

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

HARBOR FREIGHT TOOLS USA, INC.,
GENERAC POWER SYSTEMS, INC., and
MWE INVESTMENTS, LLC,
Petitioners

v.

CHAMPION POWER EQUIPMENT, INC.,

Patent Owner

Patent No. 11,143,120

Issued: Oct. 12, 2021

Title: FUEL SYSTEM FOR A MULTI-FUEL
INTERNAL COMBUSTION ENGINE

Inter Partes Review No. IPR2025-01121

DECLARATION OF TIMOTHY MORSE

TABLE OF CONTENTS

I.	INTRODUCTION	6
II.	QUALIFICATIONS AND EXPERIENCE	7
III.	MATERIALS AND OTHER INFORMATION CONSIDERED	10
IV.	SUMMARY OF OPINIONS	13
V.	UNDERSTANDING OF PATENT LAW	13
A.	Claim Construction.....	14
B.	Obviousness.....	14
C.	Anticipation	17
VI.	THE PERSON OF ORDINARY SKILL IN THE ART	18
VII.	STATE OF THE ART	20
A.	Carburetors	20
B.	Multi-Fuel Combustion Engines	21
C.	Switches and Solenoids	22
VIII.	SUMMARY OF THE '120 PATENT	23
A.	The '120 Patent	23
B.	Prosecution History	26
IX.	Level of Ordinary Skill in the Art.....	26
X.	Claim Construction.....	27
XI.	OVERVIEW OF THE ASSERTED PRIOR ART	27
A.	JPH1182083A (“Imamura”).....	27
B.	Kubota DF972-E2 Workshop Manual (“Workshop Manual”).....	28
1.	Liquid Fuel Operation.....	29

2.	Gaseous Fuel Operation.....	31
3.	Switch for Controlling Liquid/Gaseous Fuel Operation.....	34
C.	Kubota DF972-E2 Operator’s Manual (“Operator’s Manual”)	35
D.	JPS61283734A (“Nakafushi”).....	36
E.	U.S. Patent No. 5,301,644 (“Olmr”)	39
F.	U.S. Patent Pub. No. 2011/0100335A1 (“Parlatore”).....	40
G.	U.S. Patent Pub. No. 2014/0239645 (“Jungmann”).....	41
H.	U.S. Patent No. 7,165,536 (“Kirk”)	42
I.	U.S. Patent No. 1,679,159 (“French”) and U.S. Patent No. 4,065,096 (“Frantz”).....	43
XII.	THE CHALLENGED CLAIMS ARE UNPATENTABLE	44
A.	Ground 1: Claims 1-2, 4-6, and 9-10 are anticipated by Imamura or, alternatively, are obvious over Imamura	44
1.	Claim 1	44
2.	Claim 2	55
3.	Claim 4.....	55
4.	Claim 5	56
5.	Claim 6	58
6.	Claim 9	59
7.	Claim 10.....	60
B.	Ground 2: Claim 3 is obvious over Imamura in view of French and/or Frantz.....	60
1.	Claim 3	60
C.	Ground 3: Claims 7-8 are obvious over Imamura in view of Olmr.....	62

1.	Claim 7	63
2.	Claim 8	67
D.	Ground 4: Claim 11 is obvious over Imamura in view of Jungmann and Parlatore	68
1.	Claim 11	69
E.	Ground 5: Claims 12-15 and 17-19 are anticipated by The Workshop Manual	81
1.	Claim 12	81
2.	Claim 13	92
3.	Claim 14	94
4.	Claim 15	96
5.	Claim 17	97
6.	Claim 18	98
7.	Claim 19	109
F.	Ground 6: Claim 16 is obvious over The Workshop Manual in view of Parlatore	111
1.	Claim 16	111
G.	Ground 7: Claims 12-17 are obvious over Nakafushi in view of Jungmann and Parlatore	112
1.	Claim 12	113
2.	Claim 13	133
3.	Claim 14	136
4.	Claim 15	140
5.	Claim 16	140
6.	Claim 17	142

H.	Ground 8: Claims 18-19 are obvious over Nakafushi in view of Kirk and Olmr	142
1.	Claim 18	142
2.	Claim 19	165
XIII.	CONCLUSION.....	166

I, Timothy Morse, submit this Declaration and declare as follows:

I. INTRODUCTION

1. I have been retained as an expert on behalf of Petitioner Harbor Freight Tools, Inc. (“Harbor Freight”) as an independent expert consultant in support of Petitioner’s request for Inter Partes Review No. IPR2025-01121 to review the challenged claims of U.S. Patent No. 11,143,120 (“the ’120 patent,” Ex. 1001), assigned to Champion Power Equipment, Inc. (“Patent Owner” or “Champion”). My opinions are set forth below.

2. My employer, Exponent, Inc., is being compensated for my time in connection with this *Inter Partes* Review at my standard consulting rate, but my compensation is not in any way tied to or affected by the outcome of this matter.

3. I have been asked to provide my opinions regarding whether Claims 1–24 of the ’120 Patent are invalid. Specifically, this report addresses the invalidity of Claims 1–19 (the “Challenged Claims”) of the ’120 patent.

4. This report sets forth the opinions that I have formed based on the information available to me as of the date below. The opinions and facts set forth in this report are based upon my analysis of the ’120 Patent and its claims, the prior art, the state of the art at the time of the invention, as well as my knowledge and extensive experience in this field.

5. My analysis of the materials submitted in this proceeding is ongoing and I will continue to review any new material that is provided. This declaration is indicative of only those opinions that I have formed to date. I reserve the right to amend, revise, and/or supplement my opinions stated herein based on any new information that may become available to me or my continuing analysis of the materials already provided.

6. I am not currently and have not at any time in the past been an employee of Harbor Freight. I have no financial interest in Harbor Freight outside of assisting Harbor Freight as an expert in this and any related matters.

II. QUALIFICATIONS AND EXPERIENCE

7. My qualifications for forming the opinions in this report are summarized here and explained in more detail in my curriculum vitae (“CV”), which I understand is being appended hereto.

8. As detailed in my CV, I have extensive experience in the design, development, and manufacture of multi-fuel internal combustion engines and generators, with a career spanning over fifteen years in this field. I have specific expertise in thermal and flow processes and have a good understanding of the relevant mechanical principles and constraints associated with the implementation of such processes into physical products and equipment, including internal combustion engines and generators. I have also engaged in extensive consulting

work, specializing in failure analysis, failure prevention, and design risk assessment of power generation equipment and facilities, including power plants, fixed emergency power generation, and portable generators. I have personally investigated the causes of failure of many different types of portable generators.

9. I earned my Bachelor of Engineering in Mechanical Engineering from the Cooper Union for the Advancement of Science and Art in 2003. I completed a Master of Science in Mechanical Engineering in 2007 and a Doctor of Philosophy in Mechanical Engineering in 2009, both from Cornell University. I am a licensed Professional Engineer in mechanical engineering in California, Florida, Kansas, Massachusetts, New Hampshire, New York, Pennsylvania, Rhode Island, and Vermont. I am also a Certified Fire and Explosion Investigator with the National Association of Fire Investigators.

10. I am a member of the National Fire Protection Association (NFPA) and serve on two code committees responsible for developing safety standards in the US. One of these committees is the NFPA Technical Committee on Vehicular Alternative Fuel Systems (VAF-AAA), responsible for NFPA 52: Vehicular Natural Gas Fuel Systems Code. NFPA 52 applies to vehicles and vehicle internal combustion engines that operate with natural gas. One of my functions as a member of this committee is to understand how safety considerations for more common gasoline powered vehicles apply to natural gas powered vehicles. The

other committee I serve on is the NFPA Technical Committee on Liquefied Petroleum Gases (LPG-AAA), responsible for NFPA 58: Liquefied Petroleum Gas Code. NFPA 58 applies to the use of LPG in a wide range of applications, including portable generators and portable generator fueling systems.

11. I have performed research and analysis for the Portable Generators Manufacturers Association (PGMA). This work has included evaluating the safety of portable generators, including the generation of carbon monoxide, which is a byproduct of combustion. This research work has been presented to the US Consumer Product Safety Commission (CPSC).

12. I am also an active contributor to the scholarly literature in my field, being a named author on over twenty publications. Most of my publications went through the peer review process, appearing in sources like the Journal of Fluid Mechanics and the Journal of Fluids and Structures. Broadly speaking, these publications relate to the design and safety of fluid and thermal systems, like how the valve closure time affects pressure in a fluid system. In addition to researching and writing on emerging safety issues, I have presented my work over twenty-five times to various audiences including practicing engineers, which has led me to appreciate how a less experienced engineer would perceive the prior art and approach the technical problems disclosed in the prior art.

13. I also have broader consulting experience in the development and design of thermal and flow processes, products, and equipment. My project experience includes turbines, compressors, valves, heat exchangers, boilers, furnaces, refrigeration systems, piping systems, autoclaves, heat transfer systems, flammable liquids, cryogenic liquids, consumer products, and medical devices. This work has included analysis of HVAC systems, the engineering analysis of gas extraction facilities, and the investigation into failures of generators and heat exchanges, among other applications.

14. I am currently employed as a Principal Engineer at Exponent, Inc., a US-based engineering and scientific consulting firm. Before joining Exponent, I was a researcher in the Fluid Dynamics Research Laboratories at Cornell University where I conducted research on the wakes of stationary and oscillating structures in a flow and particularly on how flow-induced vibration due to vortex shedding causes fatigue and failure of structures.

III. MATERIALS AND OTHER INFORMATION CONSIDERED

15. All the opinions contained in this declaration are based on the documents I have reviewed and my professional judgment, as well as my education, experience, and professional knowledge. I am not an attorney and I am not offering any purely legal opinions in this declaration. In forming the opinions expressed in this declaration, I relied upon my education, knowledge, and

experience in the relevant field of the art, and have considered the viewpoint of a person having ordinary skill in the relevant art.

16. I have considered the materials referenced herein, including the '120 Patent (Ex. 1001), the file history of the '120 Patent (excerpts at Ex. 1002), and the prior art references listed in the table below. Each of these documents is a type of document that an expert in my field would have reasonably relied upon when forming their opinion.

Exhibit No.	Description
1001	U.S Patent No. 11,143,120 to Collie et al. (“the ’120 Patent”)
1002	File History for U.S. Patent No. 11,143,120 (“the ’120 File History”)
1004	JPS61283734A (Original) (“Nakafushi”)
1005	Certified Translation of JPS61283734A (“Nakafushi”)
1006	Small Engine Technology, Second Edition, Schuster, William A, (1999) (“Schuster”)
1007	U.S. Patent No. 5,301,644 (“Olmr”)
1009	U.S. Patent No 1,931,698 (“Holzapfel”)
1010	U.S. Patent Pub. No. 2011/0100335A1 (“Parlatore”)
1011	U.S. Patent Pub. No. 2014/0239645 (“Jungmann”)
1012	Kubota DF972-E2 Workshop Manual (“Workshop Manual”)

Exhibit No.	Description
1013	Kubota DF972-E2 Operator's Manual ("Operator's Manual")
1014	Declaration from Mr. James Strepek re Kubota Manuals
1015	Declaration from Mr. Scott Schlabach re Kubota Manuals
1016	<i>Auto Fuel Systems</i> . The Goodheart-Willcox Company. James Duffy and Howard Smith. 1987 ("Duffy")
1017	DuroMax Manual Next Generation Power Systems
1019	Oxford Dictionary of Mechanical Engineering, Tony Atkins & Marcel Escudier, 2013.
1020	U.S. Patent No. 9,175,601 ("Markoski")
1023	JPH1182083A (Original) ("Imamura")
1024	Certified Translation of JPH1182083A ("Imamura")
1025	U.S. Patent No 7,165,536 ("Kirk")
1026	U.S. Patent No. 1,679,159 ("French")
1027	U.S. Patent No. 4,065,096 ("Frantz")
1028	McGraw-Hill Dictionary of Scientific and Technical Terms, Fifth Edition, 1994

17. My opinions are additionally guided by my appreciation and understanding of how a POSA would have understood the claims of the '120

Patent at the time of the earliest possible priority date of the patents, which I understand is June 12, 2015.

IV. SUMMARY OF OPINIONS

18. Based on my experience and expertise, it is my opinion that:

- Claims 1-19 recite nothing more than devices that were already known in the industry prior to the effective filing date of the '120 Patent;
- Claims 1-2, 4-6, and 9-10 are anticipated by Imamura or, alternatively, are obvious over Imamura;
- Claim 3 is obvious over Imamura in view of French and/or Frantz;
- Claims 7-8 are obvious over Imamura in view of Olmr;
- Claim 11 is obvious over Imamura in view of Jungmann and Parlatore;
- Claims 12-15 and 17-19 are anticipated by The Workshop Manual;
- Claim 16 is obvious over The Workshop Manual in view of Parlatore;
- Claims 12-17 are obvious over Nakafushi in view of Jungmann and Parlatore;
- Claims 18-19 are obvious over Nakafushi in view of Kirk and Olmr.

V. UNDERSTANDING OF PATENT LAW

19. I am not an attorney. For purposes of this report, I have an understanding about certain aspects of the law that are relevant to my opinions, as described below.

A. Claim Construction

20. I understand that claim terms must be construed under the Phillips standard. Under that standard, words of a claim are given their plain and ordinary meaning as understood by a person of ordinary skill in the art (also “POSA”) at the time of invention, in light of the specification and prosecution history, unless those sources show an intent to depart from such meaning, as well as pertinent evidence extrinsic to the patent. For purposes of this declaration, I applied the plain and ordinary meaning of each term as would have been understood by a person of ordinary skill in art at the time of the alleged invention unless explicitly stated otherwise.

B. Obviousness

21. I understand that a patent claim can be considered to have been obvious to person of ordinary skill in the art at the time the application was filed. This means that, even if all of the elements of a claim are not found in a single prior art reference, the claim is not patentable if the differences between the subject matter in the prior art and the subject matter in the claim would have been obvious to a person of ordinary skill in the art at the time the application was filed.

22. I further understand that a determination of whether a claim would have been obvious must consider several factors, including, among others:

- the level of ordinary skill in the art at the time the application was filed;

- the scope and content of the prior art; and
- what differences, if any, existed between the claimed invention and the prior art.

23. I understand that the teachings of two or more references may be combined in the same way as disclosed in the claims, if such a combination would have been obvious to a person of ordinary skill in the art. In determining whether a combination based on either a single reference or multiple references would have been obvious, it is appropriate to consider at least the following factors:

- whether the teachings of the prior art references disclose known concepts combined in familiar ways, which, when combined, would yield predictable results;
- whether a person of ordinary skill in the art could implement a predictable variation, and would see the benefit of doing so;
- whether the claimed elements represent one of a limited number of known design choices, and would have a reasonable expectation of success by a person of ordinary skill in the art;
- whether a person of ordinary skill in the art would have recognized a reason to combine known elements in the manner described in the claim;
- whether there is some teaching or suggestion in the prior art to make the modification or combination of elements claimed in the patent; and

- whether the innovation applies a known technique that had been used to improve a similar device or method in a similar way.

24. I understand that a person of ordinary skill in the art has ordinary creativity and is not an automaton.

25. I understand that in considering obviousness, it is important not to determine obviousness using the benefit of hindsight derived from the patent being considered, and I have not done that in regard to my opinions expressed herein.

26. I understand that certain factors—often called “secondary considerations”—may support or rebut an assertion of obviousness of a claim. I understand that such secondary considerations include, among other things, commercial success of the alleged invention, skepticism of those having ordinary skill in the art at the time of the alleged invention, unexpected results of the alleged invention, any long-felt but unsolved need in the art that was satisfied by the alleged invention, the failure of others to make the alleged invention, praise of the alleged invention by those having ordinary skill in the art, and copying of the alleged invention by others in the field. I further understand that there must be a nexus—a connection—between any such secondary considerations and the alleged invention. I also understand that contemporaneous and independent invention by others is a secondary consideration tending to show obviousness.

C. Anticipation

27. I understand that a patent claim is invalid if it is anticipated by a single item of prior art. I understand that an anticipation analysis involves two steps. First, the patent claims are construed to ascertain their scope. Second, each construed asserted claim is compared to the prior art reference on an element-by-element basis. If the prior art reference discloses or contains each and every element of the claimed invention as arranged in the claim, either expressly or inherently, then it anticipates the claim.

28. I understand that anticipation by inherent disclosure is appropriate only when a prior art reference necessarily includes or discloses the unstated claim element. I also understand that the discovery of a new or previously unreported or unappreciated property of a prior art composition, or of a scientific explanation for how a prior art composition operates, does not make the prior art composition patentably new to the entity or person that discovered the new property or mode of operation. I further understand that there is no requirement that a POSA would have recognized the inherent disclosure at the time of the invention.

29. For anticipation by a prior art publication or document, I understand that the reference's description must enable a POSA to practice the claimed invention without undue experimentation. I further understand that the following

factors may be considered to determine whether any experimentation would have been undue:

- The quantity of experimentation necessary.
- The amount of direction or guidance presented.
- The presence or absence of working examples.
- The nature of the claimed invention.
- The state of the prior art.
- The relative skill of those in the art.
- The predictability or unpredictability of the art.
- The breadth of the claims.

VI. THE PERSON OF ORDINARY SKILL IN THE ART

30. I understand that there are multiple factors relevant to determining the level of ordinary skill in the pertinent art, including the educational level of active workers in the field at the time of the alleged invention, the sophistication of the technology, the type of problems encountered in the art, and the prior art solutions to those problems.

31. In determining the characteristics of a hypothetical person of ordinary skill in the art of the '120 Patent at the time of the claimed invention, I considered several things, including the type of problems encountered in this field, and the rapidity with which innovations were made. I also considered the sophistication of

the technology involved, and the educational background and experience of those actively working in the field, and the level of education that would be necessary to understand the '120 patent. Finally, I placed myself back in the relevant period of time and considered the state of the art and the level of skill of the persons working in this field at that time.

32. It is my opinion that the subject matter of the '120 Patent focuses on the fuel-delivery system(s), such as a carburetor and/or gaseous fuel regulator, for a dual-fuel engine or generator. Based on the materials I have considered (including the prior art cited herein), my own knowledge and experience, and the level of skill required to design and build a dual-fuel carburetor, I have come to the conclusion that a person of ordinary skill in the art of the '120 Patent would hold a bachelor's-level or equivalent degree in mechanical engineering, physics, or related fields and have three years of work experience in combustion engines operating on various fuel sources such as liquid fuels and gaseous fuels. This hypothetical person would be capable of performing various design tasks and would understand the basic mechanical features and operation of carburetors, regulators, engines, and generators; this hypothetical person would also have an appreciation for carburetors, regulators, engines, and generators and issues and concerns faced by users/operators that use the same. There are also basic engineering principles that the person of ordinary skill in the art would appreciate, as I discuss in Section VII

below. I believe these understandings are demonstrated, for example, by the prior art I discuss herein. A person could also have qualified as a person of ordinary skill in the art with some combination of (1) more formal education (e.g., an M.S. degree) and less technical experience or (2) less formal education and more technical or professional experience in the fields listed above. For example, a person having significant experience servicing or operating dual-fuel combustion engines, or incorporating such engines into finished products (e.g., lawnmowers, lifts, floor cleaners, or the like), would qualify as a POSA.

33. Although my qualifications and experience exceed those of the hypothetical person having an ordinary level of skill in the art, my analysis and conclusions herein are from the perspective of a person of ordinary skill in the art as of June 12, 2015 (which I understand to be the earliest possible priority date for the claims of the '120 Patent), unless otherwise noted.

VII. STATE OF THE ART

A. Carburetors

34. A carburetor is a device that supplies an air-fuel mixture to a spark-ignition engine. The diagram below shows a carburetor's basic elements.

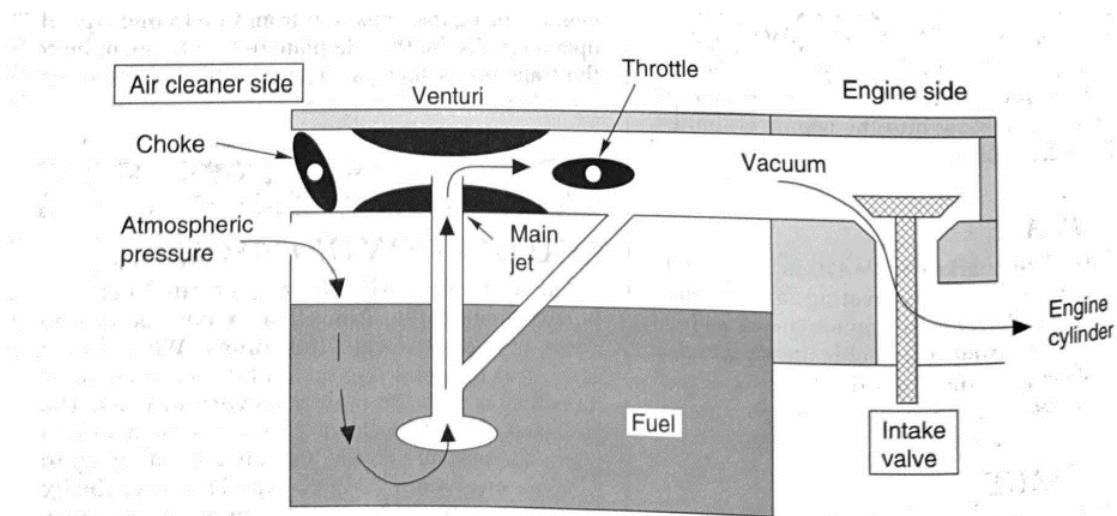


Fig. 4-7 Choke system. (Courtesy of William A. Schuster)

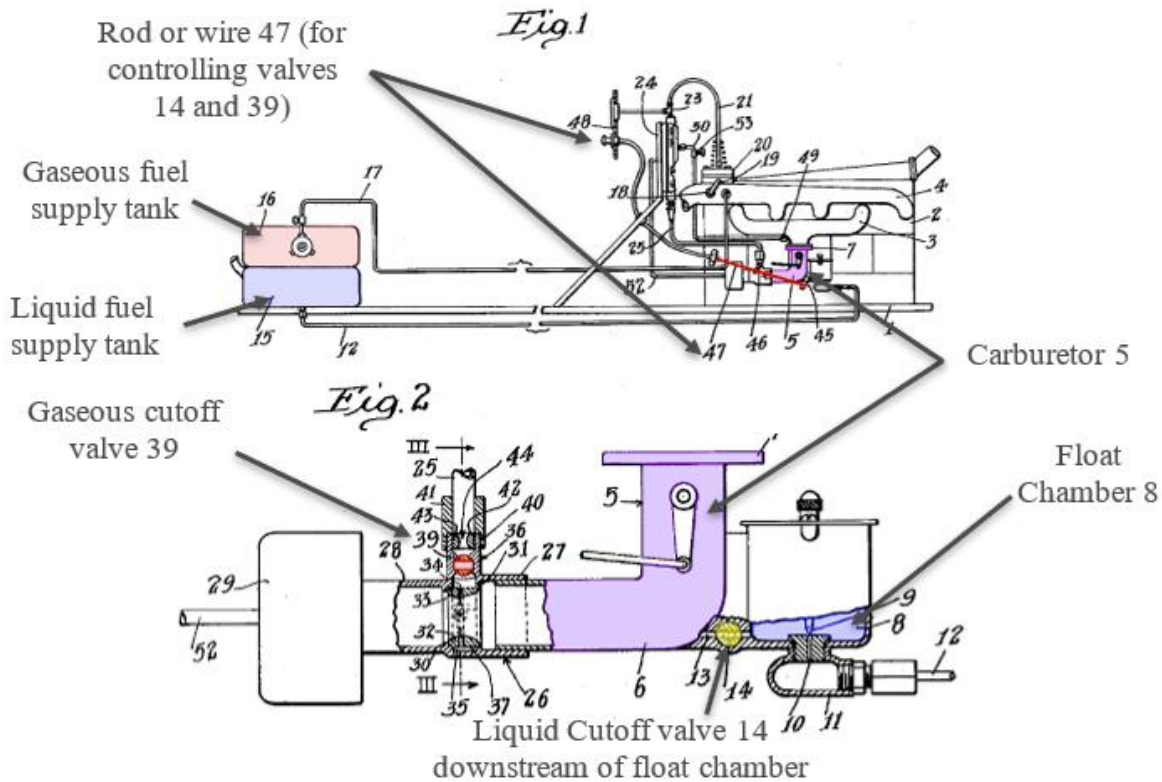
Ex. 1006, 8.

35. A carburetor contains a Venturi, a shape that is wider at the ends and narrower in the middle. When air flows through the Venturi, the velocity increases and pressure decreases through the narrow portion (the “Venturi effect”), which pulls fuel from the float bowl/chamber through the main jet and mixes it with air. The choke controls air in-flow, while the throttle controls the outflow of the air/fuel mixture to the engine.

B. Multi-Fuel Combustion Engines

36. Dual-fuel engines running alternatively on liquid or gaseous fuels have been known for nearly 100 years. For example, U.S. Patent No. 1,931,698 (“Holzapfel”) was filed in 1931 and discloses “a fuel system embodying the supplying of liquid fuel and gaseous fuel to an engine in alternation at will.” Ex.

1009, 1:1-42. A “rod or wire 47” controls both the liquid and gaseous valves, as seen in Holzapfel’s Figures 1 and 2 below (annotated):



37. Notably, Holzapfel’s liquid cutoff 14 is located downstream from the carburetor float chamber 8. Ex. 1009, 1:100-107, Fig. 2.

C. Switches and Solenoids

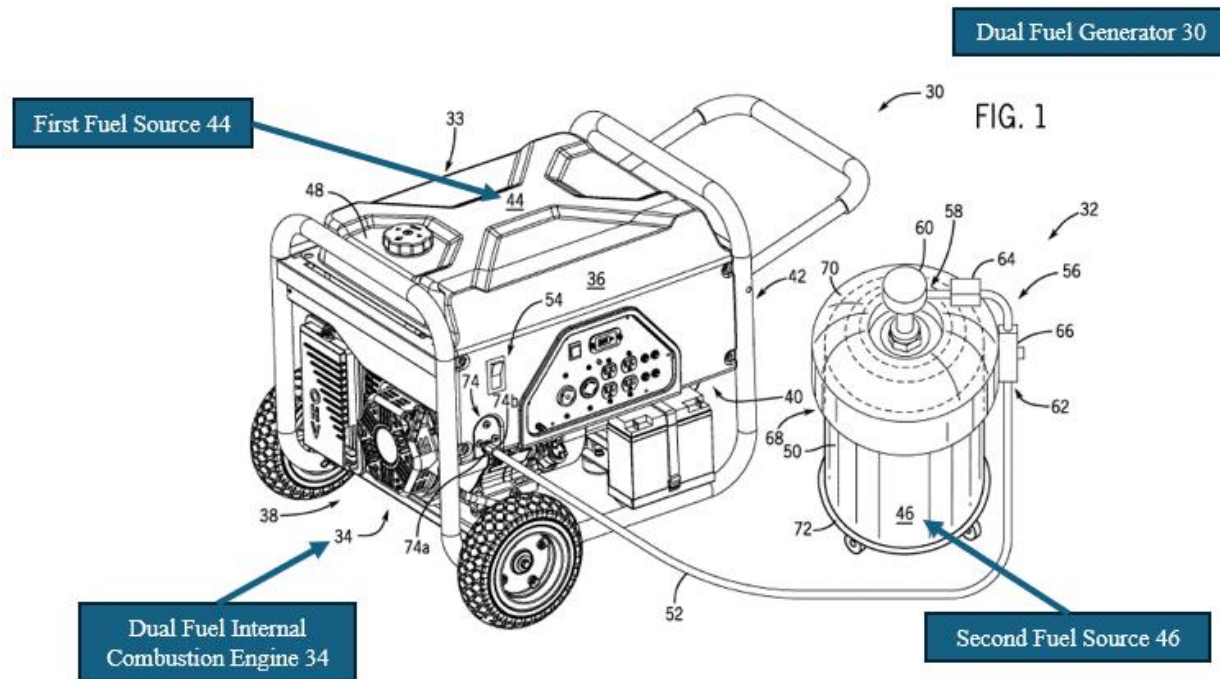
38. A solenoid valve is a type of electro-mechanical valve. It uses a wire coil to generate a magnetic field when energized, which can be controlled by an electrical switch. The magnetic field moves a piston to open or close the valve. Solenoid valves are widely used in a range of fluid control applications, including

the control of fuel flow in an engine. In carbureted engines, solenoid valves are commonly used downstream of the float chamber to control/cut off the flow of fuel and have been known for decades. *See e.g.*, Ex. 1007, Fig. 2, 1:33-48; Ex. 1016, 4-13.

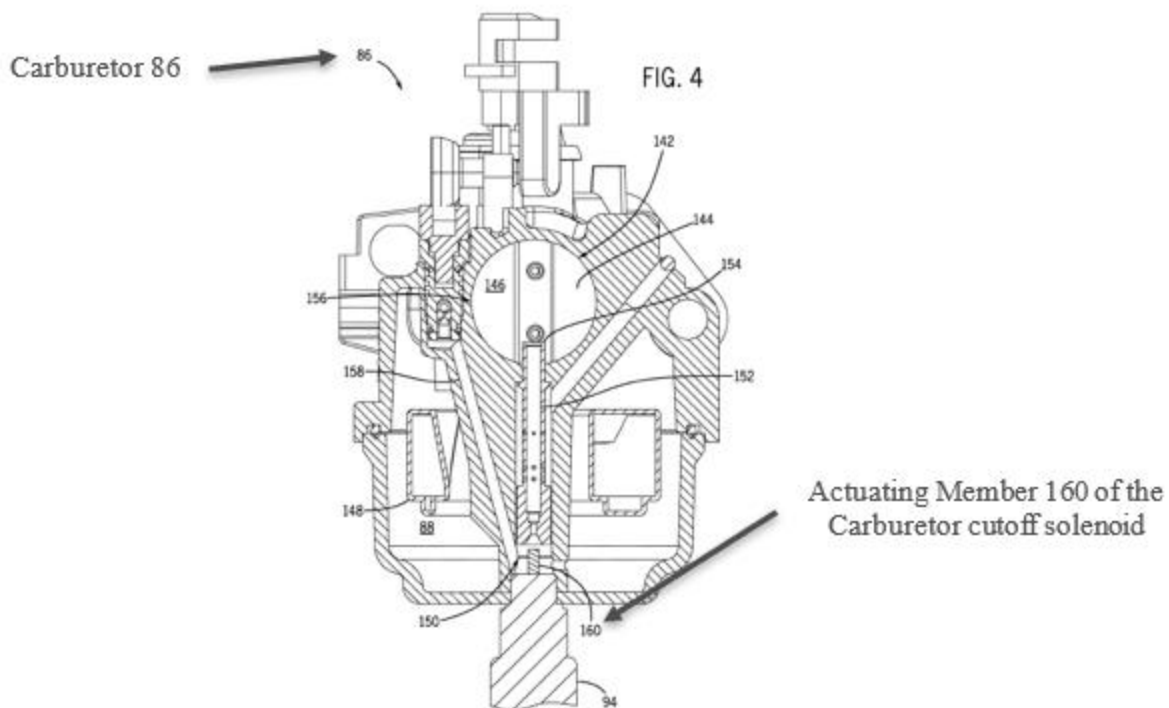
VIII. SUMMARY OF THE '120 PATENT

A. The '120 Patent

39. The '120 Patent discloses multi-fuel internal combustion engines/generators operable on liquid or gaseous fuels. Ex. 1001, 1:21-25. The '120 Patent acknowledges that multi-fuel combustion engines typically run on liquid fuel (such as gasoline) and an alternative gaseous fuel (such as propane). *Id.*, 1: 26-43. Figure 1 of the '120 Patent discloses a perspective view of a generator with such an engine, as shown below:



40. The '120 Patent states that switching fuel sources in conventional multi-fuel engines can cause overly rich air-fuel ratios and unstable operating conditions when both liquid and gaseous fuels are fed to the engine. *Id.*, 1:61-2:11. The '120 Patent purports to solve this problem by implementing a switch that powers cutoff solenoids for controlling liquid and gaseous fuel flow. *Id.*, 2:19-31. The '120 Patent also locates a gasoline cutoff downstream of the float bowl to prevent excess gasoline from passing to the engine, as depicted in Figure 4:



Id., 11:46-50.

41. The '120 Patent also discloses the use of delay circuits for any of the solenoids to delay their actuation, such as to “provide simultaneous delivery of fuels to the engine for any fraction of a second or for up to several seconds.” *Id.*, 8:22-33. The '120 Patent discusses how a “slight overlap in fuel delivery to the engine ensure[s] a smooth transition during changeover” from gasoline and LPG and vice versa. *Id.*, 8:6-21.

42. The '120 Patent further discloses using two pressure regulators in the gaseous fuel line—a primary regulator coupled to the gaseous fuel source, and a downstream regulator to further regulate the pressure of the gaseous fuel as it enters the engine. *Id.*, 4:28-39. The '120 patent further recognizes that the

regulator system may be located on the generator or “off-board.” *Id.*, 4:22-25, 4:40-45.

B. Prosecution History

43. The '120 Patent is part of a family that includes at least 12 U.S. patents and/or pending applications.¹ The '120 Patent issued from U.S. Application No. 16/946,439, which was filed on June 22, 2020, and claims priority to multiple applications, the earliest of which is U.S. Application No. 14/738,060 (“the '060 Application”), which was filed on June 12, 2015. The claims of the '120 Patent were allowed without rejection. Ex. 1002.

IX. LEVEL OF ORDINARY SKILL IN THE ART

44. I understand that a person of ordinary skill in the art (hereinafter “POSA”) would be aware of all the pertinent prior art at the time of the alleged invention. I further understand that a POSA is a person of ordinary creativity and thus is able to make inferences from the art.

45. For purposes of this IPR, I apply the level of skill in the art as possessed by the POSA I described previously in paragraph 32 above.

¹ I understand family members include U.S. Patent App. Nos. 14/738,060; 14/925,441; 15/285,215; 15/332,264, 16/191,503; 16/358,822, 16/783,455, 16/946,438, 17/937,046; 18/183,734; and 18/443,487.

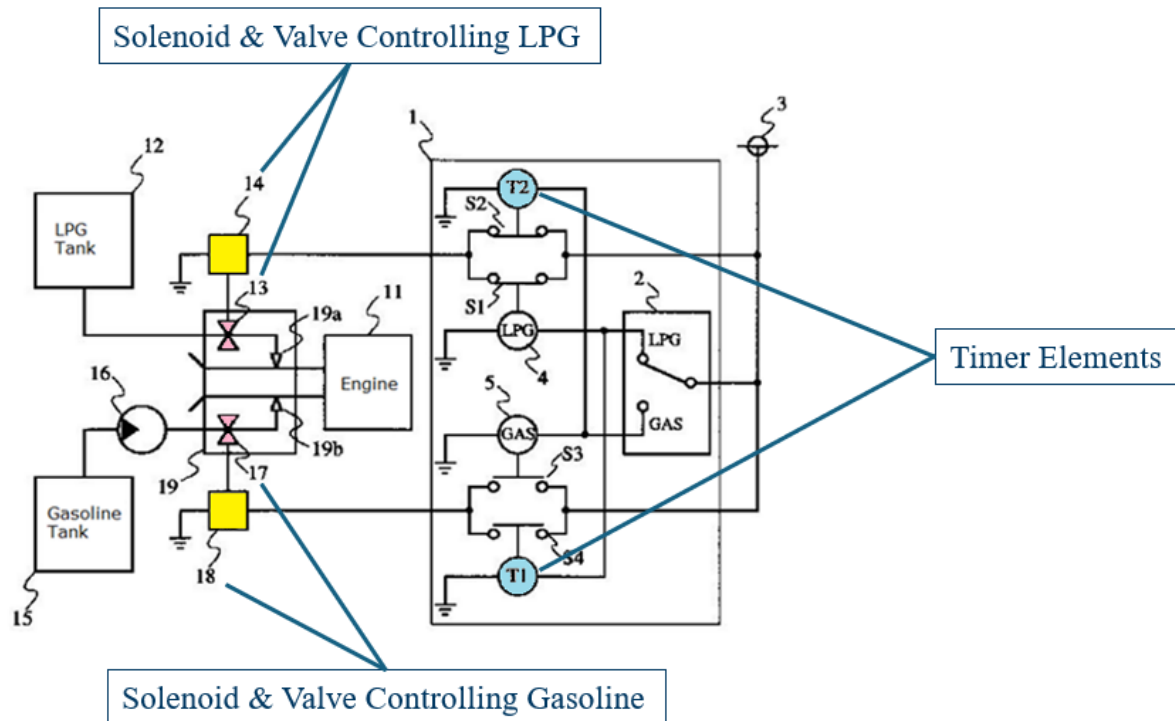
X. CLAIM CONSTRUCTION

46. I have not identified any claim terms that need an express construction in order to address the issues raised herein, but reserve the right to respond to any constructions offered by Patent Owner, its expert(s), and/or the Board. I have therefore applied the plain and ordinary meaning of the claim terms in this declaration.

XI. OVERVIEW OF THE ASSERTED PRIOR ART

A. JPH1182083A (“Imamura”)

47. Imamura discloses a dual fuel engine that runs on gasoline and LPG. Ex. 1024, ¶[0001], Fig. 1. Imamura discloses solenoids 14 and 18 that control valves 13 (for LPG) and 17 (for gasoline) that open and close to allow gasoline and LPG to flow to the engine. *Id.*, ¶[0017], Fig. 1. Imamura also discloses timing circuits (timer elements T1 and T2) that delay the closing of the valves 13 and 17 to allow a continuous supply or slight overlap of fuel when switching operation of the engine from gasoline to LPG (and vice versa) to prevent the engine from stopping. *Id.*, ¶¶[0005]-[0007], [0017]-[0023].



Id., Fig. 1 (annotated).

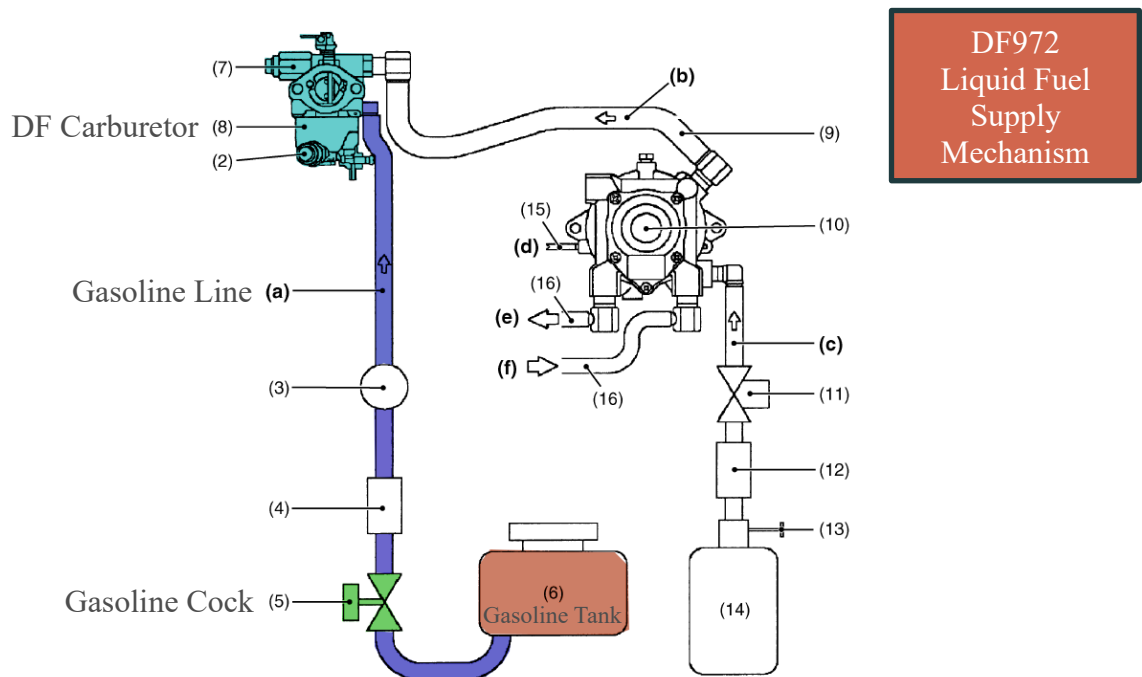
B. Kubota DF972-E2 Workshop Manual (“Workshop Manual”)

48. The Workshop Manual (Ex. 1012) discloses servicing, maintenance, and troubleshooting instructions for Kubota’s gasoline (WG972), dual-fuel gasoline/LPG (DF972), and natural gas (DG972) engines/generators. I will focus on the disclosures relating to the dual-fuel model (DF972) here. The DF972 engine/generator is designed to operate on both gasoline and LPG. Note that the Workshop Manual refers to both LPG and propane. *See e.g.* Ex. 1012, 65. LPG is mostly propane with small amounts of other hydrocarbons. (The Workshop manual refers to Gas Processors Association standards which specify >90% propane in LPG. *Id.*, 10.) Thus, a POSA would understand that the use of “LPG” and

“propane” as used in the Workshop Manual refer to the same thing for purposes of my opinions herein, i.e. a hydrocarbon fuel that is stored under pressure as a liquid, but ultimately fed to the generator engine as a gas comprising mostly propane.

1. Liquid Fuel Operation

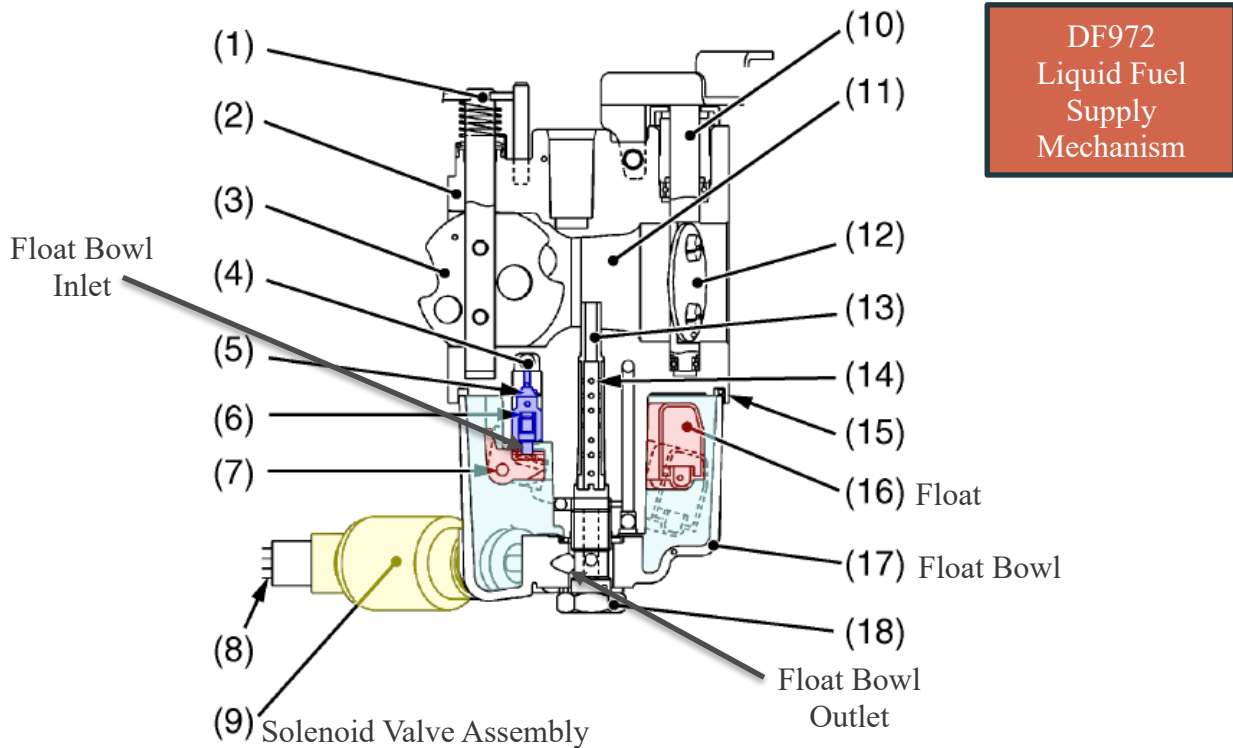
49. With respect to gasoline operation of the DF972, a Gasoline Tank (6) supplies liquid gas to a dual-fuel carburetor via a Gasoline Line (a). A manual shut-off valve (i.e. “Gasoline Cock” (5)) controls the flow of liquid fuel from the gasoline tank to the Carburetor.



Id., 65 (coloring and annotations added).

50. When the liquid fuel reaches the dual-fuel carburetor, it collects in a float chamber (17), also called a float bowl. The float (16) regulates the fuel levels in the float chamber (17). The gasoline in the float chamber can pass through to a

solenoid valve assembly (9), as shown below:

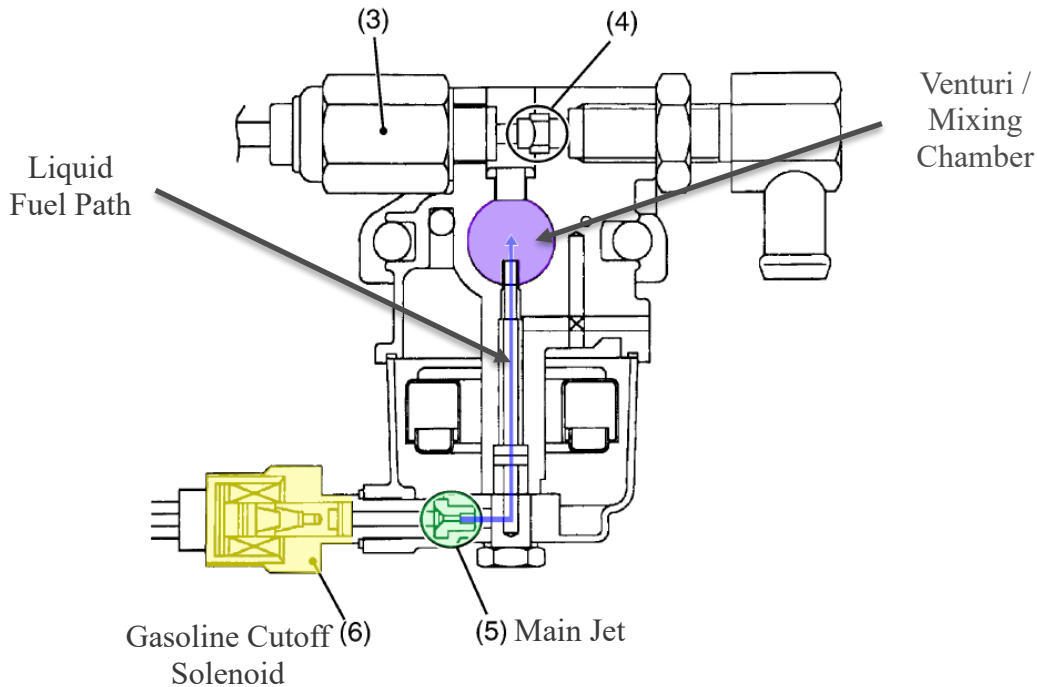


Id., 67 (coloring and annotations added).²

51. As seen above, a gasoline cut-off solenoid is positioned between the float chamber and the main jet/nozzle system. When activated (open) for gasoline mode, the gasoline cut-off solenoid valve allows fuel to pass through the main jet into the main nozzle, where it mixes with air in the venturi before entering the engine combustion chamber. When deactivated (closed) for LPG mode or when

² In the Workshop Manual, the figure corresponds to the WG972-E2 Carburetor. However, the Workshop Manual confirms that the “DF Carburetor operates the same as a gasoline carburetor in gasoline fuel.” Ex. 1012, 68.

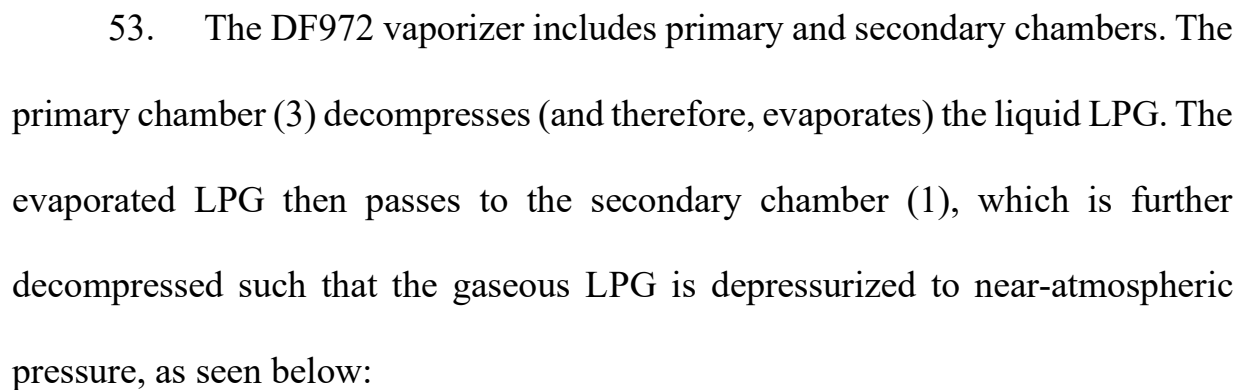
the engine is off, the gasoline cut-off solenoid blocks gasoline flow, preventing fuel from reaching the main jet. The general direction of gasoline flow when the gasoline cutoff solenoid is open is illustrated below by the blue arrow:



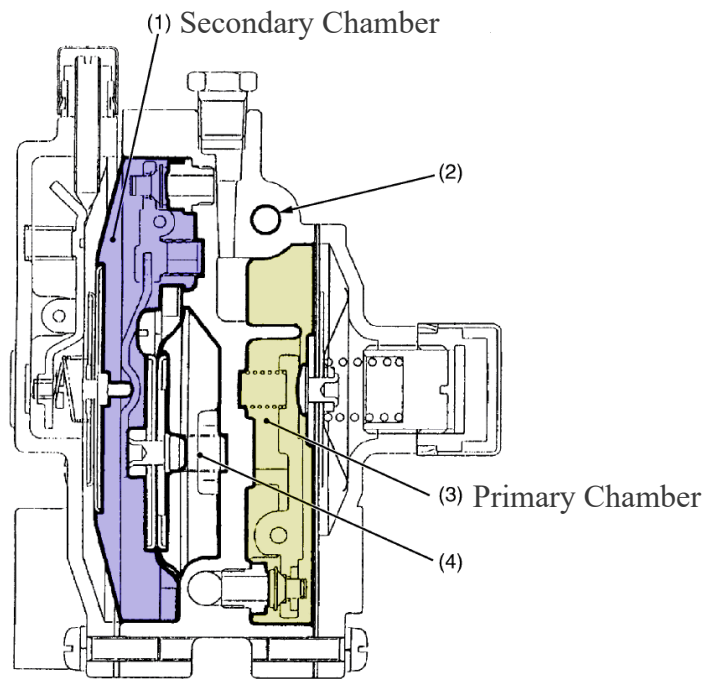
Id., 68 (coloring and annotations added).

2. Gaseous Fuel Operation

52. With respect to operation of the DF972 on gaseous fuel (LPG), an LPG Tank (14) supplies liquid propane to a vaporizer (10) via a Liquid Propane Line (c). The vaporizer converts the liquid LPG into gaseous fuel and supplies the gaseous fuel to the dual-fuel carburetor via a Gaseous Propane Line (b).

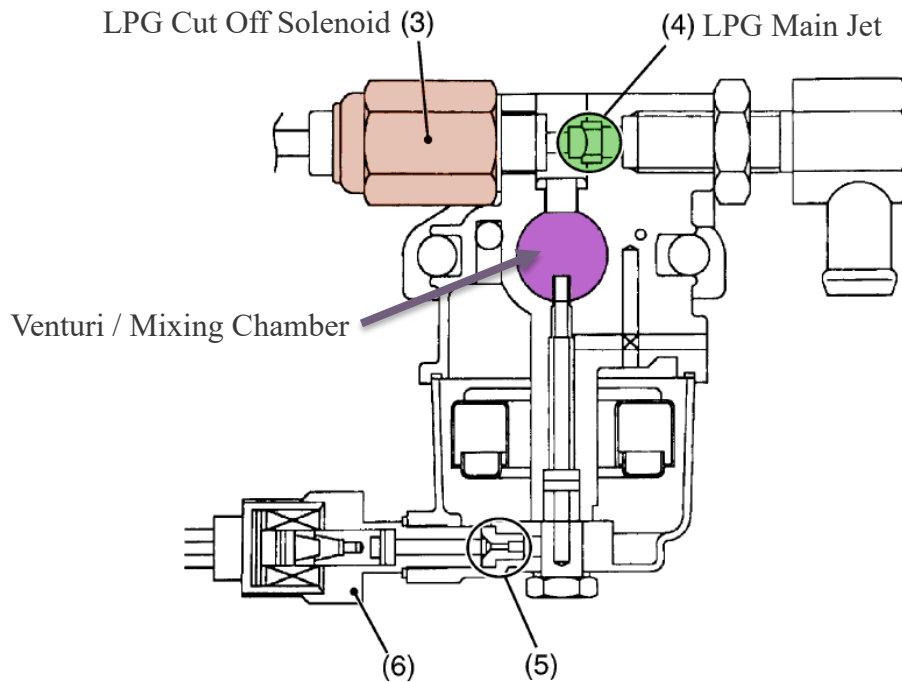


DF972
Gaseous Fuel
Supply
Mechanism



Id., 69 (coloring and annotations added).

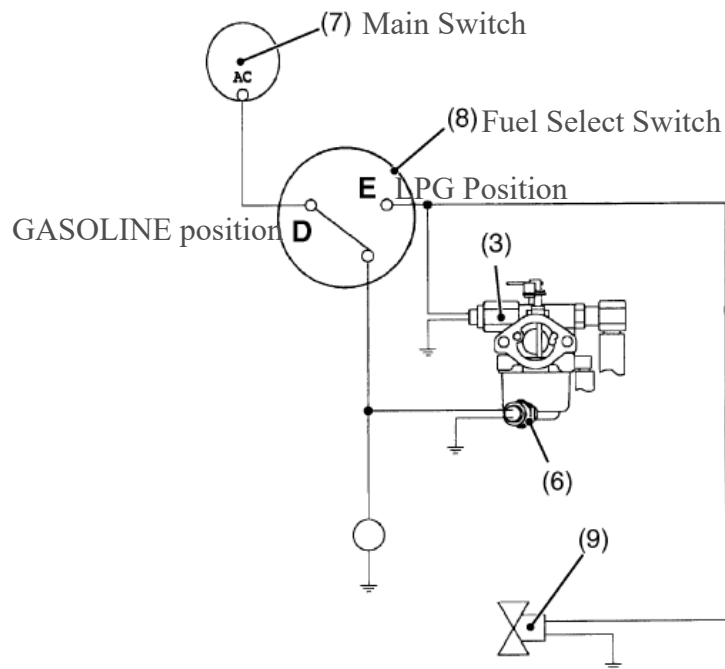
54. Downstream from the vaporizer, an LPG cut off solenoid (3) controls the flow of gaseous LPG to the venturi/mixing chamber.



Id., 68 (coloring and annotations added).

3. Switch for Controlling Liquid/Gaseous Fuel Operation

55. The user can operate a fuel select switch (8) to control whether the DF972 engine operates on liquid or gaseous fuel. The engine operates on gasoline fuel when a main switch is in an “ON” position and the fuel select switch (8) is in a “GASOLINE” position (D). When the fuel select switch (8) is turned to an “LPG” position (E), the gasoline fuel flow is shut and instead LPG fuel flows to the mixing chamber. *Id.* The positions D and E of the switch (8) are seen in the depiction below:



Id. (annotations added)

C. Kubota DF972-E2 Operator's Manual ("Operator's Manual")

56. Kubota also has an Operator's Manual (Ex. 1013) for the Kubota DF972,³ which teaches how to operate the DF972 engine. In particular, the

³ I note that the Workshop Manual of Exhibit 1012 is dated 2009, and the Operator's Manual of Exhibit 1013 is dated 2014. While I do not know if Kubota made any minor changes to the underlying DF972 engine between these years, it is clear that the two manuals cover the same DF972 engine/generator that is relevant to my opinions presented herein. For example, the figure in the Operator's Manual depicting the fuel system (Ex. 1013, 37) shows a near-identical fuel system as that shown in the Workshop Manual (Ex. 1012, 65). A POSA would thus view the

Operator's Manual specifically discloses that the user may switch between gasoline and LPG "while running the engine." Ex. 1013, 19 (bottom-most bullet item).

D. JPS61283734A ("Nakafushi")

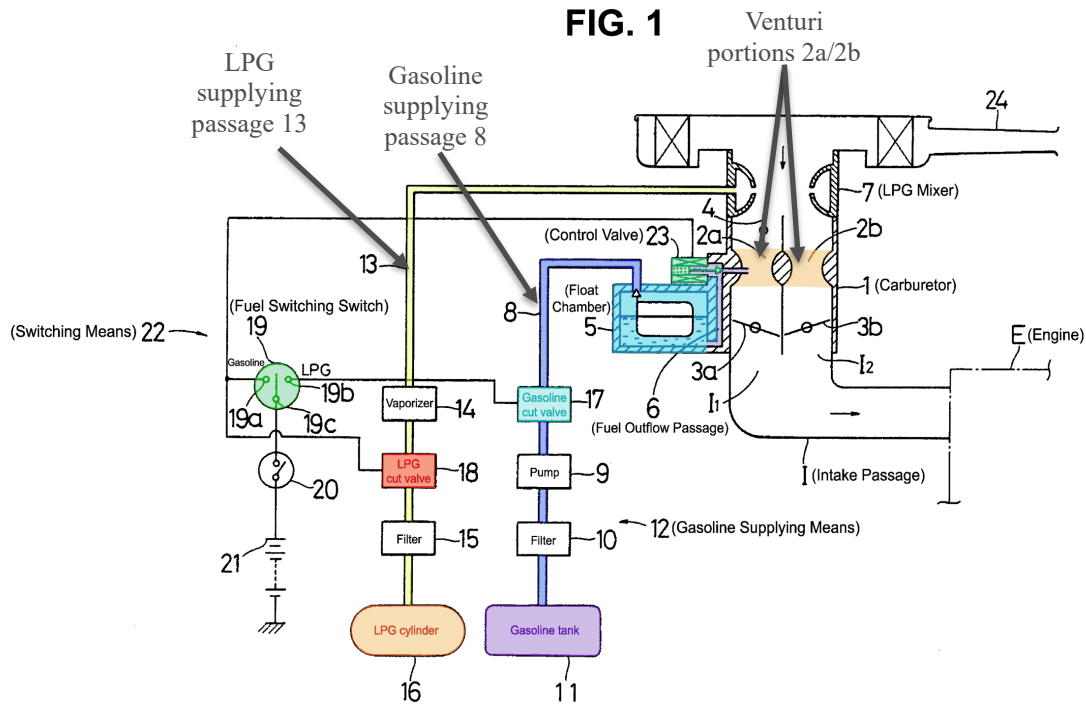
57. Nakafushi discloses an engine that can alternatively use gasoline or liquefied petroleum gas ("LPG")⁴ as fuel. Ex. 1005, ¶[0001]. Nakafushi identifies two problems to be solved by the invention. First, Nakafushi points out that when such an engine operating on gasoline is switched to LPG, a residual amount of gasoline remains in the float chamber (i.e., float bowl), and is sucked into the intake passage and mixed with the LPG, thus resulting in an over-rich air-to-fuel ratio. *Id.*, ¶[0004]. Second, because the residual gasoline is drained from the float chamber during this switching operation, when the engine is switched back to gasoline, gasoline delivery is delayed until the level of gasoline in the float chamber recovers. *Id.*, ¶[0004]. During this delay, the air-to-fuel ratio becomes over-lean. *Id.* Nakafushi solves these problems by including a control valve 23 ***downstream of the float chamber*** to prevent the float chamber from being emptied

disclosures of the Operator's Manual as applicable to the Workshop Manual as relevant to my opinions here, and vice-versa.

⁴ LPG is a general term for a group of hydrocarbon gases that are stored as liquids under pressure. LPG typically includes propane, butane, or a mix of both.

of gasoline when switching to LPG operation. *Id.*, ¶¶[0006]-[0008], Fig. 1. (emphasis added).

58. Specifically, as seen in annotated Figure 1 below, Nakafushi discloses a carburetor 1 with an intake passage I:



Id., ¶[0010], Fig. 1 (coloring and annotations added).

59. The intake passage I has a primary intake passage I₁ and a secondary intake passage I₂, with Venturi portions 2a and 2b, respectively. *Id.* Gasoline is stored in a gasoline tank 11 and pumped to a float chamber 5 through a gasoline supply passage 8. *Id.*, ¶[0012]. Gasoline cut valve 17 opens and closes the gasoline supply passage 8. *Id.*, ¶[0013]. Gasoline in the float chamber 5 is sucked into the Venturi portions 2a and 2b through a fuel outflow passage 6. *Id.*, ¶[0010]. Control

valve 23 opens and closes the fuel outflow passage 6, thus controlling gasoline flow downstream from the float chamber 5 to the intake I. *Id.*, ¶[0014].

60. Separately, LPG is stored in cylinder 16, and travels to an LPG mixer 7 in the intake I through LPG supply passage 13. *Id.*, ¶[0011]-[0012]. Similar to the gasoline supply passage 8, the LPG supply passage 13 has an LPG cut valve 18 to open and close the LPG supply passage 13. *Id.*, ¶[0013].

61. Nakafushi discloses a fuel switching switch 19 that controls which fuel, gasoline or LPG, is fed to the engine. *Id.*, ¶[0013]-[0014]. When switch 19 is set to the gasoline side contact 19a: (1) a cut signal is sent to the LPG cut valve 18 to block the LPG supply to the LPG mixer 7; (2) gasoline cut valve 17 opens to allow the flow of gasoline from the gasoline tank 11 to the float chamber; and (3) control valve 23 opens to allow gasoline to flow from the float chamber to the intake I. *Id.*

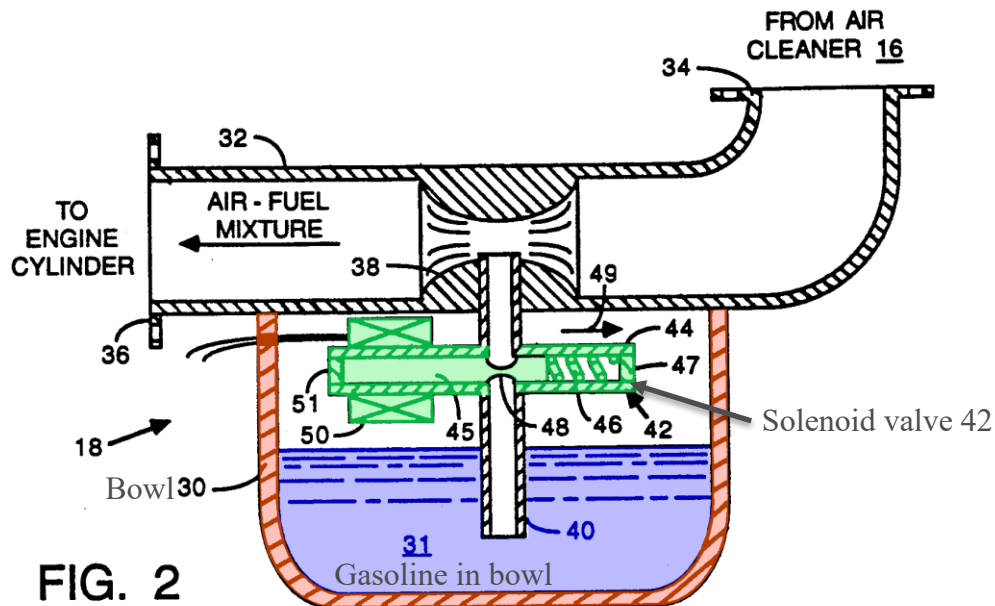
62. Conversely, when the switch 19 is set to the LPG side contact 19b: (1) a cut signal is sent to the gasoline cut valve 17 to block the flow of gasoline from tank 11 to the float chamber; (2) control valve 23 is closed, thereby blocking gasoline flow from the float chamber to the intake I; and (3) the LPG cut valve 18 is opened, allowing LPG to flow from the LPG cylinder 16 to the LPG mixer 7 in the intake I. *Id.*

63. Closing control valve 23, which is downstream of the float chamber,

prevents residual gasoline from flowing from the float chamber into the intake I when switching from gasoline to LPG operation. *Id.*, ¶[0014], Fig. 1. Conversely, because the gasoline is not drained from the float chamber when switched to LPG as the fuel source, that gasoline is more readily available to flow to the engine upon switching back to gasoline as the fuel source. *Id.*

E. U.S. Patent No. 5,301,644 (“Olmr”)

64. Olmr (Ex. 1007) is directed to a solenoid valve 42 within the float bowl 30 of the carburetor in an internal combustion engine. Ex. 1007, 1:33-48, 2:30-42, Fig. 2. The purpose of the solenoid valve 42 is to “provide a mechanism for cutting off the supply of fuel to an internal combustion engine when the engine is being stopped” (*id.*, 1:33-36), as seen in Olmr’s Figure 2 below:



Id., Fig. 2 (coloring and annotations added).

F. U.S. Patent Pub. No. 2011/0100335A1 (“Parlatore”)

65. Parlatore (Ex. 1010) is directed to a fuel delivery system that includes a propane tank, a first regulator coupled to the tank, and a second regulator connected to the first regulator, as depicted in Parlatore’s Figures 1 and 3:

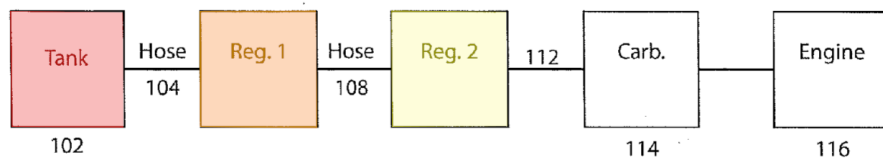


Fig. 1

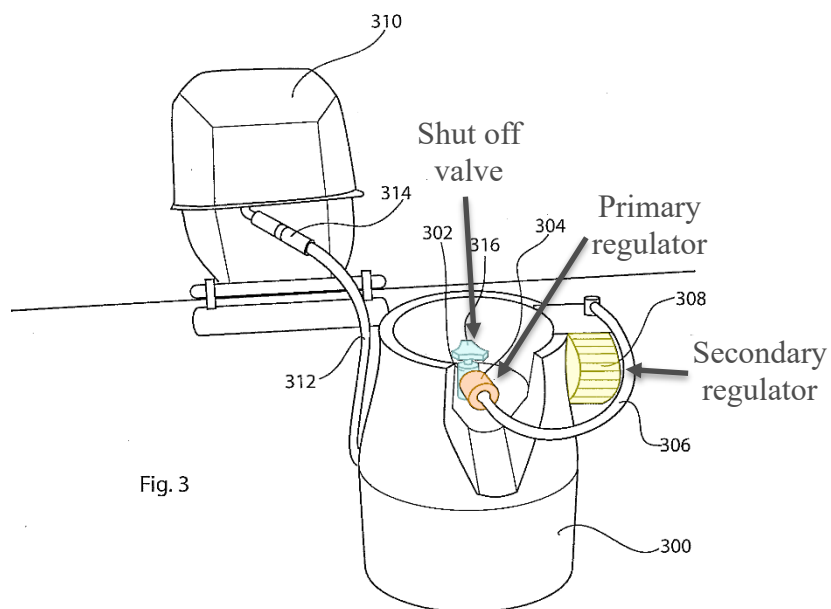


Fig. 3

Ex. 1010, ¶¶[0005]-[0006], Figs. 1, 3 (coloring and annotations added).

66. Parlatore thus discloses the use of primary and secondary pressure regulators, positioned at/near the LPG tank and remote from the engine/generator, to regulate propane delivery to an engine/generator.

G. U.S. Patent Pub. No. 2014/0239645 (“Jungmann”)

67. Jungmann (Ex. 1011) is directed to a generator that includes an internal combustion engine. Ex. 1011, Abstract. Specifically, Jungmann teaches a

generator including an enclosure, an internal combustion engine provided within the enclosure, an alternator provided within the enclosure and driven by the internal combustion engine, a fuel supply line for providing fuel to the internal combustion engine, a valve for selectively closing the fuel supply line, . . . [and] a controller configured to provide a signal to maintain the valve in an open position.

Id., ¶[0002].

68. This is shown in Figure 3:

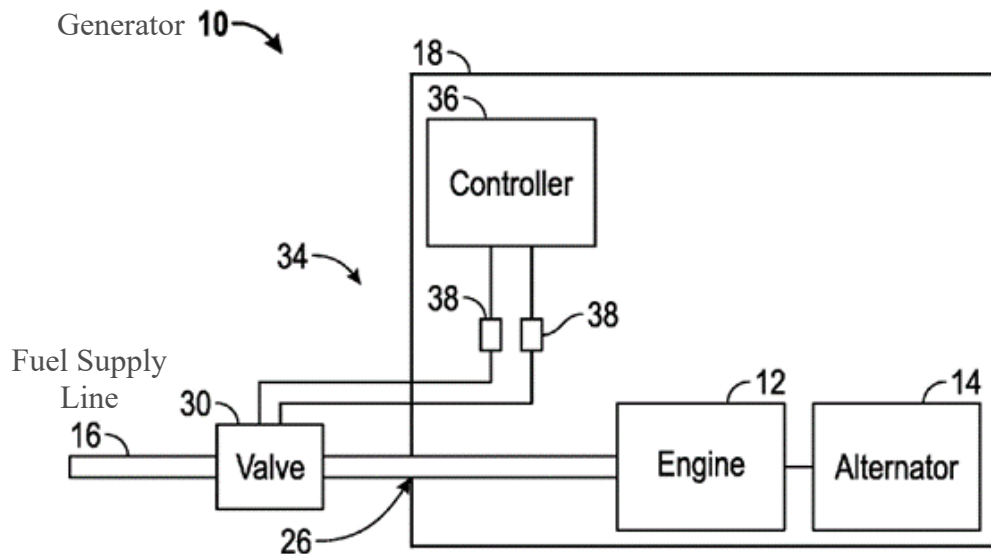
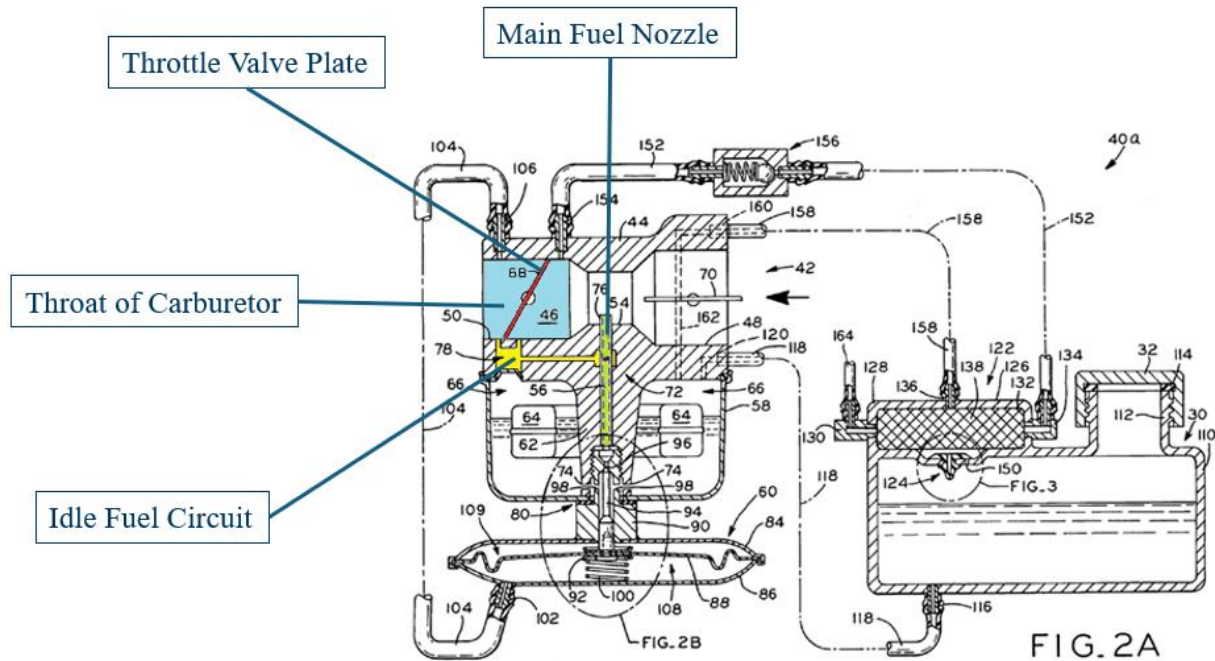


FIG. 3

Id., Fig. 3 (annotations added). Jungmann discloses the use of different fuels including gaseous fuels (propane, natural gas) and liquid fuels (gasoline, diesel). *Id.*, ¶[0015]. Jungmann thus discloses using an engine that uses liquid or gaseous fuels in a generator.

H. U.S. Patent No. 7,165,536 (“Kirk”)

69. Kirk (Ex. 1025) discloses an idle fuel circuit that provides a flow path to the throat downstream of the throttle to run the engine at idle. Ex. 1025, 6:36-46, Fig. 2A. Specifically, Kirk discloses an idle fuel circuit 78 that extends from the main fuel nozzle 76 and opens into the throat 46 of the carburetor 42. *Id.* The idle fuel circuit 78 provides a flow path to the throat downstream of the throttle (throttle valve plate 68) “to provide idling fuel to throat 46 of carburetor 42 when throttle valve plate 68 is in a closed position.” *Id.*, 6:42-46; Fig. 2A.



Id., Fig. 2A (annotated).

I. U.S. Patent No. 1,679,159 (“French”) and U.S. Patent No. 4,065,096 (“Frantz”)

French discloses the use of a rheostat in a timing circuit to control a solenoid valve (called an electromagnetically operated valve in French) in an internal combustion engine. Ex. 1026, 1:1-5, 1:27-68, 1:99-107, 2:48-60. Frantz discloses the use of a variable resistor (another name for a rheostat – as indicated by French (*see id.*, 1:108)) in a timing circuit to control a solenoid valve in a locomotive. Ex. 1027, 4:29-44; Ex. 1028 (indicates “rheostat” is also known as a “variable resistor”).

XII. THE CHALLENGED CLAIMS ARE UNPATENTABLE

70. In my opinion, the cited prior art references, alone or in combination, disclose the limitations of the Challenged Claims. Grounds 1-8 are directed to the apparatus collectively addressing Claims 1-19.

A. Ground 1: Claims 1-2, 4-6, and 9-10 are anticipated by Imamura or, alternatively, are obvious over Imamura

71. In my opinion, claims 1-2, 4-6, and 9-10 of the '120 Patent anticipated and/or obvious for at least the reasons described below.

1. Claim 1

a. Element [1.0]

72. Element [1.0] recites “a multi fuel engine.”

73. Imamura discloses a dual-fuel engine. Ex. 1024, ¶[0001]. Imamura states:

The present invention relates to a dual-fuel engine that selectively switches between supplying a gaseous fuel such as liquefied petroleum gas (LPG) and a liquid fuel such as gasoline, and more specifically to a fuel switching device for a dual-fuel engine that switches between supplying a gaseous fuel and a liquid fuel to the engine in accordance with switching commands.

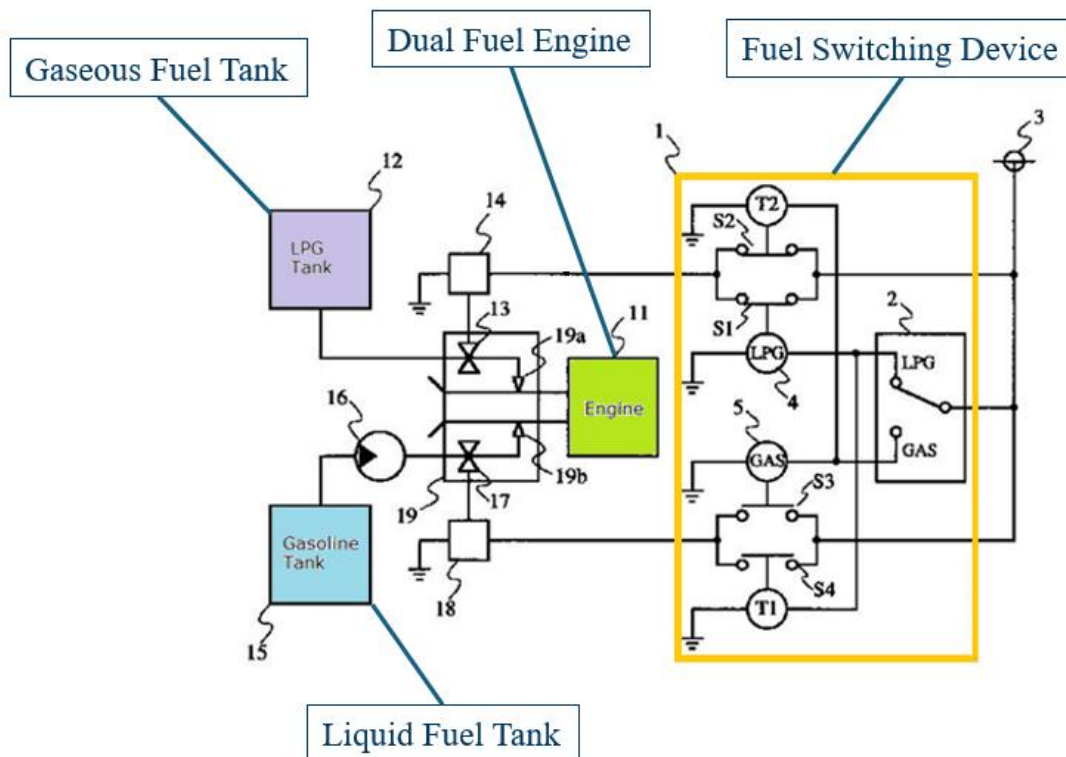
Id.

b. Element [1.1]

74. Element [1.1] recites “an engine operable on a liquid fuel and a gaseous fuel.”

75. Imamura discloses “a dual-fuel engine that selectively switches between supplying a gaseous fuel such as liquefied petroleum gas (LPG) and a liquid fuel such as gasoline, ...” Ex. 1024, ¶[0001].

76. Figure 1 shows the fuel tanks, engine, and switching circuitry:

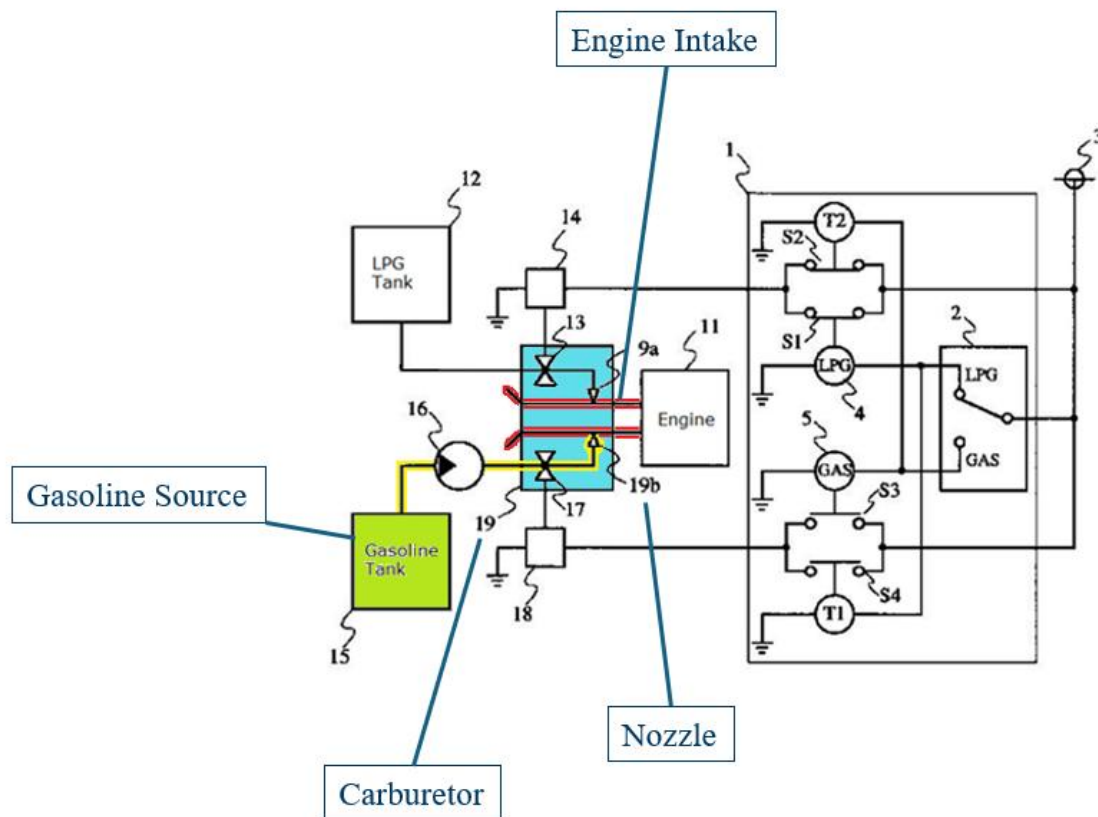


Id., Fig. 1 (annotated).

c. Element [1.2]

77. Element [1.2] recites “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.”

78. Imamura discloses a carburetor 19 attached to an intake of the engine 11. Ex. 1024, ¶[0017] (“The engine 11 is equipped with a carburetor 19.”), Fig. 1. The carburetor mixes the LPG and gasoline with air and connects the gasoline source (tank 15) to the intake through nozzle 19b. *Id.*, ¶¶[Constitution], [0017], Fig. 1.

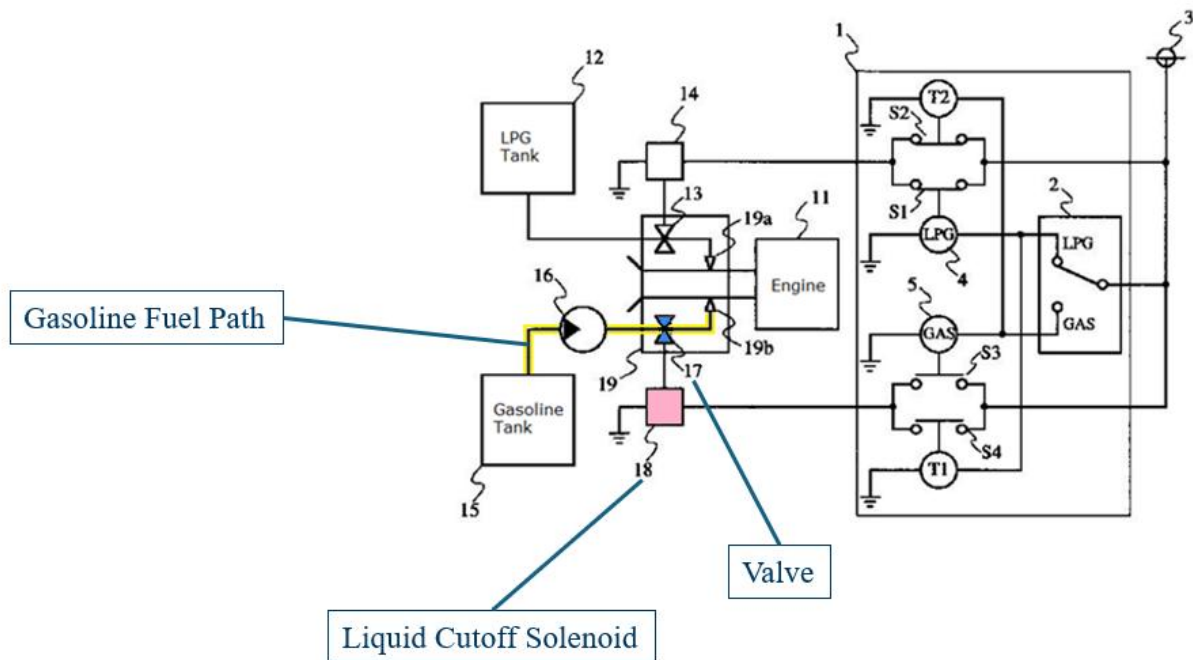


Id., Fig. 1 (annotated). The carburetor comprises a float bowl. *Id.*, ¶[0025] (“Also, a float chamber (not shown) is provided upstream of nozzle 19b inside the carburetor 19.”).

d. Element [1.3]

79. Element [1.3] recites “a liquid cutoff solenoid coupled to open and close a liquid fuel path to the engine.”

80. Imamura discloses a liquid cutoff solenoid (solenoid 18) that controls valve 17 to open and close the gasoline fuel path to the engine. Ex. 1024, ¶[0017], Fig. 1.



Id., Fig. 1 (annotated).

81. Imamura explains the operation of the solenoid 18 and valve 17 as follows:

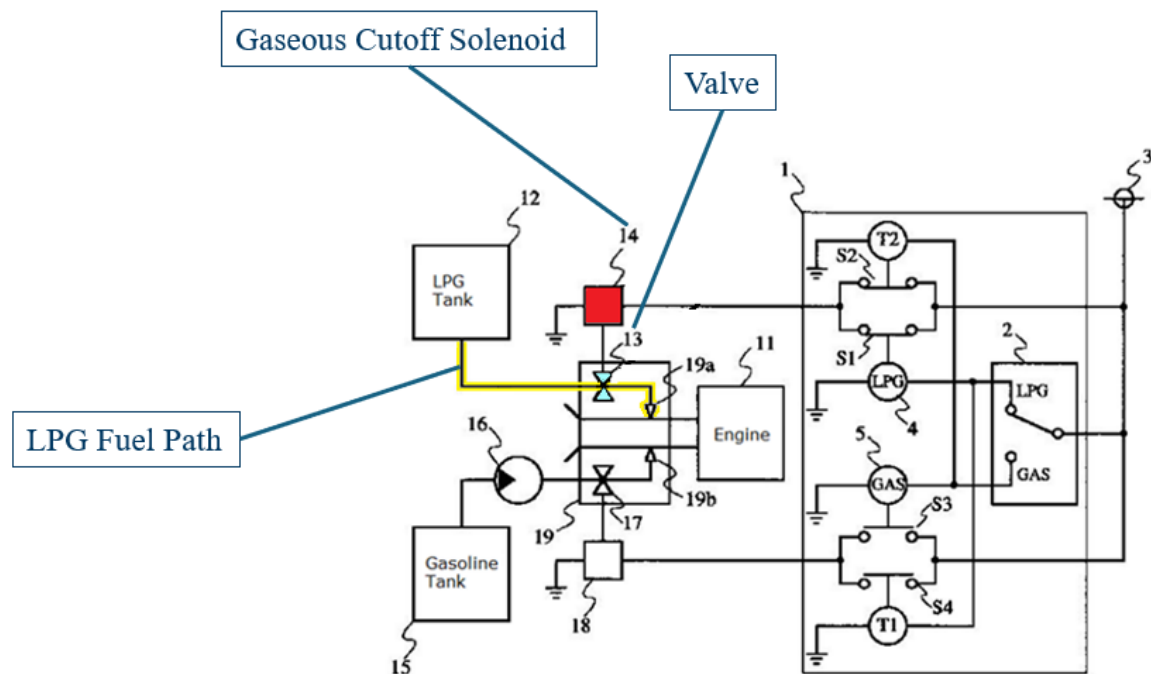
When either of opening/closing contacts S3 or S4 closes, drive current from the power supply 3 flows to solenoid 18, and opening/closing valve 17 opens to allow gasoline to flow into the carburetor 19. When both opening/closing contacts S3 and S4 are open, the drive current from the power supply 3 to solenoid 18 is cut off, the opening/closing valve 17 closes, and gasoline no longer flows into the carburetor 19.

Id., ¶[0020].

e. Element [1.4]

82. Element [1.4] recites “a gaseous cutoff solenoid coupled to open and close a gaseous fuel source to the engine.”

83. Imamura discloses a gaseous cutoff solenoid (solenoid 14) that controls valve 13 to open and close the LPG fuel source to the engine. Ex. 1024, ¶[0017], Fig. 1.



Id., Fig. 1 (annotated).

84. Imamura explains the operation of the solenoid 14 and valve 13 as follows:

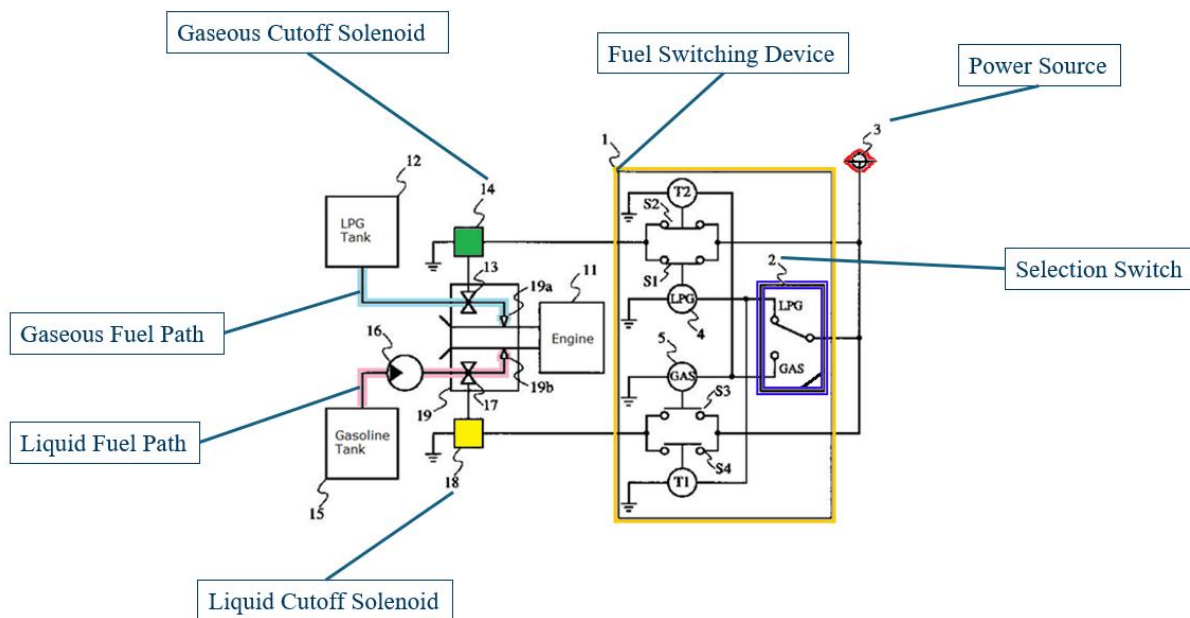
when either of the opening/closing contacts S1 or S2 closes, drive current from the power supply 3 flows to solenoid 14, opening/closing valve 13 opens, and LPG flows into carburetor 19. When both opening/closing contacts S1 and S2 are open, drive current from the power supply 3 to solenoid 14 is cut off, the opening/closing valve 13 closes, and LPG can no longer flow into the carburetor 19.

Id., ¶[0019].

f. Element [1.5]

85. Element [1.5] recites “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.”

86. Imamura discloses a fuel switching device 1 with a selection switch 2 coupling a power source 3 to the liquid cutoff solenoid (solenoid 18) and the gaseous cutoff solenoid (solenoid 14) to open and close the gasoline fuel path and the LPG fuel path. Ex. 1024, ¶¶[0017]-[0023], Fig. 1.



Id., Fig. 1 (annotated).

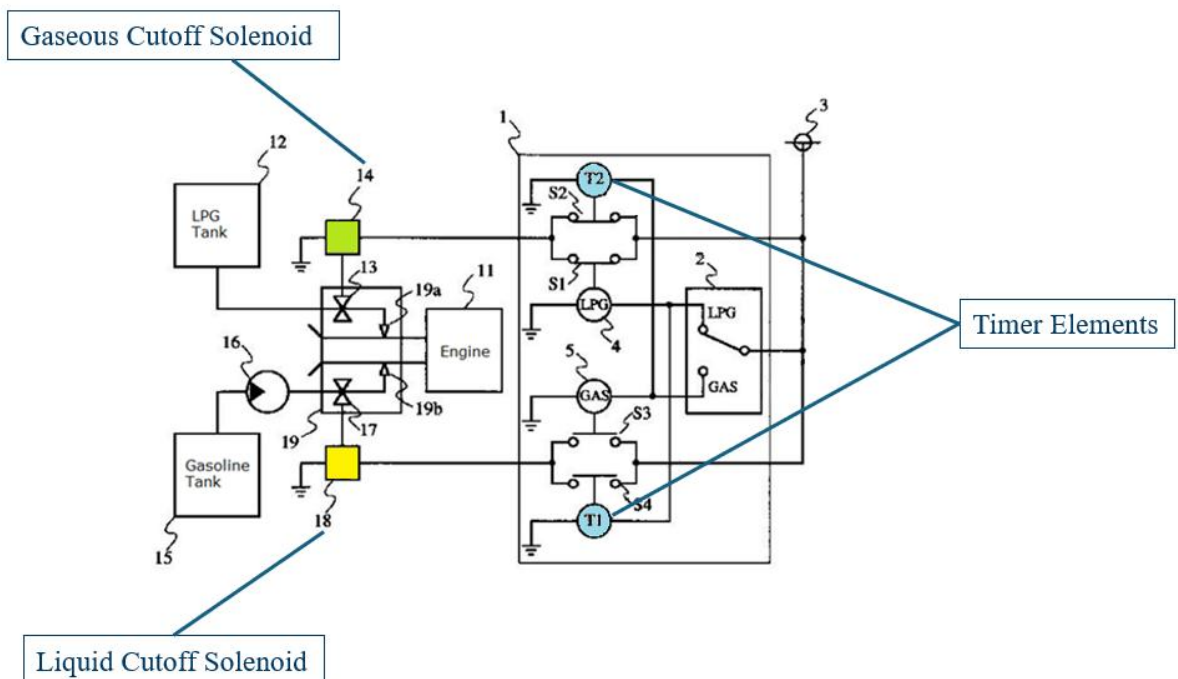
87. The opening and closing of the gasoline fuel path and the gaseous fuel path are explained above. See §§XII.A.1.d, XII.A.1.e; *see also* Ex. 1024, ¶¶[0018]-[0020].

g. Element [1.6]

88. Element [1.6] recites “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.”

89. Imamura discloses timing circuits (timer elements T1 and T2) to control the actuation time of the liquid cutoff solenoid (solenoid 18) and the gaseous cutoff solenoid (solenoid 14). Ex. 1024, ¶¶[0017]-[0023]; Fig. 1. Timer element T1 is electrically coupled to the liquid cutoff solenoid (solenoid 18) and timer element T2 is electrically coupled to the gaseous cutoff solenoid (solenoid 14). *Id.* The timer elements operate by delaying the closing of contacts S4 and S2.

Id.



Id., Fig. 1 (annotated).

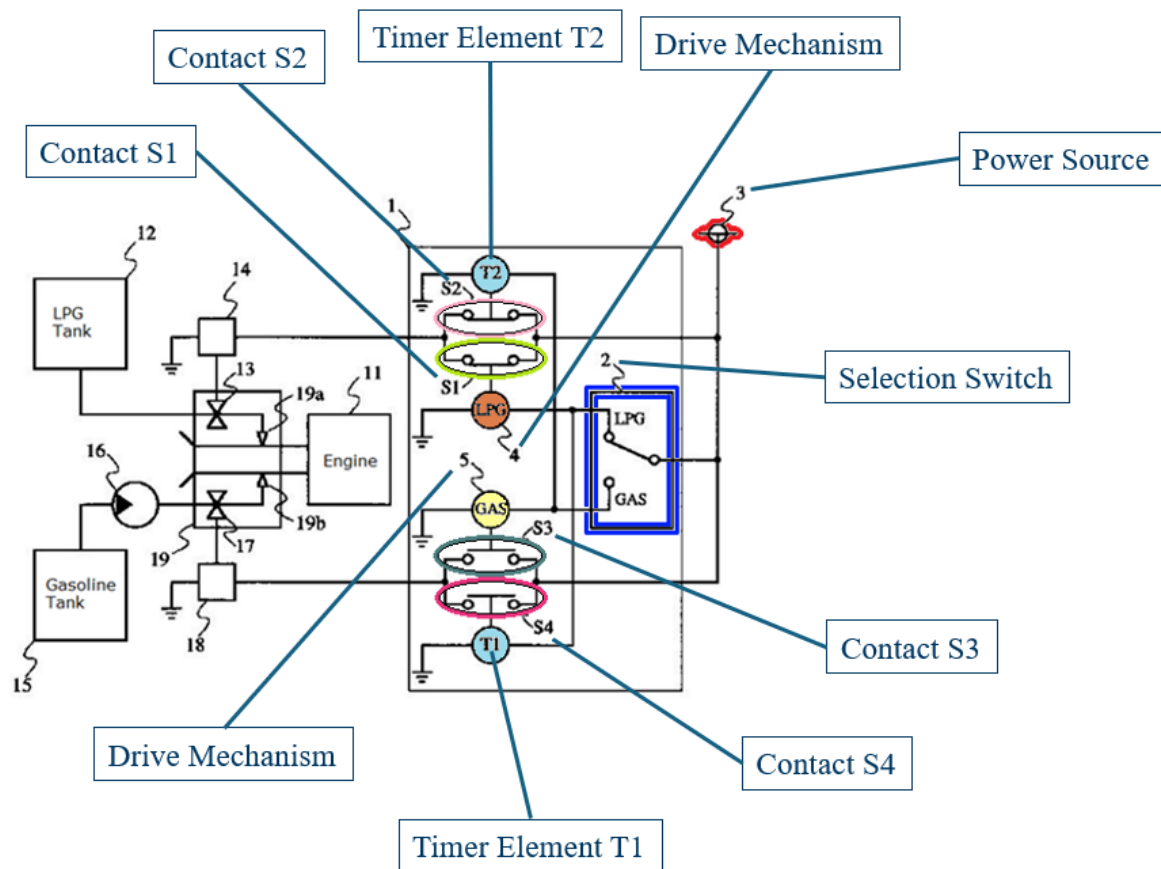
90. Imamura appears to have a mistake in ¶[0018], indicating that timer element T1 delays the opening of contact S2 and timer element T2 delays the opening of contact S4. Ex. 1024, ¶[0018]. Based on Figure 1 and other paragraphs of Imamura (e.g., paragraph [0021]), the reverse is true (T1 delays the opening of S4 and T2 delays the opening of S2). A POSA would recognize ¶[0018] contains typographical errors.

91. The opening and closing of valve 13 (for LPG) is dictated by contacts S1 and S2. *Id.*, ¶[0019], Fig. 1. When **either** contact S1 or S2 is closed, a drive current from the power source 3 flows to the solenoid 14, valve 13 is opened, and LPG flows into the carburetor 19. *Id.* When **both** contacts S1 and S2 are opened, the drive current from the power source 3 stops flowing to solenoid 14, valve 13 is closed, and LPG does not flow into the carburetor 19. *Id.*

92. Similarly, the opening and closing of valve 17 (for gasoline) is dictated by contacts S3 and S4. *Id.*, ¶[0020], Fig. 1. When **either** contact S3 or S4 is closed, a drive current from the power source 3 flows to the solenoid 18, valve 17 is opened, and gasoline flows into the carburetor 19. *Id.* When **both** contacts S3 and S4 are opened, the drive current from the power source 3 stops flowing to solenoid 18, valve 17 is closed, and gasoline does not flow into the carburetor 19. *Id.*

93. Contacts S1 and S3 are normally open contacts that are open when no current flows through drive mechanisms 4 and 5; contacts S2 and S4 are normally closed contacts that are closed when no current flows through timer elements T1 and T2. *Id.*, ¶[0021].

94. When switch 2 is switched to the LPG side, current flows through drive mechanism 4, causing S1 to close, which causes valve 13 to open, and LPG flows into the carburetor 19. *Id.*, ¶¶[0019], [0022], Fig. 1. Current also flows through timer element T1, which causes S4 to open after delay time t1 has elapsed. *Id.*, ¶[0022]. Switching switch 2 to the LPG side also causes current to stop flowing through drive mechanism 5, causing S3 to open. *Id.* Therefore, both S3 and S4 are open after delay time t1, causing valve 17 (for gasoline) to close, stopping the flow of gasoline to the engine. *Id.*, ¶¶[0020], [0022].



Id., Fig. 1 (annotated).

95. Conversely, when switch 2 is switched to the gasoline side, current flows through drive mechanism 5, causing S3 to close, which causes valve 17 to open, and gasoline flows into the carburetor 19. *Id.*, ¶¶[0020], [0023], Fig. 1. Current also flows through timer element T2, which causes S2 to open after delay time t_2 has elapsed. *Id.*, ¶[0023]. In the meantime, current stops flowing through drive mechanism 4, causing S1 to open. *Id.* Therefore, both S1 and S2 are open after delay time t_2 , causing valve 13 (for LPG) to close, stopping the flow of LPG to the engine. *Id.*, ¶¶[0019], [0023].

2. Claim 2

96. Claim 2 depends from Claim 1, and further requires “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.”

97. Imamura discloses that the timing circuits (timer elements T1 and T2) comprise delay circuits configured to institute a predefined delay before actuating the liquid cutoff solenoid (solenoid 18) and the gaseous fuel cutoff solenoid (solenoid 14). Ex. 1024, ¶¶[0017]-[0024], Fig 1, Fig 2. In particular, Imamura discloses timer element T1 has a delay time t1 and timer element T2 has a delay time t2. *Id.* When switch 2 is switched to the LPG side, timer element T1 causes a delay time t1 before actuating the gasoline solenoid 18. *Id.* When the switch 2 is switched to the gasoline side, timer element T2 causes a delay time t2 before actuating the LPG solenoid 14. *Id.*

3. Claim 4

98. Claim 4 depends from Claim 1, and further requires “wherein the one or more timing circuits provide a user adjustable preset delay before actuating the liquid cutoff solenoid and the gaseous cutoff solenoid.”

99. Imamura discloses the timing circuits provide a user adjustable preset delay before actuating the liquid cutoff solenoid (delay times t_1) and the gaseous cutoff solenoid (delay time t_2) by explaining:

if the delay times t_1 and t_2 are set too long, the time during which two types of fuel are supplied from the carburetor 19 to the engine 11 will become long, which will cause the engine 11 to malfunction. For this reason, the delay times t_1 and t_2 should be set as short as possible within a range that satisfies the above-mentioned conditions.

Ex. 1024, ¶[0026]. Because Imamura states the delay times “should be set as short as possible,” a POSA would understand that to mean the delay times are user adjustable in that a user can present the delay times of t_1 and t_2 and make adjustments, as needed, based on the specifications of the engine and after trial and error.

4. Claim 5

100. Claim 5 depends from Claim 1, and further requires “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.”

101. Imamura discloses that during the delay times t_1 and t_2 , both the LPG valve 14 and the gasoline valve 17 are open. Ex. 1024, ¶[0026]. Imamura cautions

that if the delay times t_1 and t_2 are too long, the time during which both types of fuel are supplied to the engine will be too long and will cause the engine to malfunction. *Id.* Imamura therefore teaches that “delay times t_1 and t_2 should be set to be as short as possible....” *Id.*

102. Paragraph [0026] states:

during delay times t_1 and t_2 , both opening/closing valves 13 and 17 are open, and if delay times t_1 and t_2 are set too long, the time during which two types of fuel are supplied from the carburetor 19 to the engine 11 becomes longer, which may cause the engine 11 to malfunction. Therefore, delay times t_1 and t_2 should be set to be as short as possible within the range that satisfies the conditions set forth above.

Id., ¶[0026].

103. Therefore, a POSA would understand the delay times should be set to provide simultaneous delivery of fuels for any fraction of a second or for up to several sections. Alternatively, this would have been obvious.

104. The purpose of providing a slight overlap in fuels is to ensure enough fuel during the switchover to keep the engine running. If there is a gap when no fuel is provided to the engine, the engine will stall. Providing a slight overlap of fuels ensures a continuous supply of fuel to the engine, to prevent the engine from stalling. On the other hand, providing an overlap of fuels to the engine for too long

will cause an incorrect air-fuel ratio in the engine and will be harmful to the components of the engine, as Imamura discloses. Ex. 1024, ¶[0026]. Providing an over-rich fuel supply can also cause the engine to stall, causes excess pollution, can cause the engine to run too hot and decreases the fuel efficiency of the engine. Therefore, a POSA would understand the fuel overlap should be as short as possible, including as short as a few seconds or a fraction of a second. The specific duration of overlap would depend on the size of the carburetor and float bowl, and the flow rate of gasoline in the fuel line. A POSA would have no difficulty determining the appropriate timing for a particular engine.

105. Alternatively, this would have been obvious to a POSA because these were basic principles of engine operation at the time of the invention. A POSA would have had a reasonable expectation of success in implementing this timing because timing the opening and closing of valves down to the second (or down to fractions of a second) could be achieved at the time of the invention with off-the-shelf components for analog circuits or microprocessors for digital circuits.

5. Claim 6

106. Claim 6 depends from Claim 1, and further requires “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.”

107. Imamura discloses an embodiment to prevent simultaneous gasoline and LPG fuel flow and allow switching between fuel sources on-the-fly during engine operation. Ex. 1024, ¶¶[0027]-[0028]. In this configuration, when the switch 2 is switched to LPG, “*gasoline is continuously supplied to the carburetor 19* during the period from when opening/closing valve 13 is opened *until LPG reaches nozzle 19a*, and the engine 11 does not stall due to an interruption of fuel supplied to the engine 11 during this time.” *Id.*, ¶[0027] (emphasis added). On the other hand, when the switch 2 is switched to gasoline, “*LPG is continuously supplied to the carburetor 19* during the time from when the opening/closing valve 17 is opened *until gasoline reaches nozzle 19b*, and the engine 11 does not stall due to the interruption of fuel supplied to the engine 11 during this time.” *Id.* ¶[0028] (emphasis added).

108. Therefore, Imamura discloses timing the valves to stop the flow of gasoline once LPG reaches the carburetor and vice versa.

6. Claim 9

109. Claim 9 depends from Claim 1, and further requires “wherein the engine is a dual fuel engine that operates on gasoline from the liquid fuel source and LPG from the gaseous fuel source.”

110. Imamura discloses that the dual-fuel engine operates on gasoline and LPG. Ex. 1024, ¶[0001], Fig. 1 (“The present invention relates to a dual-fuel engine that selectively switches between supplying a gaseous fuel such as liquefied petroleum gas (LPG) and a liquid fuel such as gasoline, ...”).

7. Claim 10

111. Claim 10 depends from Claim 1, and further requires “wherein the carburetor connects the gaseous fuel source to the intake.”

112. Imamura discloses that the carburetor 19 connects the LPG fuel source (tank 12) to the intake. Ex. 1024, Fig. 1. The carburetor connects the LPG fuel source to the intake through nozzle 19a. *Id.*, ¶[0024], Fig. 1.

B. Ground 2: Claim 3 is obvious over Imamura in view of French and/or Frantz

113. Claim 3 of the '120 Patent is obvious for at least the reasons described below.

1. Claim 3

114. Claim 3 depends from Claim 1, and further requires “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.”

115. It would have been obvious to us one or more rheostats in Imamura’s timing circuits T1 and T2. A POSA would have been motivated to use rheostats

because they were simple to implement and were commonly used in timing circuits at the time of the invention. A POSA would have had a reasonable expectation of success because rheostats were commonly used in circuits, like the circuits disclosed in Imamura, at the time of the invention. The use of a rheostat in a timing circuit is regularly taught in undergraduate engineering courses.

116. Frantz is directed to a solenoid-actuated valve connected to and controlled by a solid state control circuit that regulates the timing and duration of actuation. Ex. 1027, Abstract. Frantz discloses a “solenoid [...] connected in series in a solid state control circuit under adjustable timing control.” *Id.*, 1:44-46. Frantz further discloses that the control circuit includes a “variable resistor 46” and that the time delay is “predetermined by the setting of the variable resistor.” *Id.*, 5:3-4. A POSA would understand “variable resistor” to be equivalent in function to a rheostat. *See* Ex. 1028, 3 (definition of rheostat: “A resistor constructed so that its resistance value may be changed without interrupting the circuit to which it is connected. ***Also known as variable resistor.***”) (emphasis added). Thus Frantz is one example of a rheostat used to control the timing of a solenoid valve.

117. French is directed to a “circuit control mechanism for electrical systems for internal combustion engines, such as electrically controlled fuel injection systems or ignition systems for such engines.” Ex. 1026, 1:1-5. Further, French discloses an invention whose aim is to “provide a timer [...] by providing a

variable resistance and engine controlled or engine-operated means for varying this resistance to control the operation of a fuel-metering device of a fuel injection or supply system.” *Id.*, 1:19-25. French discloses:

The timer or circuit control mechanism is a variable resistance or *rheostat* associated with the control circuit of the system in which the resistance is periodically varied by engine-controlled means to cause the operation of the fuel-metering device or the ignition device during the desired or predetermined cyclic period and thus control the operation of said device.

Id., 1:99-107 (emphasis added).

118. French’s fuel injection system is “instanced here as a control valve” and French further discloses that the “electromagnetic valve may be of any suitable construction and as instanced here controls the passage of fuel.” *Id.*, 1:61-63. A POSA would understand that the electromagnetic value thus disclosed would be a solenoid valve.

119. Thus, the use of rheostats to control timing circuits was well-known at the time of the ’120 patent and it would have been obvious to a POSA to use a rheostat to control the timing in the timing circuits disclosed in Imamura.

C. Ground 3: Claims 7-8 are obvious over Imamura in view of Olmr

120. Claims 7-8 of the ’120 Patent are obvious for at least the reasons described below.

1. Claim 7

121. Claim 7 depends from Claim 1, and further requires “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.”

122. Imamura discloses a liquid cutoff solenoid (solenoid 18) positioned on a liquid fuel line coupling the liquid fuel source (gasoline tank 15) to the carburetor to open and close the liquid fuel source to the engine. Ex. 1024, ¶[0017], Fig. 1. Therefore, Imamura’s solenoid 18 is a second liquid cutoff solenoid for purposes of Claim 7. *Id.*

123. It would have been obvious to a POSA to also include a first liquid cutoff solenoid in Imamura’s engine coupled to the carburetor to control flow of gasoline within the carburetor.

124. Olmr discloses a gasoline engine having a first liquid cutoff solenoid (solenoid valve 42) coupled to a carburetor 18 in a bowl 30. Ex. 1007, 2:30-42, Fig. 2. The solenoid valve 42 controls the flow of gasoline within the carburetor 18 by preventing the flow of gasoline from the bowl 30 to the engine when the operator closes the kill switch. *Id.*, 4:11-27.

125. In particular, Olmr explains:

With additional reference to FIG. 2, the carburetor 18 has a bowl 30 into which gasoline 31 flows from a hose 26 connected to the fuel tank 20. Across the upper end of the bowl 30 is a tube 32 having an inlet 34 attached to the air cleaner 16 and outlet 36 coupled to the engine cylinder. The carburetor tube 32 includes a conventional venturi 38 in which the inner diameter of the tube 32 is reduced significantly. A gasoline feed tube 40 has a *solenoid valve 42* located above the level of the gasoline 31 in the bowl 30 and so that fuel residue will not build up on the valve.

The *solenoid valve 42* includes a cross tube 44 in which a spool valve plunger 45 is located. The spool valve plunger 45 is fabricated from a cylindrical rod of ferromagnetic material and has a smaller diameter portion 48. A compression spring 46 at one end 47 of the cross tube 44 biases the spool valve plunger 45 into a position at which the smaller diameter portion 48 is aligned with the gas feed tube 40, when the *solenoid valve 42* is deenergized. Because portion 48 is smaller in diameter than the internal diameter of the cross tube 44, a passage exists at the intersection of tubes 40 and 44 enabling gasoline within the bowl 30 to be drawn upward through the gas feed tube 40 and into the venturi 38 due to the Bernoulli effect.

Ex. 1007, 2:30–56.

When it is desired to shut off the engine 10, the operator closes a kill switch 82. Switch 82 is a double-pole, single-throw type having a first set of contacts 84 which connect the ignition circuit output to ground as is conventionally done to stop small gasoline engines. A second set of contacts 86 of the kill switch 82 connect the electromagnet coil 50 of the solenoid valve 42 across the storage capacitor 78. This action causes current to flow from the storage capacitor 78 through the coil 50 producing a magnetic field which pushes the spool valve plunger 45 against spring 46 a sufficient distance so that the spool valve plunger blocks gas from flowing through the feed tube 40 in the venturi 38. This action either cuts off the flow of gas to the venturi or significantly leans the air-fuel mixture. For example, an air-fuel mixture of 150 to 1 or greater is sufficient to prevent backfiring while the engine is stopping.

Id., 4:11–27.

126. Olmr's Figure 2, shown below, illustrates the gasoline cutoff solenoid, highlighted in green:

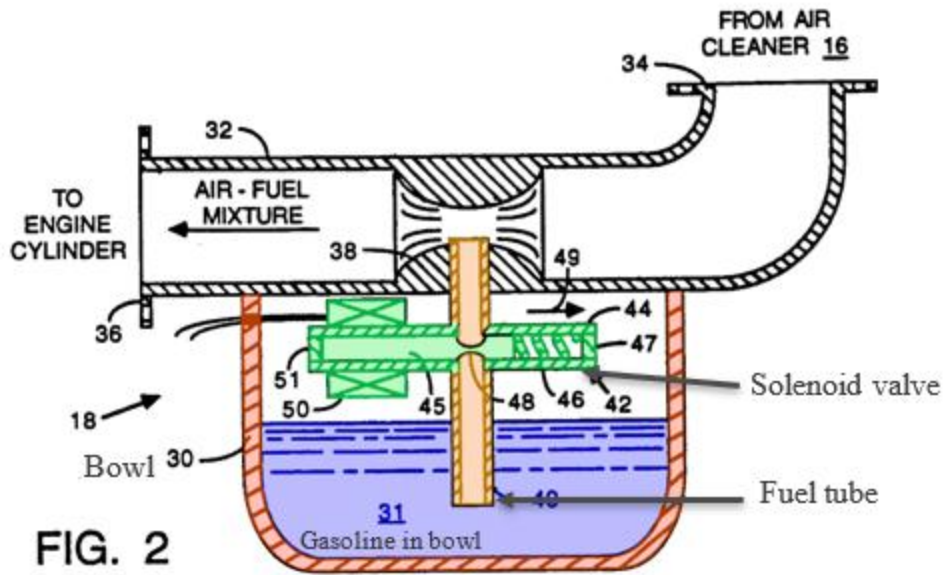


Fig. 2 (annotated).

127. As shown above, Olmr’s solenoid valve 42 would be a first liquid cutoff solenoid with the elements of Claim 7 when included in Imamura’s float bowl.

a. Motivation/Expectation of Success

128. A POSA would have been motivated to include the solenoid valve 42 of Olmr in the float bowl of Imamura for the same reasons explained in Olmr: to prevent gasoline in the float bowl from entering the engine while the engine is being stopped, which can cause backfires and damage to the muffler. *Id.*, 1:18-48. Indeed, Imamura recognized that liquid fuel in the float chamber “is sucked out by negative pressure” in the engine, downstream of the liquid fuel valve 17. Ex. 1024,

¶[0005]. Not only can this cause backfires and damage to components of the engine, burning gasoline when it is not needed causes excess pollution.

129. A POSA would have had a reasonable expectation of success in incorporating the solenoid valve 42 of Olmr into the float bowl of Imamura because it would have merely involved incorporating another solenoid valve in the system, which is a basic engineering concept and had already been done by Olmr, as well as others (such as the DF972 engine discussed in the Workshop Manual and Nakafushi).

2. Claim 8

130. Claim 8 depends from Claim 7 and further requires “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.”

131. Imamura discloses timing circuits electrically coupled to the second liquid cutoff solenoid (Imamura’s solenoid 18) and the gaseous cutoff solenoid (Imamura’s solenoid 14). *Supra* §XII.A.1.g. It would have been obvious to include Olmr’s solenoid valve 42 in Imamura’s float bowl to serve as the first liquid solenoid. *Supra* §XII.C.1. It would have been obvious to electrically couple a timing circuit to Olmr’s solenoid valve 42 when incorporated into Imamura’s float

bowl, similar to the timing circuits T1 and T2 coupled to Imamura's solenoids 18 and 14.

a. Motivation/Expectation of Success

132. A POSA would have been motivated to couple a timing circuit to a solenoid valve in Imamura's float bowl to achieve the same objects of Imamura's invention, i.e., to provide a continuous supply or slight overlap in fuel when changing operation from gasoline to LPG and vice versa. For example, it would not make sense to delay the closing of gasoline valve 17 and not a solenoid valve downstream in the float bowl because the closed solenoid valve in the float bowl would prevent the gasoline from reaching the engine during the delay time.

133. A POSA would have had a reasonable expectation of success because using a timing circuit to control a solenoid valve in the float bowl would be no different than Imamura's disclosure of using the timing circuit T1 to control solenoid 18.

D. Ground 4: Claim 11 is obvious over Imamura in view of Jungmann and Parlatore

134. Claim 11 of the '120 Patent is obvious for at least the reasons described below.

1. Claim 11

a. Element [11.1]

135. Claim 1 depends from Claim 1 and recites additional elements.

Element [11.1] recites “an alternator driven by the engine to form a generator.”

136. Imamura discloses a dual fuel engine. Ex. 1024, ¶[0001].

137. Jungmann discloses an alternator driven by an internal combustion engine to form a generator:

One embodiment of the invention relates to a generator including an enclosure, an internal combustion engine provided within the enclosure, *an alternator provided within the enclosure and driven by the internal combustion engine*, [and] a fuel supply line for providing fuel to the internal combustion engine....

Ex. 1011, ¶[0002] (emphasis added).

138. Indeed, alternators are common components in generators. *See* Ex. 1019, 5 (“**alternator** A relatively small electrical generator, usually driven by an internal-combustion engine to operate its ignition and charge the battery”).

139. A POSA would have found it obvious to combine the alternator from Jungmann with the dual-fuel engine in Imamura to create a generator.

i. Motivation/Expectation of Success

140. A POSA would have been motivated to use Imamura’s engine in a generator to provide the user with the option of alternatively using gasoline or LPG

to generate electricity. *Id.* Jungmann discloses the use of various types of fuels for an engine used in a generator, including propane (LPG) and gasoline. Ex. 1011, ¶[0015]. Jungmann thus demonstrates that using such engines in a generator was well-known. *See* Ex. 1017.

141. Multi-fuel engines such as Imamura's were recognized as especially useful for generators because, for example, in certain power outages (such as major storms), the user may not have access to gasoline if the gasoline stations are out of service. Alternatively, the user may not have LPG on hand, but may have gasoline on hand for other uses, making it a readily available fuel source. Enabling the option of using gasoline or LPG makes the generator more versatile. Purposing Imamura's engine for use in/as a generator would have involved nothing more than a simple substitution, whereby Imamura's engine is used in place of Jungmann's engine.

142. A POSA would have reasonably expected success in using Imamura's multi-fuel engine in a generator given that this implementation was already demonstrated by Jungmann. Moreover, Imamura's engine could be used in a generator simply by adding an alternator to the engine, as was already common and well known by that time (for example, alternators were (and still are) commonly combined with car engines to generate electricity, and generators driven by multi-fuel engines were already commonly available).

143. To the extent Imamura does not disclose this element, a POSA would have found it obvious to use Imamura's engine in a generator. Alternators were common components in generators to convert the mechanical energy from the engine into electrical energy for output.

b. Element [11.2]

144. Element [11.2] recites "a fuel regulator system located off-board the generator." According to the '120 Patent, the "fuel regulator system":

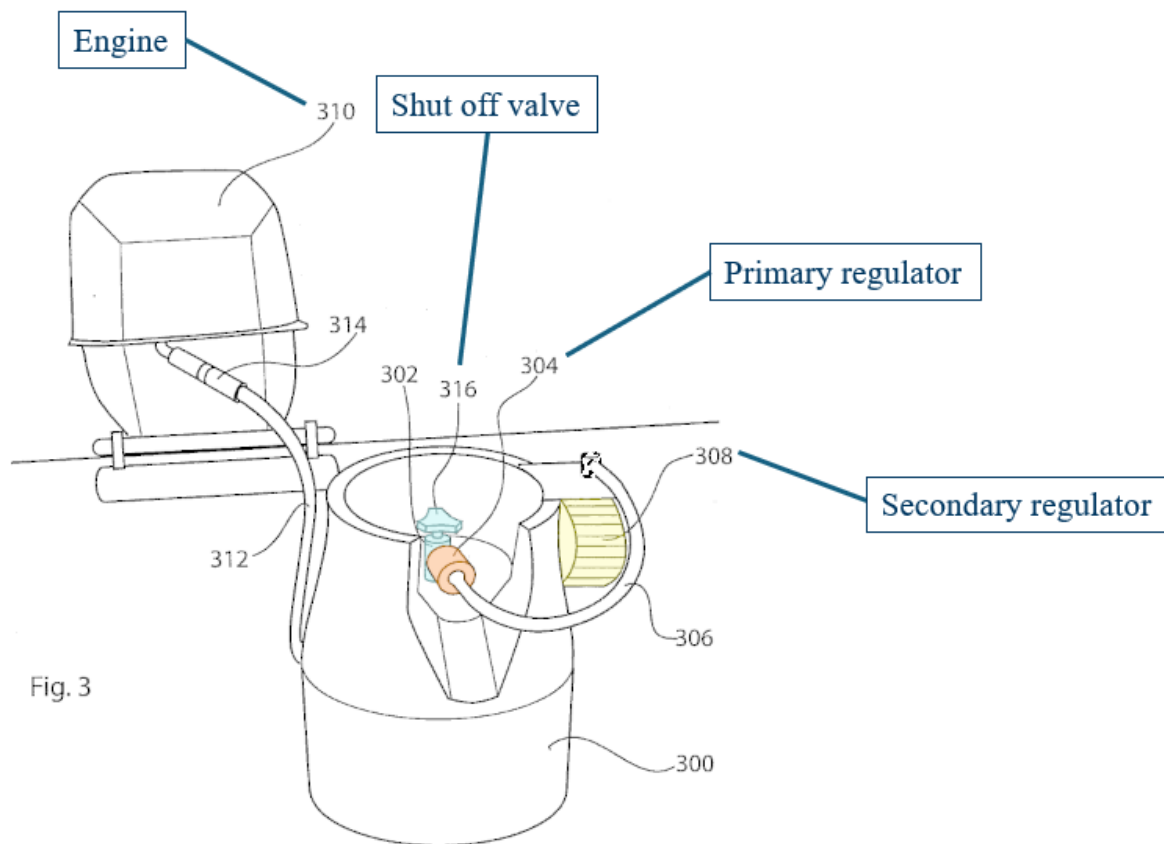
includes one or more pressure regulators that reduce and control the pressure of the fuel from pressurized fuel container 50 and delivers fuel at a desired pressure for operation of the engine.

Ex. 1001, 3:66-4:3.

145. Jungmann discloses a fuel regulator system, comprising pressure regulator 28. Ex. 1011, ¶[0017]. A POSA would have understood Jungmann's pressure regulator 28 to constitute the claimed "fuel regulator system" because it reduces pressure and controls the fuel flow from the pressurized fuel container, delivering it to the engine at the pressure desired for operation. *Id.*

146. A POSA would have found it obvious to use an off-board fuel regulator system for a generator (like Jungmann) with Imamura's engine, as explained below.

147. Parlatore discloses a fuel regulator system located off-board a generator. Specifically, Parlature's fuel-regulator system comprises primary and secondary pressure regulators 304 and 308 positioned adjacent to the LPG tank, located "off-board" the engine. Ex. 1010, ¶¶[0020]-[0022], Fig. 3.



Id., Fig. 3 (annotated).

i. Motivation/Expectation of Success

148. A POSA would have been aware of various benefits to using an off-board fuel regulator system. In general, using an off-board fuel regulator system

would allow the generator/engine itself to remain lighter, more compact, and easier to transport, while still safely handling high-pressure fuel sources like LPG remote from the engine.

149. Specifically, keeping the regulator system off-board reduces the weight and bulk of the generator. Since portability is a key feature for many generators, minimizing onboard components is an obvious design goal.

150. An off-board fuel regulator system also makes the overall generator system more flexible. An off-board regulator system can be matched to different fuel tanks and pressure ratings. This allows a single generator model to work with multiple tank sizes and types without redesigning the generator itself.

151. An off-board fuel regulator system also improves safety. Placing pressure regulators as close as possible to the high-pressure source (i.e., the tank) reduces the risk of hose rupture or leaks at high pressure and the danger associated with any such leaks or ruptures. An off-board regulator system achieves this, making the overall design safer.

152. Another key benefit is ease of transport and storage. A detachable fuel regulator system can be stored safely away from the generator or swapped out easily. This modular approach means users can keep multiple tanks and simply rotate as needed, rather than needing to re-fill an onboard tank

153. In addition, connecting a separate gaseous fuel source (e.g. a propane tank) to a dual-fuel generator using a hose offers additional flexibility and convenience, including that an off-board propane tank can be larger compared to an onboard tank if desired, providing larger fuel capacity.

154. Another benefit is that a remote, detachable propane tank can be stored safely away from the generator and swapped out easily. This modular approach means users can keep multiple tanks and simply rotate as needed, rather than needing to re-fill an onboard tank that is more likely to be connected or strapped onto the generator/end-use device.

155. It would have been obvious to a POSA to use the fuel regulator system disclosed in Parlatore because Parlatore discloses the use a fuel regulator system with “any desired form of engine.” Ex. 1010, ¶[0025]. Use with generators is also explicitly stated. *Id.*, ¶[0019].

156. Parlatore shows that a POSA would have had a reasonable expectation of success using an off-board fuel regulator system. Ex. 1010, ¶¶[0019]-[0022], Fig. 3.

c. Element [11.3]

157. Element [11.3] recites “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.”

158. Parlatore discloses a primary regulator 304 coupled to service valve 316 of the pressurized propane tank 300, explaining:

In still further exemplary embodiments, and referring to FIG. 3, the LPG tank 300 may be located separate, but coupled to, an engine 310. *The LPG tank 300 may be connected to the primary regulator 304* as described previously, for example by connector 302. Additionally, a low pressure output of the secondary regulator 308 may be attached to a propane carburetor (not pictured) on the engine 310 in any of a variety of manners, for example through hose 312 and coupling 314. Further, a low pressure output of the secondary regulator 308 may be attached to the propane carburetor either permanently or releasably.

Still referring to exemplary FIG. 3, the primary regulator 304 and the secondary regulator 308 may be two separate regulators that can be based on the design and size of an engine. The primary regulator 304 in this exemplary embodiment may be connected to LPG tank 300 as described above. Additionally, the primary regulator 304 may be connected to the secondary regulator 308 by a hose 306, pipe, tube or the like, such as that described above.

In each of the exemplary embodiments described herein the arrangement of the regulators 106 and 110, 202 and 304 and 308, as shown in FIGS. 1-3, respectively, can

maintain about an ambient temperature from the surrounding air temperature rather than utilizing an interface with a cooling circuit of the engine 116 or other heat source to function as desired. In some other exemplary embodiments, the temperature maintained by any regulators described herein may be such that the flow of propane is allowed as desired. This may be accomplished as a result of the vapor delivery nature of the system as well as a design match of the system to fit specific air-fuel requirements of an engine size, for example for a marine engine. The maintenance of the regulator at about an ambient temperature may be facilitated by both the design of the regulator or regulators which may be sized to a specific engine, for example a marine engine having a known or desired horsepower rating. Additionally, the maintenance of the about ambient temperature may be such that the regulator or regulators are not affected, for example, by freezing as a result of the conversion of the LPG from tank 102 to a gaseous state and the flow of the fuel is not negatively affected or impacted.

In still further examples, any of the embodiments described herein may include a fuel shut-off valve, such as a safety fuel shut-off valve 316 or switch. For example, a standard propane tank shut-off valve may be utilized in some embodiments. Additionally, in other embodiments,

such as embodiments where a larger, electrically actuated engine is utilized, an electric solenoid shut-off valve may be used.

Id., ¶¶[0020]-[0023] (emphasis added). An exemplary embodiment showing Parlatore's primary regulator 304 coupled to the LPG tank's service valve 316 is seen in Figure 3. An exemplary embodiment showing Parlatore's dual-stage regulator 202 coupled to the outlet of LPG tank 200 is seen in Figure 2.

159. Specifically, the primary regulator regulates the propane to a reduced pressure:

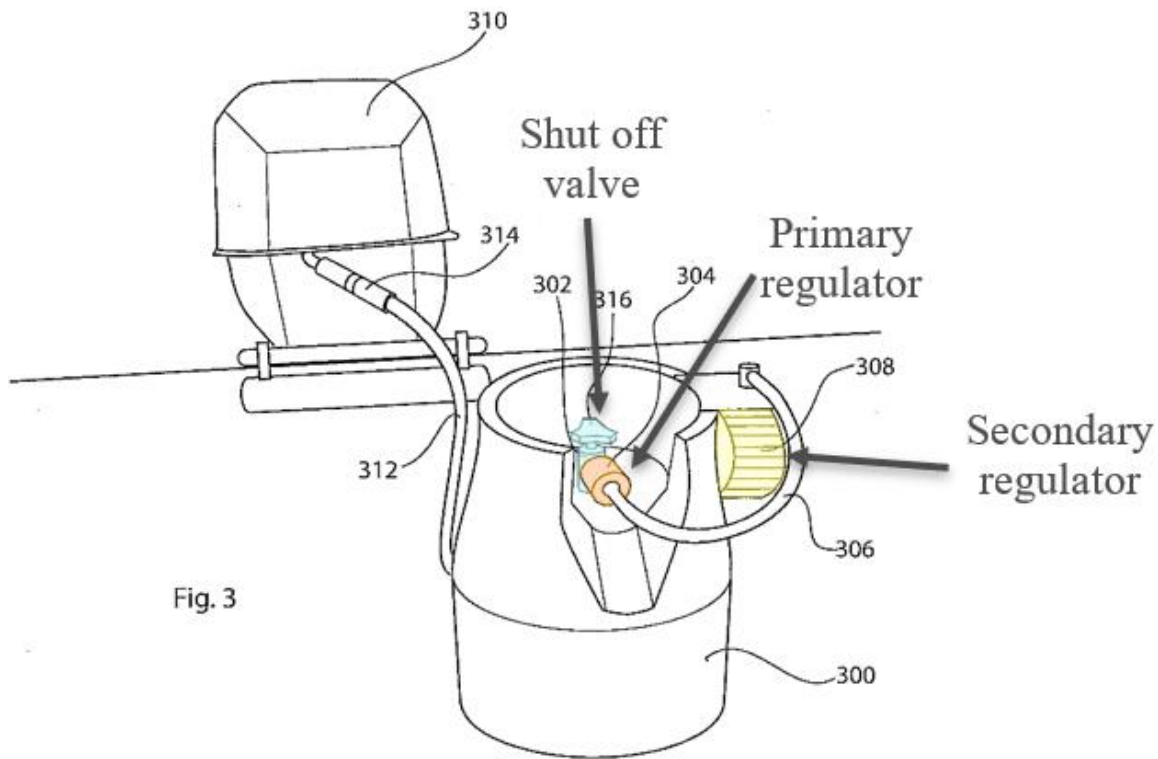
The primary regulator 106 may step down the pressure of any stored propane vapor energy in tank 102, and may further output this lowered pressure to a secondary regulator 110.

Id., ¶[0016]. As seen in Figure 3 below, Parlatore's primary regulator is connected directly to the LPG source:

In still further exemplary embodiments, and referring to FIG. 3, the LPG tank 300 may be located separate, but coupled to, an engine 310. ***The LPG tank 300 may be connected to the primary regulator 304*** as described previously, for example by connector 302. Additionally, a low pressure output of the secondary regulator 308 may be attached to a propane carburetor (not pictured) on the engine 310 in any of a variety of manners, for example

through hose 312 and coupling 314. Further, a low pressure output of the secondary regulator 308 may be attached to the propane carburetor either permanently or releasably.

Id., ¶[0020] (referring to the “primary regulator 304, as described previously [as primary regulator 106]”) (emphasis added). Parlatore’s Figure 3 shows an exemplary embodiment:



Id., Fig. 3 (annotated). Parlatore’s two-stage regulator 202 also comprises a primary, first-stage regulator coupled to the LPG tank. Ex. 1010, ¶¶[0016], [0018], & [0020]-[0021], Fig. 2.

160. Parlature's fuel regulator system would have been obvious to incorporate for use with Imamura's engine as discussed. *See above* §XII.D.1.b. Similarly, it would have been obvious to use Parlature's LPG tank 300 along with its service valve 316 with Imamura's engine given that such LPG tanks having service valves were well-known and ubiquitous. This would have involved nothing more than using Parlature's LPG tank configuration as the LPG fuel source for Imamura, with each performing their intended function without any unexpected results.

d. Element [11.4]

161. Element [11.4] recites "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."

162. Parlature discloses secondary pressure regulator 308, coupled to the primary pressure regulator 304, for regulating the propane to a low pressure for feeding to the carburetor through hose 312:

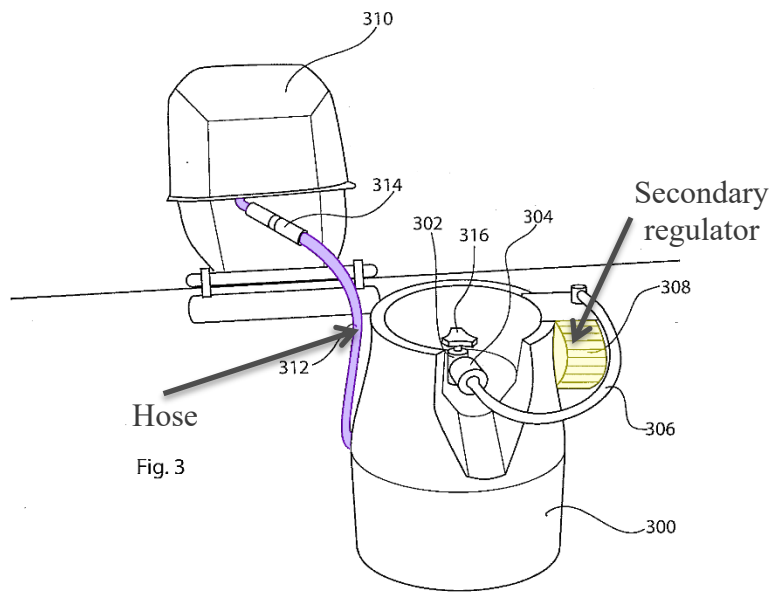
In still further exemplary embodiments, and referring to FIG. 3, the LPG tank 300 may be located separate, but coupled to, an engine 310. The LPG tank 300 may be connected to the primary regulator 304 as described previously, for example by connector 302. Additionally, a low pressure output of the *secondary regulator 308 may*

be attached to a propane carburetor (not pictured) on the engine 310 in any of a variety of manners, for example *through hose 312* and coupling 314. Further, a low pressure output of the secondary regulator 308 may be attached to the propane carburetor either permanently or releasably.

Id., ¶[0020] (emphasis added); *see also id.*, ¶¶[0005]-[0006], [0016]-[0017].

163. Parlature's two-stage regulator 202 likewise comprises a secondary regulator in the form of its second stage, which then feeds vaporized propane into the carburetor. *Id.*, ¶¶[0018], [0022], Figs. 1-2.

164. Parlature's fuel regulator system, including its secondary regulator as described above, would have been obvious to incorporate for use with Imamura's engine to provide gaseous LPG fuel to the engine at the desired pressure via a gaseous fuel line, i.e., where Parlature's hose 312 replicates Imamura fuel line from the LPG tank 12 to the engine, as seen in Figure 3:



Id., Fig. 3 (annotated).

165. It would have been obvious to use both a primary and secondary regulator when using Imamura's engine in a generator. *See below* §XII.G.1.d.

E. Ground 5: Claims 12-15 and 17-19 are anticipated by The Workshop Manual

166. Claims 12-15 and 17-19 of the '120 Patent are anticipated for at least the reasons described below.

1. Claim 12

a. Element [12.0]

167. Element [12.0] recites “a multi-fuel generator and fuel delivery system.”

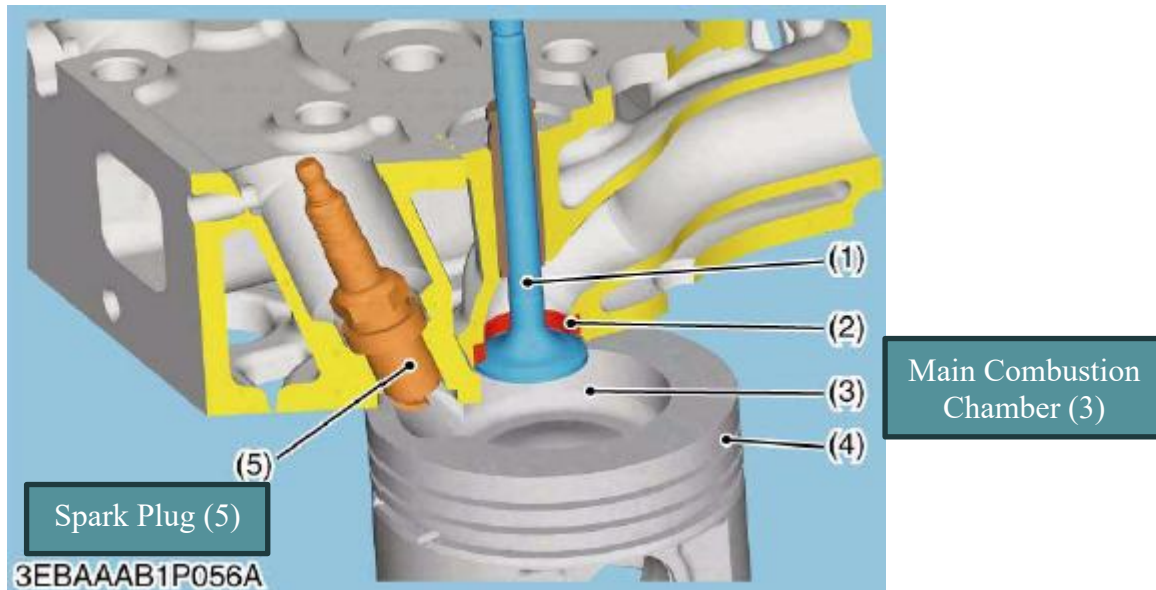
168. The Workshop Manual discloses a multi-fuel delivery system for a multi-fuel engine operating in a generator.

169. The Workshop Manual discloses a “Dual Fuel (Gasoline / LPG) Engine” Ex. 1012, 8. The engine includes “a rotating magnet type generator” (i.e., an alternator) that “produces higher voltage in slow speed rotation, and charges electric current to the battery during engine idling.” *Id.*, 77. The Workshop Manual specifies that the alternator outputs 150W at 12V. *Id.*, 8. Thus, Workshop Manual discloses a generator, powered by operation of the DF972 engine.

b. Element [12.1]

170. Element [12.1] recites “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.”

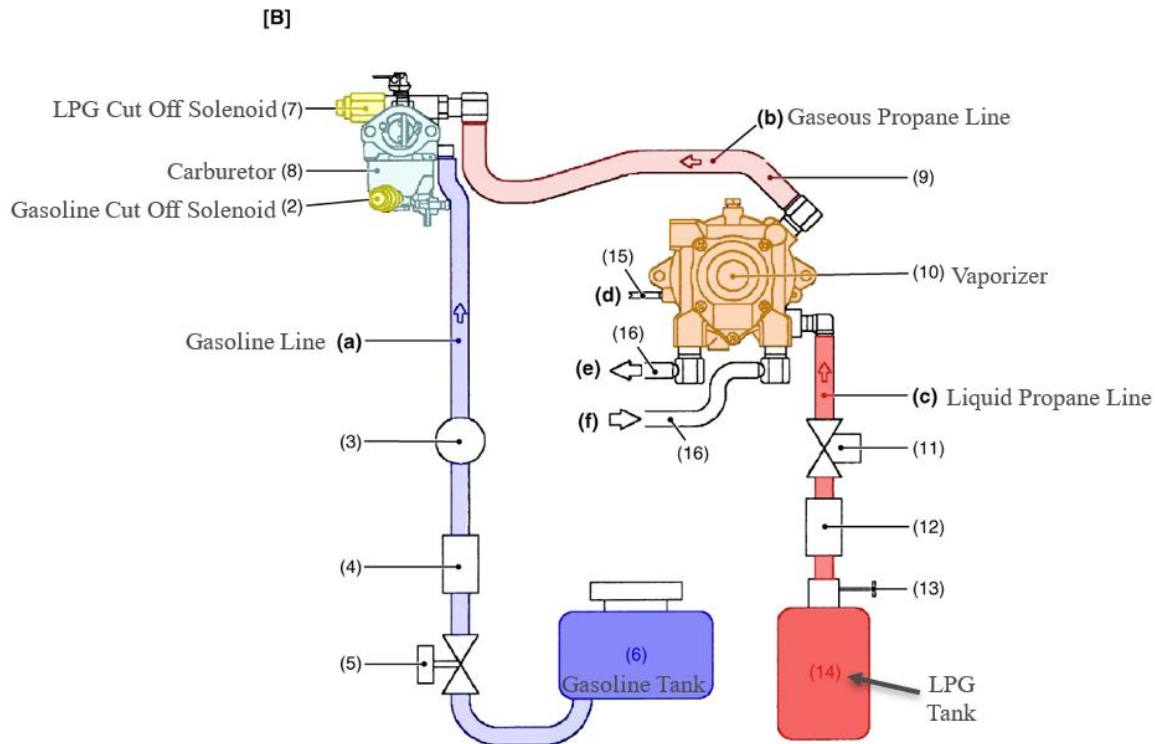
171. The Workshop Manual discloses a multi-fuel internal combustion engine, where fuel (gasoline or LPG) is combusted inside the engine, ignited by spark plugs:



Ex. 1012, 54 (annotated).

172. A POSA would readily understand that the primary function of a spark plug is to ignite an air-fuel mixture in the combustion chamber to produce power.

173. The gasoline and LPG are supplied from tanks through fuel lines:



Id., 65 (annotated) (“For LPG fuel, the liquid fuel stored in the LPG tank (14) is sent to vaporizer (10) **by pressure in the gaseous phase in the tank.**”) (emphasis added).

174. As shown, LPG is stored under pressure in the LPG tank (14). When the LPG Manual Valve (13) is opened, the pressurized LPG (which includes liquid LPG) travels through the Liquid Propane Line (c) until it reaches the Vaporizer (10). The Vaporizer (10) depressurizes the liquid LPG such that it becomes gaseous LPG, which then proceeds to the carburetor through the Gaseous Propane Line (b). *Id.*, 65.

c. Element [12.2]

175. Element [12.2] recites “an alternator driven by the multi-fuel internal combustion engine.”

176. In general, a POSA would understand that an alternator is an electrical generator that converts mechanical energy to electrical energy in the form of alternating current. Alternators generally comprise a stator (i.e. a stationary component) and a rotor (i.e. a rotating component) to generate a rotating magnetic field that generates the alternating current.

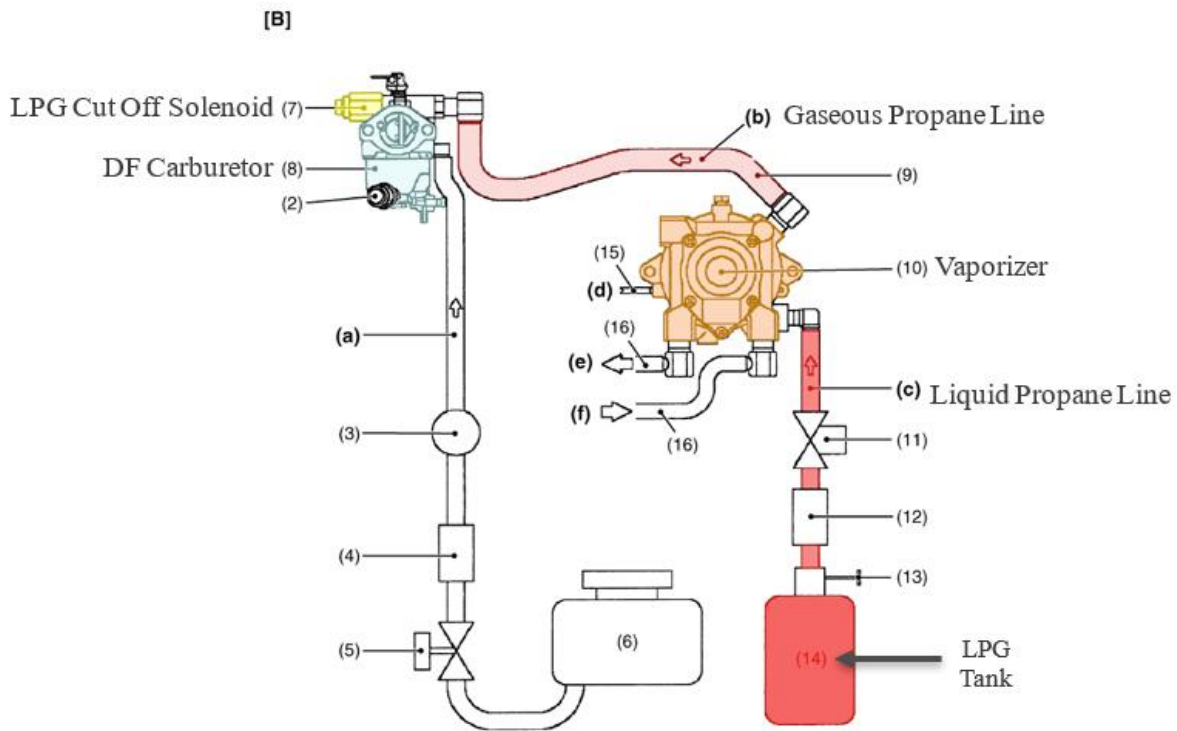
177. The Workshop Manual confirms that the alternator in the DF972 engine conforms with this general understanding. *See* Ex. 1012, 77 (describing the construction of the alternator); *see also id.*, 8, 94, 111, 132. Given that the alternator is disclosed as part of the “Charging System,” a POSA appreciated that the alternator provides electrical power.

178. The Workshop Manual also discloses an “Alternator on Unit Test” that indicates the alternator is driven by the engine. For example, the Workshop Manual says that “When the engine is operating measure the voltage between two battery terminals. If the voltage is between 13.8 V and 14.8 V, the alternator is operating normally.” A POSA would understand that the test requires the engine to be running because the alternator generates electrical power when the engine is running. *Id.*, 111.

d. Element [12.3]

179. Element [12.3] recites “a fuel regulator system.”

180. The Workshop Manual’s discloses a fuel regulator system (i.e. “Fuel System”):



Ex. 1012, 65 (annotated).

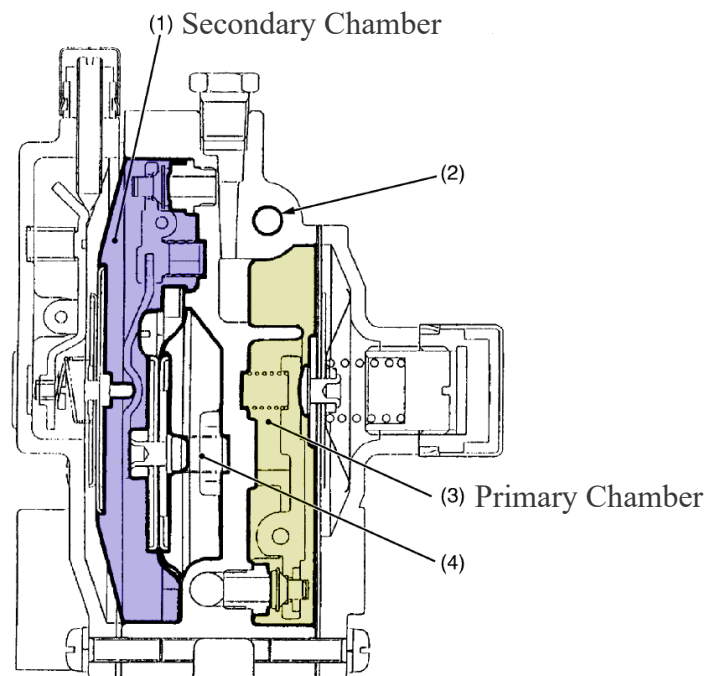
181. The Workshop Manual explains that:

For LPG fuel, the liquid fuel stored in the LPG tank (14) is sent to vaporizer (10) by pressure in the gaseous phase in the tank through the LPG filter (12) and LPG shut off solenoid valve (11). The liquid fuel is evaporated in vaporizer and is sent to the DF carburetor (8) as a gaseous fuel of gas pressure near the atmospheric pressure.

Id.

182. For LPG to be stored as a liquid it must be pressured to approximately 100 psig (with the exact pressure depending on the ambient temperature). Thus, the vaporizer must depressurize the LPG so that it can be sent to the carburetor at near atmospheric pressure (near 0 psig). The vaporizer includes primary and secondary chambers. The primary chamber (3) decompresses (and therefore, evaporates) the liquid LPG. The evaporated LPG then passes to the secondary chamber (1), which is further decompressed such that the gaseous LPG is depressurized to near-atmospheric pressure, i.e., the pressure desired for engine operation. Ex. 1012, 69.

183. The Workshop Manual includes a detailed figure of the vaporizer:



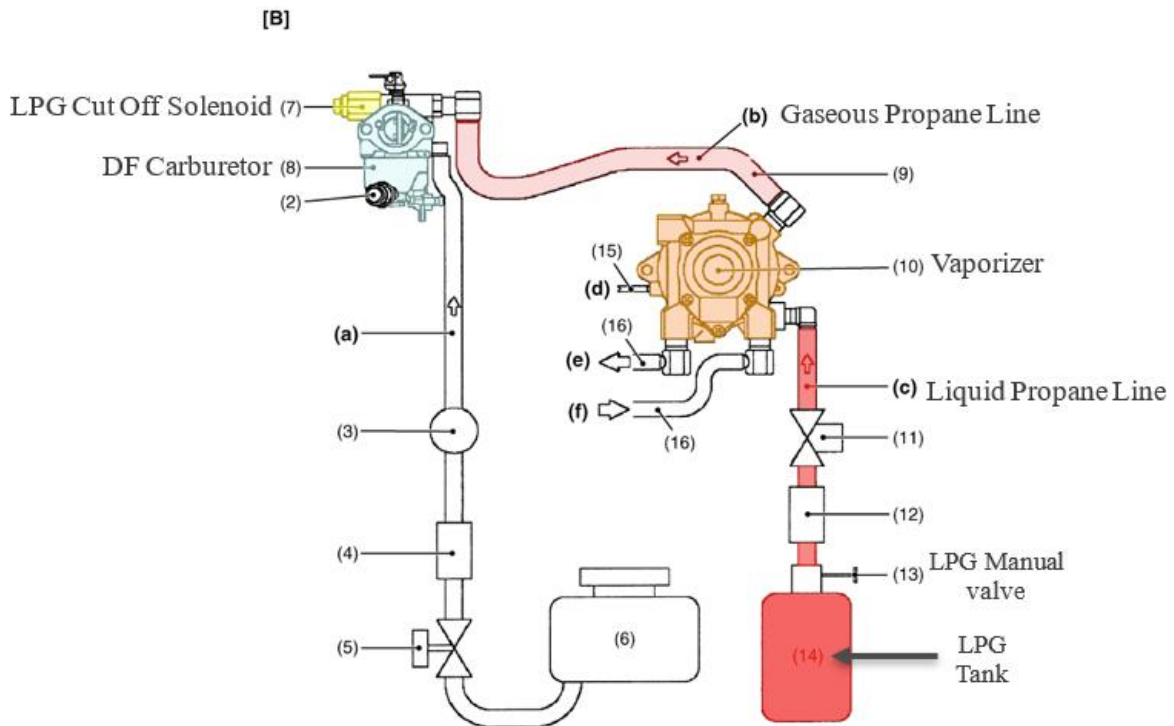
Ex. 1012, 69 (coloring and annotations added). The Workshop Manual also describes the operation of the vaporizer. *Id.*

184. Thus, the vaporizer operates as the claimed “fuel regulator system” to reduce and control the pressure of LPG from pressurized LPG container 14 and delivers it at the desired pressure for operation of the DF972 engine. *See id.*, 69–71.

e. Element [12.4]

185. Element [12.4] recites “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.”

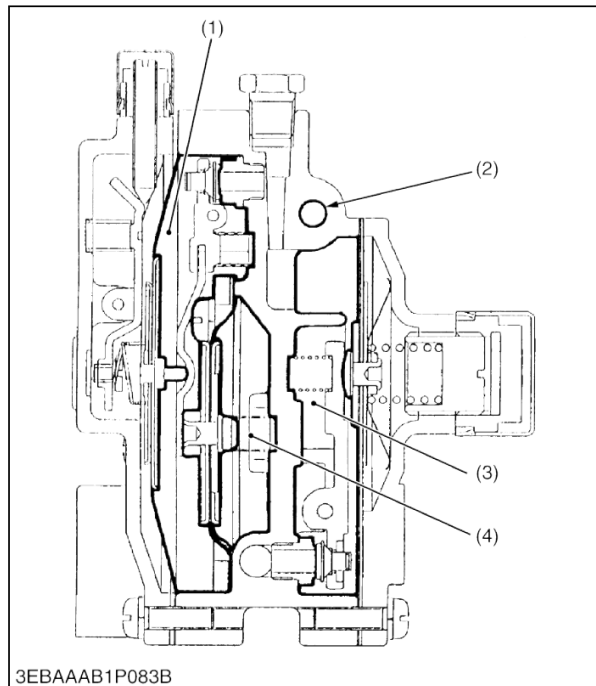
186. The DF972 engine obtains LPG fuel from the pressurized LPG tank, which has a service valve on its outlet (i.e., “LPG Manual Valve” (13)), to which vaporizer (10) is coupled:



Ex. 1012, 65 (annotated).

187. The Workshop Manual describes the primary and secondary stages of the vaporizer as follows:

[3] VAPORIZER (DF972-E2)



Vaporizer is a device which converts the liquid fuel into the gaseous fuel and the following structures and functions are possessed.

■ **Primary Chamber**

The liquid fuel is decompressed (the first decompression) and it is evaporated.

■ **Secondary Chamber**

The fuel which flows in is decompressed from the primary chamber to the vicinity of the atmospheric pressure further (the second decompression).

■ **Water Passage**

The coolant of the engine is made to circulate as a heat source to evaporate the LPG.

■ **Vacuum Lock Chamber**

When the engine stops, the fuel from primary chamber is prevented from flowing out.

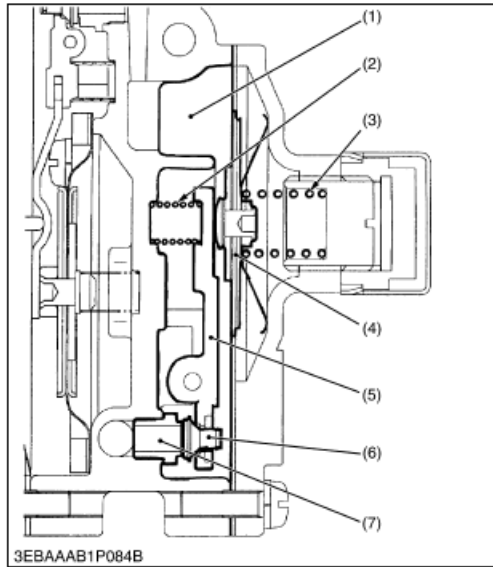
- | | |
|-----------------------|-------------------------|
| (1) Secondary Chamber | (3) Primary Chamber |
| (2) Water Passage | (4) Vacuum Lock Chamber |

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Ex. 1012, 69. The Workshop Manual thus discloses a primary pressure regulator (i.e. the “Primary Chamber”) coupled to the service valve (i.e. LPG Manual Valve (13)), whereby fuel from the pressurized tank is regulated to a reduced pressure.

Ex. 1012, 69 (explaining that in the Primary Chamber, “liquid fuel is *decompressed* (the first decompression) and it is evaporated.” (emphasis added)).

188. More specifically, the Workshop Manual describes the “Primary Chamber” operation as follows:



Primary Chamber

The liquid fuel which pushes the primary valve (6) open passes between the valve and the valve seat (7), enters primary chamber (1), and decompresses and is evaporated.

When the inflow of the fuel continues and the primary chamber pressure rises more than the specified pressure 32.7 kPa (0.3 kgf/cm², 4.3 psi), the tension in the diaphragm spring (3) is overcome and do the push up of primary diaphragm (4).

At this time, do the push up of primary valve lever spring (2) of primary valve lever (5), primary valve (6) is shut, and the inflow of the fuel is intercepted.

The tension in the diaphragm spring (3) grows more than the primary chamber pressure when the fuel is consumed and the primary chamber pressure lowers more than a regulated value and a primary diaphragm is depressed below.

The primary valve lever (5) is depressed at the same time.

A primary valve opens and the fuel flows in again.

When the diaphragm tears by any chance and the fuel flows in the primary diaphragm spring side, the primary diaphragm spring side is connected with second chamber in the balance passage so that the fuel should not flow out outside.

- | | |
|--------------------------------|-------------------------|
| (1) Primary Chamber | (5) Primary Valve Lever |
| (2) Primary Valve Lever Spring | (6) Primary Valve |
| (3) Primary Diaphragm Spring | (7) Valve Seat |
| (4) Primary Diaphragm | |

Ex. 1012, 70. The Workshop Manual thus discloses a primary pressure regulator, i.e., the primary chamber within the vaporizer (10) that is coupled to the service valve (13) of the pressurized tank (14), which regulates fuel supplied from pressurized tank (14) to a reduced pressure.

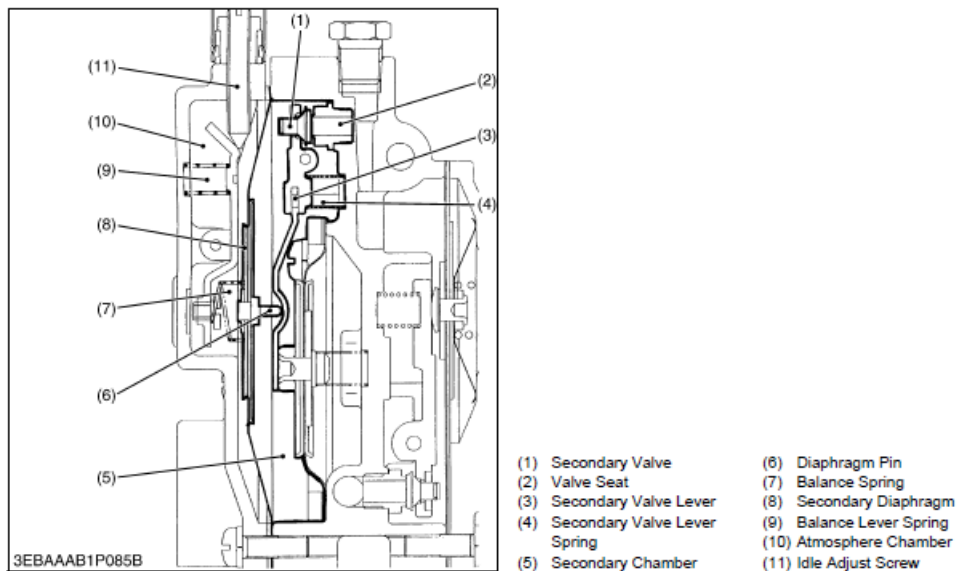
a. Element [12.5]

189. Element [12.5] recites “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.”

190. The Workshop Manual discloses a secondary pressure regulator (i.e. the “Secondary Chamber” of the vaporizer) coupled to the Primary Chamber, to

regulate fuel supplied from the Primary Chamber to a desired pressure for delivery through the gaseous fuel line to the DF972 engine. Ex. 1012, 69. The Workshop Manual depicts the Secondary Chamber and explains:

The fuel adjusted with primary chamber to the specified pressure enters secondary chamber (5) between secondary valve (1) and the valve seat (2) and is decompressed to the vicinity of the atmospheric pressure almost.



Ex. 1012, 71.

191. Thus, the Secondary Chamber further reduces the LPG pressure to near atmospheric pressure for delivery to the carburetor of the DF972 engine.

2. Claim 13

192. Claim 13 depends from Claim 12 and further recites “an electro-mechanical valve system coupled to the engine and operated by an electrical

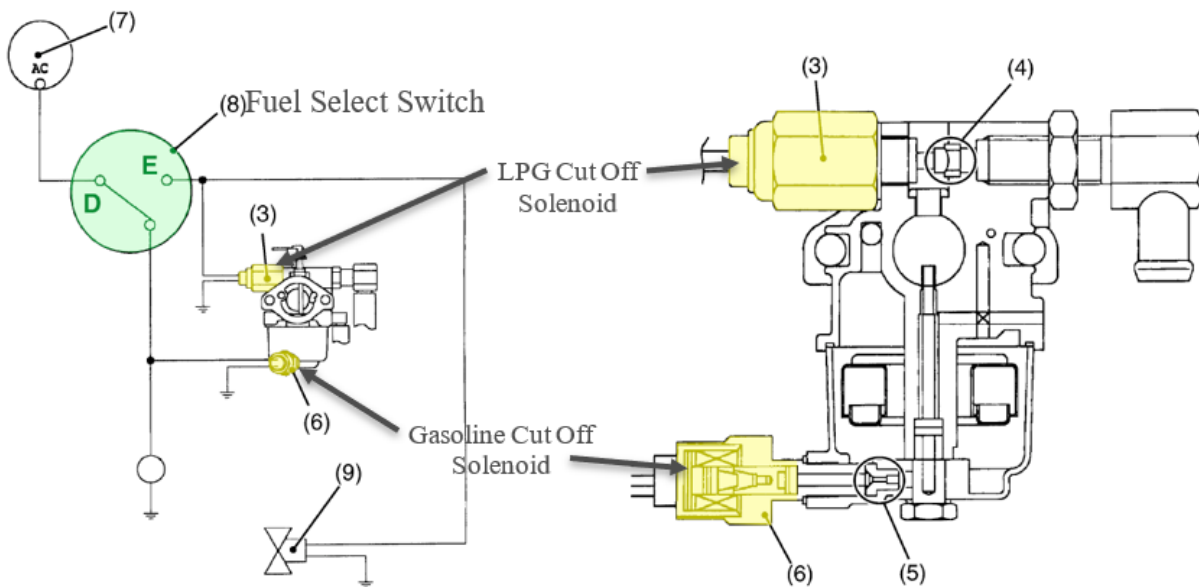
switch powered by one of the alternator, a battery, and a magneto that controls fuel flow to the engine from the liquid fuel source and the pressurized fuel source.”

193. The Workshop Manual discloses an electro-mechanical valve system (i.e. a “Fuel System”) with an electrical switch (i.e. a “Fuel Select Switch”). *See* Ex. 1012, 68. The Fuel System includes electro-mechanical valves, such as the “LPG Shut Off Solenoid Valve.” *Id.* The Fuel Select Switch is powered by a battery and controls fuel flow to the engine from the liquid fuel source (i.e. Gasoline Tank) and the pressurized fuel source (i.e. LPG Tank) by operating the gasoline and LPG cutoff valves:

With the fuel select switch (8) in the “GASOLINE” position ‘D’ and the main switch in the ‘ON’ position, the battery current flows to the gasoline cut off solenoid (6). Therefore gasoline fuel in the float chamber flows to the mixing chamber. When the fuel select switch (8) is turned to the ‘LPG’ position ‘E’, the battery current stops to the gasoline cut off solenoid (6) and flows to the LPG cut off solenoid (3) and LPG shut off solenoid valve (9). . . . When the main switch (7) turned to the ‘OFF’ position, the battery current stops to the both of (sic) solenoids.

Id..

194. The Workshop Manual also illustrates the operation of the electro-mechanical valve system (i.e., the gasoline and LPG cut off solenoids) and electrical switch:

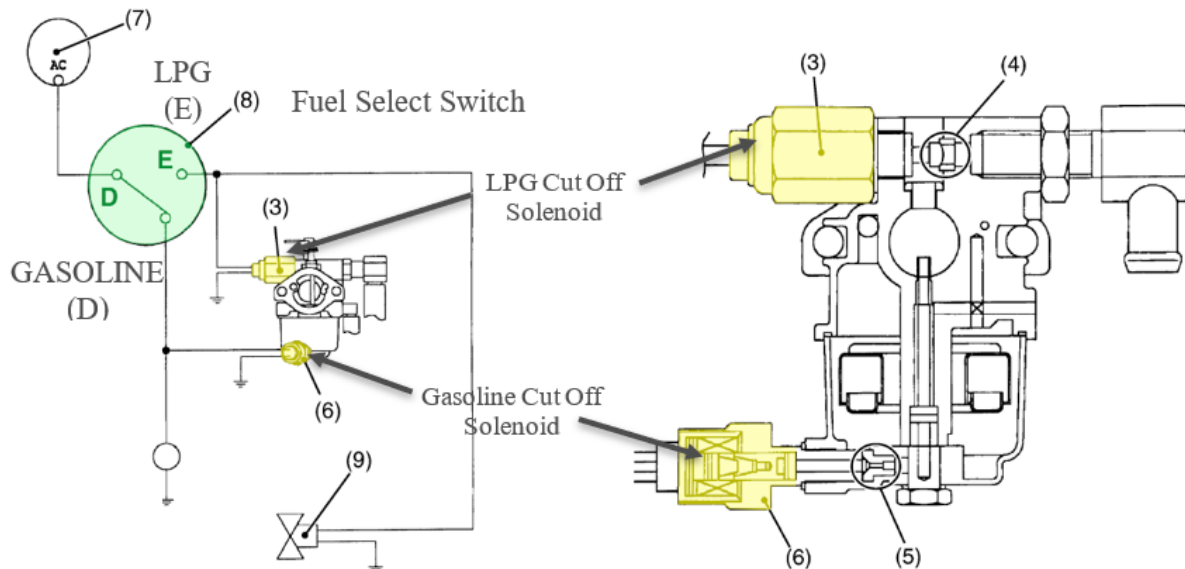


Ex. 1012, 68 (annotated).

3. Claim 14

195. Claim 14 depends from Claim 13 and further recites “the electro-mechanical valve system is configured to switch operation of the generator from multiple fuel sources while the generator is running.”

196. The Workshop Manual’s Fuel Select Switch can be toggled between positions D (gasoline) and E (LPG) and is therefore configured to switch between the fuels used for generator/engine operation:



Ex. 1012, 68 (annotated); *see also above* §XII.E.2.

197. A POSA would have understood the switch could be toggled between gasoline and LPG positions to switch between fuel sources while the generator/engine is running via operation of the gasoline and LPG cut off solenoids. *Id.*

198. Confirming how a POSA would interpret the switching capabilities of the DF972 engine, the Operator's Manual notes that users can switch the fuel from gasoline to LPG and vice versa while operating the Kubota DF972 engine:

In case of converting the fuel (gasoline ↔ LPG) ***while running the engine***, the engine should be operated with the engine speed high and no-loaded.

Ex. 1013, 19 (emphasis added).

199. Should the Workshop Manual be deemed to not sufficiently disclose allowing for switching between fuel sources while the generator is running, it would have been obvious to a POSA to combine the teachings of the Workshop Manual and Operator's Manual to satisfy this limitation. *Id.* A POSA would have been motivated to combine the teachings from the manuals and would have had a reasonable expectation of success in their combination since they both disclose and discuss the configuration and operation of Kubota's DF972 engine. Thus, a POSA would have learned from the Operator's Manual that the Workshop Manual's disclosed DF972 engine was configured to allow for switching between fuels while the generator is running, as claimed. *Id.*

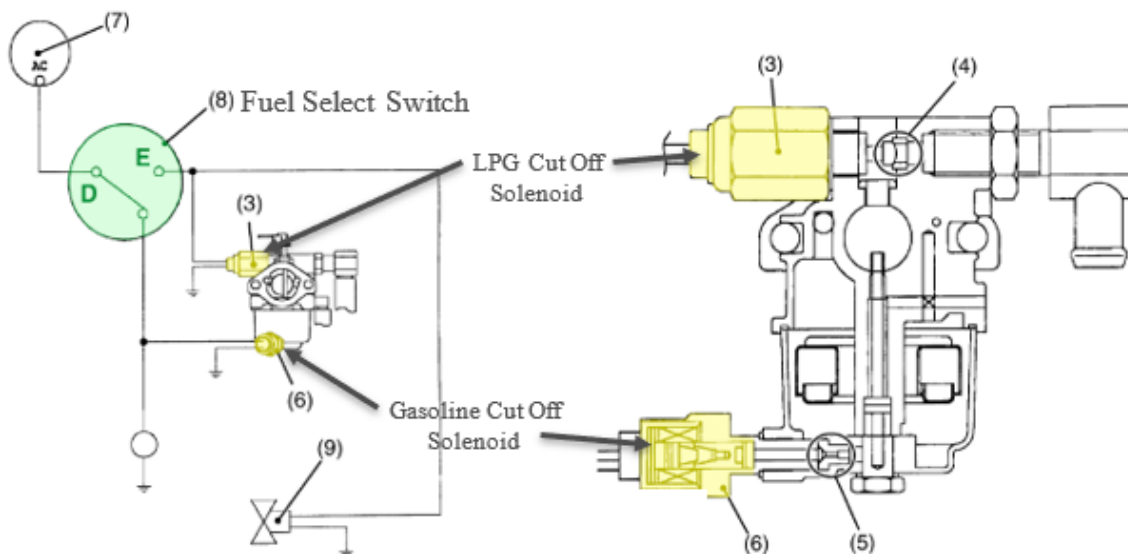
200. Thus, I conclude that the Workshop Manual anticipates Claim 14. In addition, Claim 14 is obvious in view of the Workshop and Operator's Manuals.

4. Claim 15

201. Claim 15 depends from Claim 13 and further recites "the electro-mechanical valve system is configured to prevent simultaneous delivery of the liquid fuel and the gaseous fuel to the engine."

202. The Workshop Manual describes the Fuel Select Switch switching between gasoline and LPG engine operation. Ex. 1012, 68; *supra* §XII.E.2. A POSA would have understood this description to convey that operating both cut-off solenoids with the same switch allows the engine to change between liquid and

gaseous fuels whereby simultaneous flow from the liquid and gaseous fuel sources is prevented, because when one fuel line is opened the other is simultaneously closed, and vice versa. This switching capability is illustrated below, where switching between gasoline and LPG involves closing the switch at position D or E, respectively:



Ex. 1012, 68 (annotated).

5. Claim 17

203. Claim 17 depends from Claim 12 and further recites “a dual stage pressure regulator comprises the primary pressure regulator and the secondary pressure regulator.”

204. The Workshop Manual discloses a dual-stage vaporizer having primary and secondary chambers. *See above* §XII.E.1.e-f. Therefore, a POSA

would understand these chambers are primary and secondary pressure regulators as required by Claim 17.

6. Claim 18

a. Element [18.0]

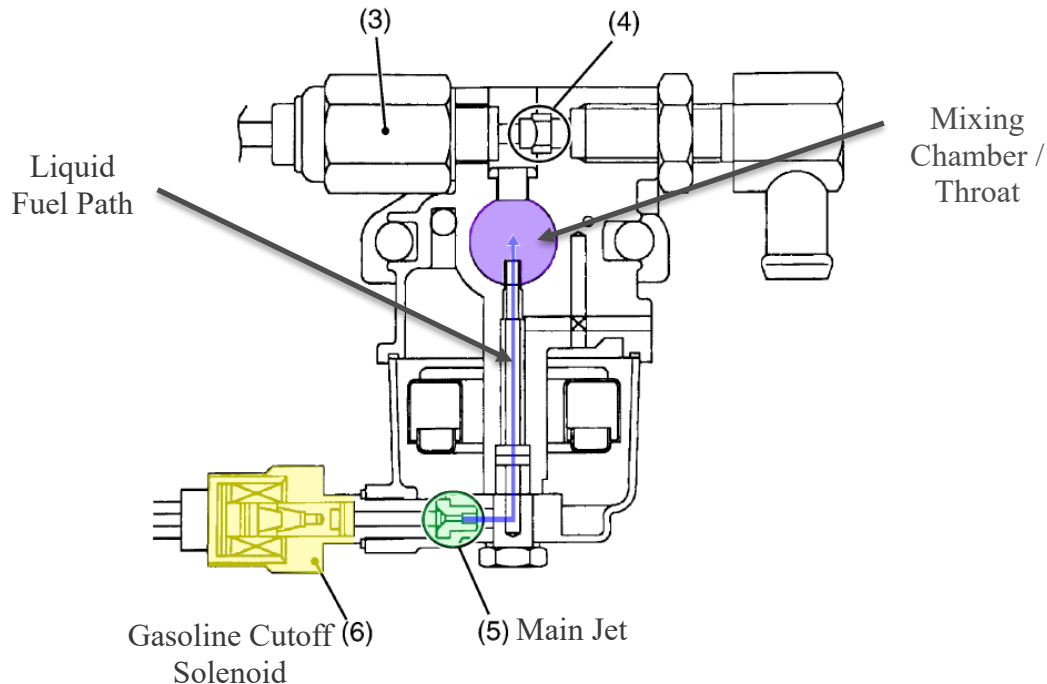
205. Element [18.0] recites “A carburetor for use in a multi-fuel internal combustion engine.”

206. The Workshop Manual discloses a carburetor (Ex. 1012, 68) for use in a multi-fuel internal combustion engine (*supra* §§XII.E.1.a, XII.E.1.b).

b. Element [18.1]

207. Element [18.1] recites “a throat in which fuel and air are mixed in throat to provide an air-fuel mixture for the multi-fuel internal combustion engine”

208. The Workshop Manual discloses carburetor mixing chamber, which a POSA would understand to be a throat of the carburetor in which fuel and air are mixed to provide an air-fuel mixture for the engine:



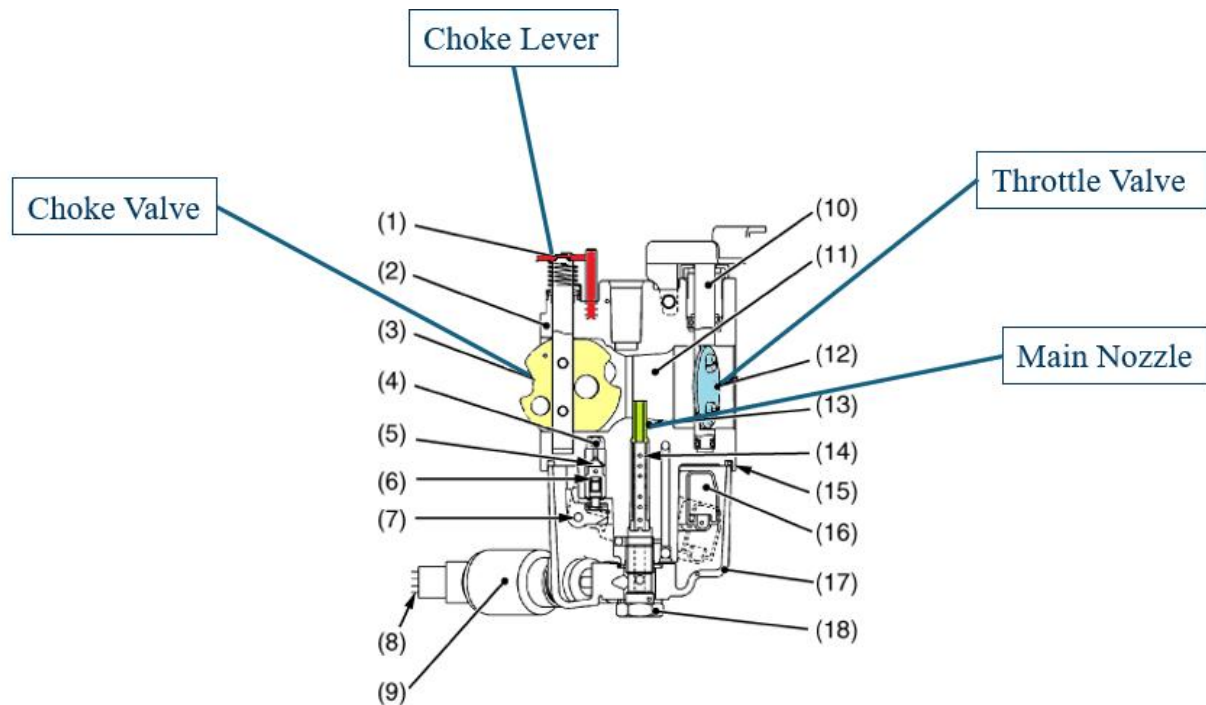
Id., 68 (annotated).

c. Element [18.2]

209. Element [18.2] recites “a valve located in the throat to provide a choke and throttle for the multi-fuel internal combustion engine.”

210. The Workshop Manual discloses a choke valve and a throttle valve in the throat to provide a choke and throttle for the engine. Ex. 1012, 67 (“To start an engine in cold weather, the fuel-air mixture must be richer than normal. A choke valve (3) controlled by the choke lever (1) is provided to enrich the mixture.”), *id.* (“When the throttle valve (12) closes, air that flows into the cylinder passes along the valve at a high speed. As a result, a negative pressure is [created] in the pilot

outlet (19) which has an outlet port in the inner wall. This causes gasoline in the main nozzle (13) to flow through the pilot jet (25) to be sucked into the cylinder.”).

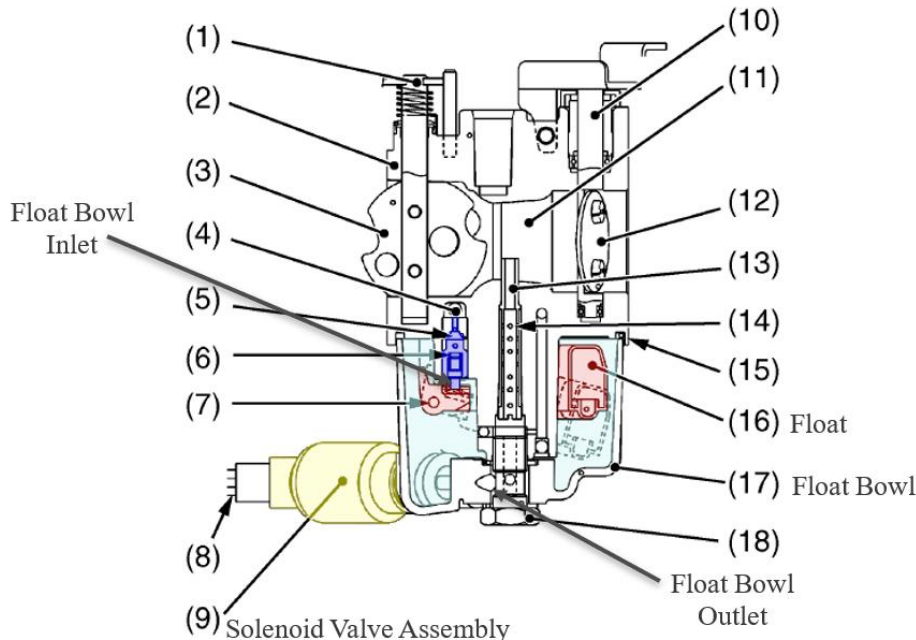


Ex. 1012, 67 (annotated).

d. Element [18.3]

211. Element [18.3] recites “a float bowl to hold liquid fuel.”

212. The carburetor for the DF972 engine comprises a float bowl that holds liquid fuel (gasoline), labeled “float chamber (17)” in the Workshop Manual figure for the WG972 engine (Ex. 1012, 67), which is the same for the DF972 engine (*see id.*, 68 (noting that the DF carburetor operates the same as the gasoline-only carburetor when operating on gasoline)).

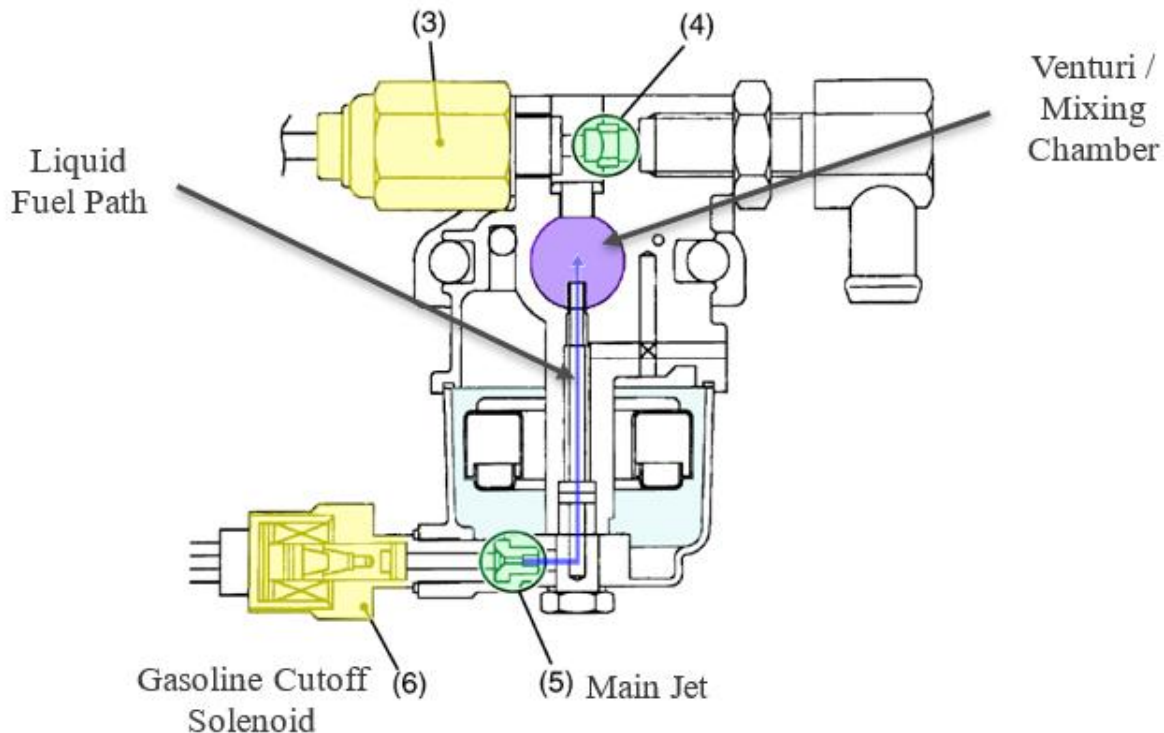


Ex. 1012, 67 (annotated).

e. Element [18.4]

213. Element [18.4] recites “a main fuel circuit positioned downstream from the float bowl and extending from the float bowl to the throat.”

214. The Workshop Manual discloses a main fuel circuit positioned downstream from the float bowl (i.e. “float chamber”). Ex. 1012, 68 (“With the fuel select switch (8) in the “GASOLINE” position “D”..., the battery current flows to the gasoline cut off solenoid (6). *Therefore gasoline fuel in the float chamber flows to the mixing chamber.*” (emphasis added)). A POSA would understand the carburetor mixing chamber to be the throat of the carburetor.



Ex. 1012, 68 (annotated). Therefore, the main fuel circuit extends from the float chamber to the throat. Ex. 1012, 67-68.

f. Element [18.5]

215. Element [18.5] recites “an idle fuel circuit that provides a flow path to the throat downstream of the throttle to run the engine at idle.”

216. The Workshop Manual discloses a “Slow System,” which includes an idle fuel circuit for purposes of Element [18.5]. Ex. 1012, 67. The Workshop Manual discloses:

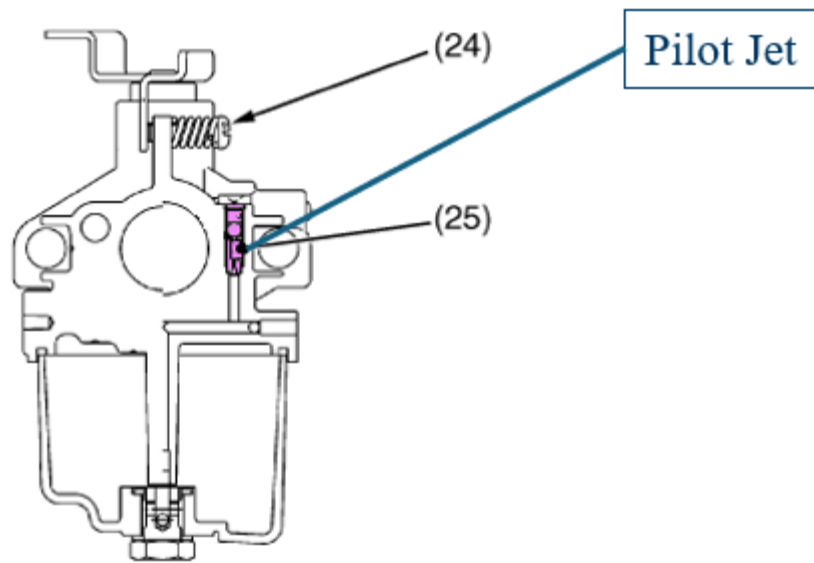
3) Slow System

When the throttle valve (12) closes, air that flows into the cylinder passes along the valve at a high speed. As a result,

a negative pressure is [created] in the pilot outlet (19) which has an outlet port in the inner wall. This causes gasoline in the main nozzle (13) to flow through the pilot jet (25) to be sucked into the cylinder. Air that enters from the slow air jet (22) is mixed with gasoline in the pilot jet (25), atomized in an appropriate condition, sprayed from the pilot outlet (19) and sucked into the cylinder through the main passage. The slow speed of the engine is controlled by changing the jet area with the pilot jet (25).

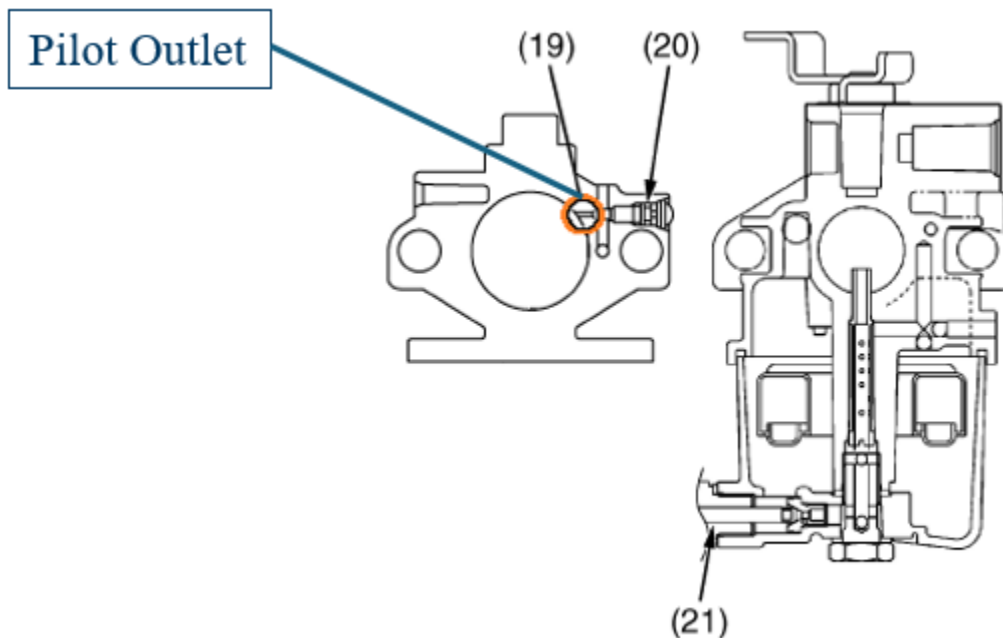
Id. A POSA would understand this to mean that when the engine is at idle (when the throttle valve closes), the gasoline flows through the pilot jet to the throat of the carburetor through the pilot outlet 19. Therefore, the pilot jet and pilot outlet comprise a flow path for the gasoline to the throat to run the engine at idle. *Id.*

217. The pilot jet (25) is shown below:



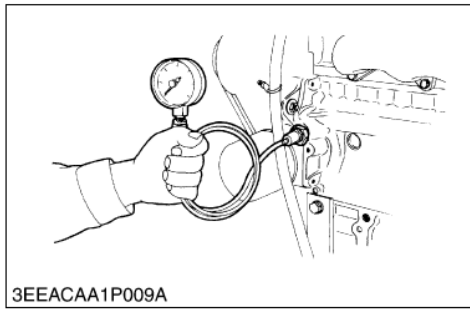
Id. (annotated).

218. As indicated by the above passage, the atomized gasoline is sprayed from the pilot outlet (19) and sucked into the cylinder, which is downstream of the throttle. *Id.*



Id. (annotated).

219. Although The Workshop Manual does not refer to this “Slow System” as an idle fuel circuit, a POSA would understand from the description of the “Slow System” and the depiction of the engine components in the Workshop Manual that “slow system” means the same thing as “idle system” that is in effect when the engine is running at an idle speed. For one, the description indicates the throttle valve is closed when operating in this “Slow System,” which is how an idle fuel circuit operates, i.e., fuel is delivered to the engine downstream of the throttle valve. *See, e.g.,* Ex. 1025, 6:36-46, Fig. 2A (Kirk idle fuel circuit); *see below* §XII.H.1.f. . In addition, the Workshop Manual refers to operation of the engine at “idle speed” and “rated speed”.

(2) Lubricating System**Engine Oil Pressure**

1. Remove the engine oil pressure switch, and set an oil pressure tester.
 2. Start the engine. After warming up, measure the oil pressure of both idling and rated speeds.
 3. If the oil pressure is less than the allowable limit, check the following.
 - Engine oil insufficient
 - Oil pump defective
 - Oil strainer clogged
 - Oil filter cartridge clogged
 - Oil gallery clogged
 - Excessive oil clearance
 - Foreign matter in the relief valve
- (When reassembling)**
- After checking the engine oil pressure, tighten the engine oil pressure switch to the specified torque.

Engine oil pressure	At idle speed	Factory spec.	More than 50 kPa 0.5 kgf/cm ² 7 psi
	At rated speed	Factory spec.	200 to 440 kPa 2.0 to 4.5 kgf/cm ² 29 to 64 psi
		Allowable limit	150 kPa 1.5 kgf/cm ² 21 psi
Tightening torque	Oil pressure switch		15 to 19 N·m 1.5 to 2.0 kgf·m 11 to 14 lbf·ft

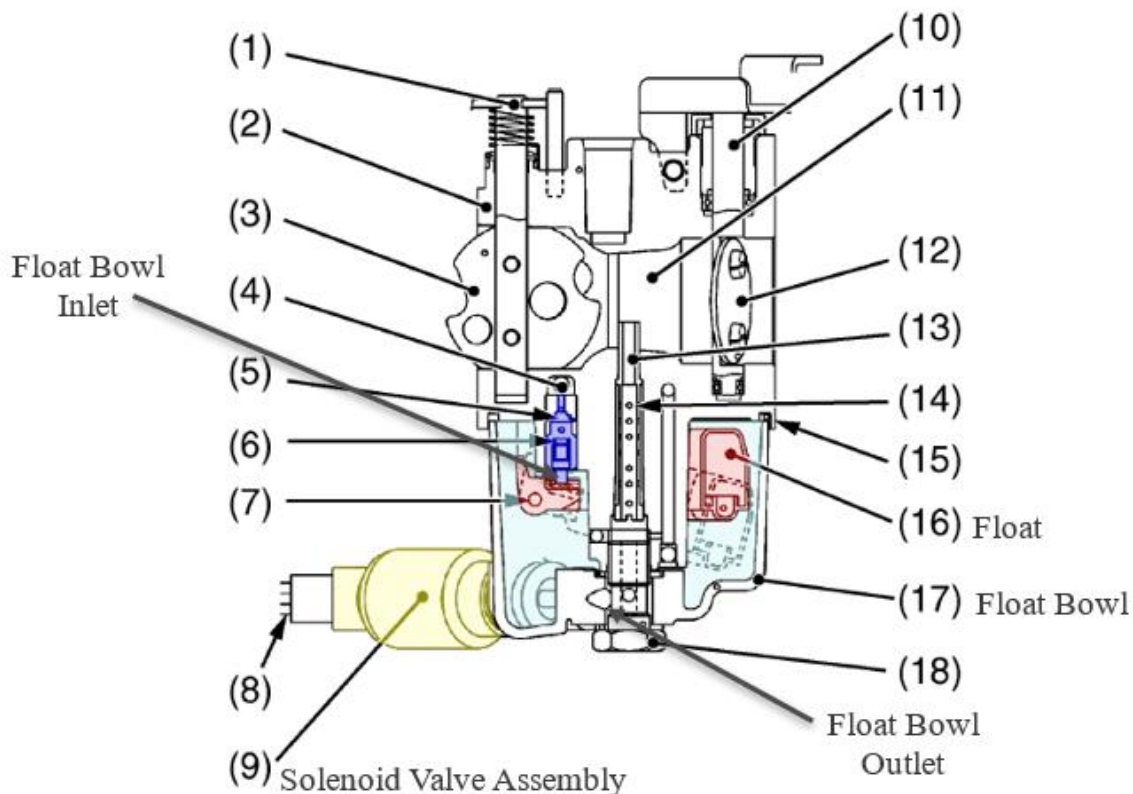
9Y1210318ENS0016US0

Ex. 1012, 100; *see also id.*, 83-84 (troubleshooting for “Rough Low-Speed Running and Idling”). The operation of the speeds is explained on page 67 of the Workshop Manual, which refers to the system as a “Slow System” as opposed to an idle fuel circuit. *Id.*, 67 (“Designed for general purpose use, the carburetor provides engines with the ideal fuel-air mixture for all speed ranges. 1) Float Chamber, ... 2) Starting System, ... 3) Slow System, ... 4) Main Carburetor System, ...”). The “slow speed” of the “Slow System” is equivalent to an idle speed.

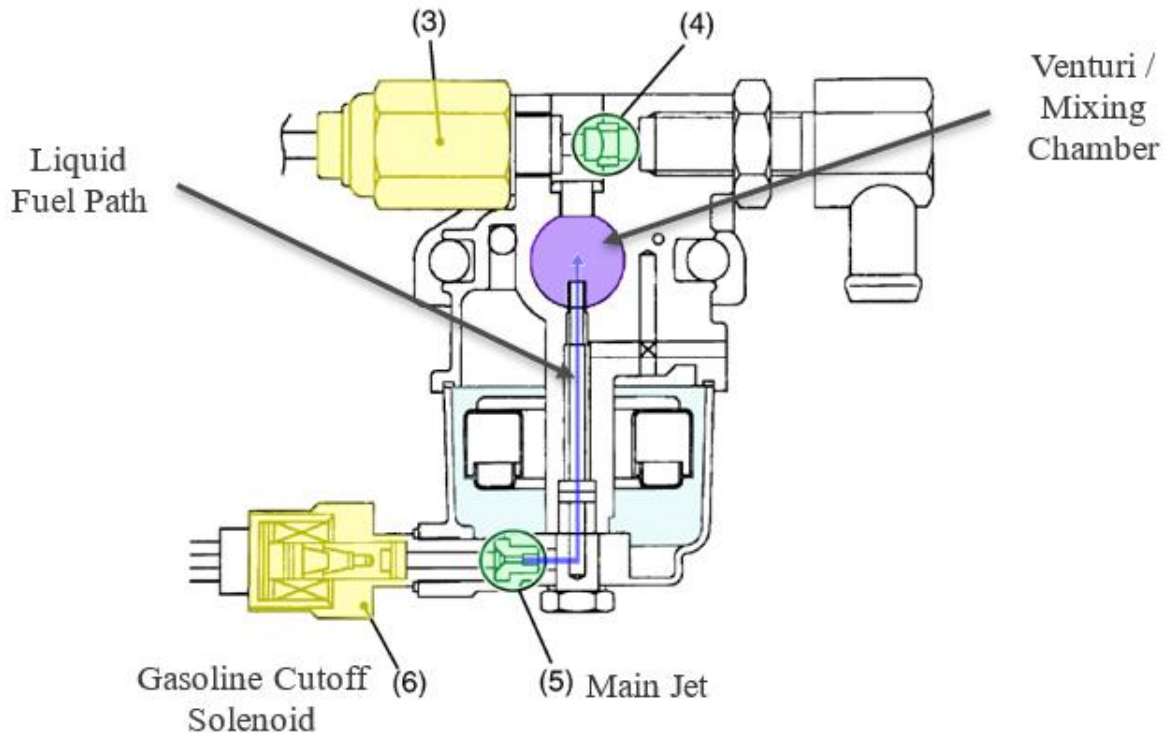
g. Element [18.6]

220. Element [18.6] recites “a carburetor cutoff solenoid configured to selectively control fuel flow through the main fuel circuit and the idle fuel circuit.”

221. The Workshop Manual discloses a carburetor cutoff solenoid (i.e., a “Gasoline Cut Off Solenoid”) configured to selectively control fuel flow through the main fuel circuit and the idle fuel circuit. Ex. 1012, 65, 68. The Workshop Manual discloses the Gasoline Cut Off Solenoid controls fuel through the main fuel circuit: “With the fuel select switch (8) in the “GASOLINE” position “D”..., the battery current flows to the gasoline cut off solenoid (6). ***Therefore gasoline fuel in the float chamber flows to the mixing chamber.***” *Id.*, 68 (emphasis added).



Id., 67 (annotated).

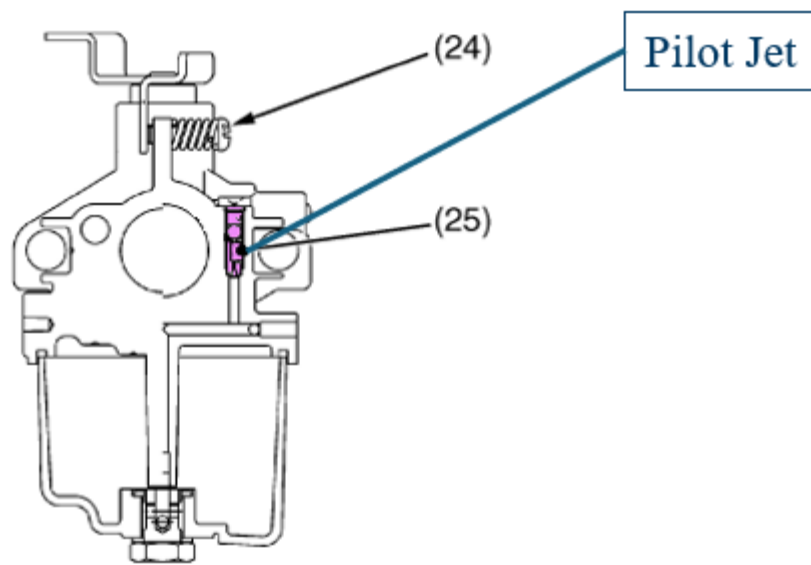


Ex. 1012, 68 (annotated).

222. The Workshop Manual discloses that in the idle fuel circuit (the Slow System), gasoline flows from the main nozzle to the pilot jet:

When the throttle valve (12) closes, air that flows into the cylinder passes along the valve at a high speed. As a result, a negative pressure is [created] in the pilot outlet (19) which has an outlet port in the inner wall. This causes gasoline in the main nozzle (13) to flow through the pilot jet (25) to be sucked into the cylinder.

Ex. 1012, 67. The pilot jet is part of the idle fuel circuit. *Supra* __.



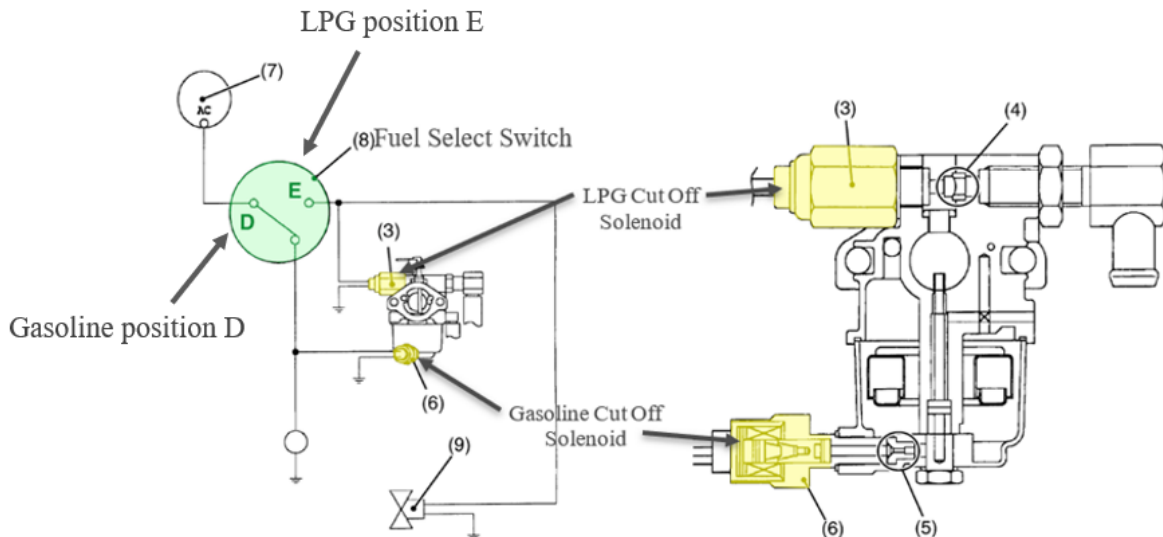
Ex. 1012, 67 (annotated).

223. Because the carburetor cutoff solenoid (i.e., the Gasoline Cutoff Solenoid) is upstream of both the main jet and the pilot jet, it selectively controls fuel flow through the main fuel circuit and the idle fuel circuit. Ex. 1012, 67.

7. Claim 19

224. Claim 19 depends from Claim 18, and further requires “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.”

225. The Workshop Manual discloses the carburetor cutoff solenoid (i.e., the Gasoline Cutoff Solenoid) is operatively coupled to a switch (the Fuel Select Switch) that changes operation of the engine from liquid fuel (gasoline) to gaseous fuel (LPG) and vice versa. Ex. 1012, 68. The Workshop Manual illustrates the operation of the switch:



Ex. 1012, 68 (annotated).

226. A POSA would understand the switch changes operation from gasoline to LPA and vice versa, while the engine is running. *See* §XII.E.3.

227. When the switch changes operation of the engine from liquid fuel to gaseous fuel, the carburetor cutoff solenoid (the Gasoline Cutoff Solenoid) also stops liquid fuel flow through both the main fuel circuit and the idle fuel circuit (the “Slow System”). *See* §XII.E.6.g.

228. A POSA would have understood the switch could be toggled between gasoline and LPG positions to switch between fuel sources while the generator/engine is running via operation of the gasoline and LPG cut off solenoids. *See above* §XII.E.3. This is confirmed by the Operator's Manual. *Id.*

229. Thus, I conclude the Workshop Manual anticipates Claim 19 under §102, as further informed by the Operator's Manual. In addition, Claim 19 is obvious in view of the Workshop and Operator's Manuals.

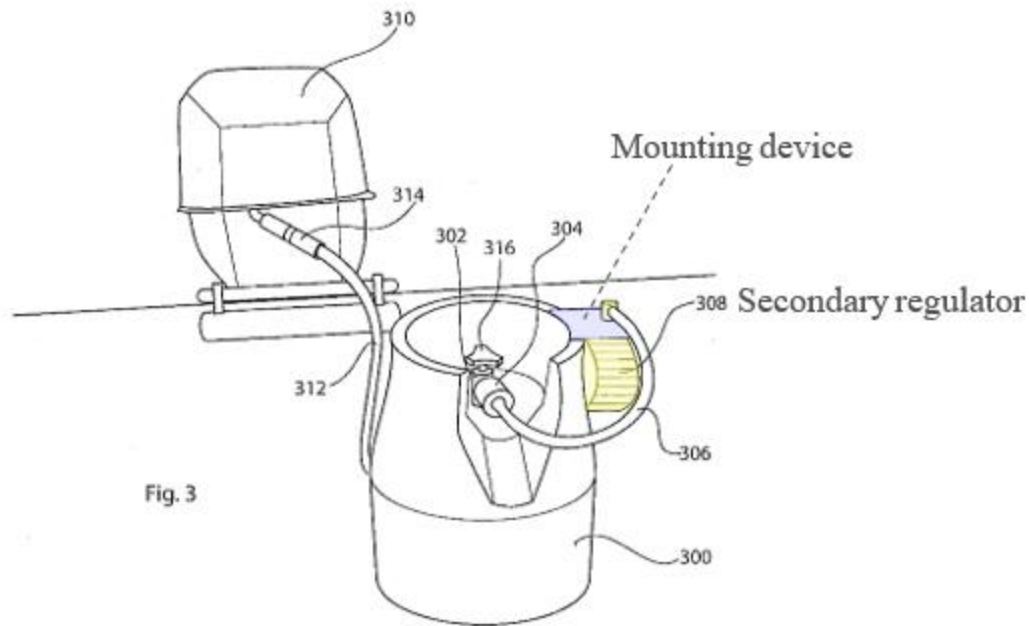
F. Ground 6: Claim 16 is obvious over The Workshop Manual in view of Parlatore

230. Claim 6 of the '120 Patent is obvious for at least the reasons described below.

1. Claim 16

231. Claim 16 depends from Claim 12 and further recites "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."

232. Parlatore discloses LPG tank 300 located off-board its engine and a regulator mounting device to secure the secondary pressure regulator 308 to the LPG tank:



Ex. 1010, Fig. 3 (annotated).

233. It would have been obvious to use Parlature's off-board configuration with the DF972 engine of the Workshop Manual for the same reasons discussed with respect to using Parlature's off-board configuration with Imamura's engine in a generator. *See* §XII.D.1.b. Parlature shows that a POSA would have had a reasonable expectation of success using an off-board fuel regulator system. Ex. 1010, ¶¶[0019]-[0022], Fig. 3.

G. Ground 7: Claims 12-17 are obvious over Nakafushi in view of Jungmann and Parlature

234. Claims 12-17 of the '120 Patent are obvious for at least the reasons described below.

1. Claim 12

a. Element [12.0]

235. Element [12.0] recites “a multi-fuel generator and fuel delivery system.”

236. Nakafushi discloses a “gasoline/LPG combined engine configured to selectively use gasoline or LPG as a fuel.” Ex. 1005, ¶[0001]. A POSA would understand that gasoline and LPG constitute multiple fuels, and therefore that the disclosed engine is a “multi-fuel” engine.

237. Jungmann discloses using an engine with a gasoline or propane fuel-delivery system in a generator:

One embodiment of the invention relates to *a generator including* an enclosure, *an internal combustion engine* provided within the enclosure, an alternator provided within the enclosure and driven by the internal combustion engine, *a fuel supply line for providing fuel to the internal combustion engine, a valve for selectively closing the fuel supply line*, the valve biased to a normally closed position, a controller configured to provide a signal to maintain the valve in an open position, and a temperature responsive device configured to provide a signal to maintain the valve in an open position, and a temperature responsive device configured to interrupt the signal from the controller to the valve upon exposure to a

threshold temperature, thereby resulting in the closing of the valve.

Ex. 1011, ¶[0002] (emphasis added).

238. As of the priority date, it was common to use an internal combustion engine in a generator. In fact, a POSA would be aware that an engine is a crucial component of most generators.

Portable generators for producing electricity are well known and have been commercially available for many years. *These devices typically include an internal combustion engine*, are designed to generate sufficient electrical power to run one or more common household or commercial electronic devices, and typically use gasoline as fuel.

See e.g., Ex. 1020, 1:5–10 (emphasis added).

239. In view of Jungmann, a POSA would have found it obvious to use Nakafushi's engine in a generator

a. Motivation/Expectation of Success

240. A POSA would have been motivated to use Nakafushi's engine in a generator so that gasoline or LPG could be used as a fuel source while generating electricity for the user.

241. Jungmann specifically discloses the use of propane, natural gas, gasoline, or diesel fuel in a combustion engine being used in a generator:

According to one exemplary embodiment, the engine 12 is an internal combustion engine that consumes a fuel such as *propane or natural gas* from a fuel supply line 16. . . . In other embodiments, the engine 12 may consume other types of fuel, such as *gasoline or diesel fuel*.

Ex. 1011, ¶[0015]; *see also* Ex. 1020, 4:7–11 (“A gasoline or propane generator is a generator including a carburetor and manual choke, which operates most efficiently using gasoline or propane, respectively, when the choke is placed in the fully open position, after the generator has been started.”).

242. A POSA would understand that using an internal combustion engine, such as that disclosed by Nakafushi, to power a generator (as shown in Jungmann) offers various advantages.

243. For example, internal combustion engines are comparatively compact and lightweight for the power they are able to deliver, making them especially ideal for portable applications, such as portable generators.

244. Internal combustion engines also run on fuels, such as propane and/or gasoline, that are common and widely available. This ensures that refueling is convenient to a user and that the generator can be used in various locations without special infrastructure, since both gasoline and gaseous fuels such as LPG and natural gas are widely available.

245. Internal combustion engines are also a cost-effective way to provide

significant power output relative to their size.

246. Internal combustion engines are also durable and reliable. With proper maintenance, they can operate efficiently for years.

247. And finally, internal combustion engines are easy to use; starting an internal combustion engine is straightforward, often requiring just a pull-start or a key ignition.

248. Because a POSA would have been aware of all of these benefits at the time of the invention, it would have been obvious to a POSA to use the internal combustion engine disclosed in Nakafushi to power a generator, as shown in Jungmann.

249. Purposing Nakafushi's engine for use in/as a generator would have involved nothing more than a simple substitution, whereby Nakafushi's engine is used in place of Jungmann's engine, with no surprising or unexpected results since the benefits of dual-fuel engines were already well-known in the art.

250. A POSA would also have had a reasonable expectation of success in using Nakafushi's multi-fuel engine in a generator given that this implementation was already demonstrated by Jungmann. Using Nakafushi's engine in a generator would be implemented in the same way as the engine is used in a generator as disclosed in Jungmann. *Id.*, ¶¶[1014]–[1015].

251. As one specific example, Nakafushi's engine could be used in a generator simply by adding an alternator to the engine, as was already common and well known by that time (for example, alternators were commonly combined with car engines to generate electricity, and generators driven by internal combustion engines were commonly sold at hardware stores well before the priority date). A POSA was well aware of how common it was for a combustion engine to produce electricity and thus function as a generator. A POSA would similarly appreciate how a combustion engine would produce electricity and function as a generator. This is illustrated by Jungmann. Ex. 1011, ¶¶[0001-0002].

b. Element [12.1]

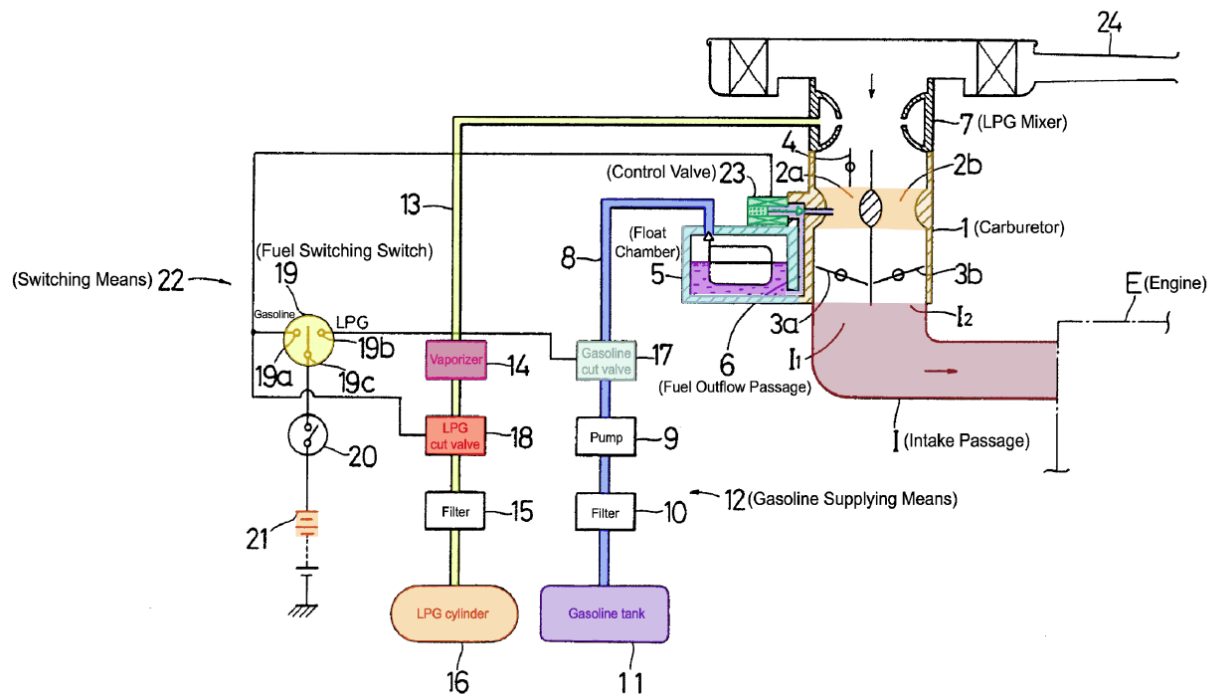
252. Element [12.1] recites “a multi-fuel internal combustion engine configured to operate on a liquid fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel supplied from a pressurized fuel source through a gaseous fuel line.”

253. Nakafushi's engine selectively uses gasoline or LPG as fuel. Ex. 1005, ¶[0001]. Nakafushi's “liquid fuel source” is gasoline tank 11, which supplies gasoline through supply passage 8 to carburetor 1, and on to the engine E through fuel outflow passage 6 and intake I. Ex. 1005, ¶¶[0010], [0012], Fig. 1.

254. Nakafushi's “pressurized fuel source” is LPG cylinder 16, which supplies gaseous fuel through supply passage 13 to the carburetor 1, and from there

to the engine E through intake I. Ex. 1005, ¶[0012], Fig. 1. A POSA would have appreciated that LPG tanks such as Nakafushi's cylinder 16 store LPG under pressure, which is necessary given LPG's boiling point of approximately minus 40°C (assuming a propane-dominant mixture). See Ex. 1001, 1:53-54 (acknowledging that LPG "can be conveniently stored under pressure in a liquid state").

FIG. 1



Ex. 1005, Fig. 1 (annotated).

c. Element [12.2]

255. Element [12.2] recites “an alternator driven by the multi-fuel internal combustion engine.”

256. Jungmann discloses an alternator driven by an internal combustion engine. Ex. 1011, ¶[0002]; *see* §XII.D.1.a. As discussed, a POSA would have found it obvious to combine the alternator from Jungmann with the dual-fuel engine in Nakafushi to create a generator. *See* §XII.G.1.a.

d. Element [12.3]

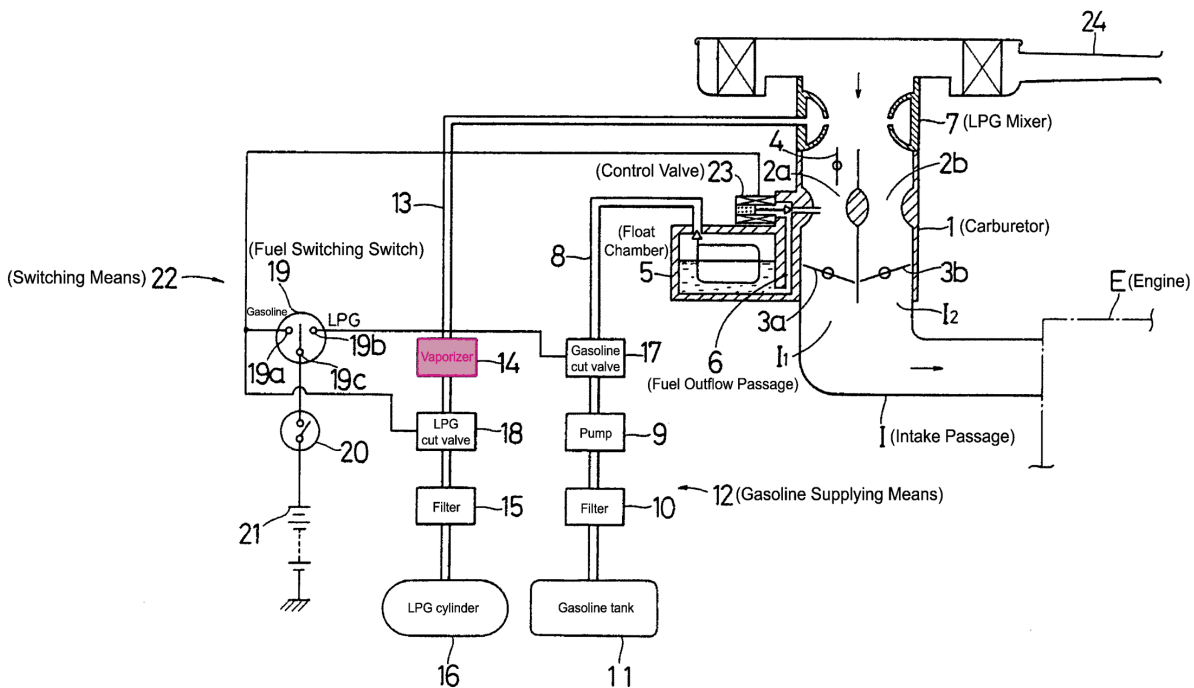
257. Element [12.3] recites “a fuel regulator system.”

258. Nakafushi discloses vaporizer 14 for vaporizing the LPG prior to delivery to the carburetor:

Furthermore, the LPG mixer 7 is communicated with an LPG bomb [sic: cylinder] 16 as an LPG supplying means by an LPG supplying passage 13 via a *vaporizer 14 for vaporizing LPG* and a filter 15.

Furthermore, a gasoline cut valve 17 configured to close the gasoline supplying passage 8 in response to a cut signal (described later) is provided in the gasoline supplying passage 8 so as to intervene between the float chamber 5 and the pump 9. On the other hand, an LPG cut valve 18 configured to close the LPG supplying passage 13 in response to a cut signal (described later) is provided in the LPG supplying passage 13 so as to intervene between the *vaporizer 14* and the filter 15.

Ex. 1005, ¶¶[0012]-[0013] (emphasis added). Nakafushi’s vaporizer is depicted in Figure 1:

FIG. 1

Id., Fig. 1 (coloring added).

259. A POSA would have appreciated that the “vaporizer” in Nakafushi is a device that turns liquid fuel into vapor/gas and regulates the pressure of the gas being delivered to the engine for operation with the pressurized LPG fuel source. Indeed, LPG is stored as a liquid and is converted to a gas (i.e. vaporized) by regulating the pressure. Thus, Nakafushi’s vaporizer 14 constitutes the claimed “fuel regulator system.”

260. Moreover, even though Nakafushi’s vaporizer is not expressly described as such, LPG vaporizers were well-known in the art to comprise dual-stage pressure regulators.

261. For example, Parlatore teaches providing fuel to an engine through a first regulator 304, followed by flow through a second regulator to regulate the pressure of the gaseous fuel that moves on to the engine:

One exemplary embodiment describes a fuel delivery system. The fuel delivery system may include a fuel tank that houses propane; *a first regulator coupled to the fuel tank; a second regulator coupled to the first regulator;* and a fuel metering system coupled to the second regulator and delivering propane to an engine.

Another exemplary embodiment can include a method for providing fuel to an engine. The method for providing fuel to an engine can include storing liquid propane in a tank; flowing the liquid propane to a first regulator; converting the liquid propane to a propane vapor by the first regulator; flowing the propane vapor to a second regulator; metering the flow of the propane vapor from the second regulator to an engine; and maintaining the temperature of the propane at about an ambient temperature.

Ex. 1010, ¶¶[0005]-[0006] (emphasis added). Parlatore further teaches that:

In a further exemplary embodiment, *the LPG tank 102 may be connected to a regulator, such as a primary regulator 106, converter or vaporizer.* This connection may be made using a hose 104, such as a high pressure hose, or any form of pipe, for example a rigid pipe. The

primary regulator 106 may step down the pressure of any stored propane vapor energy in tank 102, and may further output this lowered pressure to a secondary regulator 110. For example, *the primary regulator 106 may be such that it reduces pressure of the propane from a high pressure state* while the propane is in the LPG tank 102, which may be approximately 180-250 psi, *to a sub-atmospheric pressure*, approximately 10 psi. The secondary regulator 110 can act as a vacuum-controlled flow rate regulator. Further, *the secondary regulator 110 can meter propane gas to an engine 116*, for example, through a negative pressure signal, such as a vacuum signal, from the air-fuel mixer on a carburetor 114 designed or modified to use propane as a fuel source.

262. *Id.*, ¶[0016] (emphasis added). Parlatore's Figure 1 shows an exemplary flow of gaseous fuel to supply the engine from a storage tank:

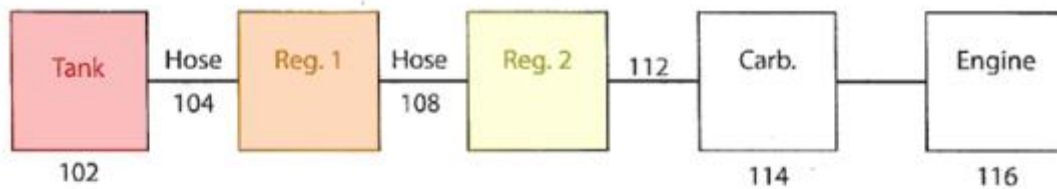


Fig. 1

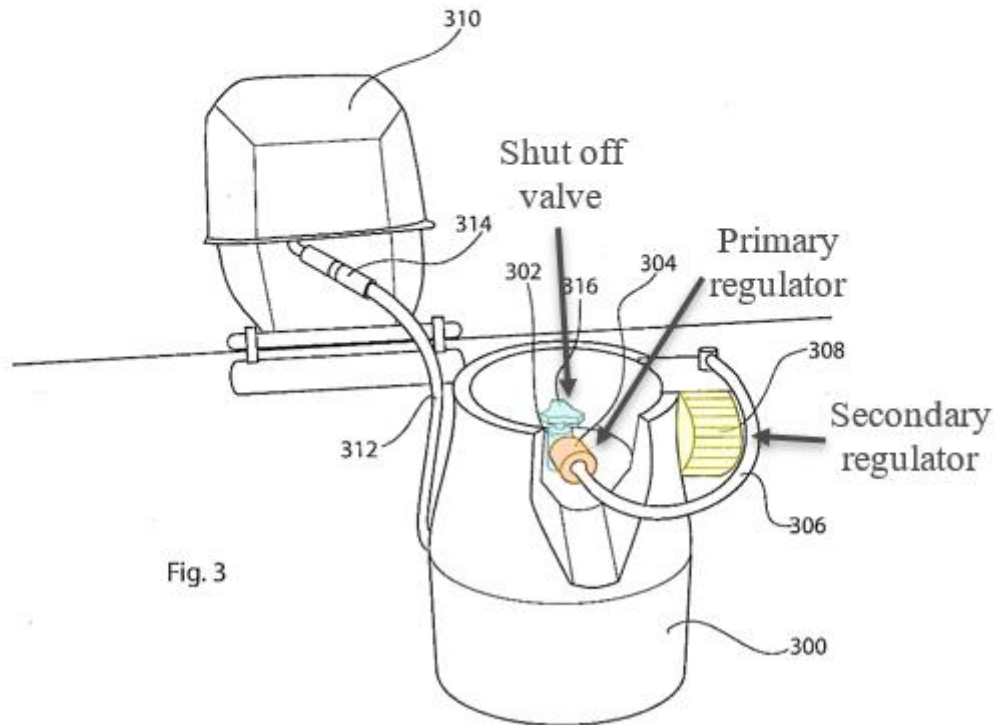


Fig. 3

Id., Figs. 1, 3 (annotated).

263. As disclosed, the first regulator (Reg. 1) acts as the main step-down pressure regulator, while the second (Reg. 2) acts as the flow meter to the engine.

Id., ¶¶[0016]-[0017] & ¶¶[0020]-[0021].

264. Parlatore further discloses that the primary and secondary regulators may be combined as a single, two-stage, regulator to feed the vaporized propane into the carburetor:

In further exemplary embodiments, and referring to FIG. 2, the regulator arrangement of the primary regulator 106 and the secondary regulator 110 *may be such that they are combined as a single, two-stage, regulator 202*. In this exemplary embodiment the combined regulator 202 would then feed the vaporized propane into carburetor 114 through hose 112. Additionally, as shown in exemplary FIG. 2, LPG tank 200, in some examples, may be coupled directly to engine 116, using any desired coupling, such as mounting bracket 204.

Id., ¶[0018] (emphasis added); *see also id.* Fig. 2 (two-stage regulator 202).

265. Jungmann also teaches a fuel regulator system, disclosing that “[t]he fuel supply line 16 may deliver fuel to a device such as a pressure regulator 28 that controls the flow of fuel to the engine 12.” Ex. 1011, ¶[0017]. A POSA would thus have also understood Jungmann’s fuel regulator 28 to constitute the claimed “fuel regulator system” since it reduces and controls the fuel from the pressurized fuel container and delivers it at the desired pressure for operation of the engine.

266. To the extent not sufficiently disclosed by Nakafushi or Jungmann, it would have been obvious to a POSA to incorporate Parlatore’s two-stage fuel regulator system (either as two separate regulators, or as a combined dual-stage regulator) to regulate the LPG gas pressure supplied to Nakafushi’s engine when operating on LPG.

i. Motivation/Expectation of Success

267. A POSA would have been motivated to utilize Parlatore's fuel regulator system with Nakafushi's engine for several reasons.

268. First, Nakafushi discloses vaporizer 14 along the LPG supply line. Ex. 1005, ¶¶[0012]-[0013]; Fig. 1. According to Parlatore (Ex. 1010, ¶[0004]), if Nakafushi's vaporizer had only a single stage, it could freeze due to the endothermic nature of vaporizing a liquid under pressure in typical conditions.

269. Specifically, Parlatore states:

Other attempted solutions, for example the use of liquid propane delivery systems, have not proved successful. In such uses of propane, the *vaporization of propane from its liquid state causes a significant amount of heat to be absorbed, ultimately freezing the regulator through which the propane flows from a tank to the engine and rendering the engine inoperable.*

Id., ¶¶[[0004] (emphasis added). Parlatore further adds:

In each of the exemplary embodiments described herein the arrangement of the regulators 106 and 110, 202 and 304 and 308, as shown in FIGS. 1-3, respectively, can maintain about an ambient temperature from the surrounding air temperature rather than utilizing an interface with a cooling circuit of the engine 116 or other heat source to function as desired. In some other

exemplary embodiments, the temperature maintained by any regulators described herein may be such that the flow of propane is allowed as desired. This may be accomplished as a result of the vapor delivery nature of the system as well as a design match of the system to fit specific air-fuel requirements of an engine size, for example for a marine engine. The maintenance of the regulator at about an ambient temperature may be facilitated by both the design of the regulator or regulators which may be sized to a specific engine, for example a marine engine having a known or desired horsepower rating. Additionally, the maintenance of the about ambient temperature may be such that the regulator or regulators are not affected, for example, by freezing as a result of the conversion of the LPG from tank 102 to a gaseous state and the flow of the fuel is not negatively affected or impacted.

Id., ¶[0022]. Parlatores thus teaches (and shows that a POSA understood) that the primary and secondary LPG regulators can be appropriately sized to avoid excessive cooling/freezing, which helpfully thereby avoids the need for using a warming stream of coolant from the engine to maintain operational temperatures within the regulators. This is one reason why Parlatores's regulators can be located remote from the engine, since engine heat is not needed to maintain the regulators' operation.

270. While this may be prevented by routing a source of heat to the vaporizer, such as from the engine cooling system (*see, e.g.,* Ex. 1010, ¶[0022]), such systems are more costly to design and build and more complicated to operate.

271. Parlatore's two-stage fuel regulator system solves this problem by partially reducing the pressure in the first regulator, and then further reducing the pressure in the second-stage regulator to more precisely control delivery to the engine, as described:

One exemplary embodiment describes a fuel delivery system. The fuel delivery system may include a fuel tank that houses propane; *a first regulator coupled to the fuel tank; a second regulator coupled to the first regulator;* and a fuel metering system coupled to the second regulator and delivering propane to an engine.

Another exemplary embodiment can include a method for providing fuel to an engine. The method for providing fuel to an engine can include storing liquid propane in a tank; flowing the liquid propane to a first regulator; *converting the liquid propane to a propane vapor by the first regulator; flowing the propane vapor to a second regulator; metering the flow of the propane vapor from the second regulator to an engine;* and maintaining the temperature of the propane at about an ambient temperature.

...

In a further exemplary embodiment, *the LPG tank 102 may be connected to a regulator, such as a primary regulator 106, converter or vaporizer*. This connection may be made using a hose 104, such as a high pressure hose, or any form of pipe, for example a rigid pipe. *The primary regulator 106 may step down the pressure of any stored propane vapor energy in tank 102, and may further output this lowered pressure to a secondary regulator 110*. For example, the primary regulator 106 may be such that it reduces pressure of the propane from a high pressure state while the propane is in the LPG tank 102, which may be approximately 180-250 psi, to a sub-atmospheric pressure, approximately 10 psi. The secondary regulator 110 can act as a vacuum-controlled flow rate regulator. Further, the secondary regulator 110 can meter propane gas to an engine 116, for example, through a negative pressure signal, such as a vacuum signal, from the air-fuel mixer on a carburetor 114 designed or modified to use propane as a fuel source.

Id., ¶¶[0005]-[0006], [0016] (emphasis added).

272. Thus, a POSA would have been motivated to utilize Parlatore's fuel regulator system in Nakafushi's engine to avoid regulator freezing and/or the need for a heat source, while maintaining better reliability and more precise control over

LPG fuel delivery to the engine.

273. A POSA would have reasonably expected success in implementing Parlatore's dual-stage fuel regulator system in Nakafushi's engine for use in a generator because Parlatore expressly states that its fuel regulator system can be implemented in generators:

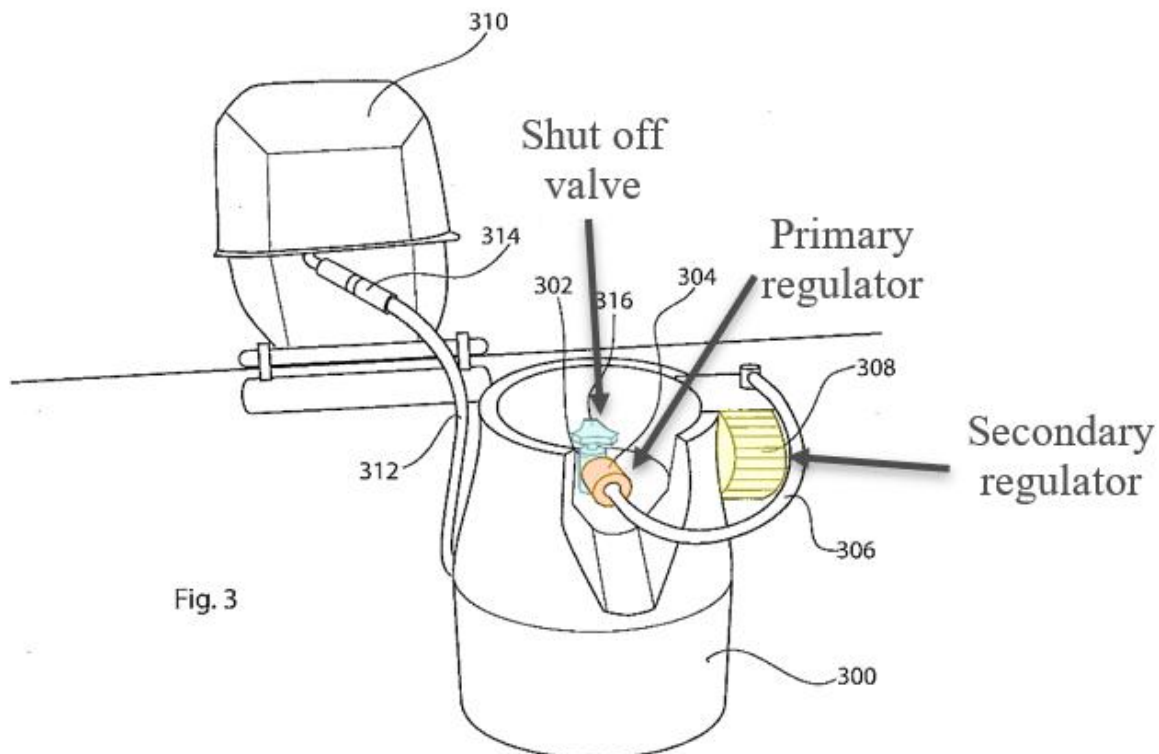
The exemplary embodiment shown in FIG. 2 may be utilized in any desired situation, such on a small or single-cylinder outboard engine. The mounting of LPG tank 200 on the engine may provide many advantages. For example, this embodiment may be beneficial in some desired situations, for example when utilizing compact fuel supplies on a general yacht tender service or for any other similar-sized application, ***such as generators*** or personal watercraft where storage space or space of a fuel tank may be limited.

Id., ¶[0019] (emphasis added). This would have involved nothing more than replacing Nakafushi's vaporizer 14 with Parlatore's first and second regulators, or its dual-stage regulator, to achieve the same function or vaporizing the LPG and providing it to the engine at the desired pressure.

e. Element [12.4]

274. Element [12.4] recites “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.”

275. Parlatore discloses a primary regulator 304 coupled to service valve 316 of the pressurized propane tank 300. Ex. 1010, Fig. 3. Regulator 304 regulates the propane to a reduced pressure. *Id.*, ¶[0016]; *see also* ¶[0020] (referring to the “primary regulator 304, as described previously [as primary regulator 106]”). Parlatore’s Figure 3 shows an exemplary embodiment:



Ex. 1010, Fig. 3 (annotated). Parlature's two-stage regulator 202 also comprises a primary, first-stage regulator coupled to the LPG tank. Ex. 1010, ¶[0018]-[0019], Fig. 2.

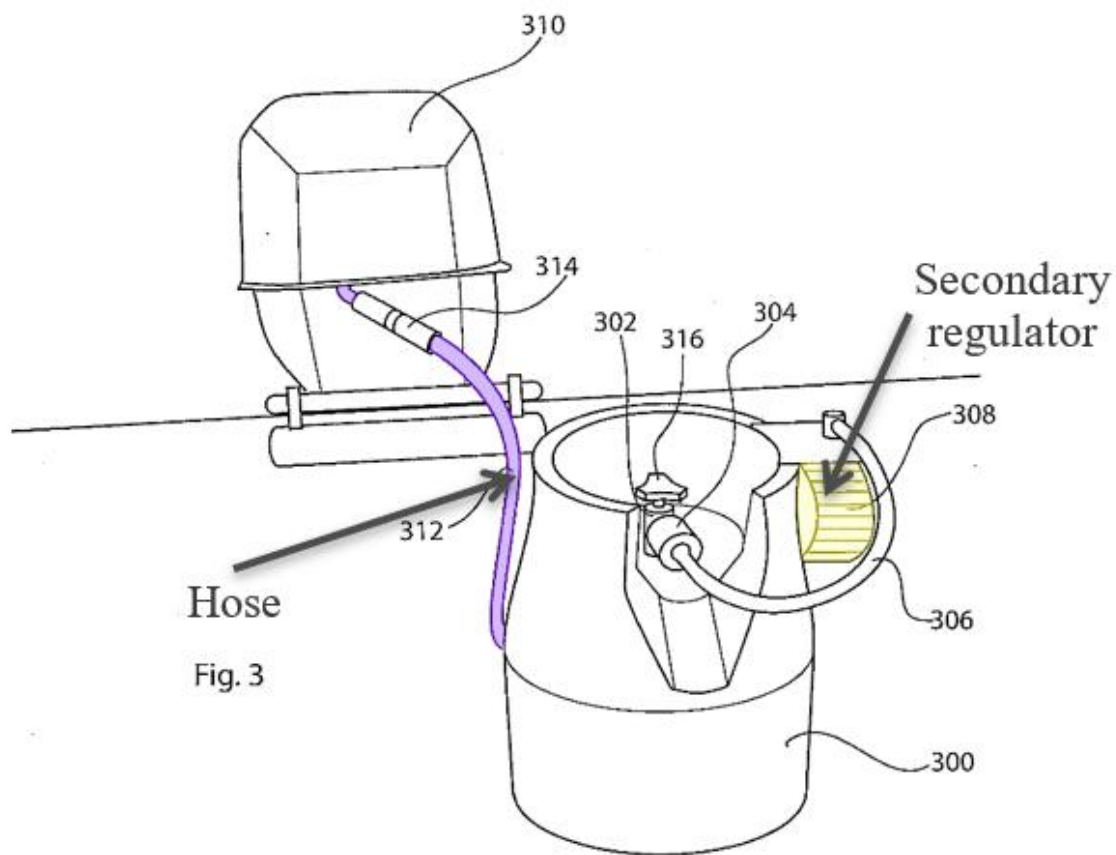
276. Parlature's fuel regulator system would have been obvious to incorporate for use with Nakafushi's engine as discussed. *See above* §§XII.G.1.d, XII.D.1.b. Similarly, it would have been obvious to use Parlature's LPG tank 300 along with its service valve 316 with Nakafushi's engine given that such LPG tanks having service valves were well-known and ubiquitous. This would have involved nothing more than using Parlature's LPG tank configuration as the LPG fuel source for Nakafushi, with each performing their intended function without any unexpected results.

f. Element [12.5]

277. Element [12.5] recites "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."

278. Parlature discloses secondary pressure regulator 308, coupled to the primary pressure regulator 304, for regulating the propane to a low pressure for feeding to the carburetor through hose 312. Ex. 1010, ¶[0020], Fig. 3; *see also id.*, ¶¶[0005]-[0006], [0016]-[0017]. Parlature's two-stage regulator 202 also

comprises a second-stage for the same purpose. *Id.*, ¶[0018]. Parlatore's fuel regulator system, including its secondary regulator as described above, would have been obvious to incorporate for use with Nakafushi's engine to provide gaseous LPG fuel to the engine at the desired pressure via a gaseous fuel line, i.e., where Parlatore's hose 312 replicates Nakafushi's gaseous fuel passage 13, as seen in Figure 3:



See above §§XII.G.1.d, XII.D.1.b.

2. Claim 13

279. Claim 13 depends from Claim 12 and further recites “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.”

280. Nakafushi discloses an electro-mechanical valve system coupled to an engine that controls liquid and pressurized gas fuel flow via operation of an electrical switch (fuel switch 19) that is powered by battery 21:

Furthermore, a gasoline cut valve 17 configured to close the gasoline supplying passage 8 in response to a cut signal (described later) is provided in the gasoline supplying passage 8 so as to intervene between the float chamber 5 and the pump 9. On the other hand, an LPG cut valve 18 configured to close the LPG supplying passage 13 in response to a cut signal (described later) is provided in the LPG supplying passage 13 so as to intervene between the vaporizer 14 and the filter 15. ***Both of the cut valves 17 and 18 are connected to a gasoline-side contact point 19a and an LPG side contact point 19b of a two-pole fuel switching switch 19, respectively, and a switching means 22 in which a common contact point 19a of the fuel switching switch 19 is connected to a battery 21 via an ignition switch 20.*** When the ignition switch 20 is turned ON, when the engine E is operated as a gasoline engine,

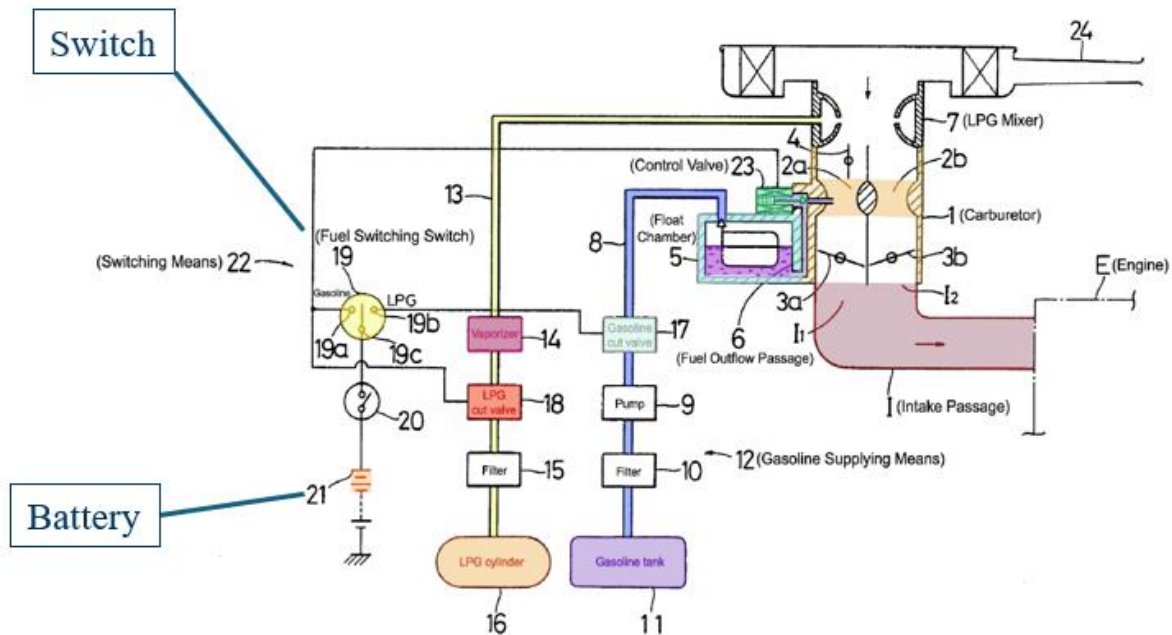
the fuel switching switch 19 is switched to the gasoline-side contact point 19a and a cut signal is input to the LPG cut valve 18 to block the supply of LPG to the LPG mixer 7 and operate the gasoline supplying means 12 to supply gasoline to the carburetor 1, whereas when the engine E is operated as an LPG engine, the fuel switching switch 19 is switched to the LPG side contact point 19b and a cut signal is input to the gasoline cut valve 17, whereby the gasoline supply to the carburetor 1 is blocked, and an LPG supplying means (LPG bomb) 16 is operated to switch so as to supply LPG to the LPG mixer 10, is provided.

Furthermore, a control valve 23 configured to open and close the fuel outflow passage 6 is disposed so as to intervene in the fuel outflow passage 6. *the control valve 23 is connected to the gasoline contact point 19a of the fuel switching switch 19, and is configured so that when the fuel switching switch 19 is switched to the gasoline contact point 19a side, that is, when the operation of the gasoline supplying means 12 is selected, the control valve 23 is turned ON* upon receiving a cut signal to open the fuel outflow passage 6, thereby allowing the gasoline to be sucked from the float chamber 5 to the Venturi portions 2a and 2b, whereas *when the fuel switching switch 19 is switched to the LPG contact point 19b side, that is, when the operation of the LPG bomb 16 is selected, the control valve 23 is turned OFF* by not receiving a cut signal to

close the fuel outflow passage 6, thereby blocking the suction of the gasoline from the float chamber 5 to the Venturi portions 2a and 2b.

Ex. 1005, ♯[0013]-[0014]. This arrangement can be seen in Figure 1:

FIG. 1



Id., Fig. 1.

281. The fuel switching switch 19 selectively connects or disconnects the valves (i.e., gasoline cut valve 17, LPG cut valve 18, and control valve 23) to/from the battery, thereby actuating the valves to their open or closed positions to control liquid and gas fuel flow. *Id.*, ¶¶[0013]-[0014], Fig. 1. Because these valves are mechanical valves that open and close the fuel paths in response to electrical signals powered by a battery pursuant to switch 19, a POSA would have

understood them to constitute an electro-mechanical valve system with an electrical switch.

3. Claim 14

282. Claim 14 depends from Claim 13 and further recites “the electro-mechanical valve system is configured to switch operation of the generator from multiple fuel sources while the generator is running.”

283. Nakafushi discloses fuel switch 19 that controls valve 23, the LPG cut valve 18 and gasoline cut valve 17 to prevent fuel flow from the liquid fuel source and the gaseous fuel source simultaneously. Ex. 1005, [0013]-[0014], Fig. 1.

284. Specifically, the switch simultaneously opens control valve 23 and gasoline cut valve 17 and closes the LPG valve 18 during gasoline operation and vice versa for LPG operation. Ex. 1005, ¶¶[0013]-[0014].

[0013] Furthermore, a gasoline cut valve 17 configured to close the gasoline supplying passage 8 in response to a cut signal (described later) is provided in the gasoline supplying passage 8 so as to intervene between the float chamber 5 and the pump 9. On the other hand, an LPG cut valve 18 configured to close the LPG supplying passage 13 in response to a cut signal (described later) is provided in the LPG supplying passage 13 so as to intervene between the vaporizer 14 and the filter 15. Both of the cut valves 17 and 18 are connected to a gasoline-side contact point 19a and an LPG side contact point 19b of a two-pole

fuel switching switch 19, respectively, and a switching means 22 in which a common contact point 19a of the fuel switching switch 19 is connected to a battery 21 via an ignition switch 20. When the ignition switch 20 is turned ON, when the engine E is operated as a gasoline engine, the fuel switching switch 19 is switched to the gasoline-side contact point 19a and a cut signal is input to the LPG cut valve 18 to block the supply of LPG to the LPG mixer 7 and operate the gasoline supplying means 12 to supply gasoline to the carburetor 1, whereas when the engine E is operated as an LPG engine, the fuel switching switch 19 is switched to the LPG side contact point 19b and a cut signal is input to the gasoline cut valve 17, whereby the gasoline supply to the carburetor 1 is blocked, and an LPG supplying means (LPG bomb [sic: cylinder]) 16 is operated to switch so as to supply LPG to the LPG mixer 10, is provided.

[0014] Furthermore, a control valve 23 configured to open and close the fuel outflow passage 6 is disposed so as to intervene in the fuel outflow passage 6. the control valve 23 is connected to the gasoline contact point 19a of the fuel switching switch 19, and is configured so that when the fuel switching switch 19 is switched to the gasoline contact point 19a side, that is, when the operation of the gasoline supplying means 12 is selected, the control valve 23 is turned ON upon receiving a cut signal to open the

fuel outflow passage 6, thereby allowing the gasoline to be sucked from the float chamber 5 to the Venturi portions 2a and 2b, whereas when the fuel switching switch 19 is switched to the LPG contact point 19b side, that is, when the operation of the LPG bomb [sic: cylinder] 16 is selected, the control valve 23 is turned OFF by not receiving a cut signal to close the fuel outflow passage 6, thereby blocking the suction of the gasoline from the float chamber 5 to the Venturi portions 2a and 2b.

285. This simultaneous operation of control valves 17, 18 and 23 prevents gasoline from entering the carburetor during LPG operation and prevents LPG from entering the carburetor during gasoline operation, i.e., it prevents both fuels from entering the carburetor simultaneously but allows for switching between the fuel sources while the engine is running (i.e., while the generator is running). Ex. 1005, [0013]-[0014].

286. Specifically, when Nakafushi's switch 19 is switched to the gasoline contact point 19a side, a cut signal is sent to the LPG cut valve 18 (the "gaseous cutoff") causing it to close (stopping the flow of LPG to the engine); simultaneously, a cut signal is sent to control valve 23 causing it to open and the lack of a cut signal causes gasoline cut valve 17 to open, thus allowing the flow of gasoline to the engine. Ex. 1005, ¶¶[0013]-[0014], Fig. 1. In contrast, when fuel switch 19 is switched to the LPG contact point 19b side, the reverse occurs where a

cut signal is sent to the gasoline cut valve 17 and the lack of a cut signal causes control valve 23 to close to stop gasoline flow; simultaneously, the lack of a cut signal causes LPG cut valve 18 to open. *Id.* Figure 1 shows the gasoline cut valve 17, LPG cut valve 18, and the control valve 23 are on the same circuit, such that the switching of switch 19 will “simultaneously” actuate all three valves to their respective open or closed positions. Ex. 1005, Fig. 1.

287. Nakafushi also discloses the claimed switching “while the generator is running,” teaching that:

even if the supply of gasoline to the float chamber is interrupted *in order to switch from the gasoline engine operation state to the LPG engine operation*, a predetermined amount of gasoline still remains in the float chamber, so that this residual gasoline is sucked into an intake passage and mixed with LPG, and as a result, the air-fuel mixture has an over-rich air-fuel ratio.

Id., ¶[0004] (emphasis added).

Nakafushi explains that the invention overcomes this problem:

an object of the present invention is, in a gasoline-LPG combined engine comprising a carburetor equipped with a float chamber, to enable *switching between a gasoline engine operation and an LPG engine operation during the operation of the engine* without causing becoming [sic] over-rich of an air-fuel mixture when switching to the

LPG engine operation and becoming over-lean when switching to the gasoline engine operation by blocking suction of gasoline from the float chamber to an intake passage during operation of the LPG engine.

Id., ¶[0005] (emphasis added); *see also id.*, ¶ [0016].

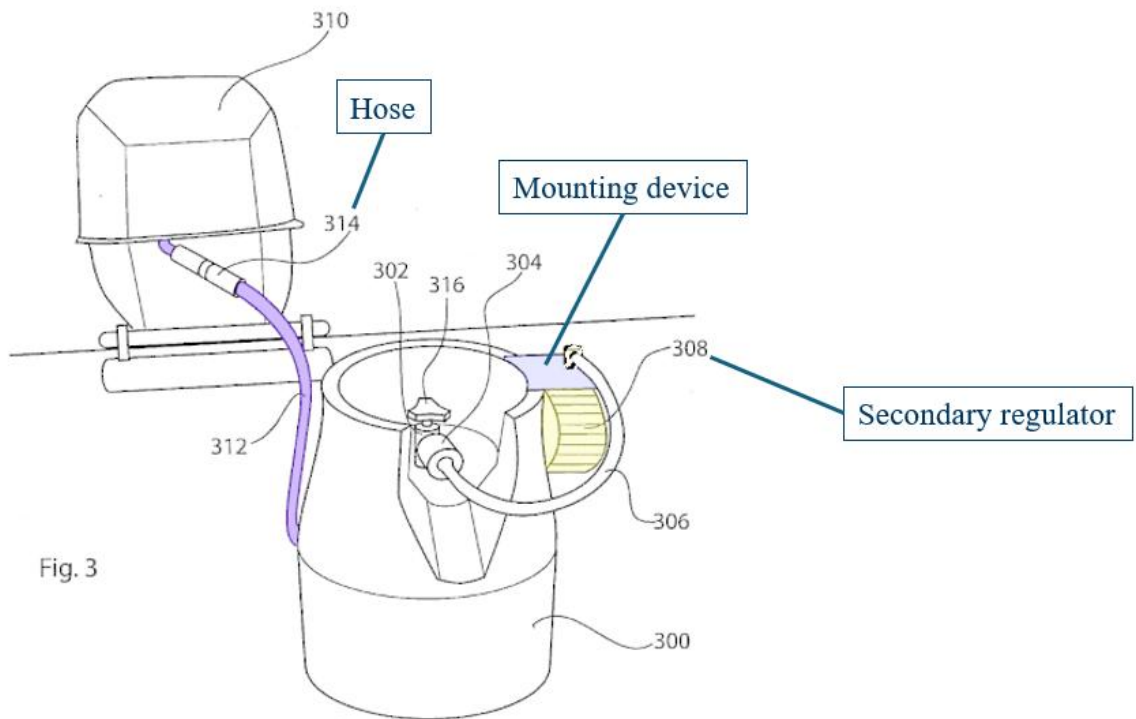
4. Claim 15

288. Claim 15 depends from Claim 13 and further recites “the electro-mechanical valve system is configured to prevent simultaneous delivery of the liquid fuel and the gaseous fuel to the engine.”

289. A POSA would have understood that because the same switch 19 operates all three valves (gasoline cut valve 17, LPG cut valve 18, and control valve 23) to change between liquid and gaseous fuels, simultaneous flow from the liquid and gaseous fuel sources is prevented, because when one fuel line is opened the other is simultaneously closed, and vice versa. **Claim 16**

290. Claim 16 depends from Claim 12 and further recites “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.”

291. Parlatore discloses LPG tank 300 located off-board its engine and a regulator mounting device to secure the secondary pressure regulator 308 to the LPG tank. The LPG tank is connected to the engine through hose 312.



Ex. 1010, Fig. 3 (annotated).

292. Parlatore further states: “[i]n still other exemplary embodiments, for example engines as shown in FIG. 3, which may be large or powerful engines, or any situation where more fuel may be desired, an LPG tank may be mounted or located in any desired position or location.” Ex. 1010, ¶[0024].

293. It would have been obvious to use this off-board configuration when using Parlatore's fuel regulator system with Nakafushi's engine in a generator for the same reasons discussed with respect to using Imamura's engine in a generator. *See above* §XII.D.1.b. Parlatore shows that a POSA would have had a reasonable

expectation of success using an off-board fuel regulator system. Ex. 1010, ¶¶[0019]-[0021], Fig. 3.

6. Claim 17

294. Claim 17 depends from Claim 12 and further recites “a dual stage pressure regulator comprises the primary pressure regulator and the secondary pressure regulator.”

295. Parlatore discloses this element: “the regulator arrangement of the primary regulator 106 and the secondary regulator 110 may be such that they are combined as a single, two-stage, regulator 202.” Ex. 1010, ¶[0018], Fig. 2.

H. Ground 8: Claims 18-19 are obvious over Nakafushi in view of Kirk and Olmr

296. Claims 18-19 of the '120 Patent are obvious for at least the reasons described below.

1. Claim 18

a. Element [18.0]

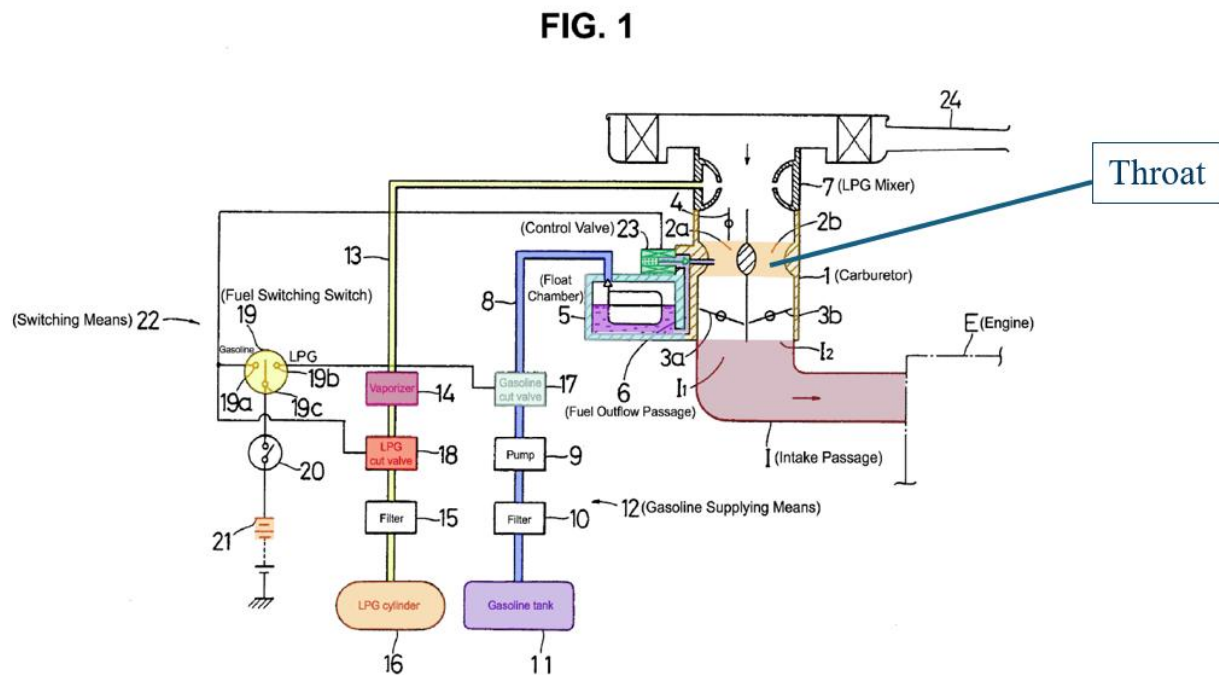
297. Element [18.0] recites “A carburetor for use in a multi-fuel internal combustion engine.”

298. Nakafushi discloses a carburetor 1 for use in a “gasoline/LPG combined engine configured to selectively use gasoline or LPG as a fuel.” Ex. 1005, ¶¶[0001], [0010], Fig. 1.

b. Element [18.1]

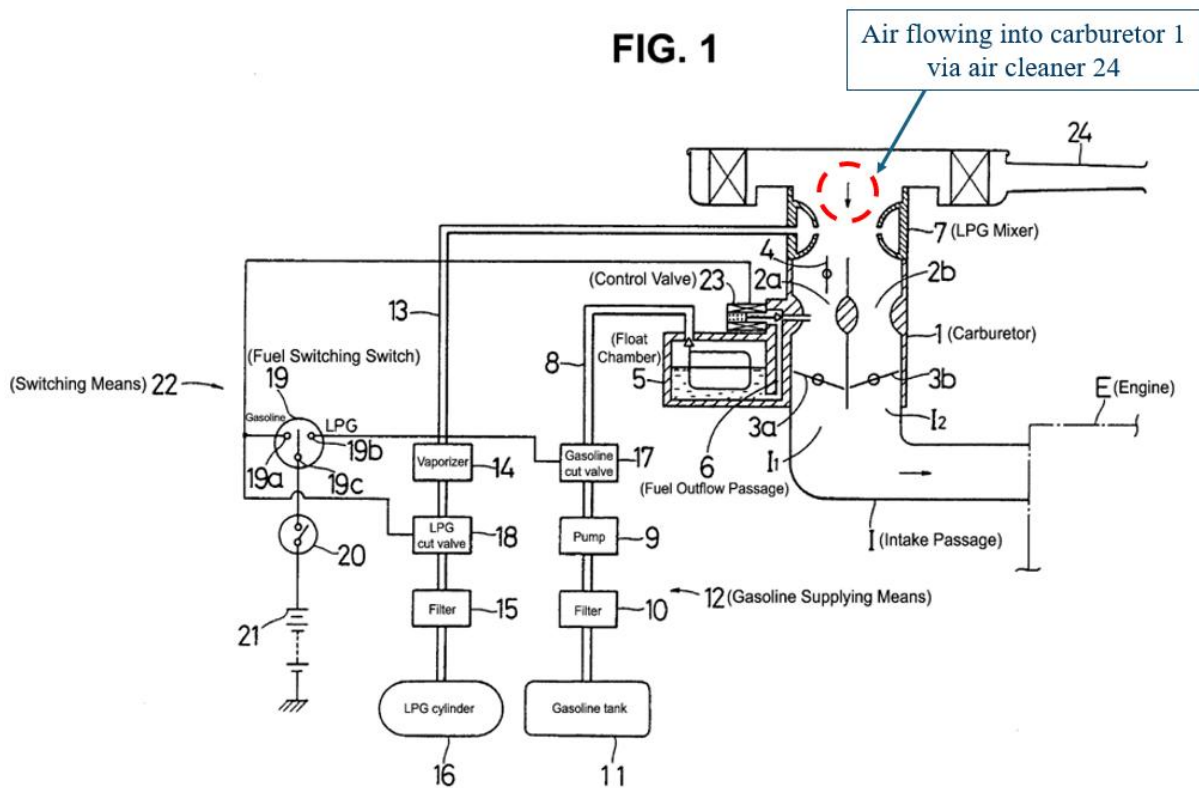
299. Element [18.1] recites “a throat in which fuel and air are mixed in throat to provide an air-fuel mixture for the multi-fuel internal combustion engine”

300. Nakafushi discloses a throat of the carburetor 1 in which fuel and air are mixed, as seen in annotated Figure 1:



Ex. 1005, Fig. 1 (annotated).

301. Nakafushi discloses air flowing into carburetor 1 through air cleaner 24 to mix with gasoline or LPG in venturi portions 2a and 2b, as seen in Figure 1:



Id., Fig. 1 (annotated), ¶[0015]. Nakafushi discloses “the float chamber 5 is communicated with the Venturi portions 2a and 2b of the carburetor 1 via a fuel outflow passage 6 having a small diameter, so that the gasoline in the float chamber 5 is sucked into the Venturi portions 2a and 2b and atomized and supplied during the operation of the engine E.” *Id.*, ¶[0010]. Nakafushi further states “5 denotes a float chamber in which gasoline is stored....” *Id.*

302. A POSA would have understood that engines such as Nakafushi’s operated by mixing fuel (either gasoline or LPG in the case of Nakafushi) with air prior to combustion in the engine. This is confirmed by Nakafushi’s numerous

references to the “air-fuel ratio” with regard to gasoline (and/or LPG) being mixed with air:

However, in this case, even if the supply of gasoline to the float chamber is interrupted in order to switch from the gasoline engine operation state to the LPG engine operation, a predetermined amount of gasoline still remains in the float chamber, so that this residual gasoline is sucked into an intake passage and mixed with LPG, and as a result, the air-fuel mixture has an over-rich *air-fuel ratio*. Furthermore, since the level of the gasoline in the float chamber decreases due to this suction of the residual gasoline, even if the supply of gasoline to the float chamber is started in order to reversely switch the LPG engine operating state to the gasoline engine operation state, the suction of the gasoline from the float chamber to the intake passage is delayed until the level of the gasoline recovers to a predetermined value, and as a result, the *air-fuel ratio* of the *air-fuel mixture* becomes over-lean.

The present invention has been made in view of such points, and an object of the present invention is, in a gasoline-LPG combined engine comprising a carburetor equipped with a float chamber, to enable switching between a gasoline engine operation and an LPG engine operation during the operation of the engine without causing becoming over-rich of an *air-fuel mixture* when switching to the LPG engine operation and becoming

over-lean when switching to the gasoline engine operation by blocking suction of gasoline from the float chamber to an intake passage during operation of the LPG engine.

Id., ¶¶[0004]–[0005] (emphasis added).

According to the above-mentioned configuration, in the present invention, during the operation of the engine, at the time of switching the LPG engine operation in which the operation of the LPG supplying means is selected by the switching means, the control valve blocks the suction of gasoline from the float chamber to the intake passage, so that the gasoline remaining in the float chamber is not sucked out to the intake passage, which blocks the *air-fuel mixture* from being over-rich. On the other hand, at the time of switching to the gasoline engine operation, the residual gasoline at the above-mentioned predetermined level is rapidly sucked out to the intake passage, which blocks the *air-fuel mixture* from being over-lean.

Id., ¶[0008] (emphasis added).

Therefore, in the above-described Example, during the operation of the engine, when the operation is switched to the LPG engine operation, the control valve 23 is turned OFF to close the fuel supplying passage 6 so that the gasoline remaining in the float chamber 5 is not sucked into the Venturi portions 2a and 2b. Therefore, becoming over-rich of the *air-fuel mixture* due to the suction of the

gasoline can be prevented, and the level of the gasoline in the float chamber 5 can be maintained at a predetermined value. Furthermore, during the engine operation, when the operation is switched to the gasoline engine operation, the control valve 23 is turned ON by a cut signal from the gasoline-side contact point 19a of the fuel switching switch 19 to open the fuel supplying passage 6, whereby the gasoline remaining in the float chamber 5 at a predetermined level is quickly sucked into the Venturi portions 2a and 2b, thereby preventing the *air-fuel mixture* from becoming over-lean. Therefore, it is possible to appropriately switch between the gasoline engine operation and the LPG engine operation during the engine operation while securing a good combustion state by preventing the *air-fuel mixture* from becoming over-rich when switching to the LPG engine operation and from becoming over-lean when switching to the gasoline engine operation.

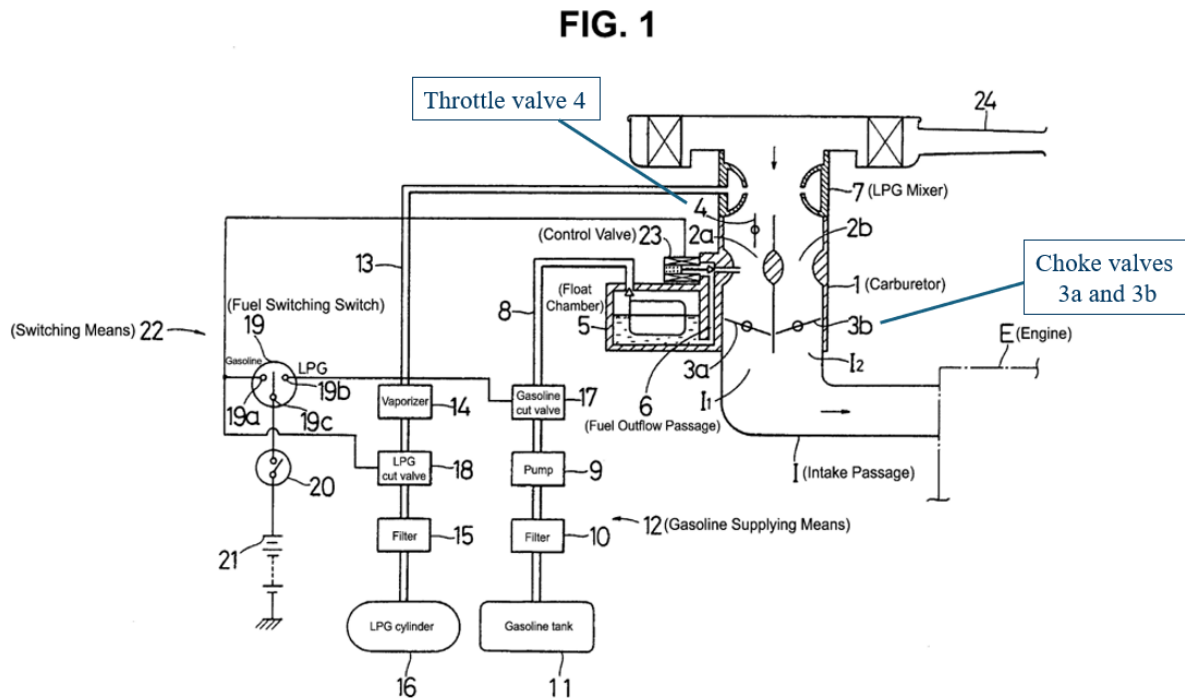
Id., ¶[0016] (emphasis added).

303. A POSA thus would have recognized that Nakafushi discloses a throat in which fuel and air are mixed in throat to provide an air-fuel mixture for the multi-fuel internal combustion engine.

c. Element [18.2]

304. Element [18.2] recites “a valve located in the throat to provide a choke and throttle for the multi-fuel internal combustion engine.”

305. Nakafushi discloses throttle valves 3a and 3b and a choke valve 4 to provide a choke and throttle for the engine. Ex. 1005, ¶[0010].



Id., Fig. 1 (annotated).

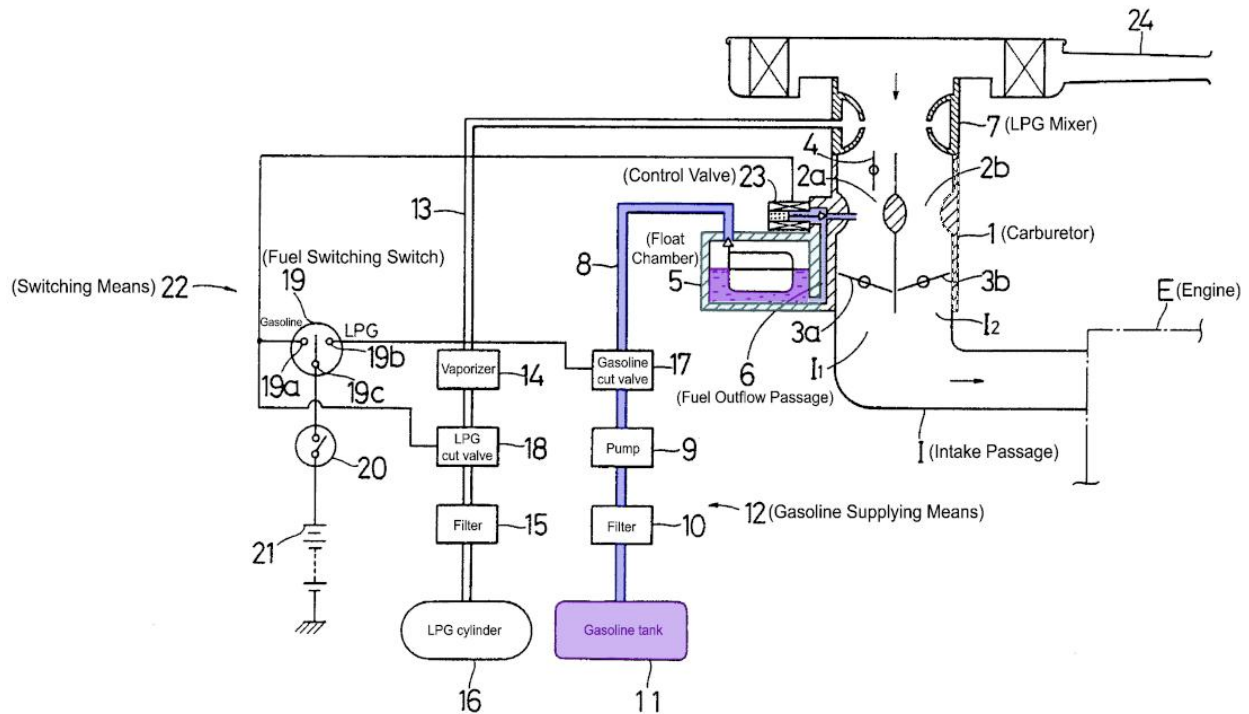
d. Element [18.3]

306. Element [18.3] recites “a float bowl to hold liquid fuel.”

307. Nakafushi discloses “the float chamber 5 is communicated with the Venturi portions 2a and 2b of the carburetor 1 via a fuel outflow passage 6 having a small diameter, so that the gasoline in the float chamber 5 is sucked into the

Venturi portions 2a and 2b and atomized and supplied during the operation of the engine E.” *Id.*, ¶[0010].

FIG. 1



Ex. 1005, Fig. 1 (annotated).

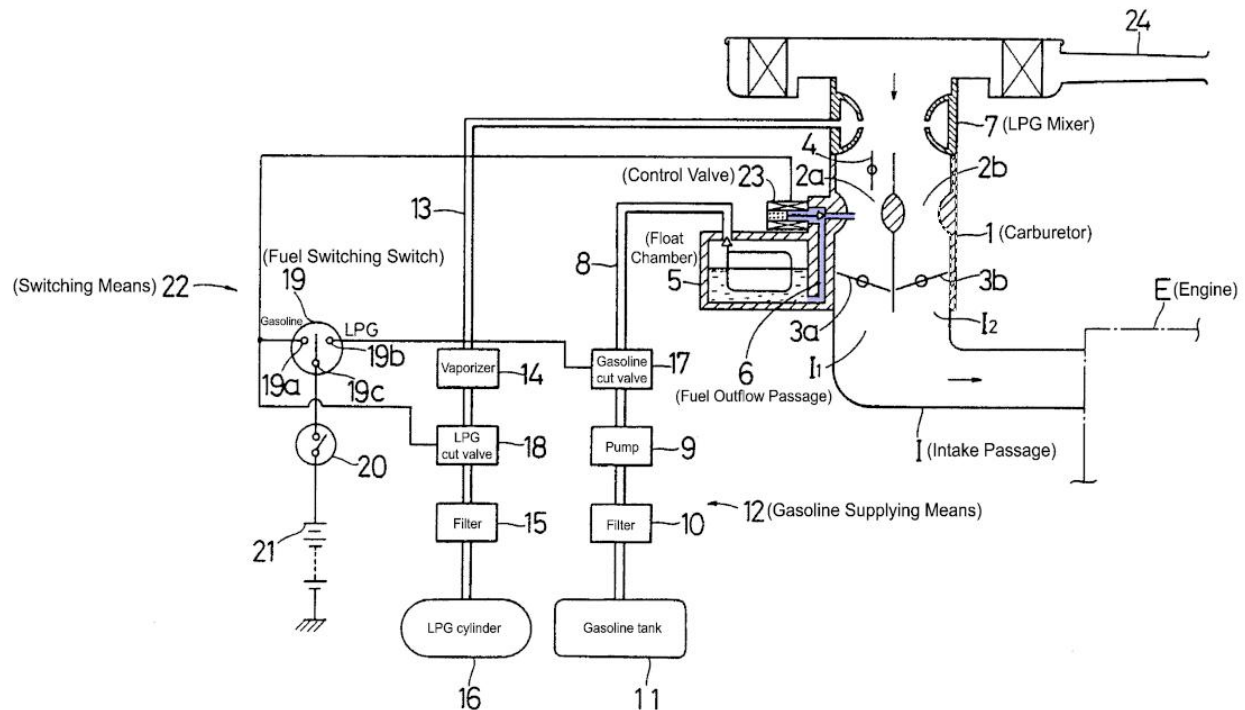
308. Nakafushi further states “5 denotes a float chamber in which gasoline is stored....” *Id.* Thus, Nakafushi’s float chamber 5 is a “float bowl,” which holds gasoline.

e. Element [18.4]

309. Element [18.4] recites “a main fuel circuit positioned downstream from the float bowl and extending from the float bowl to the throat.”

310. Nakafushi discloses fuel outflow passage 6 positioned downstream from the float chamber 5 to the throat of the carburetor. *Id.*, ¶[0010], Fig. 1.

FIG. 1



Id., Fig. 1 (annotated).

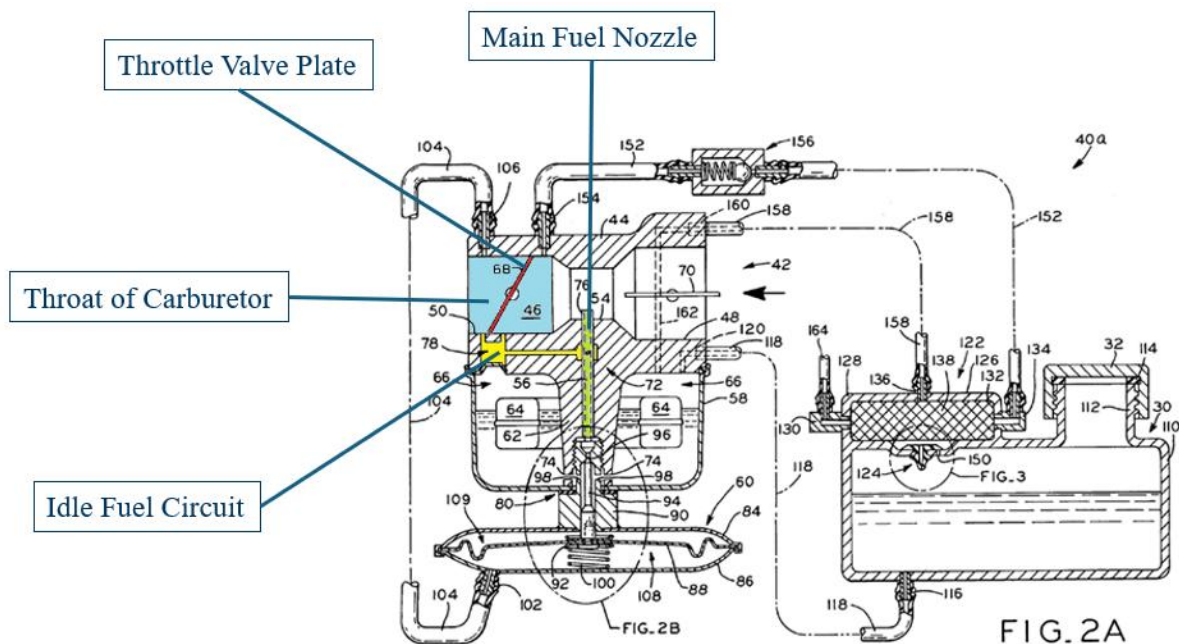
311. The fuel outflow passage 6 is a “main fuel circuit” for purposes of Element [18.4] because it is positioned downstream from the float bowl and extends from the float bowl to the throat. *Id.*, ¶[0010], Fig. 1.

f. Element [18.5]

312. Element [18.5] recites “an idle fuel circuit that provides a flow path to the throat downstream of the throttle to run the engine at idle.”

313. It would have been obvious to a POSA to include an idle fuel circuit in the Nakafushi engine because it was common to include an idle fuel circuit in the carburetor of an internal combustion engine at the time of the invention

314. Kirk discloses an idle fuel circuit that provides a flow path to the throat of a carburetor downstream of the throttle to run the engine at idle. Ex. 1025, 6:36-46, Fig. 2A. Specifically, Kirk discloses an idle fuel circuit 78 that extends from the main fuel nozzle 76 and opens into the throat 46 of the carburetor 42. *Id.* The idle fuel circuit 78 provides a flow path to the throat downstream of the throttle (throttle valve plate 68) “to provide idling fuel to throat 46 of carburetor 42 when throttle valve plate 68 is in a closed position.” *Id.*, 6:42-46; Fig. 2A.



Ex. 1025, Fig. 2A (annotated).

315. Kirk explains:

Fuel circuit 72 of carburetor 42 fluidly communicates fuel bowl 58 to supply fuel to throat 46 during running of engine 28, and includes a pair of fuel ports 74 in stem portion 62 of carburetor 42 which are in fluid communication with fuel bowl 58, as well as a combination main fuel jet and valve seat 96 and nozzle 76 extending into throat 46 of carburetor 42 at venturi 54. Idle fuel circuit 78 extends in fluid communication from main fuel nozzle 76 and opens into throat 46 of carburetor 42 proximate throttle valve plate 68 to provide idling fuel to throat 46 of carburetor 42 when throttle valve plate 68 is in a closed position.

Carburetor 42 additionally includes fuel circuit shutoff valve 80 for blocking the flow of fuel from fuel bowl 58 to fuel circuit 72 upon shutdown of engine 28, as described below.

Id., 6:36-50.

316. It would have been obvious to incorporate the idle fuel circuit 78 of Kirk into the carburetor 1 of Nakafushi to supply gasoline during engine idle, downstream of throttle valves 3a and 3b.

i. Motivation/Expectation of Success

317. A POSA would have been motivated to include an idle fuel circuit in the Nakafushi engine to provide an appropriate air-fuel mixture when the engine is running at low speeds, when the throttle is closed or only partially open.

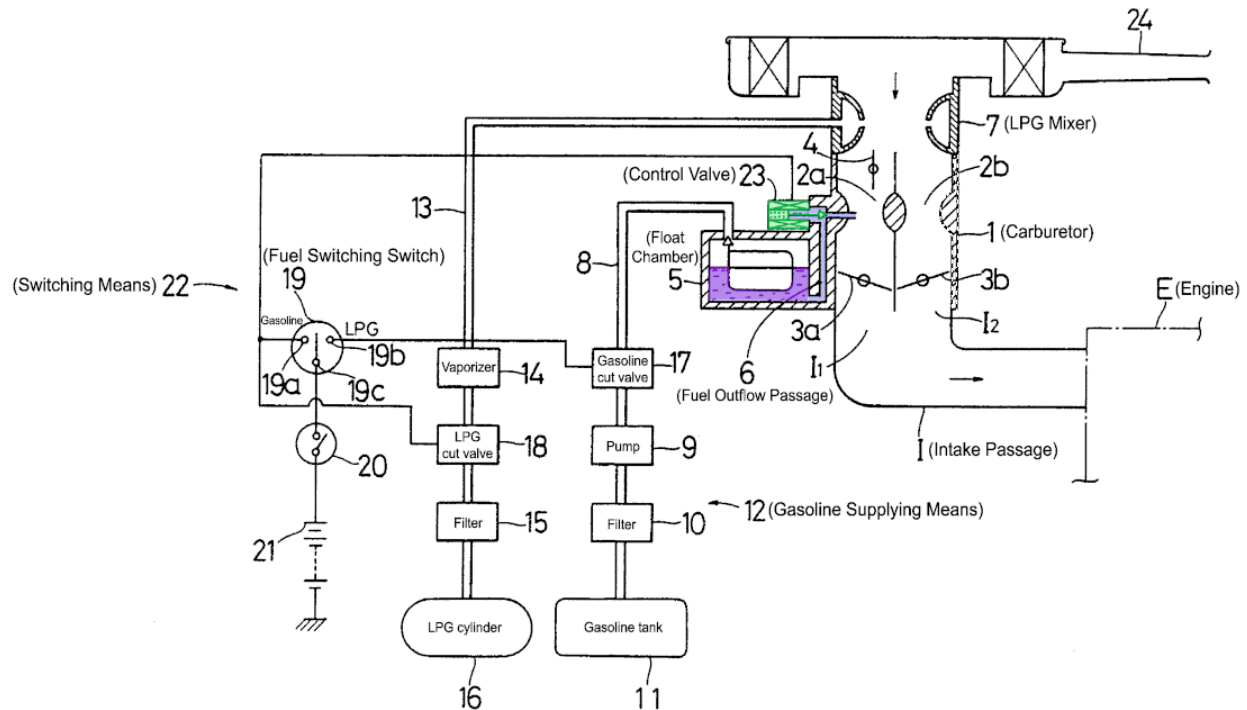
318. A POSA would have had a reasonable expectation of success because idle fuel circuits similar to those disclosed in Kirk were commonly used in internal combustion engines at the time of the invention.

g. Element [18.6]

319. Element [18.6] recites “a carburetor cutoff solenoid configured to selectively control fuel flow through the main fuel circuit and the idle fuel circuit.”

320. Nakafushi discloses control valve 23 (Ex. 1005, ¶[0014], Fig. 1), which is a “carburetor cutoff” for purposes of Element [18.6]. Specifically, Nakafushi explains that “a control valve 23 configured to open and close the fuel outflow passage 6 is disposed so as to intervene in the fuel outflow passage 6.” Ex. 1005, ¶[0014]. Nakafushi’s fuel outflow passage 6 connects the float chamber 5 to the carburetor’s venturi portions 2a and 2b, which is the main fuel circuit. *Id.*, ¶[0010], Fig. 1. This arrangement is shown in Figure 1:

FIG. 1



Id., Fig. 1 (annotated).

321. Combined with the idle fuel circuit of Kirk, the control valve 23 would also control fuel flow to the idle fuel circuit, similar to the configuration of Kirk. *Id.*, 6:36-50; Fig. 2A. Kirk discloses a shutoff valve 80 that controls the flow of gasoline from the float bowl 58 to fuel circuit 72. *Id.*, 6:47-50. The idle fuel circuit 78 branches off from fuel circuit 72, thus Kirk's shutoff valve 80 selectively controls fuel flow through the main fuel circuit and the idle fuel circuit. *Id.*, 6:36-50; Fig. 2A. Using this same configuration in Nakafushi's engine, the idle fuel circuit would branch off from the main fuel circuit (fuel outflow passage 6), and

control valve 23 would therefore selectively controls fuel flow through the main fuel circuit and the idle fuel circuit. *Id.*; Ex. 1005, Fig. 1.

322. While Nakafushi does not use the word “solenoid” to describe its control valve 23, a POSA would have understood valve 23, driven by action of an electric circuit, to be a solenoid valve, such that Nakafushi alone satisfies this element.

323. A solenoid valve is an electromechanically operated valve that uses an electromagnetic coil to control the flow of liquids or gases. When an electric current passes through the coil, it generates a magnetic field that moves a plunger that opens or closes a valve to regulate the flow. Solenoid valves allow for precise and automated control in various applications, including in carburetors. *See above* §VII.C.

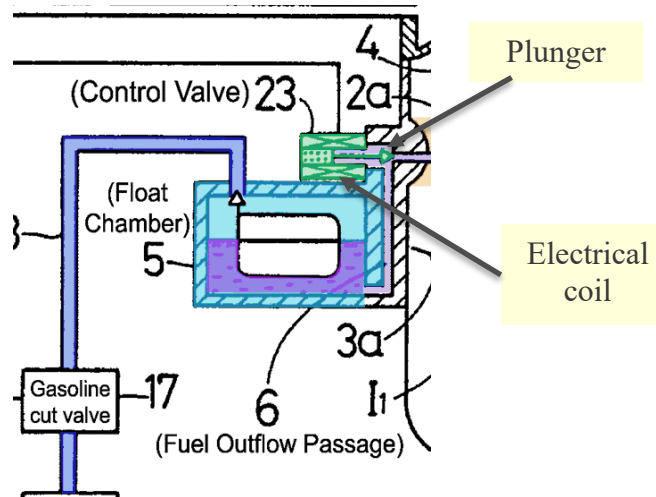
324. Nakafushi explains that the control valve is connected to an electrical circuit via a “contact point” and is “turned on” by “receiving a cut signal,” as follows:

Furthermore, a control valve 23 configured to open and close the fuel outflow passage 6 is disposed so as to intervene in the fuel outflow passage 6. ***The control valve 23 is connected to the gasoline contact point 19a of the fuel switching switch 19***, and is configured so that when the fuel switching switch 19 is switched to the gasoline contact point 19a side, that is, when the operation of the

gasoline supplying means 12 is selected, *the control valve 23 is turned ON upon receiving a cut signal* to open the fuel outflow passage 6, thereby allowing the gasoline to be sucked from the float chamber 5 to the Venturi portions 2a and 2b, whereas when the fuel switching switch 19 is switched to the LPG contact point 19b side, that is, when the operation of the LPG bomb [sic: cylinder] 16 is selected, the control valve 23 is turned OFF by not receiving a cut signal to close the fuel outflow passage 6, thereby blocking the suction of the gasoline from the float chamber 5 to the Venturi portions 2a and 2b.

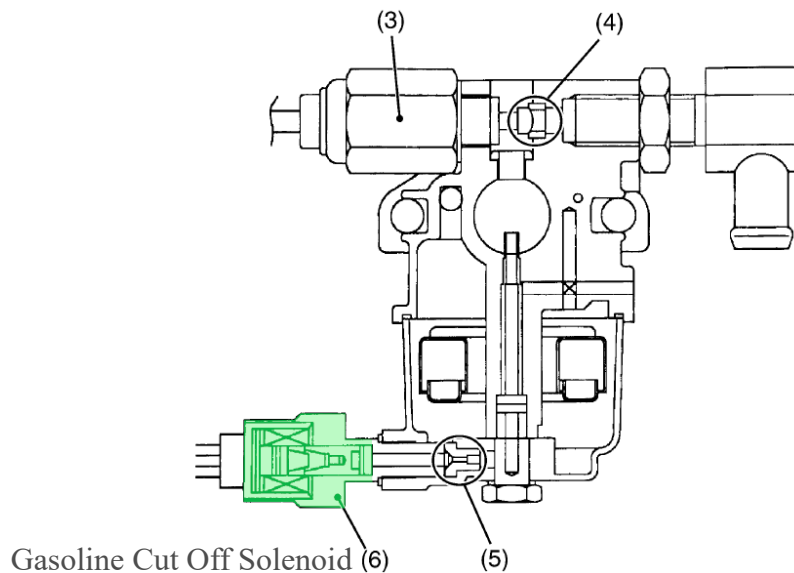
Ex. 1005, ¶[0014] (emphasis added).

325. Nakafushi's drawing of control valve 23 (i.e., Fig. 1) also indicates that the valve includes a plunger that moves laterally to open or close the fuel outflow passage 6 that leads to the venturi portions 2a/2b. Furthermore, the drawing shows a structure surrounding the plunger that a POSA would understand to be the electrical coil of a solenoid valve:



Id., Fig. 1 (cropped, colored, and annotated).

326. Notably, other publications having drawings similar to Nakafushi’s explicitly identify control valve 23 as a solenoid valve. For example, the Workshop Manual discloses a “Gasoline Cut Off Solenoid” as shown below:



Ex. 1012, 68 (coloring and annotation added).

327. Thus, for at least the reasons described above, a POSA would understand that Nakafushi discloses a solenoid as control valve 23.

328. In addition, other references likewise disclose gasoline cutoff solenoids. For example, Olmr discloses a gasoline engine having solenoid valve 42 in a bowl 30 that cuts off the flow of gasoline to the venturi 38 when the operator closes the kill switch, explaining:

With additional reference to FIG. 2, the carburetor 18 has a bowl 30 into which gasoline 31 flows from a hose 26 connected to the fuel tank 20. Across the upper end of the bowl 30 is a tube 32 having an inlet 34 attached to the air cleaner 16 and outlet 36 coupled to the engine cylinder. The carburetor tube 32 includes a conventional venturi 38 in which the inner diameter of the tube 32 is reduced significantly. A gasoline feed tube 40 has a *solenoid valve 42* located above the level of the gasoline 31 in the bowl 30 and so that fuel residue will not build up on the valve.

The *solenoid valve 42* includes a cross tube 44 in which a spool valve plunger 45 is located. The spool valve plunger 45 is fabricated from a cylindrical rod of ferromagnetic material and has a smaller diameter portion 48. A compression spring 46 at one end 47 of the cross tube 44 biases the spool valve plunger 45 into a position at which the smaller diameter portion 48 is aligned with the gas feed tube 40, when the *solenoid valve 42* is deenergized.

Because portion 48 is smaller in diameter than the internal diameter of the cross tube 44, a passage exists at the intersection of tubes 40 and 44 enabling gasoline within the bowl 30 to be drawn upward through the gas feed tube 40 and into the venturi 38 due to the Bernoulli effect.

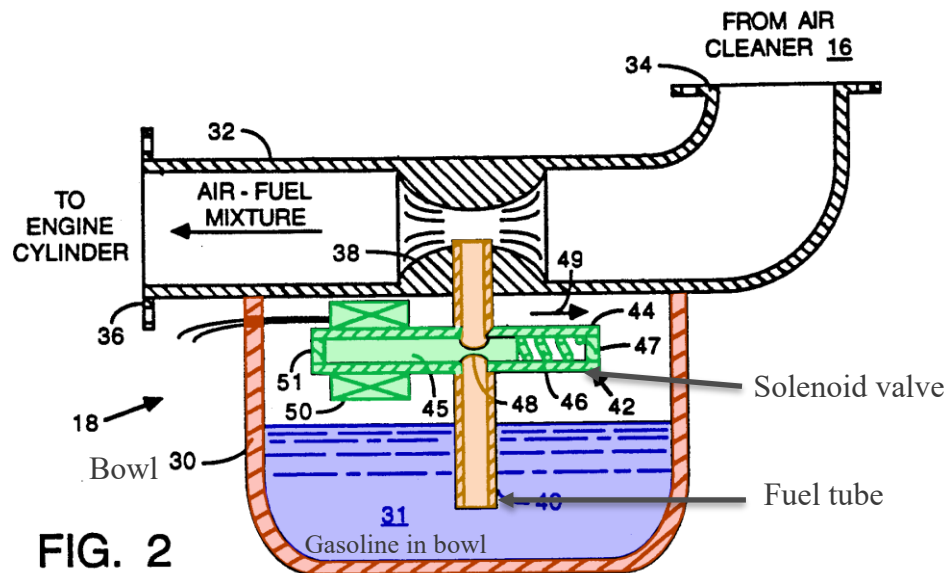
Ex. 1007, 2:30–56.

When it is desired to shut off the engine 10, the operator closes a kill switch 82. Switch 82 is a double-pole, single-throw type having a first set of contacts 84 which connect the ignition circuit output to ground as is conventionally done to stop small gasoline engines. A second set of contacts 86 of the kill switch 82 connect the electromagnet coil 50 of the *solenoid valve 42* across the storage capacitor 78. This action causes current to flow from the storage capacitor 78 through the coil 50 producing a magnetic field which pushes the spool valve plunger 45 against spring 46 a sufficient distance so that the spool valve plunger blocks gas from flowing through the feed tube 40 in the venturi 38. This action either cuts off the flow of gas to the venturi or significantly leans the air-fuel mixture. For example, an air-fuel mixture of 150 to 1 or greater is sufficient to prevent backfiring while the engine is stopping.

Id., 4:11–27.

329. Olmr's Figure 2, shown below, illustrates the gasoline cutoff solenoid,

highlighted in green:



Id., Fig. 2 (coloring and annotations added).

330. As shown above, Olmr's valve 42 is a carburetor cutoff solenoid coupled to the bowl 30 in the carburetor that opens and closes a liquid fuel path downstream from the bowl en route to the engine via venturi 38.

331. To the extent not already expressly taught by Nakafushi, a POSA would have found it obvious to utilize a solenoid such as that disclosed by Olmr for Nakafushi's control valve 23, as discussed below.

i. Motivation to Combine

332. At the time of the invention, a POSA would have been aware of various benefits of using solenoids valves in a carburetor to control the flow of fuel.

333. First, solenoid valves offer excellent precision and control. A POSA understood that solenoids allow for accurate adjustments to the air-fuel mixture, which is crucial for optimizing engine performance and efficiency.

334. Second, solenoid valves respond rapidly to changes in electrical signals, which enables quick adjustments to the fuel flow. As such, a POSA would have understood that solenoid cutoff valves can rapidly open or shut off the supply of liquid fuel to the engine, allowing better control over engine operation and performance.

335. Third, solenoid valves are known for their reliability and long lifespan. Solenoid valves can withstand the harsh conditions within an engine, such as high temperatures and vibrations, making them a durable choice.

336. And fourth, solenoid valves can be easily integrated into electronic control systems. This allows for robust control of the carburetor, which enhances the fuel-control system's overall functionality and adaptability.

337. These four benefits of solenoid valves (precise control, rapid response, reliability, and easy electrical integration) would have been known to a POSA as of the critical date and are reasons why solenoid valves have been used to control fuel flow to an engine, such as taught by Olmr (if not Nakafushi in the first instance).

338. Nakafushi relates to combustion engines that operate on gasoline (at

least some of the time). *See* Ex. 1005, ¶[0001] (“The present invention relates to a gasoline-LPG combined engine configured to selectively use gasoline or LPG as fuel.”). Olmr likewise relates to gasoline engines. *See* Ex. 1007, 1:6–8, 2:17–18 (“The present invention relates to internal combustion engines and more particularly to mechanisms for stopping the flow of fuel when such engines are to stop. . . . FIG. 1 illustrates a single cylinder gasoline engine 10 such as the type commonly found on lawn mowers.”). Accordingly, Olmr is within the same field of endeavor as both Nakafushi and the ’120 Patent.

339. In Nakafushi, control valve 23 cuts off the flow of gasoline from the float chamber 5 when engine operation is switched from gasoline to LPG. *See* Ex. 1005, ¶[0014] (“Furthermore, control valve 23 configured to open and close the fuel outflow passage 6 is disposed so as to intervene in the fuel outflow passage 6.”); *id.*, ¶[0016] (“[D]uring the operation of the engine, when the operation is switched to the LPG engine operation, the control valve 23 is turned OFF to close the fuel supplying passage 6 so that the gasoline remaining in the float chamber 5 is not sucked into the Venturi portions 2a and 2b.”).

340. While Nakafushi does not expressly say what type of valve is used for this purpose (although as explained above, I believe a POSA would have understood that Nakafushi’s control valve 23 is in fact a solenoid), Olmr expressly teaches a solenoid (valve 42) for cutting off the flow of gasoline from the float

bowl 30 when the engine is off. Ex. 1007, 2:30–51.

341. A POSA would have understood that the solenoid valve in Olmr, like the control valve in Nakafushi, controls the flow of gasoline from the float bowl to the venturi (and thus, to the engine).

342. Olmr thus teaches an express example—a solenoid valve—for accomplishing the same function taught by Nakafushi, i.e., cutting gasoline flow to the venturi when needed. It would have thus been a simple substitution to incorporate Olmr’s expressly-identified solenoid valve to accomplish the same function in Nakafushi.

ii. Reasonable Expectation of Success

343. A POSA would have had a reasonable expectation of success in using Olmr’s solenoid valve 42 with the engine of Nakafushi.

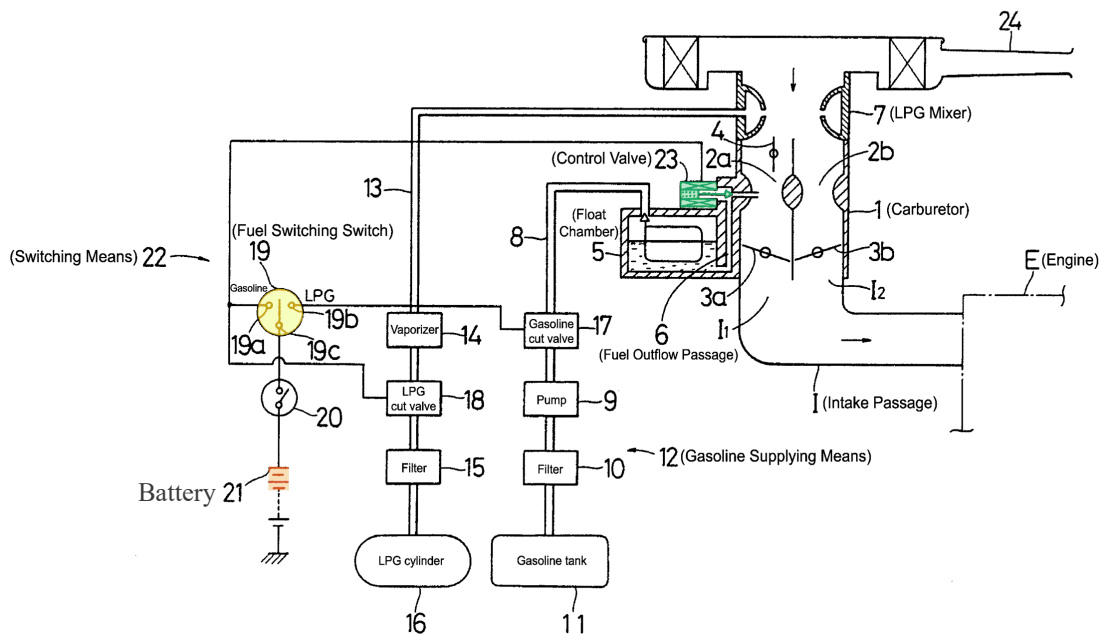
344. At the time of the invention, solenoids valves were widely used. *See, e.g.,* Ex. 1019, 4 (“Solenoids are widely used to produce linear movement to actuate valves (solenoid valves) and other devices.”). The use of solenoid valves to cut off/control the flow of fuel to an engine was also ubiquitous, with Olmr being just one example, and the Kubota Workshop Manual providing another example. *See* Ex. 1012, 68 (showing a “Gasoline Cut Off Solenoid” used in the carburetor of the DF972 engine).

345. Furthermore, Nakafushi discloses a simple electrical circuit to open

and close its control valve 23. Ex. 1005, ¶¶[0013]-[0014], Fig. 1. As described previously, a solenoid is essentially a coil of wire that generates a magnetic field when an electric current passes through it. This magnetic field can be used to move a plunger or core inside the coil, as shown in Olmr.

346. To control a solenoid with a simple circuit, a POSA would typically need a power source and a switch. Nakafushi's electrical circuit includes these basic components:

FIG. 1



Id., Fig. 1 (disclosing a control valve 23 connected to a fuel switching switch 19 and a battery 21) (coloring and annotation added).

347. Olmr teaches an essentially identical electrical circuit for operating its solenoid valve. Ex. 1007, 2:57-4:27, Figs. 2-3.

348. A POSA would therefore have recognized that Nakafushi's electrical circuit could energize a solenoid valve, such as the solenoid valve 43 disclosed in Olmr, to open and close as called for by Nakafushi's control valve 23.

349. A POSA would have therefore reasonably expected that Olmr's solenoid valve could be successfully implemented to serve as Nakafushi's liquid fuel cutoff control valve 23 to accomplish the desired function of cutting off the supply of gasoline from Nakafushi's float chamber 5 to the intake of the engine.

2. Claim 19

350. Claim 19 depends from Claim 18, and further requires "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."

351. Nakafushi discloses that control valve 23 (the carburetor cutoff solenoid when combined with Olmr) is operatively coupled to the switch 19 that changes operation of the engine from liquid fuel to gaseous fuel and from gaseous fuel while the engine is running. *See above* §§XII.G.2, XII.G.3.

352. Combined with the idle fuel circuit of Kirk, the control valve 23 would stop liquid fuel flow through both the main fuel circuit disclosed in

Nakafushi and the idle fuel circuit when the switch 19 changes operation of the engine from liquid fuel to gaseous fuel. *See above* §XII.H.1.g.

353. In particular, when Nakafushi's switch 19 is switched to the gasoline side 19a, control valve 23 opens, allowing gasoline to flow through the main fuel circuit (fuel passage 6), which would also close the idle fuel circuit incorporated from Kirk. Ex. 1005, ¶¶[0013]-[0014], Fig. 1; Ex. 1025, 6:36-52, Fig. 2A.

Conversely, when the switch 19 is switched to the LPG side 19b, control valve 23 closes, preventing gasoline from flowing through the main fuel circuit (fuel passage 6), which would also close the idle fuel circuit incorporated from Kirk. *Id.*

XIII. CONCLUSION

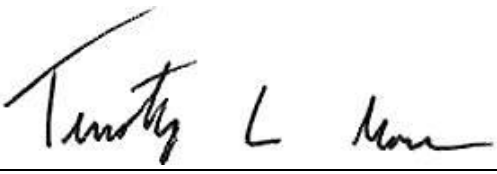
354. For at least the foregoing reasons, in my opinion, Claims 1-19 of the '120 Patent are invalid.

* * * * *

I hereby declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct, and that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true. I understand that willful false statements and the like are punishable by fine or imprisonment, or both (18 U.S.C. § 1001).

Date: June 23, 2025

Respectfully submitted,

By: 

Timothy Morse, Ph.D., P.E.



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Professional Profile

Dr. Morse is a licensed professional mechanical engineer who specializes in failure analysis, failure prevention, and design risk assessment for thermal and flow processes, products, and equipment. His project experience includes turbines, compressors, engines, generators, valves, heat exchangers, boilers, furnaces, refrigeration systems, piping systems, heat transfer systems, flammable liquids, cryogenic liquids, consumer products, and medical devices.

Dr. Morse's expertise is used in a variety of litigation matters, and he has experience testifying at both trial and international arbitration. Dr. Morse also has experience with intellectual property matters involving mechanical engineering principles, including medical devices, consumer products, and industrial equipment.

Dr. Morse applies his expertise to the investigation and prevention of fires, explosions, floods, and equipment failures. He has conducted fire origin and cause investigations involving electrical appliances, electrical systems, consumer products, heating appliances, and other combustion equipment. Dr. Morse performs testing and analysis of HVAC systems and components, including the analysis of the production and spread of carbon monoxide. Dr. Morse also investigates the origin and cause of motor vehicle fires, including post-collision fires.

Dr. Morse has performed engineering analysis for the oil and gas industry, ranging from offshore oil and gas extraction facilities to retail motor fuel stations. Dr. Morse has investigated flow-induced vibration issues over a wide range of applications, including heat exchanger tube bundles, pipelines, and offshore structures.

Dr. Morse has extensive experience with power generation equipment and facilities, including nuclear power plants, fossil fuel power plants, and renewable energy. He has investigated failures in heat exchangers, generators, compressors, turbines, and boilers. In the renewable energy area, Dr. Morse has investigated wind turbine failures and wind turbine fires.

Prior to joining Exponent, Dr. Morse was a researcher in the Fluid Dynamics Research Laboratories at Cornell University where he conducted research on the wakes of stationary and oscillating structures in a flow and particularly on how flow-induced vibration due to vortex shedding causes fatigue and failure of structures.

Academic Credentials & Professional Honors

Ph.D., Mechanical Engineering, Cornell University, 2009

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National Science Foundation Fellowship, 2004-2008

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Pi Tau Sigma Mechanical Engineering Honor Society, 2002

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Professional Affiliations

American Society of Mechanical Engineers

American Clean Power Association

- Wind Technical Standards Committee Member

National Association of Fire Investigators

National Fire Protection Association

- Alternate Member: NFPA Technical Committee on Vehicular Alternative Fuel Systems (VAF-AAA), responsible for NFPA 52: Vehicular Natural Gas Fuel Systems Code.

- Alternate Member: NFPA Technical Committee on Liquefied Petroleum Gases (LPG-AAA), responsible for NFPA 58: Liquefied Petroleum Gas Code.

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