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BOILER FOR HIGH PRESSURE

Filed Feb. 28, 1923 2 Sheets-Sheet 1

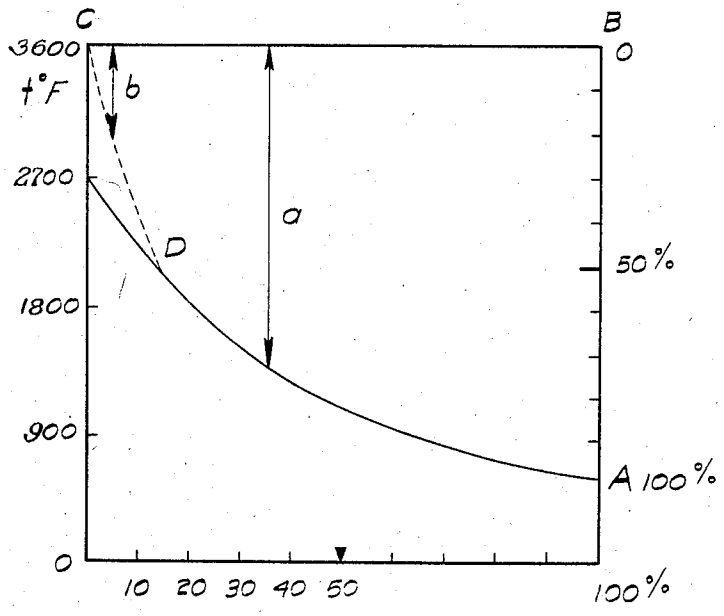


Fig. 1.

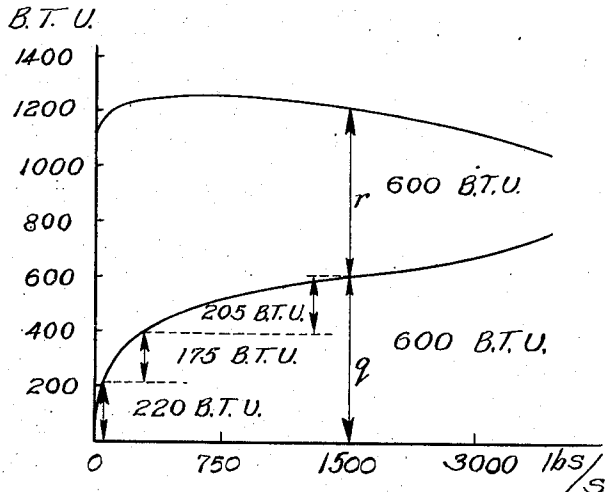


Fig. 2.

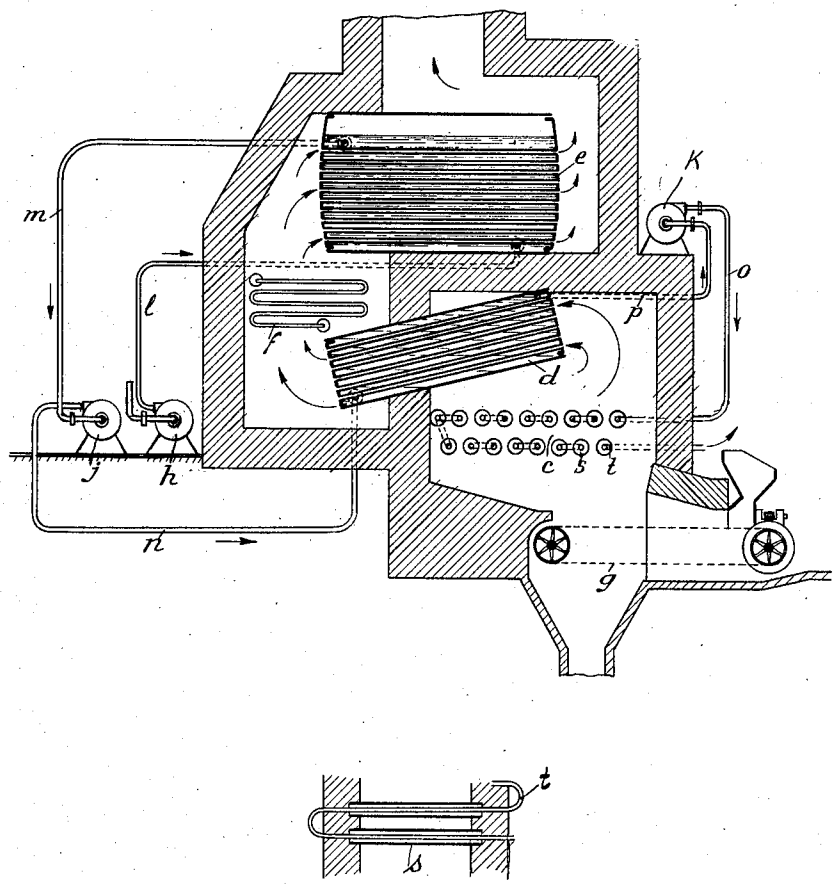
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Fig. 3



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UNITED STATES PATENT OFFICE

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BOILER FOR HIGH PRESSURE

Application filed February 28, 1923, Serial No. 621,910, and in Sweden February 22, 1922.

In any boiler the main problem to be solved is to cool the gases produced from the fuel to such an extent that as small a quantity of heat as possible remains in the flue gases when they leave the boiler. Now the cooling of the gases is in the highest degree dependent on the coefficient of heat transmission between the gases and the surface of the boiler which primarily absorbs the heat of the gases, in order to transfer the heat so as to be utilized for steam production in some way or other. Said coefficient of heat transmission is, however, rather independent of the construction of the boiler. To be sure such coefficient may be increased within certain limits, but the relatively great difficulty of varying the same, causes, nevertheless, that in any boiler construction, operated with ordinary combustion, the steam delivery from the whole boiler, in proportion to its heat absorbing surface, will usually be an average of between 2 to 6, and, in rare cases, amounting as high as 10 pounds per square foot per hour, provided the gases of the boiler are cooled to such an extent that no great loss due to cooling arises.

Thus, for a certain steam production, a certain cooling surface for the gases, usually called the heating surface of the boiler, is necessary. Generally the heating surface of the boiler is subjected on the other side to the pressure of the steam and therefore, as a rule, the entire heating surface must be so dimensioned as to sustain the highest boiler pressure. With the present standing of the technical art, it is possible, at ordinary costs, to so construct the heating surface of a boiler that it sustains a pressure of 300 lbs. per square inch above atmospheric, but at higher pressures the constructional difficulties become extraordinarily great, and consequently the costs per square foot will suddenly rise at a pressure a little above 300 lbs. per square inch.

If a boiler is to be constructed to sustain for instance 1500 lbs. per square inch, a heating surface is necessary of the same size as that of a boiler of a pressure of 300 lbs per sq. in. for the same steam production, but it is evident that if the heating surface is to be constructed for 1500 lbs. the costs become extraordinarily great.

The present invention has for its object, partly to reduce the surface necessary for the high pressure and to construct the heating surface only for the pressures that are really required, and partly to provide such a structure for the part exposed to the highest pressure, as will sustain the highest pressure, without any risk of said parts being burnt through.

The invention consists in the boiler comprising, partly water heaters arranged behind each other and operated in series, the water being forced therethrough step by step in such a way, that the pressure of a succeeding water heater will be higher than that of a preceding one, and partly a steam-generating part constructed for the high pressure desired, said part receiving water from the water heaters and being so constructed that the temperature on the gas side is the greatest in the steam-generating part.

By constructing the boiler in this manner, the heating surface for the generation of the high pressure may be considerably reduced, thus making it possible to manufacture a high pressure boiler at moderate costs.

The invention is illustrated in the accompanying drawing in which Figs. 1 and 2 show diagrams explaining the principle of the invention. Fig. 3 illustrates one embodiment of the invention. The diagram according to Fig. 1 showing the heat absorption in a common boiler illustrates the consequence of the above described division of the boiler, affording the reduced heating surface of the high pressure-generating part.

In a boiler, the temperature of the gases along the heating surface passes on a logarithmic line, and the drop in temperature, to which the gases are subjected when passing a certain area, represents approximately the heat quantity absorbed by said area. In the first parts of the boiler, however, a great heat absorption takes place by radiation, and the total quantity of heat removed from the fuel by radiation amounts usually to 25% of the entire heating value of the fuel.

Supposing no radiation to take place, then

the initial temperature of the gases, before they have passed any surface, would be for instance 3600° F. but on account of 25% of the heat being absorbed by radiation, an initial temperature of the gases amounting to 2700° F. is obtained, and thus the cooling curve begins at said temperature and extends from 2700° F. downwards to the point A, as shown in Fig. 1. Thus it will be found that the heating surface of the whole boiler absorbs a quantity of heat represented by the distance A—B, and that for instance the first 35% of the heating surface of the boiler have absorbed a quantity of heat represented by the length *a*, that is, about 72% of the heat absorbed by the whole boiler. For that part of the heating surface which receives heat of radiation (for instance 13% of the total surface), the heat absorbed is represented by the ordinate distance between the line C—B and the dotted line C—D, so that for instance the first 5% of the heating surface absorb a quantity of heat corresponding to the length *b* or about 20% of the heat absorbed by the whole boiler.

This is another proof of the old-established fact that the first parts of a boiler absorb a very great portion of the heat, whereas the last parts absorb extraordinarily small quantities of heat, which, however, must be present to cool the gases in order to prevent excessive losses in the flue gases.

Now it is only necessary, however, to supply a part of the total heat absorbed by the boiler to the water under the pressure desired, and a great part of said heat may be supplied to the water without formation of any steam, which circumstance may be of importance as a risk of the heating surfaces burning through is present only where steam is generated.

In Fig. 2, these conditions are further illustrated. In this figure, two curves are drawn above the abscissa (representing the pressure), the lower one of which curves indicates the heat of liquid q of the water, when it has been heated to the boiling temperature corresponding to the pressure, while the upper curve indicates the total heat-content $q+r$ of dry saturated steam.

In this figure, the length $q=600$ B. t. u. represents, for instance the heat of liquid at 1500 pounds per square inch, and the length $r=1200-600=600$ B. t. u. represents the heat of generation of steam. It is evident from this diagram that the heat of generation of steam decreases with the pressure, while the heat of liquid is increased so that for very high pressures the heat of generation of steam becomes smaller than the heat of liquid. For instance, if dry saturated steam of a pressure of 1500 lbs. is to be generated from water of 32° F., it will only be necessary to supply about one half of the total heat for the generation of steam.

Now, if the boiler is divided into a steam-generating part and a liquid-heating part, and the steam-generating part is placed adjacent to the furnace, only 14% of the total heating surface are necessary for the steam-generating part, as indicated in Fig. 1. Thus it is possible to reduce the heating surface of the high pressure generating part to such a degree that it only amounts to 14% of the total heating surface, and, therefore, the difficulties in high pressure generation are limited to said surface.

It is unfavorable, however, in economical respects, to construct the liquid heater which, according to the above, is to be built up for 86% of the total surface, for the high pressure of the steam desired, and consequently said liquid heater is divided, according to the present invention, into several parts arranged behind each other and operating in series. For instance, the said boiler may be constructed according to the invention in such manner that the water is heated in its first part comprising a suitable water heater, to the temperature corresponding for instance to a pressure of 30 lbs. per square inch absolute. From this water heater the water is then supplied to another water heater, in which the pressure is 300 lbs. per sq. in. absolute and then it is fed by means of a pump to a water heater having a pressure of 1500 lbs. to be finally introduced into the steam-generating part.

According to Fig. 2, there is then delivered from the 1200 B. t. u. to be supplied to every kilogram, about 220 B. t. u. in the first container, 175 B. t. u. in the water heater for a pressure of 300 lbs. per sq. in. and about 205 B. t. u. in that for a pressure of 1500 lbs, per sq. in. From these figures it is evident, that in the steam-generating part and in the water heater for a pressure of 1500 lbs., about 67.2% of the entire heat will be absorbed, and in said parts together with the water heater for a pressure of 300 lbs., 81.7% of said total quantity of heat.

From Fig. 1 it is evident that the steam-generating part shall have a heating surface of about 14%, said part together with the water heater for a pressure of 1500 lbs. about 29%, and said two parts together with the water heater for a pressure of 300 lbs. about 47% of the total heating surface. The distribution of the areas will thus be as follows:

For the steam-generating part 14%;
For the 1500 lbs. water heater 15%;
For the 300 lbs. water heater 18%;
And for the 30 lbs. water heater 53% of the total area.

Thus the present invention brings about that only about 29% of the total heating surface need be subjected to a pressure of 1500 lbs., only 18% to a pressure of 300 lbs., while 53% can be constructed for a pressure above atmospheric of only 15 lbs.

Of course, the steam-generating part and

the water heater for a pressure of 1500 lbs. may be built together to one unit.

For the high pressure part—the steam generator with the water heater for the highest pressure or these parts united—constructions previously known for high pressure boilers may be used in cases where the danger of the steam-generating parts being burnt through is eliminated, and according to the invention only a part of the boiler need be constructed as a high pressure boiler.

It will be particularly advantageous for the high pressure part to use the known construction in which a tube-coil is provided, said tube being submerged in a medium of a relatively low steam pressure, which is highly heated and in a liquid state at the temperature used, or surrounded by vapor formed by said medium, to the one end of which tube-coil water from preceding water heaters is supplied, thus preventing the tube from being burnt through.

In Fig. 3, such an embodiment of the invention is shown. In this figure, *c* is the high pressure part, generating steam for instance of a pressure of 1500 lbs., *d* and *e* are water heaters, *f* superheaters, *g* the furnace, *h*, *j*, *k* pumps, *l*, *m*, *n*, *o*, *p* hot water pipes, *s* a casing for the heat-transmitting medium in the high pressure part, and *t* pipes in the latter.

By means of the pump *h*, cold water is forced through the pipe *l* into the water heater *e* which, for instance, is constructed for a pressure of 15 lbs. above atmospheric, the cold water being introduced at the coldest place. From the warmest place in said water theater *e* hot water is conducted through the pipe *m* by means of the pump *j*, and through the pipe *n* to the water heater *d* which, for instance, is constructed for a pressure of 300 lbs. per sq. in. From the warmest place thereof, water is drawn off through the pipe *p*, the pump *k* and the pipe *o* to the pipes *t* of the high pressure part, which pipes are embedded for instance in a bath of lead within the casings *s* consisting in this case of tubes. The high pressure part *c* is located adjacent to the furnace, and on the gases having passed through said part they flow through the water heater *d*, the superheater *f* and then through the water heater *e*. According to the example given above, the water is heated in the last-named heater from 32° F. to a heat-content of 220 B. t. u., then in the water heater *d* from 220 to 395 B. t. u. to be supplied at last in the high pressure part *c* with so much heat as to permit of steam being taken out from the pipes *t*. From said pipes, the steam may be fed into the superheater *f*, or it may be superheated already in the pipes *t*. The pipes *t* within the casings *s* may be coupled in any suitable way, and the casings may be filled with any suitable material which is of low pressure at high temperature, or other suitable heating material may surround pipes *t*.

To cover peaks in the steam demand and to prevent the medium of the high pressure part from obtaining, too high a temperature when suddenly the steam consumption decreases, heat-storing material may suitably be provided in the casings *s*.

The pumps should preferably be so arranged as to operate permanently without a suction head, the water being caused to flow thereto automatically. With regard to the control said pumps are preferably constructed as centrifugal pumps.

If an existing boiler plant is to be utilized, the high pressure part is inserted above the grate and the old boiler is connected to said high pressure part and is used as a hot water generator.

What we claim as new and desire to secure by Letters Patent of the United States of America is—

1. The method of generating steam which comprises adding heat to water at low pressure until the water reaches approximately the boiling point, then increasing the pressure of the water by a predetermined increment, again adding heat until the water reaches approximately the boiling point, again increasing the pressure by a predetermined increment and so continuing until the water has a pressure equal to that at which it is desired to generate steam, and then adding heat to the water to raise it above the boiling point and generating steam therefrom.

2. The method of generating steam which comprises heating water in steps wherein heat is added to the water at a predetermined pressure until the water reaches approximately the boiling point and then the pressure is increased to a predetermined amount so that heat can again be added to reach approximately the boiling point.

3. The method of generating steam which comprises progressively increasing heat transfer to liquid in such a manner that when the condition of the liquid approaches the boiling point due to the addition of heat, the pressure of the liquid is increased so that additional heat must be added to again approach the boiling point, adding this additional heat and finally adding heat to raise the heat content to above the liquid line so that steam is generated.

4. The method of generating steam which comprises changing the condition of the liquid along a step by step line laid out on a heat content pressure diagram for steam showing the liquid line and saturation line which step by step line passes vertically upward at a value of low pressure until it reaches substantially the liquid line, then horizontally to a condition of higher pressure, then upwardly until it again reaches substan-

tially the liquid line and so continuing until the desired pressure for generation of steam is reached when the line is continued vertically upward past the liquid line to the saturation line.

5. A high pressure boiler comprising a high pressure steam generating section including a casing, a high temperature heat-transmitting medium of a relatively low vapor pressure in said casing, a steam pipe in said casing and situated in the vapor of said high temperature heat transmitting medium, interconnected water heaters of relatively large size connected to said high pressure section in series, and means to prevent vaporization in each section comprising devices for progressively increasing the pressure between the water heaters.

6. A high pressure boiler comprising a relatively small high pressure steam generating section composed of pipes, a high temperature heat-transmitting medium of a relatively low vapor pressure in which said pipes are situated, said medium being in a boiling state at the operating temperature, interconnected water heaters of relatively large size connected with said high pressure section in series, and means to prevent vaporization in each section comprising devices for progressively increasing the pressure between the water heaters.

7. A high pressure boiler comprising a high pressure steam generating section including a plurality of tubes connected in series, casings surrounding said tubes, molten metal in said casings, interconnected water heaters of relatively large size connected to said high pressure section in series, and means to prevent vaporization in each section comprising devices for progressively increasing the pressure between the water heaters.

8. A high pressure boiler comprising a high pressure steam generating section including a plurality of horizontally disposed tubes connected in series and so arranged that the steam and furnace gases have counter flow, casings surrounding said tubes, molten metal in said casings, interconnected water heaters of relatively large size connected to said high pressure section in series, and means to prevent vaporization in each section comprising devices for progressively increasing the pressure between the water heaters.

In testimony whereof we affix our signatures.

JOHANNES RUTHS.
NILS HEZEKIEL FRENNE.
MATTIAS BÄCKSTRÖM.