March 6, 1951 C. KELLER 2,544,600

MULTIPLE TUBE GAS HEATING FURNACE

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Fig. 1

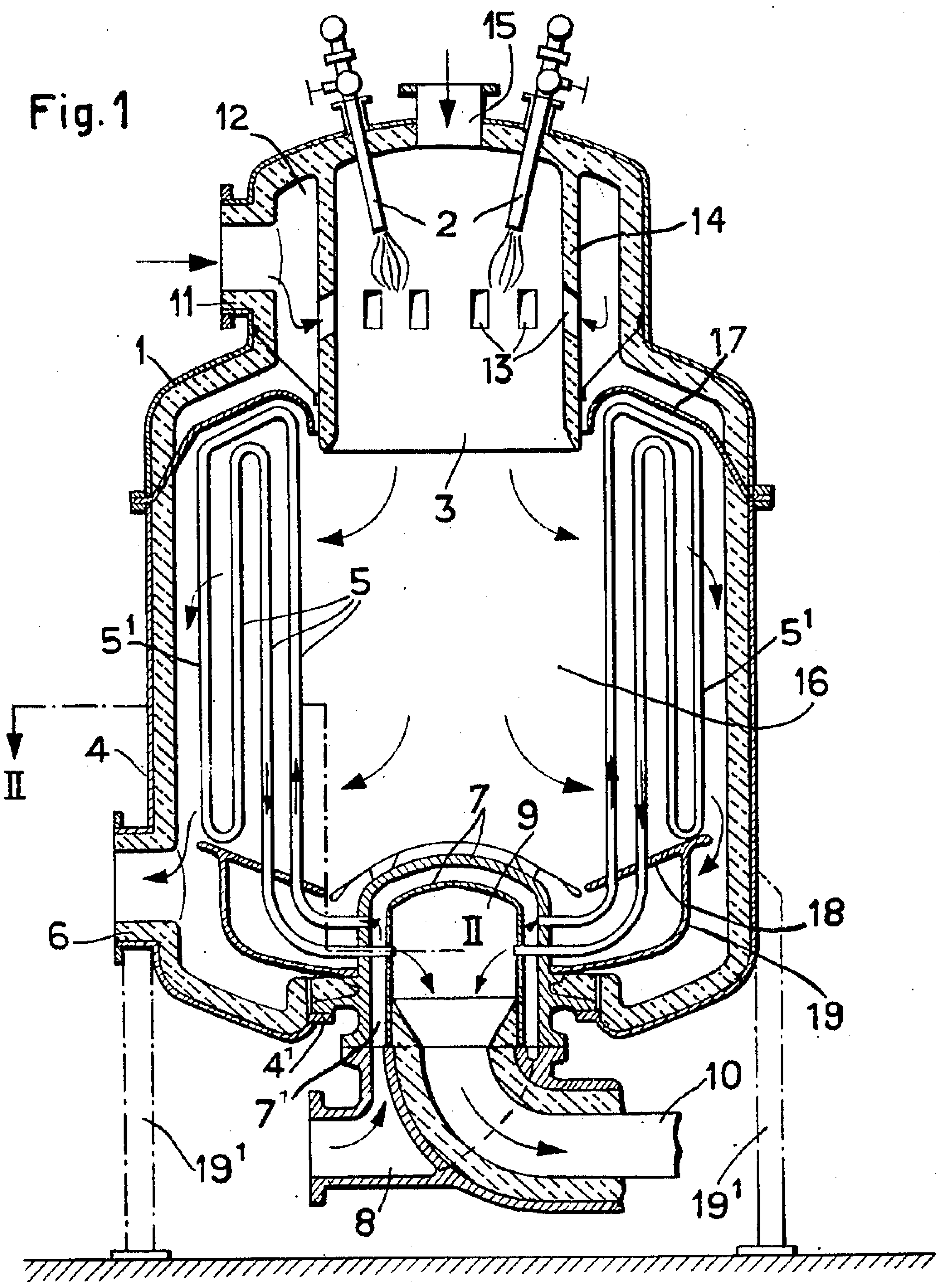
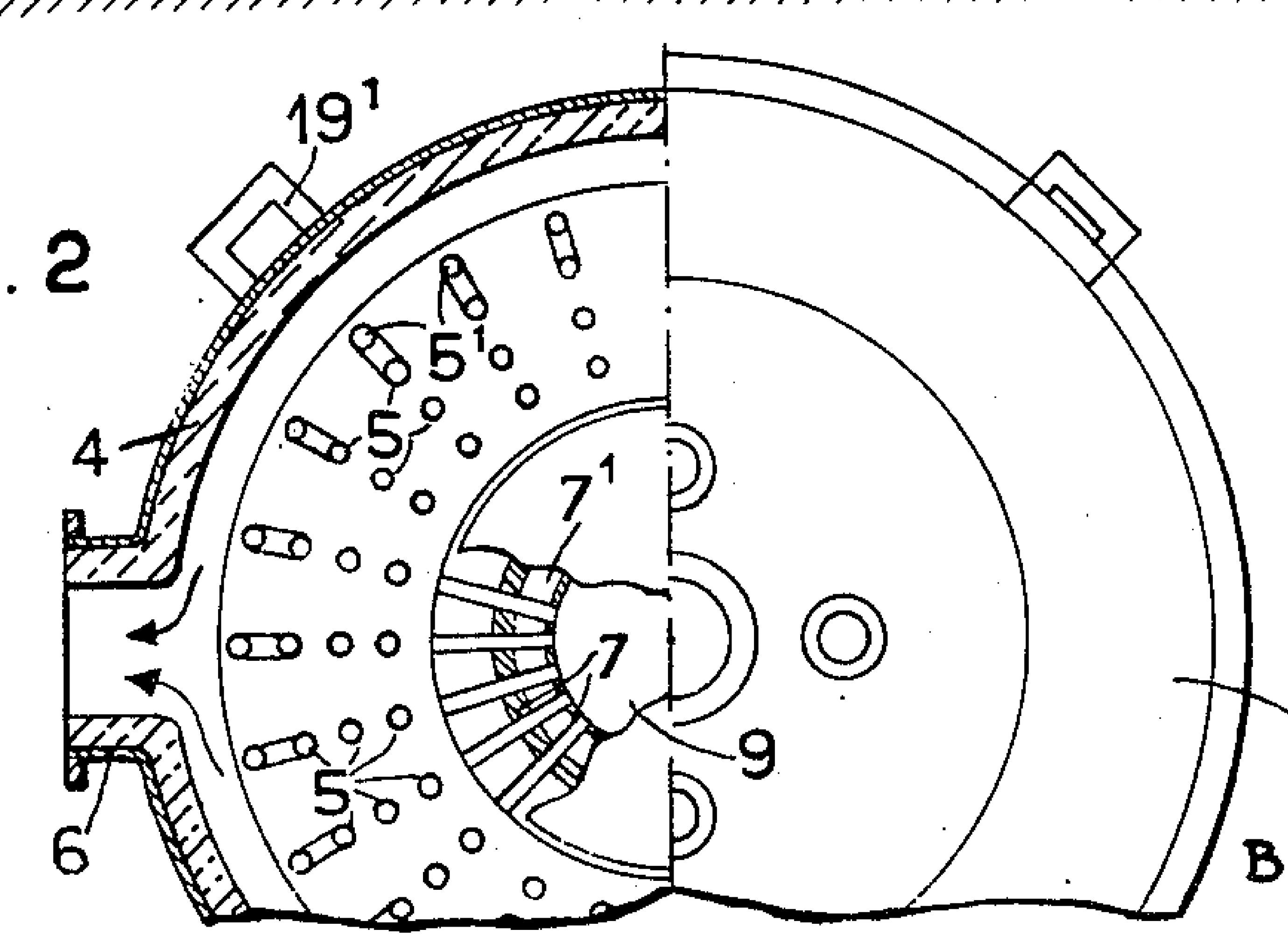


Fig. 2



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MULTIPLE TUBE GAS HEATING FURNACE

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Fig. 3

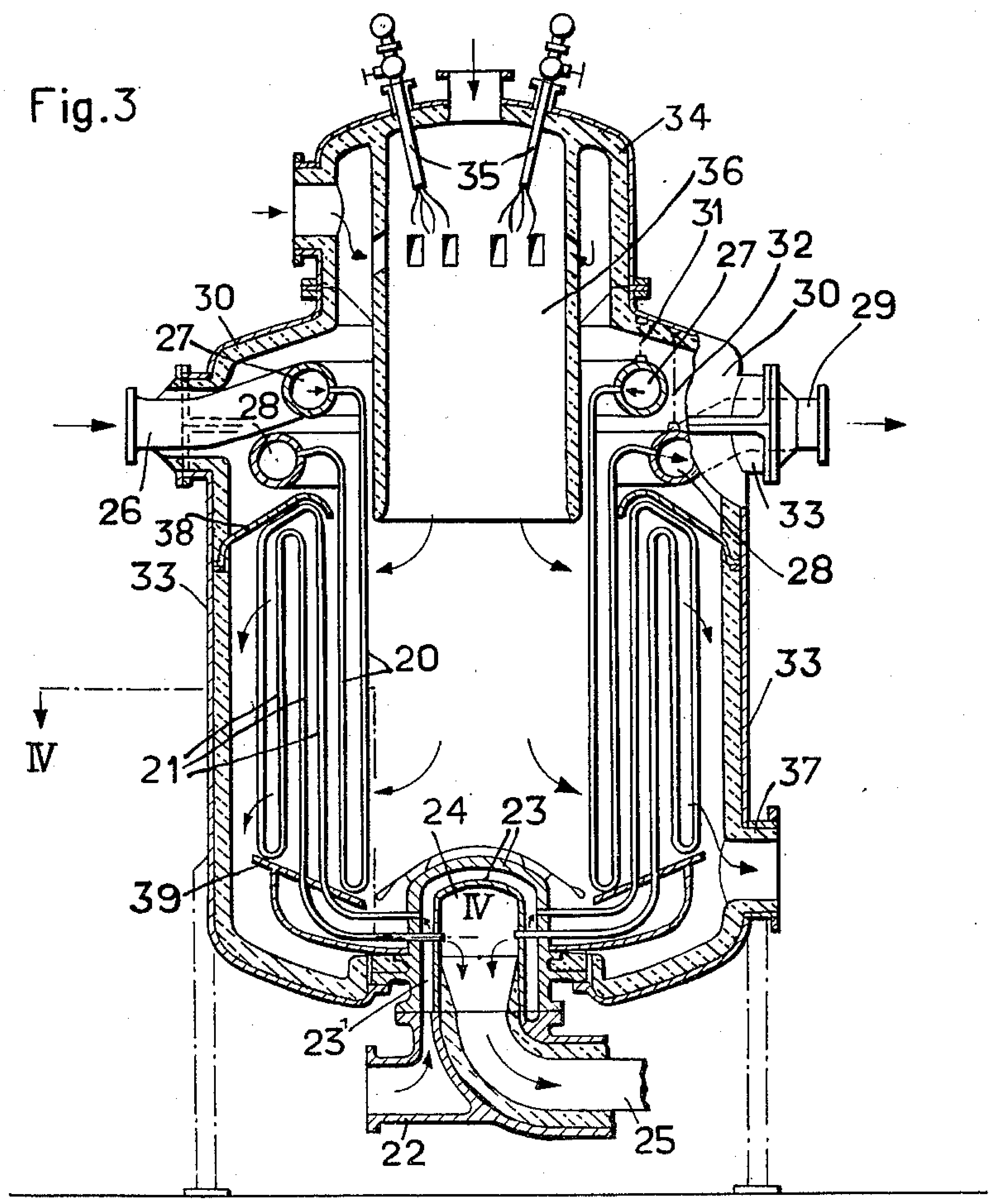
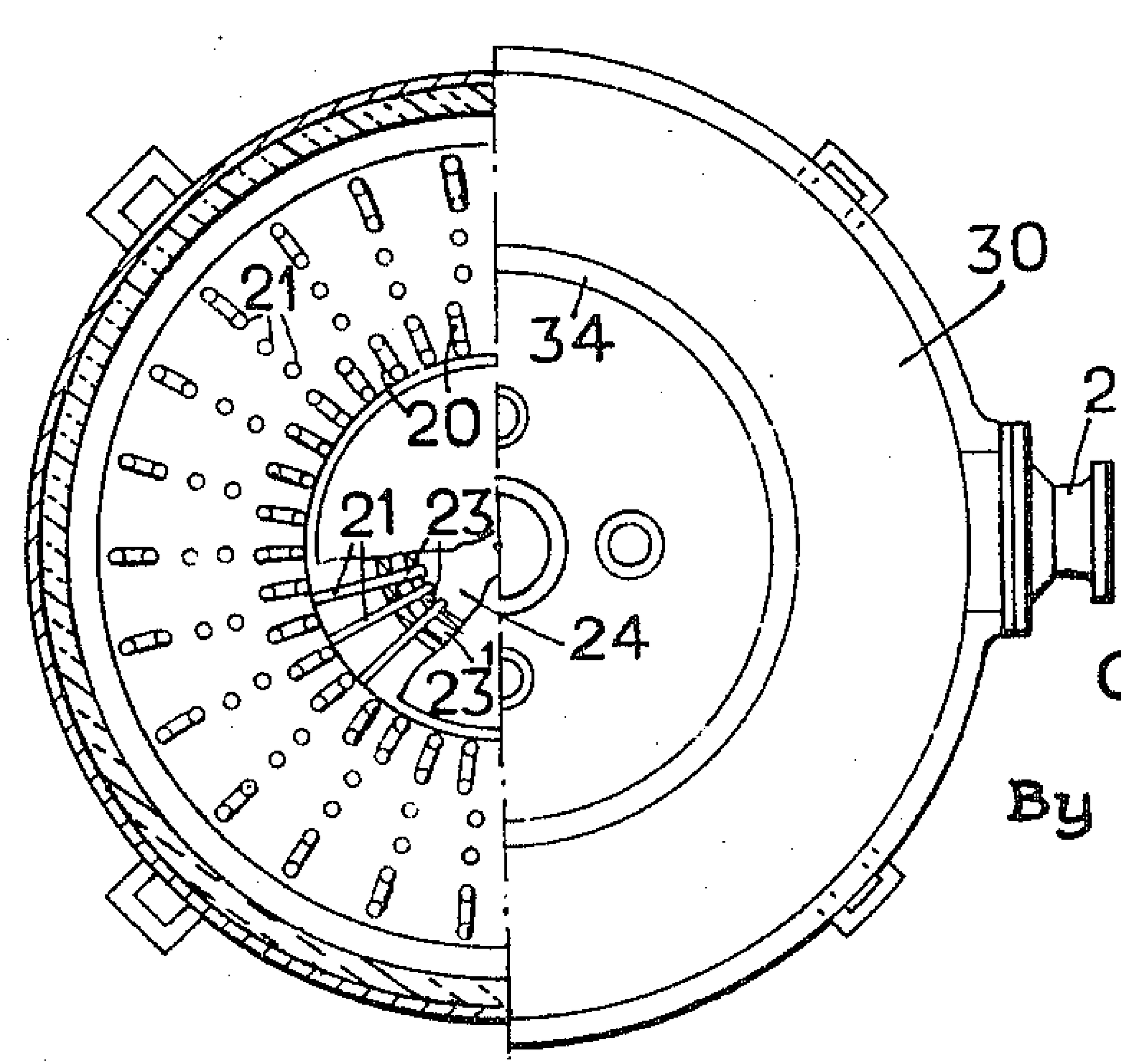


Fig. 4



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MULTIPLE TUBE GAS HEATING FURNACE

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11 Claims. (Cl. 126—109)

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This invention relates to a tubular gas heater; more especially to a heater of this kind for incorporation in a gas turbine plant with an indirect supply of heat to the working medium.

One object of the said invention is to provide a tubular gas heater in which the heating tubes though arranged in as compact a system as possible, are yet easily accessible. This last-named feature is particularly valuable when the tubular gas heater is incorporated in a gas turbine plant with an indirect supply of heat to the working medium, as, in such case, the heater tubes are subjected to severe stresses, on account of the high temperatures attained; thus it is important to be able, when necessary, to repair the tubes or to change them and to clean any fouled tubes.

Another object of this invention is to provide a tubular gas heater in which flue walls and deflector walls (which do not participate directly in the heat exchange but only cause pressure losses on the heating gas side of the heat exchange system) are reduced to a minimum. A further object of the invention is to provide a tubular gas heater needing comparatively little headroom for dismantling and having the smallest diameter possible but in which the parts subjected to the highest temperatures shall be able to move freely, while the absolute expansions are slight and the relative positions of the necessary connecting points remain practically unchanged.

In order to secure all these advantages, a tubular gas heater according to the present invention is provided with a removable combustion chamber, which is co-axial with the longitudinal axis of said heater, and is in direct communication with at least one system of heating tubes likewise arranged coaxially with respect to the said longitudinal axis so that its tube nests are traversed externally, from the inside to the outside of the system and mainly in transverse directions, by the heating gases issuing from the said combustion chamber. In such a gas heater, a distributing chamber for the gas to be heated may surround, within a double-walled structural member, a collecting chamber for the gas brought to the temperature and the pressure needed, for instance, at the inlet to a first expansion stage. The distributing chamber and the collecting chamber may, likewise, be co-axial with the longitudinal axis of the heater.

Two constructional embodiments of the subject matter of the invention are illustrated, by way of example, in the accompanying drawings, in which:

Fig. 1 shows, in axial vertical section, one form

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of construction for a tubular heater which is suitable for heating air used as the working medium in a thermal power plant of the well known kind in which such working medium operates in a closed circuit.

Fig. 2 as regards its right hand half, is a plan view of the heater shown in Fig. 1, while the left hand half of Fig. 2 is a section taken in the horizontal planes whose positions are indicated by the line II—II in Fig. 1.

Fig. 3 is a view similar to Fig. 1 showing another form of construction for a tubular heater adapted to serve the same purpose as that mentioned in connection with the first example, while

Fig. 4 is a plan view, half in section, of the heater of Fig. 3, the section being taken on line IV—IV of Fig. 3.

In Figs. 1 and 2, which show an oil-fired tubular heater, suitable for heating air, as aforesaid, the reference 1 denotes a casing element which is coaxial with the longitudinal axis of the heater and is insulated internally. This casing element embodies and contains a co-axial combustion chamber 3 and also carries the burners 2 which work in the said combustion chamber. Reference 4 denotes a second or lower casing element, which is likewise insulated internally and arranged co-axially with respect to the longitudinal axis of the heater. The casing element 1 is connected detachably (but in gastight fashion) to the casing element 4 which latter surrounds a tubular heating system 5 comprising a number of lengths of tubing arranged as compactly as possible, with the avoidance, so far as this is possible, of dead spaces and bypasses for the heating gases. This heating system 5, also arranged coaxially with respect to the longitudinal axis of the heater, is provided immediately beyond the combustion chamber 3 so that its tube nests are traversed exteriorly from the inside to the outside of the system and principally in a transverse direction, by the heating gases which issue from the said combustion chamber. The heating gases which have swept through the tube system 5 and given up heat to the tubes, escape from the heater through a branch 6 of the casing element 4. Reference 7 denotes a double-walled structural member provided at the lower part of the heater and, again, co-axial with the longitudinal axis of the latter. This member 7 is detachably connected at the seating 4^1 to the casing element 4. Reference 7^1 denotes a distributing chamber provided in the member 7 for the air which is to be heated and which flows in, under the necessary pressure, through a branch 8. This air may, for instance, come from the heat exchanger of a thermal power plant, in which air, serving as the working medium, flows in a closed circuit. The inlet ends of the tubes of the system 5 open into this distributing chamber 7^1, which concentrically surrounds a collecting chamber 9 for the air brought to the required temperature in the said heating tubes and this heated air flows through a pipe 10 to a point of consumption such, for example, as a turbine in a thermal power plant of the kind above referred to.

It will be observed that, in the heater constructed as above described, those parts of the heating tube system 5 through which flows the coldest part of the air to be heated are located nearest to the longitudinal axis of the heater. The tube parts 5^1, directly connected to the aforesaid parts next to the heater axis, are, however, so disposed in the heating chamber 16 that the coldest waste gases impinge upon them.

The air which is required for combustion and which is preferably preheated, enters the casing element 1 through a branch 11, passing first into a chamber 12 which co-axially surrounds the combustion chamber 3. From the chamber 12, part of the combustion air then flows directly into the combustion chamber 3 through slots 13 in a partition wall 14 which surrounds the said combustion chamber; the other part of said combustion air flows along the external surface of said partition wall and hereupon into the heating chamber 16. Additional air for the support of combustion also flows directly into the combustion chamber 3 through a branch 15 right at the top of the heater. This additional combustion air may be preheated.

Reference 17 denotes a guide plate which is arranged close to the upper bends of the tubing in the system 5 and which, as seen in Fig. 1, is detachably clamped in the joint between the casing elements 1 and 4. Another guide plate 18 is arranged close to the lower bends in the tubing of the system 5. The guide plate 18 rests upon a wall 19 connected with the structural part 7. These guide plates 17 and 18 are disposed convergently, in such a way that they impart the desired velocity to the fire gases and waste gases flowing between them through the heating system 5. For instance, the velocity of these gases may be kept constant. The heater may be supported in any convenient manner, for instance, on stanchions as at 19^1.

If the casing element 1 be detached from the casing element 4 it will bring with it the burners 2 and the partition wall 14 surrounding the combustion chamber 3 so exposing the tube nests of the system 5, and rendering them easily accessible from inside for such purposes as cleaning, overhauling or replacing. Moreover, when necessary, the whole of the tube system 5 together with the structural part 7 and the plate 18 and wall 19 can be lifted bodily out of the casing element 4, the headroom needed for this dismantling operation being substantially less than in the case of tubular gas heaters of the longitudinal flow type in which the wall surrounding the combustion chamber extends far deeper into the heating chamber.

Owing to the symmetrical arrangement of the nests of tubing in the system 5 and of the chambers 7^1 and 9 relatively to the longitudinal axis of the heater, free movement of these tube nests and of the structural part 7 surrounding these said chambers in permitted; thus the relative positions of the connecting flanges on the parts in question remain unchanged, because all radial expansions proceed outwards from the longitudinal axis aforesaid.

The tubular heater shown in Figs. 3 and 4 is intended for a hot air turbine plant in which the expanding air is re-heated at least once. Two systems of tube nests 20 and 21 each as compact as possible, are therefore provided, both systems being arranged co-axially in relation to the longitudinal axis of the heater. The system 21 surrounds the system 20 for the greater part of the length of the latter. The high pressure air to be heated flows through a branch 22 into a distributing chamber 23^1 in a double-walled structural member 23, which is arranged co-axially in relation to the longitudinal axis of the heater, and the inlet ends of the tube nests comprised in the system 21 open into the said chamber 23^1. The air, brought to the required temperature in the system 21, passes into a collecting chamber 24 which is located in the innermost part of the structural member 23 and is surrounded concentrically by the aforesaid distributing chamber 23^1. From the collecting chamber 24 the heated air flows through a pipe 25 to a high pressure turbine (not shown) in which it expands to a certain extent, cooling down as it does so. This expanded air then flows through a branch 26 into a distributing header 27 belonging to the second system 20 of heating tubes. From said header the air passes into and through the individual tubes of the system 20 and is thus re-heated and delivered into a collecting header 28, out of which it passes through a branch 29 and a pipe (not shown) to a low pressure turbine (likewise not shown) in which machine it expands still further.

The distributor 27 and the collector 28, on which the tube nests of the system 20 hang, are arranged inside an upper casing element 30, being movably connected thereto, as is indicated by dot and dash lines 31 and 32 in Fig. 3. The upper casing element 30 of the heater is detachably mounted on a lower casing element 33 to which also the structural member 23 is detachably secured. A hood 34, which contains the burners 35 and surrounds a combustion chamber 36 is detachably connected to the casing element 30. By a suitable inclined arrangement of guide plates 38 and 39 (whereof the guide plate 38 is detachably fixed to the element 33 while the guide plate 39 is connected to the structural part 23), it is possible to impart to the fire gases and waste gases passing, in the main, transversely through the systems 20 and 21, a desired velocity at all points of the path in question.

In the type of construction last described the two heating tube systems 20 and 21 are also in direct communication with the combustion chamber 36. At the same time, the combustion chamber 36 and the systems 20, 21 and the structural member 23 are all arranged in co-axial relation to the longitudinal axis of the heater. The tube nests of the two systems 20 and 21 are, as aforesaid, traversed, in the main, transversely from the inside to the outside by the fire gases and waste gases, the latter passing out through a branch 37.

On disconnecting the hood 34 from the casing element 30 the combustion chamber 36, together with the burners 35, can be lifted out in the upward direction and the tube nests of the system

20 are then accessible from the inside of the heating chamber. After having separated the casing elements 30 and 33, the heating tube system 20 can be lifted out upwards, quite independently of the system 21; this renders the tube nests of the said system 21 freely accessible from the heating chamber. Finally, after breaking the joint between the structural member 23 and the casing element 33, the second heating tube system 21 and, with it, the structural part 23 may also be drawn out upwards. The headroom necessary for the removal of these various parts is comparatively small.

The fact that, in both the heaters above described, a comparatively small amount of space is required to make the heating tube systems accessible from the heating chamber, and to enable them to be removed, if necessary, is of particular importance in the case of tubular heaters installed in ships, in which, as a rule space is very strictly limited.

Instead of the oil furnaces shown in the figures, furnaces for other fuels, such for example, as pulverised coal or gases may be used.

Under certain circumstances, waste gases which escape from the heating chambers of the heater, may be returned to the combustion chamber in order to help to support combustion. Thus in the case of a heater construction as in Figs. 1 and 2, for example, such waste gases will be introduced through the branch 11, while preheated fresh air can be introduced through the branch 15. With the help of returned flue gases or fresh cooling air flowing over the external surface of the partition wall bounding the combustion chamber, it is possible to produce, in the heating chamber, which is always in direct communication with the combustion chamber, such a temperature that the radiant heat emanating from the said heating chamber shall not be dangerous to the tube nests of the heating system or heating systems.

Since, in a tubular gas heater according to the present invention, the pressure losses on the heating gas side can, as already stated, be kept comparatively low, a heater of this kind is particularly well suited for cases in which the heating chamber is supercharged, that is to say, where a pressure higher than atmospheric pressure is maintained in this chamber. Under such working conditions it is important to be able to operate with low pressure losses in the heating chamber, because the output of the turbine which drives the supercharging compressor and is itself driven by the waste gases from the heating chamber will be greater the greater the residual pressure of the waste gases.

What is claimed is:

1. A heater intended for heating gases and comprising in combination a generally cylindrical casing, closed at its ends and divided transversely into first and second normally connected but separable parts, the first of said casing parts having a ported, open-ended, tubular projection extending inward from its closed end and dividing a combustion chamber within said tubular projection from an annular combustion-air chamber which encircles the same, and the second of said casing parts enclosing a heating chamber into an unobstructed axial portion of which combustion products may flow in an axial direction from said combustion chamber; combustion burners arranged to operate in said combustion chamber; a connection for supplying air

to said annular chamber; tubular heat transfer units arranged within said heating chamber and surrounding said unobstructed axial portion; two annular generally conical baffles so mounted in said heating chamber as to converge outward and to lap corresponding opposite end portions of said tubular heat transfer units, the first of said baffles extending from the peripheral wall of the cylindrical casing nearly to the open end of the tubular combustion chamber from which it is spaced to afford an annular entrance passage for secondary air, and the second of said baffles extending nearly but not quite to the peripheral wall of said casing to define behind the baffle an offtake space to which products of combustion can flow past the periphery of the baffle after sweeping the surface of said heat transfer units; means providing an outlet from said offtake space; and connections for leading gas to be heated to and from said tubular heat transfer units.

2. The combination defined in claim 1 in which the tubular heat transfer units are in the form of tubes bent to form radially arranged flat coils having passes which are approximately parallel with the axis of the heating chamber, and the course of gas to be heated through said coils is such that it first traverses a pass adjacent said unobstructed axial portion of the heating chamber and next traverses a pass adjacent the wall of the casing.

3. The combination defined in claim 1 in which the first baffle is retained in the joint between the two separable casing-parts so as to be freed for removal upon separation of said parts.

4. The combination defined in claim 1 in which the tubular heat transfer units, and the second baffle are constructed as a unit with and are supported by a manifold arranged to serve as the connections for leading the gas to be heated to and from the tubular units, the unit structure so formed being removably mounted in said cylindrical casing.

5. The combination defined in claim 1 in which the tubular heat transfer units, and the second baffle are constructed as a unit with and are supported by a manifold arranged to serve as the connections for leading the gas to be heated to and from the tubular units, the unit structure so formed being removably mounted in the second of said casing parts and the first baffle is retained in the joint between the two separable casing parts so as to be freed for removal upon separation of said parts.

6. The combination defined in claim 1 in which the connections for leading gas to be heated to and from the tubular heat transfer units comprise a double walled unit affording two manifold spaces, one enveloping the other, to which spaces the tubular heat transfer units are connected in parallel.

7. The combination defined in claim 1 in which the connections for leading gas to be heated to and from the tubular heat transfer units comprise a double walled unit affording two manifold spaces, one enveloping the other, to which spaces the tubular heat transfer units are connected in parallel, said double walled unit serving as the sole support for said tubular units and being bodily removable from the casing therewith.

8. A heater intended for heating gases and comprising in combination a generally cylindrical casing, closed at its ends and constructed in separable parts, one end part being formed with a ported open-ended tubular projection ex-

tending inward from its closed end and dividing a combustion chamber within said tubular projection from an annular combustion-air chamber which encircles the same, and the other end part enclosing a heating chamber into the unobstructed axial portion of which combustion products may flow in an axial direction from said combustion chamber; combustion burners arranged to operate in said combustion chamber; a connection for supplying air to said annular chamber; supply and collection manifolds adjacent said annular chamber; a plurality of looped heat exchange tube-passes connecting said manifolds and projecting into said heating chamber in circular series around said unobstructed axial portion thereof; an annular group of tubular heat transfer units also in said heating chamber around said circular series of heat exchange passes; two annular, generally conical baffles so mounted in said heating chamber as to converge outward and to lap corresponding end portions of the tubular heat transfer units, the first of said baffles extending from the peripheral wall of the cylindrical casing nearly to the open end of said combustion chamber and the second of said baffles extending nearly but not quite to the peripheral wall of said casing to define behind the baffle an offtake space to which products of combustion can flow around the periphery of the baffle after sweeping the surfaces of said heat exchange tube passes and tubular heat transfer units; means providing an outlet from said offtake chamber; and connections for leading gas to be heated to and from said supply and collection manifolds and to and from said tubular heat transfer units.

9. The combination defined in claim 8 in which the cylindrical casing comprises two end parts and an intermediate part and the joint between an end part and the intermediate part is so located that when these parts are separated the supply and collection manifolds and the looped heat exchange tube-passes connecting them may be withdrawn as a unit.

10. The combination defined in claim 8 in which the cylindrical casing comprises two end parts and an intermediate part and the joints between said parts are so located that separation of the three parts frees for removal said supply and collection manifolds and the looped heat exchange tube-passes connecting them, and also said first baffle.

11. The combination defined in claim 8 in which the connections for leading gas to be heated to and from the tubular heat transfer units comprise a double walled unit affording two manifold spaces, one enveloping the other, to which spaces the tubular heat transfer units are connected in parallel, said double walled unit serving to support said tubular units and being bodily removable from the casing therewith, said casing comprising two end parts and an intermediate part and the joints between said parts being so located that separation of the parts frees for removal said supply and collection manifolds with the looped heat exchange tube passes connecting them and also said first baffle.

CURT KELLER.

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