

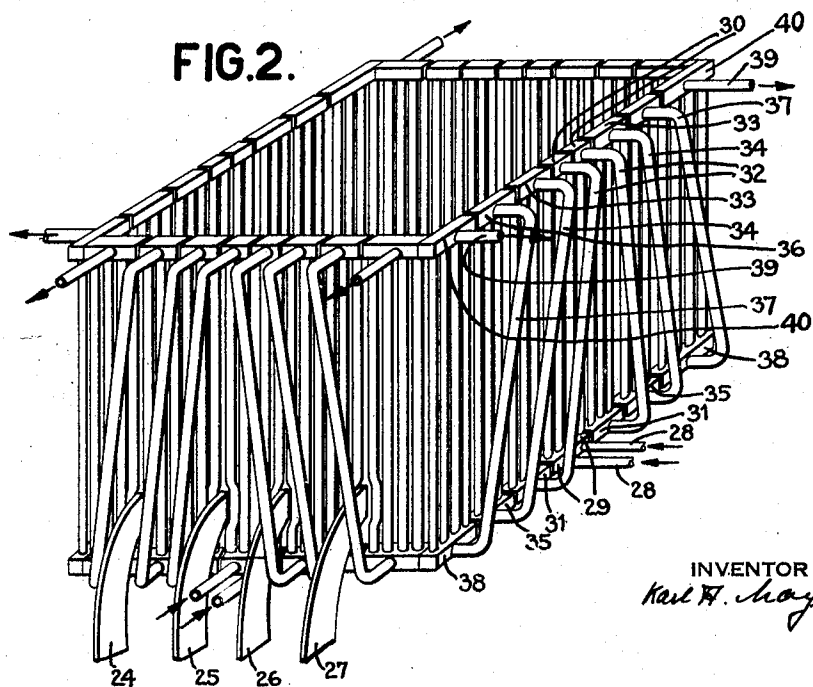
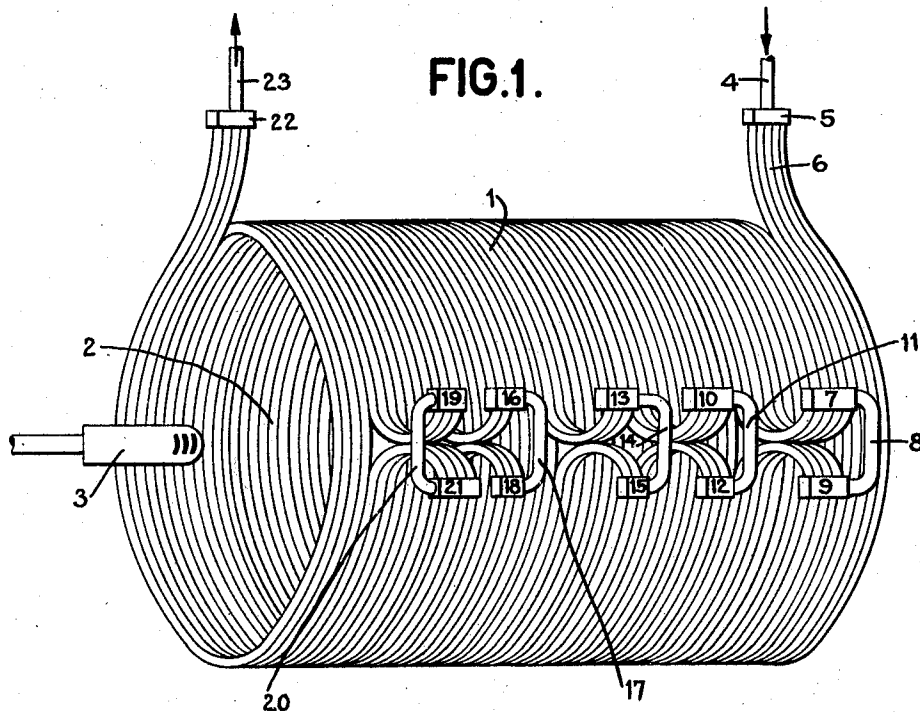
July 2, 1935.

K. A. MAYR

2,006,403

STEAM GENERATOR

Filed March 7, 1932



INVENTOR
Karl F. Mayr

UNITED STATES PATENT OFFICE

2,006,403

STEAM GENERATOR

Karl A. Mayr, New York, N. Y., assignor to
Siemens-Schuckertwerke Aktiengesellschaft,
Berlin-Siemensstadt, Germany, a corporation
of Germany

Application March 7, 1932, Serial No. 597,326

11 Claims. (Cl. 122-235)

This invention relates to an apparatus for transmitting heat to fluids, which circulate through tubular heating elements. It relates more particularly to the arrangement of heat absorbing tube sections which are built around a furnace and through which a medium to be heated passes under forced circulation. The heat transmission from tube wall to the fluid inside the tube, is approximately proportional to the 1.2nd power of the velocity of the medium i. e. if f. i. the velocity of the medium is doubled the heat transmission is $2^{1.2}$ times as much as it was before or if the velocity is three times as great the heat transmission is $3^{1.2}$ times as much. In other words, the faster the medium passes through the tube, the more heat is brushed away from the tube and the colder is the tube wall. In a combustion chamber there are always certain portions which are hotter than other portions. The flame body emanating from a fuel bed or a burner in the case of pulverized coal, oil or gas as fuel, has a part which is hottest and which may be called the heat center of such a heat radiating flame body. The tubes nearest to this hot center must absorb much more heat than other tubes. The fluid within these tubes must carry away much more heat to prevent an excessive temperature of these tubes with attending danger of burning the tubes.

To bring about an equal temperature of the tube walls throughout all heating sections, and an equal heat absorbing work of each individual tube, I propose to increase the velocity of the medium to be heated through such tube sections which are more exposed to receiving heat by radiation and/or convection than other tube sections. This can be accomplished by using tubes of smaller cross section in such section where the higher velocity is required or by arranging a smaller number of tubes in parallel in such sections, or by a combination of both methods. If these methods are used, the flow of the medium can be arranged so that the colder medium passes through the less heated section, and the hotter medium passes through the more heated sections, and still the tube wall temperature is substantially the same in all sections. In this way almost true counterflow conditions may be obtained. If the velocity cannot be changed sufficiently, e. g. due to structural limitations, I propose to arrange the flow of the medium so that the colder medium circulates through the tube sections which are more exposed to heat transmission and the hotter medium through such sections which are not so much favored with heat. In this way or by com-

bining this method with the before stated method, it also can be accomplished that the tube wall temperature is substantially the same in all heating sections.

An object of my invention is, to provide for a faster circulation of the fluid to be heated through such portions of the heat transmitting and absorbing elements, which are more exposed to higher heating temperatures than other elements.

Another object of my invention is the provision of a flow arrangement through heat absorbing tubes, surrounding a combustion chamber in which the medium in the tubes next to the burners is comparatively hot while the medium circulating through tube sections near the hottest part of the flame body is cool.

An object of my invention is the provision of a flow arrangement, in a system of heat absorbing tubes, where the tubes with the hottest medium are exposed to the hottest part of the heating medium and where the velocity of the heat absorbing medium is greatest in the tube sections which are exposed to the hottest part of the heating medium.

Referring now to the drawing:

Fig. 1 shows a perspective view of one modification of my device and Fig. 2 a perspective view of another modification thereof.

Figure 1 shows substantially a cylindrical pipe coil 1 which surrounds a combustion chamber 2. This chamber may be fired by pulverized coal, oil or gas. This fuel may be introduced by a burner 3. The chamber could also be fired from a grate which in this case would probably be of circular shape, or by means of hot gases, emanating from a separate combustion chamber, Dutch-oven, or the like not shown. The fluid to be heated enters the coil through the feed pipe 4. It is distributed by means of the header 5 into five individual tube coils 6. The distributor 5 is so dimensioned, with respect to the diameters of the tubes, that the velocity in this header is small in comparison with the velocity of the fluid in the tubes, and an equal distribution into the five tubes is secured. The five coils into which the fluid enters first, are located at one end of the combustion chamber and the end at which the combustion gases leave the chamber. The temperature of the gas leaving the chamber is low compared with the temperature of the flame which develops more in the center of the combustion chamber or close to the burner. The velocity of the fluid can be slow compared with the velocity of the fluid in the sections of the chamber which

are closer to the burner or closer to the center of the combustion chamber. The reasons have been explained in previous paragraphs. The fluid passes, as stated, through five parallel coils which are arranged around the combustion chamber in three layers. It is collected again in a header 7 where the fluids, discharged from the individual tube lines, are mixed together. The fluid passes then through a connecting tube 8 into a header 9, where it is distributed into four tube lines. Notwithstanding the change in specific volume, which may have taken place while the medium was heated up, the velocity in these four tube lines is at least $5/4$ of the velocity in the previous tube sections. These four tube lines surround the chamber in one layer and terminate in a header 10. The fluid is mixed in this header and conveyed through a conduit 11 to header 12. From this header it is distributed into three tube lines. The velocity is thus again increased to at least $4/3$ of that in the previous section and $5/3$ in the first section. The three parallel tube lines form another part of the combustion chamber and the fluid passing through these three tube lines is collected in a header 13. It passes through a conduit 14 to a header 15. From this header the fluid is conducted into two parallel tube lines around the combustion chamber and to a header 16. The parts of the combustion chamber wall which are made up of these last coils, consisting of two parallel tube lines and of the coil consisting of three parallel tube lines, are exposed to the hottest part of the flame body. The velocity through these tubes, therefore, must be greatest. Of course, at various loads the hottest part of the flame body is at different points in the combustion chamber. The hottest part will be closer to the burner at lower outputs and it will be further away from the burner at higher outputs. In very large combustion chambers arrangements may be made whereby by means of valves and the like the number of parallel arranged tube lines may be increased or decreased and the velocity of the medium to be heated can be voluntarily adjusted in any part of the combustion chamber. Continuing the description of Figure 1, the medium passes from header 16 through conduit 17 to distributor 18. From here it passes in three parallel tube lines on to header 19. From header 19 it is conveyed to header 21 through pipe 20. Header 21 distributes the fluid into four parallel tube lines which build the wall of the part of the combustion chamber which is closest to the burner. The fluid is collected in header 22 and removed from the combustion chamber tube sections through tube 23. From header 16 onward the velocity of the medium gradually decreases again in accordance with the lower temperature, which prevails in the immediate neighborhood of the burner.

In a combustion chamber, as shown in Figure 1, the various velocities of the medium to be heated are obtained by arranging a larger or smaller number of tubes in parallel. The same effect can be obtained by using tubes of smaller or larger cross-section or by combining both methods.

Figure 2 shows a cube shaped combustion chamber. This chamber may be fired by pulverized coal, oil or gas. When using such type of fuel, burners 24, 25, 26 and 27 may be arranged on one wall of the chamber. Assuming that the burners are at the lower part of the front wall and the hot gases escape through the upper part of the wall, opposite to the burner wall, or through

the top at the corner which is diagonally opposed to the corner nearest to the burners, there will be a hot center substantially in the center of the combustion chamber. In cases where the burners are arranged at the four corners of the chamber and withdrawn through the top of the combustion chamber, a hot center will develop also substantially in the neighborhood of the axis of the combustion chamber and the tube sections nearer to the center or in the middle of the individual walls will be exposed to more intensive heat transmission than the tubes located in the neighborhood of the corners of the chamber. The chamber could also be fired from a stoker. Should the hot gases escape close to the rear wall, this wall and the parts of the side wall closer to the rear wall are more favored with heat than other wall sections. In the arrangement, as shown in Figure 2, it was assumed that a hot flame center develops in the center of the combustion chamber and the center sections of the walls are exposed to higher heat intensity than the corner sections. The feed water enters through pipes 28 and is distributed by means of headers 29 into two parallel tubes. It rises upwardly through these tubes and is collected in top headers 30 and brought down to headers 31 by means of downcomer tubes 32. From 31 it is distributed into three parallel tubes and the velocity accordingly decreased. The medium is then collected in top headers 33, brought down through downcomers 34 and distributed again in headers 35. This goes on through headers 36, downcomers 37 and headers 38. The number of tubes is gradually increased so that the smallest number of tubes in parallel is in the center sections of the tube wall and the largest number of tubes in parallel is in the corner sections. In the drawing the corner sections are composed of four tubes in parallel. The medium to be heated leaves the corner sections through headers 40 and conduits 39. These may be connected to the center sections of another side wall or such sections which are particularly favored by heat or the fluid may be conducted to convection heating sections or to consumers.

In a chamber, as described before, the velocities in individual tube sections can also be influenced by using tubes of various cross-sections similarly as it was described when discussing Figure 1, or by a combination of tubes of various cross-sections and sections with various numbers of tubes in parallel. It is quite obvious that arrangements can be made by the use of valves and the like to change the velocity of the fluid in individual tube sections, while the apparatus is in operation. The number of tubes through which the fluid flows in parallel can be changed by such arrangements according to operating conditions. This may be desirable in designs where the hot part of the flame body changes its location at various output conditions, and also where a different specific volume of the medium to be heated must be encountered in the various tube sections at different load conditions.

The basic idea of this invention, as described in the opening paragraphs, may be incorporated in many other designs and shapes of tube sections which line combustion chamber walls and also tube sections which are exposed to heat transmission by convection or in a heat transmitting apparatus which may be heated by other means such as a hot fluid, steam, electricity etc.

What I claim is:

1. A heat transfer apparatus for heating fluids

comprising in combination a combustion chamber, a source of heat, walls around said combustion chamber, tubular elements carrying the fluid to be heated adjacent to said walls and disposed to receive heat from the flame body and the hot gases developing in said combustion chamber said flame body and hot gases having a locally varying heat intensity, said tubular heating elements consisting of a plurality of parallel arranged tubes with a common inlet and outlet header, connecting conduits between said inlet and outlet headers to serially connect the individual elements and a supply conduit for the fluid connected to the heating elements which are exposed to the hottest portions of the flame body and discharge conduits for the fluids connected to the heating elements which are exposed to the colder portions of the flame body whereby the fluid medium to be heated enters first those elements which are most favored with heat and flows to elements which are not so much favored with heat.

2. In heat exchange apparatus, a wall structure defining a heating chamber having sides and parallel corners and including a plurality of tubular heating units arranged substantially parallel to the corners, conduits serially interconnecting said tubular heating units, a source of heat of locally varying intensity within said heating chamber and disposed to supply heat to said tubular heating units and a medium circulating therein, supply conduits for the medium connected to those of said heating units which are exposed to the greatest heat intensity of said source and discharge conduits for the medium connected to the heating units located adjacent to said corners and exposed to least extensive heat transfer conditions whereby the medium circulates within said wall structure from units most favored with heat to units which are less favored with heat.

3. In heat transfer apparatus, means including a plurality of tubular heating units defining a heating chamber of substantially angular configuration and having a plurality of individual walls and corners, a source of heat of locally varying intensity within said heating chamber, supply conduits for the medium on each wall and connected to the heating units which are exposed to the greatest heat intensity of said source, and discharge conduits for the medium on each wall and connected to the heating units located adjacent to said corners which are exposed to the smallest heat intensity whereby the medium flows within the same wall from units which are most favored with heat to units which are less favored with heat.

4. In heat transfer apparatus, a wall structure defining a heating space and including a plurality of circumferentially-arranged tubular elements, a source of heat within said space, and means providing for the passage through the tubular elements of fluid medium to be heated, the flow area of the tubular element or elements nearest to the heat source and subject to the most intense heat being the smallest and the flow areas of tubular elements more remote from the heat source and subject to less intense heat being larger.

5. In heat transfer apparatus, tubular elements defining a cylindrical heating space, a source of heat of locally varying intensity within said space, and means providing for series flow through said tubular elements of fluid to be heated, the tubular elements located where the intensity of said heat source is the greatest hav-

ing smaller flow area than the elements located where the intensity of said heat source is smaller.

6. In heat transfer apparatus, a plurality of tubular heating elements arranged to provide a cylindrical wall structure enclosing a heating space, a source of heat of locally varying intensity within said space, each of said tubular heating elements including an inlet header connected by a plurality of tubes to an outlet header, the elements located where the intensity of said heat source is greatest having the least number of tubes and the elements located where the intensity of said heat source is smallest having the largest number of tubes, conduits arranged between outlet and inlet headers to provide for series connection of the tubular elements, means for supplying fluid to the initial inlet header, and means for discharging fluid from the final outlet header.

7. In heat transfer apparatus, heat-absorbing upright tube units arranged to define a heating space wall, a source of heat within said space, said tube units being so arranged with respect to said heat source as to be subject to heat of varying intensity, and means providing for fluid flow through said tube units, those units disposed at and forming portions of said wall exposed to the greatest heat intensity having smaller flow areas than those units disposed at and forming portions of such wall exposed to smaller heat intensity.

8. In heat transfer apparatus, heat-absorbing tube units arranged to define a heating space wall, each of said tube units including one or more vertical tubes, a source of heat, said tube units being so arranged with respect to said heat source as to be subject to heat of varying intensity, and means providing for upward flow of fluid through the tubes of said units, the number of tubes in the tube unit or units exposed to heat of greatest intensity being smaller than the number of tubes in tube unit or units exposed to heat of lower intensity.

9. In heat transfer apparatus, a plurality of vertical tubes disposed in side-by-side relation and spaced sufficiently close together to define a wall which completely surrounds a heating space, a source of heat within said space, said tubes being so arranged with respect to said heat source as to be subject to heat of varying intensity, and means providing for upward fluid flow through said tubes, the flow areas of said tubes being so arranged in relation to said heat source that the velocity of flow is greater through tubes subjected to heat of the highest intensity than through tubes subjected to heat of lower intensity.

10. In heat transfer apparatus, a plurality of parallel tube units arranged to provide a plurality of wall elements disposed in contiguous relation to form a wall structure completely encompassing a heating space, a source of heat in said space, and means providing for flow of fluid through all of said tube units in the same direction, those of said tube units which form portions of the wall elements exposed to heat of highest intensity having smaller flow areas and said fluid flowing at higher velocity therein than through tube units which form portions of the wall elements exposed to heat of less intensity, and each of said wall elements comprising a plurality of tube units having different flow areas.

11. In heat transfer apparatus, a plurality of parallel tubular elements providing a wall struc-

ture which completely encompasses a heating space, a source of heat within said space, each of said tubular elements comprising an inlet header connected by tube means to an outlet header and
5 all of the tube means being disposed in parallel relation, and means providing for fluid flow through the tubular elements and through all of the tube means thereof in the same direction, said last-named means including conduits connecting outlet to inlet headers, the number of tube means in the elements subject to heat of highest intensity being smaller than the number of tube means in elements subject to heat of lower intensity. 5

KARL A. MAYR.