

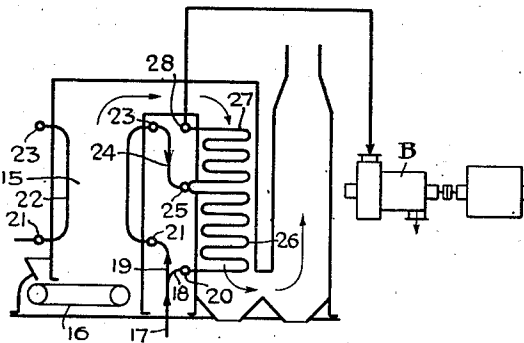
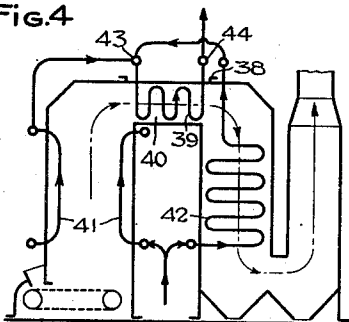
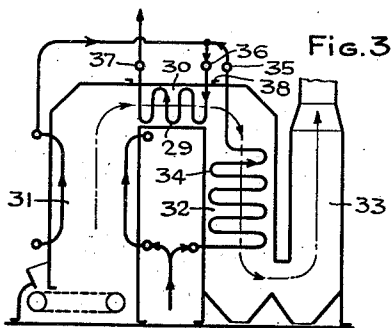
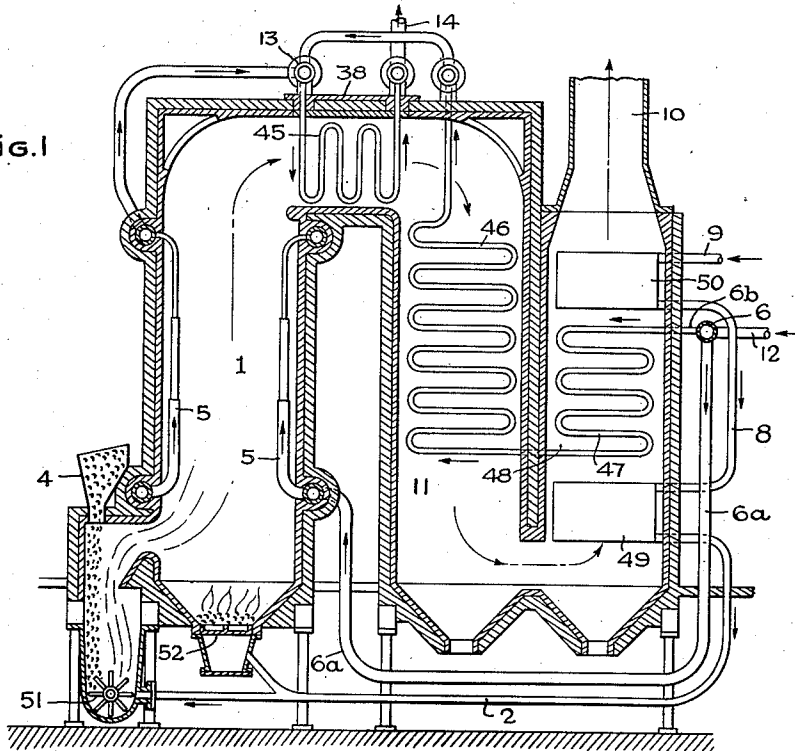
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GAS HEATER

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GAS HEATER

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This invention relates to a gas heater, particularly for thermal power plants, in which at least the greater part of a gaseous working medium, preferably air, describes a cycle and is to be heated indirectly by a supply of heat from an external source.

In plants of this kind the working medium has to be heated to 600° C. and even higher. On the other hand, the pressure drop to which the working medium is subjected in passing through the heater should be as small as possible, since such a drop greatly impairs the overall efficiency of the plant. The velocity of the working medium flowing through the heater cannot, therefore, be chosen at will, i. e., of such a magnitude as would be desirable for ensuring a good heat transmission. As a consequence, the danger exists of the maximum temperature, admissible for the materials employed for the heater, being exceeded, at least in that section of the heater which is heated by radiation.

To attain a good efficiency in plants of the kind herein referred to, it is further necessary that the heat contained in the combustion gases be utilized to the maximum possible extent; the flue gases should, therefore, leave the heater with as low a temperature as possible.

To meet these different requirements and furthermore, to provide a heater requiring a relatively small heating surface for the transmission of a given quantity of heat, whilst nevertheless offering a high degree of safety against excessive heating of the materials employed, a heater according to the present invention is so designed that the working medium, the temperature of which has to be raised, flows in parallel currents on the one hand through a section of the heater mainly heated by radiation and on the other hand through a further section heated by contact. Hereby, the medium to be heated flows parallel to the combustion gases through the heater section mainly heated by radiation and in contraflow to said gases through the section which is heated by contact.

The two streams of working medium so heated to approximately equal temperatures then join and pass through a third heater which is located in the path of the combustion gases between the combustion chamber and the space in which the contact heater is located. From this final heater the working medium passes to a point of use.

The final heater may be variously located and may be so arranged that the flow relationship between the working medium and the products of combustion is concurrent or counterflow. In

the most refined embodiment of the invention there may be a plurality of surface heaters in a succession of flues. Means are also contemplated to use waste heat flowing to the stack to heat combustion air flowing to the burner. The burner may be of any known type, using any suitable fuel, solid, gaseous or liquid.

In the accompanying drawing various embodiments are indicated.

In the drawing:

Figure 1 shows a gas heater in which the surface heated by contact is sub-divided into three sections in two of which the working medium flows in countercurrent relation to the combustion gases while in the third section, which is the final heater, the flow is concurrent. In this embodiment the final heater is arranged in a horizontal flue.

Fig. 2 shows diagrammatically a gas heater in which the surface heated by contact is subdivided into two sections which are both accommodated in a vertical flue.

Fig. 3 shows, also diagrammatically, a gas heater in which the surface heated by contact is likewise subdivided into two sections, one of which being accommodated in a vertical flue and the other in a horizontal flue which connects this flue to the combustion chamber.

Fig. 4 shows diagrammatically a similar embodiment to that illustrated in Fig. 3, with the difference, however, that the working medium to be heated flows parallel to the combustion gases through the section of the contact heated surface, which is designed as a tube nest and is accommodated in a horizontal flue connected to the combustion chamber.

Refer to Figure 1. The numeral 1 indicates the combustion chamber of a heater used to heat the gaseous medium used in the thermal power plant not shown. In such a power plant (see for example the patent to Keller 2,268,074, December 30, 1941) air used as a working medium describes a cycle in which the air is raised in pressure by at least one compressor, heated by a heater such as that shown in Figure 1 of the present application, the heat being derived from an external source, and is thereafter expanded in at least one turbine and then returns to the compressor. The turbine drives the compressor and also some external device such as a generator. In this way the heat energy derived from the external source is converted into work. The system includes certain heat exchangers fully described in the patent above mentioned. 52 indicates the grate of a pulverized fuel furnace, 51 indicates a crushing

mill for delivering fuel to the grate, and 4 indicates a source of fuel. As stated, the illustration of the burner is purely exemplary and any type of burner using any type of fuel might be substituted.

The combustion chamber 1 is lined with closely spaced tubes 5 through which the air to be heated flows. The tubes are connected at their bottom to an inlet manifold and at their top to a discharge manifold as shown. Part of the heat is transmitted to the tubes by radiation and a part by conduction from the products of combustion. The tubes 5 are shown as reduced in diameter from their lower to their upper ends, the idea being to secure comparatively free flow to the discharge end of the tubes 5 and impose whatever flow resistance exists in the circuit at these discharge ends.

The products of combustion leaving the chamber 1 pass through a horizontal connecting flue into contact with the surface heat exchanger generally indicated by the numeral 45. Thence the products of combustion flow vertically downward through a flue 11 in contact with another surface heat exchanger generally indicated at 46. Thence the products of combustion pass upward through a second vertical flue 48 to the stack 10, and in their passage through the second vertical flue 48 deliver heat in the order stated to a second stage combustion air heater 49, a preheater 47 for the working medium and a first stage combustion air heater 50.

Working medium enters through the connection 12 and branches at 8, part of the medium flowing through a connection 6a to the tubes 5 in the combustion chamber 1 and the remainder passing through the connection 6b to the exchanger 47, then through the exchanger 46 and from the exchanger 46 to the junction 13. At the junction 13 this medium joins medium which flows through the tubes 5. From the junction 13 the two flow together through the exchanger 45 and thence by way of the connection 14 to the point of use. (In the Keller patent above identified the flow would be through the pipe there numbered 3.)

Combustion air enters at 9, passes through the primary heater 50, flows thence through the pipe 8 to the secondary air heater 49 and flows thence by the connection 2 to a point of use in the burner such as that indicated at 52 or the equivalent. In this way the heat of combustion is usefully applied, and the gases escaping through the stack 10 are at relatively low temperature.

An idea of the performance of the heater may be had from the following centigrade temperatures. Assuming that air enters at 12 at about 300° it is possible to raise its temperature to a value between 500° and 600° in passage through the exchangers 47 and 46 and also in its passage through the tubes 5. The air so heated can be brought to above 600° by passage through exchanger 45. The combustion gases are reduced from about 1000° to a value between 900° and 950° at the entrance to chamber 11. They leave chamber 11 at a temperature of the order of 550° and they discharge to stack 10 at temperatures as low as 250°.

Thus a good exchange of heat is secured with relatively small heat transfer surfaces. This is important because it reduces the amount of expensive heat resisting material such as is required in a device of this type. The design of the heater permits the use of high flow velocities

without requiring excessive pressure drops. In consequence an intense exchange of heat is secured under severe conditions, particularly the conditions which exist in the chamber 1 where the heating is largely by radiation. Since the air flows in parallel through two distinct paths, these paths must be designed to divide the flow in such a way that the air from the two paths reaches the junction point 13 at approximately equal temperatures.

An important feature is the scheme of mounting the final heat exchanger 45 on a removable cover plate 38. This has two advantages. It permits the exchanger 45 to be suspended and it permits its ready removal without requiring dismantling of the remainder of the heater.

In the diagrams, Figures 2 to 4 inclusive, alternative arrangements of the final heat exchanger 45 are suggested. To simplify the diagrams exchangers used to heat the combustion air are not illustrated. A primary and a secondary heater such as the parts 50 and 49 of Figure 1 could be used or they could be combined in a single heater, the particular details of the heater for combustion air being subject to design according to known practice.

Figure 2 shows how the final heat exchanger 45 can be mounted in the upper part of a vertical flue analogous to the flue 11 of Figure 1.

In Fig. 2 the numeral 15 denotes a combustion chamber and 16 a grate. The working medium to be heated flows in through a pipe 17 and is led through pipes 18 and 19 into distributors 20 and 21 respectively. The working medium flowing through tubes 22 which are mainly heated by radiation, passes into collecting headers 23 and from these through a pipe 24 into a collector 25. The working medium issuing from the distributing header 20 flows through a system of tubes 26 representing that part of a surface heated by contact which lies in the lower temperature range, and thereafter likewise into the collector 25. Hereupon, the whole quantity of working medium flows through a system of tubes 27 forming the second part of said surface heated by contact and in which this working medium is brought to its final temperature, whereafter it then passes to a collector 28 and thence to a consumer B designed as a turbine.

In Figure 2 the working medium flows through the exchanger 27 in counterflow relation to the combustion gases. In this respect it differs from the arrangement shown in Figure 1, but the arrangement of Figure 1 might be modified to secure counterflow, and this possibility is diagrammed in Figure 3.

In the embodiment of the invention shown in Fig. 3, the part 29 of the surface heated by contact, through which flows the whole quantity of working medium to be heated and which lies in the range of higher temperature, is arranged in a horizontal flue 30 connecting the combustion chamber 31 to a first vertical flue 32. Reference numeral 33 denotes a second vertical flue connected in series to said flue 32. The section 34 of the surface heated by contact and lying in the range of lower temperature is arranged in the vertical flue 32. The working medium to be heated flows through said section 34, as also through the heater section 29 designed as a tube nest, in a counter-current to the combustion gases. Between the two heater sections 29 and 34 a collecting header 35 and a distributing header 36 are arranged. The heating tube nest 29 is connected to this distributing header 36

and to a collecting header 37 so that it can be easily removed. This can be effected without the heater section 34, lying in the range of lower temperature and likewise designed as a tube nest, having to be removed at the same time. In this manner it is possible to circumvent the drawbacks involved by a suspension of the tube nests in the flues of gas heaters of the kind referred to herein and due to the difficulty in finding a material having the creep limit and non-scaling coefficient required for the suspension means. It is particularly the suspension of the part of the tube nest coming in contact with the gases still of high temperature issuing from the combustion chamber, which presents considerable constructional difficulties in this regard.

By placing the tube nest which forms a part of the contact heated section and lies in the range of higher temperature, in a horizontal flue connecting the combustion chamber to a vertical flue, said tube nest can, as illustrated, be suspended from its own collecting header and distributing header, so that it can be easily lifted out from above. Since it is just this tube nest of the heater section heated by contact which is most likely to be subject to a certain scaling action, thus calling for periodical overhauls, the possibility of removing same in an easy manner represents an appreciable advantage. Dismantling of this part can be further simplified if parts of the horizontal connecting flue are designed as a cover plate 38 (Fig. 3).

As pointed out, Figure 3 differs from Figure 1 in that the flow through the exchanger 29 is in countercurrent, whereas in Figure 1 the flow through the exchanger 45 is concurrent. Figure 3 differs from Figure 1 in another respect. There is only one exchanger 34 analogous to exchanger 46 and nothing analogous to the preheater exchanger 47.

Figure 4 shows an arrangement similar to Figure 3 except that the exchanger 39 is arranged for concurrent flow and thus resembles what is shown in Figure 1.

In the embodiment of the invention shown in Fig. 4 numeral 39 denotes a tube nest also arranged in a horizontal connecting flue 40 and in which the working medium issuing from a heater section 41 heated by radiation and from a heater section 42 situated in the range of lower temperature and heated by contact has to be raised to its final temperature. In contradistinction to the embodiment shown in Fig. 3, the arrangement is such that the working medium does not pass through said tube nest 39 as a countercurrent to the combustion gases but parallel thereto. This involves the advantage that those parts of the tube nest 39 coming in contact with the hottest combustion gases are traversed by a flow of working medium the temperature of which is still many degrees lower than that of the working medium issuing from this tube nest. For example, the working medium flowing into the distributing header 43 may have a temperature of 500° C. and that issuing from the collecting header 44 one of 600° C.

It is contemplated that heaters for combustion air would be used in the structure diagrammed in Figures 2, 3 and 4 and would be located in the final vertical flue such as the flue 33 of Figure 3.

What is claimed is:

1. A heater intended for heating gases to high temperatures, comprising in combination, means forming a combustion chamber and a passage for

conducting products of combustion from said chamber; a single-pass tubular heat exchanger in said combustion chamber mounted adjacent to the walls of the chamber so as to be heated mainly by radiation; a multi-pass tubular heat exchanger mounted with its tubes extending across said passage so as to be swept by combustion gases flowing through the passage; connections for supplying gas to be heated to both of said exchangers in parallel; a collector for the heated gases flowing from both said exchangers, said connections and collector being so related to the exchangers that the flow of gas through the single-pass exchanger is concurrent with the flow of combustion gases and the flow of gases through the multi-pass exchanger is countercurrent to the flow of products of combustion, the two exchangers being so proportioned that the temperatures of the gases flowing there-through are approximately equal as the gases reach said collector; and a second multi-pass tubular heat exchanger located in said passage near its junction with the combustion chamber and arranged to receive gases from said collector and discharge them to a point of use.

2. A heater intended for heating gases to high temperatures, comprising in combination, means forming a combustion chamber and a passage for conducting products of combustion from said chamber; a single-pass tubular heat exchanger in said combustion chamber mounted adjacent to the walls of the chamber so as to be heated mainly by radiation; a multi-pass tubular heat exchanger mounted with its tubes extending across said passage so as to be swept by combustion gases flowing through the passage; connections for supplying gas to be heated to both of said exchangers in parallel; a collector for the heated gases flowing from both said exchangers, said connections and collector being so related to the exchangers that the flow of gas through the single-pass exchanger is concurrent with the flow of combustion gases and the flow of gases through the multi-pass exchanger is countercurrent to the flow of products of combustion, the two exchangers being so proportioned that the temperature of the gases flowing there-through are approximately equal as the gases reach said collector; and a second multi-pass tubular heat exchanger located in said passage near its junction with the combustion chamber and arranged to receive gases from said collector and discharge them to a point of use, the arrangement being such that the flow of gases through the last-named exchanger is generally concurrent with the flow of combustion gases in contact therewith.

3. A heater intended for heating gases to high temperatures, comprising in combination, means forming a combustion chamber and a passage for conducting products of combustion from said chamber; a single-pass tubular heat exchanger in said combustion chamber mounted adjacent to the walls of the chamber so as to be heated mainly by radiation, said exchanger comprising a discharge manifold adjacent the upper limit of the combustion chamber, an intake manifold adjacent the lower limit of the combustion chamber, and a plurality of rising tubes, said tubes being of diminishing cross section upwardly whereby the velocity of the heated gases is caused to increase as the temperature of the heated gases increases; a multi-pass tubular heat exchanger mounted with its tubes extending across said passage so as to be swept by combustion gases flowing

through the passage; connections for supplying gas to be heated to both of said exchangers in parallel; a collector for the heated gases flowing from both said exchangers, said connections and collector being so related to the exchangers that the flow of gases through the multi-pass exchanger is counter-current to the flow of products of combustion, the two exchangers being so proportioned that the temperatures of the gases flowing therethrough are approximately equal as the gases reach said collector; and a second multi-pass tubular heat exchanger located in said passage near its junction with the combustion chamber and arranged to receive gases from said collector and discharge them to a point of use.

4. A heater intended for heating gases to high temperatures, comprising in combination, means forming a combustion chamber, a horizontal off-take leading laterally from the upper end thereof and a substantially vertical flue leading downward from said offtake; a single-pass tubular heat exchanger in said combustion chamber mounted adjacent to the walls of the chamber so as to be heated mainly by radiation; a multi-pass tubular heat exchanger mounted with its tubes extending across said flue so as to be swept by combustion gases flowing downward therethrough; means for supplying gas to be heated in parallel to the lower ends of both said exchangers; a collector for the heated gases flowing from the upper ends of both of said exchangers, the exchangers being so proportioned that the temperatures of gases flowing therethrough are approximately equal as the gases reach said col-

lector; and a second multi-pass exchanger located in said offtake and connected to receive gases from said collector and discharge them to a point of use.

5. A heater intended for heating gases to high temperatures, comprising in combination, means forming a combustion chamber, a horizontal off-take leading laterally from the upper end thereof and a substantially vertical flue leading downward from said offtake, a portion of the enclosing wall of the said offtake being removable; a single-pass tubular heat exchanger in said combustion chamber mounted adjacent to the walls of the chamber so as to be heated mainly by radiation; a multi-pass tubular heat exchanger mounted with its tubes extending across said flue so as to be swept by combustion gases flowing downward therethrough; means for supplying gas to be heated in parallel to the lower ends of both said exchangers; a collector for the heated gases flowing from the upper ends of both of said exchangers, the exchangers being so proportioned that the temperatures of gases flowing therethrough are approximately equal as the gases reach said collector; and a second multi-pass exchanger located in said offtake and connected to receive gases from said collector and discharge them to a point of use, the last-named exchanger being suspended from the removable portion of the offtake wall and being capable of disconnection without disturbing the other exchangers, whereby it is removable for replacement or repair.

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