No. 777,578. PATENTED DEC. 13, 1904.

G. E. WHITNEY.

HYDROCARBON BURNER.

APPLICATION FILED FEB. 20, 1899.

NO MODEL. 2 SHEETS—SHEET 1.

Fig. 1.

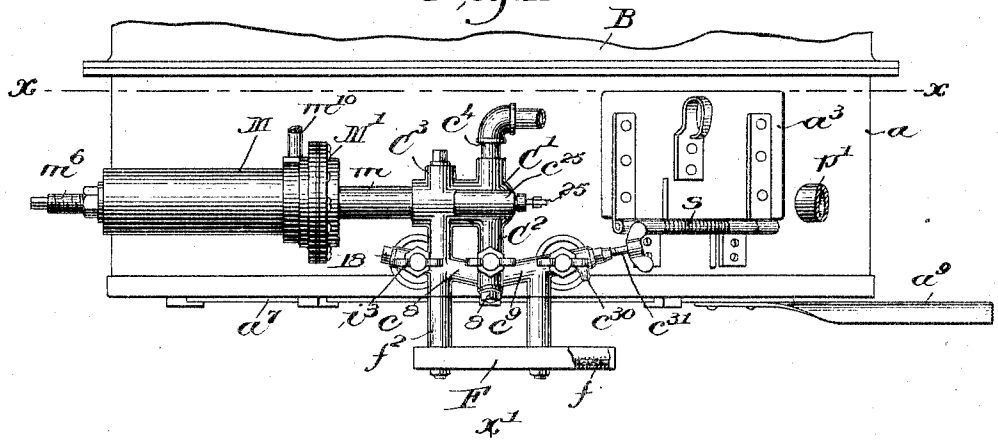
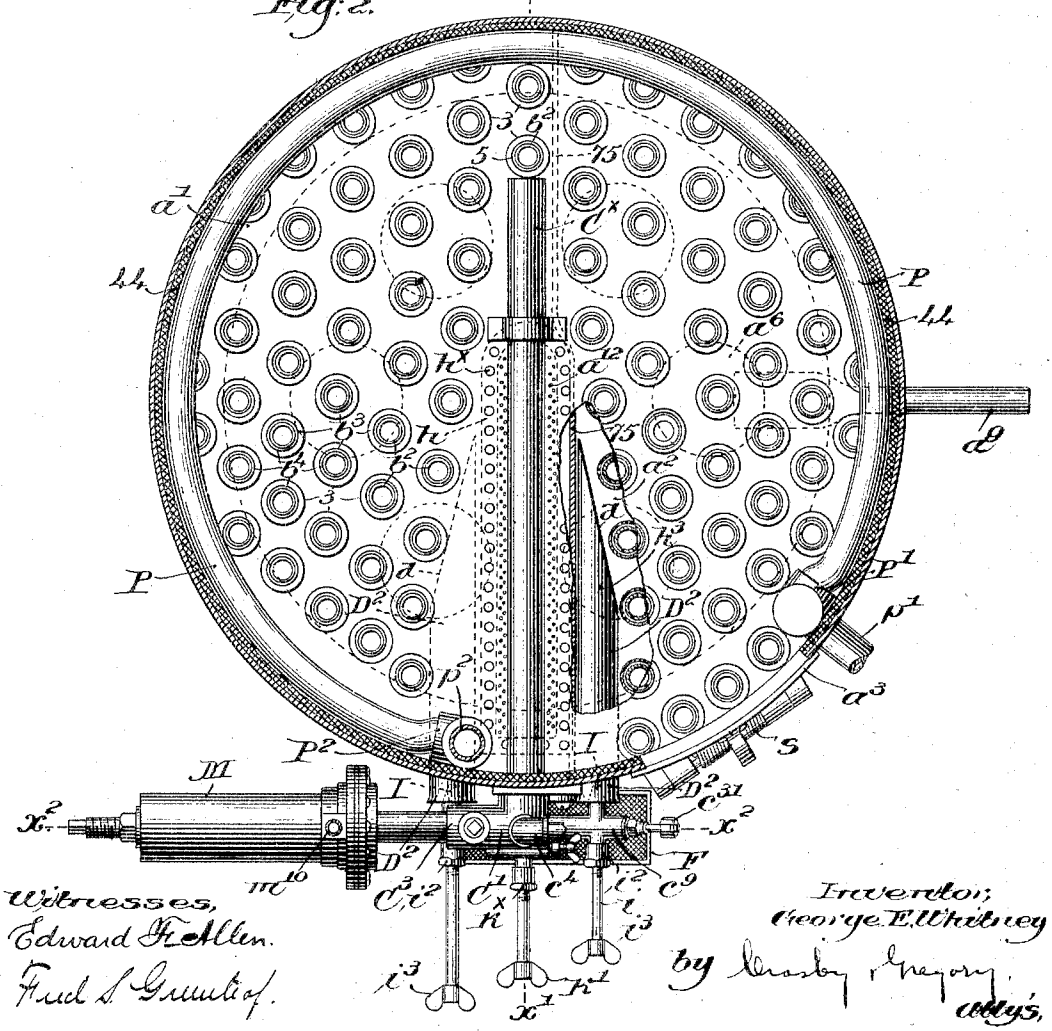


Fig. 2.



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NO MODEL. 2 SHEETS—SHEET 3.

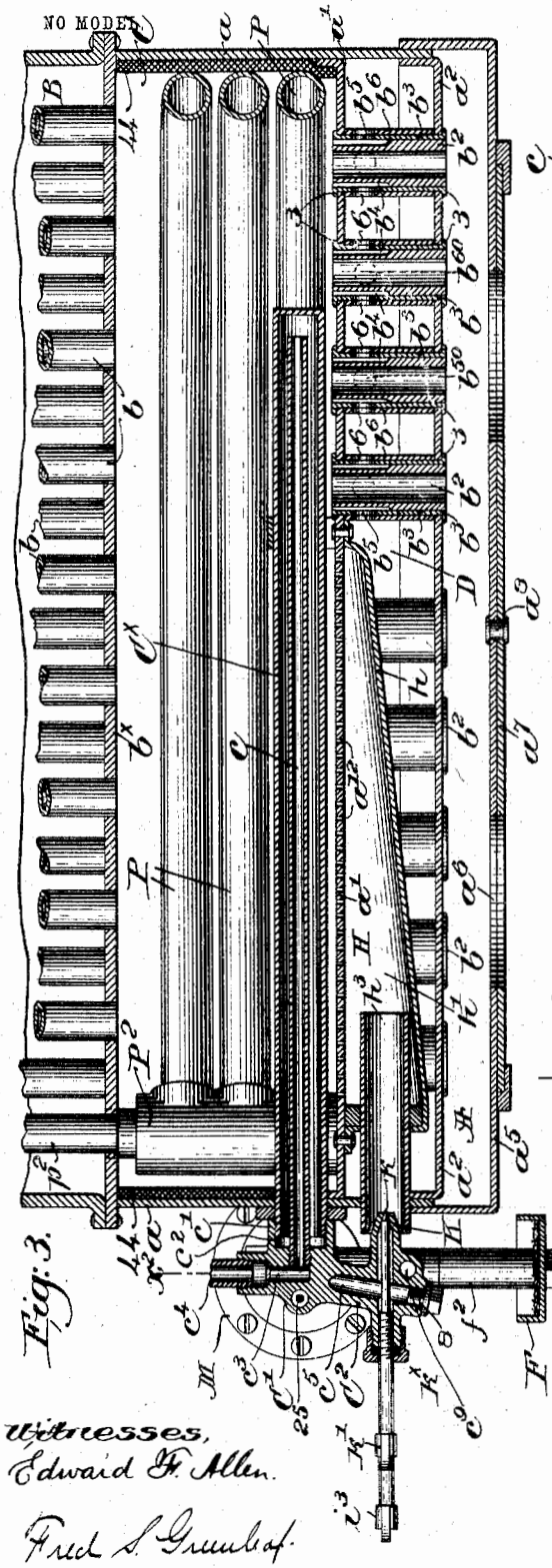

Fig. 3.

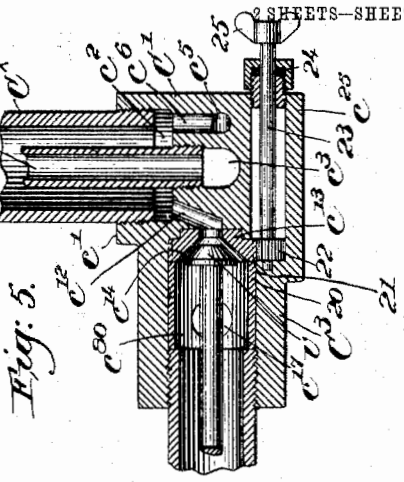

Fig. 5.

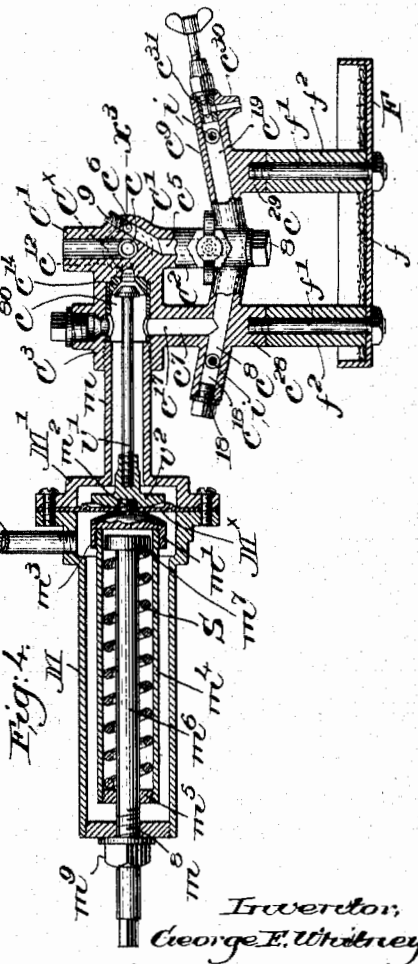

Fig. 4.

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No. 777,578. Patented December 13, 1904.

UNITED STATES PATENT OFFICE.

GEORGE E. WHITNEY, OF BOSTON, MASSACHUSETTS, ASSIGNOR TO WHITNEY MOTOR WAGON COMPANY, OF KITTERY, MAINE.

HYDROCARBON-BURNER.

SPECIFICATION forming part of Letters Patent No. 777,578, dated December 13, 1904.

Application filed February 20, 1899. Serial No. 706,253. (No model.)

To all whom it may concern:

Be it known that I, GEORGE E. WHITNEY, of Boston, county of Suffolk, State of Massachusetts, have invented an Improvement in Hydrocarbon-Burners, of which the following description, in connection with the accompanying drawings, is a specification, like characters on the drawings representing like parts.

This invention has for its object the production of a novel hydrocarbon or liquid-fuel burner for steam-generators constructed and arranged to effect great economy of fuel with high efficiency and capable of very complete regulation and adjustment.

One practical embodiment of my invention will be hereinafter described in the following specification, various novel features being particularly pointed out in the claims.

Figure 1, in elevation, represents a hydrocarbon-burner embodying one form of my invention, showing clearly the external parts of the burner, the lower portion of the boiler-shell being shown as surmounting the burner, to be heated thereby. Fig. 2 is a horizontal sectional view of the burner, taken on the line x x, Fig. 1, the bottom of the combustion-chamber being partially broken out to show more clearly some of the parts beneath. Fig. 3 is an enlarged vertical section taken on the line x' x', Fig. 2, showing also in section the lower portion of the boiler illustrated in Fig. 1. Fig. 4 is an enlarged sectional view on the line x^2 x^2, Figs. 2 and 3, of the fuel-controlling devices shown in front elevation in Fig. 1; and Fig. 5 is also an enlarged sectional detail of a portion of the fuel-controlling devices, taken on the line x^3, Fig. 4.

In my present invention I have provided a novel and highly-efficient form of burner particularly adapted for portable or other steam-generators, constructed in such manner that the consumption of the fuel is carried to substantial completion in the combustion-chamber, with the attendant results of very high efficiency, rapid and continuous generation of a great volume of heat, and the practical elimination of all disagreeable odor due to partially-consumed fuel.

The regulation of the burner is readily and effectively attained by means to be hereinafter described, the apparatus as a whole being capable of quick return to maximum or lower heating effect after the supply of fuel has been temporarily shut off.

In the preferred embodiment of my invention the fuel-vapor is mixed with air before its entrance to the burners proper or burner devices, an independent supply of air to support and effect complete combustion being delivered to the burners at or closely adjacent to the point at which combustion of the mixed air and gas is effected.

Referring to the drawings, the burner comprises an outer shell or side wall a, bent into circular form in the present instance, having a double bottom formed by continuous flat top or upper and lower or bottom plates a' a^2, Fig. 3, said plates and the side wall constituting a casing which forms a distributing-chamber D, from which the combustible gas, preferably a mixture of fuel-vapor and air, is distributed to the burner-openings to be described. The space included between the side wall and top plate a' of the casing constitutes a combustion-chamber C, which is closed at its top by the bottom or crown sheet $b^\times$ of the boiler B, (partly shown in Figs. 1 and 3,) having upright fire-tubes or flues b, opening at their lower ends into the combustion-chamber. An opening in the side wall of this chamber is closed by a door a^3, Figs. 1 and 2, conveniently located near the torch to be described, access to the latter and to the interior of the chamber C being effected by opening the door, a spring s being herein shown as arranged to normally maintain the door closed.

Each burner device is herein shown as composed of two concentric metallic tubes b^2 b^3, fitted tightly together at their lower ends, Fig. 3, interposed between and secured to the top and bottom plates of the casing by inserting the tubes tightly in registering holes in said plates and outwardly flanging or turning over the ends of the outer tube b^3 upon the plates, as at 3 3. The inner or air tube b^2 is reduced in external diameter at its upper part for about half its length to leave an annular space b^4 between it and the outer tube b^3, said tubes b^2 b^3 forming the inner and outer walls of the burner device, which thus presents a

slit-like and preferably continuous exit or burner-opening in the top plate and leading into the combustion-chamber. Opposite the annular space b^4 and opening thereinto are inlet ports or holes b^5 in the outer wall or tube b^3, thereby effecting communication between the burner-openings and the distributing-chamber D, inasmuch as said inlets b^5 are below the top plate a', which forms the bottom of the combustion-chamber. A large number of the burners or burner-openings are provided, varying in number and size according to circumstances, the burner-openings in the bottom of the combustion-chamber presenting a number of ring-like or annular slits or exit-orifices 5, Fig. 2. The flanged ends of the tubes b^3 prevent separation of the plates a' a^2 due to the warping or bending tendency caused by the high temperature, and in order to maintain the plates the proper distance apart I make use of distance members, shown as metal tubes b^6 surrounding the burner-tubes and abutting at their ends against the top and bottom plates between the end flanges 3, said tubes b^2, b^3, and b^6 being made of metal having the same rate of expansion. By this construction the burners are not only cheaply and conveniently constructed, but the top and bottom plates a' a^2 of the casing are held from warping or buckling.

The distance members b^6 are perforated at 6 opposite the inlets b^5, as shown in Fig. 3, and it will also be seen that the inner or air-supplying tubes b^2 of the burners form conduits or passages extended through but not communicating at all with the distributing-chamber D, said inner tubes serving as inlets to supply air to the burner-openings and chamber C to support combustion and also to furnish any additional air necessary for the mixture of fuel-vapor and air delivered to the burner-openings from the distributing-chamber D.

From the foregoing it will be obvious that the burner-flame is ring-like or annular and that the pure air is delivered at the interior of the flame uniformly at all points, resulting in a very hot clear flame, the hydrocarbon vapor being entirely consumed within the chamber C.

By varying the position of the upper ends of the tubes b^2 b^3 the flame may be flared or contracted, slight elevation of the inner tube or wall flaring the flame and depression below the outer tube or wall contracting it.

I have herein shown the lower ends of the conduits or air-supplying tubes b^2 as opening into an air-chamber A below and attached to the distributing-chamber, the bottom a^5 of the air-chamber having suitable air-inlets a^6, Fig. 3, adapted to be more or less closed by means of a shutter a^7, shown as pivoted to the bottom of the chamber at a^8 and provided with an actuating-handle a^9, Fig. 2. The pure external air enters the chamber through the inlets a^6 and passes to the various conduits or inner walls b^2, and by means of the shutter a^7 the air-supply delivered through such conduits can be regulated readily and with a great degree of accuracy.

The heat generated in the combustion-chamber is very intense when the apparatus is in full operation, and to protect the side walls a I use a lining of some refractory material, such as asbestos paper or cloth 44, Figs. 2 and 3, and in addition thereto I provide further protection by a series of pipe-bends P, curved to conform closely to the curvature of the side wall a and connected at their ends with manifolds or headers P' P², Fig. 2, the former communicating by a pipe p' with the source of feed-water supply, while the latter connects by pipe p^2 with the boiler. As the incoming feed-water circulates through the bends P it is heated and so passes to the boiler, while the interposition of this body of water between the burners and the wall of the combustion-chamber acts as a protection for the latter against the fierce heat.

Two concentric pipes $C^\times$ c are extended into the combustion-chamber, the larger one being closed at its inner end and rigidly secured at its outer end only to the wall of the combustion-chamber and constituting the vaporizer to receive and vaporize the hydrocarbon or other liquid fuel used. By securing the vaporizer at one end only I provide for its expansion and contraction under variations of temperature, thereby avoiding derangement or breakage of parts or their distortion.

An external casting C' has a threaded portion c', Fig. 3, screwed onto the projecting outer end of the vaporizer, leaving a chamber c^2 in the casting at the open end of and communicating directly with the vaporizer, the inner tube or fuel-supply inlet c for the vaporizer passing through said chamber and being shown as screwed into the casting in communication with a duct or passage c^3, which is connected with the source of fuel-supply by a pipe c^4. The liquid fuel thus enters the inlet-tube c and is delivered therefrom at the inner end of the vaporizer $C^\times$, so that it is subjected to high temperature at the instant it enters the vaporizer and the fuel is largely or altogether vaporized before it leaves the inlet c.

Beneath the vaporizer and at each side thereof for the greater part of its length, as herein shown, the plate a', forming the bottom of the combustion-chamber, is provided with numerous small holes or jet-openings a^{12}, Figs. 2 and 3, of a pilot-torch herein comprising a subchamber or heater H, formed in the distributing-chamber and completely shut off therefrom, the bottom h of the heater being upwardly inclined from near the side wall of the chamber D to the plate a' at the inner end of the perforated portion. The side walls h' of the heater are riveted or otherwise rigidly secured at their upper edges to the plate a',

as at $h^{\times}$, Fig. 2, so that when a combustible gas or vapor is admitted to the pilot-torch heater H it will escape through the jet-openings a^{12}, and when a lighted match or torch is applied thereto the vapor will ignite and the heat from the jets will raise the temperature of the vaporizer $C^{\times}$. An air-inlet tube h^3, Fig. 3, enters the chamber through the side wall of the distributing-chamber D, as herein shown, and a fuel-vapor injector K is located at the outer end of and projects into the said inlet in usual manner, the torch-heater being thus supplied with air and fuel-vapor or hydrocarbon gas to feed the jets a^{12}.

Referring to Figs. 1 and 4, the casting C′ has a depending foot C^2, provided with a crooked passage c^5, communicating with a nozzle on the casting forming the injector K, a short duct c^6, Fig. 5, connecting the passage c^5 with the chamber c^2 and the vaporizer $C^{\times}$. Suitable plugs 8 and 9 tightly close the ends of the crooked or bent passage c^5, formed in the casting by drilling in this instance of my invention, and it will be seen that the fuel-vapor can pass at all times to the nozzle or injector K for the torch-heater, controlled by a suitable injector-valve k, the threaded stem of which passes through a stuffing box or gland $k^{\times}$ and is provided with a handle or nut k' at its outer end.

The distributing-chamber D is preferably provided with two air-inlets or mixing-tubes D^2, one at each side of the torch-heater H, the inner ends of said inlets being beveled, as at d, Fig. 2, on their outer sides in order to provide an extended exit-opening for the mixed air and fuel-vapor as the mixture enters the distributing-chamber, each air-inlet being provided with a coöperating injector I, by which a jet of gas is injected directly into the tube D^2 and under pressure due to the vaporizing of the fuel.

At one side of its center the casting C′ is provided with a lateral chambered extension C^3, having a depending leg c^7, provided with a lateral branch c^8, connected with or forming a part of the foot C^2 and projecting beyond it at c^9, as shown in Fig. 4.

The injectors I are constructed substantially as the injector K and are formed by nozzles extended inward from the branch c^8 and its extension c^9, said nozzles communicating with passages c^{18} c^{19}, Fig. 4, formed by drilling the branch and its extension from the outer ends, a plug 18 closing the outer end of the passage c^{18}. An upright passage c^{17} in the leg c^7 connects the passages c^{18} c^{19} with the chamber c^{80}, the latter having at its inner end a circular block c^{13}, forming a valve-seat c^{14} for a valve v, a duct c^{12} leading to the opening of the valve-seat from the chambered portion c^2 of the casting C′, as best shown in Fig. 5.

It sometimes happens that by reason of some slight obstruction the valve v will not firmly seat; but such obstruction can generally be removed by a relatively rotative movement of the valve and seat without removing either, and herein I have constructed this part of the apparatus whereby such relative rotative movement can be effected independently of the valve-operating means.

The circular valve-seat block c^{13} is held in place by a thimble or sleeve 20, Fig. 5, and the periphery of said block is toothed, as at 21, to be engaged by a pinion 22 on a shaft 23, mounted in a hollow enlargement c^{25} of the casting C′. The shaft passes through a stuffing-box 24 and is provided with a handle 25, by which it may be rotated, and by turning this handle the pinion 22 will rotate the block c^{13} relatively to the valve to clear the parts of a slight obstruction.

Each injector I is provided with a needle or similar valve of usual construction, the stems i being shown in section in Fig. 4 and passing through stuffing-boxes i^2, Figs. 1 and 2, with thumb-nuts or handles i^3, by which the valves are operated.

A pan F, provided with suitable fibrous material f, Fig. 4, is connected by bolts f' to nipples c^{28} c^{29} on the branch c^8 and its extension, sleeves f^2 surrounding the bolts between the nipples and the bottom of the pan.

When the apparatus is to be started, the parts being cold, alcohol or some of the liquid fuel is poured into the pan and lighted, the valves of the injectors I being closed, and the heat soon raises the temperature of the casting C′ and adjacent parts sufficiently to vaporize such liquid fuel as is contained therein, and this vapor passing into the torch-heater H can be ignited by a match or torch in the combustion-chamber, and very quickly the vaporizer $C^{\times}$ will be in operative condition. For convenience I have provided the extension c^9 with a teat c^{30}, controlled by a valve c^{31}, Fig. 4, so that liquid fuel can be drawn therefrom into the pan F when it is desired to start the apparatus. After it has been once started and the vaporizer initially heated by the flame from the pilot-torch, as described, the fuel vaporized therein passes from the vaporizer through duct c^{12} and chamber c^{80} to the passage c^{17} and thence to the injectors I I, and when the valves of the latter are opened the vapor rushes into the inlets D^2, drawing in air and mixing therewith to supply the chamber D in the burner-casing with the combustible mixture for the burner-openings, and this combustible mixture issuing from the said burner-openings will immediately ignite from the flame of the pilot-torch, the apparatus continuing to so operate as long as fuel is supplied to the vaporizer. When the operation of the apparatus is to be stopped temporarily, the supply to the injectors I is shut off and the main burner ceases to act; but as the torch-heater injector K still remains in unobstructed connection with the vaporizer, as has been described, the said torch-heater

H will continue to operate, keeping the combustion-chamber C and the boiler heated to maintain the steam and vaporizing the fuel as it is admitted to the vaporizer. Thereafter as soon as the injectors I are opened the burners will light automatically from the heater-jets a^{12}.

By means of a burner embodying my invention I am enabled to raise steam very rapidly in the boiler of a steam-generator, for, provided the heater is in operation, there will be enough vaporized fuel in the vaporizer to mix at once with the requisite air at the inlets D^2 as soon as the injectors are opened, the combustible mixture passing at once to the distributing-chamber and burner-openings. The air-inlets D^2 and injectors I are so proportioned that the proper quantity of air will enter to mix with the vaporized fuel and be distributed to the burner-openings from the chamber D, and as the air delivered at the burner-openings is regulated at will it is unnecessary to provide adjusting means for the inlets D^2. I have provided convenient means to automatically regulate the supply of liquid fuel by or through variation in boiler-pressure, so that when said pressure passes beyond or falls below a certain point the fuel-supply will be reduced or increased, respectively.

Referring particularly to Fig. 4, a case M has an attached cap M′, provided with a hollow boss m, through which the stem v' of the valve v is extended, the end of the boss being screwed into the part C^3 of the casting C′ and opening into the chamber c^{80} thereof. A flexible diaphragm $M^\times$ is securely held between the case M of the regulator and its cap, and the valve-stem v' has a head v^2 attached thereto and resting against one side of the diaphragm, a cylinder-head m' on the opposite side of the diaphragm having a threaded stud m^2, which is screwed tightly into the head v^2, passing through the diaphragm and making a steam-tight connection between the valve-stem and cylinder-head m'. The cylinder-head is interiorly threaded at m^3 to receive the end of a cylinder m^4, loosely held in the regulator-case M, the closed outer end m^5 of said cylinder having loosely extended through it a rod m^6, having at its inner end a head m^7 and threaded at its outer end at m^8 to engage a threaded hole in the end of the case, a check-nut m^9 on the rod preventing accidental movement thereof in the case. A strong spring S surrounds said rod within the cylinder m^4, bearing at its opposite ends on the head m^7 of the rod and the end m^5 of the cylinder and tending to move the latter to the left, Fig. 4, to thereby hold the valve v off its seat. A pipe m^{10}, communicating with the steam-space of the boiler, leads to and opens into the case M on the same side of the diaphragm as the spring and cylinder, so that the boiler-pressure acts on the diaphragm in opposition to the action of the spring. By moving the rod m^6 in or out of the case M the tension of the spring is varied to adjust it to the desired degree of boiler-pressure. When such pressure passes beyond that point, the tension of the spring is overcome and the valve v is more or less closed to decrease the supply of fuel-vapor to the injectors I, thus decreasing the heating action of the burner as a whole. When the boiler-pressure falls below the desired point, the spring operates to open the valve and admit more fuel to the injectors to thereby increase the heating effect of the burner. Whether the said valve be opened or closed, however, the passage of fuel to the heater H is not interfered with in the least, so that the supply of fuel may be cut off entirely from the burner-injectors, and the heater will remain operative.

My invention marks an important advance in the art, largely because the vaporizer is located in the combustion-chamber above the main burner, so that the greater the flame therein with the resultant heating effect, calling for an increased supply of fuel, the hotter will the vaporizer become to supply the required amount of vapor, the vaporizer thus responding always to the burner, and furthermore, because the initial heating and lighting torch is itself supplied from the vaporizer so located and responsive, so that there is little or no danger of the draft of vapor for the main burner robbing the torch, the latter as the work upon the burner increases having the benefit of the increased vaporization due to the increased heating effect in the combustion-chamber. These with other apparent features of the invention insure its successful operation under the most trying conditions.

It is to be observed that the auxiliary burner is so located relatively to the main-burner vaporizer that the latter is in the direct path of its heat, thus giving the auxiliary burner a maximum of effectiveness in proportion to its capacity. Its connections to the fuel-supply conduit also are such that the reduction of fuel-supply to the main burner by the automatic regulator, even if carried to the point of total extinction of the main-burner flame, nevertheless permit the maintenance of a heating effect not less than a predetermined minimum in the main-burner vaporizer, so that the latter remains in a condition of readiness to respond quickly to fresh demands or increased demands upon the main burner, irrespective of the connections which supply the auxiliary burner, whether leading from the main vaporizer, as in the illustrated embodiment of my invention, or otherwise, and apart from other considerations these two described features lend a delicate balance to the regulation of the system, for although the total effective heat of the combustion-chamber is the combined heat both of the auxiliary burner

and the main burner the former by reason of its effective position may be made of minimum capacity, thereby contributing the minimum proportion and the smallest possible percentage to the effective heat of the chamber. This causes the variations in the main-burner supply resulting from the automatic regulation to be followed by variations in the effective heat holding the closest possible correspondence to the variations in the main supply. All this notwithstanding that any reduction in the main-burner supply however far it may be carried so long as the system remains in operation cannot reduce the vaporizing heat of the main-burner vaporizer below that limit which is necessary to make it quickly responsive to fresh demands.

I have herein shown a plurality of fuel-injectors for the distributing-chamber, and should one of said injectors fail to work properly from any accidental cause the mixture of air and gas in said distributing-chamber would tend to escape at the point adjacent the inoperative injector and would be lost, and to prevent such occurrence I separate the distributing-chamber in the casing into as many compartments as there are injectors, in the present case by means of a partition-wall 75, (see dotted lines and part full lines, Fig. 2,) one of the injectors I communicating with each compartment into which the distributing-chamber is thus divided, said partition-wall 75 being attached to the top and bottom plates a' a^2. Should one of the injectors fail to operate, it will be obvious that the gas entering the distributing-chamber from the other injector cannot pass into the compartment normally supplied by the temporarily inoperative injector, so that there is no possibility of the gas blowing back and escaping.

Referrring to Fig. 2, it will be seen that the burner-openings are very numerous, and some of them approach very closely the inlets for the distributing-chamber, while others are at a considerable distance therefrom. So to provide for uniform action of the various burner-openings I provide those farthest from the inlets with ports of greater area communicating with the distributing-chamber than for those burners which are nearer the gas and air inlets.

Referring to Fig. 3, the extreme left-hand burner device shown in section may be provided with two inlet-ports b^5, while the next burner device to the right will have an additional port b^{50}, (shown in dotted lines,) and the next two may be provided each with four ports, two being shown in section and one of the other two ports being indicated in dotted lines, as at b^{60}, its fellow port being arranged opposite thereto and not shown in the vertical sectional view.

Obviously instead of varying the number of ports for the differently-positioned burner devices the number of ports might be the same, but differing in size to produce the same effect.

A burner constructed in accordance with my invention is particularly adapted for steam generators or motors for horseless vehicles, yacht-engines, and the like, which are liable to more or less frequent stoppages, on account of its great economy, efficiency, and convenience of operation, durability, and simplicity, together with its great capacity for quickly attaining its maximum heating effect.

I have herein shown two injectors coöperating with the distributing-chamber of the burner; but my invention is not restricted thereto, as one injector or a greater number than two may be employed, as desired and according to circumstances.

I have herein shown one practical embodiment of my invention without, however, attempting to illustrate or describe various changes or rearrangements which may be made without departing from the spirit and scope of my invention, and accordingly my said invention is not restricted to the precise construction and arrangement herein shown and described.

Having described my invention, what I claim, and desire to secure by Letters Patent, is—

1. The within-described hydrocarbon-burner comprising top and bottom plates normally separated by intervening spacers and held together by tubular members passing through said plates and headed over at the outer face of each, air-supplying tubes arranged within said tubular members and in contact therewith at the bottoms of the latter but separated therefrom at the upper ends of the latter, said tubular members being constructed to furnish communication from the chamber between said plates to the resulting annular space between said tubular members and said air-supplying tubes.

2. The within-described hydrocarbon-burner comprising a closed distributing-chamber having a continuous top plate, a combustion-chamber closed at its sides and its bottom formed by the top plate of the distributing-chamber, air-conduits extended through the bottom of the distributing-chamber and the top plate thereof to supply external air to the combustion-chamber, means to regulate the supply of air to said conduits, tubular conduit members secured to the top and bottom plates and having their upper ends communicating with the combustion-chamber to provide slit-like burner-openings and having inlets within the distributing-chamber, said distributing-chamber also having means to supply the same with a mixture of air and fuel vapor.

3. In a hydrocarbon-burner, a combustion-chamber, burners therein, a chamber to contain a mixture of air and fuel-vapor, commu-

nicating with said burners, a fuel-vapor inlet for said mixing-chamber, a tubular air-inlet open at its outer end and extended into the mixing-chamber around the fuel-vapor inlet, the open inner end of said air-inlet being beveled to enlarge the opening thereof.

4. In a hydrocarbon-burner, superposed air, distributing and combustion chambers, and burners comprising concentric inner and outer walls in close contact at their lower ends and separated at their upper ends to leave an annular space communicating with the distributing-chamber and at its top with the combustion-chamber, the said inner walls of the burners extending directly from the combustion to the air chamber, to provide air-inlets opening into the combustion-chamber within the several burner-openings.

5. In a hydrocarbon-burner, superposed air, distributing and combustion chambers, tubular conduits comprising inner and outer walls separated at their upper ends to leave an annular space communicating with the distributing-chamber and opening into the combustion-chamber to form burner-openings, the said inner walls of the conduits extending directly from the combustion to the air chamber, to provide air-inlets opening into the combustion-chamber within the several burner-openings, and distance members interposed between the top and bottom of the distributing-chamber, said distance members coöperating with the outer walls of the conduits to prevent warping of the said chamber top and bottom.

6. A hydrocarbon-burner provided with an inclosed distributing-chamber having top and bottom plates, the top plate having a plurality of burner devices, each of which is formed by a plurality of concentric tubes having an annular space between their upper portions, the outer tube having a side admission-opening therein affording communication between said annular space and said distributing-chamber.

7. In a hydrocarbon-burner, a combustion-chamber, burners therein, a distributing-chamber communicating with the burners to deliver fuel-vapor thereto, means including a valve and its seat to control the passage of fuel-vapor to said distributing-chamber, and independent means to effect relative rotative movement of the valve and seat, to clear the same of an obstruction.

8. A liquid-fuel burner, a valve and its seat to control the passage of fuel to the burner, means to open and close the valve, and independent means to effect relative rotative movement of the valve and seat to clear the same of an obstruction.

9. In a steam-generating apparatus, a boiler, a liquid-fuel burner to heat the same, a controlling-valve and its seat, means to automatically open and close the valve and govern the passage of the fuel to the burner in accordance with the boiler-pressure, and independent means to effect relative rotative movement of the valve and seat to clear the same of an obstruction.

10. In a steam-generator, a burner-casing comprising a side wall and top and bottom plates each having a series of circular openings therein, a plurality of tubes arranged in concentric pairs separated at their upper ends to leave annular spaces which form burner-openings, the outer tube of each pair being rigidly secured at its ends to the top and bottom plates respectively, and an inlet in the outer tube communicating with the annular space between the tubes of the pair.

11. In a steam-generator, a burner-casing comprising a side wall and top and bottom plates each having a series of circular openings therein, a plurality of tubular conduits each having an annular recess extended thereinto from its upper end, to form a burner-opening, each conduit being rigidly secured at its lower end to the bottom plate and having the outer wall of the annular recess secured to the top plate, and an inlet from the exterior of the conduit to the recess.

12. In a steam-generator, a burner-casing comprising a side wall and top and bottom plates each having a series of circular openings therein, a plurality of tubular conduits between the top and bottom plates of the casing, attached to and supported by each, each conduit having therein an annular passage having an inlet within the casing, the upper end of each passage forming an annular outlet at the upper end of each conduit.

13. A hydrocarbon-burner provided with an inclosed distributing-chamber having top and bottom plates, the top plate having a plurality of burner devices, each of which is formed by a plurality of concentric tubes having an annular space between their upper portions, the outer tube having a side admission-opening therein affording communication between said annular space and said distributing-chamber, and the inner tube opening into the space beneath said bottom plate.

14. In an apparatus of the class described, the combination with a boiler of a main burner arranged beneath and to heat the same, the bottom of said boiler and the top of said burner constituting the top and bottom respectively of a combustion-chamber between said burner and boiler, a fuel-supply conduit for said main burner, said conduit including a vaporizer arranged in said combustion-chamber so as to be heated with said boiler by said main burner, whereby the latter aids in vaporizing its own fuel, an initial, heating and lighting torch arranged to initially heat said vaporizer and boiler and to light said main burner, said torch being itself supplied from said vaporizer, and means responsive to variations in boiler conditions to vary the supply from said vaporizer to said main burner without affecting the supply from said vaporizer to said torch.

15. In an apparatus of the class described, the combination of a suitable inclosing wall containing a combustion-chamber, a main burner constituting the bottom of said chamber, a fuel-supply conduit for said main burner, said conduit including a vaporizer arranged in said combustion-chamber to respond to the heating effect of said main burner, one or more vapor-fuel jet devices for said main burner, said jet device or devices being supplied from said vaporizer, a mixing-tube projecting through the side wall forming said combustion-chamber and through which said jet device or devices project vapor-fuel into and to supply said main burner, means positively to control the flow of fuel through each of said jet devices, an independent automatic regulator controlling the supply to said jet device or devices, an initial, heating and lighting torch for said vaporizer and supplied with fuel from said fuel-supply conduit free from the control of said automatic regulator, said torch comprising a jet device externally located relative to said combustion-chamber, positive controlling means for said torch-jet device, and a tube arranged in front of the latter and through which its jet of fuel-vapor is projected within said inclosing wall to act upon said vaporizer.

16. In an apparatus of the class described, a burner-plate provided with a series of main-burner openings, a gas-distributing chamber beneath said burner-plate and in communication with said openings, a fuel-supply conduit for said chamber, said conduit including a vaporizer located above said burner-plate, said plate being also provided with a series of auxiliary-burner openings beneath said vaporizer, said openings communicating with a second gas-distributing chamber.

17. In an apparatus of the class described, a burner-plate provided with a series of main-burner openings, a gas-distributing chamber beneath said plate and in communication with said openings, said plate being provided with a series of auxiliary-burner openings for lighting said main burner, and a gas-distributing chamber in communication with said second series of burner-openings, said main chamber and second chamber receiving a separately-controlled fuel-supply.

18. In an apparatus of the class described, a main-burner plate provided with a series of main-burner openings, a gas-distributing chamber beneath said burner-plate and in communication with said burner-openings, a fuel-supply conduit for said main burner, a vaporizer included in said conduit and above said main burner, a heating and lighting torch directly beneath said vaporizer for initially heating the vaporizer and lighting said main burner, and a second gas-distributing chamber for said heating and lighting torch.

19. In an apparatus of the class described the combination of a boiler provided with a substantially inclosed combustion-chamber beneath the same, a main burner for said boiler within said chamber, regulating means responsive to changes in boiler conditions for supplying a variable amount of fuel to said burner, a vaporizer for vaporizing the fuel supplied thereto, said vaporizer being subject to the action of the heat from said burner to cause the same to respond to the varying burner demands, and an auxiliary burner associated with said combustion-chamber to cause initial ignition and reignition of said main burner, said vaporizer being located directly within the normal path of the auxiliary-burner flame.

20. In an apparatus of the class described the combination with a boiler provided with a substantially inclosed combustion-chamber beneath the same of a main burner within said chamber, a vaporizer immediately above said main burner and subject to the direct action of the products of combustion therefrom to supply vaporized fuel thereto, means responsive to boiler condition for controlling said main burner, an auxiliary burner also within said combustion-chamber and directly adjacent to said vaporizer to impart directly thereto the auxiliary-burner heat, said auxiliary burner having a separate supply-conduit from said main burner, whereby it is caused to impart to said vaporizer a vaporizing effect, irrespective of restrictions of said main burner through the action of said controlling means, and to initially ignite and reignite said main burner.

21. In an apparatus of the class described, the combination of a steam-generator, a main burner therefor, a substantially inclosed combustion-chamber for said burner beneath said generator, a fuel-supply conduit, a vaporizing-retort in said combustion-chamber, and connected with said conduit, for vaporizing fuel supplied to said main burner, automatic regulating means for increasing or decreasing the heat of said combustion-chamber by varying the fuel-supply to said burner, and an auxiliary burner for ignition and reignition of said main burner and also connected to said fuel-supply conduit and arranged adjacent said vaporizer to transmit its heat directly thereto, the connections between said fuel-supply conduit and said auxiliary burner permitting the latter to maintain the heating of said vaporizer irrespective of the restriction of said main burner by said regulating means.

22. In an apparatus of the class described, the combination with a steam-generator, of a main burner, a substantially inclosed combustion-chamber for the same beneath said generator, a fuel-supply conduit for said burner, a vaporizer in said combustion-chamber and included in said conduit, an auxiliary burner associated with said combustion-chamber,

said vaporizer being located within the direct path of the auxiliary-burner flame, and means for regulating the heat of said combustion-chamber by varying the fuel supplied to said main burner while insuring still the heating of said vaporizer by said auxiliary burner.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

GEORGE E. WHITNEY.

Witnesses:
GEORGE B. UPHAM,
FREDERICK L. EMERY.

Corrections in Letters Patent No. 777,578.

It is hereby certified that in Letters Patent No. 777,578, granted December 13, 1904, upon the application of George E. Whitney, of Boston, Massachusetts, for an improvement in "Hydrocarbon-Burners," errors appear in the printed specification requiring correction, as follows: On page 4, line 119, a period should be substituted for the comma after the word "burner," and the following word "irrespective" should commence with a capital I, in line 124 a comma should be inserted after the word "considerations," and in line 126 a period should be substituted for the comma after the word "system," and the following word "for" should commence with a capital F. On page 5 commas should be inserted after the words "burner" and "former" in line 1, after the word "position" in line 2, after the word "supply" in line 12, after the word "carried" in line 13, and after the word "operation" in line 14; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 17th day of January, A. D., 1905.

[SEAL.]

F. I. ALLEN,
Commissioner of Patents.