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BURNER DEVICE HAVING HEAT EXCHANGE AND GAS FLOW CONTROL
MEANS FOR MAINTAINING PYROPHORIC IGNITION THEREIN.
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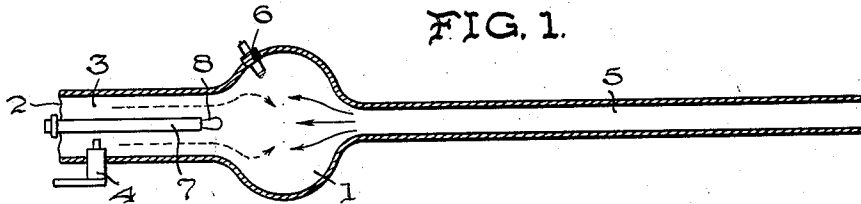


FIG. 1.

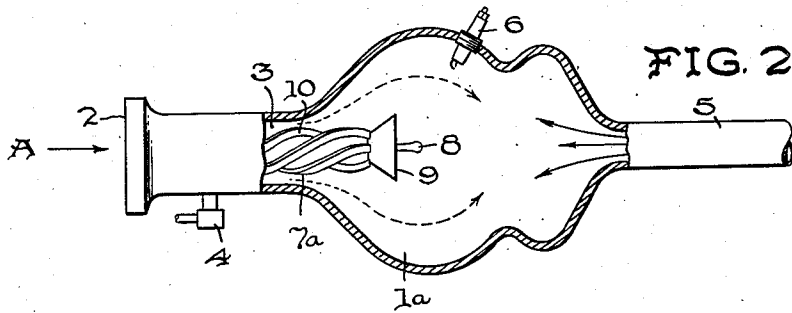


FIG. 2.

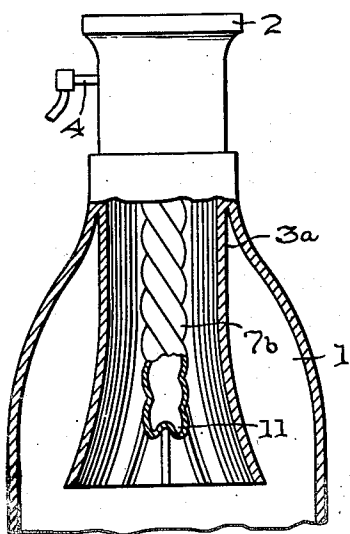


FIG. 3.

FIG. 4.

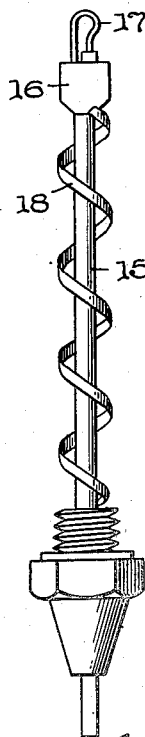
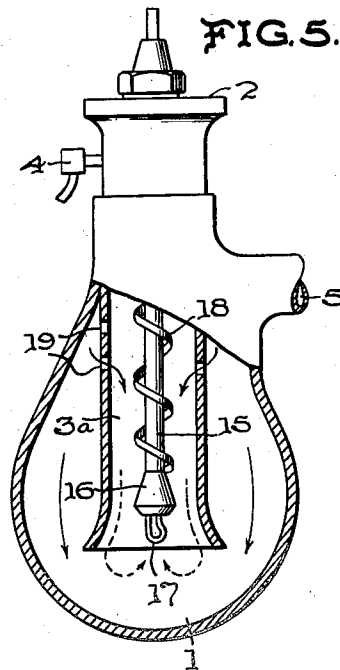


FIG. 5.



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BURNER DEVICE HAVING HEAT EXCHANGE
AND GAS FLOW CONTROL MEANS FOR
MAINTAINING PYROPHORIC IGNITION
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This invention relates to a burner device having a combustion chamber, an inlet for injecting fuel charges therein for combustion therein, and having a valveless exhaust duct connected with the combustion chamber, forming therewith an acoustic resonator which is excited by the combustions periodically or intermittently produced therein. The particular object of the invention is to provide in such a burner heat-exchange and gas-flow control means for promoting and maintaining intermittent ignition of the fuel charges injected into the combustion chamber.

Burners of the type noted above are applicable for heating purposes, and may be operated with gaseous fuel or with vaporized liquid fuel. There is a check valve, which admits fuel into the combustion chamber during the decompression phase following each combustion, the check valve being provided within a short inlet conduit to protect it against excessive heating.

It is desirable, in order to keep the cycle of the combustions in resonance with the thermally dependent acoustic frequency—assuming suitable cooling of the combustion chamber and the associated exhaust duct—to ignite by extraneous means, e. g., by electric ignition, only the first fuel charge, and to maintain the resulting oscillation by "back coupling" in such a way that the reacting residual exhaust gases surging back from the exhaust duct into the combustion chamber after each combustion cycle cause the ignition of the succeeding fuel charges meanwhile supplied thereto. However, the reacting exhaust gases do not always have the temperature required for the ignition of a normal fuel mixture, particularly at low outside temperatures, and the ignition frequently fails.

The invention overcomes this difficulty and makes it possible to ignite a fresh fuel charge in the combustion chamber by the reacting exhaust gases, even following a cycle of complete combustion, and to maintain thereby automatically the acoustic oscillation, once it has been initiated, which follows all fluctuations of the resonance frequency.

The invention employs for this purpose a heat conductive heat-exchange member which projects into the channel formed by the inlet neck of the device, such member terminating in an exposed ignition element or point which is so dimensioned and approximated to the combustion space that it assumes in operation a temperature lying within a range from about 600° to 1000° C. The length and position of the heat-exchange member must of course be proportioned in ac-

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cordance with the particular form of the inlet neck and of the combustion chamber, as well as in accordance with the heat distribution therein and the combustion temperature of the fuel mixture, all of which are affected by the position of the exhaust conduit.

The heat-exchange member absorbs heat incident to each combustion cycle, especially at its free end, the heat being conducted to its base, and thereby being transferred to the fresh fuel mixture admitted during the decompression or suction phase of the burner. The incoming fuel mixture flows along the heated surface of the heat-exchange member in the direction of increasing temperature thereof and is thus preheated to condition it for ready reaction and ignition. At the same time the fuel mixture is moved toward the walls of the inlet neck by thermal expansion, and a low gas pressure zone therefore results in direct proximity to the hot ignition element of the heat-exchange member, in which the mixture cannot ignite, due to insufficient gas pressure, in spite of the high point temperature thereof. This second effect is particularly important and may be augmented by the provision, ahead of the hot ignition element or point of the heat-exchange member, of a deflector carried thereby which may take the form of a suitable shield or of a structure which causes the fuel mixture to eddy or to gyrate with respect to the hot ignition point. At the moment when the reacting gases surge back from the exhaust duct and enter the burned chamber, they compress the preheated highly explosive fuel mixture therein. By properly proportioning the flow conditions, it is possible to concentrate the fuel mixture in direct proximity to the hot ignition point of the heat-exchange member. The ignition of the preheated fuel mixture which has thus been preconditioned for reaction, is in this manner initiated with certainty, and by correct "back coupling" in proper phase, so that succeeding combustion cycles assume the character of a stable, undamped oscillation whose periodicity follows automatically all fluctuations of the resonance frequency that may be caused by thermal or other conditions, and whose amplitude is therefore not noticeably affected by such conditions.

The inlet neck of the device thus functions in the nature of a fuel-mixing and fuel-conditioning tube which terminates in the combustion chamber.

The invention will be described below with reference to the accompanying drawings showing

embodiments thereof, to give examples. In the drawings,

Fig. 1 shows a diagrammatic embodiment of a burner made in accordance with the invention;

Fig. 2 illustrates in diagrammatic representation an embodiment having a modified combustion chamber;

Fig. 3 shows in diagrammatic form a further embodiment;

Fig. 4 illustrates a heat-exchange element which also functions as a hot wire plug for igniting the first fuel charge; and

Fig. 5 represents in partially elevational and partially sectional diagrammatic view an embodiment having an inlet and a combustion chamber of preferred form and employing the hot wire plug illustrated in Fig. 4.

The device shown in Fig. 1 comprises means forming the combustion chamber 1 which is provided with the inlet duct 3 having an air inlet controlled by a check valve 2 and carrying a fuel inlet nozzle 4. The inlet 3 thus operates in the manner of a fuel-mixing tube which terminates in the combustion chamber 1. From the combustion chamber extends the exhaust tube 5. The exhaust tube 5 and the combustion chamber 1 thus form a Helmholtz resonator with definable resonance frequency which is within a range from 50 to 200 cycles per second.

The combustion chamber 1 is initially supplied with a fuel charge, e. g., by means of a small hand pump, and such charge is ignited by means of the spark plug 6 to cause the first combustion cycle. The check valve 2 closes incident to such combustion. The combustion gases are at the same time driven for exhaust through the tube 5. Due to inertia, the gas plug in the tube 5 moves with accelerated velocity to the right, thus reducing the pressure in the combustion chamber, causing partial vacuum therein, therefore allowing the check valve 2 to open, to admit fresh air and also allowing admission of fuel through the fuel inlet nozzle 4. The resulting fuel mixture flows through the inlet neck and mixing tube 3 into the combustion chamber 1. Suction is at the same time effective to cause the gas plug in the exhaust tube 5 to react and, due to its inertia, to move inwardly with increasing velocity. The duration of this phase of the oscillation is determined by the resonance frequency of the resonator. The succeeding combustion cycles must take place in phase-correct relationship.

In accordance with the invention, the next and all following combustions are not initiated by the spark plug 6, but by the heat-exchange means which comprises a copper rod 7 disposed within the mixing tube 3 and carrying a nickel filament 8 which may form a loop or may support a ball forming an ignition point. This ignition point is heated to from 600° to 1000° C. in response to the combustion of the first fuel charge, and transfers heat to the rod 7, the latter thus being preheated and giving up the heat to the fresh fuel mixture so that the latter is preheated on its path to the combustion chamber for reaction and ignition therein. The fuel mixture is at the same time driven by thermal expansion in lateral direction along the wall of the inlet and mixing tube 3 toward the chamber 1, as indicated by the dotted lines, thereby producing a low pressure zone around the ignition point 8. The gas density in this low pressure zone is insufficient for ignition. But when the reacting exhaust gases surge from the exhaust tube 5 inwardly, during

the succeeding compression phase, in the direction of the full-line arrows, they crowd the fresh fuel mixture, as indicated by the radially inwardly directed arrows at the end of the dotted lines, compressing it in direct proximity to the ignition point 8, causing ignition of the fuel charge exactly at the right moment, with the charge fully in readiness for reaction and combustion.

The operation described above may be effected and improved by the provision of a shield 9 with or without the angular surfaces 10, as shown in Fig. 2, to cause deflection and/or gyration of the incoming fuel mixture, entering in the direction of the arrow A, relative to the ignition point 8. The compression of the fuel charge about the ignition body 8 under the action of the exhaust gases reacting inwardly, as described, may be improved by annularly constricting the wall of the combustion chamber, as shown in the figure, thus producing in effect a subchamber or pocket in which the fresh charge of the fuel mixture is compelled to flow first arcuately about the ignition body 8, ready for compression toward such body by the reacting exhaust gases to effect ignition within the pocket of the combustion chamber.

Considerable amounts of heat must be transferred from the heat-conductive heat-exchange member 7 to the incoming fresh fuel charges, especially in the case of heavy fuel oils, so as to cause proper preheating and conditioning thereof. In order to meet this requirement, a portion of the inlet and mixing tube may be formed to project into the combustion chamber in the manner of a tubular extension, as indicated in Fig. 3 at 3a, so as to cause preheating of its walls. This feature prevents an undesired rapid temperature drop of the heat-exchange device, particularly in back of its ignition point, and forms additional means for preheating the incoming fuel charges. The preheating may be further improved by wholly or partially omitting the portion of the heat-exchange member 7 which lies between the valve 2 and the shield 9, and carrying the exchange member instead upon a bridge or yoke disposed across the inlet and mixing tube.

The heat-exchange member is shown in Fig. 3 in the form of a hollow tubular element 7b which is closed at its inner end. The heat capacity of the heat-exchange element is in this manner reduced, causing quicker heating and concentrating the heat at the surface thereof. The structure also gives the possibility of heating the end 11 in the manner of a glow head, to obtain the start of the ignition. The end 11 is for this purpose preferably depressed axially inwardly, as shown. The walls of the tubular member 7b may be twisted or grooved, as shown, to increase the heat-exchange surfaces and at the same time causing the fuel charges to twist or gyrate prior to admission into the combustion or burner chamber.

The inlet of any of the embodiments including the extension 3a projecting into the combustion chamber may be provided with a riblike wall, or ribs may be suitably secured thereto in order to increase the effective heat exchange and thus improving the preheating of the fuel charges.

The heat exchange means may be combined with a hot wire plug, and the ignition portion of the device may be made in the form of an incandescent element, to form a particularly suitable embodiment which is shown in diagrammatic perspective view in Fig. 4. As shown, the

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metallic rod 15 carries an insulating member 16 from which projects the incandescent filament or wire 17, the rod itself forming one terminal therefor. The other terminal is formed by a resistance wire or ribbon 18 which surrounds the rod 15 in the manner of a spiral, and thus also operates as a deflector for the incoming fuel charge, corresponding in this respect to the function of the angular winglike surfaces 10 in Fig. 2. The insulating head 16 operates in the manner of the shield 9 shown in Fig. 2, and therefore prevents direct axial flow of the incoming fuel charge to and upon the ignition wire 17. Current is fed through the rod 15 to the wire 17 and through the ribbon 18 to ground from a current feed plug 15' similar to a conventional spark plug. It will be apparent that the structure will be at the desired operating temperature immediately after the first ignition, which is obtained by electric current conducted to the wire 17. The embodiment also prevents undesired disturbance in the flow of the fuel charge mixture and the gases in the combustion chamber, which is otherwise unavoidable when using a spark plug entering from the side, as shown in Figs. 1 and 2.

The important effect of the arrangement, according to the invention, resides in carefully keeping the fresh, preheated fuel charges initially properly spaced from the incandescent ignition bodies such as 8, 11 or 17, and then in driving the charges, each in turn, into the immediate proximity of the ignition body. This effect is obtained in particularly favorable manner by terminating the inlet 3a, in accordance with the structure shown in Fig. 5, in a pocket of the combustion chamber, and to connect the exhaust duct 5 to the combustion chamber at such a location that the reacting exhaust gases cause compression of the fresh fuel charges in the direction of the arrows shown in Fig. 5, that is, in the direction of the ignition member 17 of the heat exchanger 15. The inlet is in this embodiment at the same time heated by the combustion gases so as to cause efficient preheating of the fresh fuel charges. This results from the extension of the inlet 3a in the combustion chamber across the axis of the mouth of the exhaust duct 5. The latter effect may be increased by the provision of small apertures 19 in the wall of the inlet extension 3a, which permit circulation of the reacting exhaust gases through the wall of such extension, as indicated by the arrows in Fig. 5. The flow of the gases heats the relatively cool base portion of the inlet, and at the same time crowds the incoming fuel mixture, compressing it laterally in the direct vicinity of the incandescent body 17, and thus causing ignition in proper phase and at the proper time.

Changes may be made within the scope and spirit of the appended claims which define what is believed to be new and desired to have protected by Letters Patent of the United States.

We claim:

1. An intermittent combustion device of the type in which a combustible mixture of fuel and air is periodically detonated at acoustic frequency comprising a combustion chamber, an open exhaust tube directly connected to said combustion chamber and forming therewith an acoustic resonator, an air inlet check valve, a tubular inlet duct connecting said combustion chamber to said check valve, a fuel feed nozzle opening into said inlet duct, and an elongated heat conductive member disposed longitudinally

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within and spaced from the walls of said inlet duct and having an inner end which projects into said combustion chamber to a point where it is heated by combustion in said chamber to a temperature of from 600 to 1000° C., whereby the combustible mixture of fuel and air passing through said inlet duct to said combustion chamber is preheated by heat transferred thereto from combustion in said combustion chamber by said heat conductive member.

2. An intermittent combustion device as defined in claim 1 in which a shield is provided on the heat conductive member adjacent its inner end for deflecting incoming combustion mixture away from such end.

3. An intermittent combustion device as defined in claim 1 in which helically disposed surfaces are provided in the inlet duct for deflecting the incoming combustion mixture and causing it to gyrate about the heat conductive member.

4. An intermittent combustion device as defined in claim 1 in which the inlet duct includes a tubular extension which projects into the combustion chamber.

5. An intermittent combustion device as defined in claim 1 in which the inlet duct is provided with ribs on its walls to increase the effective heat exchanging surface of the duct.

6. An intermittent combustion device as defined in claim 1 in which the heat conductive member is hollow.

7. An intermittent combustion device as defined in claim 1 in which the heat conductive member is hollow and has helically grooved walls.

8. An intermittent combustion device as defined in claim 1 in which means are provided for conducting electric current through the heat conductive member to heat the same.

9. An intermittent combustion device as defined in claim 1 in which the heat conductive member is provided at the inner end thereof with a wire forming a glow ignition element.

10. An intermittent combustion device as defined in claim 1 in which the heat conductive member comprises a metal rod with a wire forming a glow ignition element at its inner end and an electrically conductive member helically coiled around the rod.

11. An intermittent combustion device as defined in claim 1 in which the heat conductive member comprises a metal rod with an electrically conductive member helically coiled around the rod and serving to cause gyration about the rod of the incoming combustion mixture, and a wire disposed at the inner end of the rod and electrically connected between the rod and the helically coiled conductive member and forming an ignition element.

12. An intermittent combustion device as defined in claim 1 in which a pocket is provided in the combustion chamber, the inlet duct extends within and terminates in such pocket and the exhaust tube is connected to a part of the combustion chamber other than such pocket.

13. An intermittent combustion device as defined in claim 1 in which the combustion chamber is provided with an annular constriction of its walls to form a pocket therein and the inner end of the heat conductive member extends into such pocket.

14. An intermittent combustion device as defined in claim 1 in which the inlet duct includes a tubular extension which projects into the com-

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bustion chamber, such extension having apertures therein to permit the circulation of a portion of the exhaust gases therethrough.

15. In an internal combustion device of the type in which a combustible mixture of fuel and air is periodically detonated at acoustic frequency, a bulb-like combustion chamber, a tubular inlet duct connected to and extending axially from said combustion chamber at one end thereof, an exhaust tube connected to and extending axially from said combustion chamber at the other end thereof, a metallic element extending axially within said inlet duct free of the walls thereof and having an inner end extending into said combustion chamber, and an ignition means carried by said metallic element at its inner end, said metallic element acting as a heat exchanger to preheat fuel charges entering said combustion chamber through said inlet duct.

16. In an internal combustion device of the type in which a combustible mixture of fuel and air is periodically detonated at acoustic frequency, a bulb-like combustion chamber annularly constricted to form two adjacent chamber portions on each side of an annular constriction, an inlet duct connected to one of such chamber portions, an exhaust duct connected to the other of such chamber portions, a heat conductive member axially disposed within said inlet duct, means carried by said heat conductive member for deflecting the path of flow of fuel charges entering through said inlet duct, and ignition means carried by said heat conductive member.

17. A burner device of the class described comprising a bulb-like structure forming a combustion chamber, an inlet for incoming fuel charges at one end of said chamber, a tubular member forming an extension of said inlet projecting axially into said combustion chamber, the inner end of said tubular member flaring outwardly at a point within said combustion chamber, an ignition element disposed axially within said

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burner chamber substantially within and in alignment with the flaring inner end of said tubular member, and a heat-exchange member disposed axially within said tubular member.

18. The structure and combination defined in claim 17, together with means extending from the side of said bulb-like structure and forming a duct for expelling exhaust gases from said burner chamber.

19. An intermittent combustion device as defined in claim 1, in which the inlet duct extends into the combustion chamber free of the walls thereof and in which the elongated heat conductive member extends within the inlet duct free of the walls thereof.

20. An intermittent combustion device as defined in claim 1, in which the inlet duct extends into the combustion chamber free of the walls thereof and across the axis of the mouth of the exhaust duct, whereby the inlet duct is effectively heated by reacting exhaust gases surging inwardly from the exhaust duct mouth.

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