

March 31, 1936.

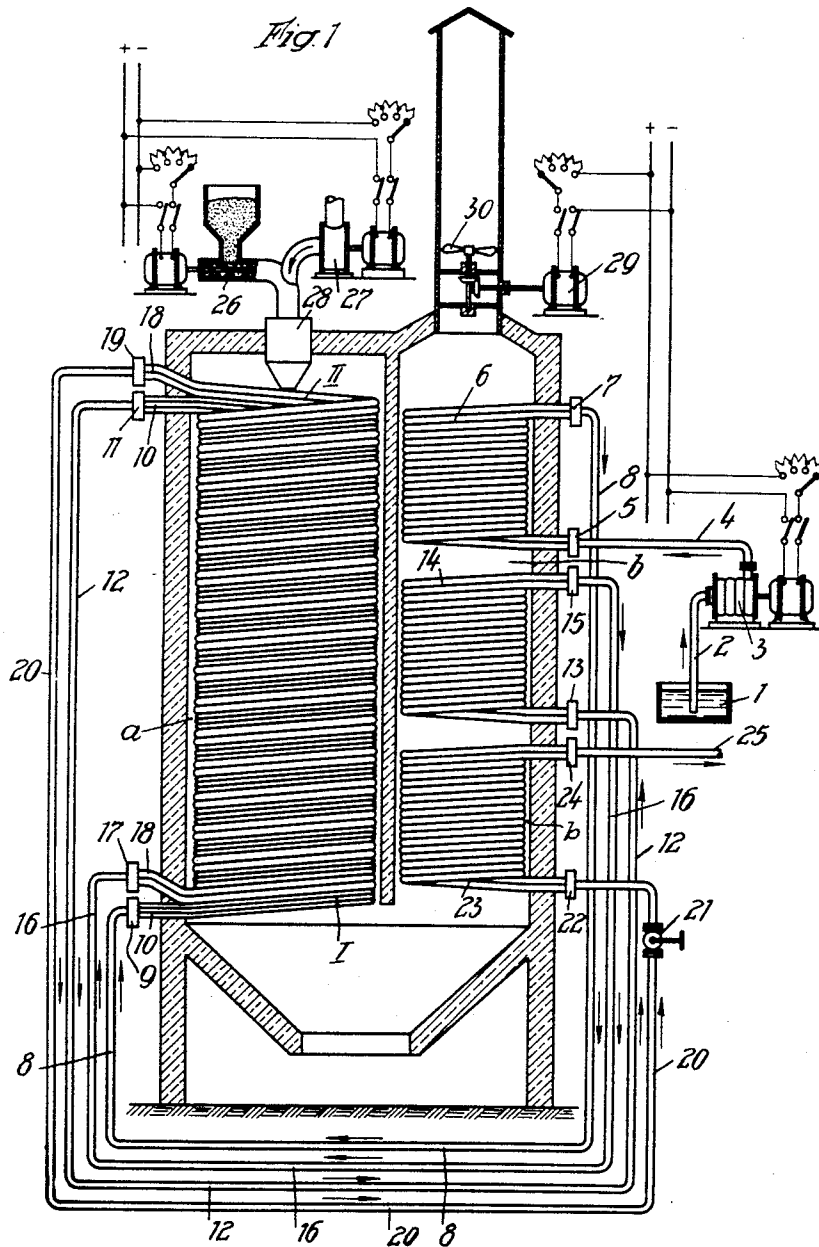
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2,035,908

STEAM GENERATOR

Filed Feb. 23, 1933

3 Sheets-Sheet 1



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Fig. 2

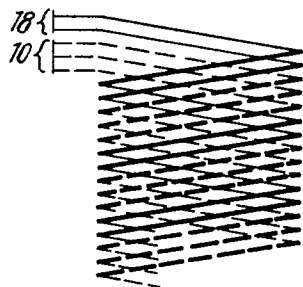


Fig. 3

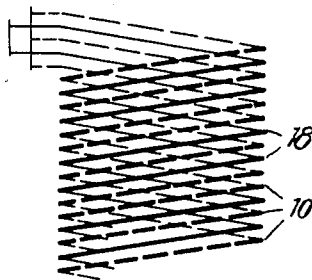
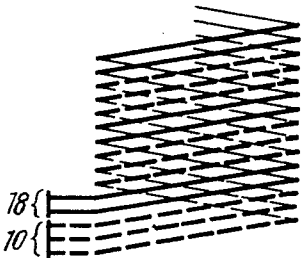
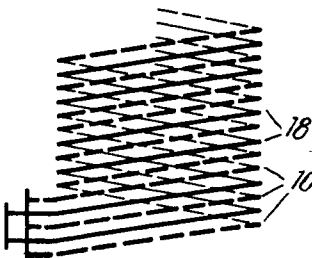


Fig. 5

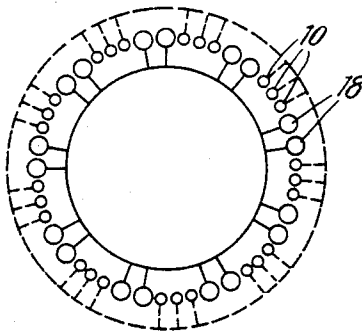
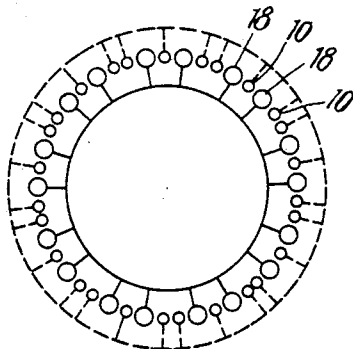


Fig. 6



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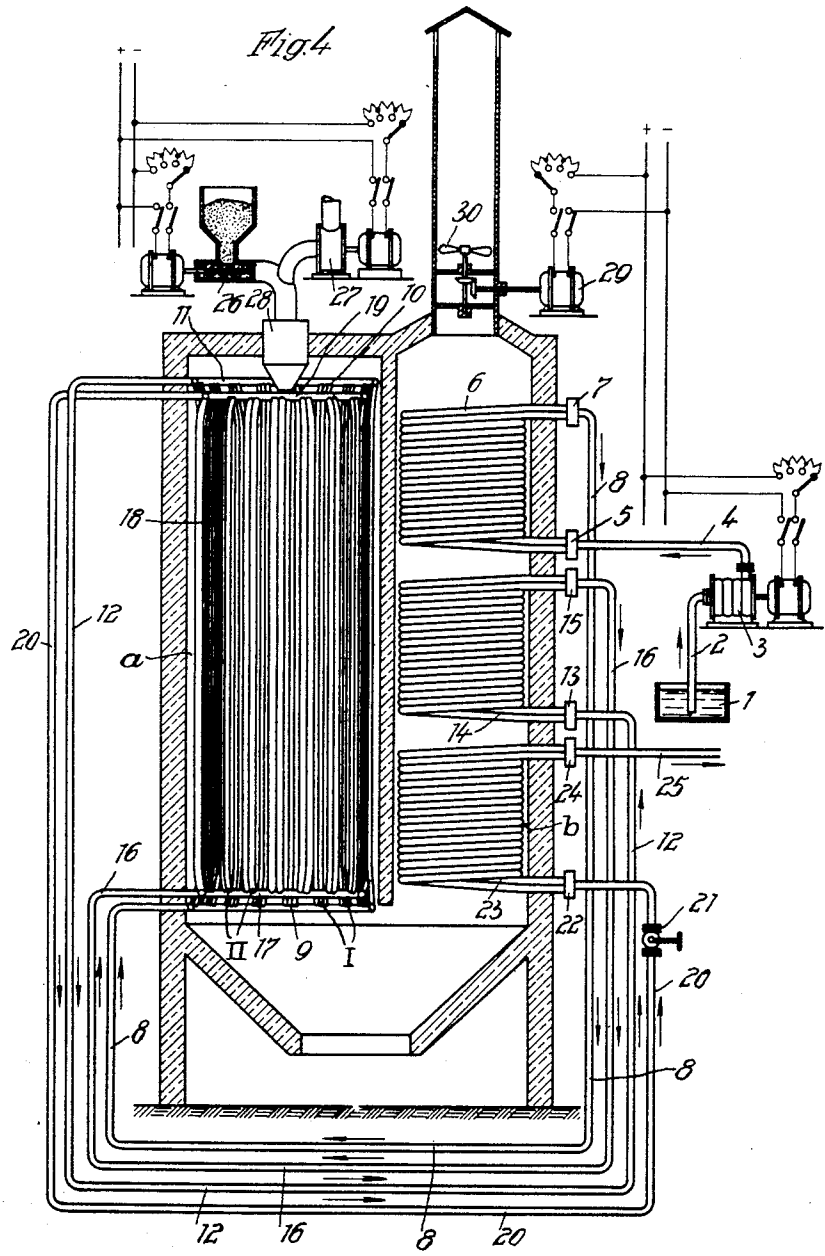
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UNITED STATES PATENT OFFICE

2,035,908

STEAM GENERATOR

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9 Claims. (Cl. 122—250)

My invention relates to a tubular steam generator and it has for its object to provide an improved arrangement of tubular heating surface.

In tubular steam generators of the forced flow type, it is preferable to arrange the tubular heating surface in such manner with respect to the heating space that the operating medium flows in series through first, second, and third sections of the tubular heating surface, the first and third sections being heated mainly by radiant heat, the second section being heated mainly by convection, and the tubular heating surface being so dimensioned that the zone thereof in which transformation of the operating medium from the liquid to the vapor state is completed is located in the second section of the heating surface, that is, in the convection heating zone of the generator.

Heretofore, the tubular heating surface has been so arranged that the first and third sections above referred to are located in a region of the heating space of relatively high heat intensity, that is, the region wherein combustion occurs, and the second section has been arranged in a region of the heating space of relatively lower heat intensity, the sections being so dimensioned that conversion of operating medium from the liquid to the vapor state is at least completed in the second section, the reason for this arrangement and operation being that deposition of salts occur during the latter part of the conversion zone and the initial part of superheating; and consequently, with disposition of heating surface in the manner indicated, it is possible to have the portion of the tubing wherein salts are deposited located in a region of the heating space of such relatively low heat intensity that injury to tubing will be minimized.

The present type of steam generator may, in operation, encounter difficulty because of a tendency of the conversion zone to shift even though the heat supply remains constant. To clarify the matter of shifting, the first and third sections of the tubular heating surface arranged in the radiant portion of the heating space are hereinafter referred to as radiant portions I and II, respectively. Shifting of the conversion zone from the second, or convection, section either to the radiant portions I or II may be caused by change in flame length resulting from variations in fineness of fuel, kind of fuel, as well as other variable conditions of combustion.

With the radiation portions I and II disposed in superposed relation in the radiant chamber, it will be apparent that, as the flame becomes longer

or shorter, the ratio of the quantities of heat absorbed by the portions I and II will vary; and, in consequence of this variation, the conversion zone, that is, the region of the heating surface wherein the operating medium is converted from the liquid to the vapor state, may shift toward the radiant portion I or the radiant portion II, depending upon whether the flame becomes shorter or longer.

To avoid the influence of variation in the ratio of heat absorption in the portions I and II causing the conversion zone to shift either in the direction of one or the other of such portions, I provide an improved arrangement of the portions I and II which operates in such a manner that the ratio of quantities of heat absorbed thereby are maintained constant even with variations in combustion conditions, as just pointed out. This result may be effected by winding the tubes of the radiation portions I and II into a coil of the helical type in such manner that the coils or convolutions of the portion I alternate with coils or convolutions of the portion II, that is, the coils are arranged similarly to the threads of a multiple thread screw. Furthermore, the coils or convolutions are arranged to line the combustion chamber to a greater or smaller extent. If the portions I and II are so arranged as to provide a single layer of tubes, then the arrangement would be similar to a double threaded screw. On the other hand, if the portions I and II are each comprised by a plurality of tubes, then different arrangements are possible: the parallel tubes of each portion may be arranged to form a ribbon and the ribbons may be wound to form a coil of the helical type in the form of a double-threaded screw; or the parallel tubes of one portion may be spread sufficiently to receive parallel tubes of the other portion, that is, the two portions may be wound to form a helix with the tubes of the portions inter-convoluted. For the sake of simplicity, the first-named manner of winding is termed the ribbon coil type and the last-named, or inter-convoluted, form of winding is referred to as the meshed coil type.

Variations in combustion conditions may also induce wandering of the conversion zone with a steam generator having vertical tubes in the combustion chamber. An irregularly burning or eccentric flame may result from clogging of a burner. If the vertical tubes are distributed about the periphery of the combustion chamber in such a manner that the tubes of the radiation portion I are grouped together so as to form a portion of the periphery and the tubes of the

radiation portion II are grouped together so as to form the remaining portion of the periphery, shifting of the conversion zone would take place as soon as either portion is more intensely heated than the other, because of inclination or irregularity of the flame. According to the present invention, a boiler of the vertical tube type may be constructed so as to avoid this objection, this result being effected by having the tubes of the radiation portion I alternately arranged with respect to the tubes of the radiation portion II, or so to arrange the tubes of the radiation portion I as to be relatively close to tubes of the radiation portion II. The number of tubes disposed in parallel relation in the radiation portion I may be varied with respect to the number of tubes so disposed in the radiation portion II. Further, the diameters of the tubes in the two radiation portions may differ relatively. In this manner, it is possible to dimension both the sizes of the heating surfaces of the two radiation portions as well as the resistance to flow therein.

These and other objects will be effected by my invention as will be apparent from the following description and claims taken in connection with the accompanying drawings, forming a part of this application, in which:

Fig. 1 is a sectional view of a steam generator incorporating my improved arrangement of tubing in the radiant heating space;

Fig. 2 shows diagrammatically the coil form used in Fig. 1;

Fig. 3 is a view similar to Fig. 2 but showing the meshed or inter-convoluted type of coil;

Fig. 4 is a vertical longitudinal section of a steam generator of the vertical tube type and incorporating my improvement; and

Figs. 5 and 6 are diagrammatic plan views of Fig. 4 showing different tube arrangements.

In all of the figures similar parts are denoted by the same reference characters. The reference character 10 designates the tube or tubes of the radiant portion I, the reference character 18 indicates the tube or tubes of the radiant portion II, and the character 14 refers to the heating surface arranged in a convection heating space, or a heating space of relatively low heat intensity, wherein conversion of the operating medium from the liquid to the vapor state is effected.

Referring now to Fig. 1, the radiation portions I and II of the tubes 10 and 18 are arranged along the wall of the radiation or combustion chamber *a* and the tubes 14 of the conversion heating zone are arranged along the wall of the heating chamber *b* in which heat is preferably transmitted to the heating surface by convection.

Heat is supplied to the combustion chamber *a* by any suitable means, for example, a burner 28 to which solid fuel may be supplied by a conveyor 26, combustion air being supplied to the burner by means of a blower 27. After passing through the combustion chamber *a*, combustion gases preferably pass through the convection chamber *b* and are discharged from the latter to the atmosphere by means of an induced draft fan 30 driven by the motor 29.

The liquid operating medium, for instance water, is forced into the tube system by a feed pump 3 first through pipe 4 and distributor 5 into the twin tube section 6, where it is preheated and thence it flows, by way of collector 7, through connecting pipe 8 and distributor 9 to the first radiation portion I, consisting, in Fig. 1, of a helical triple pipe ribbon 10. The medium traverses this portion in counter-flow relation with

respect to the combustion gases. At the end of the portion I, medium is collected at 11 and returns through pipe 12 and distributor 13 to the convection portion of the generator, traversing tube section 14 of the latter and wherein it is converted into vapor. At the end of the convection heating surface, vapor enters the collector 15 from which it passes through pipe 16 to the collector 17 of the second radiation portion II, which consists of a helical twin pipe ribbon 18 laid parallel to the triple pipe ribbon 10 of portion I, so that a twin thread ribbon coil is formed. Also, in portion II the medium flows counter to the combustion gases. At the end of coil portion II, the medium is collected at 19 and it is re-conveyed through pipe 20 and valve 21 to the convection chamber, wherein it traverses, by way of distributor 22 the third twin tube section 23, at the end of which it enters the collector 24 and is discharged as vapor into the consumer or supply line 25.

The two groups I and II arranged in the radiant heat chamber are comprised by alternately disposed or intermingled tube elements of the two groups so as to secure an average effect so far as heat transfer is concerned. With a steam generator of the present type, even through the overall heat transfer occurring in the radiant heat chamber *a* remains the same and even though the quantity of fuel supply is unchanged, nevertheless, variations in combustion or flame characteristics may occur, resulting in shifting of the flame along the radiant heat chamber. This may follow due to a variation in the volatile content of the fuel, variation in the air supply, or fineness of fuel particles. Thus, it will be apparent that the zone of high heat intensity may shift along the chamber *a*; and, if the two groups I and II were arranged in superposed relation, it would be apparent that, with a short flame, the high intensity heat region thereof would be applied to one group, and, with a longer flame the high intensity region of the flame would be applied to the other group. As already pointed out, this would cause shifting of at least the final stage of conversion from the liquid to the vapor state, more intense heating of the first radiant portion of the tubing with less intense heating of the second portion, tending to cause the conversion zone to shift backwardly toward the first portion and more intense heating of the second radiant portion of the tubing with less intense heating of the first portion causing the conversion zone to shift forwardly toward the second portion. In accordance with the present invention, therefore, the tubular elements of the two groups in the radiant heat absorbing chamber *a* are intermingled, whereby the ratio of heat absorbed in the two groups is not affected, nor does it depend upon variations of distribution of heat in the radiation chamber, and consequently the conversion zone may be restricted to the tube group 14 in the convection zone.

Referring now to the modified form of my invention shown in Figs. 4, 5, and 6, in Figs. 4 and 5 the vertical groups of tubes 10 of the radiation portion I are arranged in spaced relation so as to receive alternate groups of tubes 18 of the radiation portion II. The arrangement shown in Fig. 6 differs from Fig. 5 in that the tubes 10 and 18 are not arranged as distinct and separate groups, but the tubes of the two portions are intermingled. For example, in Fig. 6 the tubes 18 have alternate spaces therebetween including one and two tubes of the tubes 10. Thus, it will be

seen that the arrangement of Fig. 6 is similar to Fig. 3 in principle in that the tubes of the radiation portion I are intermingled with respect to tubes of the radiation portion II.

5 From the foregoing, it will be apparent that the ratio of the quantities of heat absorbed by the radiation portions I and II of the tubing in the combustion chamber 2 is not dependent upon the length and the direction of the flame, in
10 consequence of which any irregularity in the flame will not cause shifting of the conversion zone.

It will furthermore be apparent that my invention is applicable to steam generators operating at any suitable pressure including generators
15 operating at a critical pressure and temperature.

In operation, and referring to Fig. 1, the feed water is preheated in the heating surface 6 disposed in the convection chamber b, the preheated
20 water then passing in series through the radiant surface I and the convection surface 14. Completion of change from the liquid to the vapor state, and preferably some degree of superheating, is effected in the convection surface 14 for
25 the reason that the salt deposition occurs in the region of the heating surface where conversion from the liquid to the vapor state is completed and superheating begins and injury to tubing on account of such salt deposition may be avoided
30 or greatly minimized by location of the heating surface, namely the heating surface 14, in a part of the heating space where the heat is of sufficiently low intensity as to avoid injury or burning of surface even though containing salt deposits. From the heating surface 14, the operating medium in the vapor state, and preferably having some degree of superheat, passes to the second radiant portion II, wherein the medium is superheated, and further superheat is added
40 to the medium in the heating surface 23 before going to the supply or consumer line 25. Due to the intermingled relation of elements the heating surfaces I and II, irregularities in combustion conditions, which might otherwise tend to cause shifting of the conversion zone, are ineffective for
45 this purpose.

It will furthermore be apparent that my invention is applicable to steam generators operating at any suitable pressure including generators
50 operating at a critical pressure and temperature.

I claim:

1. A steam generator comprising a furnace chamber having a heat radiation zone and a heat convection zone, a tubular heating surface
55 formed of a plurality of groups of tubes, a pump adapted to force the operating medium through said groups, at least two of said groups being disposed in said radiation zone so as to chiefly absorb radiating heat, a tubular group disposed
60 in said convection zone so as to absorb heat transmitted chiefly by contact, said last group including a vapor conversion zone for the medium, and conduits for interconnecting said groups so as to cause the operating medium to flow first through one of said groups heated by radiation, then through the group heated by contact and finally through the other of said groups heated by radiation, said two groups heated by radiation being relatively so disposed that the ratio of the quantities of heat absorbed by said two groups always remain constant independent of variations in the distribution of heat in the radiation zone.

2. A steam generator comprising a furnace chamber having a heat radiation zone and a heat
75 convection zone, a tubular heating surface formed

of a plurality of groups of tubes, a pump adapted to force the operating medium at a suitable pressure through said groups, at least two of said groups being disposed in said radiation zone so as to chiefly absorb radiating heat, a tubular
5 group being disposed in said convection zone so as to absorb heat transmitted chiefly by contact, said last group including a vapor conversion zone for the medium, and conduits for interconnecting said groups so as to cause the operating medium to flow first through one of said groups heated by radiation, then through the group heated by contact and finally through the other of said groups heated by radiation, said two groups heated by radiation being formed of
10 coiled tubes with the convolutions of one group interposed between convolutions of the other group.

3. A steam generator comprising a furnace chamber having a heat radiation zone and a
20 heat convection zone, a tubular heating surface formed of a plurality of groups of tubes, a pump adapted to force the operating medium at a suitable pressure through said groups, at least two of said groups being disposed in said radiation
25 zone so as to chiefly absorb radiating heat, a tubular group disposed in said convection zone so as to absorb heat transmitted chiefly by contact, said last group including a vapor conversion zone for the medium, and conduits for interconnecting said groups so as to cause the operating medium to flow first through one of said groups heated by radiation, then through the group heated by contact and finally through the other of said groups heated by radiation, said
30 two groups heated by radiation being formed of vertical tubes lining the furnace chamber wall in the manner that the individual tubes of both groups follow one another alternately along the periphery of said furnace chamber.

4. A steam generator comprising a furnace chamber having a heat radiation zone and a heat convection zone, a tubular heating surface formed of a plurality of groups of tubes, a pump adapted to force the operating medium at a suitable
45 pressure through said groups, at least two of said groups being disposed in said radiation zone so as to chiefly absorb radiating heat, a tubular group disposed in said convection zone so as to absorb heat transmitted chiefly by contact, said
50 last group including a vapor conversion zone for the medium, and conduits for interconnecting said groups so as to cause the operating medium to flow first through one of said groups heated by radiation, then through the group heated by contact and finally through the other of said groups heated by radiation, said two groups heated by radiation being formed of tubes helically coiled with the convolutions of one group alternately disposed with respect to convolutions of the other group, the diameters of the tubes forming said two last-named heating groups differing from one another.

5. A steam generator comprising a furnace chamber having a heat radiation zone and a heat
65 convection zone, a tubular heating surface formed of a plurality of groups of tubes, a pump adapted to force the operating medium at a suitable pressure through said groups, at least two of said groups being disposed in said radiation zone so as to chiefly absorb radiating heat, a tubular group disposed in said convection zone so as to absorb heat transmitted chiefly by contact, said last group including a vapor conversion zone for the medium, and conduits for interconnecting
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said groups so as to cause the operating medium to flow first through one of said groups heated by radiation, then through the group heated by contact and finally through the other of said groups heated by radiation, said two groups heated by radiation being formed of parallel tubes lining the wall of the radiation zone of said furnace chamber in the manner that the individual tubes of both groups follow one another alternately side by side along the wall periphery of the chamber, the diameters of the tubes forming said two last-named heating groups differing from one another.

6. A steam generator comprising a furnace chamber having a heat radiation zone and a heat convection zone, a tubular heating surface formed of a plurality of groups of tubes, a pump adapted to force the operating medium at a suitable pressure through said groups, at least two of said groups being disposed in said radiation zone so as to chiefly absorb radiating heat, a tubular group disposed in said convection zone so as to absorb heat transmitted chiefly by contact, said last-named group including a vapor conversion zone for the medium, and conduits for interconnecting said groups so as to cause the operating medium to flow first through one of said groups heated by radiation, then through the group heated by contact and finally through the other of said groups heated by radiation, said two groups heated by radiation being formed of tubes helically wound in the form of a multiple thread screw lining the wall of the radiation zone of said chamber with the convolutions of one group interposed between the convolutions of the other group, said two heating groups being formed of a different number of parallel-connected tubes.

7. A steam generator comprising a furnace chamber having a heat radiation zone and a heat convection zone, a tubular heating surface formed of a plurality of groups of tubes, a pump adapted to force the operating medium at a suitable pressure through said groups, at least two of said groups being disposed in said radiation zone so as to chiefly absorb radiating heat, a tubular group being disposed in said convection zone so as to absorb heat transmitted chiefly by contact, said last-named group including a vapor conversion zone for the medium, and conduits for interconnecting said groups so as to cause the operating medium to flow first through one of said groups heated by radiation, then through the

group heated by contact and finally through the other of said groups heated by radiation, said two groups heated by radiation being formed of parallel tubes lining the wall of the radiation zone of said chamber in the manner that the individual tubes of both groups follow one another alternately side by side along the periphery of the chamber, said two heating groups being formed of a different number of parallel-connected tubes.

8. A steam generator comprising a furnace chamber having a radiant heat zone and a convection heat zone receiving heated gases from the radiant heat zone; a tubular system including a first-heat-absorbing tube group in the radiant zone, a second heat-absorbing tube group in the convection zone, and a third heat-absorbing tube group in the radiant zone arranged in series so that motive medium enters the first group, has the zone of conversion from the liquid to the vapor state completed in the second group and is heated in the third group; and means for securing forced flow of motive medium through the tubular system; said first and third heat-absorbing tube groups having the tubular elements thereof intermingled, whereby the absorption of heat by the first and third groups occurs in such a way as to minimize shifting of the conversion zone.

9. A steam generator comprising a furnace chamber having combustion means for projecting a flame therealong so as to provide a radiant zone followed by a convection zone receiving heating gases from the radiant heat zone; a tubular system including a first heat absorbing tube group in the radiant zone, a second heat absorbing tube group in the convection zone, and a third heat absorbing group in the radiant zone arranged in series so that motive medium enters the first group, is supplied from the latter to the second group wherein conversion from the liquid to the vapor state is completed, and the vapor is supplied from the second group to the third group wherein it is superheated; means for securing forced flow of motive medium through the tubular system; said first and third tube groups encompassing the direction of flame projection and each being comprised by a plurality of tubular elements with the tubular elements of the two groups intermingled so that the ratio of heat absorbed thereby may be made independent of the zone of highest heat intensity of the flame.

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