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RESONANT INTERMITTENT COMBUSTION DEVICE

Filed July 11, 1960

FIG-1

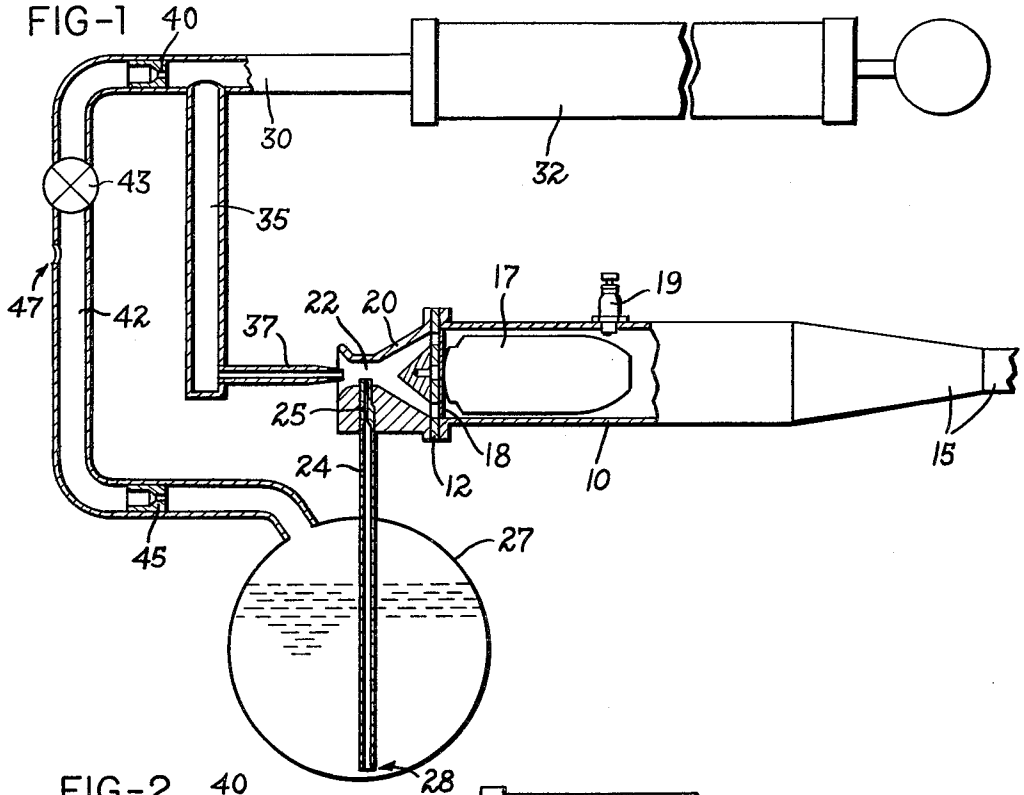
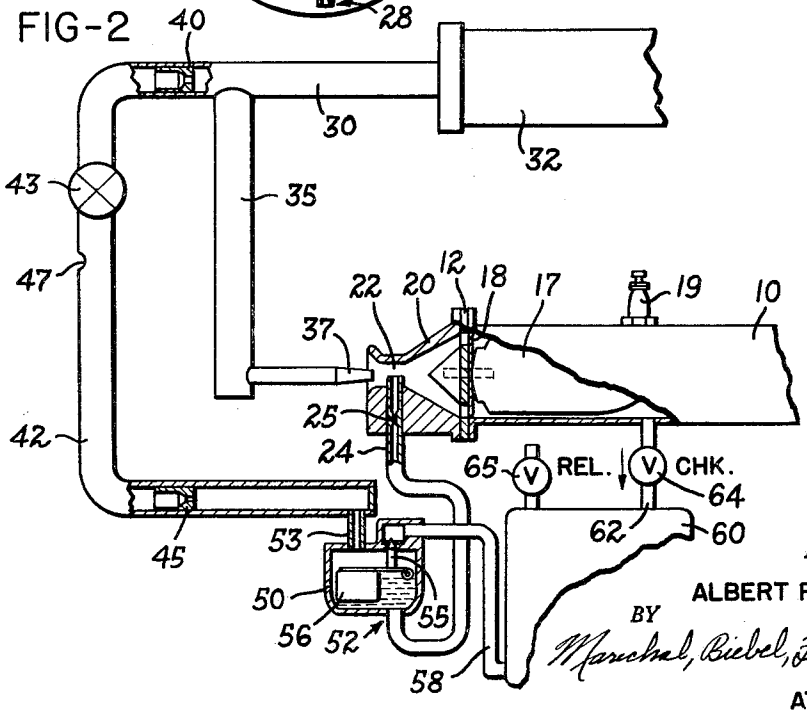


FIG-2



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RESONANT INTERMITTENT COMBUSTION DEVICE

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This application relates to resonant intermittent combustion devices, and particularly to fuel-air supply and starting fuel-air supply systems for such devices.

Resonant intermittent combustion devices and systems may be designed for use in a number of different applications. For example, they may be designed to give maximum output jet thrust at the exhaust nozzle for providing a simple and relatively inexpensive propulsion engine, or these devices may be designed to operate at lower resonant frequencies for use as heating systems or systems for vaporizing and dispersing insecticides, creating fogs, etc. Whatever the use of the resonant combustion device, it is generally characterized by its simplicity of construction and its adaptability to use under widely varrying climatic conditions, since these devices normally have but one moving part, and are of such basic and straight-forward construction that maintenance problems are kept at a minimum, and it is desirable to have simplified fuel supply and starting arrangements in accordance with this general theme.

Accordingly, the primary object of this invention is to provide a simplified and effective fuel supply system for such resonant intermittent combustion devices, wherein a proper fuel-air mixture is obtained while using a fuel source, such as a tank of fuel, which may be conveniently mounted adjacent or beneath the combustion device, in which proper fuel metering is not dependent upon maintaining a pressure head upon the liquid fuel supplied to the device.

Another object of the invention is to provide a resonant intermittent combustion device which may include a high-vacuum type of venturi for providing a properly carbureted fuel-air supply mixture.

An additional object of the invention is to provide a novel system and construction for supplying a starting fuel-air mixture to such resonant intermittent combustion devices, wherein the running fuel supply is obtained from a non-pressurized tank or chamber of liquid fuel, wherein super-atmospheric pressure may be created temporarily in the fuel chamber to initiate a supply of liquid fuel to the fuel-air mixing venturi of the device, and wherein concurrently a flow of air is induced through the venturi.

Another object of the invention is to provide a simple, effective and economical starting system for such devices which does not require flow regulators, metering adjustments, or other relatively complicated components.

A further object is to avoid the use of a pressurized or elevated fuel supply tank, and also to permit use of a larger fuel feed metering orifice than is possible when supplying fuel under pressure, thereby decreasing the likelihood of clogging of the fuel metering orifice.

Other objects and advantages of the invention will be apparent from the following description, the accompanying drawing and the appended claims.

In the drawing:

FIG. 1 is a schematic representation, with parts broken away and shown in section, of one type of fuel supply and starting mixture supply system in accordance with the invention, wherein the liquid fuel is supplied directly from a tank; and

FIG. 2 is a similar view of a modified system, wherein the fuel is supplied through an intermediate chamber in which a substantially constant liquid fuel level is maintained by supply from a main tank.

Referring to the drawing, and particularly to FIG. 1, a resonant intermittent combustion device, to which the present invention is particularly adapted, is shown schematically as including a combustion chamber **10**, and a conventional one-way or check valve **12** mounted on the inlet end of the combustion chamber, limiting the flow essentially to flow only into the combustion chamber, in known manner. The combustion chamber is connected at its other end into an open exhaust or discharge tube **15** which may be of variable length in accordance with the predetermined natural resonant frequency of the device, as is well known in the art. A conventional flame displacement **17** may also be mounted within the combustion chamber, partially for the purpose of protecting the flexible blades **18** of the valve member **12**, and a spark plug **19** also is mounted with its electrodes in the combustion chamber. This spark plug is connected to a suitable energizing source of electricity (not shown) only during starting, until the combustion device is warm enough to sustain its own ignition.

The combustible fuel-air mixture is provided by an inlet venturi **20** mounted on the inlet valve **12**, and including a throat **22** through which all of the air entering the engine is passed. Opening into the venturi throat is the fuel supply tube **24** which includes a fuel control or metering orifice **25**. This tube **24** may extend directly into the fuel tank or chamber **27**, which may conveniently be mounted to one side or beneath the combustion device, with the tube **24** terminating adjacent the bottom of the tank as indicated at **28**. Thus, a flow of air through the venturi will create a reduced pressure at the throat **22** and fuel will pass through the tube **24** and orifice **25**, to be entrained in the air flow through the venturi. The feeding of the fuel will be caused by the pressure differential thereon, resulting from atmospheric pressure normally exerted within the tank **27**, and negative pressure existing at the throat **22** of the venturi.

In order to feed the fuel the required distance from the tank to the venturi throat, it is desirable to employ a so-called "high vacuum" venturi, in which a negative pressure may be created. During starting of the engine it may be somewhat difficult to induce sufficient air flow through the venturi initially to create a sufficiently high negative pressure.

Therefore, in accordance with the invention a system is provided for inducing starting air flow through the venturi **20** while at the same time providing a temporary superatmospheric pressure within tank **27** to assist in feeding fuel through the supply tube **24**. This system includes an air supply conduit **30** which may be conveniently attached to a source of air under pressure. Any source suitable for this purpose may be used, however, in devices where portability and simplicity is important, a conventional manually operated reciprocating air pump **32** may be employed.

The conduit **30** has connected to it a branch conduit **35** which terminates in a starting air nozzle **37** directed into the venturi **20** and across the top of the fuel supply tube **24**. Pressure air issuing through nozzle **37** will thus induce a slight negative pressure in the fuel supply tube **24** and a slight positive pressure within the venturi chamber **20** sufficient to lift valve members **18** and permit the initial charge of fuel and air to enter combustion chamber **10**. Downstream of the branch conduit **35** a starting air control orifice **40** is mounted within the conduit **30**, providing a restriction to air flow which thus proportions the input of starting air between the starting air branch conduit **35** and the fuel pressurizing conduit **42** which extends downstream of orifice **40**, and which may be conveniently selectably connected thereto through

a manually operable valve 43. The conduit 42 opens into the top of tank 27, above the normal highest fuel level therein, and flow between the main portion of this conduit and the tank is controlled by an orifice 45 through which all air must pass into the tank from conduit 42. A breather orifice 47 connects the conduit 42 to atmosphere on the opposite side of the orifice 45 from the tank connection.

Thus, in a starting operation of the combustion device, the pump 32 may be manipulated to supply air under pressure through nozzle 37, inducing a starting flow of air through venturi 20. A proportionate amount of pressure air from the pump 32, as determined by the size of orifice 40, will pass through valve 43, which is assumed now to be opened, and will pass also through conduit 42 and orifice 45 into the tank 27 above the fuel. This creates a temporary superatmospheric pressure in the tank, and the resultant pressure differential across the metering fuel orifice 25 will cause a flow of fuel through the tube 24 into the venturi, providing an effective starting mixture.

The size of breather orifice 47 is so proportioned relative to the orifice 45 (being sufficiently smaller) that when air under pressure enters the conduit 42 a sufficient flow will pass the orifice 45 to raise the pressure in the tank above atmospheric before the breather orifice 47 can bleed the system and reduce the air pressure therein to atmospheric. On the other hand, when the combustion device is started, and the fuel supply becomes self-sustaining by reason of the venturi then creating its normal high vacuum in operation, the starting air supply will be stopped, and pressure in the conduit 42 will drop to atmospheric. From then on, during operation of the system, the air flow passage through orifice 45, conduit 42, and breather orifice 47, serves as a venting system for the tank which maintains air pressure therein at essentially atmospheric pressure. Obviously, the level of the liquid fuel in the tank will not fall so rapidly during normal operation as to exceed the capacity of the breather orifice to admit air thereinto.

A modified form of the invention is shown in FIG. 2. In this form of the invention most elements of the combustion device, the fuel system, and the starting fuel air mixture supply system are the same, and thus the same reference numerals have been applied to the same parts as in FIG. 1. It will be understood that the construction and function of these parts is essentially the same as above described, with the following exceptions.

In this system a fuel chamber in the form of a float bowl 50 functions as the tank or fuel supply chamber, in place of the tank 27 in FIG. 1. The fuel supply conduit 24 thus is connected into the bottom of this chamber as indicated at 52, and the end of the starting pressurizing conduit 42 opens through the closed top of chamber 50, as through the connecting tube 53. An essentially constant level of fuel is maintained in the chamber 50 by reason of a valve 55 which is controlled by float 56 to close and shut off the supply of fuel from an inlet line 58 when the level in the chamber reaches a predetermined upper limit. The line 58 extends from a main tank 60 which provides a constant supply of fuel under a slight pressure through the line 58.

A convenient method of obtaining the transferring pressure, by which fuel is moved from main tank 60 to the supply chamber 50, is provided by a pressuring line 62 extending from the combustion chamber 10 and including a check valve 64 which permits flow of gas under pressure only in the direction indicated, into the tank 60. Thus, with the combustion device operating, the pressure in the combustion chamber fluctuates in a cyclic fashion, and the valve 64 may be regulated to open only when this pressure is at or near its positive peak, the result being the supply of pulses of pressure gas through the line 62 into tank 60. A conventional relief valve 65 is connected in venting relation into the tank 60, acting to maintain a desired maximum internal pressure within tank 60.

The operation of the apparatus shown in FIG. 2 is essentially the same as described in connection with FIG. 1, the only difference being that the temporary superatmospheric fuel feeding pressure created during operation of the starting system is applied through the tube 53 over the fuel in the closed chamber 50. Likewise, during running conditions the tube 53, orifice 45, conduit 42, and breather orifice 47 cooperate to provide the venting system which maintains atmospheric pressure in the constant level fuel supply chamber 50.

From the foregoing description it will be apparent that the present invention provides a simple and effective fuel supply system in which maintenance of a pressure head on the liquid fuel is unnecessary. The tank 27, or alternately the chamber 50, may be mounted conveniently beneath or to one side of the venturi 20, and by use of a high vacuum venturi effective fuel supply and a proper fuel-air mixture for running is readily attained. There are essentially no moving parts in the fuel supply and starting systems (with the possible exception of the float operated valve 55). The fixed orifices 40, 45 and 47 may be readily proportioned so that easy starting is obtained independently of the speed with which the manual pump 32 is stroked, assuming that such a manual pump is used, and independently of variations in fuel level in the supply tank. Thus, once the system is properly installed it will require substantially no maintenance, with the possible exception of infrequent checking and cleaning of the orifice passages.

The shut off valve 43 is not essential to the operation of the device, but has been found useful when, for example, the combustion device becomes flooded for some reason during starting. Under such conditions, by closing this valve atmospheric pressure is maintained in the fuel tank or chamber and the starting fuel-air mixture may thus be "leaned out" to overcome a flooded condition.

While the forms of apparatus herein described constitute preferred embodiments of the invention, it is to be understood that the invention is not limited to these precise forms of apparatus, and that changes may be made therein without departing from the scope of the invention which is defined in the appended claims.

What is claimed is:

1. A starting system for a resonant intermittent combustion device having an air inlet venturi and a fuel supply tube extending from a closed fuel chamber into the throat of the venturi, said starting system comprising a manually operable air pump providing a source of air under pressure, a starting air supply conduit extending from said source and terminating in a nozzle adapted to direct a flow of starting air into the venturi, a fuel pressurizing line also connected to said source and adapted for direct connection to the closed fuel chamber above the level of fuel therein, a metering orifice in said pressurizing line controlling the quantity of air flow from said source through said fuel pressurizing line and maintaining free flow conditions in either direction between said fuel chamber and said pressurizing line, and a breather orifice connecting said fuel presssurizing line to atmosphere down stream of said metering orifice and dimensioned relative thereto for maintaining pressure in said pressurizing line sufficient to create a superatmospheric pressure in the fuel chamber when there is a substantial air flow through said starting orifice and for venting the closed fuel chamber during running of the device with said air pressure source inoperative.

2. A starting system for a resonant combustion device having an air inlet venturi and a fuel supply tube extending from a closed fuel chamber into the throat of the venturi, said starting system comprising means providing a source of air under pressure, a starting air supply conduit extending from said source and terminating in a nozzle adapted to direct a flow of starting air into the venturi, a fuel pressurizing line also connected to said

source and adapted for direct connection to the closed fuel chamber above the level of fuel therein, a starting orifice in said pressurizing line controlling the proportion of air flow from said source through said air supply conduit and said fuel pressurizing line, a breather orifice connecting said fuel pressurizing line to atmosphere downstream of said starting orifice and dimensioned relative thereto for maintaining a temporary starting pressure in said pressurizing line, and a control orifice in said pressurizing line downstream of said breather orifice and dimensioned relative thereto for passing a greater air flow under essentially the same pressure to create a superatmospheric pressure in the fuel chamber when there is a substantial air flow through said starting orifice and to vent the closed fuel chamber during running of the device with said air pressure source inoperative, said control orifice presenting the sole restriction to free flow between said fuel chamber and said pressurizing line in either direction.

3. In combination a resonant intermittent combustion device including a combustion chamber, a fuel mixture supply connected to said chamber and including a high vacuum venturi having a fuel supply tube opening into the throat thereof, valve means between said venturi and said chamber limiting the flow exchange therebetween essentially to flow from said venturi into said chamber, a closed fuel supply chamber normally holding a quantity of liquid fuel, said fuel supply tube communicating with said fuel supply chamber below the liquid level therein and having a metering orifice through which fuel is drawn into said venturi during normal operation of said device, a starting air pump, a starting air supply conduit receiving air under pressure from said pump, a nozzle mounted to discharge into said venturi and connected to said air supply conduit, a fuel pressurizing and venting line also connected to receive air under pressure from said pump, said pressurizing and venting line opening freely into said fuel chamber above the normal fuel level therein for controlling the pressure in said fuel chamber, and a breather orifice between said line and the atmosphere providing for maintenance of atmospheric pressure in said fuel chamber when said air pump is inoperative, said breather orifice having such flow characteristics that a temporary superatmospheric pressure is created in said fuel chamber during operation of said air pump.

4. In combination a combustion device including a combustion chamber, a fuel mixture supply connected to said chamber and including a venturi having a fuel supply tube opening into the throat thereof, a closed fuel supply chamber normally holding a quantity of liquid fuel, said fuel supply tube communicating with said fuel supply chamber below the liquid level therein, a source of starting air under pressure, a starting air supply conduit receiving air under pressure from said source, a nozzle mounted to discharge into said venturi and connected to said air supply conduit, a fuel pressurizing and venting line also connected to receive air under pressure from said source, said pressurizing and venting line opening freely into said fuel chamber above the normal fuel level therein for controlling the pressure in said fuel chamber during starting and running of the device, and a breather orifice between said line and the atmosphere providing for maintenance of atmospheric pressure in said fuel chamber when said starting air source is inoperative,

said breather orifice having such flow characteristics that a temporary superatmospheric pressure is created in said fuel chamber during operation of said starting air source.

5. In combination a combustion device including a combustion chamber, a fuel mixture supply connected to said chamber and including a venturi having a fuel supply tube opening into the throat thereof, a closed fuel supply chamber normally holding a quantity of liquid fuel, said fuel supply tube communicating with said fuel supply chamber below the liquid level therein, a source of starting air under pressure, a starting air supply conduit receiving air under pressure from said source, a nozzle mounted to discharge into said venturi and connected to said air supply conduit, a fuel pressurizing and venting line also connected to receive air under pressure from said source, a starting orifice in said line controlling the admission of pressure air thereinto, said pressurizing and venting line opening freely into said fuel chamber above the normal fuel level therein for controlling the pressure in said fuel chamber during starting and running of the device, and a breather orifice between said line and the atmosphere providing for maintenance of atmospheric pressure in said fuel chamber when said starting source is inoperative, said breather orifice having such flow characteristics with respect to said starting orifice that a temporary superatmospheric pressure is created in said fuel chamber during operation of said starting air source.

6. In combination a resonant intermittent combustion device including a combustion chamber, a fuel mixture supply connected to said chamber and including a high-vacuum venturi having a fuel supply tube opening into the throat thereof, means between said venturi and said chamber limiting the flow exchange therebetween essentially to flow from said venturi into said chamber, a closed fuel supply chamber normally holding a quantity of liquid fuel, said fuel supply tube communicating with said fuel supply chamber below the liquid level therein and having a metering orifice through which fuel is drawn into said venturi during normal operation of said device, a starting air pump, a starting air supply conduit receiving air under pressure from said pump, a nozzle mounted to discharge into said venturi and connected to said air supply conduit, a fuel pressurizing line also connected to receive air under pressure from said pump and having a starting orifice controlling flow therethrough to proportion air flow between said air supply conduit and said pressurizing line, said pressurizing line opening freely into said fuel chamber above the normal fuel level therein for creating a superatmospheric pressure in said fuel chamber during starting to force fuel through said supply tube toward said venturi, and a breather orifice between said pressurizing line and the atmosphere preventing maintenance of superatmospheric pressure in said fuel chamber when said air pump is inoperative, said breather orifice having such flow characteristics with respect to said starting orifice that a temporary superatmospheric pressure is created in said fuel chamber during operation of said air pump.

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