Oct. 22, 1946. R. RUEGG 2,409,801

HIGH TEMPERATURE GAS HEATER

Filed Feb. 15, 1944 3 Sheets-Sheet 1

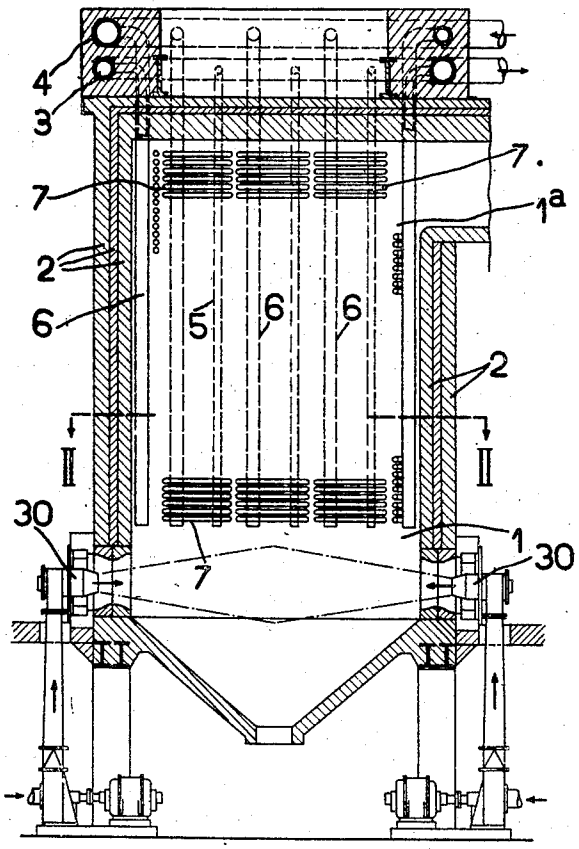

Fig. 1

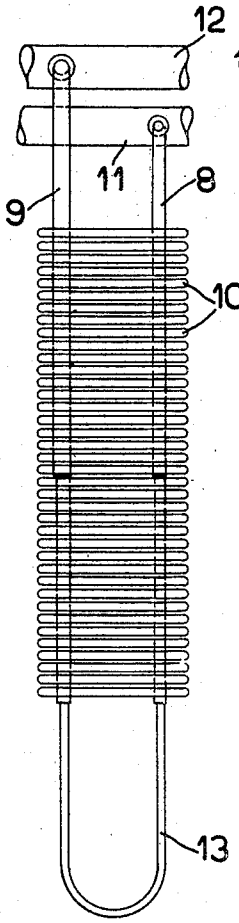

Fig. 3

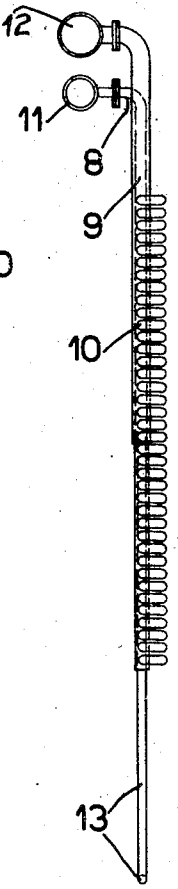

Fig. 4

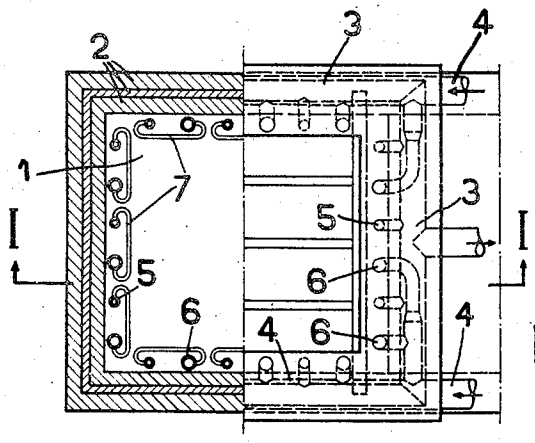

Fig. 2

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Filed Feb. 15, 1944 3 Sheets-Sheet 2

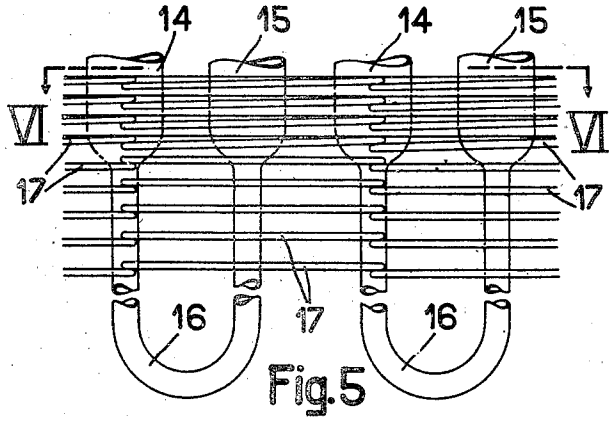

Fig.5

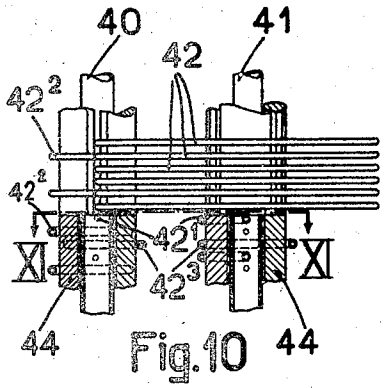

Fig.10

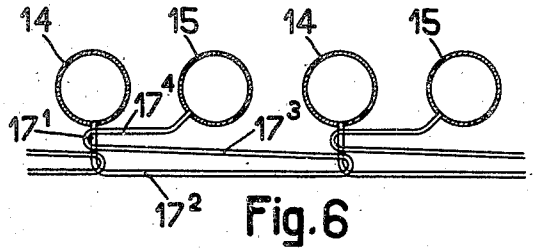

Fig.6

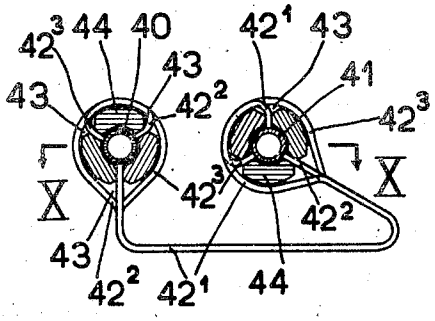

Fig. 11

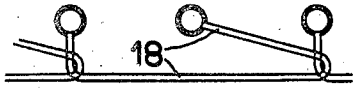

Fig.7

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Oct. 22, 1946. R. RUEGG 2,409,801

HIGH TEMPERATURE GAS HEATER

Filed Feb. 15, 1944 3 Sheets-Sheet 3

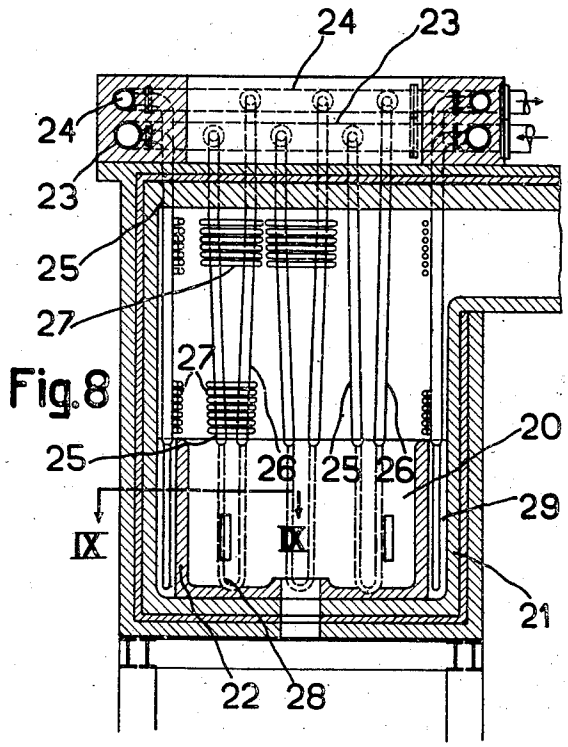

Fig. 8

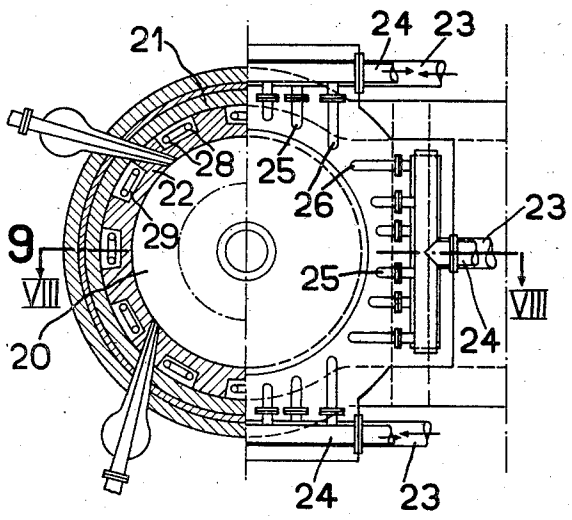

Fig. 9

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Patented Oct. 22, 1946

2,409,801

UNITED STATES PATENT OFFICE

2,409,801

HIGH-TEMPERATURE GAS HEATER

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Application February 15, 1944, Serial No. 522,470
In Switzerland March 29, 1943

7 Claims. (Cl. 126—109)

1

This invention relates to a tubular gas heater for attaining high gas temperatures of the type comprising heating surfaces arranged on the walls of a combustion chamber.

The object of the invention is to provide a device of this character in which a high velocity can be imparted to the gas to be heated, without any great losses of pressure being involved as a consequence thereof. High gas velocities are desirable as is well known, because the gases are then able to carry off a large amount of heat from the tubes through which they flow, so that no dangerous thermal stresses can arise in the tubes and safety in working is thereby increased. In order to achieve these different advantages, in a gas heater according to the present invention tubes project from at least one distributor and one collector arranged above the combustion chamber into the latter, and each of said tubes attached to the distributor is connected to a tube attached to the collector by a plurality of small tubes, which are exposed to the heat radiating from the fire produced in the heater, to form a heater element. Small connecting tubes of this kind can be made of quite a short length, which enables the object aimed at, i. e., high gas velocities and small losses of pressure, to be achieved. Thin small tubes, as is well known, afford also the advantage that, under otherwise equal conditions, the transmission of heat is better than in tubes of large diameter, so that smaller heating surfaces may be provided. In short tubes of small diameter also the thermal stresses are less than in long tubes of large diameter, as thin, short tubes can be brought to the same temperature more uniformly and more rapidly at all points, which also contributes to the attainment of greater reliability in operation.

The small tubes which connect the tubes attached to the distributor and collector, may cover the latter tubes in a curved form preferably over at least part of their periphery and in this way protect them to a considerable extent from the direct action of the heat radiating from the fire. Each heater element may also advantageously be attached to the distributor and collector by flanges, so that these elements can, for example, be detached singly and then replaced.

Several constructional forms of the subject matter of the invention are shown by way of example in the accompanying drawings in which:

Fig. 1 shows a vertical section through a gas heater on the line I—I of Fig. 2.

Fig. 2 shows at the left hand half a horizontal

2

section on the line II—II of Fig. 1, wherein the burners and the fittings to be provided with them are omitted for the sake of clearness, and at the right hand half a plan view of Fig. 1.

Fig. 3 shows on a larger scale than Figs. 1 and 2 a front view of a heater element and also of a portion of the distributor and collector to which this element is flanged, and

Fig. 4 shows a side view of this heater element.

Fig. 5 shows on a still larger scale than Figs. 3 and 4 and in elevation details of a further constructional form.

Fig. 6 is a section on the line VI—VI of Fig. 5.

Fig. 7 shows yet another constructional form of heater elements.

Fig. 8 is a section on the line VIII—VIII of Fig. 9 through a heater in which the tubes of the heater elements are arranged in the furnace chamber so as to converge towards the bottom thereof, so that the length of the small connecting tubes decreases as their distance from the distributor and collector increases.

Fig. 9 shows at the left hand half a horizontal section on the line IX—IX of Fig. 8 through the combustion chamber (the greater part of the heater elements being omitted for the cake of clearness) and at the right hand half a plan view of Fig. 8.

Fig. 10 shows, with regard to a further embodiment of the heater elements, partly a side view of a portion of two vertical tubes of a heater element and of the small tubes connecting these two tubes, and partly a section on the line X—X of Fig. 11, whilst

Fig. 11 shows a section on the line XI—XI of Fig. 10.

In Figs. 1 and 2 the reference 1 denotes a four-cornered furnace chamber of a gas heater arranged to be heated by burning coal dust and the reference 30 denotes coal dust burners of known type. The furnace chamber 1, from which the ashes are withdrawn in a solid form (granulated) is surrounded by walls 2 of fireproof building material. Above the furnace chamber 1 are arranged a collecting box 3 and a distributing box 4. To the collector 3 are suspended tubes 5 and to the distributor 4 are suspended tubes 6. The tubes 5 and 6 project vertically into the furnace chamber 1. Each tube 5 is connected to a tube 6 by a plurality of small tubes 7, which are exposed to the radiation of the fire produced in the furnace chamber 1. The small tubes 7 cover in a curved form (see particularly Fig. 2) the vertical tubes 5 and 6 co-ordinated with them over a portion of their circumference, so that said

tubes 5 and 6 are protected to a very considerable extent from the direct action of the heat radiated from the fire. Similarly the discharge end of each tube 7 lies behind and is protected by the main portion of that tube. This is important because the gases are very hot at such discharge end. A tube 5 forms with a tube 6 and the small tubes 7 connecting them, a heater element. The various heater elements are arranged as heating surfaces close to the internal surface of the walls 2. In order to eliminate any reduction of the cross sectional area of the passage for the flue gases at the outlet point 1^a therefor from the furnace chamber 1, the element tubes 5 and 6 are not connected at that point by small tubes.

In Figs. 3 and 4 is shown a single heater element. In these figures the reference numerals 8 and 9 denote the vertical tubes of the element and 10 the many small tubes which connect them. In this case the tube 8 is flanged to a collecting tube 11 and the tube 9 to a distributing tube 12, so that the elements 8, 9, 10 can be easily detached from the tubes 11 and 12 and thereafter be removed singly. The lower ends of the tubes 8 and 9 are connected by a bend-shaped tube 13 which is not protected by any small tubes from the heat radiated from the fire. It is advisable to make the diameter of the bend-shaped tube parts 13, which are not protected from the direct action of the heat radiated from the fire by small connecting tubes, smaller than the diameter of the vertical tubes connected by such bend-shaped parts, so as to obtain in the latter high velocities for the working medium to be heated.

In order to ensure as uniform a distribution as possible of the working medium to be heated over the various small connecting tubes 10, the vertical tubes 8 and 9 of the heater elements which are flanged to a collector 11 and distributor 12 respectively, are constructed in such a way that the diameter of these tubes 8 and 9 decreases as their distance from the distributor 12 and collector 11 respectively, increases. In Figs. 3 and 4 this decrease takes place by stages.

The diameter of the small connecting tubes of a heater element is always smaller by a multiple than that of the suspended element tubes which are connected by such small tubes. All the small connecting tubes of a heater element are preferably of the same length.

When the diameters of the tubes of the heater elements suspended to the distributor and collector are suitably determined, it can also be ensured that the temperatures in these tubes are at least approximately all the same throughout. Since the part of the working medium to be heated which flows through the tube attached to the collector is already more strongly heated than the part of the working medium which flows through the tube attached to the distributor, the diameter of the first-named tube may conveniently, as shown for instance in Figs. 1 to 4, be of smaller dimensions than that of the second-named one, so as to obtain greater velocities of flow therein. This difference of size has been somewhat exaggerated in the drawings in order to render it readily noticeable.

In Figs. 5 and 6, the reference numerals 14 and 15 denote the two vertical tubes of a heater element, the diameter of these tubes decreasing from top to bottom greatly. The lower ends of each two co-ordinated tubes 14, 15 are connected by a double bend 16. Reference 17 denotes in these figures the plurality of small tubes which connect the two vertical tubes 14, 15 of a heater

element. The small connecting tubes 17 are constructed in the form of coiled tubes with three deflecting bends, so that they have, as shown in Fig. 6, four limbs 17^1, 17^2, 17^3 and 17^4. The small tubes 17 are connected to the tubes 14 and 15 of the different heater elements in staggered order. The staggering is such that all the small tubes 17 are of approximately the same length. The limb 17^2 through which the colder working medium flows is exposed to the direct action of the heat radiated from the fire, while the limbs 17^3, 17^4, through which the part of the working medium already heated flows, are protected by the limbs 17^2 from direct radiation. In this way the discharge end of the tube is given even greater protection than is had with the construction described with reference to Figs. 1 to 4. The coil-shaped connecting tubes 17 interengage so that each offers support to another. The support may conveniently take place at points where the small connecting tubes 17 are traversed by comparatively cool working medium, since the strength of said tubes is the greatest at these points owing to the low tube wall temperatures prevailing there.

In Fig. 7 is shown a type of construction in which the small connecting tubes 18 which have only two deflecting bends and three limbs are supported mutually.

Figs. 8 and 9 show the application of the invention to an air heater 21 with a circular combustion chamber 20. In the lower part, that is to say in the fusion chamber proper, the boundary wall of the chamber 20 is protected from the heat radiated from the fire by a wall 22 of a highly fireproof mass of masonry built up in front of it. In these Figs. 8 and 9 the reference 23 denotes distributors and the reference 24 collectors. To the distributors 23 are connected tubes 25 which project vertically into the furnace chamber 20, and to the collectors 24 are connected vertical tubes 26. The connections in question are the longer, the farther they are from the transverse central line of the distributors 23 and collectors 24 respectively. A tube 25 and a tube 26 form, together with a plurality of small tubes 27 connecting them, a heater element, and all these elements are arranged close to the inner surface of the air heater 21. The tubes 25, 26 of each element project only close up to the masonry 22 and at the bottom are connected by a bend 28. The tubes 25, 26 of each heater element are in this case arranged convergently, so that the length of the small connecting tubes 27 decreases as the distance from the distributors 23 and collectors 24 increases. In this way it can be ensured that at the points where the radiation of heat into the small connecting tubes 27 is strong the working medium possess a high velocity, so that a sufficient carrying off of the heat is ensured. The bends 28 connecting a tube 25 to a tube 26 are arranged in recesses 29 in the masonry 22 and as this latter allows comparatively little heat to pass through it, the bends 28 do not require to be provided with any small connecting tubes to protect them from the heat radiated from the fire. In case of necessity however the two loops of the bends 28 may be connected by small tubes, in which case the division between these small tubes may be greater than between the small tubes 27.

By making the distance between the small connecting tubes of a heater element shorter at the points where the radiation of heat into them is high than at the points where it is less, the degree to which the walls of the furnace chamber

can be cooled by the heater elements may be influenced. In such case it is advisable, as shown in the constructional form illustrated in Figs. 8 and 9, to make the small connecting tubes **27** shorter at the points where the radiation of heat is high, i. e., mainly in the lower part of the combustion chamber, than at the points where the radiation is less, that is to say in the upper part of the combustion chamber, in order to obtain greater velocities of the working medium at the first named points.

To permit of the tubes of the heater elements connected to the distributor and collector being made with relatively thin walls, these tubes are preferably insulated against heat. Figs. 10 and 11 illustrate how this can be done in a convenient manner. In these figures the numerals **40** and **41** again denote the two vertical tubes of a heater element, which are connected to one another by a plurality of small tubes **42**. These tubes **42**, which are exposed to the heat radiated from the fire produced in the heater, are bent around a part of the circumference of at least one of the tubes **40** and **41** respectively, whereby an intermediate space **43** is confined. Thus, for example, the small tube denoted by its own numeral 42^1 is bent through an angle of approximately 240° in a clockwise sense around the circumference of tube **41**, whilst the adjacent small tube 42^2 is bent through an angle of approximately 240° in a clockwise sense around the circumference of tube **40**, and the small tube 42^3 below tube 42^2 is bent through an angle of 240° in an anti-clockwise sense both around the circumference of tube **40** and likewise around tube **41**. The points of connection of the three adjacent small connecting tubes 42^1, 42^2, 42^3 to the tubes **40** and **41** are, in relation to the axis of the latter, each staggered by approximately 120°. The intermediate spaces **43** between the plurality of small connecting tubes **42** and the tubes **40** and **41** are filled for the greater part with insulating material **44**, kept in place by the small connecting tubes **42** which are bent like a grid around the tubes **40**, **41**.

The points of connection of the small connecting tubes **42** with the tubes **40** and **41** of the corresponding heater element can, also in this case, be so distributed and the small tubes **42** can be bent around tubes **40**, **41** to such an amount that all small tubes **42** of at least a section of the heater elements are of practically equal length. In such a case and assuming that the small connecting tubes have all the same diameter, the velocity inside said small tubes and thus also the heat transmission coefficients and the wall temperature of all the small tubes are at corresponding points equally high.

What is claimed is:

1. A gas heater for operation at high temperatures, comprising in combination, means enclosing a combustion chamber; at least one burner for causing combustion therein; means including at least one distributor duct having a supply connection for gas to be heated, and at least one collector duct having a discharge connection for heated gas, said distributor and collector ducts being located above the combustion chamber; pairs of tubes, respective tubes of each pair communicating with and being pendant from the distributor duct and the collector duct, said tubes extending into the combustion chamber and overlying the side walls thereof; and a plurality of tubes smaller and shorter than the pendant tubes and connected in parallel with each other between the tubes of each pendant pair, said small tubes extending inward from and being curved to overlie the pendant tubes and substantially mask the same from radiant heat from said combustion means.

2. A gas heater for operation at high temperatures, comprising in combination, means enclosing a combustion chamber; at least one burner for causing combustion therein; means including at least one distributor duct having a supply connection for gas to be heated, and at least one collector duct having a discharge connection for heated gas, said distributor and collector ducts being located above the combustion chamber; pairs of tubes, respective tubes of each pair communicating with and being pendant from the distributor duct and the collector duct, said tubes extending into the combustion chamber and overlying the side walls thereof; and a plurality of tubes smaller and shorter than the pendant tubes and connected in parallel with each other between the tubes of each pendant pair, said small tubes being looped inward to overlie the pendant tubes, at least the discharge end of each small tube curving back behind another portion of the same small tube, whereby the pendant tubes and the discharge ends of the small tubes are masked from radiant heat by portions of the small tubes in which the flowing gas has not been fully heated.

3. The combination defined in claim 2 in which there are a plurality of pairs of pendant tubes and the small tubes connecting each pair are offset vertically with respect to those which connect adjacent pairs, the small tubes associated with respective adjacent pairs being formed to intermesh.

4. A gas heater for operation at high temperatures, comprising in combination, means enclosing a combustion chamber; at least one burner for causing combustion therein; means including at least one distributor duct having a supply connection for gas to be heated, and at least one collector duct having a discharge connection for heated gas, said distributor and collector ducts being located above the combustion chamber; pairs of tubes, respective tubes of each pair communicating with and being pendant from the distributor duct and the collector duct, said tubes extending into the combustion chamber and overlying the side walls thereof; and a plurality of tubes smaller and shorter than the pendant tubes and connected in parallel with each other between the tubes of each pendant pair, said pendant tubes being reduced in size toward their lower ends whereby the gas flows faster through these tubes in the region of highest temperature, the small tubes being formed to mask the pendant tubes from radiant heat.

5. A gas heater for operation at high temperatures, comprising in combination, means enclosing a combustion chamber; at least one burner for causing combustion therein; means including at least one distributor duct having a supply connection for gas to be heated, and at least one collector duct having a discharge connection for heated gas, said distributor and collector ducts being located above the combustion chamber; pairs of tubes, respective tubes of each pair communicating with and being pendant from the distributor duct and the collector duct, said tubes extending into the combustion chamber and overlying the side walls thereof; and a plurality of tubes smaller and shorter than the pendant tubes and connected in parallel with each other between the tubes of each pendant

pair, said pendant tubes being reduced in size toward their lower ends whereby the gas flows faster through these tubes in the region of highest temperature and the pendant tube connected with the collector duct being smaller than that connected with the distributor duct, whereby the gas is caused to flow faster after it has been heated in the small tubes, the small tubes being formed to mask the pendant tubes from radiant heat.

6. A gas heater for operation at high temperatures, comprising in combination, means enclosing a combustion chamber; at least one burner for causing combustion therein; means including at least one distributor duct having a supply connection for gas to be heated, and at least one collector duct having a discharge connection for heated gas, said distributor and collector ducts being located above the combustion chamber; pairs of tubes, respective tubes of each pair communicating with and being pendant from the distributor duct and the collector duct, said tubes extending into the combustion chamber and overlying the side walls thereof; and a plurality of tubes smaller and shorter than the pendant tubes and connected in parallel with each other between the tubes of each pendant pair, said small tubes being curved to overlie the pendant tubes and substantially mask the same from radiant heat from said combustion means,

the pendant tubes of a pair converging toward their lower ends and the small connecting tubes being progressively shorter toward said lower ends, whereby flow through the lower connecting tubes is facilitated.

7. A gas heater for operation at high temperatures, comprising in combination, means enclosing a combustion chamber; at least one burner for causing combustion therein; means including at least one distributor duct having a supply connection for gas to be heated, and at least one collector duct having a discharge connection for heated gas, said distributor and collector ducts being located above the combustion chamber; pairs of tubes, respective tubes of each pair communicating with and being pendant from the distributor duct and the collector duct, said tubes extending into the combustion chamber and overlying the side walls thereof; a plurality of tubes smaller and shorter than the pendant tubes and connected in parallel with each other between the tubes of each pendant pair, said small tubes overlying said pendant tubes and being looped at their ends partially around the pendant tubes whereby the pendant tubes are masked from radiant heat by the small tubes; and thermal insulating members embracing the pendant tubes and partially encircled by the looped ends of the connecting tubes.

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