Nov. 11, 1930. G. W. ELMWALL 1,781,057

STEAM BOILER

Filed March 7, 1927 2 Sheets-Sheet 1

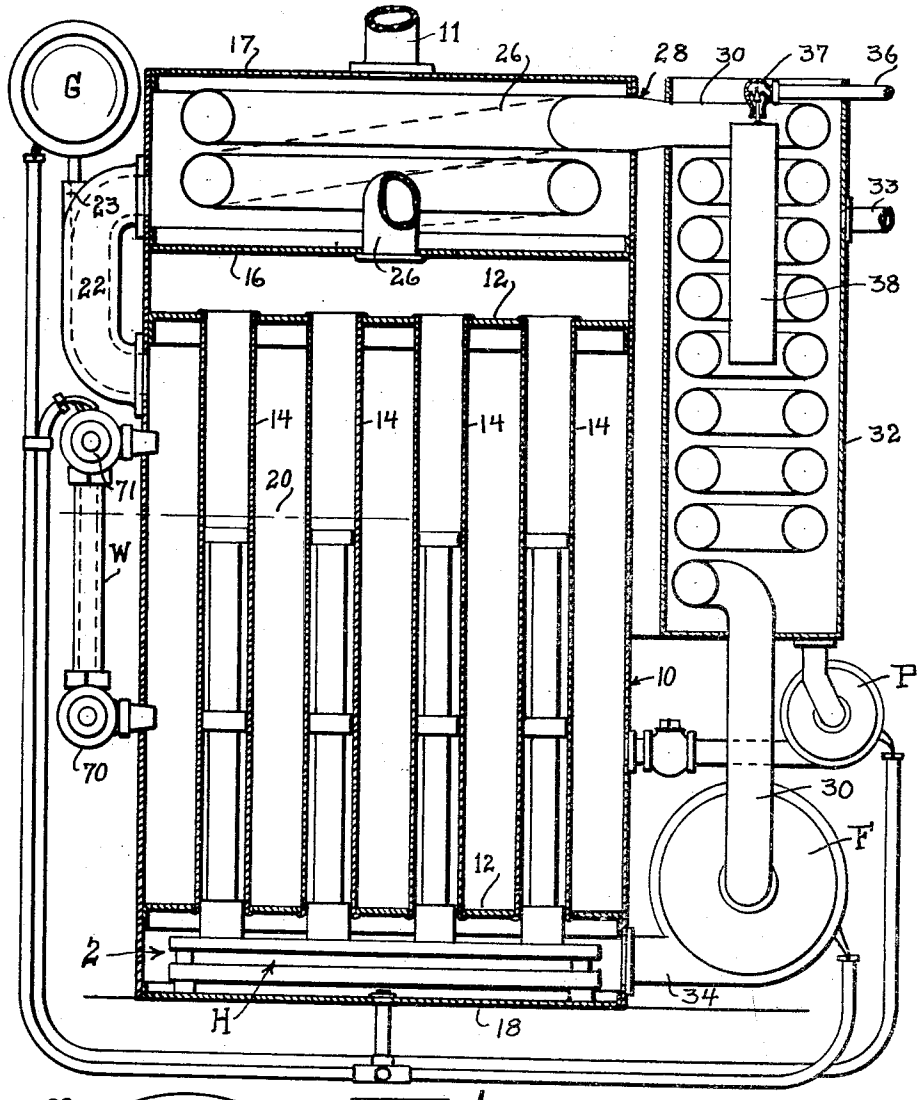


FIG 1

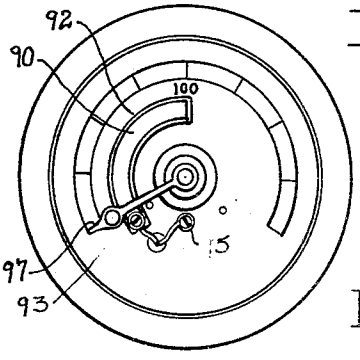


FIG 6

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Fig 2

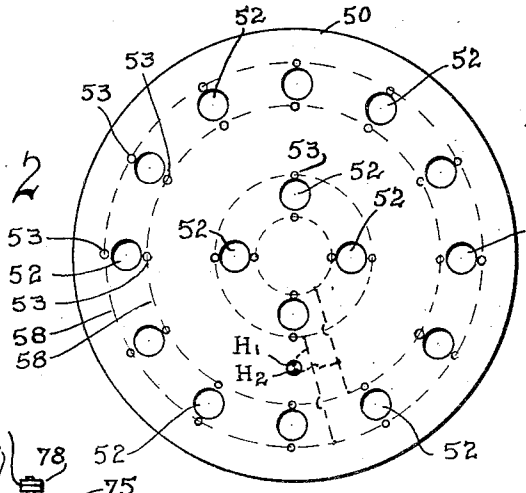


Fig 3

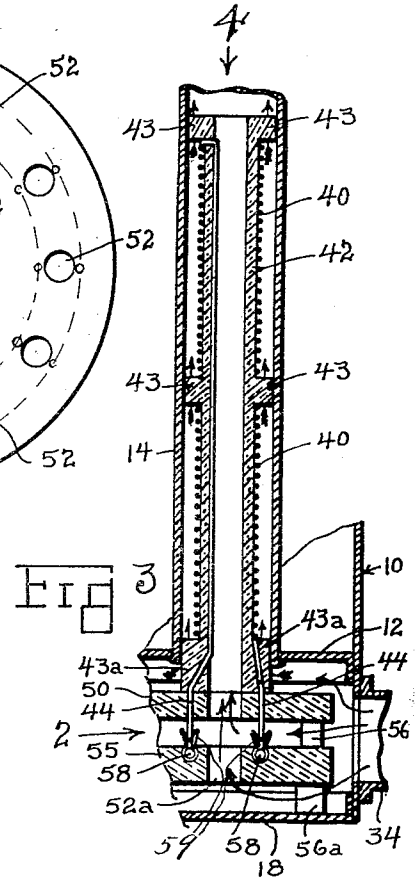


Fig 4

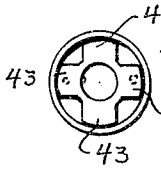


Fig 5

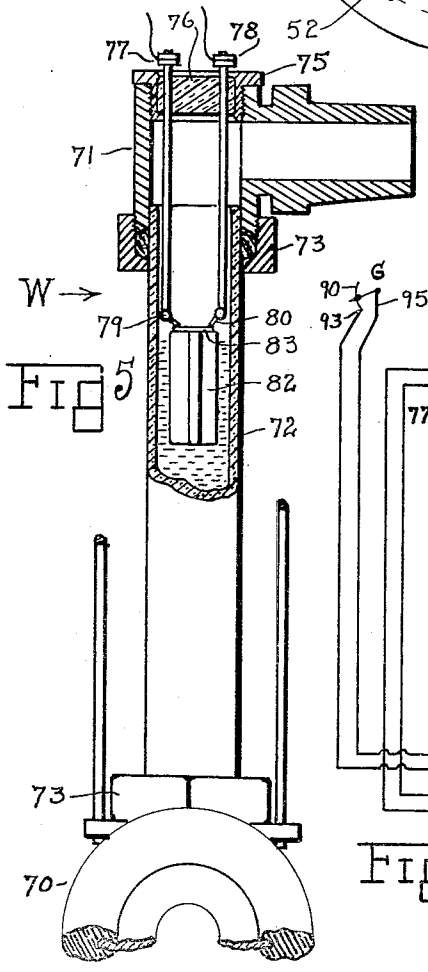
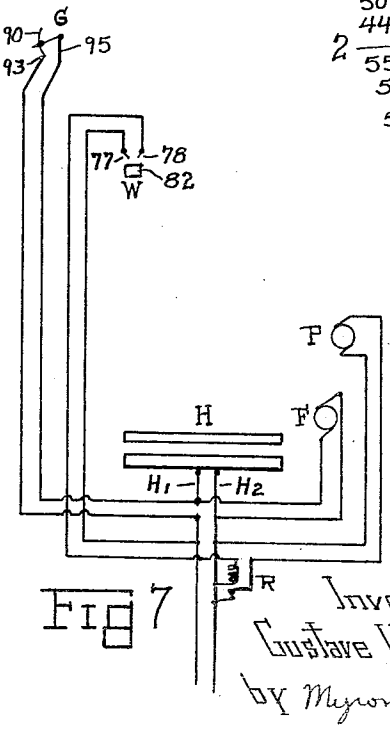


Fig 7



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UNITED STATES PATENT OFFICE

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STEAM BOILER

Application filed March 7, 1927. Serial No. 173,362.

This invention relates to liquid evaporating apparatus and more especially to steam boilers.

It is the purpose of this invention to provide an improved thermal system and method of operating the same whereby the efficiency of liquid evaporation may be substantially increased.

It is the particular object of this invention to supply means and method of operating said means so embodied as to permit improved heat transfer between the heating element and the substances to be heated; it being understood that by heat transfer, radiation, conduction, and convection are all included and intended to be indicated in the single term.

Rules relating to heat transfer are now generally accepted to include the following: Radiation of heat follows the laws for radiation of light and the intensity of rays radiated from a given source varies inversely as the square of the distance from the source. (2) Conduction of heat is proportional to the area of the section or surface through which it takes place and varies with the difference in temperature between two faces of a given layer and inversely with the thickness of the layer. (3) Convection of heat through a fluid is largely dependent upon active circulation of the fluid and in the convection of heat from one fluid to another through an intervening metal layer high circulation speeds for the fluids are an essential factor. It is my especial purpose to provide a device which will allow of obtaining the best possible radiation arrangement, the minimum radiating distance, the maximum conduction area, the maximum difference in temperature between two sides of a given layer through which heat must be conducted while maintaining minimum layer thickness, and the highest possible fluid circulation rates together with intimate fluid contacts for best convection conditions.

Theoretically it is possible to produce an apparatus capable of supplying the objects set forth above in a multitude of forms but it forms an important object of this invention to provide a form within the manufacturing capabilities of the boilermaker's art and capable of economical manufacture with standard machinery from more or less standardized materials.

Other objects of my invention lie in the provision of a steam boiler having full automatic control and particularly adapted to sudden responses to load variations without heat waste formerly inseparable from such sudden changes in rate of operation, having means for ready access to and replacement of parts exposed to heat, and having means for recovery of heat ordinarily wasted in chimney or flues.

Certain other objects and improvements accomplished by this invention will be made clear as the description progresses and will be more specifically pointed out in the appended claims.

Referring to the drawings:—

Fig. 1 is a cross sectional elevation of a complete embodiment of my invention; it being understood that certain details have been shown in full in instances where their internal construction is well known or where their full illustration is shown in the other figures.

Fig. 2 is a top plan view of the heater support unit indicated by the numeral 2 in Fig. 1.

Fig. 3 is a fragmentary cross section of one tube of the boiler shown in Fig. 1 together with the heater unit therein and its connections with the heater support unit of Fig. 2.

Fig. 4 is a top plan view looking downward as indicated by the arrow 4 in Fig. 3 and showing the arrangement of the heater unit in the boiler tube.

Fig. 5 is a detail elevation of the boiler water level indicator and controller W of Fig. 1 certain parts being sectioned to facilitate description.

Fig. 6 is a detail elevation of the steam gauge and boiler pressure control device G of Fig. 1.

Fig. 7 is a wiring diagram showing a preferred arrangement of electrical connections for the various parts of the complete device.

In general:—The drawings show a vertical firetube boiler provided with superheater and feed water heater. Feed pumps and other

feed apparatus are shown together with a closed heating fluid circuit including heaters arranged within the boiler tubes, means for circulating heating fluid within the said circuit, and control mechanism for the whole.

In detail:—The boiler shell 10 is provided with tube sheets 12 into which are expanded tubes 14. Shell 10 is further extended, upward to receive heads 16 and 17 forming a superheater drum, and downward to form a heater compartment mounting closed by a lower removable head 18. The preferred operating water line in the boiler proper is indicated by line 20 and the water level indicator and controller W is connected to the shell above and below this line. The steam space above the water line 20 communicates with the superheater drum through a suitable return bend 22 and a convenient place of attachment for the steam gauge and pressure controller G is found in a tapped boss 23 at the turn of the bend although it is of course understood that this gauge may be connected directly to the boiler proper, to the superheater, or to the steam mains connected directly with either of these. The superheater receives and evaporates any liquids carried over by the steam when these fall to the head 16 and this head area is also effective heating surface for drying the saturated vapor being supplementary to the coiled tube 26 which is expanded into head 16 preferably at or near its center and which, after several turns in the superheater drum, is secured steam tight at point 28 in the shell 10.

Tube 26 connects directly to coiled tube 30 arranged within the feed water heating tank or drum 32 and projecting therebelow to connect with the circulating fan or pump F which in turn connects through duct 34 with boiler shell 10 below tube sheet 12 in the heater mounting space there provided.

It will now be seen that the heating space (as differentiated from the water and steam space) of the boiler is closed and that a heating gas (such as air or an inert gas) or a liquid (such as oil) may be circulated through the heater mounting space, through the tubes 14, through the space between head 16 and tube sheet 12, through superheater tube 26, through coiled tube 30, through circulator F and through duct 34, in closed circuit and in a direction and speed determined by the operation of circulator F which is preferably electrically driven and automatically controlled by the steam pressure or consumption as will be described.

Steam is drawn from the boiler superheater through a nozzle 11 and the condensate formed when the heat has been used is returned to feed heater shell 32 through return pipe 33 from which it may flow by gravity or by virtue of pump P back to the boiler shell. The shell or tank 32 has been shown as an open tank but those skilled in the art will understand that under certain conditions it is preferable to close this tank and to operate it under substantial pressure while the necessity for pump P will also depend both upon this pressure and upon the boiler pressure. By pump P it is intended to indicate such main pumps and auxiliary feeding devices as are well known to the art. Make up water; necessitated by leaks in the steam system or by other steam escape from the steam system; is preferably fed through pipe 36 controlled by valve 37 responsive to the movements of float 38 within the feed tank 32 but it will be evident that this make up may be fed directly to the boiler shell upon occasion and through standard arrangement of piping although involving certain disadvantages of heat transfer as will be set forth.

Heating of the boiler is preferably accomplished through electrical means such as the resistance wire 40 wound on the porcelain spools 42 having spacer projections 43 at the ends and middle. The lower spacer projections 43^a are elongated as shown in Fig. 3 so that these may rest upon the upper surface of the heater unit mounting 2 and may serve to hold the terminal pins 44 which form the terminals of resistance wire 40. The heater unit mounting 2 consists of an upper plate 50 having heating fluid opeings 52 on either side of which are the terminal pin holes 53 through which terminal pins 44 pass when the heater units are placed on the mounting; and a lower plate 55 which is also provided with heating fluid openings 52^a registering with holes 52 when the plates are secured together in spaced relationship by spacers 56 which together with spacers 56^a serve to support the plates and the heating units mounted thereon above the bottom head 18. Plate 55 is provided with a network of conductors 58 having terminal pin receiving clips 59 positioned below the openings 53 in plate 50 so that placing the heating unit above the heating unit mounting, registering the terminal pins 44 with openings 53, and pressing downward, serves to connect the resistance coil of the unit in proper electrical relationship with all other units and with the current supply leads to the heater (numbered H^1 and H^2 in Fig. 7). It will be understood that openings 52 and the correlated structure therearound is so positioned beneath tube sheet 12 that when the heater units are mounted perfect registry with tubes 14 is assured and the whole heating device will assume the relationship indicated in Fig. 1 to the boiler.

It will be plain on referring to Fig. 3 that the heat transfer fluid introduced through duct 34 will be distributed by the plates 50 and 55 passing over, around and through these plates so that when entering the tubes parts of the fluid stream will flow through

openings 52 and 52a to the center bore of the resistance spool picking up heat from the spool walls and other parts will flow around spacers 43 and 43a to the space between spool and tube wall coming directly into contact with the resistance wire 40. Thus the heating units serve also as retarders and simultaneously serve to bring the heat transferring fluid into close contact with the tube wall at high velocity. It will also be noted that the hollow spool construction permits excess temperatures to be reduced by convection while bringing the heater wire into full exposure to the tube surface for heat transfer by radiation; further:—the extreme rapidity of flow and closeness of contact of the heat transfer fluid stream with the heating medium and its direct supports permits a very high temperature to be maintained in the resistance wire particularly since this wire is shut off from the atmosphere by the closed circulating system and is not subject to oxidation so that almost any temperature below melting is permissible.

As is most desirable in this type boiler, most of the heat is transferred to the boiler below the water line but a large portion is also removed by the tubes 14 above the water line while the tube sheet 12 also supplies active heating surface area. Heat not transferred to the boiler proper is carried to the superheater drum through head 16 and tube 26 without loss other than that through the small area of shell 10 lying between head 16 and upper tube sheet 12. Heat not transferred in the superheater is carried on to coil 30 and serves to raise the temperature of the incoming feedwater while even though some heat remains in the fluid transfer medium reaching the circulator F it is not wasted for the same volume of transfer medium flows directly back to the heater through duct 34. It will be noted that conditions particularly desirable from a boiler water circulation standpoint are set up in the boiler proper since the tubes are here much hotter than the lower boiler head or tube sheet 12 and steam bubbles do not have to rise the entire distance from the boiler bottom but rapidly split off vertically on the tube surface being swept upward with the rapid circulation from the cooler lower part to the hotter water surface (heats and temperatures being relative of course).

That the conditions within the boiler may remain as uniform as possible and that a minimum of attention may be required I prefer to provide an automatic water regulator W controlling the water supply pump P (or with gravity feed a valve replacing this pump). Referring to Fig. 5 this water regulator will be seen to consist of gauge glass fittings 70 and 71 supporting a gauge glass 72 through the usual gland arrangement 73. The lower gauge glass fitting is of substantially standard form while the upper fitting (71) contains the usual valve and the like (not shown) with certain modifications consisting of a cap plug 75 having an insulator 76 mounted therein and in turn mounting contact rods 77 and 78 connected to the current supply line to the motor driving pump P as shown in diagram Fig. 7.

The lower ends of contact rods 77 and 78 project downward through fitting and gauge glass 72 to a point just above the desired boiler water level where they terminate in hinged contact points 79 and 80 which project inward toward the center or axis of glass 72 sufficiently far to engage the top of float 82 which carries a contact plate 83 bridging the contact points and therethrough contact rods 77 and 78 so as to energize relay R (Fig. 7) and open the motor circuit to stop pump P when there is a tendency for the water level to rise above the desired level. It will be noted that the pump motor circuit is normally closed and that any failure of the water controller will result in full feed condition and not in any lack of water supply. When the water level drops float 82 will also fall and the pump will resume operation. The arrangement shown permits the float mechanism to be viewed at any time while the water level is also always visible for checking and manual supervision.

Steam pressure control is also automatically cared for by the combined steam gauge and controller G (see Fig. 6) which comprises a standard gauge mechanism with the addition of a contact strip 90 insulated from the gauge dial by an insulator 92 and connected by a suitable terminal 93 to the incoming current lead. A terminal 95 of the gauge is connected to the supply wire for heater H and circulator F, as shown in Fig. 7. Thus, through the gauge mechanism the gauge hand or pointer 97 is connected to one pole and the contact strip 90 forms the other pole. Referring to Fig. 6 it will be seen that at pressures below 100 on the gauge dial hand 97 will make contact with strip 90 and the current will flow to both heater and circulator so that the boiler will be heated until sufficient water has been evaporated to raise the steam pressure to 100 after which both heater and circulator will be cut out by hand 97 leaving the upper end of the strip 90 and breaking the circuit. It will be understood that the water level control shown and the steam pressure control just described are merely preferred forms of control and that many other devices suited to perform similar functions could be used well within the knowledge of those skilled in the arts involved.

Operation of the boiler will be fairly clear from the foregoing description, to briefly supplement this:—Water is fed by the pump P subject to the automatic control W and

this water is converted into steam by application of heat from the heater unit H assisted by closed circulation of a body of heat transfer fluid moved by circulator F assisted by thermal circulation set up by temperature differences in the various parts. The main body of heat is transferred in the boiler proper but the remaining heat in the heat transfer fluid serves to heat the superheater and the water to be fed to the boiler proper. The rate of gas or heating fluid circulation is under definite control, the fluid velocity is highest at the point of greatest temperature difference, and radiation is direct over minimum distances. The boiler form is not such as to involve difficult or unknown manufacturing problems (referring to the shell form and tubes) and the heating elements are so arranged as to operate with high effectiveness and low depreciation although readily replaceable when damaged. It will be clear that with the closed circulation of a given body of fluid all need for tube cleaning and all losses due to dirt insulated heating surfaces disappear.

Manifestly my invention is not confined to the use of electric heat, fuels such as gas and the like may be burned with certain modifications evident to those skilled in the art. It will be equally manifest that certain parts and modifications of my invention may be employed to accomplish beneficial results of a novel and useful nature even though certain other parts be absent and this well within the scope of my invention and the spirit of the appended claims.

What I claim is:—

1. In a steam generator and heating means therefor, a boiler shell, a lower tube sheet, an upper tube sheet, fire tubes connecting said tube sheets and combining with said shell and tube sheets to provide a water evaporating space, heating elements of the radiant type mounted within said tubes while supported by and connected to a heating element mounting below the lower tube sheet a top head closing the top of said shell, a head sealing the lower end of said shell below said heating element mounting and spaced therefrom, a superheater lower head within said shell above said upper tube sheet and spaced therefrom and from said top head to form a heat conduit from the upper ends of said tubes and a superheater space below said top head, a coiled superheater heating tube extending through said lower superheater head and through the superheater space to and through the said shell adjacent the top thereof, a steam conduit from the aforesaid water evaporating space to the superheater space about said coiled tube, a water preheating drum having tube means therein for heating water previous to its introduction to said evaporating space, means maintaining a constant water level in said preheating drum, a connection from said superheater heating tube to said tube means in said preheating drum, a connection from the other end of the last said tube means to the space within said shell below said lower tube sheet and said head at the lower end of said shell, water feeding means drawing from said preheating drum and discharging to said evaporating space, a pressure regulator connected to said evaporating space in said shell and controlling operation of said heating elements, and a water level regulator connected to said evaporating space and actuated by the water level therein to control said water feeding means.

2. In a steam generator, a casing, superposed partitions in the casing dividing the interior of the same into a heater chamber, a liquid chamber, an intermediate chamber and a superheater chamber, tubes extending through the liquid chamber, connecting a pair of said partitions and placing the heater chamber in communication with said intermediate chamber, a heater base arranged in the heater chamber and provided with heating projections which extend into said tubes, a pipe connecting the upper portion of the liquid chamber to the super-heater chamber, a steam outlet for the super-heater chamber, a conduit extending through the superheater chamber and connected to the upper one of said partitions, said conduit communicating with the intermediate chamber, a coil arranged exteriorly of the casing and communicating with said conduit, a feed water drum enclosing the coil, means for introducing feed water into the drum, feed water transfer means placing the drum in communication with the liquid chamber, and means including a pump for feeding fluid from the coil into said heater chamber.

3. In a steam generator as claimed in claim 2, float controlled means arranged in the drum and controlling the admission of feed water into said drum.

4. In a steam generator as claimed in claim 2, a visual gauge connected to the liquid chamber, a motor operated pump in the feed water transfer means, and float controlled means in the gauge for controlling said motor.

5. In a steam generator as claimed in claim 2, a pump forming part of the means for transferring feed water from the drum to the liquid chamber, a motor for operating the last mentioned pump, a steam gauge communicating with the pipe which places the liquid chamber in communication with the superheater chamber, and electric control means cooperating with said gauge for controlling said motor.

6. In a steam generator, a casing, partitions in the casing dividing the interior of the same into first and second intermediate compartments and first and second end com-

partments, tubes extending through the second intermediate compartment and connecting a pair of said partitions, said tubes placing the first intermediate compartment in communication with the second end compartment of the casing, a conduit extending through the first end compartment of the casing, and connected to one of the end partitions, said conduit communicating with the first intermediate compartment, the second intermediate compartment forming a liquid chamber, tubular heating elements arranged in said tubes, a pipe placing the upper portion of the second intermediate compartment in communication with the first end compartment, a steam outlet for the last mentioned compartment, a coil arranged exteriorly of the casing and communicating with said conduit, a drum enclosing said coil, means for introducing feed water into said drum, means for transferring feed water from the drum to said second intermediate compartment, and means including a pump placing said coil in communication with the second end compartment of the casing.

Signed at New York in the county of New York and State of New York this 20 day of Jan., 1927.

GUSTAVE WALFRID ELMWALL.