(No Model.)

3 Sheets—Sheet 1.

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FURNACE FOR BURNING HYDROCARBON FUEL.

No. 365,789. Patented July 5, 1887.

Fig 3

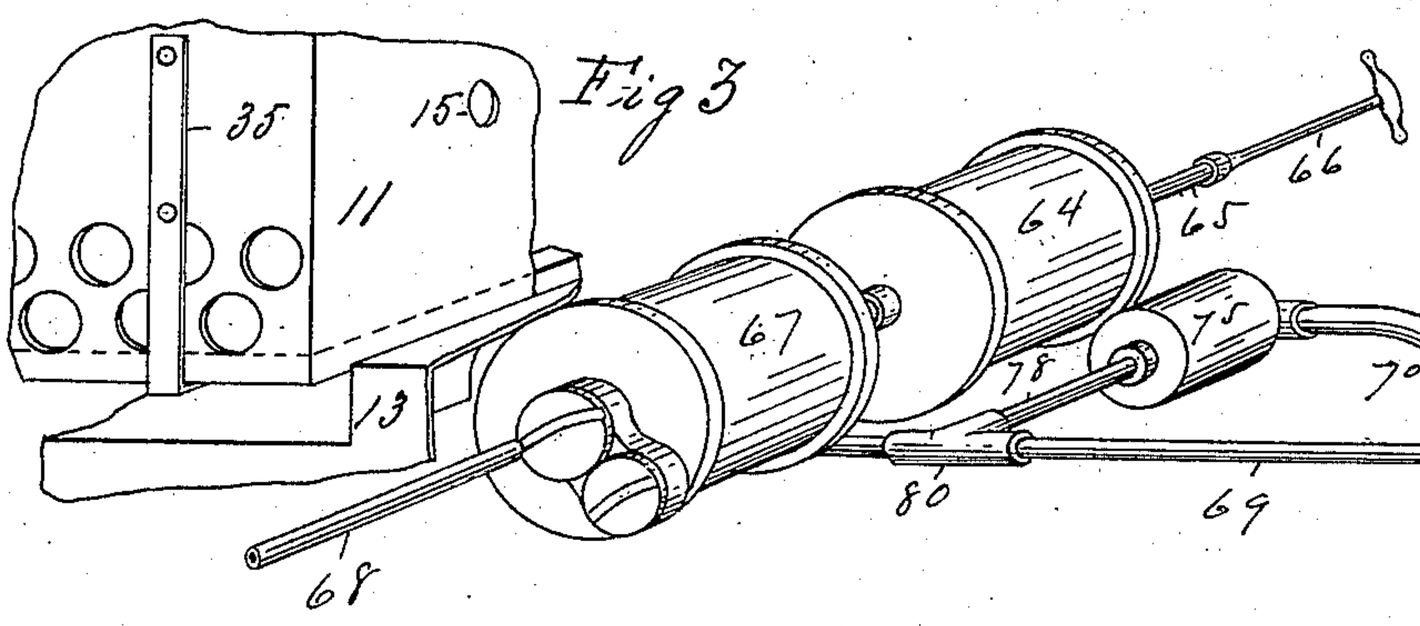

Fig 1

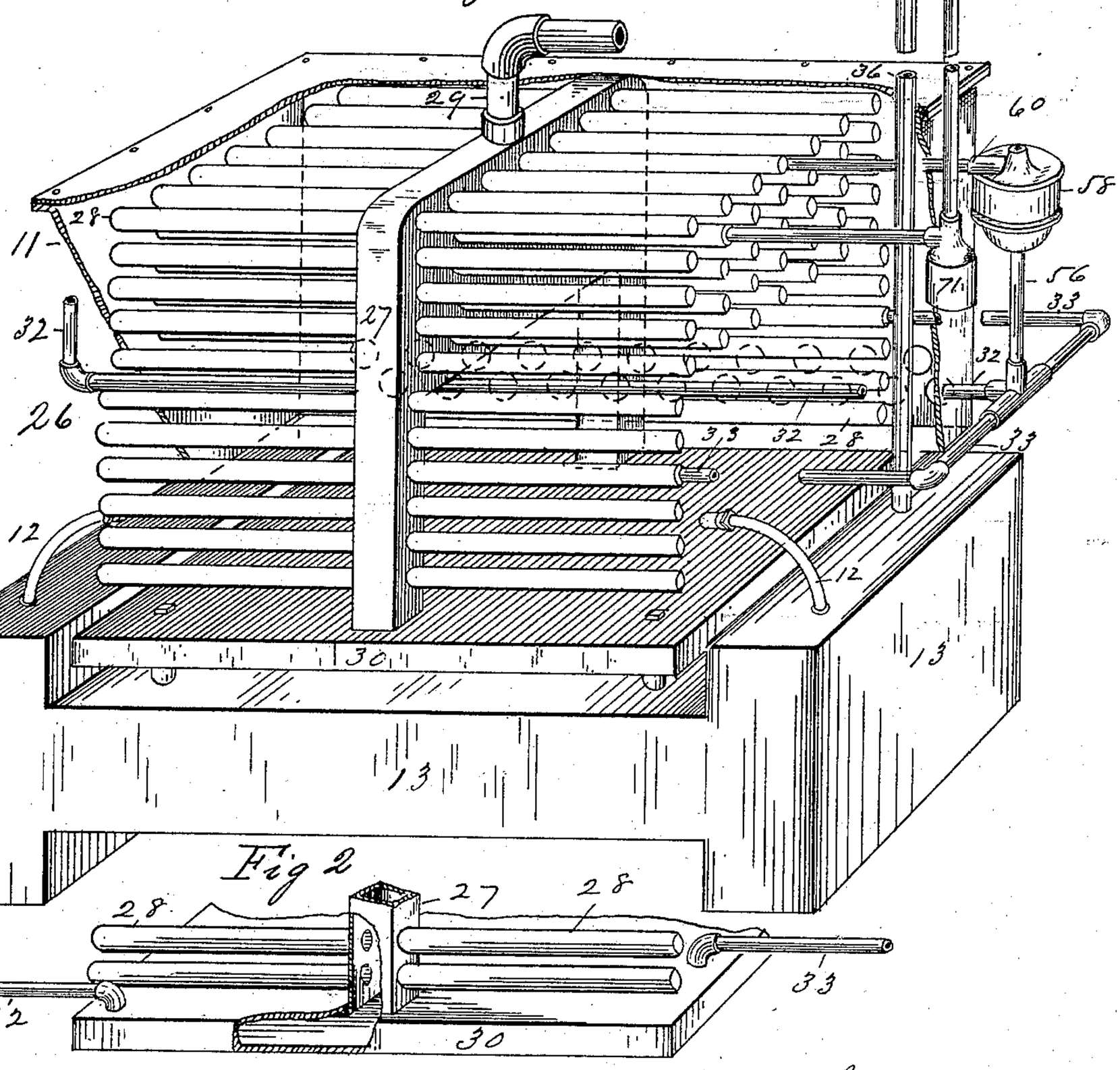

Fig 2

Witnesses
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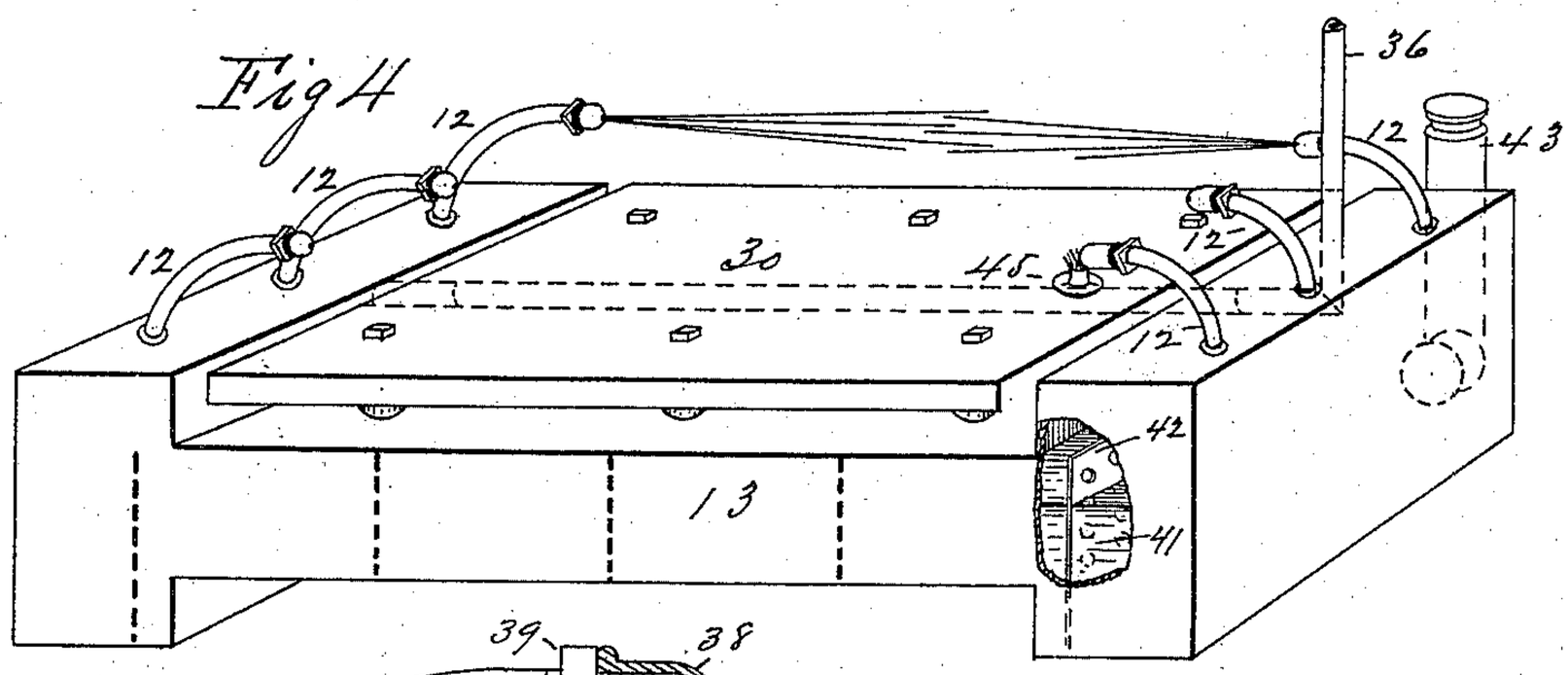
Fig 4



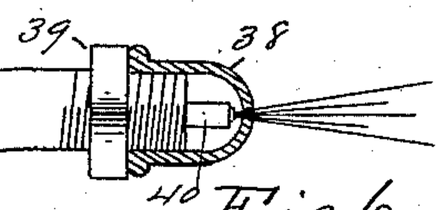
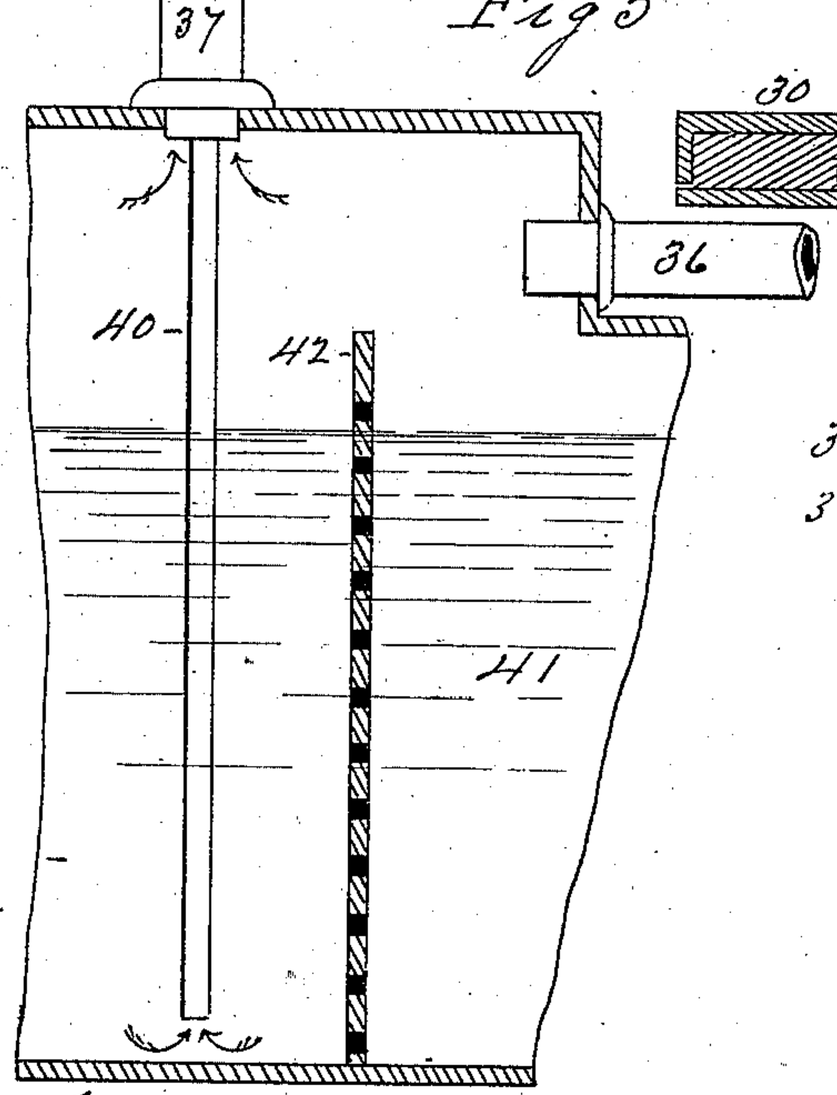


Fig 6

Fig 5



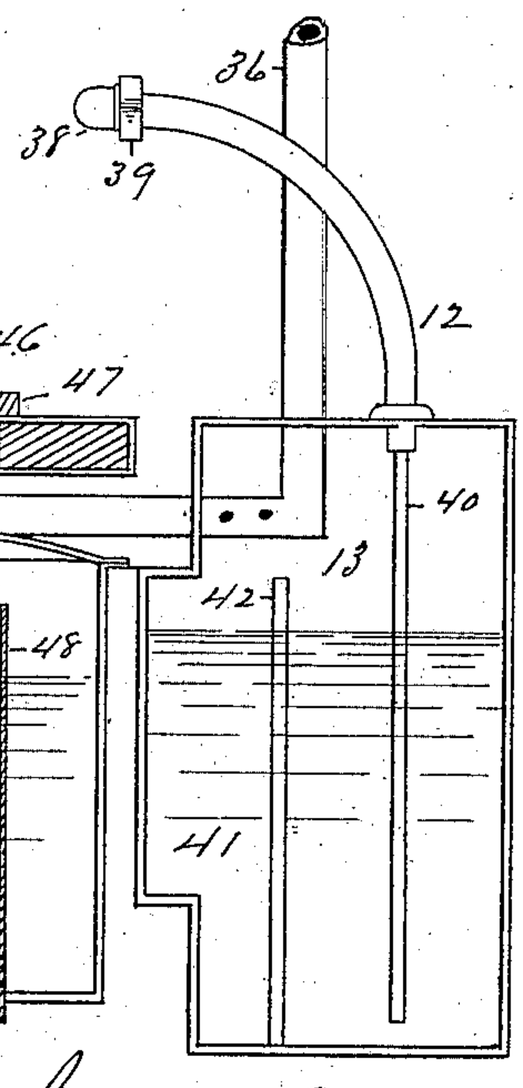


Fig 7

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Fig 8

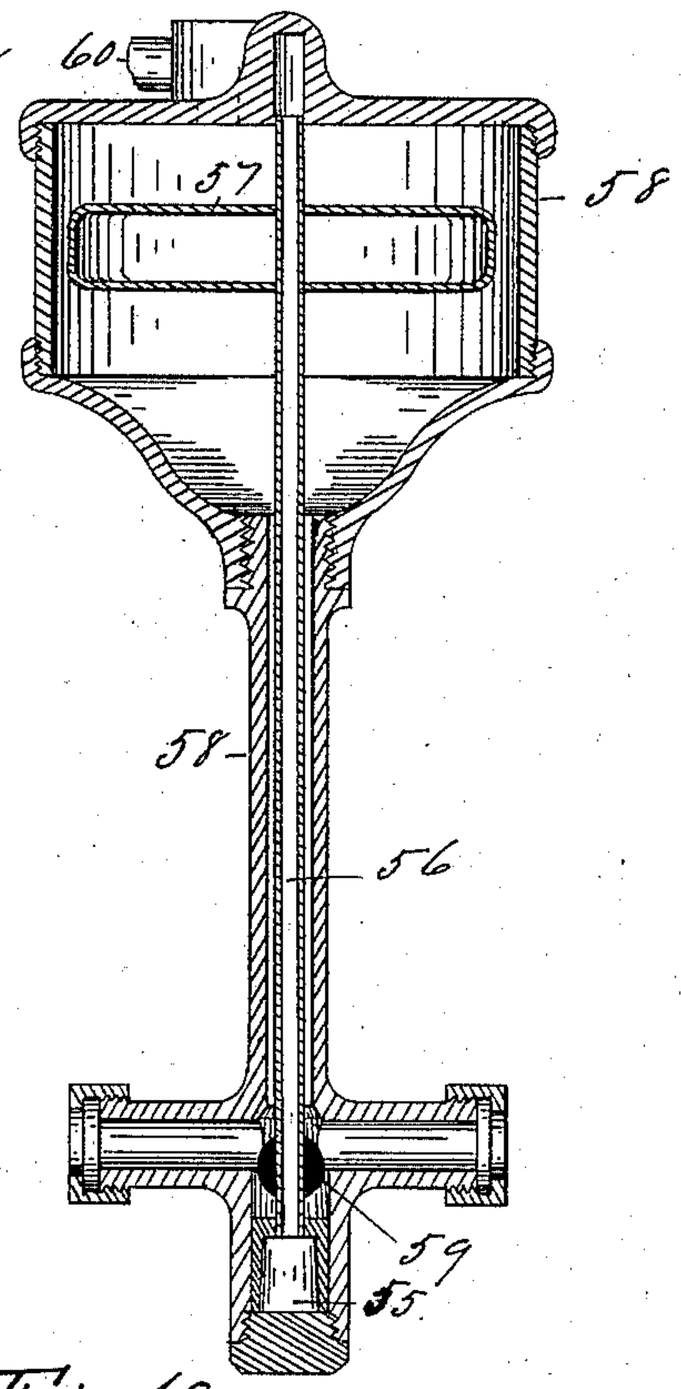


Fig 10

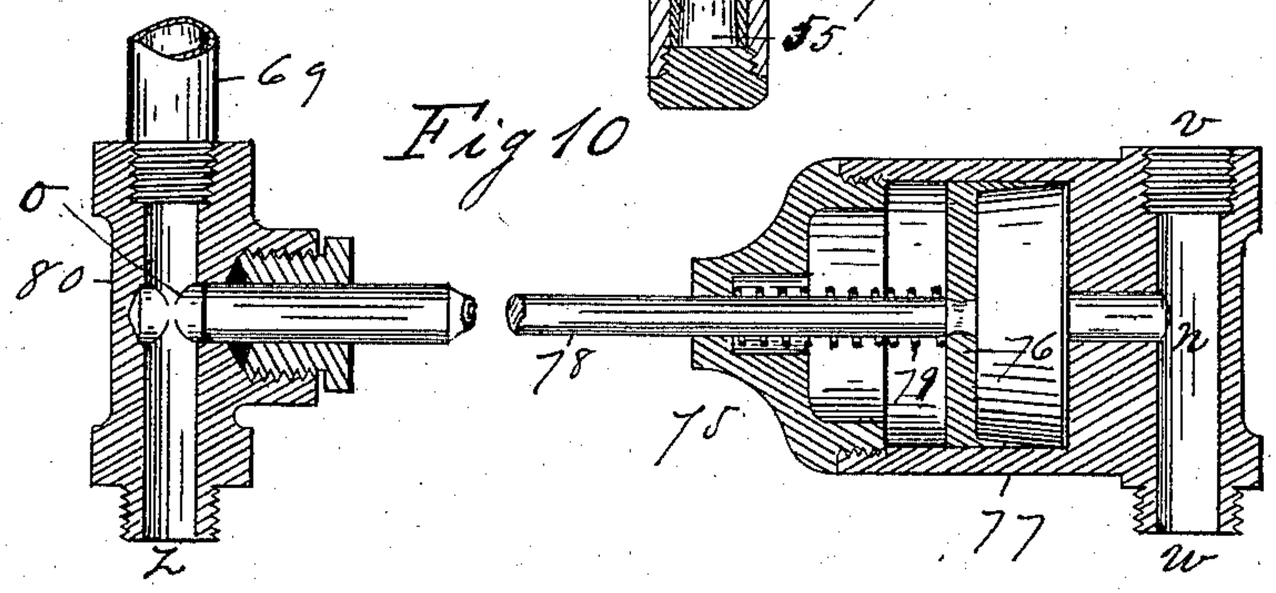
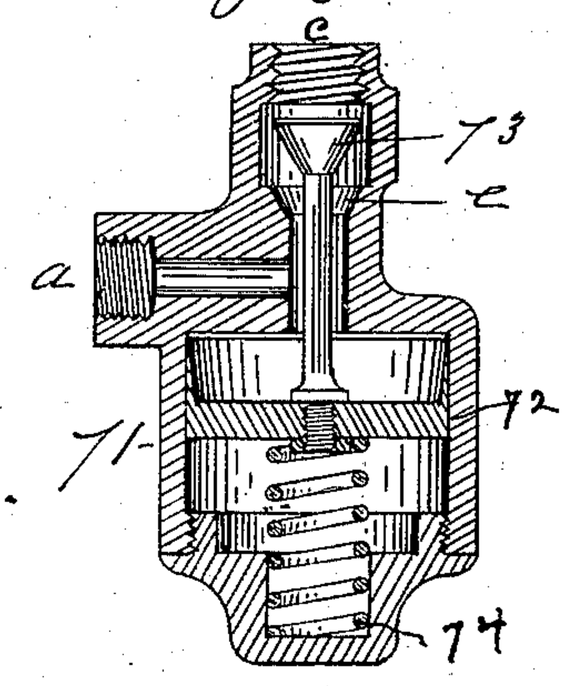


Fig 9



Witnesses
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UNITED STATES PATENT OFFICE.

JAMES H. BULLARD, OF SPRINGFIELD, MASSACHUSETTS.

FURNACE FOR BURNING HYDROCARBON FUEL.

SPECIFICATION forming part of Letters Patent No. 365,789, dated July 5, 1887.

Original application filed September 30, 1886, Serial No. 213,971. Divided and this application filed October 11, 1886. Serial No. 215,862. (No model.)

To all whom it may concern:

Be it known that I, JAMES H. BULLARD, a citizen of the United States, residing at Springfield, in the county of Hampden and State of Massachusetts, have invented new and useful Improvements in Hydrocarbon-Furnaces, of which the following is a specification.

This invention relates to improvements in furnaces for burning hydrocarbon fuels, and steam-generators therefor; and the invention consists in the peculiar construction and arrangement of the fuel-tank, furnace, and boiler, and means for injecting and atomizing fuel in said furnace and automatically regulating the supply thereof, all as hereinafter fully described, and set forth in the claims.

In the drawings, Figure 1 is a perspective view of the steam-boiler and a portion of the fire-box inclosing the same, together with a steam air-pump and regulating devices connected with the boiler and a liquid-fuel tank, above which the latter is located. Fig. 2 is a perspective view of a portion of one leg of the boiler, several pipes connected therewith, a hollow bed-plate for the same, and portions of water-supply pipes connected therewith. Fig. 3 is a perspective view of one corner of the fire-box and of the fuel-tank, showing certain details of construction, hereinafter described. Fig. 4 is a perspective view of the liquid-fuel tank, the bed-plate of the boiler connected therewith, and the fuel-ejectors attached to the tank, the latter showing, through a broken portion of the side thereof, certain details of construction hereinafter described. Fig. 5 is an enlarged side elevation, partly in section, of a portion of the fuel-tank, of the boiler bed-plate and air-induction pipe, and of one of the fuel ejectors and atomizers. Fig. 6 is a side elevation, in section, of the fuel-tank and the boiler bed-plate. Fig. 7 is a side elevation, partly in section, of the fuel-tank and boiler bed-plate, illustrating the connection with the latter of a lamp for igniting the atomized liquid fuel. Figs. 8, 9, and 10 illustrate details of construction hereinafter described.

A metallic or other suitable furnace fire-box, 11, is provided, in which the boiler 26 is located, as shown in Fig. 1. The sides of said fire-box are perforated to admit air for the purposes of combustion, as shown in Figs. 1 and 2, and at the ends thereof are suitable openings, through which liquid fuel is injected into the furnace by the injectors and atomizers 12, the latter being arranged in opposite ends of the liquid-fuel tank 13, as shown in Figs. 1 and 4, and they are arranged to inject fuel into one or both ends of the fire-box, as may be desired, through suitable openings in the walls thereof.

Fig. 1 illustrates in perspective view the steam-generating boiler 26 and other co-operating devices directly connected therewith, hereinafter described. Said boiler consists of a hollow head, 27, of suitable metallic construction, into each side of which are secured a series of tubes, 28, by one end, their opposite ends being hermetically closed. Said head 27 is made in the form shown in Fig. 1, and said pipes are attached thereto in such manner as to form on the upper side of the boiler groups of pipes with but narrow spaces therebetween, and from the latter, extending downward on each side of the boiler, single groups of pipes, as shown, the latter in effect constituting the sides of that part of the boiler in which the heat-generating flame is introduced, a chamber being formed within the (so to speak) tube-walls of the boiler, in which the combustion of the atomized liquid fuel takes place, as below described, the peculiar construction of the boiler being particularly favorable to the admission among all its tubes of said flame, whereby steam is generated therein almost instantaneously and with the expenditure of but little fuel.

The bed-plate 30 of the boiler may consist of a metallic shell, as shown in Figs. 5, 6, and 7, having an interior filling of asbestus, 31; or said bed-plate may be made in the form of a hollow metallic shell, as shown in Fig. 2, communicating with the hollow head 27 of the boiler, and when made hollow, as just described, the feed-water pipes 32 and 33 are connected therewith, as shown in Fig. 2, thereby aiding in raising the temperature of the feed-water in its passage to the boiler.

In order to cause the atomized liquid fuel to be forced directly from the tank containing it into the said chamber within the tube-walls

of the boiler above referred to, the liquid-fuel tank is located directly under the boiler, as shown in Fig. 1; and in order to protect the contents of said tank from the heat of the flame within the furnace, the bed-plate 30 is interposed between the boiler and said tank, and when made as above described, by filling a metallic shell with asbestus or other non-conducting substance—as lamp-black, for instance—and supported somewhat separated from the top of the tank 13, as shown in the drawings, whereby an air-space is formed between the bed and the tank, it is found in practice that the contents of the latter remain quite cool when heat is applied to the boiler, and practically the same result is obtained when cold feed-water is passed through a hollow bed-plate, such as is shown in Fig. 2. The bed-plate 30 lies on the upper ends of a series of metallic tubes, which pass up through the tank 13 and project above its upper side, as shown, and bolts 34 pass through the bed-plate and through said tubes, as shown by dotted lines in Fig. 6, and are secured therein by nuts under the tank, as there shown.

As means for suitably securing the boiler within the furnace 11, and for attaching the tank and the bed-plate securely to the under side of the furnace and boiler, several iron straps, 35, are bolted to the sides of the furnace, as shown in Fig. 3, and have their lower ends bent inward and extending under the bed-plate, thereby forming a hook-engagement with the latter.

The fuel-tank 13 is made in the form shown—that is to say, with its central portion between its ends thinnest—in order to provide additional air space at each end of the tank when nearly filled with liquid fuel, as shown in Fig. 7, the air-pipe 36, which conveys the air from the air-pump below described, entering the end of the tank, as shown in Figs. 6 and 7, and extending thence in a horizontal direction through one wall of the tank, between the upper side of the latter and the bed 30, and passing through a wall of the opposite end of the tank, the said pipe being perforated, as shown in said figures, to distribute the air in the end of the tank at which it enters as well as through its open end in the opposite end of the tank.

The liquid-fuel injectors and atomizers 12 consist each of an outer bent tube, 37, (see Fig. 5,) having on the outer end thereof a cap, 38, provided with a small central perforation, which screws onto the end of said tube 37, a lock-nut, 39, being placed on said tube behind said cap to lock the latter in any desired position on the tube. The tube 37 is secured in the top of the tank 13, preferably by screwing; but it may be secured thereto in any suitable manner. A tube, 40, of less external diameter than the interior of tube 37, is placed within the latter, and extends nearly to the bottom of the tank 13 through tube 37, and projects beyond the outer end thereof, as shown. By means of said construction of the ejector and atomizer an air-passage is formed between the tubes 37 and 40, which extends from and communicates with the air-space in the tank 13, above the fuel 41 therein, and terminates at the outer end of the tube 37 within the cap 38, through which air from the tank is forced, as below described; and the same force which drives the air out of the tank forces the liquid fuel into and through the tube 40, as indicated by arrows in Fig. 5, causing the same to be delivered in a small jet just within the end of the cap 38 and through said perforation therein, thereby forming an atomized spray of mingled air and liquid fuel, as indicated in Figs. 4 and 5. To the end that such a quantity of air as the best conditions for attaining a proper combustion of the atomized fuel may demand may be mixed with the jet of fuel which escapes from the end of the tube 40 when it passes through the perforation in the cap 38, the latter is made adjustable toward and from the end of the tube 40 by screwing it on the end of the tube 37, thereby restricting or enlarging the air-passage between the end of tube 40 and the inner side of that part of the cap which surrounds the perforation therein, through which the fuel is injected. Said lock-nut 39 serves to lock the cap 38 after the latter has been adjusted. By this means just the quantity of air is admitted to and mingled with the atomized liquid fuel which may be required to produce such perfect combustion as entirely obviates the production of smoke in the furnace. This adjustment of a cap on a burner is shown in an English Patent.

The fuel-tank 13 is provided with a series of perforated diaphragms, 42, which serve to prevent any inconvenient movement of the body of liquid fuel 41 from one end of the tank to the other, which might otherwise be caused by the motion of a boat or vehicle when located therein. The tank 13 is supplied with said fuel through a suitable capped tube, 43.

To provide for the most economical use of liquid fuel in maintaining any required degree of mean steam-pressure in the boiler, the supply of atomized fuel and air to the furnace is automatically governed and regulated, as hereinafter described; and by reason of such provision the supply of fuel to the furnace is caused to be either regular or intermittent, according to the amount of steam which the motive power may demand; hence it will be seen that at one moment the furnace is filled with flame and at the next the latter is totally extinguished, and these conditions of operation require that the furnace be provided with means for setting fire to the atomized fuel when, after its supply to the furnace has ceased, its injection is resumed. To that end a lamp, 44, having its wick-tube and wick 45 passing through the bed 30, is secured under the latter, as shown in Fig. 7. Said lamp is located in

an opening through the tank 13, hanging downward below the latter, its wick-tube being attached to a hollow nut, which is screwed into a bushing, 47, in the bed-plate, thereby avoiding the communication of heat to the contents of the lamp when any volatile substance is used therein for maintaining a light. To further provide against any danger from the accumulation of inflammable gas in the lamp 44, a tube, 48, is placed therein, extending from above the contents thereof down through the bottom of the lamp, through which such gas, should any be generated in the lamp, may pass freely off. The lamp is easily attached to and detached from the bed 30 by reaching under the latter and screwing or unscrewing the same.

Any desired number of the injector and atomizing tubes 12 may be attached to one or to each end of the tank 13, three being shown at each end thereof in the drawings, and as there shown in Fig. 6, the holes in the wall of the furnace through which said atomizer-tubes pass are of considerably greater diameter than the said tubes, and said holes are so made to provide for the forced introduction or draft of a certain amount of air through the holes around the said tubes, caused by the aforesaid jet of air and atomized fuel which is forced through the cap 38.

The above-described provision for the introduction of air to the furnace around the atomizer-tubes is found in practice to obviate the necessity of maintaining so high an air-pressure in the tank 13, and thereby less steam is used for driving the air-pump. The ejecting ends of the atomizer-tubes may terminate outside of the furnace-walls, opposite the openings therein, without prejudice to the supply of fuel or its perfect combustion. Said Fig. 6 shows a vertical section of a portion of the furnace-wall 11 through one of the said injector-tube holes. The feed-pump of the boiler is connected with the pipe 32, which runs through the furnace between the said inner tubular walls of the boiler to the front end thereof, and there enters a T-connection with a side branch thereon, from which connection pipes 33 branch off, which are connected with the ends of two of the boiler-tubes 28, as shown in Fig. 1.

To prevent more water from being pumped into the boiler than will fill it up to a required water-line, a valve-case and float, 58, is connected with the said T-connection in the feed-water pipes 32 and 33, in which a valve, 55, connected by a suitable stem, 56, with a float, 57, (see Fig. 8,) is arranged in the aforesaid T-connection. Said valve, valve-stem, and float are contained in said T-connection and in a hollow case, 58, the circular opening 59 in said connection, in Fig. 8, indicating the opening at the end of the feed-pipe 32 connected therewith. The central portion of said T-connection is fitted to receive the valve 55 when it is lifted up, and said valve then entirely covers the said opening 59, thereby preventing the passage of any water therethrough to the boiler; but to prevent the obstruction of communication between the lower end of the case-stem 56 and the boiler through the pipes 33, said opening 59 is formed below or to one side of the center line of the passages through the lateral branches of said T-connection, and thereby provision is made whereby the valve 55 may rise and close said opening 59 without shutting off entirely the passages through said lateral branches.

A pipe, 60, connects the hollow case 58 with one of the higher of the boiler-tubes, whereby the steam-pressure of the boiler is communicated to said case, and by the connection of the lower end of said case with the feed-water pipe, as aforesaid, water is admitted to said case and rises therein to such height as it may be in the boiler, and consequently when the float 57 and valve 55 are in the positions shown in Fig. 8 the opening 59 is closed and no water can flow from the pump.

A regular or intermittent supply of atomized liquid fuel to the furnace for the purpose of generating steam in the boiler is provided for by the below-described automatically-operating devices, which consist of a steam-actuated air-pump, a valve located in the steam-pipe between the steam-cylinder of the air-pump and the boiler, which allows steam to pass to said cylinder while the pressure in the boiler remains below a certain point, an air-pipe connecting the air-pump with the liquid-fuel tank, and a piston-valve connected between said steam-pipe and air-pipe, operated by the air-pressure of the fuel-tank to shut off the steam from the steam-cylinder of the air-pump and stop the latter when a certain degree of air-pressure is attained in the fuel-tank. The said air-pump 64 is of the ordinary construction, having the end of its piston-rod 65 projecting through one head of its cylinder and being adapted to have applied thereto the handle 66, for a purpose below described. The air pump is operated by the piston of the steam-cylinder 67, the piston rod of the latter and that of the air-pump being the same. The pipe 68, projecting from one head of the cylinder 67, is the exhaust-pipe of the latter, and the pipe 69, attached to the opposite end of the cylinder 67, is the steam-supply therefor, connecting it with the boiler.

The pipe 70 connects the air-pump 64 with the fuel-tank 13. A valve-case, 71, (see Fig. 9,) is connected in the said steam-pipe 69, the inlet to which is at *a*, and whose outlet is at *c*. Said valve-case is provided with a piston, 72, having a valve and spindle, 73, attached thereto, which valve has a seat at *e* in said case, and a spring, 74, under said piston, capable of resisting the desired working steam-pressure of the boiler, holds the valve 73 off from its seat *e*, thereby permitting steam to freely pass to the cylinder 67 until said steam-pressure exceeds said working-point, and when it

does the piston 72 is thereby moved against spring 74, causing said valve to be shut, thereby cutting off the supply of steam to said cylinder and stopping the air-pump, and consequently the supply of air-pressure to the fuel-tank 13, the result of which is that the ejection of fuel therefrom ceases and the fire in the furnace is extinguished. As soon as the steam-pressure in the boiler becomes reduced below its working-pressure, the said spring 74 lifts the valve 73 off from its seat again, letting steam pass to the cylinder 67, thereby causing the air-pump to resume its action, the result of which is that the furnace is again supplied with atomized fuel, which is lighted by the flame of the lamp 44, as above described, and the steam-pressure in the boiler is again increased to its required degree. An exhaust-steam pipe, 68, leads from the steam-cylinder 67 of the air-pump.

To provide for an economical use of the liquid fuel, or, in other words, to prevent the injection of more of the latter into the furnace than can be consumed under the best conditions, a comparatively low degree of air-pressure is maintained in the fuel-tank 13, and care is taken that said air-pressure shall be as regular as is practicable. To that end the piston-valve 75 is connected between the steam-pipe 69 and the air-pipe 70, as shown in Figs. 1 and 10, the details of the construction thereof being shown in Fig. 10, wherein 76 is the piston of the valve; 77, the piston-cylinder; 78, the piston-rod having a valve-shaped end, *o;* and 79 is a spring on the piston-rod between the piston and one end of the case 77 or cylinder. In said Fig. 10, 80 indicates a T-shaped connection in the aforesaid pipe 69, which receives through a suitable stuffing-box the valve-shaped end of said piston-rod 78, which end is adapted to be moved by excessive air-pressure against the piston 76 in a direction across the steam-passage *z* in said T-connection 80 and restrict the said passage.

The air-pipe 70, leading from the air-pump 64 to the fuel-tank 13, is connected with the valve-case 77 at each end of the passage *n* through the latter, a branch passage from said passage *n* connecting the latter passage with the internal chamber in the case 77, in which is located the piston 76. When said air-pump commences to operate, the air-pressure on the air-pipe 70 and the fuel tank 13 gradually increases, and to prevent such action of the air-pump as will create too much pressure in said tank the resistance of the spring 79 is so regulated that any excess of air-pressure above that required acts against the piston 76, giving motion to the latter and to the rod 78 against the force of the spring 79, thereby causing the end of the rod 78 to be forced partly across the passage *z*, through which steam passes to actuate the pump or to such a degree as to reduce and regulate the movement of the latter, thus keeping the air-pressure in the fuel-tank at the desired point. When the action of the pump 64 ceases, spring 79 operates to withdraw the end of the rod 78, leaving the passage *z* quite open.

It is obvious that a boiler somewhat differing in construction from that herein shown may be employed in a hydrocarbon-furnace; but for several reasons, as below set forth, that shown in Fig. 1, or substantially like it, is best adapted to the advantageous consumption of hydrocarbon fuel for generating steam, both for stationary and marine engines. First, it is indispensable that the boiler be as light as practicable; secondly, that it be capable of generating a working-pressure of steam from cold water in a few moments after lighting the fire, (the time actually required by the boiler herein shown being not more than two and one half minutes,) and thirdly, that the boiler be practically non-explosive, with a view to absolute safety.

The liquid-fuel tank and the devices connected therewith for forcing by air-pressure said fuel therefrom and atomizing it in the furnace are adapted to the employment of refined petroleum, (the latter being preferable,) naphtha, or alcohol, and the described construction and arrangement of the said air-forcing devices, the atomizers having means for regulating the admission of atmospheric air with the jet of fuel, and the described arrangement for the introduction of air to the furnace through openings surrounding the atomizer-pipes all contribute to such a perfect combustion of either of said two hydrocarbons that no smoke whatever results therefrom, and no pipe is required for the furnace either to carry off smoke or to aid combustion.

Another improved feature of the herein-described construction consists in providing a liquid-fuel boiler and furnace with injector and atomizing devices, through which the liquid fuel is forced by a regulated low-air pressure, instead of by steam-injection, thereby obtaining a more regular and economical supply of fuel to the furnace, for in practice the said air-pressure required for properly conveying the fuel into the furnace and atomizing it is only about one and one-half pound to the square inch, said pressure being so regulated in order that no more fuel be injected into the furnace than can be advantageously consumed.

A further novel feature which is embodied in the construction and operation of the aforesaid steam-generating devices consists in the means by which a given degree of steam-pressure up to any desired working-point is maintained automatically in the boiler for several hours, as hereinafter described.

The general operation of the furnace, boiler, fuel-tank, injectors, and atomizers, and their above-described regulating devices is as follows: Water is supplied to the boiler by any suitable pump. The lamp 44 is lighted, and the air-pump is then operated a few strokes by the handle 66 on the end of the piston-rod 65 of said pump, thereby providing such air-pressure in the

fuel-tank 13 as causes the fuel to be ejected into the furnace and there atomized, as described, where it is at once ignited by the flame of said lamp, the consequence of which is that in a few moments a working steam-pressure is generated in the boiler, setting the steam air-pump in motion and maintaining the requisite air-pressure in the fuel-tank. As soon, however, as the steam-pressure at all exceeds its fixed working limit—say seventy-five pounds to the square inch, more or less—the said valve 73 in the case 71 is made to shut by said excessive pressure, thereby stopping the air-pump by shutting off the steam-supply thereof, and thereby causing the fire in the furnace to be extinguished by reason of the cessation of air-pressure in the fuel-tank. In a moment or two, however, owing to the absence of said furnace-fire, the steam-pressure will decrease, letting said valve 73 open again, and the air-pump will be again set in motion, causing the fire in the furnace to be again started and the steam-pressure to be restored to its working-point. In this manner the furnace-fire is caused to be lighted and extinguished by a slight variation (say five pounds) of the steam-pressure from the fixed working-pressure. The above-described operation constitutes the aforesaid intermittent action of the furnace-fire, whereby it is maintained only when actually required for steam-generating purposes, thus effecting an important saving in fuel.

As above set forth, the air-valve in the case 75 serves also to regulate the speed of the air-pump according to the air-pressure in the fuel-tank, preventing said pressure from rising above a certain point, and thereby causing an over-supply of fuel to be injected into the furnace.

When steam is being drawn from the boiler to run an engine, the action of the air-pump is more continuous; but when the engine is not running said intermittent action of the fire-governing devices is frequent, and thereby a working-pressure is kept up in the boiler as long as any water remains in it.

This application is a division of my application No. 213,971, filed September 30, 1886, embracing claims for a steam-boiler and other parts of a road-wagon. A further division of the same application was filed November 1, 1886, No. 217,670, relating more especially to the mechanism for feeding liquid fuel and controlling the air-pressure.

I am aware that it is not new to inject oil into a furnace by air-pressure, air being mixed with the oil just before reaching the place of combustion, and serving to spray the oil.

What I claim as my invention is—

1. In combination, a steam-boiler, an air-compressor, a liquid-fuel tank connected to said compressor, a steam-pipe connecting the boiler with said compressor, and a valve, substantially such as described, controlling the passage in said pipe, said valve being operatively connected with the steam-boiler, whereby the rise of steam-pressure in the boiler tends to close said valve and thus cut off steam from the compressor, substantially as described.

2. Means for generating steam by the consumption of liquid or hydrocarbon fuel, consisting of a boiler and its fire-chamber, substantially as described, a power-actuated air-pump connected with said boiler by a suitable steam-pipe, a valve, 73, connected in said steam-pipe to automatically close the steam-passage in the latter, a liquid-fuel tank in proximity to said furnace connected with said air-pump by a suitable pipe, and a series of fuel injectors and atomizers, substantially as described, attached to said fuel-tank and injecting liquid fuel into said furnace, substantially as set forth.

3. Means for generating steam by the consumption of liquid fuel, consisting of a water-tube, steam-boiler, and inclosing-casing, a liquid-fuel tank below and connected to said casing, said tank having perforated diaphragms therein, as described, a series of fuel injectors and atomizers connected with said fuel-tank and extending into the casing under the boiler, and an air-pump for developing air-pressure in the fuel-tank, all in combination, substantially as described.

4. Means for generating steam by the consumption of liquid or hydrocarbon fuel, consisting of a boiler and a furnace, substantially as described, an air-pump connected by a steam-pipe with said boiler, a valve, 73, connected in said steam-pipe to automatically close and open the steam-passage in the latter, a liquid-fuel tank in proximity to said furnace connected with said pump by a suitable pipe, through which air is forced to said tank, a valve, substantially as described, connected in the air-pipe between the air-pump and fuel-tank and actuated by the air-pressure in the latter, having its end entering transversely the passage in said steam-pipe to restrict said passage, and a series of injectors and atomizers, substantially as described, attached to said tank and injecting liquid fuel into said furnace, substantially as set forth.

5. Means for generating steam by the consumption of liquid or hydrocarbon fuel, consisting of a boiler and a furnace, substantially as described, a power-actuated air-pump connected with said boiler, a liquid-fuel tank in proximity to said furnace and connected to said air-pump by a suitable pipe, a valve and connections, substantially as described, whereby the air-pressure is reduced and supply of fuel stopped when the steam-pressure reaches a predetermined maximum, a fuel-lighting lamp supplying a flame within said furnace, and a series of fuel injectors and atomizers, substantially as described, attached to said tank and injecting said fuel through the walls of said furnace, substantially as set forth.

6. In combination, a furnace and boiler, substantially as described, the fuel-tank 13, located under the boiler, a bed-plate, 30, interposed

between the boiler and fuel-tank and having a filling of non-conducting material, and a series of burners having pipes 12 connected to the fuel-tank and passing round the outer edge of the bed-plate 30, so that the latter may serve as a complete fire shield or screen for the fuel-tank, substantially as described.

7. In combination, a furnace and a boiler, substantially as described, the liquid-fuel tank 13, located under the latter, having a series of injector and atomizing tubes connected therewith to inject liquid fuel into said furnace and having its central portion between its ends of less thickness than the latter, a bed, 30, containing a material which is a non-conductor of heat, interposed between the boiler and fuel-tank, and a power-actuated air-pump connected with the latter and with said boiler, substantially as set forth.

8. Means for regulating the combustion of liquid fuel, consisting of a burner, a fuel-tank connected thereto, a steam-driven air-pump communicating pressure to said tank, and a valve controlling the steam-passage to the air-pump, said valve being actuated to close said passage by an excess of air-pressure in the tank, all combined substantially as described.

9. Means for mingling atomized liquid fuel and air and for injecting the same into a boiler-furnace for generating steam under the control, automatically, of varying steam-pressure in the boiler and varying air-pressure in the fuel-tank, consisting of the combination, with a steam-boiler, of an air-pump having a steam-connection with the latter, in which steam-connection is a valve which is normally open, but capable of being closed by an excessive steam-pressure, a liquid-fuel tank in proximity to said boiler, having normally an air-chamber therein above the level of its fluid contents, an air-pipe connecting said pump and air-chamber, a valve connected in said air-pipe and controlled by the air-pressure therein, having connection with the said air-pump steam-pipe to restrict the passage therethrough, and a series of atomizers, substantially as described, attached to said tank, which communicate with the fluid contents of said tank and with the air-chamber therein, substantially as set forth.

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Witnesses:
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