FORM 2

THE PATENTS ACT, 1970

(39 of 1970)

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The Patent Rules, 2003

COMPLETE SPECIFICATION

(See section 10 and rule 13)

TITLE OF THE INVENTION

“Design of novel rotary flow control valve for a gas turbine fuel injection system"

We, applicant(s)

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The following specification particularly describes the nature of the invention and the manner in which it is performed:

FIELD OF THE INVENTION

The present invention generally relates to flow control valves and particularly to flow pulsing valves and/or applications of such valves in turbine engine fuel supply systems.

DISCUSSION OF THE PRIOR ART:

Modern industrial gas turbine engines commonly suffer combustion instabilities during development and usage, particularly those with low NOx technology. Fuel combinations used in these low-pollution engines can cause instability in the combustor at frequencies of up to 700 Hz. An unstable combustor may create pressure oscillations that harm the combustor. To address these instabilities, the combustor shape is often adjusted throughout the development process. Passive approaches are the name given to these types of adjustments, and they're only useful in a small number of situations. Active control approaches have recently been put to the test in a lab with great success. Engine geometry or fuel flow may be changed at the combustion oscillation frequency but not in phase with the instability to reduce oscillations under active control. The ability to reduce oscillations across a considerably larger range of engine operating conditions and fuels may be a fundamental benefit of the active control system.

High-speed actuators and valves have been employed to pulse fuel flow in several active control systems that have been tried thus far. High-speed electrohydraulic servo-valves or magnetostrictive or piezoelectric actuators, for example, were used in the past. The use of these valves has established the principle of active control. The technology, on the other hand, hasn't proven to be viable for commercial manufacturing. Due to its low stroke, the suggested technology is currently pricey, has performance limits, and short lifespan.

As previously mentioned, technical publications and a patent application address the current state of the art more completely. These documents are thus included by reference in their entirety: Suppression of Combustion Instabilities in a Liquid Fuel Combustor Using a Fast Adaptive Control Algorithm, AIAA 2000-0476, Y Neumeier, E. Lubarsky, R. Heising, O Israeli, M Neumaier, and B. T. Zinn, Georgia Institute of Technology, 34th AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit, July 13–15, 1998. The Georgia Institute of Technology's C. E. Johnson and colleagues, including Y. Neumeier, E. Lubarsky, J. Y. Lee, M. Neumaier, and B. T. Zinn, presented their findings at the AIAA 38th Aerospace Sciences Meeting & Exhibit, which took place from 10 to January 13, 2000. 2835–2841; Active Instability Control Using Spinning Valve Actuator, GT-2002–30042, C. Hantschk and J. Hermann and D. Vortmeyer, 26th International Symposium on Combustion/The Combustion Institute, 1996/pp. The ASME Turbo Expo 2002 was held June 3–6, 2002, and was organized by the ASME. Hydraulic R-DDVTM Servovalves can be found at www.textronmotioncontrol.com, first published on July 27, 2001. Anderson et al. have filed a patent application with the U.S.Patent Office under the number US 2003/0056490 A1 for a valve assembly for use in a gas fuel nozzle. One or more of the following problems have prevented any of these references from offering a viable commercial solution: high costs, performance restrictions, dependability, lifetime concerns, and/or other difficulties. The quest for technology that can be used in both the laboratory and commercial purposes comes as a result.

While the present invention is described herein by example using embodiments and illustrative drawings, those skilled in the art will recognize that the invention is not limited to the images of drawing or drawings described and are not intended to represent the scale of the various components. Further, some features that may form a part of the invention may not be illustrated in specific figures for ease of illustration. Such omissions do not limit the embodiments outlined in any way. It should be understood that the drawings and detailed descriptions are not intended to limit the invention to the particular form disclosed. Still, on the contrary, the story is to cover all modifications, equivalents, and alternatives falling within the scope of the present invention as defined by the appended claims. As used throughout

In this description, the word "may" is used in a permissive sense (i.e., meaning having the potential to) rather than the mandatory sense (i.e., meaning must).

Further, the words "a" or "an" mean "at least one," and the word "plurality" means "one or more" unless otherwise mentioned. Furthermore, the terminology and phraseology used herein are solely for descriptive purposes and should not be construed as limiting in scope. Language such as "including," "comprising," "having," "containing," or "involving," and variations thereof, is intended to be broad and encompass the subject matter listed after that, equivalents, and additional subject matter not recited, and is not intended to exclude other additives, components, integers or steps. Likewise, the term "comprising" is considered synonymous with the words "including" or "containing" for applicable legal purposes. Any discussion of document acts, materials, devices, articles, and the like is solely included in the specification to provide a context for the present invention. It is not suggested or represented that any or all of these matters form part of the prior art base or were common general knowledge in the field relevant to the present invention.

In this disclosure, whenever a composition or an element or a group of elements is preceded with the transitional phrase "comprising," it is understood that we also contemplate the same design, component or group of elements with transitional words "consisting of," "consisting," "selected from the group of consisting of, "including," or "is" preceding the recitation of the composition, element or group of elements and vice versa.

The present invention is described from various embodiments concerning the accompanying drawings, wherein reference numerals used in the accompanying drawing correspond to the like elements throughout the description. However, this invention may be embodied in many different forms and should not be construed as limited to the embodiment set forth herein. Instead, the image is provided so that this disclosure will be thorough and complete and fully convey the invention's scope to those skilled in the art. The following detailed description provides numeric values and ranges for various aspects of the implementations described. These values and ranges are treated as examples only and are not intended to limit the claims' scope. Also, several materials are identified as suitable for various facets of the implementations. These materials are to be treated as exemplary and are not intended to limit the invention's scope.

SUMMARY OF THE PRESENT INVENTION:

There is a valve assembly for pulsed fluid flow that divides the flow into first and second paths, pulses the second path, then rejoins the first and second flows to provide a combined flow that includes a pulsed component, one aspect of the present invention is directed to this valve assembly for pulsing fluid flow. A valve housing with an inlet and an outlet may be included in the valve assembly. Two fluidic pathways connect the intake and outlet: a first path and a second path. A divider valve is used to separate fluid flow from the intake port into two distinct directions. An additional valve, located downstream of the first, regulates the flow rate. The pulsating valve may be moved around to sequentially stop the first flow route's flow and pulse the fluid along that first flow path. It is possible to communicate between the combustion chamber and the engine's turbine by connecting the two flow pathways.

In addition, a feature of this innovation is that the divider valve may be used to regulate, for example, the size of the pulses by adjusting the flow magnitude between the two flow routes. Because quick reaction or high force is not required, the divider valve may be installed with a less expensive and smaller actuator. Furthermore, the invention may contain a pulse valve that may be spun at low rates to connect and disconnect one or more chopper ports on a rotating sleeve supplied around the sleeve. Another element of the invention is that the pulsing valve may comprise a pulse generator. Many pulses may be generated from a single valve revolution (hence allowing for lower rotational speed).

The valve assembly for pulsing a metered fuel flow to a turbine engine is another element of the present invention. The valve assembly includes a valve housing with an inlet and an outlet and mechanisms for splitting metered fuel flow into a first and a second flow part. The amount of the first-to-second flow division is determined by the first actuator. With the valve assembly, the first flow portion may be pulsed while simultaneously being controlled by an actuator coupled to the second actuator. The first and second flow parts are combined for communication to the output to produce a passageway.

Additionally, the invention relates to a fuel supply system for a turbine engine that includes a fuel pump for pumping fuel to the engine and a fuel metering unit in fluid series with the fuel pump for providing a measured fuel flow. The pump pumps gasoline into the turbine engine. With means downstream of the fuel metering unit, first and second fuel flows (e.g., one or more constraints) may be divided via different passageways, and the first flow can be pulsed (e.g., chopper ports). The first and second fuel flows are mixed in a collecting route downstream of the dividing and pulsing methods, and the combined flow is sent to a combustor in the turbine engine for burning.

For the benefit of a preferred embodiment, a single fuel metering valve dedicated to both flow paths of each pulsing valve assembly may be used (which means that two or more separate fuel metering units are not required for separate flow paths and multiple fuel metering valves and associated pulsing valve assemblies are possible for larger turbine engines). Separate metering valves for the first and second flow paths and/or are used. One valve controls the whole fuel flow to the engine, making engine management simpler.

Lastly, a further aspect of the present invention relates to providing fuel to a turbine engine by pumping and metered fuel to provide a metered fuel flow, dividing the metered fuel flow into a first flow portion and second, pulsing the first flow portion, and joining the first and second flow portions for delivery to the turbine engine.

When read in combination with the accompanying drawings, the following thorough description will reveal further the invention's features, aims, and benefits.

BRIEF DESCRIPTION OF THE DRAWINGS:

FIG. 1 is a schematic representation of a fuel supply system for a turbine engine by embodiment the present invention.

A more particular description will be rendered by referencing specific embodiments illustrated in the appended drawings to clarify various aspects of some example embodiments of the present invention. It is appreciated that these drawings depict only illustrated embodiments of the story and are therefore not considered limiting its scope. The invention will be described and explained with additional specificity and detail through the accompanying drawings so that the advantages of the present invention will be readily understood. A detailed description of the story is discussed below in conjunction with the appended drawings, which should not be considered to limit the scope of the invention to the accompanying drawing.

Further, another user interface can also be used with the relevant modification to provide the results above with the same modules, its principal, and protocols for the present invention.

It is to be understood that the above description is intended to be illustrative and not restrictive. For example, the above-discussed embodiments may be used in combination with each other. Many other embodiments will be apparent to those of skill in the art upon reviewing the above description.

The benefits and advantages which the present invention may provide have been described above about specific embodiments. These benefits and advantages and any elements or limitations that may cause them to occur or become more pronounced are not construed as critical, required, or essential features of any or all of the embodiments.

While the present invention has been described concerning particular embodiments, it should be understood that the images are illustrative and that the invention's scope is not limited to these embodiments. Many variations, modifications, additions, and improvements to the embodiments described above are possible. It is contemplated that these variations, changes, additions, and improvements fall within the invention's scope.

Regarding FIG. 1, an aspect of the present invention illustrates a schematic depiction of an engine liquid fuel delivery system according to a turbine. A gas system is going to be distinct. Instead of a bypass valve, the pump's pressure output is controlled by the compressible nature of the gas. An ignition system ignites liquid or gaseous fuel in the turbine combustion chamber from a fuel source, such as a fuel tank. A pump may be used in the fuel delivery system to pressurize and pump fuel to the turbine combustion chamber.

Thanks to a fuel flow electronic controller, the fuel flow to the combustion chamber may be electronically controlled in more advanced systems. A full authority digital electrical control, or FADEC, is shown schematically in FIG. 1 to regulate the system's different actuated valves using electronic signals.

The FADEC electronically regulates a gasoline metering device to regulate the total flow rate. Along with the fuel pump 16, the fuel metering unit has a metering valve located along a primary fuel supply path. Using the fuel metering valve, the FADEC establishes a predefined fuel flow rate along the fuel supply route and delivers that fuel at a known predetermined flow rate to the turbine combustion chamber in a closed loop.

To position the fuel metering valve 20 in response to electrical signals from the FADEC, the fuel metering unit contains an actuator in the form of an electro-hydraulic servo valve (EHSV). For closed-loop control of the fuel metering valve, a position sensor such as an LVDT (linear variable displacement transducer) monitors the position of the fuel metering valve and feeds back to the FADEC.

To recirculate a portion of the liquid fuel flow generated by the pump, the bypass valve is installed in fluid parallel to the fuel metering valve on the low-pressure side (Pb) of the fuel pump to bypass the excess fuel flow generated by the pump (in gaseous fuel systems a bypass is not needed since gaseous fuel is compressible). A pressure sensor line is installed for the bypass valve since it is pressure-sensitive on the downstream side of the fuel metering valve. The bypass valve receives pressure information from the pressure sensor line, which runs from the pump to the valve. If pressure decreases downstream of the fuel metering valve, the bypass valve will block the bypass recirculation channel, causing the fuel metering valve to close as well. Additionally, when pressure builds, the bypass valve's pressure sensor line opens, allowing more air to be recalculated via the recirculation route, increasing the amount of recycled air.

Many various gasoline metering unit designs and configurations are recognized and widely exploited in the business. Thus one knowledgeable in the art can easily understand that they may be used. FADEC and fuel-metering valve configuration in the fuel metering unit is shown in the system diagram as typical components. One meter supply flow route to the engine is given for simplicity's sake in this schematic (along with one fuel metering unit). On the other hand, many big turbine engines have two or three metering valves, each for a separate set of combustor nozzles. Each metering stream may be divided into numerous flows routes, with one channel flowing to each pair of nozzles. The pulsating valve(s) (described below) may similarly be placed downstream of the metering valve(s) in these alternate implementations. Multiple "cans" of combustion are common in industrial engines. Numerous combustion cans might need pulsating valves, with one pulsing valve assigned to each can if there were multiple combustion cans. To moderate a combustor can's oscillation, use a different pulsating valve for each pulse. The annular combustion chambers seen in aviation gas turbine engines might potentially employ pulsing valves. This means that one skilled in the art will recognize that the broader claims appended hereto are intended to cover these various possible arrangements and configurations depending on the application size and requirements of the various turbine sizes and configurations commercially employed.

In further detail, the pulsating valve assembly 36 is connected to the fuel metering valve by a fluid series along the main fuel supply channel (preferably downstream thereof, but it is also possible for an upstream arrangement). The fuel metering unit already defines the complete flow rate when it is connected to the pulsating valve assembly in fluid series. As a result, controlling the fuel flow rate is not necessary or even a concern in the pulsing valve assembly's disclosed embodiment. The fact is that one fuel metering unit can be used for both pulsed. Unpulsed flow paths for each pulsing valve assembly along a single metered fuel circuit in the fuel supply system, so separate pulsed-and-unpulsed-fuel metering units aren't required, as will be shown below (this is also true for applications where there are multiple fuel metering valves, dividers, and/or pulses). To put it another way, the pulsating valve assembly eliminates the need for a separate fuel metering valve for each flow route.

An example of this is illustrated in FIG. 1. The FADEC uses engine and other sensors to regulate the pulsing valve assembly depending on the amplitude and frequency of pressure oscillations inside the turbine engine. Earlier active combustion control patents or literature indicate how a quick response transducer or sensor may be installed in the turbine combustion chamber to detect the size and frequency of the combustor oscillations. This is an important aspect of the system. The transducer could detect a variety of combustor oscillation-related physical properties. As an example, consider pressure, temperature, flame ionization, UV light, and so on. Using an electronic controller, the fuel flow pulsation amplitude, frequency, and phase angle may be adjusted to reduce oscillation.

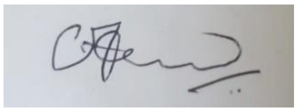
The FADEC uses the sensor input to provide control signals to the pulsating valve assembly's numerous actuators. It sends a magnitude signal to a valve actuator to position the flow divider and a frequency demand signal to control the speed of a rotor or rotary valve to facilitate fuel flow interruption and thus pulsing of the fuel flow along with one of the flow paths set up by the flow divider valve, in particular. The rotary valve that cuts or interrupts the flow may be equipped with a speed sensor to detect the speed of the sensor and so pulse the flow. The rotary valve may be controlled in a closed-loop, allowing a pulsed flow to be established along the first flow route. The main fuel supply route 24 connects to the turbine combustion chamber, as shown in FIG. 1, where the first and second flow channels are reunited and communicated.

We Claim:

1. In one embodiment, the valve assembly includes: a valve housing with an inlet, outlet, first flow path, and second flow path, the first and second flow paths fluidically interconnected; a divider valve for dividing fluid flow from an inlet port between the first and second flow paths; and a pulse-inducing valve located downstream of the divider valve and moveable to successively interrupt flow through the first and second flow paths, respectively.
2. Claims are made for a valve assembly. The divider valve provides two limitations, one on a first flow route and the other on a second flow direction. Moving the divider valve alters the magnitude of both restrictions in an inverse relationship.
3. The divider valve is driven by an actuator operating on it to manage the first and second limitation sizes, as claimed in claim 3.
4. claim 1, wherein at least one rotary actuator acts on at least one of the bodies to enable relative rotation between them about an axis, the first body having at least one first chopper port and the second body having at least a plurality of second choppers ports spaced from each other around and separated by respective pluralities of port blockade portions, wherein relative rotation between the two bodies is made possible by the rotary actuator acting on the at least one body, and wherein relative rotation between the two bodies is made possible

5. According to claim 4, the valve assembly wherein the rotary actuator is chosen from an electric motor or a rotary turbine.
6. According to claim 1, the flow divider valve includes a linearly-movable, first and second cylindrical-lands spool valve, the first and second cylindrical-lands spool valve serving to regulate fluid flow from the inlet to the first and second flow paths, respectively, and where the pulsing valve includes a sleeve mounted for rotation concentrically around the spool valve, with the sleeve having at least one rotationally-rotatable chopper port.

Dated this 01st day of November 2021

Signature: 

Applicant(s)

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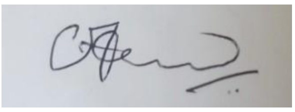
ABSTRACT

A pulsing valve assembly pulses metered fuel flow to a turbine engine. The pulsing valve assembly comprises a valve housing having an inlet and an outlet. A divider valve divides metered fuel flow into a first flow portion and a second flow portion. A first actuator sets a magnitude of a flow divide between the first and second flow portions. The valve assembly also includes a pulsing valve for pulsing the first flow portion and a second actuator for setting the frequency of the pulsing valve. The pulsed and unpulsed flow portions are then joined and delivered to the turbine engine combustion chamber.

Dated this 01st day of November 2021

Signature: 

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