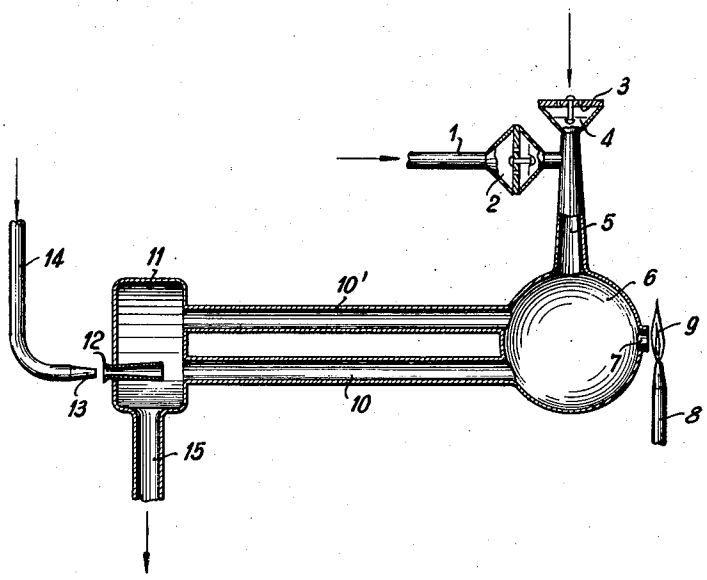
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APPARATUS FOR STARTING A PULSATORY COMBUSTION DEVICE

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APPARATUS FOR STARTING A PULSATORY COMBUSTION DEVICE

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The present invention relates to pulse jet combustion devices, and more particularly to an apparatus for starting a pulse jet combustion device.

In known pulse jet combustion devices it is necessary to provide compressors or pumps for supplying to the combustion chamber a combustible fuel-air mixture for starting the device, and besides the additional source of energy required for such auxiliary devices, it is necessary to provide the combustion chamber with a special opening to receive the fuel-air mixture for starting purposes, and such an opening is very undesirable because the greater the number of openings in the combustion chamber the less is the average top pressure in the combustion chamber and therefore the smaller is the vacuum force which is available for sucking in a combustible mixture for the successive impulses during normal operation.

One of the objects of the present invention is to provide a pulse jet combustion device which does not require a special supply structure for supplying the pulse jet combustion device with a combustible mixture for starting the device.

Another object of the present invention is to provide an arrangement where one of the resonant tubes used during the normal operation of the pulse jet combustion device also serves to convey to the combustion chamber a combustible fuel-air mixture for starting purposes.

A further object of the present invention is to provide a pulse jet combustion device which requires no outside power or source of compressed air or the like for starting purposes.

An additional object of the present invention is to provide an exceedingly simple and inexpensive structure for starting a pulse jet combustion device.

Also it is an object of the present invention to provide a pulse jet combustion device which requires no special opening in the combustion chamber for receiving a combustible fuel-air mixture for starting purposes.

With the above objects in view the present invention mainly consists of a pulse jet combustion device which includes a combustion chamber and an exhaust chamber spaced from the combustion chamber. A plurality of resonant tubes each communicate at one end with the combustion chamber and at its opposite end with the exhaust chamber. A means cooperates with one of said resonant tubes for supplying through the latter a combustible fuel-air mixture to the combustion chamber for starting the device.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawing.

Referring now to the drawing, it will be seen that the pulse jet combustion device illustrated therein includes a fuel supply tube 1 provided with an inlet valve 2 which

permits fuel to be sucked from the supply tube 1 along the tube 5 into the interior of the combustion chamber 6. The tube 5 also communicates with an air inlet valve 4 having an inlet end 3 through which air may be sucked into the tube 5 for movement into the combustion chamber 6. As is apparent from the diagrammatically illustrated structure of the drawing, during the normal operation of the pulse jet combustion device a suction force in the combustion chamber will automatically draw air and fuel through the above described structure into the combustion chamber to be exploded therein.

The combustion chamber 6 is formed with an ignition opening 7 adjacent which is located a tube 8 supplied with a combustible gas so that this gas may be ignited to form a flame 9 located adjacent the opening 7 for igniting a combustible fuel-air mixture in the combustion chamber 6 for starting the device.

In accordance with the present invention a plurality of resonant tubes communicate with the combustion chamber 6, and in the illustrated example two tubes 10 and 10′ are shown. These tubes 10 and 10′ communicate at their ends opposite from the combustion chamber 6 with a common exhaust chamber 11.

According to the present invention a combustible fuel-air mixture is supplied through one of the resonant tubes 10 and 10′ into the interior of the combustion chamber 6 for starting purposes, and an injector means 12—14 is provided for injecting through one of these resonant tubes the combustible fuel-air mixture which is delivered to the combustion chamber 6. Thus, this injector means includes a Venturi-shaped tubular member 12 carried by a wall of the exhaust chamber 11, extending slightly outwardly beyond the same, and extending along the interior thereof to a point closely adjacent the end of the tube 10 which communicates with the chamber 11. Thus, the Venturi 12 has its inlet end located at the exterior of the exhaust chamber 11 and its outlet end located adjacent the end of the tube 10 which communicates with the exhaust chamber 11. The nozzle 13 is aligned with and spaced from the inlet end of the Venturi 12, and a combustible fuel is supplied by the conduit 14 to the nozzle 13.

An exhaust tube 15 leads from the common exhaust chamber 11.

As will be apparent from the description below a plurality of resonant tubes, such as the tubes 10 and 10′, are of advantage because one of these tubes simultaneously serves to conduct to the exhaust chamber a combustible fuel-air mixture for starting purposes. However, such a plurality of resonant tubes are of further advantage. Thus, two tubes 10 and 10′, as shown in the drawing, are superior to a single tube whose cross section is equal to the total of the cross sectional areas of the tubes 10 and 10′, because a pair of such tubes of smaller cross section can be bent along a smaller radius.

The above described structure operates as follows.

In order to start the pulse jet combustion device, the combustible fuel is supplied by the conduit 14 to the nozzle 13 and streams from the latter to the air-gap between elements 12 and 13 into the inlet end of the Venturi 12. As the combustible fuel streams cross the gap, it automatically sucks air with itself into the Venturi 12, and from the Venturi 12 this combustible fuel-air mixture enters into the tube 10 and moves along the latter into the combustion chamber 6. The movement of the combustible fuel-air mixture along the tube 10 into the combustion chamber 6 displaces gases from the latter in the opposite direction along the tube 10′ into the exhaust chamber 11. The combustible mixture which thus becomes located in the interior of the combustion chamber 6 is ignited by the flame 9, and in this way the periodic combustion of the device starts, and now, that is, after

the device is started the main combustible fuel is automatically sucked in through the supply pipe **1** and valve **2** and the main air is sucked in through the inlet **3** and valve **4** and along the tube **5** into the combustion chamber **6**. The combustible mixture which is in this way supplied to the tube **10** displaces from the latter gases previously located therein, and these displaced gases move into the combustion chamber **6** to be displaced with the gases in the latter along the tube **10'** back into the exhaust chamber **11**, in the manner described above. Thus, it will be seen that where an installation including a plurality of resonant tubes, such as the tubes **10** and **10'**, is provided, it is possible with the present invention to use one of of these resonant tubes to serve the additional purpose of conducting to the interior of the combustion chamber a combustible mixture for starting purposes, and in this way a special structure for guiding the starting mixture to the combustion chamber is unnecessary. Furthermore it will be seen that special compressors or pumps or the like for starting purposes also are unnecessary. It will be noted that the flame **9** continues to burn during normal operation.

The invention is also usable with pulsating jet combustion devices where only aerodynamic means, such as, for example, diffusors, nozzles, return flow throttles, and the like are provided for supplying the combustible mixture. This aerodynamic means is intended for the normal operation.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of pulse jet combustion devices differing from the types described above.

While the invention has been illustrated and described as embodied in structure for starting pulse jet combustion devices, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. In a pulse jet combustion device, in combination, a combustion chamber; an exhaust chamber spaced from said combustion chamber; a plurality of resonant tubes each communicating at one end with said combustion chamber and at its opposite end with said exhaust chamber; and injector means cooperating with one of said tubes for transmitting through the latter to said combustion chamber a combustible fuel-air mixture for starting the device, said injector means comprising a tubular member carried by said exhaust chamber and extending into the same, said tubular member having an inlet end at the exterior of said exhaust chamber and an outlet end located closely adjacent to the end of said one of said tubes which communicates with said exhaust chamber, and said injector means including a nozzle aligned with and spaced from the inlet end of said tubular member and located at the exterior of said exhaust chamber and a conduit communicating with said nozzle for supplying to the latter a combustible fuel which passes through the free space between said nozzle and tubular member into the latter to supply through said tubular member fuel and air drawn into said tubular member through said space which then pass through said one of said tubes into said combustion chamber.

2. In a pulse jet combustion device, in combination, a combustion chamber; an exhaust chamber spaced from said combustion chamber; a plurality of resonant tubes each of which communicates at one end thereof with said combustion chamber and at its opposite end with said exhaust chamber, said combustion chamber, tubes and exhaust chamber forming together a resonant burner system in which the exhaust gases pass through said tubes in one direction from said combustion chamber to said exhaust chamber; and starting fuel supply means supplying a combustible fuel-air mixture only during starting of said device, said starting fuel supply means communicating with one of said tubes spaced from the combustion chamber for propelling through said tube and in a direction opposite to said one direction into the combustion chamber, a combustible starting fuel-air mixture for starting the device, whereby during the starting period exhaust gas present in said combustion chamber may be expelled by the introduced starting combustion fuel-air mixture through the other of said resonant tubes.

3. In a pulse jet combustion device, in combination, a combustion chamber; an exhaust chamber spaced from said combustion chamber; a plurality of resonant tubes each of which communicates at one end thereof with said combustion chamber and at its opposite end with said exhaust chamber, said combustion chamber, tubes and exhaust chamber forming together a resonant burner system in which the exhaust gases pass through said tubes in one direction from said combustion chamber to said exhaust chamber; and starting fuel injector means supplying a combustible fuel-air mixture only during starting of said device, said starting fuel injector means being carried in part by said exhaust chamber and having an end portion in line and spaced from said opposite end of one of said resonant tubes for propelling through said tube and in direction opposite to said one direction into the combustion chamber a combustible starting fuel-air mixture for starting the device, whereby during the starting period exhaust gas present in said combustion chamber may be expelled by the introduced starting combustion fuel-air mixture through the other of said resonant tubes.

4. In a pulse jet combustion device, in combination, a combustion chamber; an exhaust chamber spaced from said combustion chamber; a plurality of resonant tubes each of which communicates at one end thereof with said combustion chamber and at its opposite end with said exhaust chamber, said combustion chamber, tubes and exhaust chamber forming together a resonant burner system in which the exhaust gases pass through said tubes in one direction from said combustion chamber to said exhaust chamber; main fuel supply means for supplying a combustible fuel-air mixture after starting of the device directly into said combustion chamber; and additional starting fuel supply means supplying a combustible fuel-air mixture only during starting of said device, said additional starting fuel supply means communicating with one of said tubes spaced from the combustion chamber for propelling through said tube and in direction opposite to said one direction into the combustion chamber a combustible starting fuel-air mixture for starting the device, whereby during the starting period exhaust gas present in said combustion chamber may be expelled by the introduced starting combustion fuel-air mixture through the other of said resonant tubes.

5. In a pulse jet combustion device, in combination, a combustion chamber; an exhaust chamber spaced from said combustion chamber; a plurality of resonant tubes each communicating at one end thereof with said combustion chamber and at its opposite end with said exhaust chamber; and injector means cooperating with at least one but not all of said resonant tubes for transmitting through at least one of said resonant tubes to said combustion chamber a combustible fuel-air mixture for starting the device, said injector means comprising at least one tubular member carried by said exhaust chamber and extending into the same, said tubular member having an inlet

end at the exterior of said exhaust chamber and an outlet end located closely adjacent to the end of one of the resonant tubes cooperating with said injector means and communicating with said exhaust chamber, and said injector means including at least one nozzle aligned with and spaced from said inlet end of said tubular member and located at the exterior of said exhaust chamber and conduit means communicating with said nozzle for supplying to the latter a combustible fuel which passes through the free space between said nozzle and tubular member into the latter to supply through said tubular

member fuel and air drawn into the tubular member through said space which then pass through the resonant tube aligned with said tubular member into said combustion chamber.

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