Oct. 30, 1928.

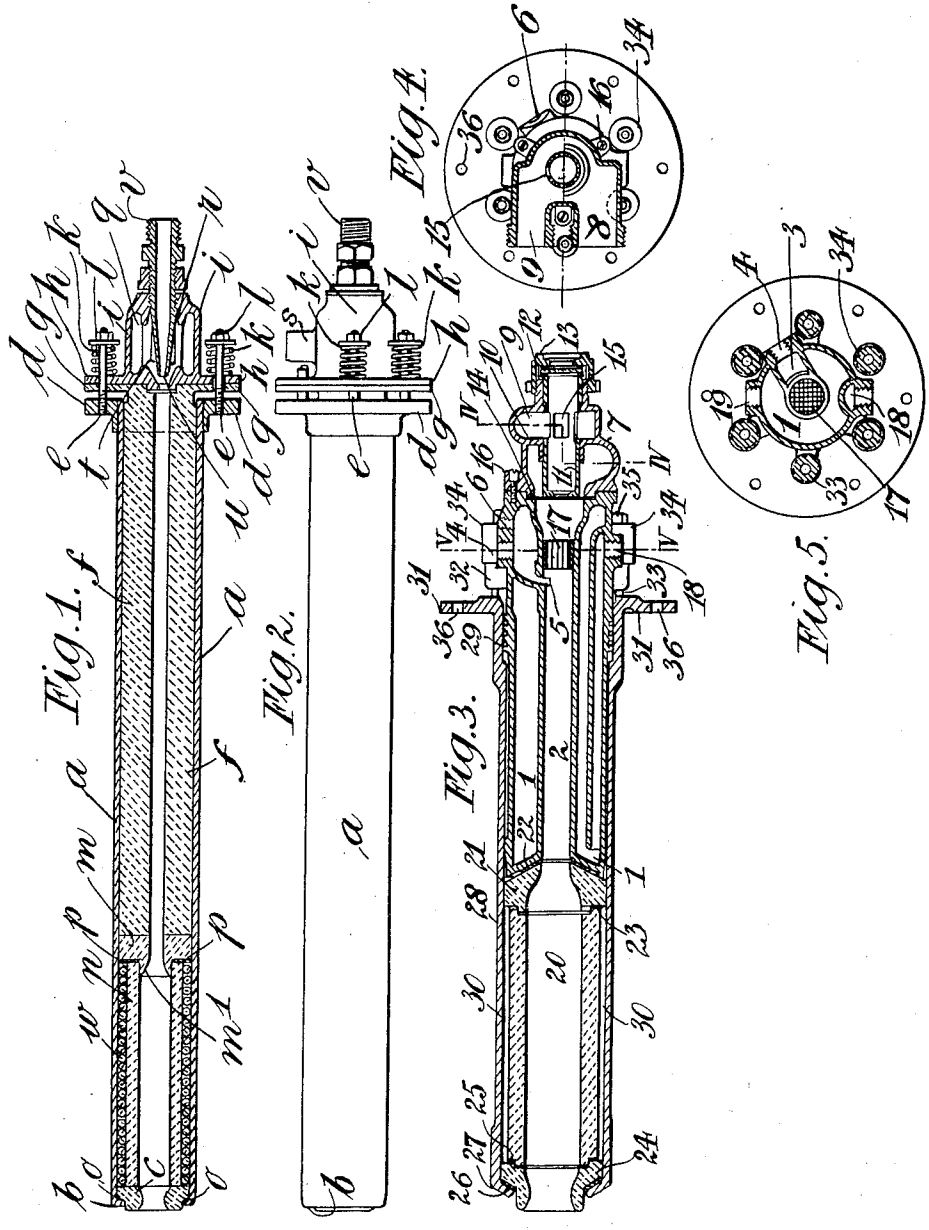
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GASEOUS FUEL BURNER

Filed June 2, 1926

2 Sheets-Sheet 1



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Oct. 30, 1928.

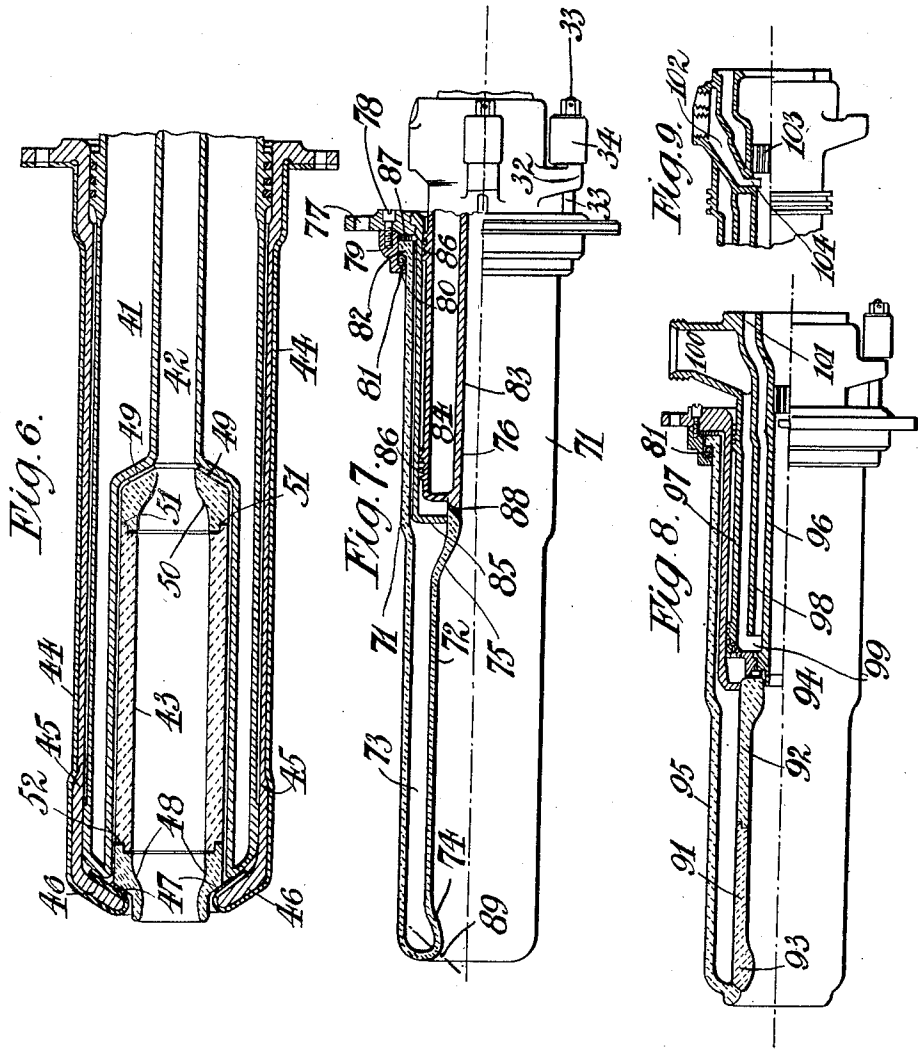
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GASEOUS FUEL BURNER

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE.

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GASEOUS-FUEL BURNER.

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This invention relates to improvements in and connected with burners for the combustion of liquid, gaseous or powdered fuel and is applicable for use in steam generation, chemical concentration and other heating operations. The improvements are particularly concerned with burners adapted for being immersed in the liquid or body to be heated. It is very desirable that such burners should have a capacity for producing intense heat and attaining a complete combustion of the fuel within the burner. In the event of combustion within the burner being incomplete, combustible particles escape with the gases of combustion into the liquid to be heated and are instantly cooled by such liquid so that they are wasted and not consumed. It has been realized that it is necessary to provide for the intimate mixing of the air and fuel before reaching the combustion chamber and to avoid overheating of the mixture. Consequently mixing tubes have been employed and these tubes were cooled or not exposed to the high temperature which the combustion chamber must withstand. Also, to prevent overheating or fusing of the materials of which the combustion chamber is made, air jacket cooling has been resorted to.

The object of the present invention is to provide a construction of submersible burner possessing the desirable characteristics above referred to, and capable of producing and maintaining for long periods complete combustion within itself without liability of firing back. A further object is to provide an assemblage of burner parts such as will ensure a maximum degree of safety for those parts and enable a combustion chamber part, for example, to be exchanged or renewed without difficulty or much loss of time.

According to this invention, the burner comprises two tubular parts of different diameter and freely communicating one with the other, the part of smaller bore being the mixing chamber which is adapted or designed so that it is maintained at a lower temperature and the part of larger bore being the combustion chamber which is adapted or designed so that it accumulates heat and is thereby maintained at a high temperature, the length of the mixing chamber being pre-determined for ensuring proper mixing and the length of the combustion chamber being predetermined for ensuring complete combustion within the burner. The fuel and air admission means are suitably designed for promoting mixture of the fuel and air and imparting a considerable velocity of flow through the mixing chamber. The reliability of such a burner in operation is explained by the fact that the velocity of the mixture through the mixing tube exceeds the velocity of propagation of flame, so that once the burner has been ignited and started, the flame is carried forward into the combustion chamber and cannot strike back so long as the normal admission conditions of the fuel and air are preserved. In order that the aforesaid velocity may be maintained, there must be free communication between the mixing tube and combustion chamber, and in order that the combustion may be complete before the burner nozzle is reached, the tubular combustion chamber must have a proper length, capacity and temperature as will be readily understood.

In the operation of this burner, a temperature of 850° C. and over, is maintained at the inner surface of the combustion chamber, and a surface heated to this degree exercises a catalytic action on the constituents of the combustible mixture coming into contact with it, this action being conducive to the complete combustion which takes place entirely within the combustion chamber as aforesaid. At the same time, the parts are designed, or expedients are adopted, to prevent overheating and fusing of the walls or parts of the combustion chamber.

The burner nozzle is advantageously contracted or of so-called vena contracta form so that the incandescent gases making their exit acquire velocity and penetrate the liquid to be heated. Moreover, this form of nozzle is of particular utility, for example, when the burner is employed for the concentration of salt solutions as it eliminates low pressure zones within the combustion chamber and resists creeping of the salt into the chamber which consequently is not liable to become fouled by salt deposit.

The combustion chamber is of such a nature as to acquire and preserve, during the operation of the burner, a radiant temperature calculated to promote the desired combustion. Thus, an intensely hot flame is produced, the combustion is completed within the chamber, and the gases of combustion are ejected from the nozzle with no

tendency to eddy back or return and dilute the combustible mixture in process of combustion.

The combustion chamber is advantageously of refractory material, or has a lining of refractory material, and is adapted for holding an appropriate quantity of heat. So long as this condition is observed, the walls of the combustion chamber may be solid or hollow and may be lagged, or provided with heat insulation, and such insulation may be a vacuous space, a dead air space, or the equivalent. The combustion chamber may be enclosed in an outer casing of metal, glass, or other suitable material.

As refractory and other parts of the burner cannot safely be connected together by ordinary bolt and nut or like rigid mechanical connections, and as expansion and contraction must be provided for, the parts constituting the assemblage are held together by elastic or resilient means. Moreover, the joints are made tight, and danger of fracture is reduced by the insertion of packing rings between the parts.

By suitable arrangement of the air and fuel admissions, it is possible to avoid obstruction in the whole length of the tubular burner and to provide an observation window in the end cover for enabling the operator to observe the flame and exercise intelligently an appropriate control of the combustion.

And in order that the invention may be easily understood and readily carried into effect, reference will be made to the accompanying drawings, illustrating several submersible burners constructed according to this invention in which drawings:—

Figure 1 is a longitudinal section, and

Figure 2 is an elevation of a simple construction of burner.

Figure 3 is a longitudinal section of a modification.

Figure 4 is a section on the line IV—IV of Figure 3, and

Figure 5 is a section on the line V—V of Figure 3.

Figures 6, 7 and 8 are longitudinal sections of parts of further modification, and

Figure 9 is a sectional plan of a fragment of Figure 8.

In Figures 1 and 2, the burner comprises an elongated cylindrical metal casing *a*, internally flanged at *b* at the forward end to retain a refractory burner nozzle *c* of vena contracta shape. The casing *a* is provided with an external flange *d* at the rear end for the mounting of a series of screw studs *e*. Into the rear end of the casing is passed a reducing bushing or sleeve *f* of metal or other suitable material, said bushing having a flange *g* perforated to freely pass over the studs *e*, in order to allow for contraction and expansion. The studs *e* serve for the mounting of a perforated flange *h* of an air and gas supply fitting *i*. Helical springs *k* are passed on to the studs *e*, and nuts *l* engaging washers bearing upon the said springs cause the latter to bear on the flange *h* and draw the parts tightly together. At the forward end of the reducing bushing *f* there is a refractory nipple or nozzle *m* formed at its forward end with a spigot portion *m'* the bore of which is flared at the forward end. A hollow cylinder *n* of refractory material constitutes the combustion chamber and has an internal diameter corresponding to the external diameter of the spigot *m'* of the refractory nipple *m*. This cylinder *n* is inserted in the casing between the vena contracta nozzle *c* and the nipple *m*, with the spigot of the latter entering the bore of the combustion chamber *n*. A ring *o* of asbestos or the like is interposed between the flange *b* and the nozzle *c* and a packing ring *p* may be interposed between the nipple *m* and the combustion chamber *n*. The combustion chamber *n* has an external diameter somewhat less than the internal diameter of the casing *a* to allow of being encircled with asbestos cord *w* or other insulating material. Or, the annular space between the metal casing *a* and the combustion chamber *n* may be a dead air space. The air and gas supply fitting *i* is of substantially cylindrical form and comprises two concentric chambers *q* and *r*, the outer chamber *q* having a lateral connection *s* (Fig. 2) for the supply of air under pressure and communicating with the central chamber *r* through a series of ports *t*. The central chamber *r* encloses a contracting nozzle *u* directed towards the bore of the reducing bushing or mixing chamber *f* and adapted at the rear end for connection by a screw coupling *v* with a gas supply pipe. Also, the exit from the chamber *r* is of coned or nozzle formation. Gas from the nozzle *u* mixes with air admitted through the ports *t*, and the stream of mixture is directed into the bore of the bushing *f*. The latter provides a passage of reduced cross sectional area between the air and gas supply fitting *i* and the combustion chamber *n* and the length thereof is sufficient for enabling an intimate mixture of air and gas to be effected by the time that the combustion chamber is reached. In this example the mixing chamber *f* is of a length equal to about two thirds of the length of the burner casing *a*.

The streams of air and fuel being injected into the bore of the bushing *f* at high velocity by the nozzle combination become thoroughly mixed in their passage. Upon being ignited by suitable means, combustion takes place in the chamber *n*, so that the refractory wall becomes heated to a high temperature. The mixture emerging from the nipple *m*

expands instantly in the chamber *n* and loses velocity and comes into contact with the heated wall and complete combustion of the mixture is effected within the chamber *n* so that no unconsumed fuel remains at the moment that the gases of combustion make their exit at increased velocity through the nozzle *c*. The bushing *f* being preferably of metal or alloy, does not become overheated owing to its conductivity and the cooling at its exterior. Thus, there is no striking back of the flame, due to the fact that the velocity of the gases through the bushing *f* is greater than the velocity of flame propagation with the mixture at the temperature prevailing within the bushing. The combustion chamber, on the other hand, being of refractory material and suitably insulated, retains sufficient heat for the preservation of the high temperature required for effecting the complete combustion as aforesaid. Nevertheless, it must not be possible for the walls of the combustion chamber to accumulate so great a quantity of heat as to incur the risk of fusing the refractory material or its casing.

It will be observed that the compression springs *k* serve for holding the fitting *i* tight against the bushing *f* and for holding the bushing *f*, nipple *m*, combustion chamber *n*, nozzle *c* and flange *b* in tight endwise engagement, but nevertheless with such resilience as to permit of expansion and contraction and of vibration of the parts without risk of fracture of the refractory material.

According to the modification illustrated in Figures 3, 4 and 5, the mixing chamber is a jacketed tube comprising a cooling jacket 1 enclosing the tubular mixing chamber 2. Near the rear end it is formed with an ignition chamber 3 perforated at 4 to receive a sparking plug or a torch device, the ignition chamber being provided with port or ports 5 leading to the mixing chamber 2. The chamber 3 may have also a screw threaded hole 6 to receive a cock with air pipe connection, the cock being opened for a few seconds prior to ignition in order to blow out or scavenge any products of combustion remaining in the burner after previous use. The air and gas supply fitting 7, comprises two annular chambers 8 and 9 separated by a partition 10, a nozzle 11, which constitutes the inner wall of both chambers, being closed at the rear end by a glass window retained in position by a cap 13. Several interchangeable nozzles 11 of different effective dimensions may be provided so that conditions can be suited by the removal of one nozzle and the insertion of another. The air and gas supply fitting is formed at its forward end with a spigot adapted to engage in an annular depression or recess in the end of the mixing chamber. A concentric ring 14 is interposed in the recess between the spigot and the end of the mixing chamber and the internal diameter of this ring determines the superficial area of the annular passage through which the compressed air passes to mingle with the gas issuing from the nozzle 11. Several interchangeable rings of different internal diameters may be provided with a burner so that any one of these rings may be employed according to circumstances. The fitting 7 is secured in any convenient manner, for example, by means of screws 16. The forward end of the wall enclosing the chamber 8 is coned or of nozzle form as is also the inner wall of the ignition chamber 3. If desired, the mixing chamber may be provided with a nest of small tubes or gauze gratings, or with a Meaker grid 17 of known construction to prevent lighting back. The cooling jacket 1 may be provided with water inlets and outlets 18 and 19, as shown in Figure 5. A nipple ring 21 with an expanding bore is inserted between the mixing chamber 2 and the combustion chamber 20 and packing rings 22 and 23 of asbestos or the like are suitably inserted between these parts. As in the previous example, the forward end of the combustion chamber is fitted with a vena contracta nozzle 24 and an asbestos ring 25 is inserted between it and the combustion chamber 20, a similar ring 26 being interposed between the nozzle 24 and the flange 27 of the metal casing 28. The rear end of this casing is somewhat enlarged as is also the outer wall of the water jacket 1 and the latter is grooved to receive packing rings 29 which make a tight joint in the enlarged part of the metal casing 28. It should be noted that there is a dead air space 30 between the combustion chamber 20 and the casing 28 and also a smaller dead air space or clearance between the outer wall of the water jacket 1 and the said casing. The rear end of the casing is provided with a flange 31 and the jacketed mixing chamber is formed with radial arms carrying eyes 32 for passing on to studs 33 on the flange 31. Resilient bodies 34 are passed on to the studs and compressed by the tightening of nuts 35. The holes 36 in the flange 31 are adapted to receive bolts not shown for securing the burner in place to a bracket or other object.

The parts of the burner in Figures 3 to 5 are readily assembled, and the resilient bodies or springs hold them together with sufficient pressure for making good joints whilst avoiding any danger of breaking the refractory parts. The flame is ignited by a sparking plug or a torch inserted into the ignition chamber 3 before full pressure is turned on. As the pressure is increased, the velocity in the mixing tube 2 is increased, and the flame travels along the tubular combustion chamber 20 and remains there owing to the velocity in the mixing tube 2 being

greater than the velocity of flame propagation. The mixing tube 2 is cooled by the jacket 1, particularly when water is circulated in this jacket and heat accumulates in the wall of the combustion chamber 20, with the same result as that above described in connection with Figure 1.

According to the further modifications illustrated in Figure 6, which is somewhat similar to that described with reference to Figures 3, 4 and 5, the cooling jacket 41 is extended so as to enclose the refractory wall 43 of the combustion chamber. If desired, an acid-proof covering 44, such as rubber or vulcanite, may be applied to the outer surface of the burner casing 45 when it is to be immersed in corrosive liquor. The forward end of the covering 44 is turned in inside the end flange 46 of the casing and a packing ring 47 is inserted between the covered flange 46 and the vena contracta nozzle 48. A packing ring 49 is inserted between the nipple 50 and the end of the mixing chamber 42, and packing rings 51 and 52 are inserted at respective ends of the wall 43 of the combustion chamber. For use in corrosive liquids, the combustion chamber may be made entirely of silica or other appropriate material.

The extended portion of the cooling jacket is merely for the purpose of preventing fusing of the walls or parts of the combustion chamber, and it must not rob the refractory wall 43 of so much heat as to prevent it from having the high temperature necessary for the attainment of complete combustion in the manner above explained.

In the modification in Figure 7 which also is somewhat similar to Figure 3, the nozzle fitting is attached by the means 32 to 35 described with reference to Figures 3 to 5. According to this modification, however, the outer casing 71 is made of refractory material and in one piece with an inner tubular part 72 which is the wall of the combustion chamber. The walls 71 and 72 are spaced apart so as to provide a jacket space 73 and a suitable formation is imparted at 74 to constitute the burner nozzle. The inner end of the tubular part 72 is coned or tapered at 73 to reduce the bore to that of the tubular mixing chamber 76. As the casing 71 is of refractory material, the attachment flange 77 must be made separately, and for holding the casing 71 a socket ring 79 is passed over the casing and secured to the flange ring 77 by screws 78. The socket ring is formed with an interned flange 80 for pressing a rubber or other gasket 81 against an end flange 82 of the casing 71. The jacket space 73 may be a dead air space, or it may be packed with granular refractory material or other heat insulating material. The tubular mixing chamber 76 is formed with a cooling jacket 83. In order to enable the mixing chamber to be packed against a machined metal surface a liner tube 84 formed with an inturned flange 85 at its inner end, is inserted into the casing 71, the flange 85 fitting loosely around the reduced end of the tubular part 72 and forming a partition between the jacket space 73 and the space in which the cooling jacket 83 is situated. Packing rings 86 around the mixing tube jacket make a tight joint with the liner tube 84, and a packing ring 87 makes a tight joint between the flange 77 and the end flange 82 of the casing. Also, a packing ring 88 makes a tight joint between the abutting ends of the tubular mixing and combustion chambers. The operation of this burner needs no description. The mode of resiliently holding together and packing the parts, enables refractory material to be employed for the casing without liability to fracture. If desired, the tubular combustion chamber 72 may be made separately from the casing and may be inserted into the latter and jointed therewith at the lines 89.

The construction in Figures 8 and 9 is similar in many respects to the construction in Figure 7. However, in Figure 8 it will be seen that the combustion chamber is composed of two tubular parts 91, 92 of refractory material having the nozzle formation 93 and expanding nipple formation 94 formed thereon. The said parts 91, 92 are made separately from the casing 95 which is of refractory material and is attached to a socket ring in the manner described with reference to Figure 7. Also, the refractory casing has a metal liner as described with reference to Figure 7. The jacketed tubular mixing chamber comprises inner and outer cylindrical walls 96 and 97 respectively, and an intermediate wall 98 which stops short at the inner end to leave a communicating passage 99 between the two annular chambers enclosed by the walls, Thus, cooling air, being admitted at 100 to the outer jacket space, flows inwardly to the passage 99 and then performs a return flow to the outlet 101, the said air becoming heated or warmed in its passage. It may be very advantageous in some constructions to employ this warmed or heated air for combustion purposes, and in this event the air is conducted from the outlet 101 into an air supply chamber of an air and fuel supply fitting such as has been described with reference to preceding figures. Figure 9 illustrates a convenient construction of ignition chamber 102 which extends through the double jacket just described, the port 104 of such ignition chamber being disposed just in advance of the grid, gauze or like device 103. This point of ignition is very convenient and advantageous, and upon ignition taking place and the pressure of the supply being increased, the flame travels along the

mixing tube and is maintained in the combustion chamber in the manner hereinbefore described.

Other modifications are possible without departing from the scope of the invention as hereinbefore set forth and as defined in the appended claims.

I claim:

1. Submersible burner comprising two tubular parts of different bore freely communicating one with the other, the part of smaller bore being adapted for low temperature maintenance during operation and the part of larger bore being adapted for high temperature maintenance during operation, and combustible fluid mixture supply means in communication with the part of smaller bore, the length of the part of larger bore being predetermined to ensure complete combustion within the burner, and the relation between the bores of these parts being such as to ensure that the velocity of the mixture from the supply to the combustion chamber shall exceed the velocity of flame propagation substantially as set forth.

2. A submersible burner comprising a tubular combustion chamber having heat retaining walls, a tubular mixing chamber of smaller bore than said combustion chamber, said mixing chamber freely communicating with said combustion chamber and having heat dissipating walls, combustible mixture supply means on said mixing chamber, and a vena contracta nozzle on the outlet end of said combustion chamber, substantially as set forth.

3. A submersible burner comprising a tubular combustion chamber having heat resistive walls, a tubular mixing chamber of smaller bore than said combustion chamber and freely communicating with the latter, said mixing chamber having heat conductive walls, a fuel nozzle fitting at the free end of said mixing chamber, said nozzle fitting comprising admission means for air to mix with the jet of fuel injected into said mixing chamber, and a contracting nozzle at the outlet end of said combustion chamber, substantially as set forth.

4. A submersible burner comprising a tubular combustion chamber having heat resistive walls, a tubular mixing chamber of smaller bore than said combustion chamber, said chambers being axially aligned and freely communicating with one another and said mixing chamber having heat conductive walls, a fuel nozzle fitting on the inlet end of said mixing chamber, and resilient connecting means for securing these parts together in axial alignment substantially as set forth.

5. A submersible burner comprising a cylindrical casing, a refractory tube and a heat conductive tube of smaller bore than said refractory tube arranged end to end within said casing, a fuel nozzle on the free end of said heat conductive tube, and resilient retaining means operative between said casing and one of said tubes substantially as set forth.

6. A submersible burner comprising a cylindrical casing enclosing, in the order named, a contracting nozzle, a refractory tube and a heat conductive tube of smaller bore than said refractory tube, a fuel nozzle fitting on the free end of said heat conductive tube, and resilient retaining means operative between said casing and the heat conductive tube, substantially as set forth.

7. A submersible burner comprising a cylindrical casing enclosing a refractory tube, having a contracting nozzle ring at each end and a heat conductive tube having a smaller bore than the refractory tube, the bore of intermediate nozzle ring expanding from the bore of the heat conductive tube to that of the refractory tube, a fuel injector device on the free end of said heat conductive tube, and resilient retaining means operative between said casing and the last named tube, substantially as set forth.

8. A submersible burner comprising a cylindrical casing enclosing, in the order named, a contracting nozzle, a refractory tube and a heat conductive tube of smaller bore than said refractory tube, a fuel nozzle fitting on the free end of said conductive tube, said fitting comprising a laterally disposed fuel admission, a peep device on the outer end of said nozzle fitting and resilient retaining means operative between said casing and the heat conductive tube, substantially as set forth.

9. A submersible burner comprising a tubular combustion chamber having heat retaining walls, a tubular mixing chamber of smaller bore and of substantial length freely communicating with said combustion chamber, a cooling jacket surrounding said mixing chamber, said jacket having appropriate inlet and outlet for cooling fluid, combustible mixture supply means on said mixing chamber at the free end thereof and a nozzle at the outlet of said combustion chamber, substantially as set forth.

10. A submersible burner comprising a cylindrical casing, a burner nozzle, a refractory combustion tube and a heat conductive mixing tube axially aligned within said casing, means separating said refractory tube from said casing, cooling means on said mixing tube, a fuel nozzle on the free end of said mixing tube, and resilient retaining means operative between said casing and said mixing tube, substantially as set forth.

11. A submersible burner comprising a cylindrical casing, a burner nozzle, a refractory combustion tube and a heat conductive

mixing tube axially aligned within said casing, a sliding joint packing between said mixing tube and casing, combustible mixture supply means on said mixing tube, and resilient retaining means operative between said casing and said mixing tube, substantially as set forth.

12. A submersible burner comprising a cylindrical casing, a burner nozzle, a refractory combustion tube and a heat conductive mixing tube of smaller bore than said combustion tube axially aligned within said casing, a fuel nozzle fitting on the free end of said mixing tube, a flame guard between the bore of said mixing tube and said nozzle, and resilient retaining means operative between said mixing tube and said casing, substantially as set forth.

13. A submersible burner comprising a cylindrical casing, a burner nozzle, a refractory combustion tube and a heat conductive mixing tube of smaller bore than said combustion tube axially aligned within said casing, a fuel nozzle fitting on the free end of said mixing tube, said fitting comprising an ignition chamber and port in advance of said nozzle and a flame guard between such port and nozzle, and resilient retaining means operative between said mixing tube and said casing, substantially as set forth.

14. A submersible burner comprising a cylindrical casing, a refractory combustion tube of relatively large bore and a metal mixing tube of relatively small bore axially aligned within said casing, jointing means between said tubes and between said refractory tube and the casing, an air and fuel supply fitting detachably secured to said mixing tube, and resilient retaining means operative between said mixing tube and said casing and adapted for compressing said jointing means, substantially as set forth.

15. A submersible burner comprising a cylindrical casing having an abutment at one end, a refractory nozzle ring jointed against said abutment, a refractory combustion tube of relatively large bore tube centered at one end in said nozzle ring, a reducing nipple centered on the other end of such combustion tube, a mixing tube centered on said nipple and having a bore corresponding with the reduced end of said nipple, an air and fuel supply fitting detachably secured to said mixing tube, and resilient retaining means operative axially between said mixing tube and said casing, substantially as set forth.

16. A submersible burner comprising a cylindrical casing of refractory material, metal mounting means affixed to the rear end of said casing, a refractory combustion tube in said casing and extending rearwardly from the forward end thereof, a metal mixing tube of smaller bore than said combustion tube, said mixing tube being inserted into said casing co-axially with and abutting against the rear end of said combustion tube, a fuel and air supply fitting detachably secured to the rear end of said mixing tube, and resilient retaining means operative between said mounting means and said mixing tube, substantially as set forth.

17. A submersible burner comprising a refractory tubular combustion chamber, a combustible mixture supply tube axially aligned and freely communicating at one end with the combustion chamber and having heat dissipating walls, the cross-sectional area of said tube being smaller than the cross-sectional area of the combustion chamber, combustible mixture supply-means on the free end of said tube adapted to impart velocity to said mixture, a nozzle at the outlet of said combustion chamber, and resilient means securing the said tube and combustion chamber together.

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