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FUEL SUPPLY APPARATUS FOR RESONANT PULSE JET COMBUSTION DEVICE

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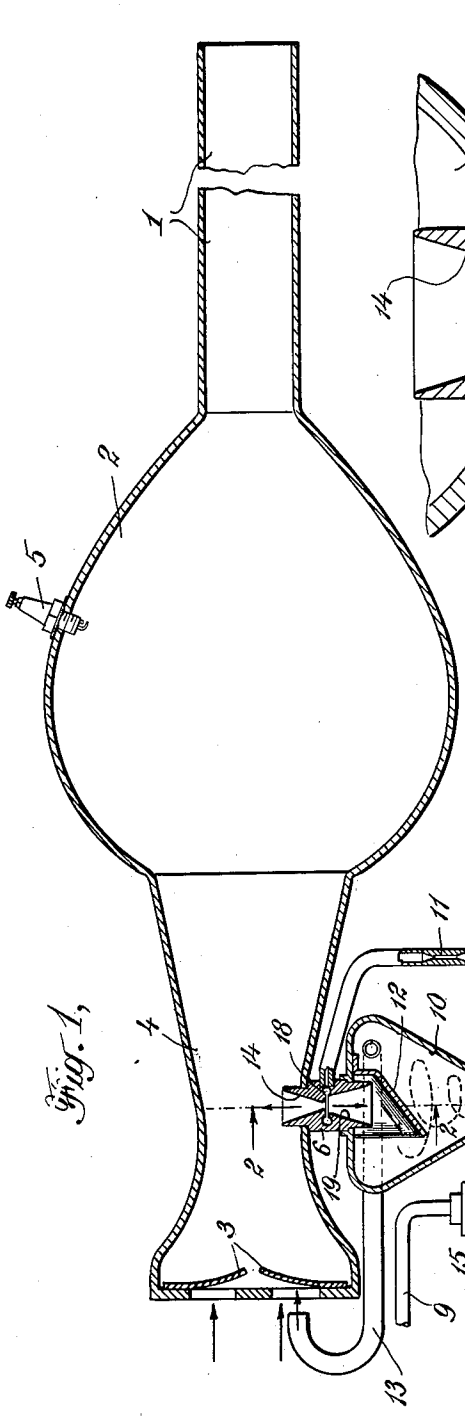


Fig. 1.

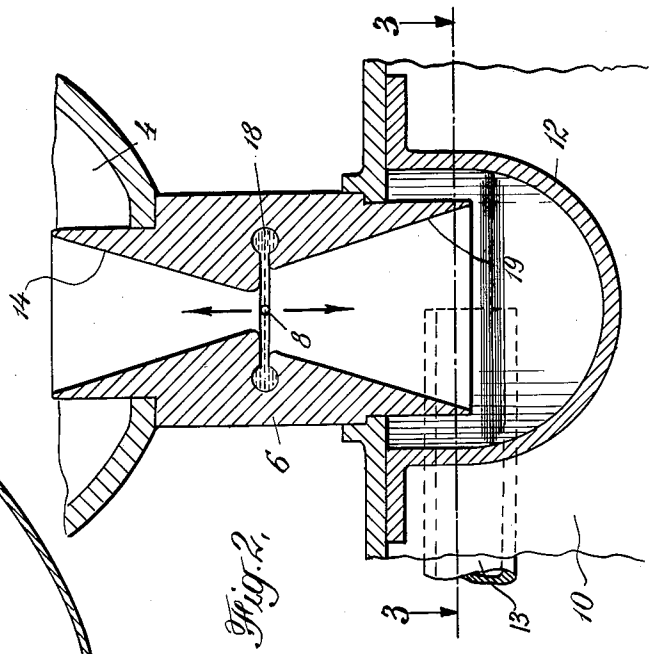


Fig. 2.

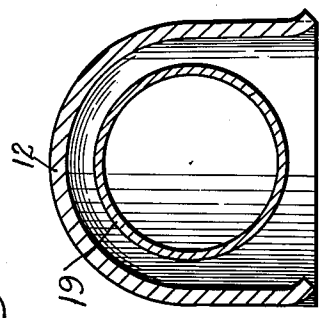


Fig. 3.

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FUEL SUPPLY APPARATUS FOR RESONANT PULSE JET COMBUSTION DEVICE

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10 Claims. (Cl. 158—4)

This invention relates to apparatus for supplying fuel to a resonant pulse jet combustion device.

This application is a continuation-in-part of my copending application Serial No. 28,917, filed May 24, 1948, now abandoned, and entitled "Process and Means for the Measured Admixture of a Fluent Material in a Cyclic Process."

A resonant pulse jet combustion device comprises generally a combustion chamber having connected thereto an unrestricted or valveless exhaust pipe or resonance tube. Fuel for combustion is periodically drawn into the combustion chamber and detonated therein at the natural acoustic frequency of the chamber and exhaust pipe, and air to support combustion of the fuel is drawn in with, or at the same time as, the fuel through a suitable check valve or check valves connected to the combustion chamber. The combustion chamber pressure periodically fluctuates, at the natural frequency of the apparatus, between superatmospheric and subatmospheric values, and the fuel and air for combustion are drawn into the chamber when this pressure is subatmospheric. The periodic interval when the pressure is subatmospheric may be termed the suction phase of operation and the period when the pressure is superatmospheric may be termed the detonation phase of the operation. Resonant pulse jet combustion apparatus of this nature is disclosed, for example, in the copending application of Walter Dürr et al., Serial No. 166,611, filed June 7, 1950, and entitled "Burner Device Having Heat Exchange and Gas Flow Control Means for Maintaining Pyrophoric Ignition Therein," now Patent No. 2,644,512. Apparatus of this nature is useful to provide a reaction drive for airplanes, heating devices, apparatus for atomizing and spraying liquids and for other purposes.

In earlier embodiments of resonance pulse jet combustion devices, fuel has been fed into the combustion chamber from a carburetor or nozzle discharging fuel through the check valve that periodically admits air to the combustion chamber. This arrangement has the disadvantage that the check valve mechanism is wetted and so damaged by the fuel. For this reason, efforts have been made to introduce fuel through a nozzle or the like which opens into the combustion chamber inside the air admission check valve. In previously proposed arrangements of this kind, the fuel is periodically forced back from the nozzle mouth by the detonation phase pressure in the combustion chamber to such an extent that the vacuum in the chamber during the ensuing suction phase is insufficient to draw the fuel back to and through the nozzle mouth and into the combustion chamber in time to support the next ensuing detonation.

It is the object of the present invention to provide a novel fuel supply apparatus for combustion devices of the type described which permits the reliable introduction of fuel to the combustion chamber during the suction phase of operation and without passing the fuel through a check valve. In accordance with the invention, this object is accomplished by connecting to the combustion

chamber a venturi tube having a restricted throat intermediate its ends, into which throat a fuel feed pipe discharges. Due to the periodic pressure fluctuations in the combustion chamber, gases are forced to flow alternately in opposite directions through the venturi tube, with the result that fuel is drawn into the tube from its throat both when the flow is toward the combustion chamber during a suction phase and when the flow is away from the combustion chamber during a detonation phase of operation. Thus, a combustible mixture of air and fuel is drawn into the combustion chamber during a suction phase of operation and exhaust gas is forced out of the combustion chamber through the venturi tube during a detonation phase of operation. With this arrangement, a supply of fuel is constantly maintained at the mouth of the fuel pipe where it opens into the throat of the venturi tube, so that fuel is at all times available for introduction into the combustion chamber without delay during a suction phase of operation. The fuel drawn into the combustion chamber during the suction phase of operation supports combustion therein during the ensuing detonation phase. The fuel drawn from the fuel feed pipe during the detonation phase is carried into a condensation chamber connected to the outer end of the venturi tube and is there condensed and preferably returned from that chamber to the fuel feed pipe or to a fuel supply container to which the feed pipe is connected. Although not essential to the invention, the condensation chamber may be designed to separate fuel from gases by centrifugal or "cyclone" action. The condensation chamber may, however, comprise a fuel supply container, such as the float chamber from which fuel is fed to the venturi throat, and in this connection, the flow of gases through the narrow venturi throat does not disturb the normal operation of the float.

In describing the invention in detail, reference will be made to the accompanying drawings, in which an embodiment thereof is illustrated.

In the drawings—

Fig. 1 is a sectional elevation of apparatus embodying the invention;

Fig. 2 is an enlarged sectional elevation taken along the line **2—2** of Fig. 1 and viewed in the direction of the arrows, and

Fig. 3 is a horizontal section view taken along the line **3—3** of Fig. 2 and viewed in the direction of the arrows.

Referring to the drawing, there is shown a combustion chamber **2** having connected thereto a valveless exhaust pipe or resonance tube **1** which together form a resonant pulse jet combustion device. Air for supporting combustion in the chamber **2** is periodically drawn into the chamber during the suction phase of operation through one or more check valves **3** of suitable construction which are connected to the chamber **2** by an inlet passage **4**. Fuel is drawn into the combustion chamber during the suction phase from a narrow venturi tube **6** opening into the inlet passage **4** and the air and fuel mixture is ignited and so detonated by an ignition plug **5** or by compression.

According to the invention, the outer end of the venturi tube **6** is connected to a condensation chamber so that the venturi passage directly connects the combustion chamber with the condensation chamber without any intervening check valve. As shown, the condensation chamber **10** may take the form of a centrifugal separator having a baffle **12** for directing the fuel and gas mixture in a spiral path, as illustrated by the broken arrow. A pipe **13** conducts air and such fuel or fuel vapor as may be expelled from the condensation chamber **10** during a detonation phase of operation, from the condensation chamber **10** to a point near the air intake check valves **3**, from which point the air and fuel are drawn into the air

inlet of the combustion device. In some cases the pipe 13 may be omitted. The condensation chamber 10 opens into a fuel supply container, here shown as a float chamber 7 disposed below the chamber 10. Fuel from a suitable supply enters the chamber 7 through a pipe 9 under control of a float operated valve 15.

The venturi tube 6 is formed of two conical passages 14 and 19 meeting at a restricted throat into which a ring channel 18 surrounding the throat opens. The ring channel 18 is connected to the float chamber 7 through a fuel pipe 8 having a metering orifice 11 therein.

During operation of the device, gases flow through the venturi tube 6 alternating in opposite directions. When the flow is toward the combustion chamber, fuel is drawn from the ring channel 18 at the throat of the venturi tube and is drawn into the combustion chamber. When the flow is outward toward the condensation chamber 10, fuel is similarly drawn from the ring channel 18 and entrained with the gas, and this fuel is condensed in the chamber 10 and returned to the fuel supply container illustrated as the float chamber 7, and so is eventually returned to the ring channel through the fuel pipe 8. Since fuel is drawn from the ring channel 18 during both the suction cycle and the detonation cycle of the device, fuel is at all times present at the mouth of this channel and is drawn into the venturi tube and entrained with the entering air without delay at the start of each suction cycle.

The spiral path of the gaseous mixture in the condensation chamber 10 due to the baffle 12 assists in separating the fuel from the gases in this chamber, but this is not essential to the invention in its broader aspects. In fact, the separation of the fuel from the gases and its return to the fuel feed pipe, while constituting a desirable innovation, is not essential to my broader concept of feeding fuel to the restricted throat of the venturi tube so that fuel is dependably drawn into the combustion chamber during a suction phase of operation, and this without either feeding the fuel through the air intake check valve, employing a fuel pump, or employing a check valve in the fuel feed pipe.

In order to insure that a sufficiently low pressure is provided at the ring channel 18 during the detonation cycle of operation to cause fuel to be drawn from the ring channel during that cycle, it is desirable that the constricted mouth of the inner conical passage 14 be smaller in section than the constricted mouth of the outer conical passage 19, and such an arrangement is illustrated in the drawings and particularly in Fig. 2. With this arrangement, the reduction in pressure at the ring channel 18 due to the flow of gases outwardly of the combustion chamber through the venturi tube 6, due to the high superatmospheric pressure of a detonation cycle, is sufficient to draw fuel from the ring channel and so to maintain fuel at the mouth of this channel at the start of the ensuing suction cycle of operation. During a suction phase of operation, the inlet passage 4 is under vacuum which readily applies suction sufficient to draw fuel from the ring channel 18 under low velocity of inward flow of gases through the venturi tube 6. No corresponding vacuum is available to draw fuel from the ring channel 18 during a detonation phase of operation, and for this reason a relatively higher velocity of flow, producing an injector effect, is then desirable to draw fuel to and out of the ring channel 18.

I claim:

1. Apparatus of the type described comprising the combination, with a resonant pulse jet combustion device in which a combustible mixture of fuel and air is periodically detonated at acoustic frequency and which comprises a combustion chamber, a valveless resonant exhaust pipe directly connected with the combustion chamber and forming therewith an acoustic resonator, and an inlet check valve connected to the combustion chamber, of fuel supply apparatus comprising a fuel condensation chamber, a venturi tube having a restricted throat intermediate its ends and connected between said fuel condensation chamber and said combustion chamber, a fuel feed pipe connected to deliver fuel to the restricted throat of said venturi tube, said condensation chamber having a discharge opening for fuel condensed therein, and means connecting said discharge opening with said fuel feed pipe whereby fuel condensed in said condensation chamber may be passed back to said venturi tube through said fuel feed pipe.

2. Apparatus of the type described comprising the combination, with a resonant pulse jet combustion device in which a combustible mixture of fuel and air is periodically detonated at acoustic frequency and which comprises a combustion chamber, a valveless resonant exhaust pipe directly connected with the combustion chamber and forming therewith an acoustic resonator, and an inlet check valve connected to the combustion chamber, of fuel supply apparatus comprising a fuel condensation chamber, a venturi tube having a restricted throat intermediate its ends and connected between said fuel condensation chamber and said combustion chamber, a fuel storage container disposed below and connected to receive fuel from said condensation chamber and a fuel feed pipe connected between said fuel storage container and the restricted throat of said venturi tube.

3. Apparatus of the type described comprising the combination, with a resonant pulse jet combustion device in which a combustible mixture of fuel and air is periodically detonated at acoustic frequency and which comprises a combustion chamber, a valveless resonant exhaust pipe directly connected with the combustion chamber and forming therewith an acoustic resonator, and an inlet check valve connected to the combustion chamber, of fuel supply apparatus comprising a fuel condensation chamber, a venturi tube having a restricted throat intermediate its ends and connected between said fuel condensation chamber and said combustion chamber, a fuel storage container disposed below and connected to receive fuel from said condensation chamber, means for maintaining a supply of fuel in said fuel storage container, and a fuel feed pipe connected between said fuel storage container and the restricted throat of said venturi tube.

4. Apparatus of the type described comprising the combination, with a resonant pulse jet combustion device in which a combustible mixture of fuel and air is periodically detonated at acoustic frequency and which comprises a combustion chamber, a valveless resonant exhaust pipe directly connected with the combustion chamber and forming therewith an acoustic resonator, and an inlet check valve connected to the combustion chamber, of fuel supply apparatus comprising a fuel condensation chamber, a venturi tube comprising two conical passages converging toward each other to form a restricted throat with the outer ends of said conical passages connected respectively to said fuel condensation chamber and said combustion chamber, the restricted end of said conical passage which is connected to said combustion chamber having a smaller cross section than the restricted end of said conical passage which is connected to said condensation chamber, and a fuel feed pipe connected to deliver fuel to the restricted throat of said venturi tube at the periphery of the constricted end of said conical passage which is connected to said condensation chamber.

5. Apparatus of the type described comprising the combination, with a resonant pulse jet combustion device in which a combustible mixture of fuel and air is periodically detonated at acoustic frequency and which comprises a combustion chamber, a valveless resonant exhaust pipe directly connected with the combustion chamber and forming therewith an acoustic resonator, and an inlet check valve connected to the combustion chamber, of fuel supply apparatus comprising a fuel condensation chamber, a venturi tube comprising two conical passages

converging towards each other to form a restricted throat with the outer ends of said conical passages connected respectively to said fuel condensation chamber and said combustion chamber, the restricted end of said conical passage which is connected to said combustion chamber having a smaller cross section than the restricted end of said conical passage which is connected to said condensation chamber, and means connected to deliver fuel from said condensation chamber to the restricted throat of said venturi tube.

6. Apparatus of the type described comprising the combination, with a resonant pulse jet combustion device in which a combustible mixture of fuel and air is periodically detonated at acoustic frequency and which comprises a combustion chamber, a valveless resonant exhaust pipe directly connected with the combustion chamber and forming therewith an acoustic resonator, and an inlet check valve connected to the combustion chamber, of fuel supply apparatus comprising a fuel condensation chamber, a venturi tube comprising two conical passages converging towards each other to form a restricted throat with the outer ends of said conical passages connected respectively to said fuel condensation chamber and said combustion chamber, the restricted end of said conical passage which is connected to said combustion chamber having a smaller cross section than the restricted end of said conical passage which is connected to said condensation chamber, a fuel storage container disposed below and connected to receive fuel from said condensation chamber, and a fuel feed pipe connected between said fuel storage container and the restricted throat of said venturi tube.

7. Apparatus of the type described comprising the combination, with a resonant pulse jet combustion device in which a combustible mixture of fuel and air is periodically detonated at acoustic frequency and which comprises a combustion chamber, a valveless resonant exhaust pipe directly connected with the combustion chamber and forming therewith an acoustic resonator, and an inlet check valve connected to the combustion chamber, of fuel supply apparatus comprising a fuel condensation chamber, a venturi tube comprising two conical passages converging toward each other to form a restricted throat with the conical passages respectively connected at their outer ends to said combustion chamber and to said condensation chamber, and a fuel feed pipe connected to deliver fuel to the restricted throat of said venturi tube.

8. Apparatus of the type described comprising the combination, with a resonant pulse jet combustion device in which a combustible mixture of fuel and air is periodically detonated at acoustic frequency and which comprises a combustion chamber, a valveless resonant exhaust pipe directly connected with the combustion chamber and forming therewith an acoustic resonator, and an inlet check valve connected to the combustion chamber, of fuel supply apparatus comprising a fuel condensation chamber, a venturi tube comprising two conical passages converging toward each other to form a restricted throat with the conical passages respectively connected at their outer ends to said combustion chamber and to said condensation chamber, a baffle in said condensation chamber adjacent the connection of said venturi tube thereto for deflecting air and fuel to flow in a circular path in said condensation chamber, a fuel storage chamber disposed below and connected to receive fuel from said condensation chamber, and a fuel feed pipe connected between said fuel storage container and the restricted throat of said venturi tube.

9. Apparatus of the type described comprising the combination, with a resonant pulse jet combustion device, in which a combustible mixture of fuel and air is periodically detonated at acoustic frequency and which comprises a combustion chamber, a valveless resonant exhaust pipe directly connected with said combustion chamber and forming therewith an acoustic resonator, an inlet check valve and an inlet passage connecting said combustion chamber to said check valve, the combination of fuel supply apparatus comprising a fuel condensation chamber, a venturi tube having a restricted throat intermediate its ends connected between said fuel condensation chamber and said inlet passage, fuel conduit means connected to deliver fuel to the restricted throat of said venturi tube, and means for passing fuel condensed in said condensation chamber to said fuel conduit means.

10. Apparatus of the type described in claim 1 in which the inlet check valve is connected to the combustion chamber by an inlet passage and the venturi tube is connected between the fuel condensation chamber and said inlet passage.

References Cited in the file of this patent

UNITED STATES PATENTS

2,427,845 Forsyth ---------- Sept. 23, 1947

FOREIGN PATENTS

270,782 Switzerland ---------- Dec. 16, 1950