

this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER
Title 35, United States Code, Section 184
Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign Assets Control, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

SelectUSA

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop

technology, manufacture products, deliver services, and grow your business, visit <http://www.SelectUSA.gov> or call +1-202-482-6800.

POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

Application Number	Filing Date

(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)



I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above:

26629

OR



I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:



The address associated with the above-mentioned Customer Number

OR



The address associated with Customer Number:

OR



Firm or Individual Name

Address

City

State

Zip

Country

Telephone

Email

I am the Applicant (If the Applicant is a juristic entity, list the Applicant name in the box):



Inventor or Joint Inventor (title not required below)



Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)



Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)



Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

SIGNATURE of Applicant for Patent

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

Signature

Date (Optional)

01-05-2019

Name

Dennis Trine

Title

Chief Executive Officer, Champion Power Equipment, Inc.

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.



Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.



ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #
16/946,439

RECEIPT DATE / TIME
06/22/2020 03:17:51 PM ET

ATTORNEY DOCKET #
CET1090.077

Title of Invention

FUEL SYSTEM FOR A MULTI-FUEL INTERNAL COMBUSTION ENGINE

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	2699	FILED BY	Robyn Templin
PATENT CENTER #	60042081	FILING DATE	-
CUSTOMER #	26629	FIRST NAMED INVENTOR	Kendall Collie
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	Kevin Rosin

Documents

TOTAL DOCUMENTS: 6

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
2020.06.22 ADS.pdf	10	Application Data Sheet	1198 KB
2020.06.22 Declaration.pdf	5	Oath or Declaration filed	995 KB
2020.06.22 POA Transmittal.pdf	1	Power of Attorney	191 KB
2020.06.22 Drawings.pdf	4	Drawings-only black and white line drawings	3876 KB
2020.06.22 Pat App-APP.TEXT.docx	27	Application body structured text document	50 KB

Warning: Text decorations have been removed

2020.06.22 General POA.pdf

1

Power of Attorney

532 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
2020.06.22 ADS.pdf	D114A1C47AD737BA939BEBB18890645FBABC6AF639B70D69 CB7A616057D6FDD3BE80B4AB798C775A38F1EBF3BC25FCB2 9683E5618F5F69B344FE989DDE95171A
2020.06.22 Declaration.pdf	90280287DDA8B9B5F36325665101BBA66E8032C7D09F4D80A9 F07483547ABB89C53C0A5C9B81C1585E45B11AE713460BA89 648A61931D6291E97530DEA1AB3E9
2020.06.22 POA Transmittal.pdf	17BDA50EE6D21505749D2C7F723136A2AB879C2608637A016 CF710AD5601ED4AB8AB67864D8E0F01CC827689C2DE5E9E2 A6FAED5DE11C60C37486B7471779928
2020.06.22 Drawings.pdf	33BF4BB09575A64EC5AE7D5508A26B34CBBD3336872E2B7A5 1841694FAD1E0F56EC0BD6B131A54D1C046EC195931CCD347 942C27D67C9174D096B7B12ECC3DCD
2020.06.22 Pat App- APP.TEXT.docx	30146D123509B5E8233F8819278E0C2903837A48804392A202F 545590CAECC1F534837981C6589CF0DDC9EEE5AD2CE8518A 52B135D3D47B106FE8A04473D28B5
2020.06.22 General POA.pdf	EEE57956C00EA36439F3ECE88A916468E3E89FD7148120590B EA9FD6029EA56802800079ABA1694B6C5ACAAE418CC562026 80338D97979D157FAA73230CFFEB7

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.



ELECTRONIC PAYMENT RECEIPT

APPLICATION #
16/946,439

RECEIPT DATE / TIME
06/22/2020 03:17:51 PM ET

ATTORNEY DOCKET #
CET1090.077

Title of Invention

FUEL SYSTEM FOR A MULTI-FUEL INTERNAL COMBUSTION ENGINE

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	-
CONFIRMATION #	2699	FILED BY	Robyn Templin
PATENT CENTER #	60042081	AUTHORIZED BY	Kevin Rosin
CUSTOMER #	26629	FILING DATE	-
CORRESPONDENCE ADDRESS	-	FIRST NAMED INVENTOR	Kendall Collie

Payment Information

PAYMENT METHOD CARD / 4529	PAYMENT TRANSACTION ID E20206LF18478049	PAYMENT AUTHORIZED BY Robyn Templin
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FEE CODE	DESCRIPTION	ITEM PRICE(\$)	QUANTITY	ITEM TOTAL(\$)
2111	UTILITY PATENT APPL. SEARCH FEE	330.00	1	330.00
4011	BASIC FILING FEE- UTILITY	75.00	1	75.00
2311	EXAMINATION OF ORIGINAL PATENT APPLICATION	380.00	1	380.00
TOTAL AMOUNT:				\$785.00

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	CET1090.077
		Application Number	
Title of Invention	FUEL SYSTEM FOR A MULTI-FUEL INTERNAL COMBUSTION ENGINE		
The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76. This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.			

Secrecy Order 37 CFR 5.2:

☐	Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)
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Inventor Information:

Inventor	1				Remove
Legal Name					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Kendall	J.	Collie		
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service					
City	Anaheim Hills	State/Province	CA	Country of Residence	US

Mailing Address of Inventor:

Address 1	751 S Weir Canyon Rd, Suite 157 PMB 391				
Address 2					
City	Anaheim Hills	State/Province	CA		
Postal Code	92809	Country	US		

Inventor	2				Remove
Legal Name					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Mark	J.	Sarder		
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service					
City	Waukesha	State/Province	WI	Country of Residence	US

Mailing Address of Inventor:

Address 1	208 Oxford Rd				
Address 2					
City	Waukesha	State/Province	WI		
Postal Code	53186	Country	US		

Inventor	3				Remove
Legal Name					
Prefix	Given Name	Middle Name	Family Name	Suffix	
	Aleko	D.	Sotiriades		
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service					

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	CET1090.077
		Application Number	
Title of Invention	FUEL SYSTEM FOR A MULTI-FUEL INTERNAL COMBUSTION ENGINE		

City	Cedarburg	State/Province	WI	Country of Residence	US
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Mailing Address of Inventor:

Address 1	W245 N5551 Corporate Circle				
Address 2					
City	Sussex	State/Province	WI		
Postal Code	53089	Country	US		
Inventor	4				Remove
Legal Name					

Prefix	Given Name	Middle Name	Family Name	Suffix	
	James	J.	Dehn		
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service					
City	Brookfield	State/Province	WI	Country of Residence	US

Mailing Address of Inventor:

Address 1	W245 N5551 Corporate Circle				
Address 2					
City	Sussex	State/Province	WI		
Postal Code	53089	Country	US		
Inventor	5				Remove
Legal Name					

Prefix	Given Name	Middle Name	Family Name	Suffix	
	Leigh	A.	Jenison		
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service					
City	Hartland	State/Province	WI	Country of Residence	US

Mailing Address of Inventor:

Address 1	W245 N5551 Corporate Circle				
Address 2					
City	Sussex	State/Province	WI		
Postal Code	53089	Country	US		
All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the Add button. Add					

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below. For further information see 37 CFR 1.33(a).	
☐	An Address is being provided for the correspondence information of this application.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	CET1090.077
		Application Number	
Title of Invention	FUEL SYSTEM FOR A MULTI-FUEL INTERNAL COMBUSTION ENGINE		

Customer Number	26629		
Email Address		Add Email	Remove Email

Application Information:

Title of the Invention	FUEL SYSTEM FOR A MULTI-FUEL INTERNAL COMBUSTION ENGINE		
Attorney Docket Number	CET1090.077	Small Entity Status Claimed	☒
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)		Suggested Figure for Publication (if any)	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)
☐ Request Not to Publish. I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application has not and will not be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.			
Please Select One:	☒ Customer Number	☐ US Patent Practitioner	☐ Limited Recognition (37 CFR 11.9)
Customer Number	26629		

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	CET1090.077
		Application Number	
Title of Invention	FUEL SYSTEM FOR A MULTI-FUEL INTERNAL COMBUSTION ENGINE		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending	Remove			
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
	Continuation of	16358822	2019-03-20		
Prior Application Status	Patented	Remove			
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
16358822	Continuation of	15285215	2016-10-04	10393034	2019-08-27
Prior Application Status	Pending	Remove			
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)		
15285215	Continuation in part of	14925441	2015-10-28		
Prior Application Status	Patented	Remove			
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
14925441	Continuation in part of	14738060	2015-06-12	10221780	2019-03-05
Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the Add button.					

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)ⁱ the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove			
Application Number	Country ⁱ	Filing Date (YYYY-MM-DD)	Access Code ⁱ (if applicable)
Additional Foreign Priority Data may be generated within this form by selecting the Add button.			

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	CET1090.077
		Application Number	
Title of Invention	FUEL SYSTEM FOR A MULTI-FUEL INTERNAL COMBUSTION ENGINE		

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013. ☐ NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.	
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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	CET1090.077
		Application Number	
Title of Invention	FUEL SYSTEM FOR A MULTI-FUEL INTERNAL COMBUSTION ENGINE		

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	CET1090.077
		Application Number	
Title of Invention	FUEL SYSTEM FOR A MULTI-FUEL INTERNAL COMBUSTION ENGINE		

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant	1	Remove
If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section. Clear		
☒ Assignee	Legal Representative under 35 U.S.C. 117	Joint Inventor
Person to whom the inventor is obligated to assign.		Person who shows sufficient proprietary interest
If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:		
Name of the Deceased or Legally Incapacitated Inventor:		
If the Applicant is an Organization check here. ☒		
Organization Name	Champion Power Equipment, Inc.	
Mailing Address Information For Applicant:		
Address 1	12039 Smith Avenue	
Address 2		
City	Santa Fe Springs	State/Province
Country	US	Postal Code
Phone Number		Fax Number
Email Address		
Additional Applicant Data may be generated within this form by selecting the Add button. Add		

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	CET1090.077
		Application Number	
Title of Invention	FUEL SYSTEM FOR A MULTI-FUEL INTERNAL COMBUSTION ENGINE		

Assignee 1				
Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.				
				Remove
If the Assignee or Non-Applicant Assignee is an Organization check here.				☐
Prefix	Given Name	Middle Name	Family Name	Suffix
Mailing Address Information For Assignee including Non-Applicant Assignee:				
Address 1				
Address 2				
City		State/Province		
Country ⁱ		Postal Code		
Phone Number		Fax Number		
Email Address				
Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.				Add

Signature:

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). However, if this Application Data Sheet is submitted with the **INITIAL** filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).

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See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Kevin R. Rosin/		Date (YYYY-MM-DD)	2020-06-22
First Name	Kevin R.	Last Name	Rosin	Registration Number
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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	CET1090.077
		Application Number	
Title of Invention	FUEL SYSTEM FOR A MULTI-FUEL INTERNAL COMBUSTION ENGINE		

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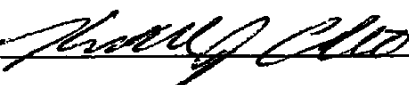
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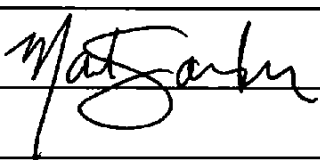
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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN
APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	FUEL SYSTEM FOR A MULTI-FUEL INTERNAL COMBUSTION ENGINE
As the below named inventor, I hereby declare that: This declaration ☒ The attached application, or is directed to: ☐ United States application or PCT international application number _____ filed on _____ The above-identified application was made or authorized to be made by me. I believe that I am the original inventor or an original joint inventor of a claimed invention in the application. I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both. WARNING: Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.	
LEGAL NAME OF INVENTOR	
Inventor: <u>Kendall J. Collie</u> Date (Optional): <u>9/13/16</u>	
Signature: 	
Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form. Use an additional PTO/AIA/01 form for each additional inventor.	

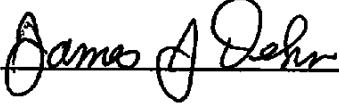
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LEGAL NAME OF INVENTOR	
Inventor: Mark J. Sarder Date (Optional): _____	
Signature: 	
Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form. Use an additional PTO/AIA/01 form for each additional inventor.	

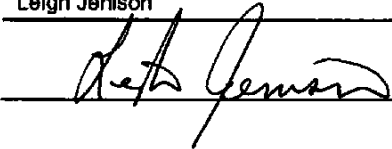
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As the below named inventor, I hereby declare that: This declaration ☐ The attached application, or is directed to: ☒ United States application or PCT international application number <u>15/285,215</u> filed on <u>October 4, 2016</u> The above-identified application was made or authorized to be made by me. I believe that I am the original inventor or an original joint inventor of a claimed invention in the application. I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both. WARNING: Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.	
LEGAL NAME OF INVENTOR	
Inventor: <u>Aleko D. Sotiriades</u> Date (Optional): <u>10/6/2016</u>	
Signature: <u>Aleko Sotiriades</u>	
Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form. Use an additional PTO/AIA/01 form for each additional inventor.	

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LEGAL NAME OF INVENTOR	
Inventor: James J. Dehn Date (Optional): 9-13-2016	
Signature: 	
Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form. Use an additional PTO/AIA/01 form for each additional inventor.	

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LEGAL NAME OF INVENTOR	
Inventor: Leigh Jenison Date (Optional): 09.13.2016	
Signature: 	
Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form. Use an additional PTO/AIA/01 form for each additional inventor.	

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Application Number	
Filing Date	
First Named Inventor	Kendall J. Collie
Title	FUEL SYSTEM FOR A MULTI-FUEL INTERNAL COMBUSTION ENGINE
Art Unit	
Examiner Name	
Attorney Docket Number	CET1090.077

SIGNATURE of Applicant or Patent Practitioner

Signature	/Kevin R. Rosin/	Date (Optional)	2020-06-22
Name	Kevin R. Rosin	Registration Number	55584
Title (if Applicant is a juristic entity)	Patent Practitioner		
Applicant Name (if Applicant is a juristic entity)	Champion Power Equipment, Inc.		

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.



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This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

FUEL SYSTEM FOR A MULTI-FUEL INTERNAL COMBUSTION ENGINE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application is a continuation of and claims priority to U.S. Patent Application Ser. No. 16/358,822, filed March 20, 2019, which is a continuation of and claims priority to U.S. Patent Application Ser. No. 15/285,215, filed October 4, 2016, now Issued U.S. Patent 10,393,034, which is a continuation-in-part of and claims priority to U.S. Patent Application Ser. No. 14/925,441, filed October 28, 2015, which is a continuation-in-part of and claims priority to U.S. Patent Application Ser. No. 14/738,060, filed June 12, 2015, now Issued U.S. Patent 10,221,780, the disclosures of which are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

[0002] Embodiments of the invention relate generally to dual fuel and other multi-fuel internal combustion engines, and more particularly, to an apparatus and method for delivering liquid fuel and gaseous fuel to a generator driven by a multi-fuel internal combustion engine.

[0003] Electric generators are frequently driven by internal combustion engines that use gasoline as a fuel source. Gasoline is a common fuel source for generators in a variety of applications. However, alternative fuel sources also provide a desirable fuel source. For instance, alternative fuels may provide a cleaner burning fuel that limits undesirable emissions. Alternative fuels may also be stored for longer periods of time without degradation, whereas gasoline can degrade over a period of months leading to hard starting, rough running, and also lead to gum and varnish deposits in the fuel system. In addition, generators that operate on alternative fuels are able to generate electricity when gasoline is not readily available. For instance, generators are frequently used when power outages in the utility grid result from severe weather. Unfortunately, gas stations may also be closed as a result of the power outage. Such a circumstance presents just one example where it would be advantageous to operate electric generators on alternative fuels.

[0004] Certain generators are configured to operate as “dual fuel” generators, otherwise known as bi-fuel generators. These generators are driven by an internal combustion engine that is configured to operate on either liquid fuel or an alternative fuel. The alternative fuel may exist in a gaseous state at normal temperature and pressure and can be any one of liquefied petroleum gas, compressed natural gas, hydrogen, or the like. Liquefied petroleum gas (LPG), often referred to as propane, exists in a gaseous state at normal temperature and pressure but can be conveniently stored under pressure in a liquid state. LPG may be a desirable fuel source for internal combustion engines because it can be stored for extended periods of time and contains fewer impurities than gasoline, resulting in smoother and cleaner operation. In addition, propane fueled engines typically have a longer life cycle due to less carbon build-up and virtually no fuel gumming or varnish accumulation.

[0005] In order to provide the liquid and gaseous fuel to the engine, the dual fuel engine may have a first fuel line for liquid fuel and a second fuel line for gaseous fuel. A liquid fuel source and a gaseous fuel source may be coupled to the respective lines to provide fuel to the engine. However, a common problem with such configurations that couple two fuel sources to a single fuel inlet, such as a carburetor, of an engine is that during cross-over switching between the fuel sources the engine can experience overly rich air-fuel ratio. This is particularly problematic when switching from a liquid fuel to a gaseous fuel because carburetors have a fuel bowl containing fuel that is drawn into the engine even after the liquid fuel source is cut-off. Therefore, for a period of time, the engine is running on both liquid and gaseous fuels causing an overly rich fuel mixture. Further, such simultaneous delivery of fuel from the first fuel line and the second fuel line, even if for a brief time, may make the engine hard to start and lead to unstable operating conditions.

[0006] Therefore, it would be desirable to design a generator having a liquid fuel and gaseous fuel delivery system that overcomes the aforementioned detriments without substantially increasing the overall cost of the system.

BRIEF DESCRIPTION OF THE INVENTION

[0007] In accordance with one aspect of the invention, a multi-fuel engine includes an engine operable on a liquid fuel, a first gaseous fuel from a first gaseous fuel source, and a second gaseous fuel from a second gaseous fuel source. The multi-fuel engine also includes a liquid cutoff solenoid coupled to open and close a liquid fuel path to the engine, a first gaseous cutoff solenoid coupled to open and close the first gaseous fuel source to the engine, a second gaseous cutoff solenoid coupling the engine to the second gaseous fuel source to control flow of the second gaseous fuel to the engine, and a switch coupling a power source to the liquid cutoff solenoid and the first gaseous cutoff solenoid to switch between fuel sources on-the-fly during engine operation.

[0008] In accordance with another aspect of the invention, a multi-fuel engine includes an engine operable on a liquid fuel, a first gaseous fuel from a first gaseous fuel source, and a second gaseous fuel from a second gaseous fuel source. The multi-fuel engine also includes a liquid cutoff solenoid selectively operable between open and closed positions to allow and inhibit a flow of the liquid fuel to the engine, at least one gaseous cutoff valve selectively operable between open and closed positions to allow and inhibit a flow of the first gaseous fuel and the second gaseous fuel to the engine, and a jet block coupling the first gaseous fuel source and the second gaseous fuel source to a carburetor connected to an intake of the engine, wherein the jet block is located downstream from the at least one gaseous cutoff valve. The jet block further includes a first gaseous fuel jet configured to meter the first gaseous fuel to the carburetor and a second gaseous fuel jet configured to meter the second gaseous fuel to the carburetor.

[0009] Various other features and advantages will be made apparent from the following detailed description and the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The drawings illustrate preferred embodiments presently contemplated for carrying out the invention.

[0011] In the drawings:

[0012] FIG. 1 is a perspective view of a multi-fuel generator coupled to a fuel delivery system, according to an embodiment of the invention.

[0013] FIG. 2 is a schematic diagram of a fuel system for the multi-fuel generator of FIG. 1 configured in a bi-fuel arrangement, according to an embodiment of the invention.

[0014] FIG. 3 is a schematic diagram of a fuel system for the multi-fuel generator of FIG. 1 to operate in a tri-fuel arrangement, according to an embodiment of the invention.

[0015] FIG. 4 is a cross-sectional view of a carburetor for the multi-fuel generator of FIG. 1 taken transverse to a throat of the carburetor and through a fuel passage that provides fuel from a float bowl to the throat of the carburetor, according to an embodiment of the invention.

[0016] FIG. 5 is a cross-sectional view of the carburetor of FIG. 4 coupled to an engine intake taken lengthwise to the throat and through the fuel passage, according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0017] The operating environment of the invention is described with respect to a multi-fuel generator. However, it will be appreciated by those skilled in the art that the invention is equally applicable for use with any multi-fuel internal combustion engine. Moreover, the invention will be described with respect to a dual fuel or other multi-fuel generator configured to operate on liquid fuel and gaseous fuel. However, one skilled in the art will further appreciate that the invention is equally applicable for use with other fuel combinations for multi-fuel generators and internal combustion engines.

[0018] Referring to FIG. 1, a dual fuel generator 30 is coupled to fuel delivery systems 32, 33 in accordance with an embodiment of the invention. Dual fuel generator 30 includes a dual fuel internal combustion engine 34 within housing 36 at one end 38, operatively connected to an alternator 40 also enclosed in housing 36 at another end 42 by conventional means. Dual fuel generator 30 is configured to operate on different fuels via either a first fuel source 44 or a second fuel source 46. In an exemplary embodiment of the invention, first fuel source 44 is a liquid fuel and second fuel source 46 is a gaseous fuel. In one preferred embodiment, the liquid fuel is gasoline and the gaseous fuel is liquid petroleum gas (LPG). An operator can selectively operate the generator on either fuel as desired. For instance, generator 30 may operate on gasoline for a first period of operation and then switch to LPG for a second period of operation. However, it is contemplated that dual fuel generator 30 is configured to operate on fuels other than gasoline and LPG (e.g., natural gas, biodiesel, etc.), and thus the scope of the invention is not meant to be limited strictly to a dual fuel arrangement where first fuel source 44 provides gasoline and second fuel source 46 provides LPG. In addition, embodiments of the invention contemplate tri-fuel, quad-fuel, and other multi-fuel arrangements.

[0019] In one embodiment of the invention, dual fuel generator 30 includes a gasoline tank 48 or, generally, a liquid fuel tank, located inside cover 36 onboard generator 30 to provide gasoline to the engine as first fuel source 44. Gasoline tank 48 connects to a first fuel line to provide gasoline to the carburetor to run the engine, as

will later be described with reference to FIG. 2. Generator 30 is also coupled to a pressurized fuel container 50, or a pressurized fuel source, located off board generator 30 to provide LPG to the engine as second fuel source 46. Pressurized fuel container 50 is coupled to generator 30 with an LPG supply hose 52. LPG supply hose 52 is coupled to a second fuel line within generator 30 to provide LPG to the engine via the carburetor. Dual fuel generator 30 includes an electrical fuel switch 54 for selecting a desired fuel to the engine.

[0020] In an exemplary embodiment, fuel 46 from pressurized fuel container 50 is regulated using a fuel regulator system 56 for delivery to the engine. Fuel regulator system 56 includes one or more pressure regulators that reduce and control the pressure of the fuel from pressurized fuel container 50 and delivers fuel at a desired pressure for operation of the engine. Fuel regulator system 56 has an inlet 58 operatively coupled to a service valve 60 of pressurized fuel container 50 and an outlet 62 coupled to LPG supply hose 52. Fuel regulator system 56 includes a primary pressure regulator 64 coupled to pressurized fuel container 50 and a secondary pressure regulator 66. Primary pressure regulator 64 protects downstream components from high pressure of pressurized fuel container 50. Primary pressure regulator 64 receives LPG through service valve 60 of pressurized fuel container 50 and reduces the pressure of the LPG to a first stage. In one embodiment of the invention, the first stage may be delivered directly to generator 30 at a pressure required for operation of the engine.

[0021] In an exemplary embodiment of the invention, fuel regulator system 56 includes secondary pressure regulator 66 coupled to the outlet of primary pressure regulator 64 in order to use standard “off-the-shelf” components. Typically, the primary pressure regulator is mounted on the LPG tank, while the secondary pressure regulator is mounted on the component using the fuel, such as an engine or grill. Here, since generator 30 can be used as a gasoline only generator, secondary pressure regulator 66 is mounted off-board the generator to reduce size and cost of the generator. Secondary pressure regulator 66 receives LPG from primary pressure regulator 64 and further reduces the pressure of LPG to a second stage to be delivered to generator 30. In a system with two regulators, primary pressure regulator 64 regulates fuel received from

pressurized fuel container 50 and reduces the pressure of the fuel to a level required for operation of secondary pressure regulator 66. Secondary pressure regulator 66 regulates fuel received from primary pressure regulator 64 and further reduces the pressure of the fuel to a level required for operation of generator 30. In addition, primary pressure regulator 64 may compensate for varying tank pressure as fuel is depleted while secondary pressure regulator 66 may compensate for varying demand from generator 30.

[0022] In accordance with an exemplary embodiment of the invention, fuel regulator system 56 includes both the primary and secondary regulators or a customized single regulator to perform both regulator functions in one, but in any case, in this embodiment, is located remotely, or off-board, from dual fuel generator 30. Fuel regulator system 56 may be directly mounted to pressurized fuel container 50 using a regulator mounting structure 68. Regulator mounting structure 68 is a device having mounting locations for primary pressure regulator 64 and secondary pressure regulator 66. Regulator mounting structure 68 also has a securing mechanism 70 to secure regulator mounting structure 68 to pressurized fuel container 50. The securing mechanism 70 is a cover or dome that sits on the container with an opening therein that fits around service valve 60.

[0023] In another embodiment of the invention, primary pressure regulator 64 is mounted on regulator mounting structure 68 while secondary pressure regulator 66 could be mounted on or near generator 30. In yet another embodiment of the invention, a dual stage regulator regulates the fuel received from pressurized fuel container 50 and delivers fuel at a pressure required for operation of generator 30. Such a dual stage regulator regulates the fuel to the second stage within a single structure and may comprise both the primary pressure regulator 64 and the secondary pressure regulator 66. The dual stage regulator may be mounted directly on fuel container 50. Pressurized fuel container 50 may be secured to a platform or mobile cart 72 for stability or transportation. In another embodiment, a regulator mounting structure 68 is secured directly to a platform or a mobile cart.

[0024] A quick-disconnect hose coupling 74, also referred to as a quick-connect hose coupling, connects LPG supply hose 52 to generator 30 so that LPG supply hose 52 may be quickly attached and detached from generator 30. Hose coupling 74 has a first end 74a mounted on the external surface of generator 30 and coupled to supply the second fuel to the engine. Hose coupling 74 has a second end 74b coupled to the outlet of LPG supply hose 52. Hose coupling 74 has a valve that opens when the couplings are engaged and closes when the couplings are disengaged. As such, quick-disconnect hose coupling 74 automatically opens when connected to enable fuel flow from LPG supply hose 52 to the engine. Hose coupling 74 automatically disconnects fluid communication when disconnected. Accordingly, when the supply hose is detached from generator 30, the coupling 74 is automatically closed so that fuel does not escape and unwanted air does not enter the fuel system.

[0025] Referring now to FIG. 2, a schematic diagram of a fuel system for the dual fuel generator is shown, in accordance with an embodiment of the invention. The fuel system includes an electro-mechanical valve system 76 that includes a carburetor cutoff solenoid 94, gasoline cutoff solenoid 96, and a LPG cutoff solenoid 98. The electro-mechanical valve system 76 is coupled to a multi-fuel internal combustion engine configured to operate on a liquid fuel supplied from a liquid fuel source 78 through a liquid fuel line 80, and a gaseous fuel supplied from a gaseous fuel source 82, or a pressurized fuel source, through a gaseous fuel line 84. Electro-mechanical valve system 76 is operated by electrical fuel switch 54 that controls fuel flow to the engine from liquid fuel source 78 and gaseous fuel source 82. In an exemplary embodiment of the invention, the dual fuel engine operates on gasoline from liquid fuel source 78 and LPG from gaseous fuel source 82.

[0026] In one embodiment of the invention, the engine has a carburetor 86 coupled to an intake of the engine to mix air and fuel and connect to liquid fuel line 80 and gaseous fuel line 84. Carburetor 86 has a mixing passage or throat with an inlet for air and an outlet for the air-fuel mixture. Carburetor 86 also has a float bowl 88 that receives liquid fuel through a liquid fuel inlet 90 coupled to liquid fuel line 80. Carburetor 86 may also have a gaseous fuel inlet 92 in the throat and coupled to gaseous

fuel line 84. Gaseous fuel inlet 92 is preferably located upstream from a venturi in the throat for improved fuel and air mixing. Air is mixed with either of the fuels in the throat to provide the air-fuel mixture for operation of the engine. In another embodiment of the invention, a gaseous fuel mixer couples to the engine intake to mix gaseous fuel and air separately from carburetor 86.

[0027] In an exemplary embodiment of the invention, electro-mechanical valve system 76 includes a carburetor cutoff solenoid 94 coupled to carburetor 86 to control liquid fuel flow to the engine. Carburetor cutoff solenoid 94 operates to open and close a liquid fuel path to the engine downstream from float bowl 88 in carburetor 86. The liquid fuel path in carburetor 86 provides fuel to the throat from float bowl 88 and will later be described with reference to FIG. 4. The liquid fuel path may comprise a main fuel circuit within carburetor 86, and in some cases, also includes an idle fuel circuit within carburetor 86. Carburetor cutoff solenoid 94 cuts off liquid fuel flow through the liquid fuel path to provide a liquid fuel cutoff solenoid that controls fuel flow from liquid fuel line 80 to the engine.

[0028] Electro-mechanical valve system 76 may include a gasoline cutoff solenoid 96, or generally a liquid fuel cutoff solenoid, coupling liquid fuel source 78 to carburetor 86 and to control flow of the liquid fuel to carburetor 86. That is, gasoline cutoff solenoid 96 provides a liquid fuel valve coupled along liquid fuel line 80 to open and close liquid fuel source 78 to the engine. Electro-mechanical valve system 76 can operate with either or both the gasoline cutoff solenoid 96 and carburetor cutoff solenoid 94 to control liquid fuel flow to the engine. However, gasoline cutoff solenoid 96 is advantageous to quickly cut-off all liquid fuel flow to carburetor 86, and particularly, through the idle fuel circuit if carburetor cutoff solenoid 94 is regulating fuel through the main fuel circuit only. While limited fuel flow through the idle fuel circuit may not noticeably affect gaseous fuel operation, gasoline cutoff solenoid 96 prevents drawing gasoline through the idle fuel circuit after carburetor cutoff solenoid 94 closes the main fuel circuit.

[0029] Electro-mechanical valve system 76 may include an LPG cutoff solenoid 98, or generally a gaseous fuel cutoff solenoid, coupling gaseous fuel source 82 to the intake and to control flow of the gaseous fuel to the engine. LPG cutoff solenoid 98 provides a gaseous fuel valve coupled along gaseous fuel line 84 to open and close gaseous fuel source 82 to the engine. LPG cutoff solenoid 98 is preferably located downstream from fuel regulator system 56, shown in FIG. 2 as dual stage regulator 100, for a fast response in controlling gaseous fuel delivery to the engine.

[0030] Electro-mechanical valve system 76 also includes electrical switch 54 coupling a power source 102 to one or more of carburetor cutoff solenoid 94, gasoline cutoff solenoid 96 and LPG cutoff solenoid 98 to actuate the solenoids and provide a one-touch fuel selector to switch engine operation between fuels. Power source 102 is shown as a battery in FIG. 2, but could be from an engine driven power source, such as an alternator 40 (FIG. 1), a magneto, or any other suitable power supply. Switch 54 selectively powers solenoids 94, 96, 98 to engage liquid fuel operation when actuated to a first position and gaseous fuel operation when actuated to a second position. In an exemplary embodiment of the invention, switch 54 engages gasoline operation by closing LPG cutoff solenoid 98, opening gasoline cutoff solenoid 96, and operating carburetor cutoff solenoid 94 to open the main fuel circuit in the carburetor, and switch 54 engages LPG operation by closing gasoline cutoff solenoid 96, operating carburetor cutoff solenoid 94 to close the main fuel circuit, and opening LPG cutoff solenoid 98.

[0031] In an exemplary embodiment of the invention, gasoline cutoff solenoid 96, LPG cutoff solenoid 98, and carburetor cutoff solenoid 94 operate as normally closed solenoid valves to ensure excess fuel is not delivered to the engine if power to the solenoids is interrupted. To engage LPG operation, electrical fuel switch 54 provides electrical connection between power source 102 and a first contact 104 to power LPG cutoff solenoid 98 to open gaseous fuel line 84 while gasoline cutoff solenoid 96 and carburetor cutoff solenoid 94 are unpowered to close liquid fuel line 80 and the main fuel circuit in carburetor 86, respectively. To engage gasoline operation, electrical switch 54 provides electrical connection between power source 102 and a second contact 106 to power gasoline cutoff solenoid 96 and carburetor cutoff solenoid 94 to

open liquid fuel line 80 and the main fuel circuit in carburetor 86, respectively, while LPG cutoff solenoid 98 is unpowered to close gaseous fuel line 84.

[0032] In an alternative embodiment of the invention, gasoline cutoff solenoid 96, LPG cutoff solenoid 98, and carburetor cutoff solenoid 94 operate as normally open solenoid valves to ensure fuel is provided to the engine if power to the solenoids is interrupted. To engage gasoline operation, switch 54 provides electrical connection between power source 102 and first contact 104 to power LPG cutoff solenoid 98 to close gaseous fuel line 84 while gasoline cutoff solenoid 96 and carburetor cutoff solenoid 94 are unpowered to open liquid fuel line 80 and the main fuel circuit in carburetor 86, respectively. To engage LPG operation, switch 54 provides electrical connection between power source 102 and second contact 106 to power gasoline cutoff solenoid 96 and carburetor cutoff solenoid 94 to close liquid fuel line 80 and the main fuel circuit in carburetor 86, respectively, while LPG cutoff solenoid 98 is unpowered to open gaseous fuel line 84.

[0033] Electro-mechanical valve system 76 can be configured to switch operation of the generator from multiple fuel sources while the generator is running, also referred to as “on-the-fly” fuel changeover. That is, switch 54 couples power source 102 to LPG cutoff solenoid 98 and one or more of the gasoline cutoff solenoid 96 and carburetor cutoff solenoid 94 to change operation of the engine from liquid fuel to gaseous fuel and from gaseous fuel to liquid fuel while the engine is running. Electro-mechanical valve system 76 provides for precisely timed fuel changeover between the fuel sources to switch engine operation with minimal or no interruption in the performance of the engine, and it can be timed to prevent or substantially prevent fuel overlap between the fuel sources.

[0034] To quickly start and stop liquid fuel delivery to the engine, carburetor cutoff solenoid 94 regulates fuel flow through a liquid fuel path downstream of float bowl 88. Carburetor cutoff solenoid 94 also traps enough gasoline in float bowl 88 to provide quick delivery of gasoline to the engine during changeover from LPG to gasoline to prevent any lag or hesitation in engine performance. During changeover from gasoline

to LPG, carburetor cutoff solenoid 94 blocks fuel flow from float bowl 88 to the engine, thereby preventing an over-rich condition. That is, carburetor cutoff solenoid 94 can block gasoline remaining in float bowl 88 after gasoline cutoff solenoid 96 closes liquid fuel line 80 to prevent mixing gasoline with the LPG. Accordingly, carburetor cutoff solenoid 94 responds quickly upon actuation of switch 54 to limit fuel overlap and prevent overly rich fuel conditions that could adversely affect engine performance.

[0035] In addition, gasoline cutoff solenoid 96 may be opened to fill float bowl 88 with liquid fuel prior to switching engine operation to liquid fuel. That is, float bowl 88 will empty through the idle fuel circuit if carburetor cutoff solenoid 94 only blocks the main fuel circuit. Gasoline delivery to the engine during changeover is delayed if float bowl 88 must first be filled, and such delay could cause the engine to lose power or stall. Therefore, switch 54 may be configured to actuate gasoline cutoff solenoid 96 prior to actuating carburetor cutoff solenoid 94 to ensure adequate fuel in float bowl 88 for a smooth transition from LPG to gasoline.

[0036] In one embodiment of the invention, switch 54 actuates carburetor cutoff solenoid 94 and LPG cutoff solenoid 98 to change engine operation between the liquid fuel and the gaseous fuel so as to prevent fuel flow from liquid fuel source 78 and gaseous fuel source 82 simultaneously. In such an embodiment, electro-mechanical valve system 76 operates as a dual fuel lockout to ensure only one fuel is delivered to the engine. Switch 54 may simultaneously actuate carburetor cutoff solenoid 94 and LPG cutoff solenoid 98 to prevent or substantially prevent simultaneous fuel delivery of the liquid fuel and the gaseous fuel to the engine. In other embodiments, switch 54 actuates any of solenoids 94, 96, 98 in succession to prevent or substantially prevent simultaneous fuel delivery of the liquid fuel and the gaseous fuel to the engine. As such, switch 54 can operate the electro-mechanical valve system 76 to prevent an overly rich air-fuel ratio during cross-over switching between fuel sources, even while operating at full load.

[0037] In another embodiment of the invention, electro-mechanical valve system 76 provides a slight overlap in fuel delivery to the engine to ensure a smooth transition

during changeover. Carburetor cutoff solenoid 94 may close the liquid fuel path in carburetor 86 after LPG cutoff solenoid 98 opens to ensure fuel flow to the engine is not interrupted during changeover from gasoline to LPG. LPG cutoff solenoid 98 may close after carburetor cutoff solenoid 94 opens the liquid fuel path in carburetor 86 to ensure fuel flow to the engine is not interrupted during changeover from LPG to gasoline. Accordingly, switch 54 may actuate LPG cutoff solenoid 98 and carburetor cutoff solenoid 94 in succession to provide fuel overlap when changing engine operation between the liquid fuel and the gaseous fuel. Electro-mechanical valve system 76 can also be configured to provide blended fuel operation, if so desired.

[0038] Switch 54 can institute a predefined delay between actuating any of gasoline cutoff solenoid 96, carburetor cutoff solenoid 94, and LPG cutoff solenoid 98. Adjustable rheostats or predefined electronic delay circuits 108, 110, 112 can be coupled to the electrical connections of any of solenoids 94, 96, 98 to delay their actuation. As such, any of solenoids 96, 94, 98 may be configured to operate according to a user adjustable preset delay to actuate one or more of the solenoids in succession. In some embodiments of the invention, electronic delay circuits 108, 110, 112 provide simultaneous delivery of fuels to the engine for any fraction of a second or for up to several seconds.

[0039] Electro-mechanical valve system 76 can also change engine operation between fuel sources on-the-fly without gasoline cutoff solenoid 96 regulating fuel through liquid fuel line 80. In such an embodiment, upon actuation of switch 54 from gaseous fuel to liquid fuel, carburetor cutoff solenoid 94 can open a liquid fuel path in the carburetor to engage engine operation on liquid fuel and LPG cutoff solenoid 98 can actuate to stop engine operation on gaseous fuel. Also, upon actuation of switch 54 from liquid fuel to gaseous fuel, LPG cutoff solenoid 98 can open the gaseous fuel line 84 to engage engine operation on gaseous fuel and carburetor cutoff solenoid 94 can actuate to stop engine operation on liquid fuel.

[0040] Alternatively, electro-mechanical valve system 76 can change engine operation between fuel sources on-the-fly without carburetor cutoff solenoid 94. In

such an embodiment, gasoline cutoff solenoid 96 can open the liquid fuel line 80 to engage engine operation on liquid fuel upon actuation of switch 54 from gaseous fuel to liquid fuel, and gasoline cutoff solenoid 96 can stop engine operation on liquid fuel upon actuation of switch 54 from liquid fuel to gaseous fuel. Further, gasoline cutoff solenoid 96 and LPG cutoff solenoid 98 can be precisely timed to limit or prevent fuel overlap during changeover without interrupting engine performance. For instance, gasoline cutoff solenoid 96 may be opened prior to closing LPG cutoff solenoid 98 to ensure adequate fuel in float bowl 88 for on-the-fly changeover. Also, gasoline cutoff solenoid 96 may be closed before LPG cutoff solenoid 98 is opened to reduce fuel in float bowl 88 and limit fuel overlap during on-the-fly changeover. Accordingly, switch 54 may be precisely timed to operate gasoline cutoff solenoid 96 and LPG cutoff solenoid 98 to prevent, or substantially prevent, simultaneous fuel delivery of the liquid fuel and the gaseous fuel to the engine.

[0041] Referring now to FIG. 3, a schematic diagram of a fuel system to operate the generator in a tri-fuel arrangement is shown, in accordance with an embodiment of the invention. The fuel system includes an electro-mechanical valve system 114 coupled to a multi-fuel internal combustion engine configured to operate on a liquid fuel supplied from a liquid fuel source 78 and first and second gaseous fuels supplied from a respective first gaseous fuel source 116 and second gaseous fuel source 118. Electro-mechanical valve system 114 is operated by a tri-fuel electrical switch 120 that controls fuel flow to the engine from liquid fuel source 78 and gaseous fuel sources 116, 118. In an exemplary embodiment of the invention, the multi-fuel engine operates on gasoline from liquid fuel source 78, liquid petroleum gas (LPG) from first gaseous fuel source 116, and natural gas (NG) from second gaseous fuel source 118.

[0042] Electro-mechanical valve system 114 may include gasoline cutoff solenoid 96 to open and close a liquid fuel path through liquid fuel line 80 to carburetor 86, a carburetor cutoff solenoid 94 to control liquid fuel flow through the carburetor, and LPG cutoff solenoid 98 to open and close a gaseous fuel path for the first gaseous fuel through LPG line 122 to the engine. Electro-mechanical valve system 114 may also include an NG cutoff solenoid 124, or generally a gaseous fuel cutoff solenoid, to

couple the engine intake to second gaseous fuel source 118 and to control flow of the second gaseous fuel to the engine. NG cutoff solenoid 124 provides a gaseous fuel valve coupled along an NG line 126 to open and close second gaseous fuel source 118 to the engine. That is, NG cutoff solenoid 124 operates to open and close a gaseous fuel path for the second gaseous fuel through NG line 126 to the engine.

[0043] In an exemplary embodiment of the invention, a gaseous fuel line 128 provides NG and LPG to the engine by coupling to carburetor 86 and to both gaseous fuel sources 116, 118. A jet block 80 may be used to couple gaseous fuel line 128 to LPG line 122 and NG line 126. In one embodiment of the invention, jet block 80 is a 2-way branched fitting coupling first gaseous fuel source 116 and second gaseous fuel source 118 to carburetor 86 and located downstream from LPG cutoff solenoid 98 and NG cutoff solenoid 124. Jet block 80 may also comprise a first gaseous fuel jet 82 sized for the first gaseous fuel coupled to the first gaseous fuel source 116, and a second gaseous fuel jet 84 sized for the second gaseous fuel coupled to the second gaseous fuel source 118. The gaseous fuel jets 82, 84 comprise gaseous fuel main jets sized to meter the respective fuels as desired for a particular engine, or based on desired performance for each fuel in a given application. Jet block 80 has an outlet port 86 coupled to gaseous fuel line 128 to provide fuel from first gaseous fuel jet 82 and second gaseous fuel jet 84 to the engine.

[0044] Jet block 80 may be used to modify a dual fuel internal combustion engine into a tri-fuel engine by coupling a second gaseous fuel source to the engine intake. Jet block 80 can incorporate more than two gaseous fuel jets to couple additional gaseous fuel lines to carburetor 86. Each fuel line has a gaseous fuel valve to open and close the line. A fuel switch is wired appropriately to operate the additional solenoids. As such, jet block 80 allows a dual fuel engine to operate as a tri-fuel engine, quad-fuel engine or to operate with additional fuel sources.

[0045] Electro-mechanical valve system 114 includes a tri-fuel switch 120 coupling power source 102 to any of gasoline cutoff solenoid 96, LPG cutoff solenoid 98, NG cutoff solenoid 124, and carburetor cutoff solenoid 94 to selectively operate the

solenoids and engage gasoline operation when actuated to a first position, engage LPG operation when actuated to a second position, and engage NG operation when actuated to a third position. When tri-fuel switch 120 engages engine operation on one of the fuels, it may also stop delivery of the remaining fuels to the engine. As such, solenoids 94, 96, 98, 124 engage engine operation on their respective fuel source upon selection of the tri-fuel switch 120 to the respective fuel source, and the solenoids 94, 96, 98, 124 stop engine operation on their respective fuel source upon selection of the switch to another fuel source.

[0046] Electro-mechanical valve system 114 can be configured to switch operation of the generator from any single fuel to any other single fuel from first gaseous fuel source 116, second gaseous fuel source 118, and liquid fuel source 78 on-the-fly while the engine is running. For instance, tri-fuel switch 120 can actuate any combination of the carburetor cutoff solenoid 94, LPG cutoff solenoid 98, NG cutoff solenoid 124 and gasoline cutoff solenoid 96 to change operation of the engine among the liquid fuel, the first gaseous fuel, and the second gaseous fuel while the engine remains running. Electro-mechanical valve system 114 provides for precisely timed fuel changeover to switch engine operation among fuel sources with minimal or no interruption in the performance of the engine, and it can be timed to prevent or substantially prevent fuel overlap between the fuel sources.

[0047] To change between gaseous fuel and liquid fuel, tri-fuel switch 120 may operate NG cutoff solenoid 124 for NG and LPG cutoff solenoid 98 for LPG corresponding to the description of switch 54 operating LPG cutoff solenoid 98 with respect to FIG. 2. Referring back to FIG. 3, to switch between first gaseous fuel source 116 and second gaseous fuel source 118, tri-fuel switch 120 may simultaneously actuate LPG cutoff solenoid 98 and NG cutoff solenoid 124 to prevent or substantially prevent simultaneous fuel delivery of first gaseous fuel source 116 and second gaseous fuel source 118 to the engine. As such, electro-mechanical valve system 114 can operate as a tri-fuel lockout to ensure only one fuel is delivered to the engine. In other embodiments, tri-fuel switch 120 actuates the NG cutoff solenoid 124 and LPG cutoff solenoid 98 in succession to ensure appropriately timed on-the-fly fuel changeover

between the two gaseous fuels. Adjustable rheostats or predefined electronic delay circuits 108, 110, 112, 88, may be coupled to the electrical connections of any of solenoids 94, 96, 98, 124, to delay their actuation.

[0048] In one embodiment of the invention, solenoids 98, 124, 94, 96 operate as normally closed solenoid valves to ensure excess fuel is not provided to the engine if power to the solenoids is interrupted. To engage LPG operation, tri-fuel switch 120 provides electrical connection between power source 102 and first contact 104 to power LPG cutoff solenoid 98 to open LPG line 122 while gasoline cutoff solenoid 96, carburetor cutoff solenoid 94, and NG cutoff solenoid 124 are unpowered to close liquid fuel line 80, the main fuel circuit in carburetor 86, and NG line 126, respectively. To engage gasoline operation, tri-fuel switch 120 provides electrical connection between power source 102 and second contact 106 to power gasoline cutoff solenoid 96 and carburetor cutoff solenoid 94 to open liquid fuel line 80 and the main fuel circuit in carburetor 86 while LPG cutoff solenoid 98 and NG cutoff solenoid 124 are unpowered to close LPG line 122 and NG line 126, respectively. To engage NG operation, tri-fuel switch 120 provides electrical connection between power source 102 and a third contact 140 to power NG cutoff solenoid 124 to open NG line 126 while gasoline cutoff solenoid 96, carburetor cutoff solenoid 94 and LPG cutoff solenoid 98 are unpowered to close liquid fuel line 80, the main fuel circuit in carburetor 86, and LPG line 122, respectively.

[0049] In an alternative embodiment of the invention, solenoids 98, 124, 94, 96 operate as normally open solenoid valves to ensure fuel is provided to the engine if power to the solenoids is interrupted. To engage LPG operation, tri-fuel switch 120 provides electrical connection between power source 102 and both second contact 106 and third contact 140 to power gasoline cutoff solenoid 96, carburetor cutoff solenoid 94, and NG cutoff solenoid 124 to close liquid fuel line 80, main fuel circuit in carburetor 86, and NG line 126, respectively, while LPG cutoff solenoid 98 is unpowered to open LPG line 122. To engage gasoline operation, tri-fuel switch 120 provides electrical connection between power source 102 and both first contact 104 and third contact 140 to power LPG cutoff solenoid 98 and NG cutoff solenoid 124 to close

LPG line 122 and NG line 126 while gasoline cutoff solenoid 96 and carburetor cutoff solenoid 94 are unpowered to open liquid fuel line 80 and the main fuel circuit in carburetor 86, respectively. To engage NG operation, tri-fuel switch 120 provides electrical connection between power source 102 and both first contact 104 and second contact 106 to power gasoline cutoff solenoid 96, carburetor cutoff solenoid 94, and LPG cutoff solenoid 98 to close liquid fuel line 80, main fuel circuit in carburetor 86, and LPG line 122, respectively, while NG cutoff solenoid 124 is unpowered to open NG line 126.

[0050] Referring now to FIG. 4, a cross-sectional view of carburetor 86 taken transverse to a barrel or throat 142 of the carburetor is shown, in accordance with an embodiment of the invention. Fuel and air are mixed in throat 142 to provide an air-fuel mixture for the multi-fuel internal combustion engine. A butterfly valve 144 is located in throat 142 to provide a choke and throttle 146 for the engine. Carburetor 86 has a float bowl 88 to hold liquid fuel with a float valve 148 to control the fuel level in the bowl. Carburetor 86 has a liquid fuel path 150 from float bowl 88 to throat 142. Liquid fuel path 150 is shown in FIG. 4 referring to main fuel circuit 152 in carburetor 86, but may also include other fuel circuits in the carburetor. Main fuel circuit 152 provides a flow path from float bowl 88 to a nozzle 154 in a venturi 156 upstream from throttle 146. An idle fuel circuit 158 provides a flow path to the throat 142 downstream of throttle 146 to run the engine at idle.

[0051] In one embodiment of the invention, carburetor 86 has a carburetor cutoff solenoid 94 coupled to carburetor 86 to regulate liquid fuel flow to the engine. Carburetor cutoff solenoid 94 actuates to open and close liquid fuel path 150 to the engine downstream from float bowl 88. Carburetor cutoff solenoid 94 has an actuating member 160 that moves to selectively block fuel flow through liquid fuel path 150, comprising main fuel circuit 152, and may be positioned to selectively block fuel flow into the inlet of main fuel circuit 152. Gasoline cutoff solenoid 96 (FIG. 2) closes off the liquid fuel line to carburetor 86 and fuel flowing through idle fuel circuit 158 stops when float bowl 88 empties. In another embodiment of the invention, carburetor cutoff solenoid 94 is configured to control fuel flow through both main fuel circuit 152 and

idle fuel circuit 158. For instance, idle fuel circuit 158 may branch off from main fuel circuit 152 with carburetor cutoff solenoid 94 actuating to block fuel flow into both circuits.

[0052] Referring now to FIG. 5, a cross-sectional view of carburetor 86 is shown taken lengthwise to throat 142, in accordance with an embodiment of the invention. Carburetor 86 is attached to the engine at engine intake 162 to supply a metered mixture of air and fuel and connect a liquid fuel source to the intake. Throat 142 includes venturi 156 and throttle 146 located downstream from venturi 156. A float bowl 88 and a float 166 control and maintain the fuel level in the bowl from an inlet valve 164. Main fuel circuit 152 provides a flow path from float bowl 88 to nozzle 154 in a narrow portion of venturi 156. Idle fuel circuit 158 provides a flow path from float bowl 88 to throat 142 downstream of throttle 146. Transition fuel circuit 168 provides a flow path to throat 142 upstream from throttle 146 and branches off from idle fuel circuit 158. Transition fuel circuit 168 is opened to vacuum conditions as the throttle 146 moves slightly from a closed position to provide additional fuel as the engine transitions from idle.

[0053] Carburetor cutoff solenoid 94 couples to float bowl 88 to selectively control liquid fuel flow through main fuel circuit 152. Carburetor cutoff solenoid 94 includes actuating member 160 capable of blocking fuel flow through main fuel circuit 152 when actuated. FIG. 5 shows actuating member 160 in an extended or blocking position, while FIG. 4 shows actuating member 160 in a retracted or open position. Carburetor cutoff solenoid 94 actuates to quickly start and stop liquid fuel flow from float bowl 88 to the engine through main fuel circuit 152 to provide precisely timed engine changeover between liquid and gaseous fuel sources.

[0054] Beneficially, embodiments of the invention thus provide for a multi-fuel internal combustion engine capable of switching between liquid fuel and gaseous fuel sources while the engine is running. Embodiments of the invention also provide for a multi-fuel internal combustion engine having a fuel system to prevent an overly rich air-fuel ratio during cross-over switching between fuel sources. Embodiments of the

invention also provide for a multi-fuel generator with a remotely mounted gaseous fuel pressure regulator system.

[0055] Therefore, according to one embodiment of the invention, a multi-fuel engine includes an engine operable on a liquid fuel, a first gaseous fuel from a first gaseous fuel source, and a second gaseous fuel from a second gaseous fuel source. The multi-fuel engine also includes a liquid cutoff solenoid coupled to open and close a liquid fuel path to the engine, a first gaseous cutoff solenoid coupled to open and close the first gaseous fuel source to the engine, a second gaseous cutoff solenoid coupling the engine to the second gaseous fuel source to control flow of the second gaseous fuel to the engine, and a switch coupling a power source to the liquid cutoff solenoid and the first gaseous cutoff solenoid to switch between fuel sources on-the-fly during engine operation.

[0056] According to another embodiment of the invention, a multi-fuel engine includes an engine operable on a liquid fuel, a first gaseous fuel from a first gaseous fuel source, and a second gaseous fuel from a second gaseous fuel source. The multi-fuel engine also includes a liquid cutoff solenoid selectively operable between open and closed positions to allow and inhibit a flow of the liquid fuel to the engine, at least one gaseous cutoff valve selectively operable between open and closed positions to allow and inhibit a flow of the first gaseous fuel and the second gaseous fuel to the engine, and a jet block coupling the first gaseous fuel source and the second gaseous fuel source to a carburetor connected to an intake of the engine, wherein the jet block is located downstream from the at least one gaseous cutoff valve. The jet block further includes a first gaseous fuel jet configured to meter the first gaseous fuel to the carburetor and a second gaseous fuel jet configured to meter the second gaseous fuel to the carburetor.

[0057] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are

intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

ABSTRACT

A multi-fuel engine includes an engine operable on a liquid fuel and first and second gaseous fuels. The multi-fuel engine also includes a liquid cutoff solenoid selectively operable between open and closed positions to allow and inhibit a flow of the liquid fuel to the engine and at least one gaseous cutoff valve selectively operable between open and closed positions to allow and inhibit a flow of the first and second gaseous fuels to the engine. A jet block couples the first gaseous fuel source and the second gaseous fuel source to a carburetor connected to an intake of the engine, with the jet block being located downstream from the at least one gaseous cutoff valve. The jet block includes a first gaseous fuel jet to meter the first gaseous fuel to the carburetor and a second gaseous fuel jet to meter the second gaseous fuel to the carburetor.

CLAIMS

What is claimed is:

1. A multi-fuel engine comprising:
 - an engine operable on a liquid fuel and a gaseous fuel;
 - a carburetor attached to an intake of the engine to mix air and fuel and connect a liquid fuel source to the intake, the carburetor comprising a float bowl;
 - a liquid cutoff solenoid coupled to open and close a liquid fuel path to the engine;
 - a gaseous cutoff solenoid coupled to open and close a gaseous fuel source to the engine;
 - a switch selectively coupling a power source to the liquid cutoff solenoid and the gaseous cutoff solenoid to open and close the liquid fuel path and the gaseous fuel path; and
 - one or more timing circuits electrically coupled to the liquid cutoff solenoid and the gaseous cutoff solenoid that operate to control an actuation time of the liquid cutoff solenoid and the gaseous cutoff solenoid.
2. The multi-fuel engine of claim 1 wherein the one or more timing circuits comprise one or more delay circuits configured to institute a predefined delay before actuating the liquid cutoff solenoid and the gaseous fuel cutoff solenoid.
3. The multi-fuel engine of claim 1 wherein the one or more timing circuits comprise one or more rheostats configured to institute a delay before actuating the liquid cutoff solenoid and the gaseous fuel cutoff solenoid.
4. The multi-fuel engine of claim 1 wherein the one or more timing circuits provide a user adjustable preset delay before actuating the liquid cutoff solenoid and the gaseous cutoff solenoid.

5. The multi-fuel engine of claim 1 wherein the one or more timing circuits control the actuation time of the liquid cutoff solenoid and the gaseous cutoff solenoid to provide simultaneous delivery of fuels to the engine for any fraction of a second or for up to several seconds.

6. The multi-fuel engine of claim 1 wherein the switch and the one or more timing circuits control actuation of the liquid cutoff solenoid and the gaseous cutoff solenoid to enable changing engine operation between the liquid fuel and the gaseous fuel, so as to prevent fuel flow from the liquid fuel source and the gaseous fuel source simultaneously and allow switching between fuel sources on-the-fly during engine operation.

7. The multi-fuel engine of claim 1 wherein the liquid cutoff solenoid comprises a first liquid cutoff solenoid coupled to the carburetor to control flow of liquid fuel within the carburetor, and wherein the multi-fuel engine further comprises a second liquid cutoff solenoid positioned on a liquid fuel line coupling the liquid fuel source to the carburetor to open and close the liquid fuel source to the engine.

8. The multi-fuel engine of claim 7 wherein one of the one or more timing circuits is electrically coupled to the second liquid cutoff solenoid to control an actuation time of the second liquid cutoff solenoid, such that the actuation time of the second liquid cutoff solenoid is controlled along with the actuation time of the first liquid cutoff solenoid and the gaseous cutoff solenoid.

9. The multi-fuel engine of claim 1 wherein the engine is a dual fuel engine that operates on gasoline from the liquid fuel source and LPG from the gaseous fuel source.

10. The multi-fuel engine of claim 1 wherein the carburetor connects the gaseous fuel source to the intake.

11. The multi-fuel engine of claim 1 further comprising:
an alternator driven by the engine to form a generator; and
a fuel regulator system located off-board the generator and comprising:
a primary pressure regulator coupled to a service valve of the
pressurized fuel source to regulate the fuel supplied from the pressurized fuel source to
a reduced pressure, and
a secondary pressure regulator coupled to the primary pressure
regulator to regulate the gaseous fuel supplied from the primary pressure regulator to a
desired pressure for delivery through the gaseous fuel line to operate the engine.

12. A multi-fuel generator and fuel delivery system comprising:
a multi-fuel internal combustion engine configured to operate on a liquid
fuel supplied from a liquid fuel source through a liquid fuel line and a gaseous fuel
supplied from a pressurized fuel source through a gaseous fuel line;
an alternator driven by the multi-fuel internal combustion engine; and
a fuel regulator system comprising:
a primary pressure regulator coupled to a service valve of the
pressurized fuel source to regulate fuel supplied from the pressurized fuel source to a
reduced pressure, and
a secondary pressure regulator coupled to the primary pressure
regulator to regulate fuel supplied from the primary pressure regulator to a desired
pressure for delivery through the gaseous fuel line to operate the engine.

13. The multi-fuel generator and fuel delivery system of claim 12 an electro-
mechanical valve system coupled to the engine and operated by an electrical switch
powered by one of the alternator, a battery, and a magneto that controls fuel flow to the
engine from the liquid fuel source and the pressurized fuel source.

14. The multi-fuel generator and fuel delivery system of claim 13 wherein
the electro-mechanical valve system is configured to switch operation of the generator
from multiple fuel sources while the generator is running.

15. The multi-fuel generator and fuel delivery system of claim 13 wherein the electro-mechanical valve system is configured to prevent simultaneous delivery of the liquid fuel and the gaseous fuel to the engine.

16. The multi-fuel generator and fuel delivery system of claim 12 wherein the pressurized fuel source comprises a pressurized fuel container located off-board the generator having a regulator mounting device to secure at least the secondary pressure regulator thereto.

17. The multi-fuel generator and fuel delivery system of claim 12 wherein a dual stage pressure regulator comprises the primary pressure regulator and the secondary pressure regulator.

18. A carburetor for use in a multi-fuel internal combustion engine, the carburetor comprising:

- a throat in which fuel and air are mixed in throat to provide an air-fuel mixture for the multi-fuel internal combustion engine;

- a valve located in the throat to provide a choke and throttle for the multi-fuel internal combustion engine;

- a float bowl to hold liquid fuel;

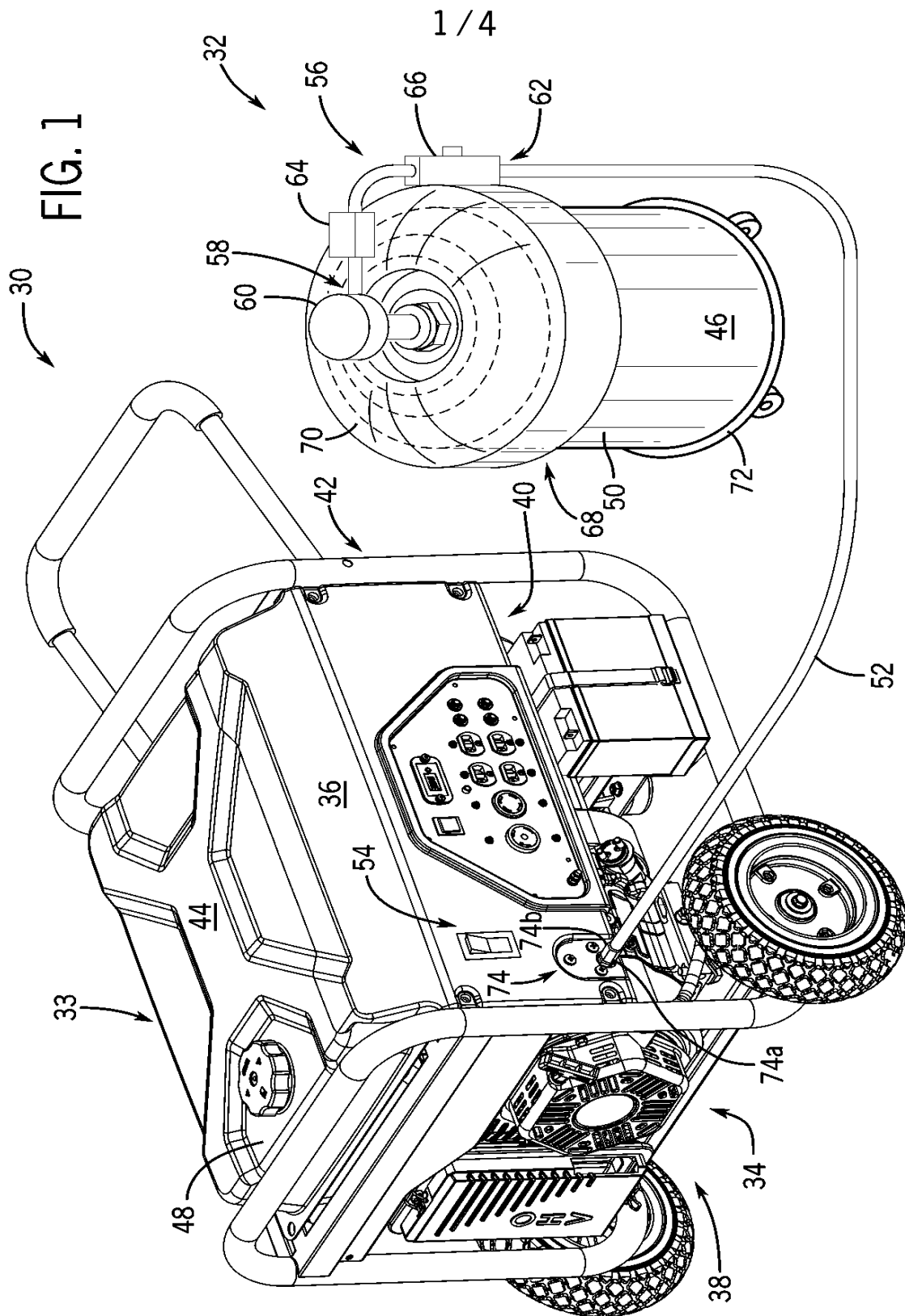
- a main fuel circuit positioned downstream from the float bowl and extending from the float bowl to the throat;

- an idle fuel circuit that provides a flow path to the throat downstream of the throttle to run the engine at idle; and

- a carburetor cutoff solenoid configured to selectively control fuel flow through the main fuel circuit and the idle fuel circuit.

19. The carburetor of claim 18 wherein the carburetor cutoff solenoid is operatively coupled to a switch that changes operation of the engine from liquid fuel to gaseous fuel and from gaseous fuel to liquid fuel while the engine is running, and

wherein the carburetor cutoff solenoid is closed to stop liquid fuel flow through the main fuel circuit and the idle fuel circuit when the switch changes operation of the engine from liquid fuel to gaseous fuel.



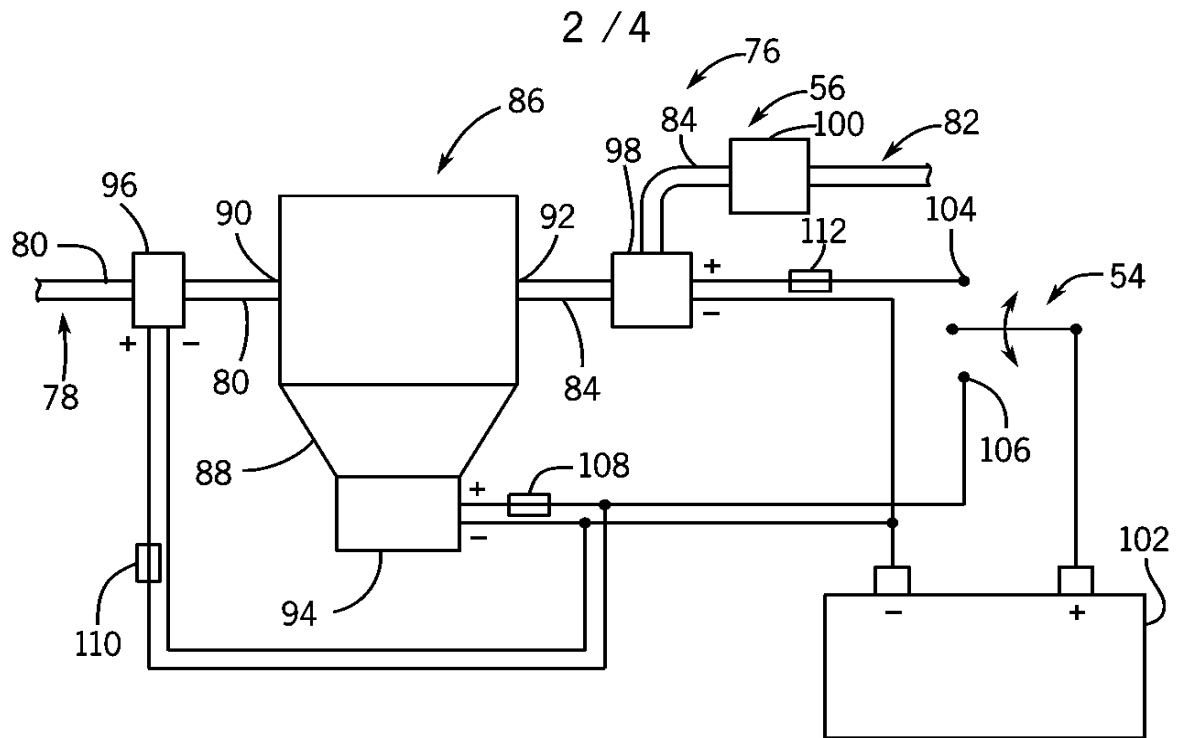


FIG. 2

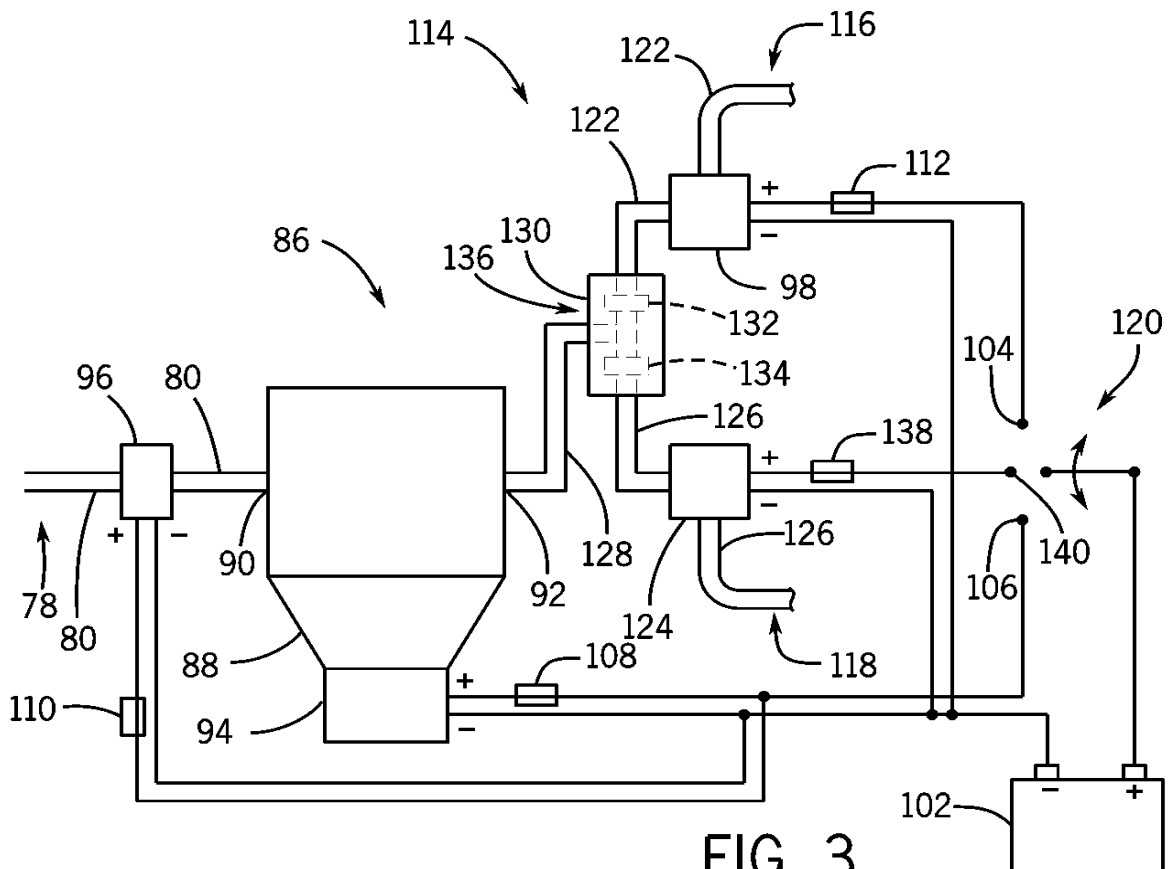


FIG. 3

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