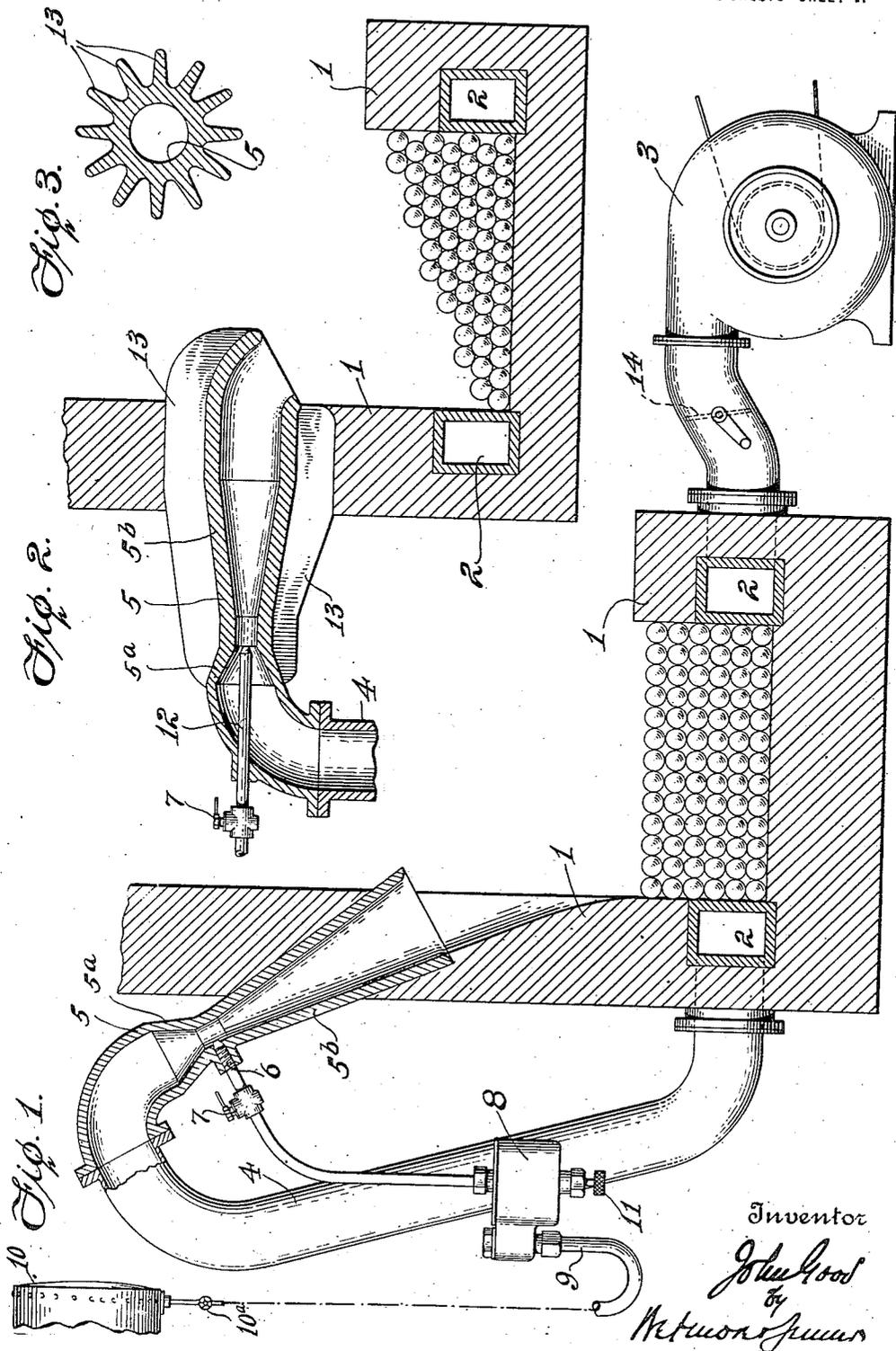


1,267,760.

J. GOOD.
LIQUID FUEL COMBUSTION.
APPLICATION FILED MAR. 24, 1916.

Patented May 28, 1918.
3 SHEETS—SHEET 1.



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Fig. 4

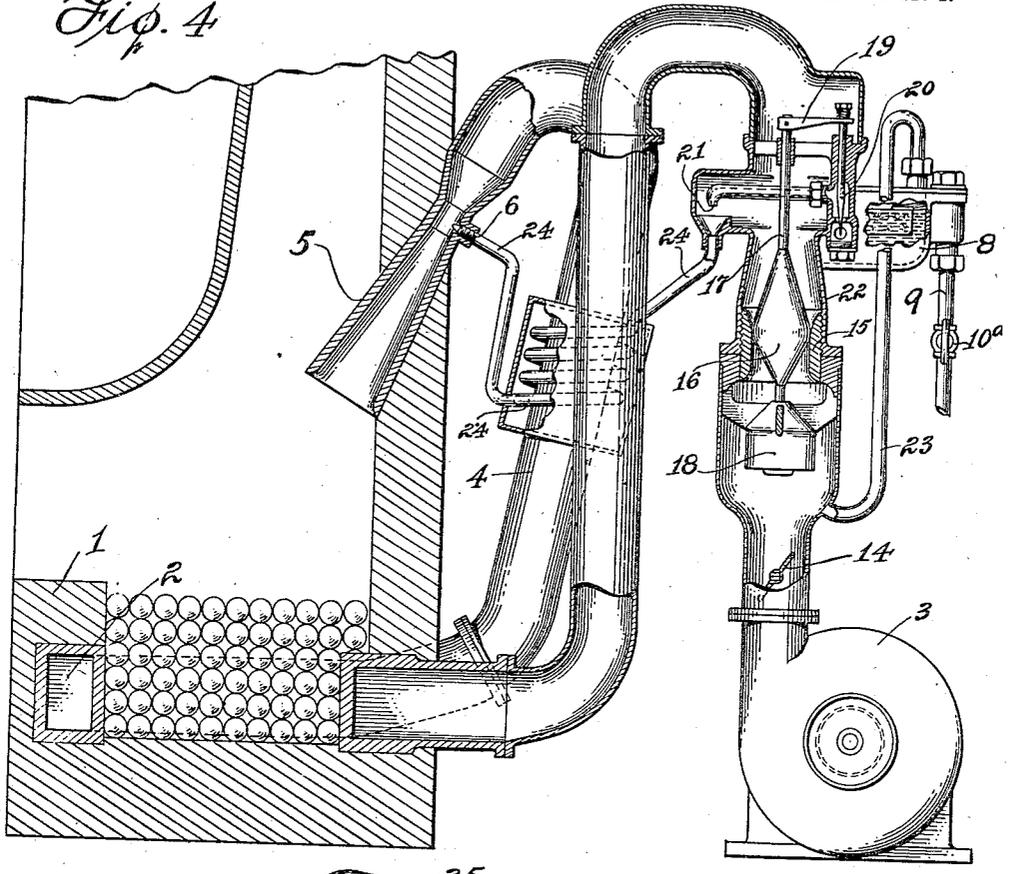


Fig. 5.

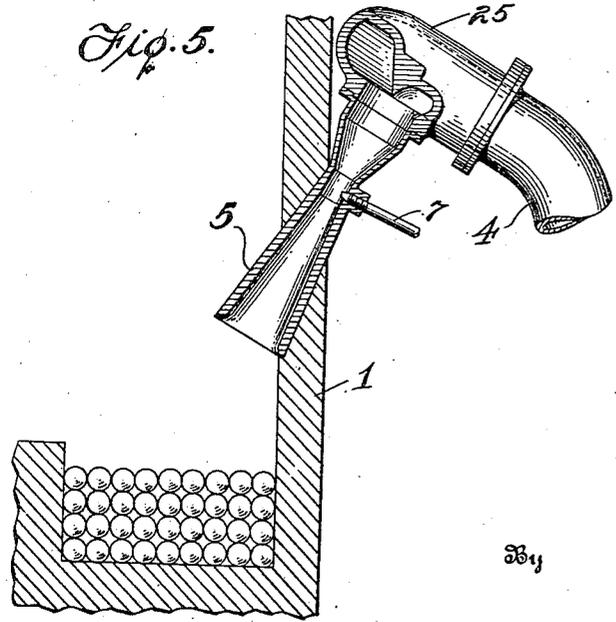
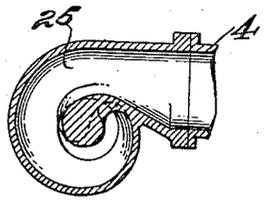


Fig. 6.



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LIQUID-FUEL COMBUSTION.

1,267,760.

Specification of Letters Patent. Patented May 28, 1918.

Application filed March 24, 1916. Serial No. 86,455.

To all whom it may concern:

Be it known that I, JOHN GOOD, a resident of the United States, residing in Brooklyn, New York, have invented the following-described improvements in Liquid-Fuel Combustion.

My invention is an improvement in the art of burning heavy liquid fuels such as kerosene, petroleum, solar oil, fuel oil of commerce, and the like, and more particularly consists in a method of burning such liquids according to the principle of combustion generally identified as surface or flameless combustion, and provides a means for creating a blast of combustible mixture containing such liquid fuel, which ignites cold and burns with a so-called flame cap at a desired and predetermined distance from the discharge nozzle or place of mixture, as for example upon the surface of a bed of refractory bodies as commonly used to establish the locus of combustion in the surface combustion art, the said mixture being adapted to maintain such combustion substantially without flame and to all effects and purposes the same as heretofore commonly accomplished only by the use of combustible gaseous mixtures.

I am aware that it has been proposed to burn a spray of liquid fuel in a flame cap determined by the surfaces of a bed of refractory bodies, or otherwise, but in such cases the method and means of creating the spray have required the establishment of a high temperature in the bed as a necessary preliminary to the combustion of the liquid, or the liquid fuel (of volatile character) has first been required to be converted into vapor or gaseous form before its discharge into the bed, and no apparatus has to my knowledge yet been produced possessing the practical and commercial advantage of instant ignitibility when cold, nor the further advantages and conveniences which the present invention provides.

Supplementary to the method and means of utilizing liquid fuel to produce these results my invention further contemplates the automatic regulation and maintenance of true and correct proportions of the liquid and air constituting the combustible or explosive mixture whereby various degrees of combustion can be produced with the least manipulation and without requiring skilled

attendance to operate and control the apparatus.

The invention also concerns various supplementary features of the apparatus shown in the drawings herewith, all as hereinafter fully explained and more particularly and definitely pointed out in the appended claims. In the accompanying drawings—

Figure 1 is a partly sectional and partly elevational view of one form of my invention;

Fig. 2 shows a modified form of the burner nozzle thereof;

Fig. 3 is a cross-section of the modified form of nozzle;

Fig. 4 represents the preferred form illustrating also the proportioning apparatus;

Figs. 5 and 6 are a vertical and a horizontal section, respectively, of a modified form of elbow fitting for the blast nozzle.

Fig. 7 is a partly sectional and partly elevational view of a modified form of burner illustrating also the proportioning apparatus.

In each of these figures the combustion locating surface is constituted by a bed of round bodies or balls of alundum or other refractory material but the said surface may also be formed in other ways known to be suitable for the purpose. The bed of balls is contained by a support 1, of suitably refractory material, and of any desired form and construction, and within or associated with this support and in heat-receiving relation to the bed of balls or the exhaust from them, is an air passage 2, supplied with air from any suitable source such as the power-driven blower illustrated at 3. The air delivered by the blower through the passage 2, and becoming highly heated therein when the apparatus is in action, passes thence by pipe 4 directly to the blast nozzle 5, which for convenience, is mounted in an upright wall of the support with its connections in rear of the wall and its discharge orifice opening on the other side and directly toward the bed. The blast nozzle 5 in this form includes or consists of a Venturi-tube of which the relatively abrupt convergent entrance section is marked 5^a and the more gradually divergent recovery section is marked 5^b, the throat or region of least internal diameter being cylindrical for a short distance between sections in order to accommodate the

fuel nozzle 6. The latter is threaded laterally into the cylindrical throat section so as to project slightly into the passageway through it, being thereby adapted to discharge the liquid fuel as a spray which thoroughly impregnates the air stream. The nozzle 6 takes its fuel liquid through the cock 7 from a constant-level liquid receptacle 8 the latter being supplied by a pipe 9 from a larger source of fuel 10 placed at a higher level so as to feed to the receptacle by gravity. The said receptacle 8 may be a float-controlled liquid supply chamber such as commonly used in carbureters for gasoline engines, and is provided with a needle valve 11 to give close adjustment of the liquid delivery through the nozzle 6.

In the construction of Fig. 1 the blower is preferably operated to deliver air to the burner nozzle at a pressure of somewhere between one quarter of a pound and four pounds and the Venturi tube is designed with reference to the volume of air so delivered to produce a very considerable reduction of pressure or relative vacuum in its throat. This reduced pressure being much less than the pressure (atmospheric) acting on the surface of the liquid in the receptacle 8 causes the discharge of the liquid from the nozzle 6 so that there issues from the large end of the Venturi tube a blast of combustible mixture consisting of air and liquid fuel in finely divided form. The proportions of the air and liquid are those of an explosive mixture and the subdivision of the liquid therein is so fine, resulting from the relative vacuum and high relative velocity in the Venturi tube, that notwithstanding the non-volatility of the liquid fuels employed, as I have discovered, it may nevertheless be ignited cold, that is to say, before the air has become heated by the passage 2 and without the aid of heat otherwise applied. For this effect it is essential that the combustion end of the Venturi tube be not remotely separated from the bed and that no material part or passage intervene between the venturi and bed upon which the finely divided fuel may collect by impingement so as to form a drip, that is to say, the spray developed by the venturi must be allowed to blow freely therefrom to the bed without interference by lateral confining walls which by collecting and separating the liquid prevent ignition. For this reason it is preferred that the orifice of the burner be constituted by the end of the recovery section of the Venturi tube itself, as shown in Fig. 1, although a short non-Venturi extension might be added onto the tube without creating serious dripping or separation as will presently be observed in connection with Fig. 2. It is important also that the delivery of liquid from the nozzle 6 be regulated with nicety which can

be readily done by the needle valve 11 above referred to. By the adjustment of this valve when the blower is in operation, the critical proportion in which the blast nozzle will ignite cold can be easily found. Regulation of the liquid delivery from the nozzle 6 can obviously also be accomplished in various other ways.

The blast mixture is ignited by placing a lighted taper or a bunch of cotton waste on top of the bed of balls and then starting the blower. The ensuing combustion is initially accompanied by some flame playing up from the bed but presently and as the bed becomes heated, the flame disappears and the balls become and continue in a state of high incandescence without appreciable flame. The air delivered to the Venturi blast nozzle thereupon acquires a high temperature by its passage through the duct 2, and correspondingly facilitates the combustion by vaporization within the nozzle, but such heating of the air is not essential for all purposes. Prompt vaporization is also promoted by the heat absorbed by the discharge end of the tube and conducted back through its metal walls to the throat of the venturi at which point it is most effective to produce vaporization because of the local pressure depression existing at that point.

In the form of Fig. 2 the Venturi nozzle is disposed horizontally in the upright wall of the support 1 and the recovery end 5^b of the venturi proper is provided with a short, full diameter extension which curves slightly downwardly at its extreme end or orifice so as to direct the blast against the bed. This extension should not cause such precipitation of the liquid upon the extended wall as would give rise to dripping of the liquid and prevent ignition, the length and curvature of the extended part being slight. The liquid nozzle 12 in this form is mounted in the burner longitudinally and so as to spray on the axis of the tube at the throat, the effect being otherwise the same as in the form of Fig. 1 and producing a homogeneous fine mixture of the liquid and air and also igniting and burning in the same way as above described. Air and liquid are understood to be supplied by the same means as already described, the air becoming heated after combustion has been established. Conduction of heat from the orifice of the blast nozzle to the throat part of the venturi is in this case specially promoted by supplying the exterior of the nozzle with a series of longitudinal ribs 13 (Fig. 3).

The combustion at the bed can be regulated by controlling the speed of the blower, or changing the throttle 14 between the blower and the burner, while correspondingly adjusting the liquid supply to maintain proportions, but of course always keep-

ing the velocity of the blast higher than the rate of flame preparations through it and so that the combustion will localize at the intended place. When the combustion is to be stopped it is well to close the cock 10^a in the main fuel line before discontinuing the air supply in order that the fuel pipe and particularly the fuel nozzle 6, may be cleared of residual liquid which might subsequently carbonize from the heat of the burner and clog the spray orifice.

For automatically maintaining the proportion of liquid fuel and air for different rates of combustion my invention includes also the proportioning apparatus illustrated in Fig. 4 and which maintains the proportions fixed and correct throughout wide ranges and so that they are not disturbed by change of temperature of either the air or the liquid. In this apparatus air supplied from the blower, the same being the whole supply that goes to the burner, passes under the control of the throttle 14 through a special passage formed by a bushing 15 and acts therein to lift against gravity, and sustain at different elevations, a control body 16 which normally rests by gravity upon the bushing and to close the passage. The body 16 is fixed on a staff 17 appropriately guided for true longitudinal and vertical motion in the passage and its lower end is connected to a dash-pot 18 to steady the movement and prevent fluttering. Through the cross-arm 19 at the upper end of the staff the air sustained body 16 operates a tapered metering pin 20 giving it different positions in the restricted outlet hole of the liquid receptacle 8, according to the elevation of the body 16 and hence according to the volume of air passing between said body and its seat 15. The outlet hole referred to intervenes between the liquid supply and an outlet nozzle 21 which has its discharge opening inside of the casing 22, above the control body and hence where it is subject to whatever pressure condition is determined by the weight of said body or by its tendency to return to its seat upon the bushing 15. Inasmuch as the surface pressure in the receptacle 8 is equal to the air pressure below the body, by virtue of the pipe connection 23, the liquid is thereby caused to flow through the hole and the outlet nozzle 21 and at such rate as is determined by the extent of protrusion of the tapered pin 20 in the said hole. The shape or taper of the pin is correlated to the range of movement of the body 16 so that such rate of liquid flow always bears a predetermined or fixed relation to the inflow of the air, thus maintaining constant proportions of liquid and air for all speeds of the blower. Such correlation between pin and body can be established in various ways to accomplish the results stated; in the present case the pin

has a straight or conical taper and the bushing or seat 15 of the air body 16 is given a special curvature designed to control the elevation of the body so as to accommodate the known characteristics of variation of flow of liquid from nozzle outlets, or in other ways. The gravity-controlled body is preferred because of its constant uniformity of action, and with gravity control the pressure condition above said body will of course be constant for all values of air inflow. The seat 15 can be threaded in the casing 22 as shown and is hence adjustable to vary the proportions. The metering pin 20 is loosely connected with the cross-arm 19, the lost motion in the connection being taken up by a small spring whereby the pin is centralized to the restricted outlet it controls. The liquid discharged by the nozzle 21 and measured by the metering pin in accordance with the air flow, squirts into the funnel-shaped receiving end of a transfer pipe 24 which leads to the liquid nozzle 6 in the Venturi nozzle 5 and such liquid moves through the pipe, by the effect of the lower pressure existing at the throat of the venturi. The liquid is thereby effectively sprayed into and mixes with the air of the venturi, quite the same as in the forms of Figs. 1 and 2 and producing the same kind of blast mixture which is ignitable cold. Such air as happens to be drawn through the transfer pipe with the liquid is measured air, being taken from the casing above the body 16 and assists in the atomization within the tube, without affecting proportions. The main air supply becomes heated after combustion is established, by passage through the bed duct 2, as before, and the liquid may also be heated by the heat of the bed, as for example by leading the pipe 24 around the air pipe 4 which, after the apparatus is in operation, of course assumes a high temperature. It will be observed that in consequence of the measurement of the liquid and air prior to their admixture and atomization, the thermal expansion of either, when thus heated is without effect upon the proportions of the mixture, and also that the degree of heating of the air can be as high as desired without trouble from any effect of the heat upon the hydrocarbon since the entire mixture is projected onto the combustion bed. It will therefore become apparent that the proportioning apparatus above described can be constructed in other ways within this invention to carry out the principle of measurement, of the liquid and the air while in their cold or natural temperature, whereby the subsequent heating of one or both of the constituents of the mixture cannot change the proportions of the blast, this broad feature being an important part of my invention.

The modification shown in Fig. 5 consists

in the application of an elbow type fitting 25 between the blast nozzle and the hot air pipe 4 which fitting imparts a violent whirling motion to the air entering the nozzle and in consequence of which a substantial improvement is obtained in the homogeneity of the blast mixture with little added expense of construction. Conversely, the whirling motion permits a coarser adjustment of the liquid nozzle in the tube to produce a satisfactory thorough mixture and also allows of the use of a pipe extension of the burner or blast nozzle beyond the Venturi tube proper, if ever that should be desired without producing excessive dripping or such as might interfere with the cold ignition of the blast. This fitting may obviously be employed with any of the burner tubes herein disclosed.

The modified form of Fig. 7 accomplishes the same result as the apparatus described above, and by substantially the same means, excepting that the Venturi tube nozzle is not employed for creating the blast mixture and that on this account two blowers are employed instead of one, one for delivering low pressure air to the burner and the other for delivering air at higher pressure for atomizing the liquid fuel therein. The low pressure blower is marked 26 and takes its air through the pipe 27 and the proportioning apparatus which will be recognized as the same as that already described. A throttle 28 interposed between the blower and the proportioning apparatus controls the air inflow. From this blower the air passes through the air heating duct 2 and an air pipe 4 to the burner or blast nozzle proper 29 which in this form is merely a straight cylindrical tube mounted in the bed support similarly to the several Venturi blast nozzles above described.

The liquid fuel discharged from the fuel nozzle 21 and which has been measured cold and in accordance with the air-sustained position of the control body 16, is led by a transfer pipe 24 to a nozzle 30 mounted within and close to the axis of the tube 29 from which it is discharged by the aspirating effect of an associated air nozzle 31 also mounted in the tube and alined with its axis. This atomizing air nozzle is supplied with air of requisite high pressure (2 to 6 pounds being adequate) from the other blower 32 and the air so supplied is taken by pipe 33 from the interior of the casing 22 above the control body therein so that all of the air which reaches the burner 29 is measured air and the mixture proportions are not thereby disturbed. This high pressure air is conveniently and desirably led through the heating duct 2 and the hot air pipe 4, so as to increase its vaporizing effect upon the fuel. The spray it produces, even when cold, is formed within the main

stream of air passing through the tube 29 from the blower 26, but near to the outlet or orifice of said tube, so that no dripping from the tube occurs. It is essential to the operation of this apparatus and especially its cold ignition that the atomizing nozzles 30 and 31 be disposed close to, or within a few inches from, the open end or orifice of the tube 29. Otherwise the impingement of the liquid upon the wall of the tube may be so great as to preclude its cold ignition and satisfactory combustion.

In all of the forms above described it will be understood that the velocity of the blast issuing from the nozzle exceeds the rate of propagation of flame through it, so that the locus of the flame cap is maintained at or in the bed where the velocity slows down and substantially the same as where gaseous fuels are employed. In each case the blast, whether of the Venturi tube form of Figs. 1 to 6 or the straight tube form of Fig. 7, is ignitable in its initial cold state and consequently the apparatus of this invention possesses the commercial and practical advantage of being at all times ready for instant use to give the well known very efficient surface combustion effect but from heavy fuel oils. Because of the need for only one blower or air source, I prefer the form of my apparatus shown in Fig. 1 or in Fig. 4, but it is evident that in producing a free and unstricted blast of atomized liquid, which is ignitable cold and in automatically proportioning the mixture, all the forms shown herein embody the same generic principles, and also the same essential differences over prior art methods and structures. To safeguard the transfer pipe 24 from clogging with cooked or carbonized oil, it is desirable to shut off the oil before the air, so as to clear it of any residuum. Closure of the cock 10^a will cause air only to pass through the transfer pipe thereby stopping combustion and at the same time cleaning the pipe.

It will be evident that the method of burning liquid fuel above described can be carried out in various different forms of apparatus from that herein shown.

The term "combustion locating bed," as used herein and in the following claims, refers to the well-known refractory bed common in the art of so-called surface combustion and which serves to change the direction of the blast of the explosive mixture and by so doing to slow its velocity down to the point where it equals or is less than the velocity of flame propagation through the mixture, the velocity of said mixture between the bed and the nozzle being of course in excess of the rate of flame propagation.

Those features of the invention herein described which relate solely to the maintenance of fuel delivery in proportion to vary-

ing air supplies form the subject of another application Serial No. 210,298 copending herewith.

I claim:—

5 1. The method of burning heavy liquid fuels which consists in maintaining a supply of such liquid fuel at a nozzle orifice, directing a blast of air in atomizing relation to such nozzle thereby forming a blast mixture
10 of finely atomized liquid fuel and air in the proportions of an explosive mixture of such fuel, ignitable in an initially cold condition, directing such mixture in free and substantially
15 unconfined form from its place of formation to and against a combustion-locating bed and maintaining said blast mixture between the nozzle and bed at a velocity exceeding the rate of flame propagation through it, whereby the locus of the combustion
20 is determined in or on said bed.

2. The method of burning heavy liquid fuels which consists in creating a homogeneous blast mixture of finely atomized liquid fuel and air in the proportions of an explosive mixture of such fuel, directing such
25 mixture in free and substantially unconfined form from its place of formation to a combustion-locating bed while maintaining the blast velocity between said place of formation and the said bed in excess of the
30 rate of flame propagation through the mixture at such rate as will locate the combustion at said bed and then transferring heat from the bed to said place of formation of said mixture, the atomization of said liquid fuel being of such degree of fineness as to
35 adapt the said mixture to ignite in an initially cold state.

3. The method of burning liquid fuels
40 which consists in controlling the liquid fuel and air in the proportions of an explosive mixture of such liquid fuel, heating said proportioned air and then finely atomizing and mixing the proportioned liquid therewith to
45 form a blast mixture, and directing said mixture against a combustion-locating bed at a velocity, between its place of formation and said bed, which exceeds the rate of flame propagation through said mixture, whereby
50 the locus of the combustion is established and maintained in or on said bed.

4. Surface combustion apparatus comprising in combination with a combustion locating bed, an air-blast nozzle provided with
55 means for producing therein a homogeneous mixture of liquid fuel and air and adapted to atomize the liquid to an extent rendering said mixture ignitable in a cold condition, and an air source to supply said nozzle adapted to maintain the blast mixture therefrom at a velocity between said nozzle and bed exceeding the rate of flame propagation through said mixture.

5. Combustion apparatus comprising a
60 combustion-locating bed, an air supply hav-

ing a Venturi blast nozzle directed toward said bed and means for introducing liquid fuel to said nozzle to form a blast mixture having explosive proportions of air and fuel, said air supply being adapted to maintain a blast velocity between the nozzle and the bed in excess of the rate of flame propagation through the mixture. 70

6. Combustion apparatus comprising a combustion-locating bed, an air supply passage receiving heat from said bed and having a Venturi blast nozzle directed toward said bed and means for introducing liquid fuel to said nozzle to form a blast mixture therein, impinging on said bed, said air supply being adapted to establish a blast velocity between the nozzle and bed in excess of the rate of flame propagation through the mixture. 80

7. Combustion apparatus comprising a combustion-locating bed, a Venturi blast nozzle directed toward said bed, an air source adapted to discharge initially cold air through said nozzle and means for introducing liquid fuel into the throat of the
90 Venturi tube in proportions producing a blast mixture which is ignitable in a cold condition.

8. Combustion apparatus comprising a combustion-locating bed, a Venturi blast nozzle connected to means to supply it with air at a suitable pressure and directed toward the bed, means for introducing liquid fuel to the throat of said nozzle and means for applying heat to the air and liquid fuel
100 supplied to said nozzle.

9. Combustion apparatus comprising a combustion locating bed, a Venturi blast nozzle directed toward the same, a liquid supply pipe connected to the throat of said
105 venturi, through which liquid fuel moves by virtue of the pressure depression existing at the throat of said venturi, a source of liquid fuel for said liquid pipe, and means for forcing air through said blast
110 nozzle to create a blast mixture between said nozzle and bed exceeding in velocity the rate of flame propagation through it.

10. Combustion apparatus comprising a combustion-locating bed, a blast nozzle directed toward the same and means supplying air thereto adapted to create a velocity of the blast mixture exceeding the rate of flame propagation through it, in combination with a liquid fuel source from which
120 liquid is moved to said blast nozzle by the effect of the air flow therethrough, and means controlled by the air flow automatically controlling the liquid flow and maintaining constant proportions of liquid and
125 air in said blast mixture.

11. Combustion apparatus comprising a combustion-locating bed, a blast nozzle directed toward the same and means for supplying air under pressure thereto adapted
130

to create a velocity of the blast mixture exceeding the rate of flame propagation through it, in combination with a liquid fuel source from which liquid is moved to said blast nozzle by the effect of the air flow therethrough, the said parts being correlated to discharge the blast mixture in free and unconstricted form and in proportions adapting it to ignite in an initially cold state, and means controlled by the air flow to said blast nozzle automatically controlling the liquid flow thereto and maintaining constant proportions of liquid and air in said blast mixture.

12. Combustion apparatus comprising a combustion locating bed and a blast nozzle directed toward it, separate pipes for delivering liquid fuel and air to said nozzle, means for automatically maintaining constant proportions of liquid and air deliveries to said nozzle, and means for heating the air between the said proportioning means and the blast nozzle, whereby the thermal expansion of said air is without effect upon the proportions of the mixture issuing from said blast nozzle, and an air source adapted to create a velocity of said blast mixture exceeding the rate of flame propagation through it.

13. Combustion apparatus comprising a combustion locating bed and a blast nozzle directed toward it, and an air pipe leading to said nozzle having an air-sustained control body therein, in combination with a liquid fuel supply chamber having means for delivering liquid to said nozzle and arranged to discharge said liquid according to the difference of pressure on opposite sides of said body, and means whereby the position of said body regulates the said discharge.

14. Combustion apparatus comprising a combustion locating bed, a blast nozzle directed toward it and an air pipe leading to said nozzle having an air-sustained body therein, in combination with a liquid fuel chamber having its outlet within said pipe and arranged to discharge liquid according to the difference of pressure in said pipe on opposite sides of said body, means whereby the position of said body regulates the liquid discharge outlet, and a transfer pipe conducting the so-discharged liquid to the blast nozzle.

15. Combustion apparatus comprising a

Venturi tube blast nozzle discharging against a combustion-locating bed, a pipe for supplying air thereto, and an air-sustained body in said pipe, in combination with a liquid fuel supply receptacle having its liquid surface and outlet respectively subjected to the pressure existing on opposite sides of said body and a transfer pipe for conducting liquid from said outlet to the blast nozzle by the effect of the local pressure depression produced at the throat thereof.

16. Combustion apparatus comprising a Venturi tube blast nozzle, a pipe for supplying air thereto under pressure and an air-sustained control body in said pipe, in combination with a liquid fuel receptacle having its discharge outlet subject to the pressure in said pipe and provided with a metering member controlled by the position of said air-sustained body and a transfer pipe conducting the liquid from said outlet to the Venturi tube.

17. Combustion apparatus comprising a combustion-locating bed, a blast nozzle directed toward it and supplied with air under pressure, and a liquid transfer pipe conducting liquid to said nozzle by the effect of the air flow therein, in combination with a liquid fuel receptacle and means independent of the flow or pressure conditions in said blast nozzle for maintaining delivery of liquid from said receptacle to said transfer pipe in substantially constant proportions to the air supply to said blast nozzle.

18. Combustion apparatus comprising a combustion-locating bed, an air pipe, an air-sustained body therein, a liquid fuel supply receptacle having its liquid surface and liquid outlet respectively subjected to the pressure existing on opposite sides of said body, in combination with a blast nozzle supplied with air from said pipe and directed toward said combustion-locating bed, a transfer pipe for conducting liquid from said outlet to the blast nozzle and means independent of the pressure affecting said liquid surface and liquid outlet of the supply receptacle, for maintaining liquid flow through said transfer pipe.

In testimony whereof, I have signed this specification.

JOHN GOOD.