**, which may be a flange, coupled to fuel valve handle **56** so that fuel inlet cover **61** rotates with the handle. Fuel inlet cover **61** extends radially outward from fuel valve handle **56** and sweeps over fuel inlet **59** for LPG as fuel valve handle **56** rotates. That is, fuel inlet cover **61** rotates transversely across fuel inlet **59** and blocks access thereto. Accordingly, fuel inlet cover **61** prevents LPG flow to generator **20** when fuel valve handle **56** is in first position **38**(*a*) to allow gasoline to run the engine.

Referring to FIG. **3**, a detail view of a portion of generator **20** of FIG. **1** depicts mechanical fuel lockout switch **38** in a second position **38**(*b*), in accordance with an embodiment of the invention. In this position, the mechanical fuel lockout switch **38** provides a disconnect to stop gasoline flow from gasoline tank **32** to the engine while allowing connection of LPG supply hose **36** to fuel inlet **59** of the second fuel line. FIG. **3** further shows LPG supply hose **36** coupling second fuel source **30** to generator **20** to deliver LPG to run the generator.

Mechanical fuel lockout switch **38** includes mechanical fuel valve **54** coupled to fuel lockout apparatus **58** to prevent gasoline flow to generator **20** when LPG from the LPG service hose **36** is supplied to the engine. In one embodiment of the invention, actuation of mechanical fuel valve **54** to second position **38**(*b*) causes fuel lockout apparatus **58** to allow communication of second fuel source **30** to the dual fuel engine, and interrupts the first fuel source **28** communication with the dual fuel engine. The position of fuel lockout apparatus **58** prevents the fuel valve handle **56** from moving to first position **38**(*a*) (FIG. **2**) while LPG supply hose **36** is connected to generator **20**.

A quick-disconnect hose coupling **50**, also referred to as a quick-connect hose coupling, connects LPG supply hose **36** to generator **20** so that LPG supply hose **36** may be quickly attached and detached from generator **20**. Hose coupling **50** has a first end **50***a* mounted on the external surface of generator **20** and coupled to supply the second fuel to the engine. Hose coupling **50** has a second end **50***b* coupled to the outlet of LPG supply hose **36**. Hose coupling **50** has a valve that opens when the couplings are engaged and closes when the couplings are disengaged. As such, quick-disconnect hose coupling **50** automatically opens when connected to enable fuel flow from LPG supply hose **36** to the engine. Hose coupling **50** automatically disconnects fluid communication when disconnected. Accordingly, when the supply hose is detached from generator **20**, the coupling **50** is automatically closed so that fuel does not escape and unwanted air does not enter the fuel system.

In one embodiment, fuel inlet cover **61** is coupled to fuel valve handle **56** so that it is spaced apart from the surface of generator **20** to provide clearance for first end **50***a* of the quick-disconnect hose coupling **50** that protrudes from the surface of generator **20**. As shown in FIG. **2**, fuel inlet cover **61** blocks off first end **50***a* of the quick-disconnect hose coupling when fuel valve handle **56** is rotated to first position **38**(*a*) to enable gasoline flow so that fuel inlet cover **61** prevents connection of LPG supply hose **36** (FIG. **3**) to generator **20**. As shown in FIG. **3**, fuel inlet cover **61** uncovers first end **50***a* of the quick-disconnect hose coupling **50** when fuel valve handle **56** is rotated to second position **38**(*b*) to disable gasoline flow so that fuel inlet cover **61** permits connection of LPG supply hose **36** to generator **20**.

To operate generator **20** on LPG, fuel valve handle **56** is turned to second position **38**(*b*) to disable the flow of gasoline to the engine and to expose first end **50***a* of hose coupling **50** on generator **20**. LPG supply hose **36** is then connected to generator **20** via hose coupling **50** to enable the flow of LPG to the engine. To operate generator **20** on gasoline, LPG supply hose **36** is disconnected from generator **20** via hose coupling **50** to disable the flow of LPG to the engine and to unblock fuel valve handle **56** from rotating to the first position. As shown in FIG. **2**, fuel valve handle **56** is then turned to first position **38**(*a*) to enable the flow of gasoline to generator **20**.

Referring to FIG. **4**A, a schematic diagram of a fuel system for a dual fuel engine shows mechanical fuel lockout switch **38** in first position **38**(*a*) to provide communication between the first fuel source **28** and dual fuel carburetor **62**, according to an embodiment of the invention. Mechanical fuel lockout switch **38** prevents communication between second fuel source **30** and dual fuel carburetor **62** when the switch is in first position **38**(*a*). In one embodiment of the invention, first fuel source **28** includes a gasoline tank **32** to provide gasoline to carburetor **62** through a first fuel line **66**, and second fuel source **30** includes a propane or LPG tank **68** to provide propane or LPG to carburetor **62** through a second fuel line **70**. Accordingly, first fuel line **66** may be a liquid fuel line and second fuel line **70** may be a gaseous fuel line.

Mechanical fuel lockout switch **38** includes a mechanical fuel valve **54** actuatable between first position **38**(*a*) as shown in FIG. **4**A and second position **38**(*b*) as shown in FIG. **4**B to selectively control fuel flow to the dual fuel engine from first fuel source **28** through first fuel line **66** and second fuel source **30** through second fuel line **70**. Referring back to FIG. **4**A, mechanical fuel valve **54** selectively controls fuel flow through first fuel line **66** by opening the line when the mechanical fuel lockout switch **38** actuates to first position **38**(*a*). Mechanical fuel valve **54** may be coupled to fuel lockout apparatus **58** that actuates with mechanical fuel valve **54** to block and unblock fuel inlet **59** of second fuel line **70**. First end **50***a* of the quick-disconnect hose coupling is located at fuel inlet **59** and a mating end **50***b* of the quick-disconnect hose coupling is coupled to the propane or LPG tank **68**. Actuation of mechanical fuel valve **54** to first position **38**(*a*) causes fuel lockout apparatus **58** to block fuel inlet **59** to prevent coupling the first end **50***a* and second end **50***b* of the quick-disconnect hose coupling together, and actuation of mechanical fuel valve **54** to another position causes fuel lockout apparatus **58** to unblock fuel inlet **59** to permit attaching first end **50***a* and second end **50***b* together.

In one embodiment of the invention, a fuel cut solenoid **63** couples to carburetor **62** to regulate liquid fuel flow into a main nozzle within the carburetor. Fuel cut solenoid **63** is advantageous to control liquid fuel flow downstream of a float bowl in the carburetor and can stop fuel flow to the engine immediately after ignition shutdown. As such, fuel cut solenoid **63** prevents the engine from drawing in fuel

from the float bowl while the engine shuts off. Fuel cut solenoid **63** also traps fuel in the float bowl to eliminate delay in filling the bowl when starting the engine on liquid fuel, and prevents liquid fuel flow from the float bowl to the engine when starting on gaseous fuel.

Fuel cut solenoid **63** may regulate fuel flow through multiple fuel lines in carburetor **62** that provide fuel from the float bowl to the engine. For instance, carburetor **62** may have a main fuel line and an idle fuel line that receive fuel from the float bowl. Fuel cut solenoid **63** may control fuel flow through all of the fuel lines that receive fuel from the float bowl or may regulate only some of the fuel lines. As such, fuel cut solenoid **63** may block fuel flow through the main fuel line while small amounts of fuel can flow through the idle fuel line.

Fuel cut solenoid **63** preferably operates as a normally closed valve that opens when powered by a 12 volt battery **65**, although fuel cut solenoid **63** may also be operated as a normally open valve. The normally closed valve is opened for gasoline mode to allow gasoline flow to the engine and closed for LPG mode to prevent gasoline flow to the engine. Fuel cut solenoid **63** is operated by an electrical switch **67** which may be mechanically actuated and controlled by mechanical fuel lockout switch **38**. As such, actuation of mechanical fuel lockout switch **38** to first position **38**(*a*) closes electrical switch **67** to power and open fuel cut solenoid **63** as represented in FIG. **4**A, and actuation of mechanical fuel lockout switch **38** to second position **38**(*b*) opens electrical switch **67** to interrupt power and close fuel cut solenoid **63** as represented in FIG. **4**B.

Referring to FIG. **4**B, a schematic diagram of a fuel system for a dual fuel engine shows mechanical fuel lockout switch **38** in second position **38**(*b*) to provide communication between second fuel source **30** and dual fuel carburetor **62**, according to an embodiment of the invention. Mechanical fuel lockout switch **38** prevents communication between first fuel source **28** and dual fuel carburetor **62** when the switch is in second position **38**(*b*). The dual fuel engine has a first fuel line **66** to provide fuel from first fuel source **28** to carburetor **62** and a second fuel line **70** to provide fuel from second fuel source **30** to carburetor **62**.

Mechanical fuel lockout switch **38** includes mechanical fuel valve **54** that selectively controls fuel flow through first fuel line **66** by closing the line when mechanical fuel lockout switch **38** actuates to second position **38**(*b*). Mechanical fuel lockout switch **38** may also include a mechanical lockout apparatus **58** to block and unblock fuel inlet **59** of the second fuel line **70**. Fuel inlet **59** may include first end **50***a* of the quick-connect hose coupling mounted on the generator and coupled to second fuel line **70**. Second end **50***b* of the quick-connect hose coupling is coupled to the outlet of second fuel source **30**, and the first end **50***a* mates with second end **50***b* to quickly attach propane or LPG tank **68** to second fuel line **70**. Fuel lockout apparatus **58** may also hold mechanical fuel lockout switch **38** in second position **38**(*b*) when the propane or LPG tank **68** is coupled to the engine via the ends **50***a*, **50***b* of the quick-connect hose coupling.

Fuel cut solenoid **63** couples to carburetor **62** to regulate liquid fuel flow through the carburetor as described with respect to FIG. **4**A. FIG. **4**B shows electrical switch **67** opened to interrupt power and close fuel cut solenoid **63** for LPG mode when mechanical fuel lockout switch **38** is in second position **38**(*b*).

FIGS. **4**A and **4**B depict an embodiment where mechanical fuel valve **54** operates along first fuel line **66** to provide a flow path for first fuel source **28** to carburetor **62** when the valve is in first position **38**(*a*). That is, mechanical fuel valve **54** may control a single fuel line that runs through the valve while operating fuel lockout apparatus **58** to control fuel flow through second fuel line **70**. Embodiments of the invention also contemplate mechanical fuel valve **54** configured to operate along second fuel line **70** to provide a flow path for second fuel source **30** to carburetor **62** when the valve is in second position **38**(*b*). Mechanical fuel valve **54** may be configured to control multiple fuel lines that run through the valve according to embodiments of the invention.

Referring now to FIG. **5**, a perspective view of fuel delivery system **22** for dual fuel generator **20** of FIG. **1** is shown, in accordance with an embodiment of the invention. Fuel delivery system **22** includes a mounting arrangement for fuel regulator system **39**. The mounting arrangement includes regulator mounting bracket **46** for mounting fuel regulator system **39**. Regulator mounting bracket **46** extends around the outer periphery of collar **136** on pressurized fuel container **34**. Regulator mounting bracket **46** has securing mechanism **48** to secure to collar **136**. In one embodiment, securing mechanism **48** is a rigid component that extends inward from regulator mounting bracket **46** with a slot for receiving collar **136** to hold regulator mounting bracket **46** to collar **136**.

Regulator mounting bracket **46** provides mounting locations for pressure regulators. In one embodiment, regulator mounting bracket **46** is made of sheet metal bent in two locations to provide a central panel **138**, a first outer panel **140**, and a second outer panel **142** for mounting the regulators. The panels may be angled from each other such that regulator mounting bracket **46** fits around collar **136**. Primary pressure regulator **42** mounts on first outer panel **140** and secondary pressure regulator **44** mounts on second outer panel **142**. The panels are sized according to their respective regulators. Accordingly, second outer panel **142** is larger than first outer panel **140** if secondary pressure regulator **44** is larger than primary pressure regulator **42**. Panels **140**, **142** have fasteners or openings to receive fasteners to couple respective regulators **42**, **44** to the panels. Regulator mounting bracket **46** rests on top of pressurized fuel container **34** and engages the periphery of collar **136** to support fuel regulator system **39** on the container.

In one embodiment of the invention, primary pressure regulator **42** couples to two ninety degree elbows **144**, **145** to reach around collar **136** in order to couple to service valve **40**. The two elbows **144**, **145** are joined by a hose or pipe **146** that leads from elbow **144** at service valve **40** to elbow **145** at the outer periphery of collar **136**. The outlet of primary pressure regulator **42** couples to a hose **148** that extends to another ninety degree elbow **150** coupled to the inlet of secondary pressure regulator **44**. Secondary pressure regulator **44** couples to LPG supply hose **36**. Pressurized fuel container **34** may be strapped to a dolly **152**.

Referring now to FIG. **6**, a side view of another fuel delivery system **22** for dual fuel generator **20** of FIG. **1** is shown, in accordance with an embodiment of the invention. Fuel delivery system **22** includes a mounting arrangement for fuel regulator system **39**. The mounting arrangement includes a regulator mounting structure **154** for mounting fuel regulator system **39** to pressurized fuel container **34**. Regulator mounting structure **154** includes a cylinder **156** that surrounds the circumference of pressurized fuel container **34** to secure regulator mounting structure **154** radially along the circumference of pressurized fuel container **34**. Cylinder **156** couples to a dome **158** to support cylinder **156** relative to the top of pressurized fuel container **34**. Dome **158** has a central opening **160** through which collar **136** of

pressurized fuel container **34** extends. Collar **136** of pressurized fuel container **34** extends through dome **158** so that service valve **40** is easily accessible from above regulator mounting structure **154** and so that dome **158** sits on pressurized fuel container **34** around collar **136**.

Regulator mounting structure **154** supports pressure regulators around the outer circumference of cylinder **156**. In some embodiments of the invention, a dual stage pressure regulator **162** functions as both a primary pressure regulator and a secondary pressure regulator in a single integral component, and dual stage pressure regulator **162** may be mounted on regulator mounting structure **154**. In other embodiments of the invention, primary pressure regulator **42** (FIG. **5**) is mounted to service valve **40** while secondary pressure regulator **44** (FIG. **5**) is mounted on regulator mounting structure **154**. Alternatively, both primary pressure regulator **42** (FIG. **5**) and secondary pressure regulator **44** (FIG. **5**) may be mounted on regulator mounting structure **154**.

Fuel regulator system **39** may be coupled to service valve **40** by a flexible connector called a pigtail **164**. Pigtail **164** absorbs shock in the system from pressure surges and from movement of downstream components. Pigtail **164** can be looped to conserve space and therefore pressurized fuel container **34** is referred to as an LPG pig. Accordingly, regulator mounting structure **154** is referred to as a pig hat because it fits on the LPG pig. Pressurized fuel container **34** may be secured to a platform or mobile cart **64** for stability or transportation. In another embodiment, a regulator mounting device, including regulator mounting structure **154** or regulator mounting bracket **46** (FIG. **5**), is secured directly to a platform or a mobile cart.

Beneficially, embodiments of the invention provide for a mechanical fuel lockout switch to ensure that two fuels are not simultaneously delivered to a dual fuel internal combustion engine. Embodiments of the invention also provide for a dual fuel generator with a remotely mounted gaseous fuel regulator system.

Therefore, according to one embodiment of the invention, a dual fuel generator and fuel delivery system includes a dual fuel generator including an engine configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line, and a carburetor attached to an intake of the engine to mix air and fuel and connect the liquid fuel line to the intake. A fuel regulator system may be located off board the dual fuel generator that includes a primary pressure regulator coupled to a service valve of the pressurized fuel source and configured to regulate the fuel supplied from the pressurized fuel source to a reduced pressure, and a secondary pressure regulator coupled to the primary pressure regulator and configured to regulate the gaseous fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the dual fuel generator. A mechanical fuel valve may be actuatable between a first position and a second position to selectively control fuel flow to the engine from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line.

According to another embodiment of the invention, a dual fuel generator and fuel delivery system includes a dual fuel generator including a generator housing, an alternator mounted within the generator housing, and an engine driving the alternator and mounted within the generator housing, the engine configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line. The dual fuel generator is preferably free of any pressure regulator mounted within the generator housing. A fuel regulator system may be located off board the dual fuel generator that is configured to regulate the gaseous fuel supplied from the pressurized fuel source in a first stage, the gaseous fuel regulated down to a reduced pressure in the first stage; and regulate the reduced pressure gaseous fuel in a second stage, the reduced pressure gaseous fuel from the first stage regulated down to a desired pressure in the second stage for delivery through the gaseous fuel line to operate the dual fuel generator. A mechanical fuel valve may be actuatable between a first position and a second position to selectively control fuel flow to the dual fuel generator from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line.

According to yet another embodiment of the invention, a dual fuel generator and fuel delivery system includes a dual fuel generator configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line. The dual fuel generator may include a gaseous fuel valve coupled to an inlet of the gaseous fuel line and connectible to the pressurized fuel source, and a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel generator from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line. A fuel regulator system may be located off board the dual fuel generator that includes a primary pressure regulator connectable to a service valve of the pressurized fuel source and configured to regulate the fuel supplied from the pressurized fuel source to a reduced pressure, and a secondary pressure regulator coupled to the primary pressure regulator and connectable to the gaseous fuel valve. The secondary pressure regulator may be configured to regulate the gaseous fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the dual fuel generator.

According to yet another embodiment of the invention, a dual fuel generator and fuel delivery system includes a dual fuel generator configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line. A fuel regulator system may be located off board the dual fuel generator that includes a primary pressure regulator coupled to a service valve of the pressurized fuel source and configured to regulate the fuel supplied from the pressurized fuel source to a reduced pressure, and a secondary pressure regulator coupled to the primary pressure regulator and configured to regulate the gaseous fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the dual fuel generator. A mechanical fuel valve may be actuatable between a first position and a second position to selectively control fuel flow to the dual fuel generator from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line, and the mechanical fuel valve may output gaseous fuel to the dual fuel generator during operation thereof on gaseous fuel at the desired pressure from the secondary pressure regulator.

According to yet another embodiment of the invention, a dual fuel generator includes an alternator and a dual fuel engine coupled to drive the alternator, the dual fuel engine configured to operate on a liquid fuel supplied from a liquid fuel source and a gaseous fuel supplied from a pressurized

fuel source. The dual fuel generator may also include a liquid fuel line coupled to the dual fuel engine to provide the liquid fuel from the liquid fuel source, a gaseous fuel line coupled to the dual fuel engine to provide the gaseous fuel from the pressurized fuel source, and a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel engine from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line. The dual fuel generator is preferably free from any gaseous fuel pressure regulator.

This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

What is claimed is:

1. A dual fuel generator and fuel delivery system comprising:

a dual fuel generator comprising:

an engine configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line, and

a carburetor attached to an intake of the engine to mix air and fuel and connect the liquid fuel line to the intake;

a fuel regulator system located off board the dual fuel generator, the fuel regulator system comprising:

a primary pressure regulator coupled to a service valve of the pressurized fuel source and configured to regulate the fuel supplied from the pressurized fuel source to a reduced pressure, and

a secondary pressure regulator coupled to the primary pressure regulator and configured to regulate the gaseous fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the dual fuel generator; and

a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the engine from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line.

2. The dual fuel generator and fuel delivery system of claim **1** wherein the carburetor connects the gaseous fuel line to the intake.

3. The dual fuel generator and fuel delivery system of claim **1** further comprising a fuel lockout apparatus coupled to the mechanical fuel valve; and

wherein when the mechanical fuel valve is in the first position, the fuel lockout apparatus communicates the liquid fuel source to the dual fuel generator and prevents the pressurized fuel source from coupling to the dual fuel generator, and actuation of the mechanical fuel valve to the second position causes the fuel lockout apparatus to permit the pressurized fuel source to couple to the dual fuel generator, and interrupts the liquid fuel source communication with the dual fuel generator.

4. The dual fuel generator and fuel delivery system of claim **1**, wherein the mechanical fuel valve opens and closes the liquid fuel line to selectively control fuel flow from the liquid fuel source to the dual fuel generator; and further comprises:

a fuel lockout apparatus coupled to the mechanical fuel valve and configured to prevent the pressurize fuel source from coupling to the gaseous fuel line while the mechanical fuel valve opens the liquid fuel line, and permit the pressurized fuel source to couple to the gaseous fuel line while the mechanical fuel valve closes the liquid fuel line.

5. The dual fuel generator and fuel delivery system of claim **4**, wherein the fuel lockout apparatus is further configured to prevent the mechanical fuel valve from opening the liquid fuel line while the dual fuel generator receives fuel from the pressurized fuel source.

6. The dual fuel generator and fuel delivery system of claim **4**, wherein the fuel lockout apparatus further comprises a fuel inlet cover that actuates with the mechanical fuel valve to cover an inlet of the gaseous fuel line while the mechanical fuel valve opens the liquid fuel line and to uncover the inlet of the gaseous fuel line when the mechanical fuel valve closes the liquid fuel line.

7. The dual fuel generator and fuel delivery system of claim **1**, further comprising:

a first end of a quick-connect hose coupling coupled to an outlet of the secondary pressure regulator; and

a second end of the quick-connect hose coupling coupled to an inlet of the gaseous fuel line to mate with the first end of the quick-connect hose coupling to couple the secondary pressure regulator to the gaseous fuel line.

8. The dual fuel generator and fuel delivery system of claim **1**, further comprising a regulator mounting device fixed to the pressurized fuel source with at least the secondary pressure regulator mounted on the regulator mounting device.

9. The dual fuel generator and fuel delivery system of claim **8**, wherein the primary pressure regulator is mounted on the regulator mounting device.

10. The dual fuel generator and fuel delivery system of claim **9**, wherein the pressurized fuel source comprises a pressurized fuel container having a collar; and

wherein the regulator mounting device fixes to the collar so that the primary and secondary pressure regulators are positioned adjacent each other along an outer periphery of the collar.

11. The dual fuel generator and fuel delivery system of claim **1**, wherein the primary and secondary pressure regulators are integral components of a dual stage pressure regulator.

12. A dual fuel generator and fuel delivery system comprising:

a dual fuel generator comprising:

a generator housing,

an alternator mounted within the generator housing, and

an engine driving the alternator and mounted within the generator housing, the engine configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line;

a fuel regulator system located off board the dual fuel generator, the fuel regulator system configured to:

regulate the gaseous fuel supplied from the pressurized fuel source in a first stage, the gaseous fuel regulated down to a reduced pressure in the first stage; and

regulate the reduced pressure gaseous fuel in a second stage, the reduced pressure gaseous fuel from the first stage regulated down to a desired pressure in the second stage for delivery through the gaseous fuel line to operate the dual fuel generator; and

a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel generator from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line;

wherein the dual fuel generator is free of any pressure regulator mounted within the generator housing.

13. The dual fuel generator and fuel delivery system of claim **12** wherein the mechanical fuel valve is mounted on or within the generator housing.

14. The dual fuel generator and fuel delivery system of claim **12** wherein the first stage comprises a primary pressure regulator coupled to a service valve of the pressurized fuel source and configured to regulate the gaseous fuel supplied from the pressurized fuel source to the reduced pressure; and

wherein the second stage comprises a secondary pressure regulator coupled to the primary pressure regulator and configured to regulate the gaseous fuel supplied from the primary pressure regulator to the desired pressure for delivery through the gaseous fuel line to operate the dual fuel generator.

15. The dual fuel generator and fuel delivery system of claim **14** further comprising:

a first end of a quick-connect hose coupling coupled to an outlet of the secondary pressure regulator; and

a second end of the quick-connect hose coupling coupled to an inlet of the gaseous fuel line to mate with the first end of the quick-connect hose coupling to couple the secondary pressure regulator to the gaseous fuel line.

16. The dual fuel generator and fuel delivery system of claim **14**, further comprising a regulator mounting device fixed to the pressurized fuel source with at least one of the primary pressure regulator and the secondary pressure regulator mounted on the regulator mounting device.

17. The dual fuel generator and fuel delivery system of claim **16**, wherein the pressurized fuel source comprises a pressurized fuel container having a collar; and

wherein the regulator mounting device fixes to the collar so that the primary and secondary pressure regulators are positioned adjacent each other along an outer periphery of the collar.

18. The dual fuel generator and fuel delivery system of claim **12** wherein the first and second stages comprise a dual stage regulator configured to regulate the gaseous fuel supplied from the pressurized fuel source and regulate the reduced pressure gaseous fuel.

19. The dual fuel generator and fuel delivery system of claim **18** wherein the dual stage regulator is mounted directly onto the pressurized fuel source.

20. A dual fuel generator and fuel delivery system comprising:

a dual fuel generator configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line, the dual fuel generator comprising:

a gaseous fuel valve coupled to an inlet of the gaseous fuel line and connectable to the pressurized fuel source, and

a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel generator from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line; and

a fuel regulator system located off board the dual fuel generator, the fuel regulator system comprising:

a primary pressure regulator connectable to a service valve of the pressurized fuel source and configured to regulate the fuel supplied from the pressurized fuel source to a reduced pressure, and

a secondary pressure regulator coupled to the primary pressure regulator and connectable to the gaseous fuel valve, the secondary pressure regulator configured to regulate the gaseous fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the dual fuel generator.

21. The dual fuel generator and fuel delivery system of claim **20** wherein the pressurized fuel source is independent and disconnected from the dual fuel generator.

22. The dual fuel generator and fuel delivery system of claim **21** wherein the fuel regulator system is disconnected from the dual fuel generator.

23. The dual fuel generator and fuel delivery system of claim **21** wherein the primary pressure regulator is disconnected from the pressurized fuel source.

24. The dual fuel generator and fuel delivery system of claim **20** wherein the gaseous fuel valve comprises at least one end of a quick-connect hose coupling mounted to an external surface of the dual fuel generator.

25. The dual fuel generator and fuel delivery system of claim **20** further comprising a fuel lockout apparatus coupled to the mechanical fuel valve; and

wherein when the mechanical fuel valve is in the first position, the fuel lockout apparatus communicates the liquid fuel source to the dual fuel generator and prevents the pressurized fuel source from coupling to the dual fuel generator, and actuation of the mechanical fuel valve to the second position causes the fuel lockout apparatus to permit the pressurized fuel source to couple to the dual fuel generator, and interrupts the liquid fuel source communication with the dual fuel generator.

26. The dual fuel generator and fuel delivery system of claim **20**, wherein the mechanical fuel valve opens and closes the liquid fuel line to selectively control fuel flow from the liquid fuel source to the dual fuel generator; and further comprises:

a fuel lockout apparatus coupled to the mechanical fuel valve and configured to prevent the pressurize fuel source from coupling to the gaseous fuel line while the mechanical fuel valve opens the liquid fuel line, and permit the pressurized fuel source to couple to the gaseous fuel line while the mechanical fuel valve closes the liquid fuel line.

27. The dual fuel generator and fuel delivery system of claim **26**, wherein the fuel lockout apparatus is further configured to prevent the mechanical fuel valve from opening the liquid fuel line while the dual fuel generator receives fuel from the pressurized fuel source.

28. The dual fuel generator and fuel delivery system of claim **26**, wherein the fuel lockout apparatus further com-

prises a fuel inlet cover that actuates with the mechanical fuel valve to cover an inlet of the gaseous fuel line while the mechanical fuel valve opens the liquid fuel line and to uncover the inlet of the gaseous fuel line when the mechanical fuel valve closes the liquid fuel line.

29. The dual fuel generator and fuel delivery system of claim **20**, wherein the gaseous fuel valve comprises:

a first end of a quick-connect hose coupling coupled to an outlet of the secondary pressure regulator; and

a second end of the quick-connect hose coupling coupled to an inlet of the gaseous fuel line to mate with the first end of the quick-connect hose coupling to couple the secondary pressure regulator to the gaseous fuel line.

30. The dual fuel generator and fuel delivery system of claim **20**, further comprising a regulator mounting device fixed to the pressurized fuel source with at least the secondary pressure regulator mounted on the regulator mounting device.

31. The dual fuel generator and fuel delivery system of claim **30**, wherein the primary pressure regulator is mounted on the regulator mounting device.

32. The dual fuel generator and fuel delivery system of claim **31**, wherein the pressurized fuel source comprises a pressurized fuel container having a collar; and

wherein the regulator mounting device fixes to the collar so that the primary and secondary pressure regulators are positioned adjacent each other along an outer periphery of the collar.

33. The dual fuel generator and fuel delivery system of claim **20**, wherein the primary and secondary pressure regulators are integral components of a dual stage pressure regulator.

34. A dual fuel generator and fuel delivery system comprising:

a dual fuel generator configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line;

a fuel regulator system located off board the dual fuel generator, the fuel regulator system comprising:

a primary pressure regulator coupled to a service valve of the pressurized fuel source and configured to regulate the fuel supplied from the pressurized fuel source to a reduced pressure, and

a secondary pressure regulator coupled to the primary pressure regulator and configured to regulate the gaseous fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the dual fuel generator; and

a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel generator from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line;

wherein the mechanical fuel valve outputs gaseous fuel to the dual fuel generator during operation thereof on gaseous fuel at the desired pressure from the secondary pressure regulator.

35. The dual fuel generator and fuel delivery system of claim **34** further comprising a fuel lockout apparatus coupled to the mechanical fuel valve; and

wherein when the mechanical fuel valve is in the first position, the fuel lockout apparatus communicates the liquid fuel source to the dual fuel generator and prevents the pressurized fuel source from coupling to the dual fuel generator, and actuation of the mechanical fuel valve to the second position causes the fuel lockout apparatus to permit the pressurized fuel source to couple to the dual fuel generator, and interrupts the liquid fuel source communication with the dual fuel generator.

36. The dual fuel generator and fuel delivery system of claim **34**, wherein the mechanical fuel valve opens and closes the liquid fuel line to selectively control fuel flow from the liquid fuel source to the dual fuel generator; and further comprises:

a fuel lockout apparatus coupled to the mechanical fuel valve and configured to prevent the pressurize fuel source from coupling to the gaseous fuel line while the mechanical fuel valve opens the liquid fuel line, and permit the pressurized fuel source to couple to the gaseous fuel line while the mechanical fuel valve closes the liquid fuel line.

37. The dual fuel generator and fuel delivery system of claim **36**, wherein the fuel lockout apparatus is further configured to prevent the mechanical fuel valve from opening the liquid fuel line while the dual fuel generator receives fuel from the pressurized fuel source.

38. The dual fuel generator and fuel delivery system of claim **36**, wherein the fuel lockout apparatus further comprises a fuel inlet cover that actuates with the mechanical fuel valve to cover an inlet of the gaseous fuel line while the mechanical fuel valve opens the liquid fuel line and to uncover the inlet of the gaseous fuel line when the mechanical fuel valve closes the liquid fuel line.

39. The dual fuel generator and fuel delivery system of claim **34**, further comprising:

a first end of a quick-connect hose coupling coupled to an outlet of the secondary pressure regulator; and

a second end of the quick-connect hose coupling coupled to an inlet of the gaseous fuel line to mate with the first end of the quick-connect hose coupling to couple the secondary pressure regulator to the gaseous fuel line.

40. The dual fuel generator and fuel delivery system of claim **34**, further comprising a regulator mounting device fixed to the pressurized fuel source with at least the secondary pressure regulator mounted on the regulator mounting device.

41. The dual fuel generator and fuel delivery system of claim **40**, wherein the primary pressure regulator is mounted on the regulator mounting device.

42. The dual fuel generator and fuel delivery system of claim **41**, wherein the pressurized fuel source comprises a pressurized fuel container having a collar; and

wherein the regulator mounting device fixes to the collar so that the primary and secondary pressure regulators are positioned adjacent each other along an outer periphery of the collar.

43. The dual fuel generator and fuel delivery system of claim **34**, wherein the primary and secondary pressure regulators are integral components of a dual stage pressure regulator.

44. A dual fuel generator comprising:

an alternator;

a dual fuel engine coupled to drive the alternator, the dual fuel engine configured to operate on a liquid fuel supplied from a liquid fuel source and a gaseous fuel supplied from a pressurized fuel source;

a liquid fuel line coupled to the dual fuel engine to provide the liquid fuel from the liquid fuel source;

a gaseous fuel line coupled to the dual fuel engine to provide the gaseous fuel from the pressurized fuel source; and

a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel engine from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line;

wherein the dual fuel generator is free from any gaseous fuel pressure regulator.

45. The dual fuel generator of claim **44** further comprising a gaseous fuel valve coupled to an inlet of the gaseous fuel line to connect the pressurized fuel source thereto.

46. The dual fuel generator of claim **45** further comprising a generator housing surrounding at least the dual fuel engine and the alternator with the gaseous fuel valve mounted on or within the generator housing.

47. The dual fuel generator of claim **44** wherein the mechanical fuel valve is located upstream from the liquid fuel line and the gaseous fuel line to selectively control fuel flow into the liquid fuel line from the liquid fuel source and the gaseous fuel line from the pressurized fuel source.

48. The dual fuel generator of claim **44** wherein the mechanical fuel valve comprises a liquid fuel valve coupled to the liquid fuel line and a gaseous fuel valve coupled to the gaseous fuel line.

49. The dual fuel generator of claim **44** further comprising:

a first end of a quick-connect hose coupling coupled to an outlet of the pressurized fuel source; and

a second end of the quick-connect hose coupling coupled to an inlet of the gaseous fuel line to mate with the first end of the quick-connect hose coupling to couple the pressurized fuel source to the gaseous fuel line.

50. The dual fuel generator of claim **44**, wherein the mechanical fuel valve opens and closes the liquid fuel line to selectively control fuel flow from the liquid fuel source to the dual fuel engine; and further comprises:

a fuel lockout apparatus coupled to the mechanical fuel valve and configured to prevent the pressurize fuel source from coupling to the gaseous fuel line while the mechanical fuel valve opens the liquid fuel line, and permit the pressurized fuel source to couple to the gaseous fuel line while the mechanical fuel valve closes the liquid fuel line.

51. The dual fuel generator of claim **50**, wherein the fuel lockout apparatus is further configured to prevent the mechanical fuel valve from opening the liquid fuel line while the dual fuel generator receives fuel from the pressurized fuel source.

52. The dual fuel generator of claim **50**, wherein the fuel lockout apparatus further comprises a fuel inlet cover that actuates with the mechanical fuel valve to cover an inlet of the gaseous fuel line while the mechanical fuel valve opens the liquid fuel line and to uncover the inlet of the gaseous fuel line when the mechanical fuel valve closes the liquid fuel line.

* * * * *

EXHIBIT J

US011905895B2

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Sarder et al.

(10) **Patent No.: US 11,905,895 B2**
(45) **Date of Patent: *Feb. 20, 2024**

(54) **DUAL FUEL LOCKOUT SWITCH FOR GENERATOR ENGINE**

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(73) Assignee: **Champion Power Equipment, Inc.**, Santa Fe Springs, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **18/183,734**

(22) Filed: **Mar. 14, 2023**

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(63) Continuation of application No. 17/937,046, filed on Sep. 30, 2022, now Pat. No. 11,840,970, which is a continuation of application No. 16/783,455, filed on Feb. 6, 2020, now Pat. No. 11,492,985, which is a continuation of application No. 16/191,503, filed on Nov. 15, 2018, now Pat. No. 11,530,654, which is a continuation of application No. 14/738,060, filed on Jun. 12, 2015, now Pat. No. 10,221,780.

(51) **Int. Cl.**
F02D 19/06 (2006.01)

(52) **U.S. Cl.**
CPC ***F02D 19/0613*** (2013.01); ***F02D 19/0605*** (2013.01); ***F02D 19/0647*** (2013.01); ***F02D 19/0673*** (2013.01); *Y02T 10/30* (2013.01)

(58) **Field of Classification Search**
CPC F02D 19/0673; F02D 19/0647; F02D 19/0605; F02D 19/0613
See application file for complete search history.

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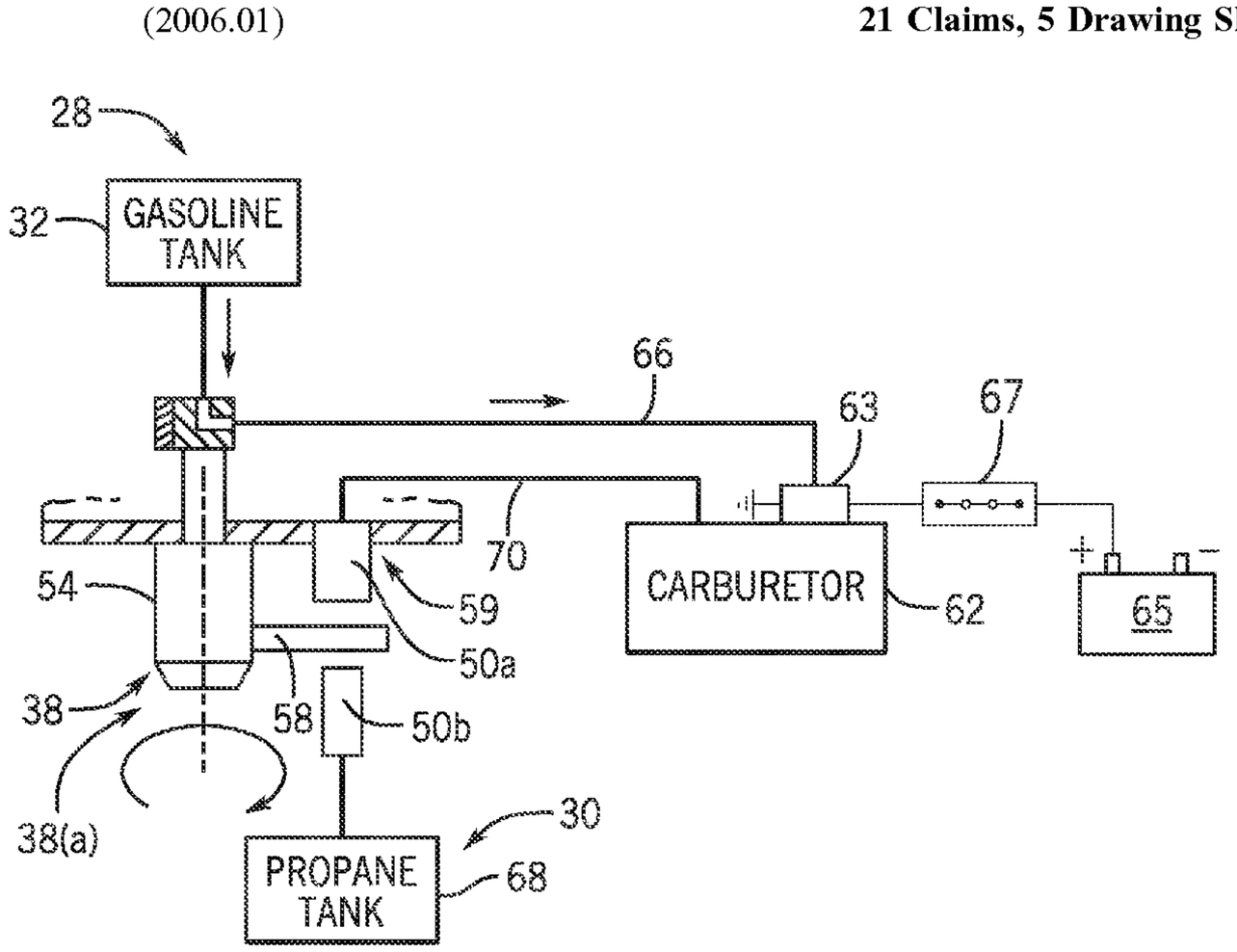
(57) **ABSTRACT**

A mechanical fuel lockout switch for a dual fuel engine includes a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel engine from a first fuel source through a first fuel line and a second fuel source through a second fuel line. The mechanical fuel lockout switch may also include a fuel lockout apparatus coupled to the mechanical fuel valve. The mechanical fuel valve may be configured to allow communication between the first fuel source and the dual fuel engine and prevent communication between the second fuel source and the dual fuel engine while in the first position, and prevent communication between the first fuel source and the dual fuel engine while in the second position.

21 Claims, 5 Drawing Sheets



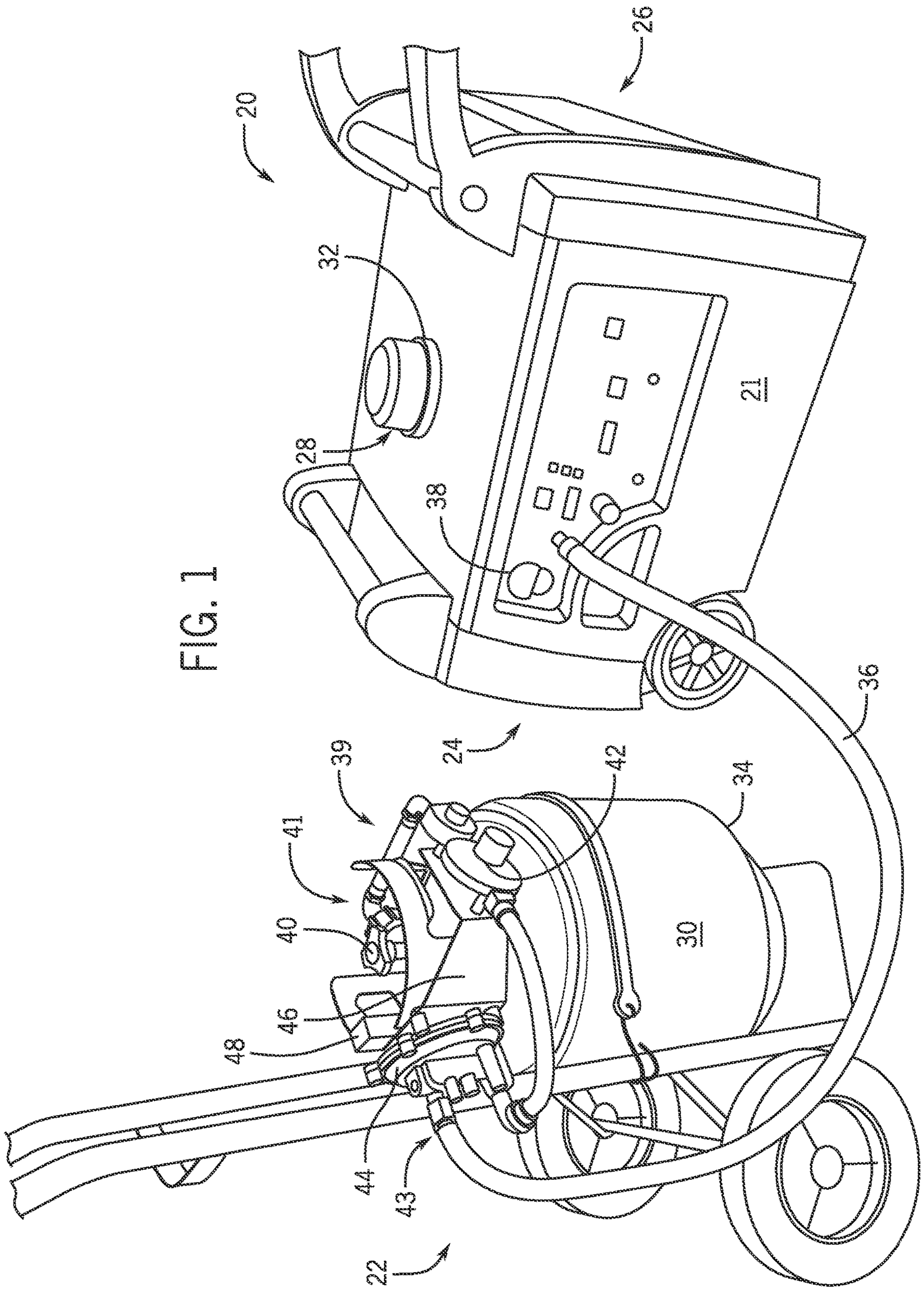
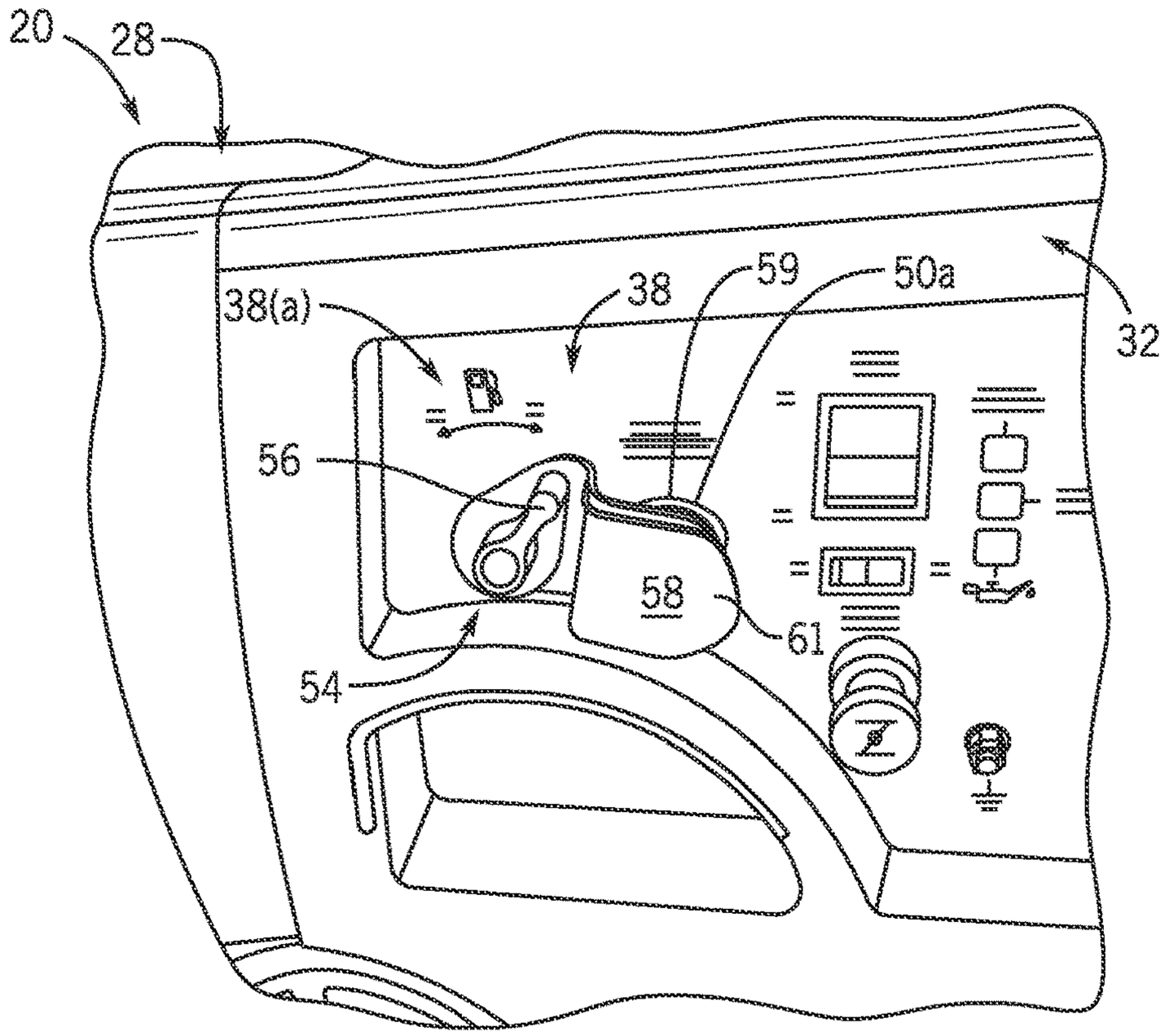


FIG. 1


20
28
38(a)
38
59
50a
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56
58
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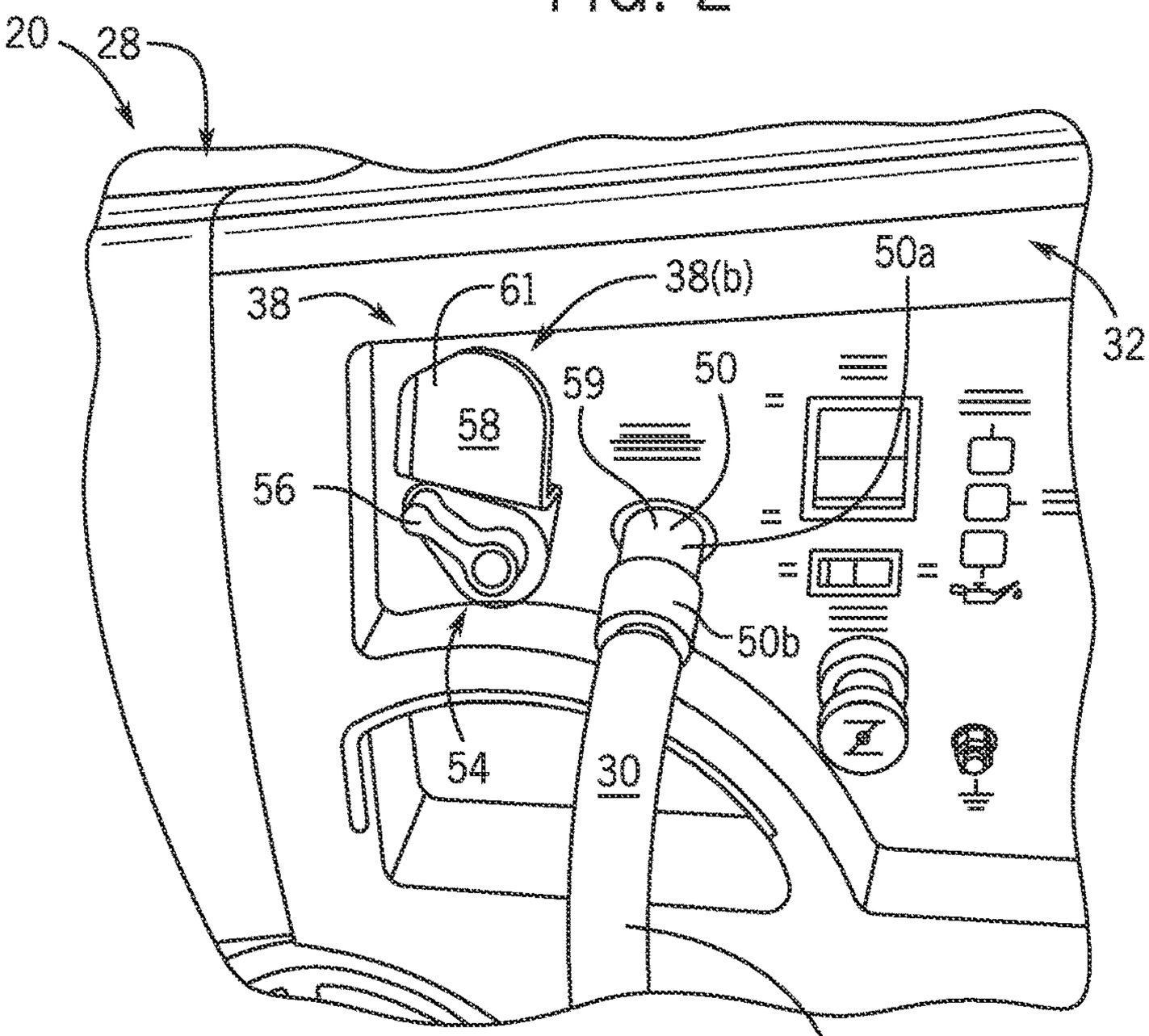
54

FIG. 2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38(b)
50a
32
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50b
54
30
36

FIG. 3

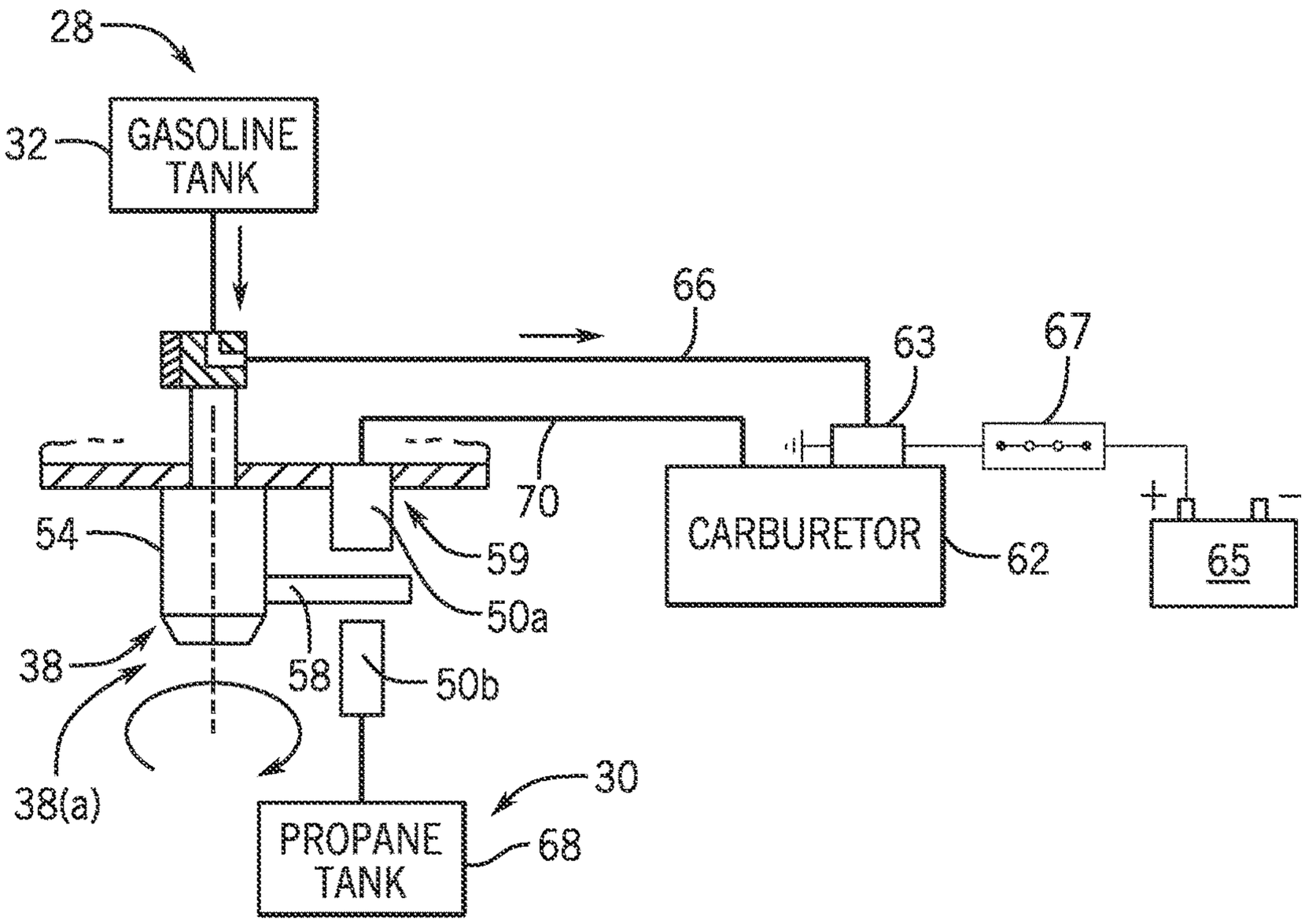

FIG. 4A

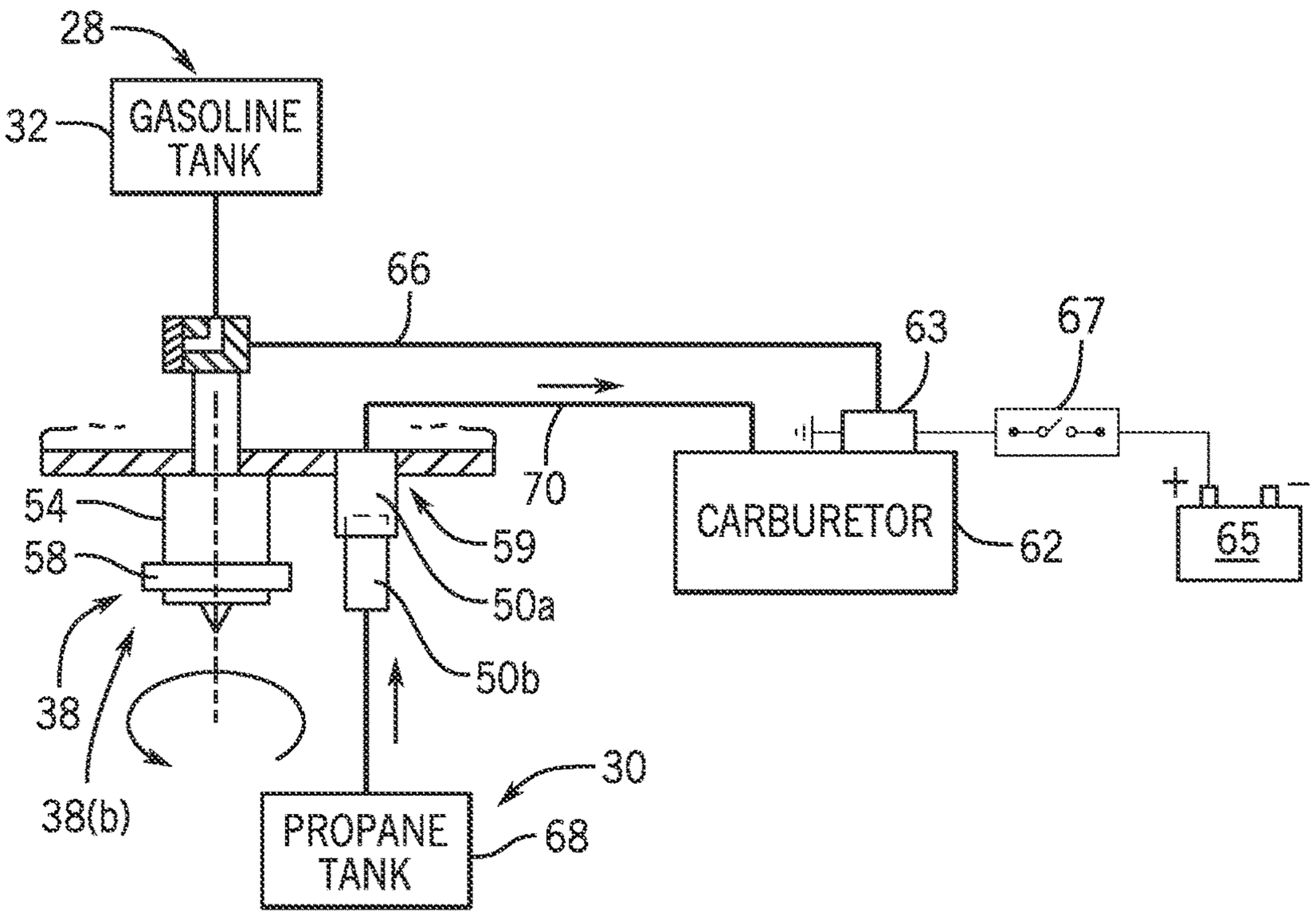

FIG. 4B

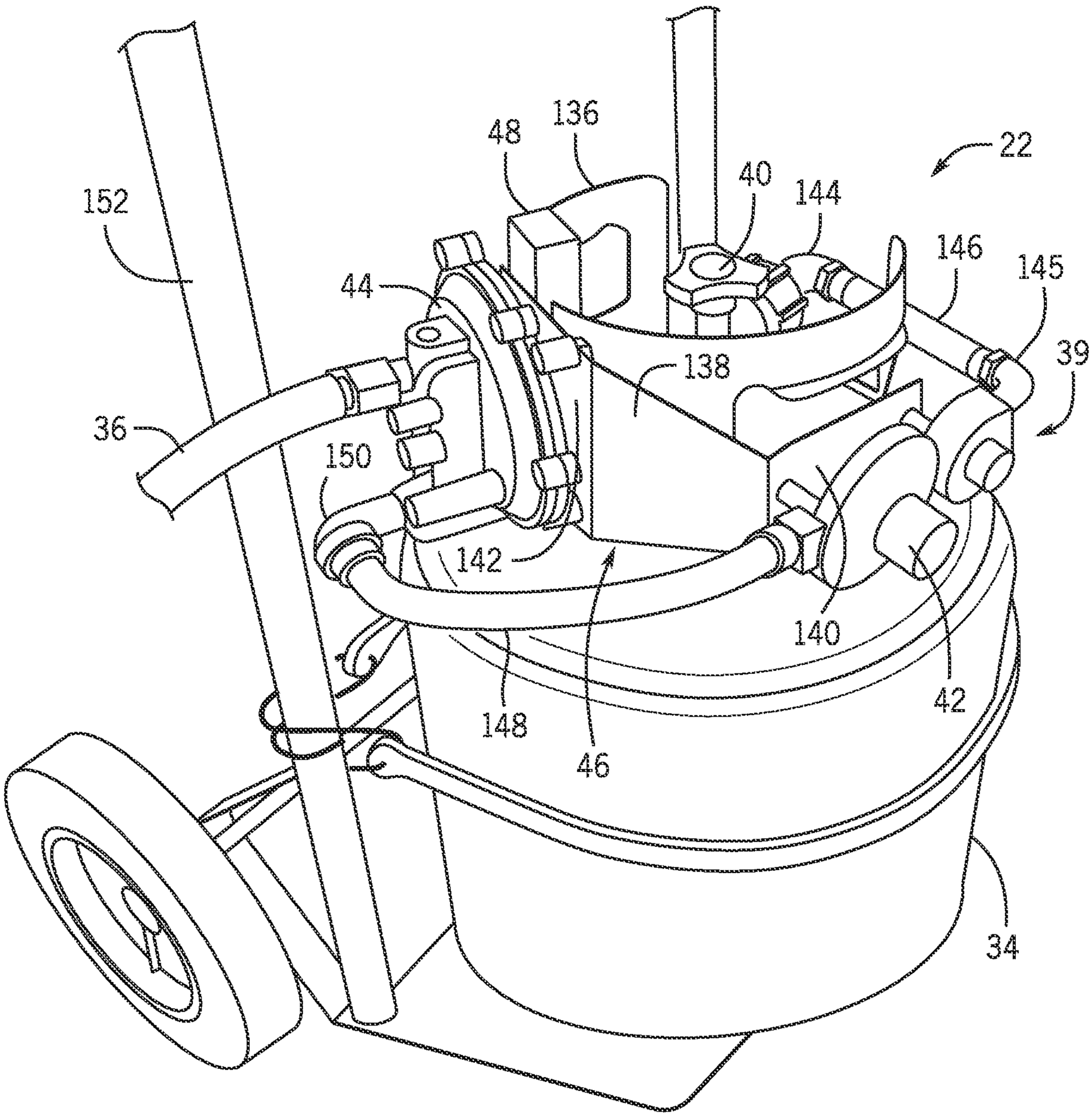

FIG. 5

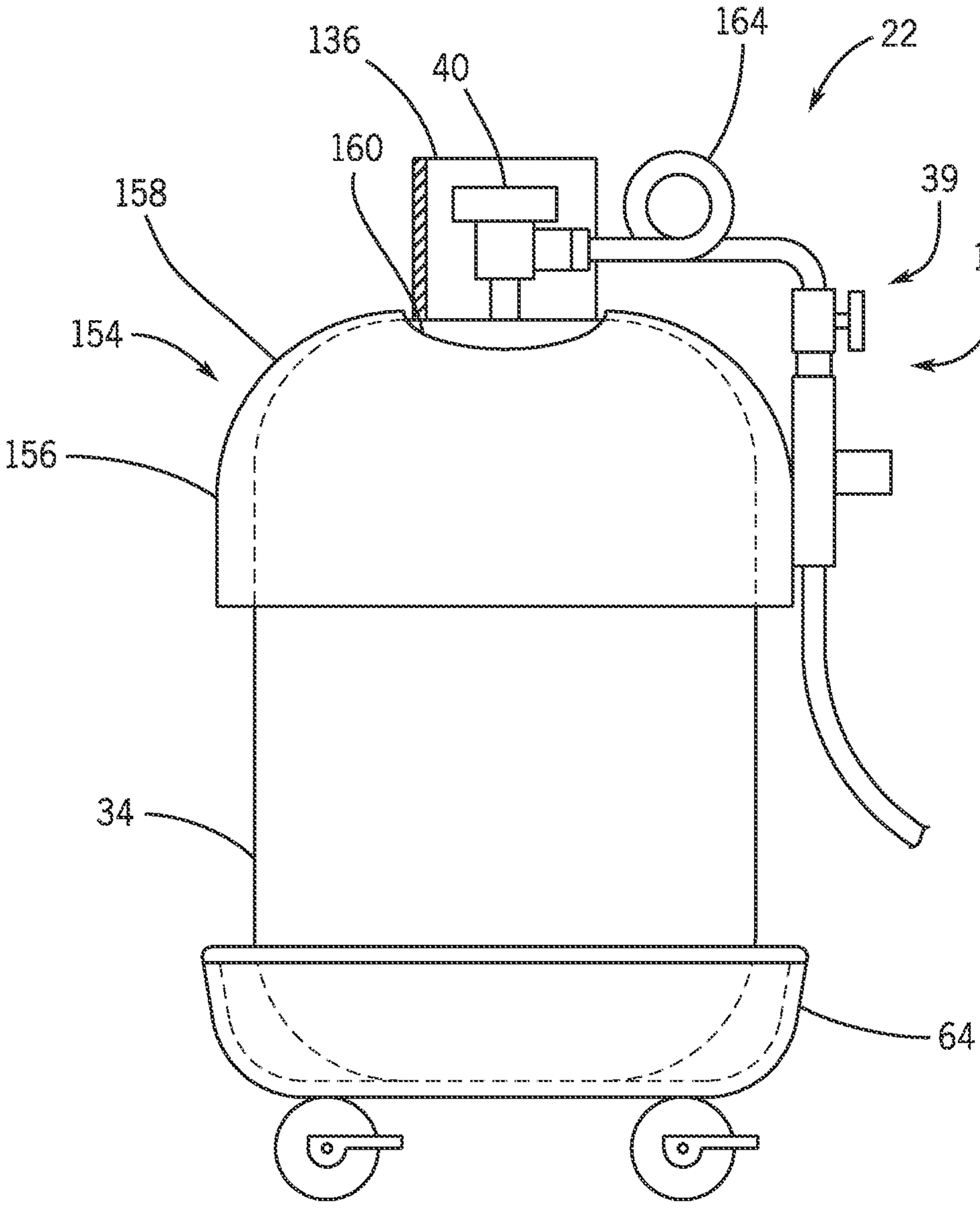

FIG. 6

DUAL FUEL LOCKOUT SWITCH FOR GENERATOR ENGINE

CROSS-REFERENCE TO RELATED APPLICATION

The present application is a continuation of, and claims priority to, U.S. patent application Ser. No. 17/937,046, filed on Sep. 30, 2022, which is a continuation of, and claims priority to, U.S. patent application Ser. No. 16/783,455, filed on Feb. 6, 2020, now U.S. Pat. No. 11,492,985, which is a continuation of, and claims priority to, U.S. patent application Ser. No. 16/191,503, filed on Nov. 15, 2018, now U.S. Pat. No. 11,530,654, which is a continuation of, and claims priority to, U.S. patent application Ser. No. 14/738,060, filed on Jun. 12, 2015, now U.S. Pat. No. 10,221,780, the disclosures of which are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

Embodiments of the invention relate generally to dual fuel generators, and more particularly, to an apparatus and method for delivering liquid fuel and gaseous fuel to a dual fuel generator.

Electric generators are frequently driven by internal combustion engines that use gasoline as a fuel source. Gasoline is a common fuel source for generators in a variety of applications. However, alternative fuel sources also provide a desirable fuel source. For instance, alternative fuels may provide a clean burning fuel that limits hazardous emissions. Alternative fuels may also be stored for long periods of time without degradation, whereas gasoline can degrade over a period of months leading to hard starting, rough running, and also lead to gum and varnish deposit left in the fuel system. In addition, generators that operate on alternative fuels may generate electricity when gasoline is not readily available. For instance, generators are frequently used when power outages in the utility grid result from severe weather. Unfortunately, gas stations may also be closed as a result of the power outage. Such a circumstance presents just one example where it would be advantageous to operate electrical generators on alternative fuels.

Certain generators are configured to operate as "dual fuel" generators, otherwise known as bi-fuel generators. These generators are driven by an internal combustion engine that is configured to operate on a liquid fuel for a period of operation and an alternative fuel for another period of operation. The alternative fuel source may exist in a gaseous state at normal temperature and pressure and can be any one of liquefied petroleum gas, compressed natural gas, hydrogen, or the like. Liquefied petroleum gas (LPG), often referred to as propane, exists in a gaseous state at normal temperature and pressure but can be conveniently stored under pressure in a liquid state. LPG may be a desirable fuel source for internal combustion engines because it can be stored for longer periods of time and contains fewer impurities than gasoline, resulting in smoother and cleaner operation, and often resulting in a longer lasting engine.

In order to provide the liquid and gaseous fuel to the engine, the dual fuel engine may have a first fuel line for liquid fuel and a second fuel line for gaseous fuel. A liquid fuel source and a gaseous fuel source may be coupled to the respective lines to provide fuel to the engine. However, a common problem with such configurations that couple two fuel sources to a single engine is the engine can experience overly rich air-fuel ratio when both fuels are simultaneously

engaged during cross-over switching between the fuel sources. Further, such simultaneous delivery of fuel from the first fuel line and the second fuel line may make the engine hard to start or lead to unstable operating conditions.

Therefore, it would be desirable to design a dual fuel generator having a liquid fuel and gaseous fuel delivery system that overcomes the aforementioned detriments without substantially increasing the overall cost of the system.

BRIEF DESCRIPTION OF THE INVENTION

In accordance with one aspect of the invention, a mechanical fuel lockout switch for a dual fuel engine includes a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel engine from a first fuel source through a first fuel line and a second fuel source through a second fuel line. The mechanical fuel valve may be configured to allow communication between the first fuel source and the dual fuel engine and prevent communication between the second fuel source and the dual fuel engine while in the first position, and prevent communication between the first fuel source and the dual fuel engine while in the second position. The mechanical fuel lockout switch may also include a fuel lockout apparatus coupled to the mechanical fuel valve and configured to prevent the second fuel source from coupling to the second fuel line while the mechanical fuel valve is in the first position, and permit the second fuel source to couple to the second fuel line while the mechanical fuel valve is in the second position.

In accordance with another aspect of the invention, a mechanical fuel lockout switch for a dual fuel engine includes a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel engine from a first fuel source through a first fuel line and a second fuel source through a second fuel line. The mechanical fuel valve may be configured to allow communication between the first fuel source and the dual fuel engine and prevent communication between the second fuel source and the dual fuel engine while the first position, and prevent communication between the first fuel source and the dual fuel engine while in the second position. The mechanical fuel lockout switch may also include a fuel lockout apparatus coupled to the mechanical fuel valve and configured to prevent actuation of the mechanical fuel valve to the first position when the second fuel source is in communication with the dual fuel engine.

In accordance with yet another aspect of the invention, a dual fuel generator and fuel delivery system includes a dual fuel generator configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line, and a fuel regulator system located off board the dual fuel generator. The fuel regulator system may include a primary pressure regulator couplable to a service valve of the pressurized fuel source and configured to regulate the gaseous fuel supplied from the pressurized fuel source to a reduced pressure, and a secondary pressure regulator couplable to the primary pressure regulator and configured to regulate the gaseous fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the dual fuel generator. The dual fuel generator and fuel delivery system may also include a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel generator from the liquid fuel source through the liquid fuel line and the pressurized fuel

source through the gaseous fuel line, the mechanical fuel valve configured to open and close the liquid fuel line to selectively control fuel flow from the liquid fuel source to the dual fuel generator. A fuel lockout apparatus may couple to the mechanical fuel valve configured to prevent the pressurized fuel source from coupling to the gaseous fuel line while the liquid fuel line is open, and permit the pressurized fuel source to couple to the gaseous fuel line while the liquid fuel line is closed by the mechanical fuel valve.

Various other features and advantages will be made apparent from the following detailed description and the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings illustrate preferred embodiments presently contemplated for carrying out the invention.

In the drawings:

FIG. **1** is a perspective view of a dual fuel generator coupled to a fuel delivery system, according to an embodiment of the invention.

FIG. **2** is a detail view of a portion of the generator of FIG. **1** about a mechanical fuel lockout switch with the switch in a first position, according to an embodiment of the invention.

FIG. **3** is a detail view similar to FIG. **2** and showing the mechanical fuel lockout switch in a second position, with an LPG supply line connected thereto, according to an embodiment of the invention.

FIG. **4**A is a schematic diagram of a fuel system for the dual fuel generator of FIG. **1** showing a liquid fuel source in communication with a carburetor of the generator consistent with the first position of the switch as shown in FIG. **2**, according to an embodiment of the invention.

FIG. **4**B is a schematic diagram of the fuel system of FIG. **4**A showing a gaseous fuel source in communication with a carburetor of the generator of FIG. **1** consistent with the second position of the switch as shown in FIG. **3**, according to an embodiment of the invention.

FIG. **5** is a perspective view of a fuel delivery system for the dual fuel generator of FIG. **1**, according to an embodiment of the invention.

FIG. **6** is a side view of a fuel delivery system for the dual fuel generator of FIG. **1**, according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The operating environment of the invention is described with respect to a dual fuel generator. However, it will be appreciated by those skilled in the art that the invention is equally applicable for use with any dual fuel internal combustion engine. Moreover, the invention will be described with respect to a dual fuel generator configured to operate on a liquid fuel and a gaseous fuel. However, one skilled in the art will further appreciate that the invention is equally applicable for use with other fuel combinations for dual fuel generators and internal combustion engines.

Referring to FIG. **1**, a dual fuel generator **20** is coupled to a fuel delivery system **22**, in accordance with an embodiment of the invention. Dual fuel generator **20** includes an internal combustion engine (not shown) within housing **21** at one end **24**, operatively connected to an alternator also enclosed in housing **21** at another end **26**, by conventional means. Dual fuel generator **20** is configured to operate on different fuels via either a first fuel source **28** or a second fuel source **30**. In an exemplary embodiment of the invention, first fuel source **28** is a liquid fuel and second fuel source **30** is a gaseous fuel. The liquid fuel may be gasoline and the gaseous fuel may be liquid petroleum gas (LPG). Each can selectively operate the generator as desired and controlled by an operator. For instance, generator **20** may operate on gasoline for a first period of operation and then switch to LPG for a second period of operation. However, it is contemplated that dual fuel generator **20** is configured to operate on fuels other than gasoline and LPG (e.g., natural gas, biodiesel, etc.), and thus the scope of the invention is not meant to be limited strictly to a dual fuel arrangement where first fuel source **28** provides gasoline and second fuel source **30** provides LPG.

In one embodiment of the invention, dual fuel generator **20** includes a gasoline tank **32** or, generally, a liquid fuel tank, located inside cover **21** onboard generator **20** to provide gasoline to the engine as first fuel source **28**. Gasoline tank **32** connects to a first fuel line to provide gasoline to the carburetor to run the engine, as will later be described with reference to FIGS. **4**A and **4**B. Generator **20** is also coupled to a pressurized fuel container **34**, or a pressurized fuel source, located off board generator **20** to provide LPG to the engine as second fuel source **30**. Pressurized fuel container **34** is coupled to generator **20** with an LPG supply hose **36**. LPG supply hose **36** is coupled to a second fuel line within generator **20** to provide LPG to the carburetor to run the engine. Dual fuel generator **20** includes a mechanical fuel lockout switch **38** for selecting a desired fuel to be provided to the engine. The mechanical fuel lockout switch **38** is actuated to select first fuel source **28** when in a first position, as shown in FIG. **2**, and alternately to select second fuel source **30** when in a second position, as shown in FIG. **3**.

Referring back to FIG. **1**, in an exemplary embodiment, fuel **30** from pressurized fuel container **34** is regulated using a fuel regulator system **39** for delivery to the engine. Fuel regulator system **39** includes one or more pressure regulators that reduce and control the pressure of the fuel from pressurized fuel container **34** and delivers fuel at a desired pressure for operation of the engine. Fuel regulator system **39** has an inlet **41** operatively coupled to a service valve **40** of pressurized fuel container **34** and an outlet **43** coupled to LPG supply hose **36**. Fuel regulator system **39** includes a primary pressure regulator **42** coupled to pressurized fuel container **34** and a secondary pressure regulator **44**. Primary pressure regulator **42** protects downstream components from high pressure of pressurized fuel container **34**. Primary pressure regulator **42** receives LPG through service valve **40** of pressurized fuel container **34** and reduces the pressure of the LPG to a first stage. In one embodiment of the invention, the first stage may be delivered directly to generator **20** at a pressure required for operation of the engine.

In an exemplary embodiment of the invention, fuel regulator system **39** includes secondary pressure regulator **44** coupled to the outlet of primary pressure regulator **42** in order to use standard "off-the-shelf" components. Typically, the primary pressure regulator is mounted on the LPG tank, while the secondary pressure regulator is mounted on the component using the fuel, such as an engine or grill. Here, since generator **20** can be used as a gasoline only generator, secondary pressure regulator **44** is mounted off-board the generator to reduce size and cost of the generator. Secondary pressure regulator **44** receives LPG from primary pressure regulator **42** and further reduces the pressure of LPG to a second stage to be delivered to generator **20**. In a system

with two regulators, primary pressure regulator **42** regulates fuel received from pressurized fuel container **34** and reduces the pressure of the fuel to a level required for operation of secondary pressure regulator **44**. Secondary pressure regulator **44** regulates fuel received from primary pressure regulator **42** and further reduces the pressure of the fuel to a level required for operation of generator **20**. In addition, primary pressure regulator **42** may compensate for varying tank pressure as fuel is depleted while secondary pressure regulator **44** may compensate for varying demand from generator **20**.

In accordance with an exemplary embodiment of the invention, fuel regulator system **39** includes both the primary and secondary regulators, or a custom single regulator, but in any case is located remotely, or off-board, from dual fuel generator **20**. Fuel regulator system **39** may be directly mounted to pressurized fuel container **34** using a regulator mounting bracket **46**. Regulator mounting bracket **46** has mounting locations for primary pressure regulator **42** and secondary pressure regulator **44**. Regulator mounting bracket **46** also has a securing mechanism **48** to secure regulator mounting bracket **46** to pressurized fuel container **34**.

In another embodiment of the invention, primary pressure regulator **42** is mounted on regulator mounting bracket **46** while secondary pressure regulator **44** could be mounted on or near generator **20**. In yet another embodiment of the invention, a dual stage regulator may regulate the fuel received from pressurized fuel container **34** and deliver fuel at a pressure required for operation of generator **20**. Such a dual stage regulator may regulate the fuel to the second stage within a single structure. The dual stage regulator may be mounted directly on fuel container **34**.

Referring to FIG. **2**, a detail view of a portion of generator **20** of FIG. **1** depicts mechanical fuel lockout switch **38** in a first position **38**(*a*), in accordance with an embodiment of the invention. In this position, mechanical fuel lockout switch **38** provides gasoline flow from gasoline tank **32** to the engine while preventing connection of an LPG supply line to fuel inlet **59** of the second fuel line, as will later be discussed in detail with reference to FIGS. **4**A and **4**B. Still referring to FIG. **2**, mechanical fuel lockout switch **38** provides a combination liquid fuel shutoff valve and a gaseous fuel supply lockout that prevents simultaneous delivery of fuel to the engine from gasoline tank **32** and pressurized fuel container **34**, FIG. **1**. As such, mechanical fuel lockout switch **38** provides a fuel selector to ensure only the selected fuel is provided to dual fuel generator **20**.

Mechanical fuel lockout switch **38**, FIG. **2**, includes mechanical fuel valve **54** actuatable between first position **38**(*a*) as shown in FIG. **2** and second position **38**(*b*) as shown in FIG. **3** to selectively control fuel flow to the dual fuel engine from first fuel source **28** through a first fuel line and second fuel source **30** through a second fuel line **36**. Mechanical fuel lockout switch **38** may also include fuel lockout apparatus **58** coupled to mechanical fuel valve **54** to communicate fuel sources individually to generator **20**. In one embodiment of the invention, fuel lockout apparatus **58** communicates first fuel source **28** to the engine by actuating mechanical fuel valve **54** to first position **38**(*a*) to open the first fuel line as shown in FIG. **2**, and communicates second fuel source **30** to the engine by actuating mechanical fuel valve **54** to second position **38**(*b*) to open communication of the second fuel source **30** to the engine as shown in FIG. **3**. Referring back to FIG. **2**, when mechanical fuel valve **54** is in first position **38**(*a*), fuel lockout apparatus **58** communicates first fuel source **28** to the dual fuel engine and prevents communication between the second fuel source and the dual fuel engine.

In an exemplary embodiment of the invention, mechanical fuel valve **54** controls the flow of LPG to the engine by actuating fuel lockout apparatus **58** to block or unblock fuel inlet **59** for the second fuel source. Mechanical fuel valve **54** is coupled to the first fuel line, as shown in FIGS. **4**A and **4**B, and therefore can control the flow of gasoline to the engine by opening and closing the first fuel line. When the mechanical fuel valve **54**, FIG. **2**, is in the first position **38**(*a*), gasoline flows from the gasoline tank to the engine and the fuel lockout apparatus **58** blocks the fuel inlet **59**. Accordingly, fuel lockout apparatus **58** prevents LPG flow to generator **20** when the mechanical fuel valve **54** is in first position **38**(*a*) wherein the engine is operated on gasoline.

Mechanical fuel valve **54** includes a fuel valve handle **56** to control the opening and closing of the valve. Fuel valve handle **56** is movable between first position **38**(*a*) as shown in FIG. **2** and second position **38**(*b*) as shown in FIG. **3**. Mechanical fuel valve **54** opens the first fuel line (to enable liquid fuel flow to the engine) when fuel valve handle **56** is in the first position, and mechanical fuel valve **54** closes the first fuel line (to prevent liquid fuel flow to the engine) when fuel valve handle **56** is in the second position. Thus, when fuel valve handle **56** is in first position **38**(*a*) as shown in FIG. **2**, mechanical fuel valve **54** opens the first fuel line and allows gasoline from gasoline tank **32** to flow to the engine.

Fuel valve handle **56** is coupled to fuel lockout apparatus **58**. Fuel valve handle **56** actuates with fuel lockout apparatus **58** to prevent LPG flow to generator **20** when gasoline flow to the generator is enabled. Fuel lockout apparatus **58** is controlled by fuel valve handle **56** so that moving fuel valve handle **56** to the first position causes fuel lockout apparatus **58** to block fuel inlet **59** for LPG, and moving fuel valve handle **56** to the second position causes fuel lockout apparatus **58** to unblock fuel inlet **59** for LPG.

In an exemplary embodiment of the invention, fuel valve handle **56** rotates between the first position and the second position and fuel lockout apparatus **58** is rigidly coupled to the rotating handle. Fuel lockout apparatus **58** may include a fuel inlet cover **61**, which may be a flange, coupled to fuel valve handle **56** so that fuel inlet cover **61** rotates with the handle. Fuel inlet cover **61** extends radially outward from fuel valve handle **56** and sweeps over fuel inlet **59** for LPG as fuel valve handle **56** rotates. That is, fuel inlet cover **61** rotates transversely across fuel inlet **59** and blocks access thereto. Accordingly, fuel inlet cover **61** prevents LPG flow to generator **20** when fuel valve handle **56** is in first position **38**(*a*) to allow gasoline to run the engine.

Referring to FIG. **3**, a detail view of a portion of generator **20** of FIG. **1** depicts mechanical fuel lockout switch **38** in a second position **38**(*b*), in accordance with an embodiment of the invention. In this position, the mechanical fuel lockout switch **38** provides a disconnect to stop gasoline flow from gasoline tank **32** to the engine while allowing connection of LPG supply hose **36** to fuel inlet **59** of the second fuel line. FIG. **3** further shows LPG supply hose **36** coupling second fuel source **30** to generator **20** to deliver LPG to run the generator.

Mechanical fuel lockout switch **38** includes mechanical fuel valve **54** coupled to fuel lockout apparatus **58** to prevent gasoline flow to generator **20** when LPG from the LPG service hose **36** is supplied to the engine. In one embodiment of the invention, actuation of mechanical fuel valve **54** to second position **38**(*b*) causes fuel lockout apparatus **58** to allow communication of second fuel source **30** to the dual

fuel engine, and interrupts the first fuel source **28** communication with the dual fuel engine. The position of fuel lockout apparatus **58** prevents the fuel valve handle **56** from moving to first position **38**(*a*) (FIG. **2**) while LPG supply hose **36** is connected to generator **20**.

A quick-disconnect hose coupling **50**, also referred to as a quick-connect hose coupling, connects LPG supply hose **36** to generator **20** so that LPG supply hose **36** may be quickly attached and detached from generator **20**. Hose coupling **50** has a first end **50***a* mounted on the external surface of generator **20** and coupled to supply the second fuel to the engine. Hose coupling **50** has a second end **50***b* coupled to the outlet of LPG supply hose **36**. Hose coupling **50** has a valve that opens when the couplings are engaged and closes when the couplings are disengaged. As such, quick-disconnect hose coupling **50** automatically opens when connected to enable fuel flow from LPG supply hose **36** to the engine. Hose coupling **50** automatically disconnects fluid communication when disconnected. Accordingly, when the supply hose is detached from generator **20**, the coupling **50** is automatically closed so that fuel does not escape and unwanted air does not enter the fuel system.

In one embodiment, fuel inlet cover **61** is coupled to fuel valve handle **56** so that it is spaced apart from the surface of generator **20** to provide clearance for first end **50***a* of the quick-disconnect hose coupling **50** that protrudes from the surface of generator **20**. As shown in FIG. **2**, fuel inlet cover **61** blocks off first end **50***a* of the quick-disconnect hose coupling when fuel valve handle **56** is rotated to first position **38**(*a*) to enable gasoline flow so that fuel inlet cover **61** prevents connection of LPG supply hose **36** (FIG. **3**) to generator **20**. As shown in FIG. **3**, fuel inlet cover **61** uncovers first end **50***a* of the quick-disconnect hose coupling **50** when fuel valve handle **56** is rotated to second position **38**(*b*) to disable gasoline flow so that fuel inlet cover **61** permits connection of LPG supply hose **36** to generator **20**.

To operate generator **20** on LPG, fuel valve handle **56** is turned to second position **38**(*b*) to disable the flow of gasoline to the engine and to expose first end **50***a* of hose coupling **50** on generator **20**. LPG supply hose **36** is then connected to generator **20** via hose coupling **50** to enable the flow of LPG to the engine. To operate generator **20** on gasoline, LPG supply hose **36** is disconnected from generator **20** via hose coupling **50** to disable the flow of LPG to the engine and to unblock fuel valve handle **56** from rotating to the first position. As shown in FIG. **2**, fuel valve handle **56** is then turned to first position **38**(*a*) to enable the flow of gasoline to generator **20**.

Referring to FIG. **4**A, a schematic diagram of a fuel system for a dual fuel engine shows mechanical fuel lockout switch **38** in first position **38**(*a*) to provide communication between the first fuel source **28** and dual fuel carburetor **62**, according to an embodiment of the invention. Mechanical fuel lockout switch **38** prevents communication between second fuel source **30** and dual fuel carburetor **62** when the switch is in first position **38**(*a*). In one embodiment of the invention, first fuel source **28** includes a gasoline tank **32** to provide gasoline to carburetor **62** through a first fuel line **66**, and second fuel source **30** includes a propane or LPG tank **68** to provide propane or LPG to carburetor **62** through a second fuel line **70**. Accordingly, first fuel line **66** may be a liquid fuel line and second fuel line **70** may be a gaseous fuel line.

Mechanical fuel lockout switch **38** includes a mechanical fuel valve **54** actuatable between first position **38**(*a*) as shown in FIG. **4**A and second position **38**(*b*) as shown in FIG. **4**B to selectively control fuel flow to the dual fuel engine from first fuel source **28** through first fuel line **66** and second fuel source **30** through second fuel line **70**. Referring back to FIG. **4**A, mechanical fuel valve **54** selectively controls fuel flow through first fuel line **66** by opening the line when the mechanical fuel lockout switch **38** actuates to first position **38**(*a*). Mechanical fuel valve **54** may be coupled to fuel lockout apparatus **58** that actuates with mechanical fuel valve **54** to block and unblock fuel inlet **59** of second fuel line **70**. First end **50***a* of the quick-disconnect hose coupling is located at fuel inlet **59** and a mating end **50***b* of the quick-disconnect hose coupling is coupled to the propane or LPG tank **68**. Actuation of mechanical fuel valve **54** to first position **38**(*a*) causes fuel lockout apparatus **58** to block fuel inlet **59** to prevent coupling the first end **50***a* and second end **50***b* of the quick-disconnect hose coupling together, and actuation of mechanical fuel valve **54** to another position causes fuel lockout apparatus **58** to unblock fuel inlet **59** to permit attaching first end **50***a* and second end **50***b* together.

In one embodiment of the invention, a fuel cut solenoid **63** couples to carburetor **62** to regulate liquid fuel flow into a main nozzle within the carburetor. Fuel cut solenoid **63** is advantageous to control liquid fuel flow downstream of a float bowl in the carburetor and can stop fuel flow to the engine immediately after ignition shutdown. As such, fuel cut solenoid **63** prevents the engine from drawing in fuel from the float bowl while the engine shuts off. Fuel cut solenoid **63** also traps fuel in the float bowl to eliminate delay in filling the bowl when starting the engine on liquid fuel, and prevents liquid fuel flow from the float bowl to the engine when starting on gaseous fuel.

Fuel cut solenoid **63** may regulate fuel flow through multiple fuel lines in carburetor **62** that provide fuel from the float bowl to the engine. For instance, carburetor **62** may have a main fuel line and an idle fuel line that receive fuel from the float bowl. Fuel cut solenoid **63** may control fuel flow through all of the fuel lines that receive fuel from the float bowl or may regulate only some of the fuel lines. As such, fuel cut solenoid **63** may block fuel flow through the main fuel line while small amounts of fuel can flow through the idle fuel line.

Fuel cut solenoid **63** preferably operates as a normally closed valve that opens when powered by a 12 volt battery **65**, although fuel cut solenoid **63** may also be operated as a normally open valve. The normally closed valve is opened for gasoline mode to allow gasoline flow to the engine and closed for LPG mode to prevent gasoline flow to the engine. Fuel cut solenoid **63** is operated by an electrical switch **67** which may be mechanically actuated and controlled by mechanical fuel lockout switch **38**. As such, actuation of mechanical fuel lockout switch **38** to first position **38**(*a*) closes electrical switch **67** to power and open fuel cut solenoid **63** as represented in FIG. **4**A, and actuation of mechanical fuel lockout switch **38** to second position **38**(*b*) opens electrical switch **67** to interrupt power and close fuel cut solenoid **63** as represented in FIG. **4**B.

Referring to FIG. **4**B, a schematic diagram of a fuel system for a dual fuel engine shows mechanical fuel lockout switch **38** in second position **38**(*b*) to provide communication between second fuel source **30** and dual fuel carburetor **62**, according to an embodiment of the invention. Mechanical fuel lockout switch **38** prevents communication between first fuel source **28** and dual fuel carburetor **62** when the switch is in second position **38**(*b*). The dual fuel engine has a first fuel line **66** to provide fuel from first fuel source **28** to carburetor **62** and a second fuel line **70** to provide fuel from second fuel source **30** to carburetor **62**.

Mechanical fuel lockout switch **38** includes mechanical fuel valve **54** that selectively controls fuel flow through first fuel line **66** by closing the line when mechanical fuel lockout switch **38** actuates to second position **38**(*b*). Mechanical fuel lockout switch **38** may also include a mechanical lockout apparatus **58** to block and unblock fuel inlet **59** of the second fuel line **70**. Fuel inlet **59** may include first end **50***a* of the quick-connect hose coupling mounted on the generator and coupled to second fuel line **70**. Second end **50***b* of the quick-connect hose coupling is coupled to the outlet of second fuel source **30**, and the first end **50***a* mates with second end **50***b* to quickly attach propane or LPG tank **68** to second fuel line **70**. Fuel lockout apparatus **58** may also hold mechanical fuel lockout switch **38** in second position **38**(*b*) when the propane or LPG tank **68** is coupled to the engine via the ends **50***a*, **50***b* of the quick-connect hose coupling.

Fuel cut solenoid **63** couples to carburetor **62** to regulate liquid fuel flow through the carburetor as described with respect to FIG. **4**A. FIG. **4**B shows electrical switch **67** opened to interrupt power and close fuel cut solenoid **63** for LPG mode when mechanical fuel lockout switch **38** is in second position **38**(*b*).

FIGS. **4**A and **4**B depict an embodiment where mechanical fuel valve **54** operates along first fuel line **66** to provide a flow path for first fuel source **28** to carburetor **62** when the valve is in first position **38**(*a*). That is, mechanical fuel valve **54** may control a single fuel line that runs through the valve while operating fuel lockout apparatus **58** to control fuel flow through second fuel line **70**. Embodiments of the invention also contemplate mechanical fuel valve **54** configured to operate along second fuel line **70** to provide a flow path for second fuel source **30** to carburetor **62** when the valve is in second position **38**(*b*). Mechanical fuel valve **54** may be configured to control multiple fuel lines that run through the valve according to embodiments of the invention.

Referring now to FIG. **5**, a perspective view of fuel delivery system **22** for dual fuel generator **20** of FIG. **1** is shown, in accordance with an embodiment of the invention. Fuel delivery system **22** includes a mounting arrangement for fuel regulator system **39**. The mounting arrangement includes regulator mounting bracket **46** for mounting fuel regulator system **39**. Regulator mounting bracket **46** extends around the outer periphery of collar **136** on pressurized fuel container **34**. Regulator mounting bracket **46** has securing mechanism **48** to secure to collar **136**. In one embodiment, securing mechanism **48** is a rigid component that extends inward from regulator mounting bracket **46** with a slot for receiving collar **136** to hold regulator mounting bracket **46** to collar **136**.

Regulator mounting bracket **46** provides mounting locations for pressure regulators. In one embodiment, regulator mounting bracket **46** is made of sheet metal bent in two locations to provide a central panel **138**, a first outer panel **140**, and a second outer panel **142** for mounting the regulators. The panels may be angled from each other such that regulator mounting bracket **46** fits around collar **136**. Primary pressure regulator **42** mounts on first outer panel **140** and secondary pressure regulator **44** mounts on second outer panel **142**. The panels are sized according to their respective regulators. Accordingly, second outer panel **142** is larger than first outer panel **140** if secondary pressure regulator **44** is larger than primary pressure regulator **42**. Panels **140**, **142** have fasteners or openings to receive fasteners to couple respective regulators **42**, **44** to the panels. Regulator mounting bracket **46** rests on top of pressurized fuel container **34** and engages the periphery of collar **136** to support fuel regulator system **39** on the container.

In one embodiment of the invention, primary pressure regulator **42** couples to two ninety degree elbows **144**, **145** to reach around collar **136** in order to couple to service valve **40**. The two elbows **144**, **145** are joined by a hose or pipe **146** that leads from elbow **144** at service valve **40** to elbow **145** at the outer periphery of collar **136**. The outlet of primary pressure regulator **42** couples to a hose **148** that extends to another ninety degree elbow **150** coupled to the inlet of secondary pressure regulator **44**. Secondary pressure regulator **44** couples to LPG supply hose **36**. Pressurized fuel container **34** may be strapped to a dolly **152**.

Referring now to FIG. **6**, a side view of another fuel delivery system **22** for dual fuel generator **20** of FIG. **1** is shown, in accordance with an embodiment of the invention. Fuel delivery system **22** includes a mounting arrangement for fuel regulator system **39**. The mounting arrangement includes a regulator mounting structure **154** for mounting fuel regulator system **39** to pressurized fuel container **34**. Regulator mounting structure **154** includes a cylinder **156** that surrounds the circumference of pressurized fuel container **34** to secure regulator mounting structure **154** radially along the circumference of pressurized fuel container **34**. Cylinder **156** couples to a dome **158** to support cylinder **156** relative to the top of pressurized fuel container **34**. Dome **158** has a central opening **160** through which collar **136** of pressurized fuel container **34** extends. Collar **136** of pressurized fuel container **34** extends through dome **158** so that service valve **40** is easily accessible from above regulator mounting structure **154** and so that dome **158** sits on pressurized fuel container **34** around collar **136**.

Regulator mounting structure **154** supports pressure regulators around the outer circumference of cylinder **156**. In some embodiments of the invention, a dual stage pressure regulator **162** functions as both a primary pressure regulator and a secondary pressure regulator in a single integral component, and dual stage pressure regulator **162** may be mounted on regulator mounting structure **154**. In other embodiments of the invention, primary pressure regulator **42** (FIG. **5**) is mounted to service valve **40** while secondary pressure regulator **44** (FIG. **5**) is mounted on regulator mounting structure **154**. Alternatively, both primary pressure regulator **42** (FIG. **5**) and secondary pressure regulator **44** (FIG. **5**) may be mounted on regulator mounting structure **154**.

Fuel regulator system **39** may be coupled to service valve **40** by a flexible connector called a pigtail **164**. Pigtail **164** absorbs shock in the system from pressure surges and from movement of downstream components. Pigtail **164** can be looped to conserve space and therefore pressurized fuel container **34** is referred to as an LPG pig. Accordingly, regulator mounting structure **154** is referred to as a pig hat because it fits on the LPG pig. Pressurized fuel container **34** may be secured to a platform or mobile cart **64** for stability or transportation. In another embodiment, a regulator mounting device, including regulator mounting structure **154** or regulator mounting bracket **46** (FIG. **5**), is secured directly to a platform or a mobile cart.

Beneficially, embodiments of the invention provide for a mechanical fuel lockout switch to ensure that two fuels are not simultaneously delivered to a dual fuel internal combustion engine. Embodiments of the invention also provide for a dual fuel generator with a remotely mounted gaseous fuel regulator system.

Therefore, according to one embodiment of the invention, a mechanical fuel lockout switch for a dual fuel engine

includes a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel engine from a first fuel source through a first fuel line and a second fuel source through a second fuel line. The mechanical fuel valve may be configured to allow communication between the first fuel source and the dual fuel engine and prevent communication between the second fuel source and the dual fuel engine while in the first position, and prevent communication between the first fuel source and the dual fuel engine while in the second position. The mechanical fuel lockout switch may also include a fuel lockout apparatus coupled to the mechanical fuel valve and configured to prevent the second fuel source from coupling to the second fuel line while the mechanical fuel valve is in the first position, and permit the second fuel source to couple to the second fuel line while the mechanical fuel valve is in the second position.

According to another embodiment of the invention, a mechanical fuel lockout switch for a dual fuel engine includes a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel engine from a first fuel source through a first fuel line and a second fuel source through a second fuel line. The mechanical fuel valve may be configured to allow communication between the first fuel source and the dual fuel engine and prevent communication between the second fuel source and the dual fuel engine while the first position, and prevent communication between the first fuel source and the dual fuel engine while in the second position. The mechanical fuel lockout switch may also include a fuel lockout apparatus coupled to the mechanical fuel valve and configured to prevent actuation of the mechanical fuel valve to the first position when the second fuel source is in communication with the dual fuel engine.

According to yet another embodiment of the invention, a dual fuel generator and fuel delivery system includes a dual fuel generator configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line, and a fuel regulator system located off board the dual fuel generator. The fuel regulator system may include a primary pressure regulator couplable to a service valve of the pressurized fuel source and configured to regulate the gaseous fuel supplied from the pressurized fuel source to a reduced pressure, and a secondary pressure regulator couplable to the primary pressure regulator and configured to regulate the gaseous fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the dual fuel generator. The dual fuel generator and fuel delivery system may also include a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel generator from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line, the mechanical fuel valve configured to open and close the liquid fuel line to selectively control fuel flow from the liquid fuel source to the dual fuel generator. A fuel lockout apparatus may couple to the mechanical fuel valve configured to prevent the pressurized fuel source from coupling to the gaseous fuel line while the liquid fuel line is open, and permit the pressurized fuel source to couple to the gaseous fuel line while the liquid fuel line is closed by the mechanical fuel valve.

This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

What is claimed is:

1. A mechanical fuel lockout switch for a dual fuel engine comprising:

a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel engine from a first fuel source through a first fuel line and a second fuel source through a second fuel line, the mechanical fuel valve configured to:

allow communication between the first fuel source and the dual fuel engine and prevent communication between the second fuel source and the dual fuel engine while in the first position, and

prevent communication between the first fuel source and the dual fuel engine while in the second position; and

a fuel lockout apparatus coupled to the mechanical fuel valve and configured to:

prevent the second fuel source from coupling to the second fuel line while the mechanical fuel valve is in the first position, and

permit the second fuel source to couple to the second fuel line while the mechanical fuel valve is in the second position.

2. The mechanical fuel lockout switch of claim **1** wherein the fuel lockout apparatus prevents actuation of the mechanical fuel valve to the first position when the second fuel source is in communication with the dual fuel engine.

3. The mechanical fuel lockout switch of claim **1** wherein the fuel lockout apparatus comprises a flange rigidly coupled to the mechanical fuel valve and configured to:

cover an inlet of the second fuel line while the mechanical fuel valve is in the first position, and

uncover the inlet of the second fuel line while the mechanical fuel valve is in the second position.

4. The mechanical fuel lockout switch of claim **3** wherein the mechanical fuel valve is configured to rotate between the first position and the second position and the flange is configured to rotate transversely across the inlet of the second fuel line.

5. The mechanical fuel lockout switch of claim **3** further comprising:

a first end of a quick-disconnect hose coupling attached to the inlet of the second fuel line; and

a second end of the quick-disconnect hose coupling configured to mate with the first end of the quick-disconnect hose coupling to couple the second fuel source to the second fuel line.

6. The mechanical fuel lockout switch of claim **1** wherein the mechanical fuel valve and the fuel lockout apparatus operate together to ensure that fuel from the first fuel source and fuel from the second fuel source are not simultaneously delivered to the dual fuel engine.

7. The mechanical fuel lockout switch of claim **6** wherein the mechanical fuel valve is configured to:

provide liquid fuel from a liquid fuel tank of the first fuel source to the dual fuel engine while in the first position, and

provide gaseous fuel from a pressurized fuel container of the second fuel source to the dual fuel engine while in the second position.

8. A mechanical fuel lockout switch for a dual fuel engine comprising:

a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel engine from a first fuel source through a first fuel line and a second fuel source through a second fuel line, the mechanical fuel valve configured to:

allow communication between the first fuel source and the dual fuel engine and prevent communication between the second fuel source and the dual fuel engine while the first position, and

prevent communication between the first fuel source and the dual fuel engine while in the second position; and

a fuel lockout apparatus coupled to the mechanical fuel valve and configured to prevent actuation of the mechanical fuel valve to the first position when the second fuel source is in communication with the dual fuel engine.

9. The mechanical fuel lockout switch of claim **8** wherein the fuel lockout apparatus comprises a flange rigidly coupled to the mechanical fuel valve and configured to:

cover an inlet of the second fuel line while the mechanical fuel valve is in the first position, and

uncover the inlet of the second fuel line while the mechanical fuel valve is in the second position.

10. The mechanical fuel lockout switch of claim **9** wherein the mechanical fuel valve is configured to rotate between the first position and the second position and the flange is configured to rotate transversely across the inlet of the second fuel line.

11. The mechanical fuel lockout switch of claim **9** further comprising:

a first end of a quick-disconnect hose coupling attached to the inlet of the second fuel line; and

a second end of the quick-disconnect hose coupling configured to mate with the first end of the quick-disconnect hose coupling to couple the second fuel source to the second fuel line.

12. The mechanical fuel lockout switch of claim **8** wherein the mechanical fuel valve and the fuel lockout apparatus operate together to ensure that fuel from the first fuel source and fuel from the second fuel source are not simultaneously delivered to the dual fuel engine.

13. The mechanical fuel lockout switch of claim **12** wherein the mechanical fuel valve is configured to:

provide liquid fuel from a liquid fuel tank of the first fuel source to the dual fuel engine while in the first position, and

provide gaseous fuel from a pressurized fuel container of the second fuel source to the dual fuel engine while in the second position.

14. A dual fuel generator and fuel delivery system comprising:

a dual fuel generator configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line;

a fuel regulator system located off board the dual fuel generator, the fuel regulator system comprising:

a primary pressure regulator couplable to a service valve of the pressurized fuel source and configured to regulate the gaseous fuel supplied from the pressurized fuel source to a reduced pressure, and

a secondary pressure regulator couplable to the primary pressure regulator and configured to regulate the gaseous fuel supplied from the primary pressure regulator to a desired pressure for delivery through the gaseous fuel line to operate the dual fuel generator;

a mechanical fuel valve actuatable between a first position and a second position to selectively control fuel flow to the dual fuel generator from the liquid fuel source through the liquid fuel line and the pressurized fuel source through the gaseous fuel line, the mechanical fuel valve configured to open and close the liquid fuel line to selectively control fuel flow from the liquid fuel source to the dual fuel generator; and

a fuel lockout apparatus coupled to the mechanical fuel valve and configured to:

prevent the pressurized fuel source from coupling to the gaseous fuel line while the liquid fuel line is open, and

permit the pressurized fuel source to couple to the gaseous fuel line while the liquid fuel line is closed by the mechanical fuel valve.

15. The dual fuel generator and fuel delivery system of claim **14** wherein the fuel lockout apparatus is further configured to prevent the mechanical fuel valve from opening the liquid fuel line while the fuel regulator system is coupled to the gaseous fuel line.

16. The dual fuel generator and fuel delivery system of claim **14** wherein the fuel lockout apparatus comprises a fuel inlet cover that actuates with the mechanical fuel valve to cover an inlet of the gaseous fuel line while the liquid fuel line is open and to uncover the inlet of the gaseous fuel line when the liquid fuel line is closed.

17. The dual fuel generator and fuel delivery system of claim **14** further comprising:

a first end of a quick-connect hose coupling coupled to an outlet of the secondary pressure regulator; and

a second end of the quick-connect hose coupling coupled to an inlet of the gaseous fuel line and configured to mate with the first end of the quick-connect hose coupling to couple the secondary pressure regulator to the gaseous fuel line.

18. The dual fuel generator and fuel delivery system of claim **14** further comprising a regulator mounting device fixed to the pressurized fuel source; and

at least the secondary pressure regulator is mounted on the regulator mounting device.

19. The dual fuel generator and fuel delivery system of claim **18** wherein the primary pressure regulator is mounted on the regulator mounting device.

20. The dual fuel generator and fuel delivery system of claim **19** wherein the regulator mounting device is configured to attach onto a collar of a pressurized fuel container of the pressurized fuel source so that the primary and secondary pressure regulators are positioned adjacent each other along an outer periphery of the collar.

21. The dual fuel generator and fuel delivery system of claim **14** wherein:

the fuel regulator system comprises a dual stage pressure regulator; and

the primary and secondary pressure regulators are integral components of the dual stage pressure regulator.

* * * * *

EXHIBIT K

US011905896B2

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Sarder et al.

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(45) **Date of Patent: *Feb. 20, 2024**

(54) **DUAL FUEL SELECTOR SWITCH**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

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CPC ..... ***F02D 19/0676*** (2013.01); ***F02D 19/0613*** (2013.01); ***F02D 19/0647*** (2013.01); (Continued)

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CPC F02D 19/0676; F02D 19/0613; F02D 19/1647; F02D 29/06; F02D 19/0681; F02M 21/0293; F02M 21/0236; F02M 13/08; F02B 53/00; F02B 63/00; H02K 1/22

See application file for complete search history.

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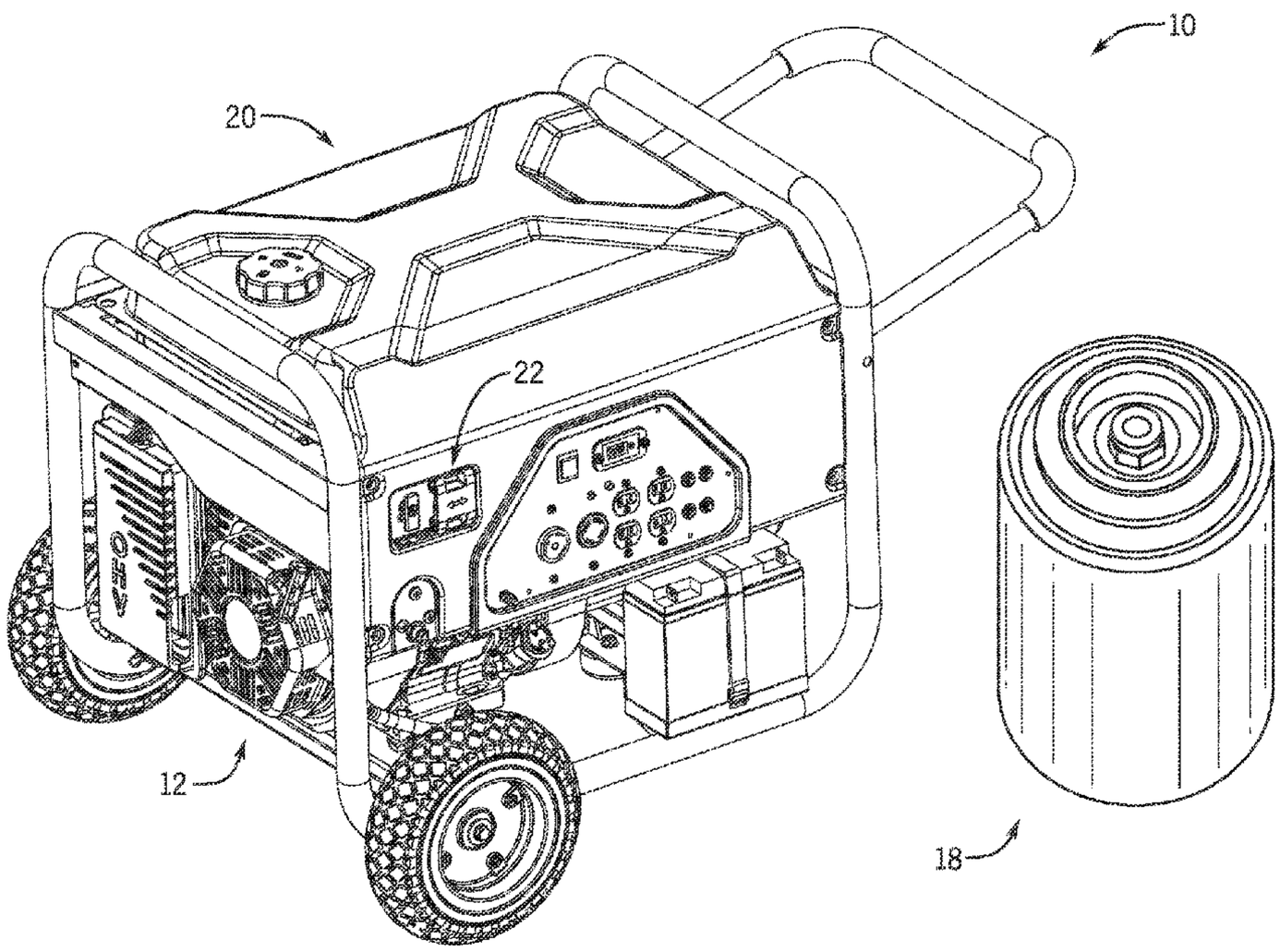
(57) **ABSTRACT**

A fuel selector for use with a dual fuel generator includes a selector plate, a first fuel valve assembly positioned adjacent the selector plate and actuatable between an ON position and an OFF position to selectively control a first fuel flow to an engine of the dual fuel generator, and a second fuel valve assembly positioned adjacent the selector plate and actuatable between an ON position and an OFF position to selectively control a second fuel flow to the engine of the dual fuel generator. A selector switch coupled to the selector plate is linearly translatable from a first position to a second position, so as to enable positioning of only one of the first fuel valve assembly and the second fuel valve assembly in the ON position at a given time, such that the first and second fuel valve assemblies cannot be in the ON position concurrently.

38 Claims, 6 Drawing Sheets



Related U.S. Application Data

continuation of application No. 16/789,722, filed on Feb. 13, 2020, now Pat. No. 11,306,667, which is a continuation of application No. 15/015,205, filed on Feb. 4, 2016, now Pat. No. 10,598,101, which is a continuation of application No. 14/069,747, filed on Nov. 1, 2013, now Pat. No. 9,435,273.

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CPC ***F02D 29/06*** (2013.01); ***F02M 13/08*** (2013.01); *Y02T 10/30* (2013.01); *Y10T 137/0318* (2015.04); *Y10T 137/0491* (2015.04); *Y10T 137/87684* (2015.04)

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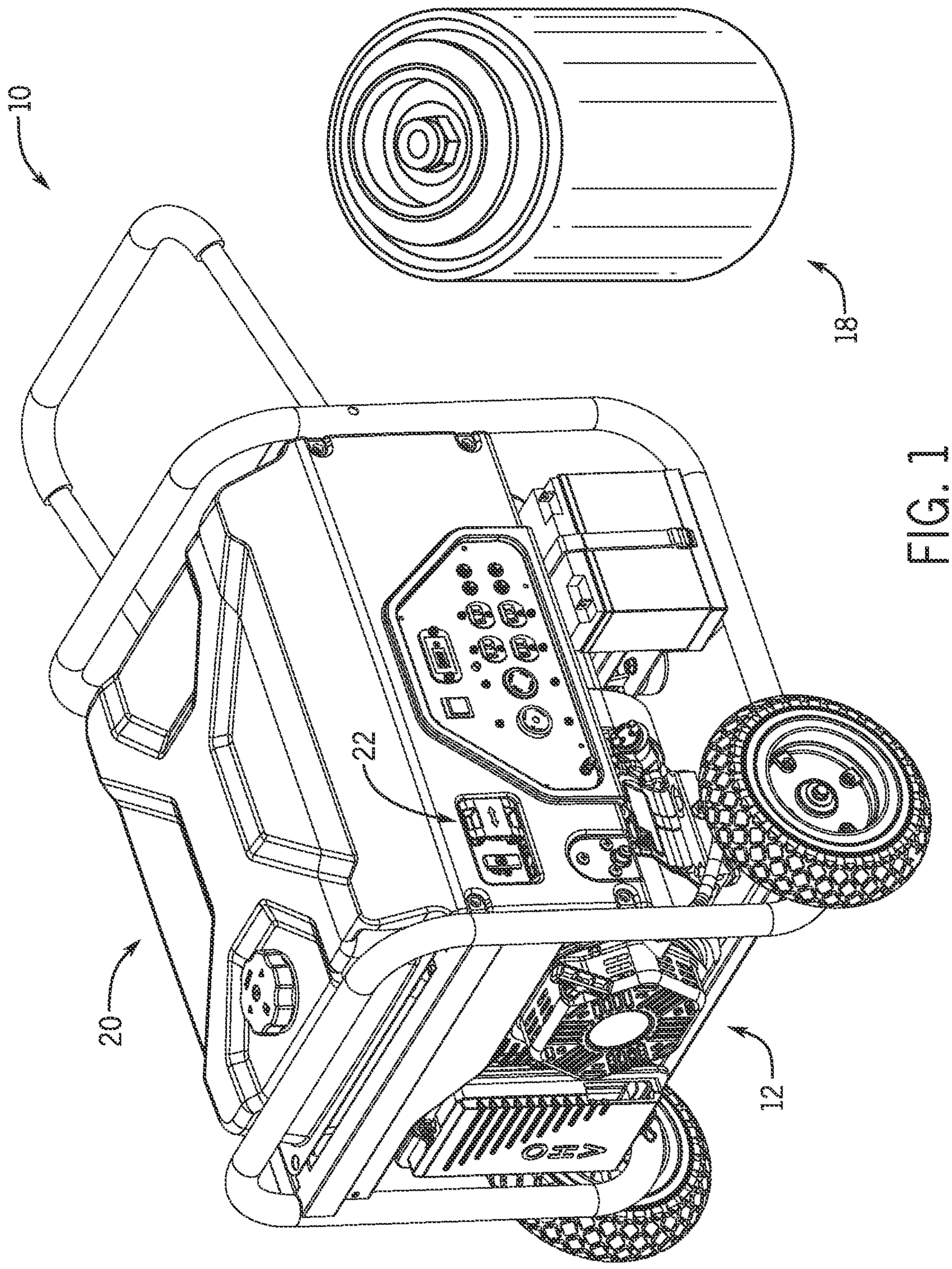

FIG. 1

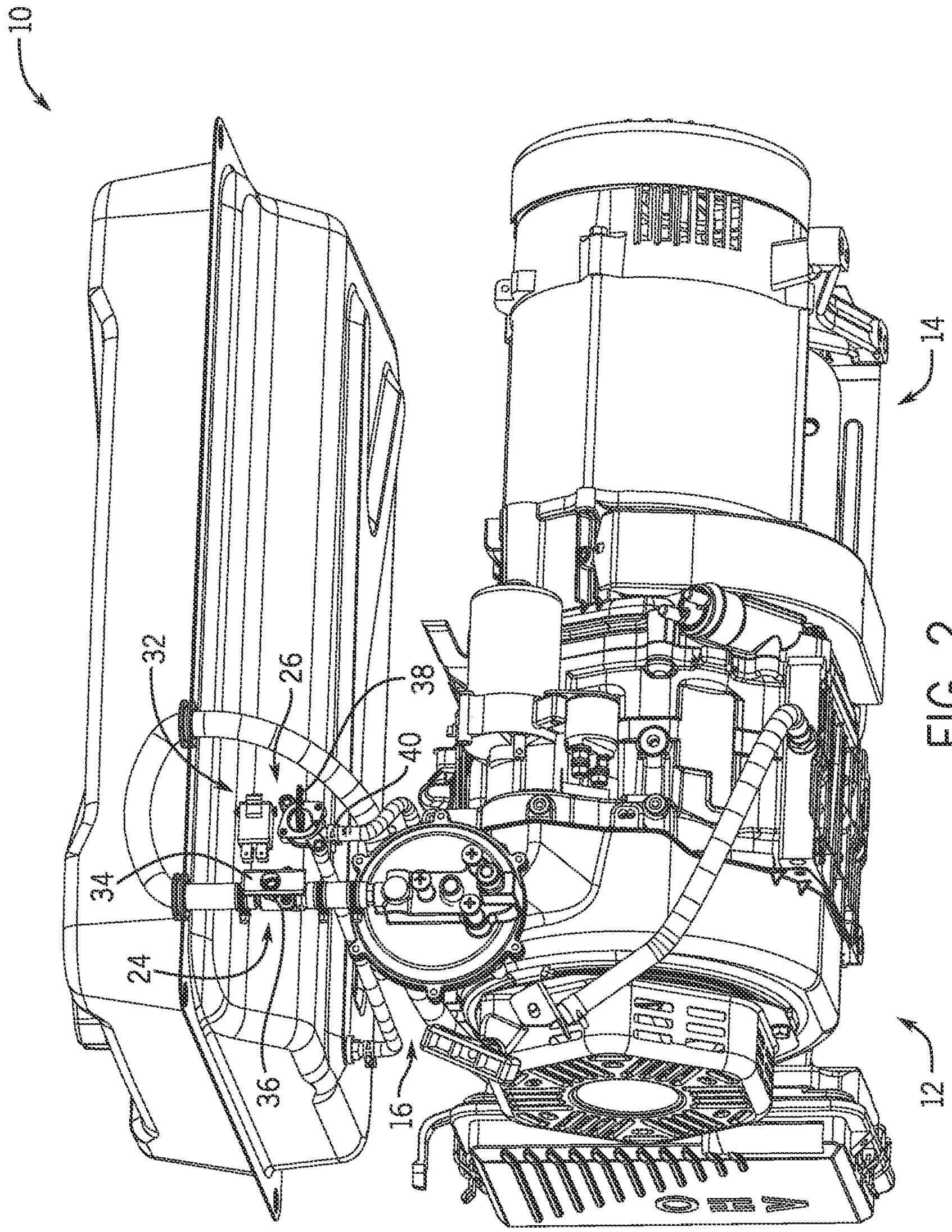

FIG. 2

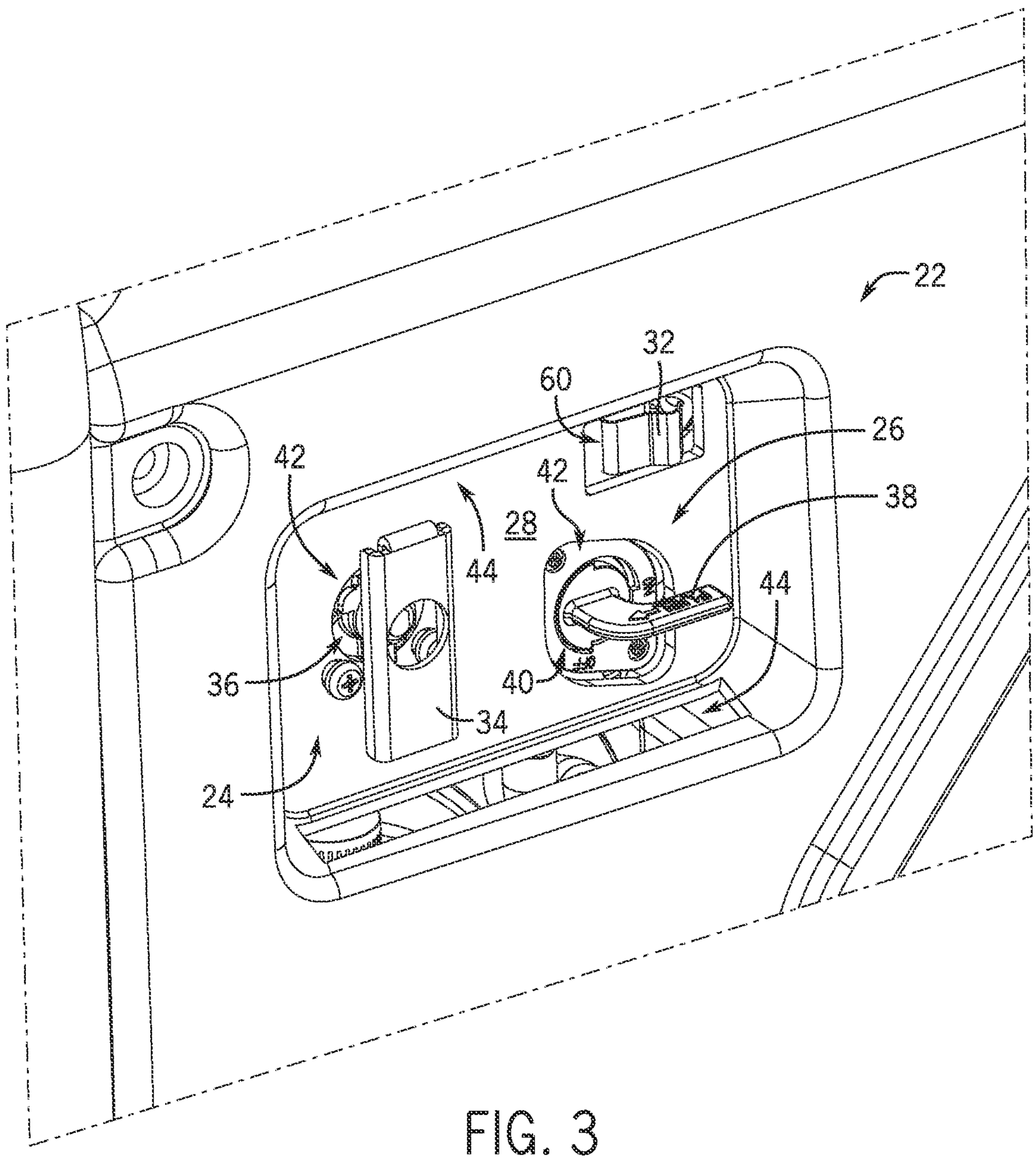

FIG. 3

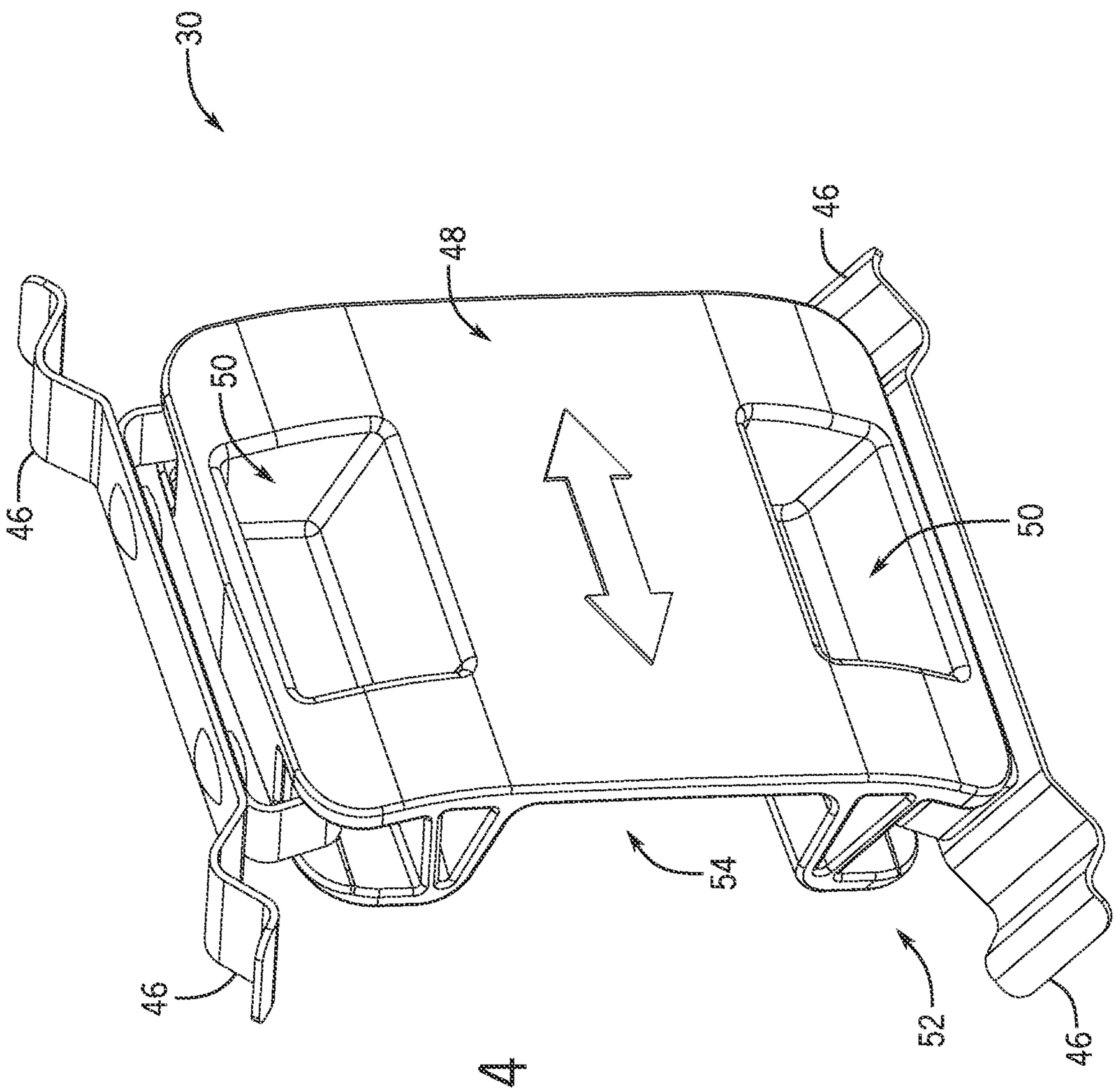

FIG. 4

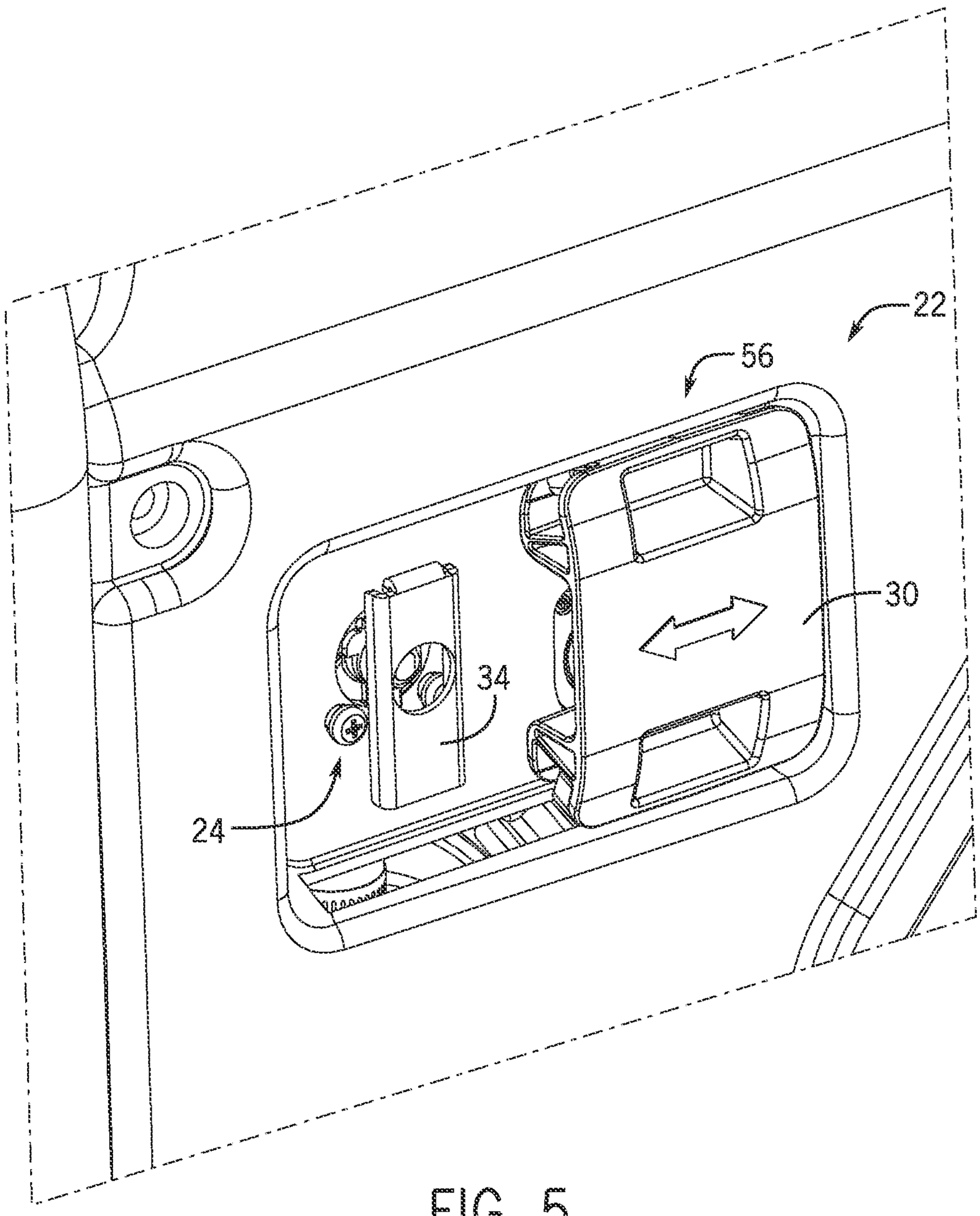

FIG. 5

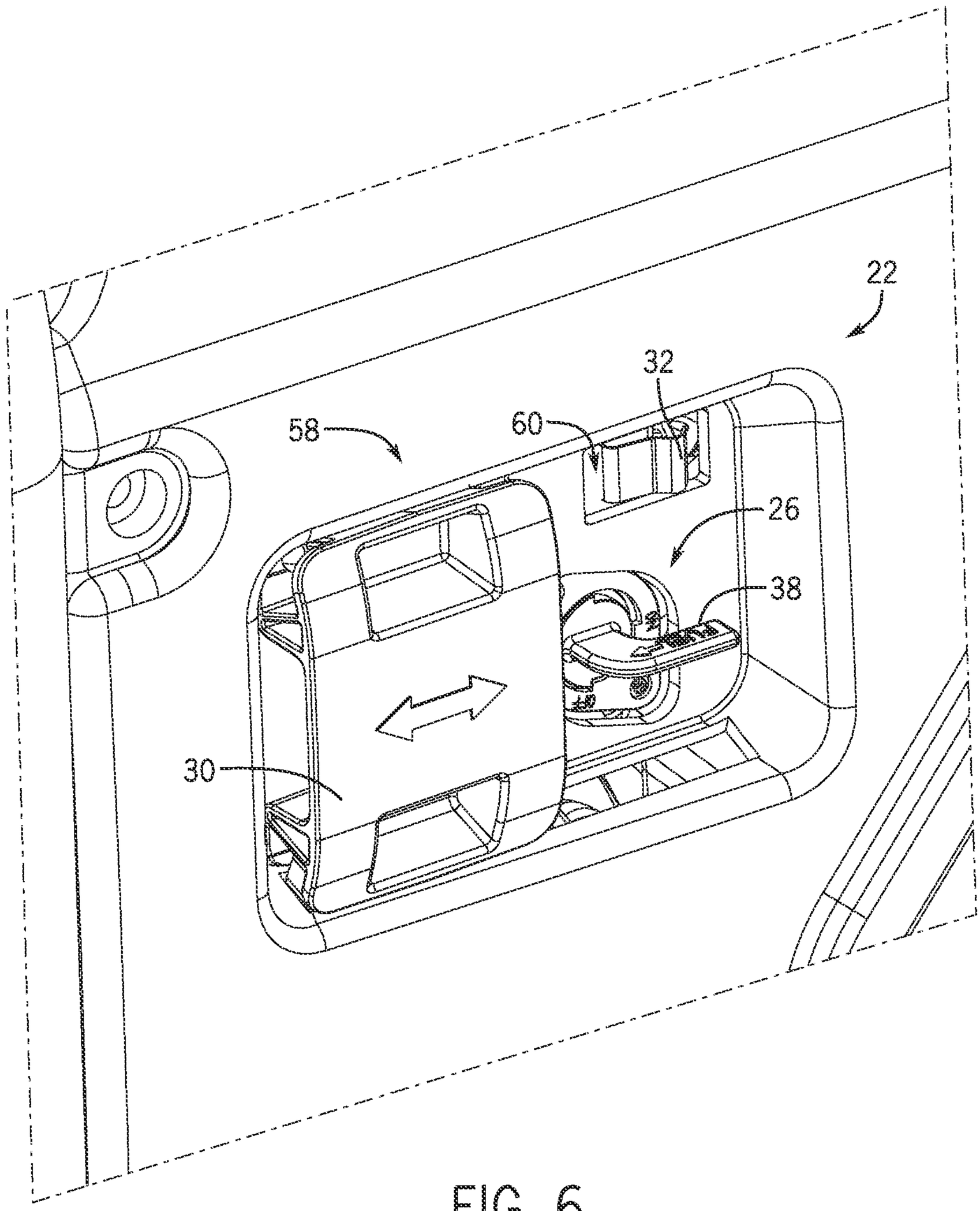

FIG. 6

DUAL FUEL SELECTOR SWITCH

CROSS-REFERENCE TO RELATED APPLICATION

The present application is a continuation of, and claims priority to, U.S. Ser. No. 17/651,245, filed on Feb. 16, 2022, which is a continuation of, and claims priority to, U.S. patent application Ser. No. 16/789,722, filed on Feb. 13, 2020, now U.S. Pat. No. 11,306,667, issued Apr. 19, 2022, which is a continuation of, and claims priority to, U.S. patent application Ser. No. 15/015,205, filed on Feb. 4, 2016, now U.S. Pat. No. 10,598,101, issued Mar. 24, 2020, which is a continuation of, and claims priority to, U.S. patent application Ser. No. 14/069,747, filed on Nov. 1, 2013, now U.S. Pat. No. 9,435,273, issued Sep. 6, 2016, the disclosures of which are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

Embodiments of the invention relate generally to dual fuel generators and, more particularly, to a selector switch for use on a dual fuel generator that is configured to ensure that only one type of fuel may be in use at a given time in the generator.

Engine-driven, electrical generators are used in a wide variety of applications. Typically, an electrical generator utilizes a single driving engine directly coupled to a generator or alternator through a common shaft. Upon activation of the generator, a fuel and air mixture is provided to the combustion chambers of corresponding cylinders of the engine. The fuel mixture in each combustion chamber is ignited causing an explosion within the cylinders. The explosive forces within the combustion chambers in the cylinders cause linear motion of the pistons within their corresponding cylinders. The linear motion of the pistons is converted into rotational motion by a crankshaft that, in turn, drives the alternator. As is conventional, the driven alternator generates electrical power.

Certain generators are defined as "dual fuel" generators that include an engine having the ability to be fueled with either of two fuels, such as either gasoline or liquefied petroleum gas (LPG), for example. These "dual fuel" engines may selectively operate on gasoline or LPG as desired and controlled by an operator, such as being operated on LPG/gasoline for a first period of operation and selectively switching over to the other of LPG/gasoline for another period of operation, with such a switching of fuels being controlled as desired by an operator. Typical dual fuel generators utilize separate valves for each fuel type, such as an LPG valve and a gasoline valve, to control flow of the respective fuels to the engine. While the existence of two separate valves allows one fuel type to have its valve "on" while the other has its valve "off," there is nothing to prevent both valves from being "on" at the same time. As such, it is possible for both valves to be in the "on" position, which can lead to a potentially unsafe condition resulting from the mixture of the fuels.

Therefore, it would be desirable to provide a dual fuel generator with a selector switch that would prohibit the mixing of two differing types of fuels. It would further be desirable for such a selector switch to inhibit positioning/actuation of the valves in such a manner that the valve for a first fuel source is prevented from being "on" when the valve for a second fuel source is "on", and vice versa.

BRIEF DESCRIPTION OF THE INVENTION

In accordance with one aspect of the invention, a fuel selector for use with a dual fuel generator includes a selector plate, a first fuel valve assembly positioned adjacent the selector plate and actuatable between an ON position and an OFF position to selectively control a first fuel flow to an engine of the dual fuel generator, and a second fuel valve assembly positioned adjacent the selector plate and actuatable between an ON position and an OFF position to selectively control a second fuel flow to the engine of the dual fuel generator. The fuel selector also includes a selector switch coupled to the selector plate so as to be linearly translatable from a first position to a second position, wherein translation of the selector switch between the first and second positions enables positioning of only one of the first fuel valve assembly and the second fuel valve assembly in the ON position at a given time, such that the first and second fuel valve assemblies cannot be in the ON position concurrently.

In accordance with another aspect of the invention, a method of controlling fuel flow in a dual fuel generator includes providing a first fuel valve assembly to control fuel flow from a first fuel source to an internal combustion engine of the dual fuel generator, the first fuel valve assembly including a first fuel valve handle movable between an ON position and an OFF position to control fuel flow from the first fuel source to the internal combustion engine. The method also includes providing a second fuel valve assembly to control fuel flow from a second fuel source to the internal combustion engine of the dual fuel generator, the second fuel valve assembly including a second fuel valve handle movable between an ON position and an OFF position to control fuel flow from the second fuel source to the internal combustion engine. The method further includes providing a fuel selector switch adjacent the first fuel valve assembly and the second fuel valve assembly such that the fuel selector switch is translatable to a first position and a second position, wherein the fuel selector switch is translatable between the first position and the second position to selectively inhibit actuation of the first fuel valve handle and the second fuel valve handle, so as to prevent a simultaneous flow of fuels from the first and second fuel sources to the internal combustion engine.

In accordance with yet another aspect of the invention, a dual fuel generator includes a first fuel source, a second fuel source, and an internal combustion engine coupled to the first fuel source and the second fuel source to selectively receive fuel therefrom. The dual fuel generator also includes a fuel selector configured to control a flow of fuel from the first and second fuel sources to the internal combustion engine, with the fuel selector comprising a first fuel valve assembly including a first fuel valve and a first fuel valve handle that is actuatable between an open position and a closed position to selectively open and close the first fuel valve, a second fuel valve assembly including a second fuel valve and a second fuel valve handle that is actuatable between an open position and a closed position to selectively open and close the second fuel valve, a selector plate having the first fuel valve assembly and the second fuel valve assembly coupled to a front side thereof, and a selector switch slideably coupled to the selector plate so as to be movable from a first position to a second position. Positioning of the selector switch in the first position causes the selector switch to cover the second fuel valve handle so as to prevent the second fuel valve handle from moving to the open position and positioning of the selector switch in the second position causes the selector switch to cover the first fuel valve handle so as to prevent the first fuel valve handle from moving to the open position.

These and other advantages and features will be more readily understood from the following detailed description of preferred embodiments of the invention that is provided in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings illustrate embodiments presently contemplated for carrying out the invention.

In the drawings:

FIG. **1** is a perspective view of a dual fuel generator, according to an embodiment of the invention.

FIG. **2** is a partial view of the dual fuel generator of FIG. **1**, according to an embodiment of the invention.

FIG. **3** is a front perspective view of a fuel selector for use with the dual fuel generator of FIG. **1**, according to an embodiment of the invention.

FIG. **4** is a front perspective view of a selector switch for use with the fuel selector of FIG. **3**, according to an embodiment of the invention.

FIG. **5** is a front perspective view of the fuel selector of FIG. **3** with the selector switch in a first position, according to an embodiment of the invention.

FIG. **6** is a front perspective view of the fuel selector of FIG. **3** with the selector switch in a second position, according to an embodiment of the invention.

DETAILED DESCRIPTION

Referring first to FIGS. **1** and **2**, a dual fuel generator **10** is illustrated, according to an embodiment of the invention—with a perspective view of the generator **10** being shown in FIG. **1** and a more detailed partial view of the generator **10** being shown in FIG. **2** to further illustrate features thereof. Dual fuel generator **10** includes an internal combustible engine **12** operatively connected to an alternator **14** in a conventional manner. The engine **12** includes pistons (not shown) that are slideably received within corresponding cylinders (not shown) thereof, with each cylinder further including an intake valve for admitting a fuel-air mixture and an exhaust valve for venting exhaust gases following combustion. The fuel-air mixture is provided by a carburetor **16** that includes a movable throttle, with a position of the throttle regulating the amount of fuel and air admitted into the cylinders and thus the speed and power developed by the engine **12** when the air-fuel mixture is ignited to generate reciprocal movement of the pistons. The reciprocal movement of the pistons of engine **12** is translated to rotational movement by a crankshaft (not shown) that, in turn, drives the alternator **14**, so as to generate an electrical output power from the generator **10**.

As the generator **10** is a dual fuel generator, the engine **12** is designed to use different fuels from either a first fuel source **18** or a second fuel source **20**. In an exemplary embodiment of the invention, first fuel source **18** supplies a liquefied petroleum gas (LPG) to the engine **12** and second fuel source **20** supplies gasoline to the engine **12**, with the generator **10** selectively operating on LPG or gasoline as desired and controlled by an operator, such as for example operating on LPG for a first period of operation and then switching over to gasoline for another period of operation. However, it is contemplated that the first fuel source **18** and/or second fuel source **20** may be other types of fuel sources (e.g., natural gas, biodiesel, etc.), according to additional embodiments of the invention—and thus the scope of the invention is not meant to be limited strictly to a gasoline-LPG dual fuel embodiment.

For selectively controlling the flow of gasoline and LPG to the engine **12**, dual fuel generator **10** includes a fuel selector **22** constructed to provide for selection of a desired fuel source **18**, **20** for supplying fuel to engine **12**. The fuel selector **22** not only provides for selection of a desired fuel source **18**, **20** for supplying fuel to engine **12**, but also selectively restricts the selection of a fuel source so as to enable the use of only one fuel at a time. As a result, fuel from first fuel source **18** cannot flow to engine **12** while fuel from second fuel source **20** is flowing to engine **12**, and vice versa.

The fuel selector **22** of generator **10** is shown in greater detail in FIGS. **3-6** according to an embodiment of the invention. In general, the fuel selector **22** includes a first valve assembly **24**, a second valve assembly **26**, a selector plate **28**, a selector switch **30**, and a carburetor solenoid switch **32**. These elements of the fuel selector **22** collectively function to provide for selective control of a fuel flow (of gasoline or LPG) to the engine **12**, with the fuel selector **22** enabling selection of a desired fuel source **18**, **20** to provide a fuel flow therefrom while also inhibiting the selection of the other fuel source **18**, **20** so as to prevent a fuel flow therefrom, thereby enabling only a single fuel to flow to the engine **12** at one time.

Referring first to FIG. **3**, a front view of fuel selector **22** is shown with selector switch **30** removed therefrom, so as to best illustrate the construction of the first valve assembly **24** and the second valve assembly **26**. The first valve assembly **24** and the second valve assembly **26** are attached, respectively, to first fuel source **18** and second fuel source **20** to selectively control a flow of fuel from the fuel sources to the engine **12**. First valve assembly **24** includes a first fuel valve handle **34** that is operatively connected to a first fuel valve **36** to control an opening and closing of the first fuel valve. Similarly, second valve assembly **26** includes a second fuel valve handle **38** that is operatively connected to a second fuel valve **40** to control an opening and closing of the second fuel valve.

Each of the first valve assembly **24** and the second valve assembly **26** are movable between an ON position and an OFF position to control opening and closing of their respective fuel valve. More specifically, first and second fuel valve handles **34**, **38** are movable between an ON position and an OFF position, with the fuel valves **36**, **40** being open (to enable fuel flow to the engine **12**) when their respective fuel valve handle **34**, **38** is in the ON position and being closed (to prevent fuel flow to the engine **12**) when their respective fuel valve handle **34**, **38** is in the OFF position. Thus, when first fuel valve handle **34** is in an ON position, first fuel valve **36** is open and allows the fuel from first fuel source **18** to flow to the engine **12**, and when second fuel valve handle **38** is in an ON position, second fuel valve **40** is open and allows the fuel from second fuel source **20** to flow to the engine **12**.

In the preferred embodiments of the invention, first valve assembly **24** and second valve assembly **26** are located adjacent to each other on the same horizontal plane or parallel horizontal planes. In such an embodiment, first valve assembly **24** is in the ON position when first fuel valve handle **34** is moved to a vertical orientation/position and first valve assembly **24** is in an OFF position when first fuel valve handle **34** is moved to a horizontal orientation/position. Similarly, second valve assembly **26** is in the ON position when second fuel valve handle **38** is moved to a vertical orientation/position second valve assembly **26** is in an OFF position when second fuel valve handle **38** is moved to a horizontal orientation/position. It is recognized, however, that an alternative embodiment of the invention may have

first valve assembly **24** and second valve assembly **26** located adjacent to each other on the same vertical plane or parallel vertical planes. One having ordinary skill in the art would recognize that in such an alternative embodiment of the invention, first and second valve assemblies **24** would be in the ON position when their respective fuel valve handles **34**, **38** are horizontal, and would be in the OFF position when their respective fuel valve handles **34**, **38** are vertical.

As shown in FIG. **3**, first valve assembly **24** and second valve assembly **26** are positioned adjacent to the selector plate **28** of fuel selector **22**. The selector plate **28** may be integrally formed as part of a larger outer frame assembly of generator **10** or may be an insert attachable to such a frame assembly. Openings **42** are formed in selector plate **28** so as to accommodate positioning of the first valve assembly **24** and second valve assembly **26**—with the openings **42** enabling positioning of first and second fuel valve handles **34**, **38** in front of selector plate **28**, such that they may be actuated by an operator of the generator **10** in order to open/close their respective valves **36**, **40**. Selector plate **28** also includes slots or grooves **44** formed therein that are positioned both above and below the first and second fuel valve handles **34**, **38**, with the slots **44** extending generally in a lengthwise fashion along a length of the selector plate **28**. Each of the slots **44** is configured to receive a protrusion or flange formed on selector switch **30**, such that the selector switch **30** can be slideably coupled to the selector plate **28**—with the selector switch **30** being translatable in a linear fashion by way of its mating with the slots **44**.

Detailed views of the selector switch **30** and of its mating with the selector plate **28** are shown in FIGS. **4-6**. Referring first to FIG. **4**, the general structure of selector switch **30** is shown according to an exemplary embodiment. Protrusions or flanges **46** are formed on each of top and bottom surfaces of the selector switch **30** that are configured to mate with the corresponding slots **44** formed in selector plate **28** (FIG. **3**). The protrusions **46** may be flexible so as to accommodate coupling of the selector switch **30** to the selector plate **28**. A front surface **48** of selector switch **30** includes finger-hold depressions **50** formed therein that accommodate the fingers of an operator, with the finger-holds providing a convenient feature by which the operator can operate (i.e., slide) the selector switch **30**. A back surface **52** of the selector switch **30** includes a groove or channel **54** formed therein having a width and depth sufficient to receive the first and second fuel valve handles **34**, **38** therein when in their horizontal position (i.e., the OFF position). The groove **54** is further sized and configured such that the first and second fuel valve handles **34**, **38** will not fit therein when in their vertical position (i.e., the ON position).

Positioning of the selector switch **30** relative to the selector plate **28** and first and second valve assemblies **24**, **26** is shown in FIGS. **5** and **6**. As shown therein, positioning of the first valve assembly **24** and second valve assembly **26** adjacent selector plate **28**—and on the same horizontal plane—provides for selective positioning of the selector switch **30** relative to the fuel valve handles **34**, **38** in what are generally referred to hereafter as a first position and a second position **56**, **58**. The selector switch **30** is translatable in a horizontal motion—via a sliding motion within slots **44** of the selector plate **28**—from the first position **56** (FIG. **5**) to the second position **58** (FIG. **6**) to selectively restrict actuation of the first and second fuel valve handles **34**, **38**. As the groove **54** formed in selector switch **30** is configured such that the first and second fuel valve handles **34**, **38** will not fit therein when in their vertical position (i.e., the ON position), it is recognized that in order to translate the selector switch **30** back and forth between the first and second positions **56**, **58**, both of the fuel valve handles **34**, **38** must be in their horizontal OFF position.

In FIG. **5**, selector switch **30** is illustrated in the first position **56**. When selector switch **30** is in first position **56**, selector switch **30** covers second fuel valve handle **38**, and groove **54** formed on the back surface **52** of the fuel selector switch **30** locks second fuel valve handle **38** in an OFF position, so as to prohibit the second valve assembly **26** from moving to the ON position. Further, when selector switch **30** is in first position **56**, first valve assembly **24** is able to move freely between the ON position and the OFF position, with the first fuel valve handle **34** being actuatable by the operator. In one embodiment of the invention, when first valve assembly **24** is in the ON position, first fuel valve handle **34** is in a vertical position and prevents selector switch **30** from moving horizontally from first position **56** to second position **58**.

In operation, when selector switch **30** is moved from second position **58** into first position **56**, second fuel valve handle **38** slides into the groove **54** formed in selector switch **30**. As a result, when selector switch **30** is in first position **56**, second fuel valve handle **38** is unable to move, as it is locked in place by groove **54**, and second valve assembly **26** is locked in the OFF position, with movement from the OFF position to the ON position being prohibited.

In FIG. **6**, selector switch **30** is illustrated in the second position **58**. When selector switch **30** is in second position **58**, selector switch **30** covers first fuel valve handle **34**, and groove **54** formed on the back surface **52** of the fuel selector switch **30** locks first fuel valve handle **34** in an OFF position, so as to prohibit the first valve assembly **24** from moving to the ON position. In addition, when selector switch **30** is in second position **58**, second valve assembly **26** is able to freely move between the ON position and the OFF position, with the second fuel valve handle **38** being actuatable by the operator. In one embodiment of the invention, when second valve assembly **26** is in the ON position, second fuel valve handle **38** is in a vertical position and prevents selector switch **30** from moving horizontally from second position **58** to first position **56**.

In operation, when selector switch **30** is moved from first position **56** into second position **58**, first fuel valve handle **34** slides into groove **54** formed in selector switch **30**. Therefore, when selector switch **30** is in second position **58**, first fuel valve handle **34** is unable to move, as it is locked in place by groove **54**, and first valve assembly **24** is locked in the OFF position, with movement from the OFF position to the ON position being prohibited.

Referring still now to FIG. **6**, according to an exemplary embodiment of the invention, the fuel selector **22** of generator **10** further comprises a carburetor solenoid switch **32** that is positioned within an opening **60** formed in selector plate **28** so as to extend therethrough and is further positioned adjacent second valve assembly **26** (i.e., second fuel valve handle **38**. As solenoid switch **32** is located adjacent to the second valve assembly **26**—which is in turn connected to the gasoline fuel source **20**—selector switch **30** covers and triggers solenoid switch **32** when slid from the second position **58** to the first position **56**—by depressing the solenoid switch **32** as it comes in contact therewith. When solenoid switch **32** is triggered, a carburetor shutoff solenoid operatively connected to the solenoid switch **32** is activated and shuts off the flow of gasoline to the carburetor **16** (FIG. **2**). In the preferred embodiment of the invention, solenoid switch **32** is a depressible switch, but it is contemplated that solenoid switch **32** may be another type of switch

that can be activated via interaction with selector switch **30** or via interaction with either valve handle **34**, **38**, so as to activate the carburetor shutoff solenoid.

Beneficially, the design of the fuel selector **22** and of the selector switch **30** described herein prevents differing fuels from two separate fuel sources from flowing to the engine of a dual fuel generator at the same time. The interaction of the selector switch **30** with the first and second fuel valve assemblies **24**, **26**— with the selector switch **30** sliding back and forth to selectively cover/engage first and second fuel valve assemblies **24**, **26**—prohibits both valve assemblies from being in the "ON" position at the same time. The selector switch **30** is thus a foolproof device that prevents the mixing of fuels so as to provide additional safety to the usage of dual fuel generators.

Therefore, according to one embodiment of the invention, a fuel selector for use with a dual fuel generator includes a selector plate, a first fuel valve assembly positioned adjacent the selector plate and actuatable between an ON position and an OFF position to selectively control a first fuel flow to an engine of the dual fuel generator, and a second fuel valve assembly positioned adjacent the selector plate and actuatable between an ON position and an OFF position to selectively control a second fuel flow to the engine of the dual fuel generator. The fuel selector also includes a selector switch coupled to the selector plate so as to be linearly translatable from a first position to a second position, wherein translation of the selector switch between the first and second positions enables positioning of only one of the first fuel valve assembly and the second fuel valve assembly in the ON position at a given time, such that the first and second fuel valve assemblies cannot be in the ON position concurrently.

According to another embodiment of the invention, a method of controlling fuel flow in a dual fuel generator includes providing a first fuel valve assembly to control fuel flow from a first fuel source to an internal combustion engine of the dual fuel generator, the first fuel valve assembly including a first fuel valve handle movable between an ON position and an OFF position to control fuel flow from the first fuel source to the internal combustion engine. The method also includes providing a second fuel valve assembly to control fuel flow from a second fuel source to the internal combustion engine of the dual fuel generator, the second fuel valve assembly including a second fuel valve handle movable between an ON position and an OFF position to control fuel flow from the second fuel source to the internal combustion engine. The method further includes providing a fuel selector switch adjacent the first fuel valve assembly and the second fuel valve assembly such that the fuel selector switch is translatable to a first position and a second position, wherein the fuel selector switch is translatable between the first position and the second position to selectively inhibit actuation of the first fuel valve handle and the second fuel valve handle, so as to prevent a simultaneous flow of fuels from the first and second fuel sources to the internal combustion engine.

According to yet another embodiment of the invention, a dual fuel generator includes a first fuel source, a second fuel source, and an internal combustion engine coupled to the first fuel source and the second fuel source to selectively receive fuel therefrom. The dual fuel generator also includes a fuel selector configured to control a flow of fuel from the first and second fuel sources to the internal combustion engine, with the fuel selector comprising a first fuel valve assembly including a first fuel valve and a first fuel valve handle that is actuatable between an open position and a closed position to selectively open and close the first fuel valve, a second fuel valve assembly including a second fuel valve and a second fuel valve handle that is actuatable between an open position and a closed position to selectively open and close the second fuel valve, a selector plate having the first fuel valve assembly and the second fuel valve assembly coupled to a front side thereof, and a selector switch slideably coupled to the selector plate so as to be movable from a first position to a second position. Positioning of the selector switch in the first position causes the selector switch to cover the second fuel valve handle so as to prevent the second fuel valve handle from moving to the open position and positioning of the selector switch in the second position causes the selector switch to cover the first fuel valve handle so as to prevent the first fuel valve handle from moving to the open position.

While the invention has been described in connection with only a limited number of embodiments, it should be readily understood that the invention is not limited to such disclosed embodiments. Rather, the invention can be modified to incorporate any number of variations, alterations, substitutions or equivalent arrangements not heretofore described, but which are commensurate with the spirit and scope of the invention. Additionally, while various embodiments of the invention have been described, it is to be understood that aspects of the invention may include only some of the described embodiments. Accordingly, the invention is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

What is claimed is:

1. A dual fuel generator comprising:

an internal combustion engine couplable to a first fuel source and a second fuel source to selectively receive fuel therefrom; and

a fuel selector configured to control a flow of fuel to the internal combustion engine, the fuel selector comprising:

a selector plate;

a first fuel valve assembly positioned adjacent to the selector plate and including a first fuel valve and a first fuel valve handle, the first fuel valve handle being actuatable between an ON position and an OFF position to selectively open and close the first fuel valve;

a second fuel valve assembly positioned adjacent to the selector plate and including a second fuel valve and a second fuel valve handle, the second fuel valve handle being actuatable between an ON position and an OFF position to selectively open and close the second fuel valve;

a selector switch slidably coupled to the selector plate so as to be movable between:

a first position in which the selector switch covers the second fuel valve handle so as to prevent actuation of the second valve handle to the ON position; and

a second position in which the selector switch covers the first valve handle so as to prevent actuation of the first valve handle to the ON position; and

a carburetor fuel shutoff solenoid that is activated when the selector switch is in the first position.

2. The dual fuel generator of claim **1** wherein:

the first fuel valve assembly is configured to couple to a liquefied petroleum gas (LPG) fuel source; and

the second fuel valve assembly is configured to couple to a gasoline source.

3. The dual fuel generator of claim 1 wherein:
the selector plate comprises first and second openings;
the first valve assembly extends through the first opening of the selector plate; and
the second valve assembly extends through the second opening of the selector plate.

4. The dual fuel generator of claim 1 wherein the selector switch comprises:
a front side;
a back side; and
a groove located on the back side and configured to:
prohibit actuation of the first fuel valve handle to the ON position when the selector switch is in the second position; and
prohibit actuation of the second fuel valve handle to the ON position when the selector switch is in the first position.

5. The dual fuel generator of claim 4 wherein the groove is configured to prevent movement of the selector switch from the first position to the second position and from the second position to the first position unless the first and second fuel valve handles are both in the OFF position.

6. The dual fuel generator of claim 1 wherein the first and second valve handles are in the ON position when positioned vertically and in the OFF position when positioned horizontally.

7. A fuel selector for use with a dual fuel generator, the fuel selector comprising:
a valve assembly fluidly couplable to each of a first fuel source and a second fuel source and operable to selectively control a first fuel flow and a second fuel flow from the first fuel source and the second fuel source, respectively, to an engine of the dual fuel generator, the valve assembly comprising:
a first mechanical fuel valve having open and closed positions to selectively control the first fuel flow to the engine; and
a second mechanical fuel valve having open and closed positions to selectively control the second fuel flow to the engine; and
a selector switch movable with respect to the valve assembly to allow a user to manually select the first fuel flow or the second fuel flow.

8. The fuel selector of claim 7 wherein the selector switch provides for manual actuation of the first fuel valve and the second fuel valve between the open and closed positions.

9. The fuel selector of claim 8 further comprising:
a first valve handle coupled to the first fuel valve and actuatable between an ON position and an OFF position to selectively actuate the first fuel valve between the open position and the closed position, respectively; and
a second valve handle coupled to the second fuel valve and actuatable between an ON position and an OFF position to selectively actuate the second fuel valve between the open position and the closed position, respectively;
wherein the selector switch is positioned relative to the first and second valve handles so as to provide for only one of the first and second valve handles to be in the ON position at a given time.

10. The fuel selector of claim 9 further comprising a selector plate positioned adjacent to the first and second valve handles;
wherein the selector switch is coupled to the selector plate so as to be movable between a first position and a second position, with movement of the selector switch between the first and second positions enabling positioning of only one of the first and second valve handles in the ON position at a given time.

11. The fuel selector of claim 10 wherein:
when the selector switch is in the first position, the first valve handle is actuatable between the ON position and the OFF position, and the second valve handle is prohibited from being in the ON position; and
when the selector switch is in the second position, the first valve handle is prohibited from being in the ON position, and the second valve handle is actuatable between the ON position and the OFF position.

12. The fuel selector of claim 10 further comprising a carburetor solenoid switch extending through an opening in a front surface of the selector plate and comprising a depressible switch configured to activate an associated solenoid when depressed.

13. The fuel selector of claim 12 wherein, when the selector switch is in the first position and prohibiting the second valve handle from being in the ON position, the selector switch depresses the carburetor solenoid switch so as to activate the carburetor solenoid and prohibit the second fuel flow to the engine.

14. The fuel selector of claim 7 wherein:
the first fuel valve is couplable to a liquefied petroleum gas (LPG) fuel source; and
the second fuel valve is couplable to a gasoline source.

15. A fuel selector for use with a dual fuel generator, the fuel selector comprising:
a valve assembly fluidly couplable to each of a first fuel source and a second fuel source and operable to selectively control a first fuel flow and a second fuel flow from the first fuel source and the second fuel source, respectively, to an engine of the dual fuel generator, the valve assembly comprising:
a first fuel valve having open and closed positions to selectively control the first fuel flow to the engine; and
a second fuel valve having open and closed positions to selectively control the second fuel flow to the engine; and
at least one valve handle mechanically coupled to the first fuel valve and the second fuel valve to selectively open and close the first fuel valve and the second fuel valve responsive to actuation thereof so as to enable the first fuel flow to the engine or the second fuel flow to the engine.

16. The fuel selector of claim 15 wherein the at least one valve handle enables only one of the first and second fuel flows to the engine at a given time.

17. The fuel selector of claim 15 wherein the at least one valve handle comprises:
a first valve handle coupled to the first fuel valve and actuatable between an ON position and an OFF position to selectively actuate the first fuel valve between the open position and the closed position, respectively; and
a second valve handle coupled to the second fuel valve and actuatable between an ON position and an OFF position to selectively actuate the second fuel valve between the open position and the closed position, respectively.

18. The fuel selector of claim 17 further comprising a selector switch positioned relative to the first and second valve handles so as to provide for only one of the first and second valve handles to be in the ON position at a given time.

19. The fuel selector of claim 18 further comprising a selector plate positioned adjacent to the first and second valve handles;

wherein the selector switch is coupled to the selector plate so as to be movable between a first position to a second position, with movement of the selector switch between the first and second positions enabling positioning of only one of the first and the second valve handles in the ON position at a given time.

20. The fuel selector of claim 19 wherein:

when the selector switch is in the first position, the first valve handle is actuatable between the ON position and the OFF position, and the second valve handle is prohibited from being in the ON position; and

when the selector switch is in the second position, the first valve handle is prohibited from being in the ON position, and the second valve handle is actuatable between the ON position and the OFF position.

21. A fuel selector of a dual fuel generator comprising:

a valve assembly fluidly couplable to each of a first fuel source and a second fuel source and operable to selectively control a first fuel flow and a second fuel flow from the first fuel source and the second fuel source, respectively, to an engine of the dual fuel generator;

a selector switch having a first fuel mode and a second fuel mode;

a fuel solenoid having open and closed positions; and

a solenoid switch having open and closed positions;

wherein, when the selector switch is in the first fuel mode, the solenoid switch and the fuel solenoid are in the closed positions;

wherein, when the selector switch is in the second fuel mode, the solenoid switch and the fuel solenoid are in the open positions; and

wherein positioning of the selector switch in the first fuel mode and the second fuel mode enables a selection of the first fuel flow or the second fuel flow.

22. The fuel selector of claim 21 wherein:

positioning the selector switch in the first fuel mode enables the selection of the first fuel flow; and

positioning the selector switch in the second fuel mode enables the selection of the second fuel flow.

23. The fuel selector of claim 21 wherein the selector switch triggers the solenoid switch when changed from the second fuel mode to the first fuel mode so as to cause the solenoid switch and the fuel solenoid to operate in the closed positions.

24. The fuel selector of claim 21 wherein the fuel solenoid is a carburetor shutoff solenoid.

25. The fuel selector of claim 21 wherein the selector switch is positioned adjacent to the valve assembly.

26. The fuel selector of claim 21 wherein the valve assembly comprises:

two fuel inputs comprising:

a first fuel input couplable to the first fuel source; and

a second fuel input couplable to the second fuel source; and

two fuel outputs for selectively supplying fuel to the engine from the first fuel source or the second fuel source.

27. The fuel selector of claim 26 wherein the two fuel outputs selectively supply fuel to the engine from only one of the first and second fuel sources responsive to selection of the first fuel flow or the second fuel flow via the selector switch and a corresponding operation of the valve assembly.

28. The fuel selector of claim 26 wherein the valve assembly comprises:

a first fuel valve having open and closed positions to selectively control the first fuel flow to the engine; and

a second fuel valve having open and closed positions to selectively control the second fuel flow to the engine.

29. The fuel selector of claim 28 further comprising:

a first valve handle coupled to the first fuel valve and actuatable between an ON position and an OFF position to selectively actuate the first fuel valve between the open position and the closed position, respectively; and

a second valve handle coupled to the second fuel valve and actuatable between an ON position and an OFF position to selectively actuate the second fuel valve between the open position and the closed position, respectively.

30. A fuel selector for use with a dual fuel generator, the fuel selector comprising:

a valve assembly fluidly couplable to each of a first fuel source and a second fuel source and operable to selectively control a first fuel flow and a second fuel flow from the first fuel source and the second fuel source, respectively, to an engine of the dual fuel generator, the valve assembly comprising:

two fuel inputs comprising:

a first fuel input couplable to the first fuel source; and

a second fuel input couplable to the second fuel source; and

two fuel outputs configured to selectively supply fuel to the engine from the first fuel source or the second fuel source; and

a selector switch positioned on the valve assembly to allow a user to manually select the first fuel flow or the second fuel flow.

31. The fuel selector of claim 30 wherein the two fuel outputs are configured to selectively supply fuel to the engine from only one of the first and second fuel sources responsive to selection of the first fuel flow or the second fuel flow via the selector switch and a corresponding operation of the valve assembly.

32. The fuel selector of claim 30 wherein the valve assembly comprises:

a first fuel valve having open and closed positions to selectively control the first fuel flow to the engine; and

a second fuel valve having open and closed positions to selectively control the second fuel flow to the engine.

33. The fuel selector of claim 32 further comprising:

a first valve handle coupled to the first fuel valve and actuatable between an ON position and an OFF position to selectively actuate the first fuel valve between the open position and the closed position, respectively; and

a second valve handle coupled to the second fuel valve and actuatable between an ON position and an OFF position to selectively actuate the second fuel valve between the open position and the closed position, respectively.

34. The fuel selector of claim 32 wherein the first fuel valve and the second fuel valve are non-solenoid, mechanical valves.

35. The fuel selector of claim 32 wherein the selector switch provides for manual actuation of the first fuel valve and the second fuel valve between the open and closed positions.

36. The fuel selector of claim 30 further comprising a carburetor solenoid switch configured to activate an associated carburetor solenoid when actuated.

37. The fuel selector of claim 36 wherein, when the selector switch is in a first position, the selector switch actuates the carburetor solenoid switch so as to activate the carburetor solenoid and prohibit the second fuel flow to the engine.

38. The fuel selector of claim 37 wherein, when the selector switch is in a second position, the carburetor solenoid allows the second fuel flow to the engine.

* * * * *

JS 44 (Rev. 10/20)

CIVIL COVER SHEET

The JS 44 civil cover sheet and the information contained herein neither replace nor supplement the filing and service of pleadings or other papers as required by law, except as provided by local rules of court. This form, approved by the Judicial Conference of the United States in September 1974, is required for the use of the Clerk of Court for the purpose of initiating the civil docket sheet. *(SEE INSTRUCTIONS ON NEXT PAGE OF THIS FORM.)*

Place an "X" in the appropriate box (required): ☐ Green Bay Division ☒ Milwaukee Division

I. (a) PLAINTIFFS
Champion Power Equipment, Inc.

(b) County of Residence of First Listed Plaintiff _____
(EXCEPT IN U.S. PLAINTIFF CASES)

(c) Attorneys *(Firm Name, Address, and Telephone Number)*
Thomas P. Heneghan, Husch Blackwell LLP, 33 E. Main Street, Suite 300, Madison, WI 53703 (608) 255-4440

DEFENDANTS
Generac Power Systems, Inc.

County of Residence of First Listed Defendant _____
(IN U.S. PLAINTIFF CASES ONLY)
NOTE: IN LAND CONDEMNATION CASES, USE THE LOCATION OF THE TRACT OF LAND INVOLVED.

Attorneys *(If Known)*

II. BASIS OF JURISDICTION *(Place an "X" in One Box Only)*

☐ 1 U.S. Government Plaintiff
☒ 3 Federal Question *(U.S. Government Not a Party)*
☐ 2 U.S. Government Defendant
☐ 4 Diversity *(Indicate Citizenship of Parties in Item III)*

III. CITIZENSHIP OF PRINCIPAL PARTIES *(Place an "X" in One Box for Plaintiff and One Box for Defendant)*

(For Diversity Cases Only)

	PTF	DEF		PTF	DEF
Citizen of This State	☐ 1	☐ 1	Incorporated *or* Principal Place of Business In This State	☐ 4	☒ 4
Citizen of Another State	☐ 2	☐ 2	Incorporated *and* Principal Place of Business In Another State	☒ 5	☐ 5
Citizen or Subject of a Foreign Country	☐ 3	☐ 3	Foreign Nation	☐ 6	☐ 6

IV. NATURE OF SUIT *(Place an "X" in One Box Only)*

Click here for: Nature of Suit Code Descriptions.

CONTRACT
☐ 110 Insurance
☐ 120 Marine
☐ 130 Miller Act
☐ 140 Negotiable Instrument
☐ 150 Recovery of Overpayment & Enforcement of Judgment
☐ 151 Medicare Act
☐ 152 Recovery of Defaulted Student Loans (Excludes Veterans)
☐ 153 Recovery of Overpayment of Veteran's Benefits
☐ 160 Stockholders' Suits
☐ 190 Other Contract
☐ 195 Contract Product Liability
☐ 196 Franchise

REAL PROPERTY
☐ 210 Land Condemnation
☐ 220 Foreclosure
☐ 230 Rent Lease & Ejectment
☐ 240 Torts to Land
☐ 245 Tort Product Liability
☐ 290 All Other Real Property

TORTS

PERSONAL INJURY
☐ 310 Airplane
☐ 315 Airplane Product Liability
☐ 320 Assault, Libel & Slander
☐ 330 Federal Employers' Liability
☐ 340 Marine
☐ 345 Marine Product Liability
☐ 350 Motor Vehicle
☐ 355 Motor Vehicle Product Liability
☐ 360 Other Personal Injury
☐ 362 Personal Injury - Medical Malpractice

PERSONAL INJURY
☐ 365 Personal Injury - Product Liability
☐ 367 Health Care/ Pharmaceutical Personal Injury Product Liability
☐ 368 Asbestos Personal Injury Product Liability

PERSONAL PROPERTY
☐ 370 Other Fraud
☐ 371 Truth in Lending
☐ 380 Other Personal Property Damage
☐ 385 Property Damage Product Liability

CIVIL RIGHTS
☐ 440 Other Civil Rights
☐ 441 Voting
☐ 442 Employment
☐ 443 Housing/ Accommodations
☐ 445 Amer. w/Disabilities - Employment
☐ 446 Amer. w/Disabilities - Other
☐ 448 Education

PRISONER PETITIONS
Habeas Corpus:
☐ 463 Alien Detainee
☐ 510 Motions to Vacate Sentence
☐ 530 General
☐ 535 Death Penalty
Other:
☐ 540 Mandamus & Other
☐ 550 Civil Rights
☐ 555 Prison Condition
☐ 560 Civil Detainee - Conditions of Confinement

FORFEITURE/PENALTY
☐ 625 Drug Related Seizure of Property 21 USC 881
☐ 690 Other

LABOR
☐ 710 Fair Labor Standards Act
☐ 720 Labor/Management Relations
☐ 740 Railway Labor Act
☐ 751 Family and Medical Leave Act
☐ 790 Other Labor Litigation
☐ 791 Employee Retirement Income Security Act

IMMIGRATION
☐ 462 Naturalization Application
☐ 465 Other Immigration Actions

BANKRUPTCY
☐ 422 Appeal 28 USC 158
☐ 423 Withdrawal 28 USC 157

PROPERTY RIGHTS
☐ 820 Copyrights
☒ 830 Patent
☐ 835 Patent - Abbreviated New Drug Application
☐ 840 Trademark
☐ 880 Defend Trade Secrets Act of 2016

SOCIAL SECURITY
☐ 861 HIA (1395ff)
☐ 862 Black Lung (923)
☐ 863 DIWC/DIWW (405(g))
☐ 864 SSID Title XVI
☐ 865 RSI (405(g))

FEDERAL TAX SUITS
☐ 870 Taxes (U.S. Plaintiff or Defendant)
☐ 871 IRS—Third Party 26 USC 7609

OTHER STATUTES
☐ 375 False Claims Act
☐ 376 Qui Tam (31 USC 3729(a))
☐ 400 State Reapportionment
☐ 410 Antitrust
☐ 430 Banks and Banking
☐ 450 Commerce
☐ 460 Deportation
☐ 470 Racketeer Influenced and Corrupt Organizations
☐ 480 Consumer Credit (15 USC 1681 or 1692)
☐ 485 Telephone Consumer Protection Act
☐ 490 Cable/Sat TV
☐ 850 Securities/Commodities/ Exchange
☐ 890 Other Statutory Actions
☐ 891 Agricultural Acts
☐ 893 Environmental Matters
☐ 895 Freedom of Information Act
☐ 896 Arbitration
☐ 899 Administrative Procedure Act/Review or Appeal of Agency Decision
☐ 950 Constitutionality of State Statutes

V. ORIGIN *(Place an "X" in One Box Only)*

☒ 1 Original Proceeding
☐ 2 Removed from State Court
☐ 3 Remanded from Appellate Court
☐ 4 Reinstated or Reopened
☐ 5 Transferred from Another District *(specify)*
☐ 6 Multidistrict Litigation - Transfer
☐ 8 Multidistrict Litigation - Direct File

VI. CAUSE OF ACTION

Cite the U.S. Civil Statute under which you are filing ***(Do not cite jurisdictional statutes unless diversity)***:
35 U.S.C. §§ 271, et seq.

Brief description of cause:
Action for patent infringement under the patent laws of the United States

VII. REQUESTED IN COMPLAINT:

☐ CHECK IF THIS IS A **CLASS ACTION** UNDER RULE 23, F.R.Cv.P.

DEMAND $

CHECK YES only if demanded in complaint:
JURY DEMAND: ☒ Yes ☐ No

VIII. RELATED CASE(S) IF ANY

(See updated instructions):
JUDGE _____ DOCKET NUMBER _____

DATE
10/09/2024

SIGNATURE OF ATTORNEY OF RECORD
s/ Thomas P. Heneghan

FOR OFFICE USE ONLY

RECEIPT # _____ AMOUNT _____ APPLYING IFP _____ JUDGE _____ MAG. JUDGE _____

INSTRUCTIONS FOR ATTORNEYS COMPLETING CIVIL COVER SHEET FORM JS 44

Authority For Civil Cover Sheet

The JS 44 civil cover sheet and the information contained herein neither replaces nor supplements the filings and service of pleading or other papers as required by law, except as provided by local rules of court. This form, approved by the Judicial Conference of the United States in September 1974, is required for the use of the Clerk of Court for the purpose of initiating the civil docket sheet. Consequently, a civil cover sheet is submitted to the Clerk of Court for each civil complaint filed. The attorney filing a case should complete the form as follows:

I.(a) **Plaintiffs-Defendants.** Enter names (last, first, middle initial) of plaintiff and defendant. If the plaintiff or defendant is a government agency, use only the full name or standard abbreviations. If the plaintiff or defendant is an official within a government agency, identify first the agency and then the official, giving both name and title.

(b) **County of Residence.** For each civil case filed, except U.S. plaintiff cases, enter the name of the county where the first listed plaintiff resides at the time of filing. In U.S. plaintiff cases, enter the name of the county in which the first listed defendant resides at the time of filing. (NOTE: In land condemnation cases, the county of residence of the "defendant" is the location of the tract of land involved.)

(c) **Attorneys.** Enter the firm name, address, telephone number, and attorney of record. If there are several attorneys, list them on an attachment, noting in this section "(see attachment)".

II. **Jurisdiction.** The basis of jurisdiction is set forth under Rule 8(a), F.R.Cv.P., which requires that jurisdictions be shown in pleadings. Place an "X" in one of the boxes. If there is more than one basis of jurisdiction, precedence is given in the order shown below.
United States plaintiff. (1) Jurisdiction based on 28 U.S.C. 1345 and 1348. Suits by agencies and officers of the United States are included here.
United States defendant. (2) When the plaintiff is suing the United States, its officers or agencies, place an "X" in this box.
Federal question. (3) This refers to suits under 28 U.S.C. 1331, where jurisdiction arises under the Constitution of the United States, an amendment to the Constitution, an act of Congress or a treaty of the United States. In cases where the U.S. is a party, the U.S. plaintiff or defendant code takes precedence, and box 1 or 2 should be marked.
Diversity of citizenship. (4) This refers to suits under 28 U.S.C. 1332, where parties are citizens of different states. When Box 4 is checked, the citizenship of the different parties must be checked**.** (See Section III below**; NOTE: federal question actions take precedence over diversity cases.**)

III. **Residence (citizenship) of Principal Parties.** This section of the JS 44 is to be completed if diversity of citizenship was indicated above. Mark this section for each principal party.

IV. **Nature of Suit.** Place an "X" in the appropriate box. If there are multiple nature of suit codes associated with the case, pick the nature of suit code that is most applicable. Click here for: Nature of Suit Code Descriptions.

V. **Origin.** Place an "X" in one of the seven boxes.
Original Proceedings. (1) Cases which originate in the United States district courts.
Removed from State Court. (2) Proceedings initiated in state courts may be removed to the district courts under Title 28 U.S.C., Section 1441.
Remanded from Appellate Court. (3) Check this box for cases remanded to the district court for further action. Use the date of remand as the filing date.
Reinstated or Reopened. (4) Check this box for cases reinstated or reopened in the district court. Use the reopening date as the filing date.
Transferred from Another District. (5) For cases transferred under Title 28 U.S.C. Section 1404(a). Do not use this for within district transfers or multidistrict litigation transfers.
Multidistrict Litigation – Transfer. (6) Check this box when a multidistrict case is transferred into the district under authority of Title 28 U.S.C. Section 1407.
Multidistrict Litigation – Direct File. (8) Check this box when a multidistrict case is filed in the same district as the Master MDL docket. **PLEASE NOTE THAT THERE IS NOT AN ORIGIN CODE 7.** Origin Code 7 was used for historical records and is no longer relevant due to changes in statue.

VI. **Cause of Action.** Report the civil statute directly related to the cause of action and give a brief description of the cause. **Do not cite jurisdictional statutes unless diversity.** Example: U.S. Civil Statute: 47 USC 553 Brief Description: Unauthorized reception of cable service.

VII. **Requested in Complaint.** Class Action. Place an "X" in this box if you are filing a class action under Rule 23, F.R.Cv.P.
Demand. In this space enter the actual dollar amount being demanded or indicate other demand, such as a preliminary injunction.
Jury Demand. Check the appropriate box to indicate whether or not a jury is being demanded.

VIII. **Related Cases.** This section of the JS 44 is used to reference related pending and previously filed cases, if any. If there are related cases, insert the docket numbers and the corresponding judge names for such cases and file a Notice of Related Action pursuant to Civil L.R. 3(b).

Date and Attorney Signature. Date and sign the civil cover sheet.

UNITED STATES DISTRICT COURT

for the

Eastern District of Wisconsin

Champion Power Equipment, Inc. *Plaintiff(s)*	)	
v.	)	Civil Action No.
Generac Power Systems, Inc. *Defendant(s)*	)	

SUMMONS IN A CIVIL ACTION

To: *(Defendant's name and address)* Generac Power Systems, Inc.
S45W29290 State Road 59
Waukesha, WI 53189-9071

A lawsuit has been filed against you.

Within 21 days after service of this summons on you (not counting the day you receive it) – or 60 days if you are the United States or a United States agency, or an officer or employee of the United States described in Fed. R. Civ. P. 12(a)(2) or (3) – you must serve on the plaintiff an answer to the attached complaint or a motion under Rule 12 of the Federal Rules of Civil Procedure. The answer or motion must be served on the plaintiff or the plaintiff's attorney, whose name and address are:

Thomas P. Heneghan
Husch Blackwell LLP
33 East Main Street, Suite 300
Madison, WI 53703

If you fail to respond, judgment by default will be entered against you for the relief demanded in the complaint. You also must file your answer or motion with the court.

GINA M. COLLETTI, CLERK OF COURT

Date: _____

_____
Signature of Clerk or Deputy Clerk

Civil Action No.

PROOF OF SERVICE

(*This section should not be filed with the court unless required by Fed. R. Civ. P. 4(l)*)

This summons and the attached complaint for *(name of individual and title, if any):* _____

were received by me on *(date)* _____.

☐ I personally served the summons and the attached complaint on the individual at *(place):* _____

_____ on *(date)* _____ ; or

☐ I left the summons and the attached complaint at the individual's residence or usual place of abode with *(name)* _____, a person of suitable age and discretion who resides there, on *(date)* _____, and mailed a copy to the individual's last known address; or

☐ I served the summons and the attached complaint on *(name of individual)* _____ who is designated by law to accept service of process on behalf of *(name of organization)* _____

_____ on *(date)* _____ ; or

☐ I returned the summons unexecuted because _____ ; or

☐ Other *(specify):* _____

_____.

My fees are $ _____ for travel and $ _____ for services, for a total of $ 0.00

I declare under penalty of perjury that this information is true.

Date: _____

_____
Server's signature

_____
Printed name and title

_____
Server's address

Additional information regarding attempted service, etc.:

Print Save As... Reset