

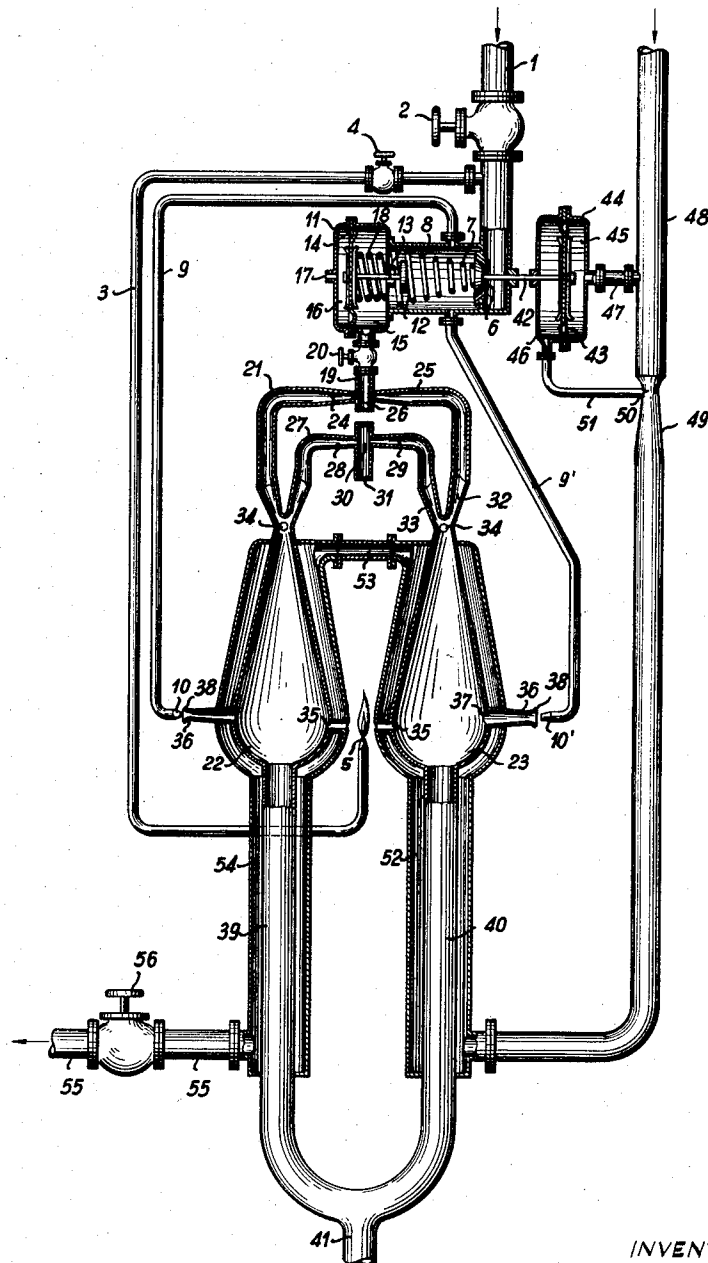
June 10, 1958

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2,838,102

PULSE JET BURNER SYSTEM

Filed Aug. 25, 1955



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2,838,102

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Application August 25, 1955, Serial No. 530,537

Claims priority, application Germany August 28, 1954

7 Claims. (Cl. 158—4)

The present invention relates to a pulse jet burner system of the type where a combustion chamber together with one or more tubes communicating therewith form a Helmholtz resonator wherein the combustion process takes place cyclically at a frequency for which the parts are designed.

More particularly, the present invention relates to a pulse jet burner system where a pair of combustion chambers are interconnected and operate in phase opposition to each other. Great difficulties have been encountered in systems of this latter type because of the necessity of including in such systems such components as extremely sensitive non-return valves which must be very carefully installed and adjusted and which nevertheless give rise to faulty operation as well as to a decrease in efficiency and to difficulties in maintaining such elements at a low enough temperature for efficient operation. All known attempts to overcome these drawbacks have resulted in extremely complicated cumbersome systems involving the use of a great number of tubes and in the use of additional sources of energy, all of which decrease the efficiency of the system and do not provide a practical solution to the problem.

One of the objects of the present invention is to overcome the above drawbacks by controlling the flow of combustible mixture to a pair of combustion chambers without any movable elements whatsoever, such as valves or the like, and with an exceedingly simple structure which requires no source of energy outside of the burner system itself for properly regulating the flow of combustible gases to the combustion chambers.

Another object of the present invention is to provide a system where, for starting purposes, the combustible mixtures in a pair of combustion chambers may be ignited by a single ignition means.

A further object of the present invention is to provide a tube means leading to a pair of combustion chambers and capable of supplying the latter with a sufficient volume of combustible mixture even though the tube means itself is of a relatively small cross section.

An additional object of the present invention is to incorporate a pulse jet burner system capable of accomplishing the above objects into a heat exchanger, and especially into a gas water heater.

Still another object of the present invention is to provide a gas water heater of this type which is automatically started and stopped whenever water drawn from the gas water heater is started and stopped, respectively.

Also, it is an object of the present invention to provide in a pulse jet burner system of the type discussed above a means for automatically adding a combustible gas-air mixture to the system after the operation thereof has started.

Furthermore, it is an object of the present invention to provide an apparatus capable of accomplishing all of the above objects and at the same time composed of simple and ruggedly constructed elements capable of operating reliably for a long period of time.

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With the above objects in view the present invention mainly consists of a pulse jet burner system which includes a pair of combustion chambers adapted to operate in phase opposition to each other, each of these combustion chambers being formed with an inlet opening for admitting a combustible mixture. A resonant tube means interconnects these inlet openings of the combustion chambers and communicates permanently with the interiors of these chambers for using the explosion pressure in one chamber to transmit the contents of the resonant tube means to the other chamber and for adding to these contents additional gas to be transmitted together with the original contents of the resonant tube means to the other of the combustion chambers, this resonant tube means being composed in its entirety of a succession of tubular portions communicating freely with each other and providing a permanent uninterrupted fluid path between the inlet portions of the combustion chambers.

20 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 advantage 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 which illustrates schematically one embodiment of a pulse jet burner system according to the present invention, it will be seen that a combustible gas supply conduit 1 communicates downstream of a main valve 2 carried thereby with a conduit 3 for supplying combustible gas for ignition purposes, this conduit 3 carrying a valve 4 for opening and closing the same. The conduit 3 terminates in a nozzle 5 where the gas issuing from the nozzle 5 may be ignited to form a flame.

The combustible gas supply conduit 1 also leads to and communicates with a valve means 6 which includes a valve member acted on by a coil spring 7 in a chamber 8 in such a way that this spring 7 urges the valve member of valve means 6 and the valve stem 42 connected thereto to the right, as viewed in the drawing, to an end position locating this valve means in its closed position preventing gas from flowing into the chamber 8. The valve means 6 is automatically controlled in a manner described below.

A pair of impulse-producing combustible-gas supply conduits 9 and 9' respectively communicate with the interior of the chamber 8 and lead therefrom respectively to the nozzle outlets 10 and 10' of the conduits 9 and 9'. Instead of a pair of impulse-producing combustible-gas supply conduits, a single such conduit may be provided, and in this latter event such a conduit would lead to only one of the two combustion chambers 22 and 23.

The chamber 8 communicates further with a control means 11 which is sensitive to pressure and which in the combination shown in the drawing senses the degree of vacuum in a part of the pulse jet burner system, as described below. This control means 11 includes a valve 12 for closing and opening a passage providing communication between control means 11 and the chamber 8, and this valve 12 is fixed to a valve stem 13 which is in turn fixed to a membrane 14 so that the membrane 14 moves the valve 12 will be actuated through the valve stem 13. The membrane 14 divides the outer housing of control means 11 into a chamber 15 which communicates with chamber 8 when the valve 12 is open and a chamber 16 which is in permanent communication with the outer atmosphere through an opening 17 formed in the wall of the housing of the control means 11. Furthermore, a coil spring 18 is located within the chamber 15 about the

valve stem 13 in engagement with the membrane 14 to urge the latter to the left, as viewed in the drawing, to a position where the valve 12 cuts off communication between chambers 8 and 15.

A combustible gas supply conduit 19 communicates with and leads from the chamber 15 to a resonant tube 21 constructed in accordance with the present invention and communicating permanently with the combustion chambers 22 and 23, this gas supply conduit 19 being provided with a valve 20 for regulating the flow of gas.

It will be noted that the resonant tube 21, which is in permanent communication with the inlet portions of the combustion chambers 22 and 23, is provided midway between these inlet portions with a gas intake 26 communicating with the gas supply conduit 19, and furthermore, the resonant tube 21 is formed at opposite sides of the intake 26 with a pair of nozzle portions 24 and 25, respectively, directed toward each other and communicating with the gas intake 26. It is evident, therefore, that the nozzles 24 and 25 together with the gas intake 26 form in the portion of resonant tube 21 which is located midway between the inlets of the combustion chambers 22 and 23 a Venturi portion at the throat of which the gas intake 26 is located.

Connected in parallel with the resonant tube 21 is a second resonant tube 27 which in the same way interconnects the inlet portions of the combustion chambers 22 and 23, the resonant tube 27 serving to supply fresh air to the combustion chambers while the resonant tube 21 serves to provide a combustible gas to the combustion chambers, so that the tubes 21 and 27 together form a resonant tube means operating in a manner described below to supply a combustible gas-air mixture to the combustion chambers 22 and 23. The resonant tube 27 is formed midway between the inlet portions of combustion chambers 22 and 23 with a gas intake 30 communicating through a tube 31 permanently with the outer atmosphere, and at opposite sides of the intake 30 the resonant tube 27 is in the form of a pair of nozzles 28 and 29 directed toward each other and communicating with the gas intake 30. Thus, as is evident from the drawing the nozzles 28 and 29 form in the portion of resonant tube 27 which is located midway between the inlet portions of combustion chambers 22 and 23 a Venturi portion at the throat of which the intake 30 is located.

Each of the resonant tubes 21 and 27 is provided at its junctions with the combustion chambers 22 and 23 with a pair of diffuser-like enlargements, respectively. Thus, the resonant tube 21 terminates at the inlets to the combustion chambers in a pair of diffuser-like enlargements 32, respectively, and the resonant tube 27 terminates at the inlets to the combustion chambers in a pair of diffuser-like enlargements 33, respectively.

The resonant tubes 21 and 27 are united together at the narrowest parts of their diffuser-like enlargements 32 and 33 to form at these narrowest parts a pair of common passages respectively located at the junctions between the resonant tubes 21 and 27 and the combustion chambers 22 and 23. The passage common to each pair of united ends of the resonant tubes 21 and 27 is also in the form of a diffuser-like enlargement. If desired, however, the resonant tubes 21 and 27 need not be joined together at their ends and can, instead, lead independently at their diffuser-like enlargements 32 and 33, respectively, into the combustion chambers 22 and 23. Furthermore, it is also possible to provide a single resonant tube interconnecting the combustion chambers, instead of the pair of tubes 21 and 27, and with such a single tube the gas intake opening between the pair of oppositely directed nozzles sucks in both the combustible gas and the fresh air to be mixed therewith. At the neck or narrowest portion between each combustion chamber and the diffuser-like enlargements of the resonant tubes joined thereto there is formed an opening 34 of small size whose opera-

tion is described below. The openings 34 may have, for example, a diameter of approximately 1-5 mm.

The combustion chambers 22 and 23 increase in cross section in a diffuser-like manner from their narrow inlet portions where the openings 34 are located, respectively, and the diffuser-like portion of each combustion chamber is joined at its bottom end to a substantially hemispherical portion of the chamber so that the combustion chambers have a shape approximating that of a drop of liquid. However, it is also possible for the combustion chambers to have a spherical shape or a cylindrical shape. Each of the combustion chambers 22 and 23 is provided approximately at its part of greatest cross section with an ignition opening 35. It will be noted that these openings 35 are formed in portions of the chambers 22 and 23 which are located adjacent to and directed toward each other so that the ignition openings 35 are located opposite each other and at not too great a distance from each other. Approximately at the elevation of the ignition openings 35 a pair of short tubular supply conduits 36 are arranged and communicate at their inner ends 37 with the interiors of the chambers 22 and 23, respectively. At their opposite outer ends, which are flared outwardly at 38, the supply conduits 36 are located closely adjacent to the nozzle outlets 10 and 10' of the impulse-producing combustible-gas supply conduits 9 and 9', respectively. If it is desired to do without the conduits 36, which provide additional openings in the combustion chambers, respectively, then the impulse-producing conduit 9 may communicate with the resonant tube 21 at its intake 26 between the oppositely directed nozzles 24 and 25, and the conduit 9' may be entirely eliminated.

The combustion chambers 22 and 23 are also formed respectively with outlet openings communicating respectively with the resonant exhaust tubes 39 and 40 which are joined together at their ends distant from the combustion chambers and both of which communicate with a common exhaust tube 41. The cross sections of both exhaust tubes 39 and 40 are equal to each other, and the cross section of the exhaust tube 41 is the same as that of either tube 39 or 40. However, it is also possible to maintain the exhaust tubes leading from the combustion chambers separate from each other so that each exhaust tube discharges its own combustion gases.

As was pointed out above a valve stem 42 is connected to the valve member of the valve means 6, and this valve stem 42 is also connected to a membrane 43 of the automatic control means 44. This membrane 43 divides the housing of the control means 44 into a high-pressure chamber 45 and a low-pressure chamber 46. A tube 47 communicates with and leads from the chamber 45 into a water supply conduit 48, and downstream of its connection to the tube 47 the water supply conduit 48 is formed with a Venturi portion 49 whose throat 50 communicates through a suction tube 51 with the low-pressure chamber 46. Downstream of the Venturi portion 49 the water supply conduit 48 leads to a water jacket 52 which surrounds a considerable portion of the exhaust tube 40 and combustion chamber 23. The water jacket 52 communicates with a tube 53 which in turn communicates with another water jacket similar to the water jacket 52 and surrounding a considerable portion of exhaust tube 39 and combustion chamber 22. Approximately at the end of exhaust tube 39 distant from combustion chamber 22 the water jacket 54 communicates with a discharge tube 55 which carries a valve 56 for opening and closing the discharge tube 55.

The structure described above and illustrated in the drawing operates as follows:

If both of the valves 2 and 4 are open then the combustible gas will flow from the supply conduit 1 to the conduit 3 and along the latter to the ignition nozzle 5 where the gas is ignited so that the flame produced thereby places the gas water heater in readiness for operation.

After the discharge valve 56 is opened water will flow

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through the discharge conduit 55 to the left, as viewed in the drawing. Simultaneously, water will flow along the supply conduit 43 so that pressure builds up upstream of the Venturi portion 49 and acts through the tube 47 and chamber 45 on the membrane 43. At the same time water is sucked out of the chamber 46 through the tube 51 into the throat of the Venturi 49 because the water flows through the throat of the Venturi 49 at such a high speed that a certain degree of vacuum is created at the opening 50. As a result of the pressure differential thus produced on opposite sides of the membrane 43, this membrane is bulged to the left, as viewed in the drawing, and as a result the valve stem 42 shifts to the left to open the valve means 6 against the influence of the coil spring 7 in the chamber 8.

Thus, the combustible gas in the conduit 1 can now flow into the chamber 8 and from the latter along the impulse-producing conduits 9 and 9' to the outlet nozzles 10 and 10', respectively, from where the combustible gas is blown together with fresh air from the outer atmosphere through the enlarged ends 38 of conduits 36 and through the latter into the combustion chambers 22 and 23, respectively, so that in this way a combustible gas-air mixture is supplied to the interiors of the combustion chambers, respectively. This combustible mixture is then ignited in one of the combustion chambers, for example the combustion chamber 22, by the flame located directly above the nozzle 5, this flame igniting the gas in combustion chamber 22 through the ignition opening 35.

Upon ignition there is produced in the combustion chamber 22 an explosion wave which spreads out in all directions. A large part of the hot combustion gas thus flows into the exhaust tube 39. The remainder of the combustion gas flows to the resonant tubes 21 and 27 so that cyclical operation is started in such a way that an explosion takes place in the combustion chamber 23, and the explosion wave of the chamber 23 is out of phase with that of the combustion chamber 22 by 180°.

The resonant tubes 21 and 27 influence the frequency of operation with their length, and these tubes act in a manner similar to a tube of a Helmholtz resonator. The distance from the gas intake of each resonant tube 21 and 27 to either of the combustion chambers is equal to a quarter of a wave length. Inasmuch as the speed of propagation of sound in a combustible gas and in air is not the same and inasmuch as the densities of the combustible gas and air are not equal, the lengths and diameters of both resonant tubes 21 and 27 must have a proper relationship to each other to produce the desired results.

In order to explain the operating cycle, a combustion chamber may be considered as a point. Inasmuch as the pressure waves emanating from the combustion chamber are reflected negatively to the gas intake of the resonant tube 21 or 27, each resonant tube is provided between its gas intake and the combustion chamber with a standing wave in such a way that with the resonant tubes such as the tubes 21 and 27 which have a constant diameter, the maximum amplitude point of the wave becomes located in the combustion chamber and the nodal point of the wave becomes located at the gas intake of the resonant tube. Since, however, both pressure waves emanating respectively from the pair of combustion chambers to the gas intake of each resonant tube 21 and 27 are out of phase with each other by 180°, the pressure wave which emanates from the combustion chamber 22, for example, will appear as an extension of the wave reflected from the combustion chamber 23.

Because a phase opposition process as described above produces velocity waves which are out of phase with pressure waves by 90°, there is simultaneously formed in each combustion chamber a nodal point of the velocity wave and at the gas intake of each resonant tube 21 or 27 the maximum amplitude point of the velocity wave.

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Thus, the greatest speed will take place precisely at the gas intakes of the resonant tubes 21 and 27.

Because the oppositely directed nozzles 24, 25 and 28, 29 respectively form Venturis in the resonant tubes 21 and 27, respectively, at the throats of which the intakes 26 and 30 are respectively located, the suction force at these intakes is increased in addition to the suction produced by the above-mentioned maximum gas speed located at these gas intakes. Thus, there is produced at these gas intakes 26 and 30 a relatively high vacuum which serves to suck in combustible gas and fresh air through the intakes 26 and 30, respectively.

Therefore, when the control valve 20 in the combustible gas supply conduit 19 is opened, the suction in the conduit 19 will be transferred to the chamber 15 to produce a substantial vacuum therein. Since chamber 16 is at atmospheric pressure the membrane 14 bulges to the right, as viewed in the drawing, and in this way the valve 12 is opened against the influence of the spring 13 so that gas flows automatically from the chamber 8 through the chamber 15 and conduit 19 to the gas intake 26 of the resonant tube 21. As soon as there is no appreciable vacuum at the gas intake 26 the valve 12 will be automatically closed by the spring 13 so that the supply of gas to the intake 26 will then stop.

In order to provide reliable operation of the above-described burner system, the entrance cross sections of the resonant tubes 21 and 27 at the inlets to the combustion chambers must have a predetermined ratio to the cross sections of the exhaust tubes 39 and 40, this ratio being for example 1:2, that is, the cross section of the inlet opening of combustion chamber 22, for example, where this inlet opening is joined to the resonant tubes 21 and 27, must be approximately one-half the cross section of the tube 39, and the same relationship holds for the tubes leading to and from the combustion chamber 23. With such a relatively small entrance cross section the resonant tubes 21 and 27 which have a permanent unchanging size could only allow a relatively small volume of combustible gas and air to pass through the nozzles 24, 28 and 25, 29 which at their narrowest portions are considerably smaller than the cross sections of the tubes 21 and 27 at the inlet portions of the combustion chambers. The combustible gas-air mixture drawn into the combustion chambers in this way would not be sufficient to maintain the operation of the system reliably, and in order to overcome this drawback the resonant tubes 21 and 27 are formed directly at their connections to the inlet portions of the combustion chambers with the above-described diffuser-like enlargements 32 and 33.

The openings 34 respectively located at the narrowest portions of the inlets to the combustion chambers act very favorably on the operation particularly during the starting of the system. Since these openings 34 have only a small size the gases leaving the combustion chambers can be sucked in again as a result of the suction forces at the gas intakes 26 and 30. If desired, the openings 34 of the chambers 22 and 23 can communicate with each other through a tube. It is also possible to use the openings 34 for ignition purposes. Such ignition openings of the two chambers, respectively could be located directly opposite each other so that the combustible mixture in both combustion chambers can be ignited from a single flame.

The resonant exhaust tubes 39 and 40 extend respectively from the combustion chambers up to the place where they are joined to each other and where the exhaust tube 41 begins, and the length of each exhaust tube 39 and 40 is equal to a quarter of the wave length so that a pressure nodal point is also located where exhaust tubes 39 and 40 meet exhaust tube 41. There is produced in this manner from the resonant tubes 21 and 27, the combustion chambers 22 and 23, and the exhaust tubes 39 and 40 a closed wave path in which all of the energy is retained except for friction losses.

When an explosion takes place in chamber 22, for example, a part of the exhaust gas flows to the resonant tubes 21 and 27. In this way, a volume of exhaust gas V_1 reaches the resonant tubes 21 and 27, and this exhaust gas displaces the fresh combustible gas contents of the tube 21 and the fresh air contents of the tube 27 so that simultaneously an equal volume V_1 of gas flows from the nozzles 24 and 28 respectively to the nozzles 25 and 29. However, simultaneously the nozzles 25 and 29 suck into the tubes 21 and 27, respectively, a volume of fresh combustible gas and fresh air, respectively, equal to V_2 , for example. Therefore, after the explosion in the chamber 22 there is supplied to the chamber 23 a volume of gas V_1 plus V_2 , and this latter volume of gas is exploded in the chamber 23 at the instant when fresh combustible gas and fresh air are sucked into the chamber 22. This process repeats itself in the reverse direction, that is from the chamber 23 to the chamber 22. While one combustion chamber sucks in gases the other explodes the gases already located therein, that is, both of the combustion chambers operate in phase opposition to each other. The flame located above the nozzle 5 is thus necessary only for starting the burner system.

The combustion chambers 22 and 23 as well as the exhaust tubes 39 and 40 are heated to a very high degree by the combustion gases, and therefore, the water in the water jackets 52 and 54 is also heated in such a way that the cold water supplied to the water jacket 52 is preheated by the exhaust tube 40 and combustion chamber 23, and then this preheated water flows through the tube 53 to the water jacket 54 where it is further heated by the combustion chamber 22 and exhaust tube 39. In this way, hot water is derived from the discharge conduit 55. When the valve 56 is closed then water stops flowing along the water supply conduit 48, and as a result the pressures in chambers 45 and 46 of control means 44 will become equalized so that the spring 7 will automatically close the valve means 6 to cut off the flow of combustible gas to the chamber 8. In this way the operation of the pulse jet burner system is stopped.

The above-described structure of the invention also is useful with turbines which may be driven by the exhaust gases. With such an arrangement advantage is taken of the pressure differential between the suction and exhaust portions of the system.

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 burner systems differing from the types described above.

While the invention has been illustrated and described as embodied in a pulse jet burner system for heat exchangers, 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 burner system, in combination, a pair of combustion chambers adapted to operate in phase opposition to each other, each of said combustion chambers being formed with an inlet opening for admitting a combustible mixture; and resonant tube means interconnecting said inlet openings of said chambers and communicating permanently with the interiors of the latter for using the explosion pressure in one chamber to transmit the gas contents of said resonant tube means to the other

chamber and for adding to said gas contents additional gas to be transmitted together with said gas contents to said other chamber, said resonant tube means being composed in its entirety of a succession of tubular portions communicating freely with each other and providing a permanent uninterrupted fluid path between said inlet portions of said chambers, and said resonant tube means having at a portion thereof located midway between said inlet openings a pair of diffusor-shaped nozzles having their smallest ends directed towards each other, said resonant tube means having between said nozzles an intake for admitting said additional gas and said intake forming between said nozzles a gap separating said nozzles from each other and providing a free spacing completely surrounding said smallest ends of said nozzles.

2. In a pulse jet burner system, in combination, a pair of combustion chambers adapted to operate in phase opposition to each other, each of said combustion chambers being formed with an inlet opening for admitting a combustible mixture; and an elongated resonant tube interconnecting said inlet openings of said chambers and communicating permanently with the interiors of the latter, said resonant tube being formed midway between said inlet openings with an intake portion for admitting gas into said tube and said resonant tube having respectively at opposite sides of said intake portion a pair of diffusor-shaped nozzles having their smallest ends directed toward each other and said intake portion and communicating with the latter, said intake portions forming between said nozzles a gap separating said nozzles from each other and providing a free spacing completely surrounding said smallest ends of said nozzles, and said resonant tube having a pair of diffusor-like enlargements respectively located at the junctions between said resonant tube and said inlet openings of said chambers, whereby, without the use of any movable elements such as valves and the like, the pressure of an explosion in one combustion chamber will move the contents of said resonant tube together with additional gas admitted through said intake portion thereof to the other combustion chamber.

3. In a pulse jet burner system, in combination, a pair of combustion chambers adapted to operate in phase opposition to each other, each of said combustion chambers being formed with an inlet opening for admitting a combustible mixture; and a pair of elongated resonant tubes each of which interconnects said inlet openings of said chambers and communicates permanently with the interiors of the latter, each resonant tube being formed midway between said inlet openings with a gas intake portion and having at opposite sides of said intake portion, respectively, a pair of diffusor-shaped nozzles having their smallest ends directed toward each other and said intake portion and communicating with the latter, said intake portions forming between said nozzles a gap separating said nozzles from each other and providing a free spacing completely surrounding said smallest ends of said nozzles, each of said resonant tubes also having a pair of diffusor-like enlargements respectively located adjacent said inlet openings of said chambers, said diffusor-like enlargements of said resonant tubes forming at their narrowest portions at the ends of said tubes a pair of common passages communicating respectively with said inlet openings of said chambers, whereby a combustible gas may be admitted into one resonant tube through its intake portion and air may be admitted into the other resonant tube through its intake portion, and whereby, without the use of any movable elements such as valves, the pressure of an explosion in one combustion chamber will move the contents of said resonant tubes together with additional gases respectively admitted thereto through said intake portions thereof to the other combustion chamber.

4. In a pulse jet burner system, in combination, a pair of combustion chambers adapted to operate in phase opposition to each other, each of said combustion chambers being formed with an inlet opening for admitting a

combustible mixture; and an elongated resonant tube interconnecting said inlet openings of said chambers and communicating permanently with the interiors of the latter, said resonant tube being formed midway between said inlet openings with an intake portion for admitting gas into said tube and said resonant tube having respectively at opposite sides of said intake portion a pair of diffusor-shaped nozzles having their smallest ends directed toward each other and said intake portion and communicating with the latter, said intake portions forming between said nozzles a gap separating said nozzles from each other and providing a free spacing completely surrounding said smallest ends of said nozzles, and said resonant tube having a pair of diffusor-like enlargements respectively located at the junctions between said resonant tube and said inlet openings of said chambers, said diffusor-like enlargements respectively tapering to their narrowest portions as they approach said combustion chambers and respectively being formed at said narrowest portions with a pair of small openings, whereby, without the use of any movable elements such as valves, the pressure of an explosion in one combustion chamber will move the contents of said resonant tube together with additional gas admitted through said intake portion thereof to the other combustion chamber.

5. In a pulse jet burner system, in combination, a pair of combustion chambers adapted to operate in phase opposition to each other, each of said combustion chambers being formed with an inlet opening for admitting a combustible mixture; and an elongated resonant tube interconnecting said inlet openings of said chambers and communicating permanently with the interiors of the latter, said resonant tube being formed midway between said inlet openings with an intake portion for admitting gas into said tube and said resonant tube having respectively at opposite sides of said intake portion a pair of diffusor-shaped nozzles having their smallest ends directed toward each other and said intake portion and communicating with the latter, said intake portions forming between said nozzles a gap separating said nozzles from each other and providing a free spacing completely surrounding said smallest ends of said nozzles, and said resonant tube having a pair of diffusor-like enlargements respectively located at the junctions between said resonant tube and said inlet openings of said chambers, said diffusor-like enlargements respectively tapering to their narrowest portions as they approach said combustion chambers and respectively being formed at said narrowest portions with a pair of small openings, whereby, without the use of any movable elements such as valves, the pressure of an explosion in one combustion chamber will move the contents of said resonant tube together with additional gas admitted through said intake portion thereof to the other combustion chamber and whereby said small openings at said narrowest portions of said diffusor-like enlargements may be used for ignition purposes.

6. In a pulse jet burner system, in combination, a pair of combustion chambers each formed with an inlet opening for admitting a combustible mixture; a pair of resonant tubes each extending between said inlet openings and being in permanent communication with the interiors of said combustion chambers, said tubes being joined

together and communicating with each other at each of said inlet openings, each tube having a Venturi portion located midway between said inlet openings, one of said Venturi portions being formed at its throat with an intake portion communicating permanently with the outer atmosphere and dividing said throat into two opposing throat portions, said intake portion forming a gap between said opposing throat portions and providing a free spacing between the smallest ends of said throat portions and the other of said Venturi portions being formed at its throat with an intake portion communicating with a source of combustible gas and dividing said throat into two opposing throat portions, said intake portion forming a gap between said opposing throat portions and providing a free spacing between the smallest ends of said throat portions, and each of said resonant tubes providing a permanent uninterrupted fluid path between said chambers.

7. In a pulse jet burner system, in combination, a pair of combustion chambers each formed with an inlet opening for admitting a combustible mixture; a pair of resonant tubes each extending between said inlet openings and being in permanent communication with the interiors of said combustion chambers, said tubes being joined together and communicating with each other at each of said inlet openings, each tube having a Venturi portion located midway between said inlet openings, one of said Venturi portions being formed at its throat with an intake portion communicating permanently with the outer atmosphere and dividing said throat into two opposing throat portions, said intake portion forming a gap between said opposing throat portions and providing a free spacing between the smallest ends of said throat portions and the other of said Venturi portions being formed at its throat with an intake portion communicating with a source of combustible gas and dividing said throat of said other Venturi portion into two opposing throat portions, said latter intake portion forming a gap between said latter opposing throat portions and providing a free spacing between the smallest ends of said latter throat portions, and each of said resonant tubes providing a permanent uninterrupted fluid path between said chambers; a gas supply conduit communicating with said gas intake opening of said other Venturi portion; valve means communicating with said gas supply conduit for opening and closing the same; and means communicating with the throat of said other Venturi portion for sensing the degree of vacuum therein and operatively connected to said valve means for opening the same when said degree of vacuum is above a predetermined value and for closing the same when said degree of value is below said value.

References Cited in the file of this patent

UNITED STATES PATENTS

1,948,536	Noack	Feb. 27, 1934
2,258,590	Merten	Oct. 14, 1941
2,427,845	Forsyth	Sept. 23, 1947
2,503,584	Lipkowski	Apr. 11, 1950
2,523,308	Kemmer et al.	Sept. 26, 1950
2,525,782	Dunbar	Oct. 17, 1950

FOREIGN PATENTS

533,330	Great Britain	Feb. 11, 1941
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