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TUBULAR GAS HEATER, PARTICULARLY FOR THE HEATING OF COMPRESSED PROPULSIVE GASES FOR TURBINES

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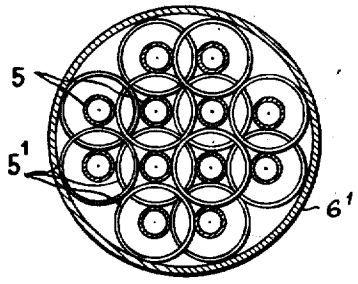


Fig. 4

Fig. 1

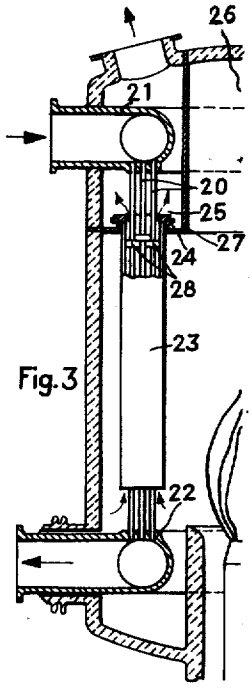


Fig. 3

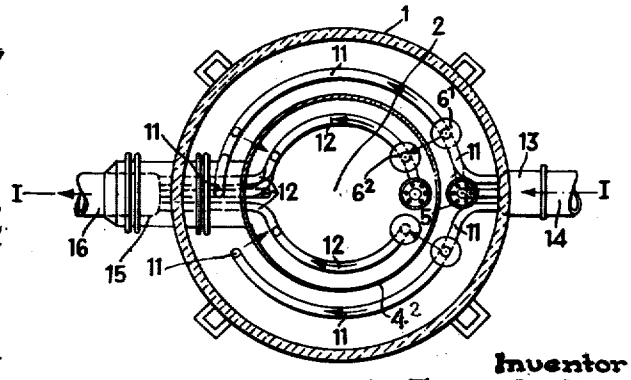


Fig. 2

Inventor
Eugen Villiger
By Dodge & Dodge
Attorneys

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TUBULAR GAS HEATER, PARTICULARLY FOR THE HEATING OF COMPRESSED PROPULSIVE GASES FOR TURBINES

Eugen Villiger, Zurich, Switzerland, assignor to Aktiengesellschaft Fuer Technische Studien, Zurich, Switzerland, a corporation of Switzerland

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8 Claims. (Cl. 126—109)

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This invention relates to a tubular gas heater, particularly for the heating of compressed propulsive gases for turbines, in which the heat is transmitted mainly by contact.

Tubular gas heaters of this kind are used for example in thermal power plants in which the whole or the greater part of a gaseous working medium, preferably air, flowing in a closed circuit is compressed in one or more compressors, then heated by heat derived from an external source and afterwards expanded in one or more turbines. If the working medium is air, it enters the tubular heater at a temperature of 200° to 400° C. and is heated therein to a temperature above 500° C.

The tubes of a heater of this kind are subjected to high temperatures and must, therefore, be highly resistant to heat. All possible precautions must be taken to avoid excessive local temperatures in the tubes, so that they shall not be subjected to stresses which cannot be tolerated in continuous working.

In tubular heaters for plants of the kind in question, the heater tubes usually are vertical, and are arranged in radial and concentric rows around the axis of a centrally located furnace and waste gas chamber. In such an arrangement, the length of the tubes may be 10 metres or more. In order to ensure in such heaters the high velocity of the furnace and flue gases necessary to assure the most effective transmission of heat, the spacing of the tubes must be nicely proportioned and accurately maintained, and the stream of heating gases must be closely confined so as to assure contact with the tubes. The furnace flue gases will be referred to hereinafter as the "heating gases." In any case, the tubes have to be arranged comparatively close to each other. This is particularly the case in pressure fired furnaces where the specific volume of the heating gases is less than when the pressure in the furnace chamber is practically atmospheric. In heaters in which temperatures of the order mentioned exist on the two sides of the tubes, there is serious risk that the comparatively long tubes may move relatively to each other owing to thermal expansions, thermal stresses and so on. Furthermore, the cross sectional area of the space available for the passage of the heating gases between the several tubes may be reduced by impurities which may be deposited thereon. Phenomena of this kind may disturb and tend to localize the flows between the heater tubes, and this may lead to excessively high temperatures and to a jeopardizing of the safe working of the plant.

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The object of the present invention is, therefore, to provide a tubular gas heater of the kind referred to, in which the spaces between the heater tubes can be made appropriate to the desired velocity of the heating gases and stable, so that they will remain substantially equal under all working conditions. For this purpose, according to the present invention, some or all of the heater tubes are grouped in similar nests, each surrounded by a coaxial tubular jacket. The position of each jacket relatively to the tubes which it surrounds does not change under the different working conditions, and the heating gases flow necessarily and exclusively inside the jacket and in contact with the tubes. Since the distance between individual tubes in a nest and between the tubes and the associated surrounding jacket does not vary, the tubes in each nest will always be impinged upon equally by the heating gases. In this way, local excessive temperatures are avoided.

Since the total cross sectional area of passage available for the heating gases between the several tubes of the nests and between said tubes and the associated surrounding jackets is small in proportion to the cross sectional area of the furnace and waste gas chamber, the desired high velocity of the heating gases will be attained even though the distance between the several tubes of each nest is comparatively great. If, however, this distance is ample, the tubes of the nest can be comparatively easily cleaned and easily replaced, each of which is an advantage of considerable practical importance.

If the tubes be fixed (preferably by a lattice work of separating holders) relatively to each other and to the jacket which surrounds them, the desired spacing is ensured in a simple manner.

The various nests of tubes may be movably mounted, e. g. by suspension, so that thermal expansions of the inlet or outlet pipes (or both) for the propulsive medium to be heated may be compensated by movement, for instance swaying, of the nest of tubes inside the heater. If the jackets of the tube nests are also arranged movably, for example by being suspended so that they can follow the movements of the tubes of the nests, the desired relative positions of the nest and jacket can be maintained under all conditions.

The various tube nests may also, conveniently, be connected by flexible connecting tubes to a header at least of the inlet pipe for the propulsive medium which is to be heated in the heater, so that longitudinal thermal expansions of the

tubes of the nests and of the inlet pipe are accommodated by the flexibility of these connecting tubes. In this way, any appreciable thermal stresses can be prevented from arising in the inlet pipe and in the tubes of the nests.

Since the flexible connecting tubes can be connected directly to the headers of the inlet and outlet pipes it is not necessary to provide an annular distributor or an annular collector. This is important, because such annular elements are subjected to severe stresses at high temperatures and high pressures of the propulsive medium. In most cases they must be made as castings and homogeneity of castings of this kind commonly leaves much to be desired. In contra-distinction thereto, the above-mentioned flexible connecting tubes may be made of wrought material. Another advantage is the fact that the various tube nests, together with the connecting pipes associated therewith, can be tested hydraulically separately, so that it is easy to determine whether the nests are tight and to find any nest which has become leaky.

Two examples of construction of tubular heaters according to the present invention are shown in a simplified form in the accompanying drawing in which:

Fig. 1 is a vertical axial section on the line I—I of Fig. 2 through a tubular gas heater. A turbine forming part of a thermal power plant driven by hot air, and a pipe for conducting air heated in the heater from the heater to the turbine are shown in elevation.

Fig. 2 is a horizontal section on the line II—II in Fig. 1.

Fig. 3 is a fragmentary vertical longitudinal section similar to a portion of Fig. 1, showing details of a second form of construction.

Fig. 4 shows in a horizontal section on the line IV—IV of Fig. 1 details on an enlarged scale.

Because of the necessarily small scale of Figs. 1 and 2 the tube nests are there shown as comprising only seven tubes each. A larger number of tubes would commonly be used in a nest and Fig. 4 is intended to indicate one possible arrangement. No claim is here made for the tube spacing arrangement shown in Fig. 4 since that is not the sole invention of the present applicant and cannot be claimed herein.

The tubular gas heater 1 shown in Figs. 1 and 2 has a central furnace and combustion chamber 2. In the lower part of the body of this heater, a burner 3 is provided. Partly in the furnace and combustion chamber 2, concentric with the axis thereof, are arranged a number of U-shaped tube nests of which, for the sake of clearness, only two are shown in Fig. 1 and only three in Fig. 2. Furthermore in these two figures, and likewise for the sake of clearness, the corresponding tube nests have been only partially shown. It will be understood, however, that similar units are arranged in circular series and at substantially uniform intervals around the chamber 2.

Each tube nest comprises a number of tubes 5 bent into the shape of a U and two jackets 6^1, 6^2 which surround the limbs of these U-shaped tubes over a portion of their length. The jackets 6^1, 6^2 are suspended singly by their upper ends at 5^2 in a chamber 4^1 called for lack of a better name, the return chamber. This is separated by partitioning means indicated at 4 both from the combustion chamber 2 and the offtake chamber 4^3. In the return chamber 4^1 are located the arches of the U-shaped tube

nests, these arches being suspended from carriers 7 which in their turn are supported on a part 8 which forms the top cover of the furnace and waste gas chamber 2. As above stated, the tube nests are located partly in the furnace and combustion chamber 2 and as will be seen by inspection of Fig. 1 that part of each nest which is enclosed in the sleeve 6^2 is within the chamber 2, whereas that part of each nest which is within the sleeve 6^1 is in an annular surrounding chamber 4^3 which may be called the offtake chamber, and from which the offtake 1^1 leads. The suspension of the tube nests above described imparts a certain amount of flexibility to the tube nests 5 at the arch so that when longitudinal thermal expansions occur, they can yield at the arches so that any such thermal expansions cannot give rise to any additional thermal stresses in the tubes.

In the type of construction described above, the heating gases in the chamber 2 are compelled to flow (owing to the provision of the partitions 4 and 4^2 and a resilient sleeve 19 connecting the lower end of the partition 4^2 with the shell of the heater 1) inside the jackets 6^2, 6^1 which surround the tubes and thence through the offtake chamber 4^3 to the flue gas outlet 1^1 which is formed in the outer shell of the heater 1. The total heating surface is consequently divided up into a number of separate U-shaped tube nests. In an arrangement of this kind, the distance between the several tubes of a nest and the velocity of the heating gases in the spaces within the jackets is comparatively large. The jackets 6^1, 6^2 may be constructed as telescopic sleeves, as shown in connection with the jacket 6^1 on the extreme left of Fig. 1. In the latter case a short sleeve 6^3 provided with a longitudinal slot 6^4 is mounted in such a manner on the lower end of the jacket 6^1 as to be adjustable in the longitudinal direction of the jacket, a stud 6^5 passing through said slot 6^4 and adapted to be screwed into said jacket allowing of fixing the sleeve 6^3 in the particular position into which it has been adjusted. Thus, with the help of the short sleeve 6^3 the surface of the limb of the tubes 5, which is surrounded by the left hand jacket 6^1 and over which the heating gases play, can be varied. These tubes 5 are fixed inside the several nests relatively to each other and to the jackets 6^1 and 6^2 which surround them, in the required position by a latticework of holders 5^1 (see also Fig. 4), serving as distance pieces. Three of such holders are shown in Fig. 1 in connection with the tube nest limb shown on the extreme left.

The inlet and outlet ends of the tubes 5 of the nests are each fixed nest-wise at the enlarged ends of the distributing and collecting members 9, 10 (see Fig. 1) which, in their turn, are connected to flexible connecting tubes 11 and 12. The flexible connecting tubes 11 lead from the header 13 of the inlet pipe 14, and the connecting tubes 12 lead to the header 15 of the outlet pipe 16. The outlet pipe 16 leads to the inlet connection of a turbine 17 in which the propulsive air heated in the heater expands and gives off energy.

As shown in Fig. 2, the flexible connecting tubes 11 and 12 some of which are of considerable length, have curved parts which are arranged concentrically with the axis of the heater, and the distributing and collecting members 9 and 10 of the various tube nests are so positioned with regard to the pipes 14 and 16 that the distances which the partial air streams have to travel in

the associated connecting tubes 11 and 12 are approximately the same. Consequently, the air streams are subjected to practically equal pressure drops, a fact which contributes to uniform distribution of the air to be heated to the different tube nests.

In the tubular gas heater described, thermal expansions of the exhaust pipe 16, which start from a fixed point 18 outside the heater, are accommodated inside the heater by the swaying movements of the nest tubes 5 connected to the header 15 by the flexible connecting tube 12, the jackets 6^2 being thereby compelled by the distance pieces 5^1 to follow the movements of the tube nests 5. The position of the jacket 6^2 relatively to the associated nest tubes 5 consequently undergoes no change under different working conditions so that the tubes of the nest will always be impinged upon by the heating gases equally.

The flexible connecting tubes 11 and 12 also compensate longitudinal thermal expansions of the nest tubes 5 and of the inlet and exhaust pipes 14 and 16, which likewise contributes to the fact that no appreciable thermal stresses can arise in the pipes 14, 16 and in the nest tubes 5.

Instead of connecting the tubes of the nests to the inlet and exhaust pipes for the propulsive medium to be heated in the heater, the tubes 20 of the nests can be connected in the manner shown in Fig. 3 directly to the header 21 of the inlet pipe and the header 22 of the exhaust pipe. The jacket 23 which surrounds the associate tubes 20 of a nest is suspended by its upper end at the point 24 in this construction also. This point 24 lies in a space or chamber 25 which is separated by sheet metal partitions 27 from the furnace and waste gas chamber 26. 28 denotes holders forming distance pieces which fix the nest tubes 20 in the necessary position both relatively to each other and to the jacket 23. If the header 22 is subjected to thermal expansion and, as is usually the case, from a fixed point situated outside the heater, the tubes 20 can sway out correspondingly, the jacket 23 being compelled to follow these movements of the tubes 20. Thus the tubes 20 are impinged upon by the gases in a substantially equal manner, so that no appreciable thermal stresses can consequently arise in them.

Realization of the invention is not limited to furnaces of the kind referred to herein, since the kind of furnaces plays no part in its application. The invention can thus be adopted in conjunction with furnaces for solid, liquid or gaseous fuels.

What is claimed is:

1. A gas heater comprising in combination a furnace structure including a shell and partitions which divide the space within the shell into at least two chambers, namely a combustion chamber, and an offtake chamber having an offtake for products of combustion; means for causing combustion in said combustion chambers; a plurality of heat exchange units, a substantial part of each of which is located within said combustion chamber, each said unit comprising a group of generally parallel spaced tubes and means forming inlet and outlet manifolds arranged to connect the tubes of the unit for parallel flow of gas to be heated; at least one open-ended flow-confining jacket for each unit, each jacket surrounding the corresponding group of tubes, said jackets defining enclosed flow paths for products of combustion extending in the direction of the length of the surrounded tubes and each such path communicating at its entrance end with the combustion chamber and at its discharge end with the offtake chamber; spacing means serving to maintain the spacing of the tubes of each unit from one another and from the associated jacket; inlet and discharge connections leading respectively to and from said manifolds, and serving to connect the various units in parallel; and means for supporting said jackets upon said partitions of the furnace structure.

2. The combination defined in claim 1 in which means are provided by which each group of spaced tubes is movably suspended from the furnace structure near the upper extremity of the unit, and by which the associated jacket is movably supported.

3. The combination defined in claim 1 in which means are provided by which each group of spaced tubes is movably suspended from the furnace structure near the upper extremity of the unit, and by which the associated jacket is movably supported at its upper end so as to be capable of pendulous motion with the associated tube group, and the inlet and discharge connections to the manifolds are flexible.

4. The combination defined in claim 1 in which at least some of the flow-confining jackets comprise telescoping sections whereby the effective length of the jacket is adjustable.

5. The combination defined in claim 1 in which the shell of the heater is generally cylindrical and the offtake chamber is annular in form and surrounds at least a portion of the combustion chamber.

6. A gas heater comprising in combination a furnace structure including a generally cylindrical shell and partitioning means which divide the space within the shell into a central combustion chamber, a surrounding offtake chamber having an offtake for products of combustion, and a return chamber which overlies at least portions of the combustion chamber and of the offtake chamber; means for causing combustion in said combustion chambers; a plurality of heat exchange units each unit comprising a group of generally parallel spaced tubes bent to inverted U form and means forming inlet and outlet manifolds located one in the offtake chamber and the other in the combustion chamber and each at the lower extremity of the corresponding arm of the U, said manifolds connecting the tubes for parallel flow of gas to be heated and the bent portion of the tubular unit being located in said return chamber with the arms of the U passing downward therefrom into the combustion and offtake chambers respectively, through openings provided therefor in said partitioning means; means by which the heat exchange units are suspended from the furnace structure; an open-ended flow-confining jacket for each arm of each unit, each jacket surrounding the corresponding group of tubes, and the jackets enclosing a flow path for products of combustion extending in the direction of the length of the tubes from the combustion chamber into the lower end of one jacket, through the jacket to the return chamber and thence downward through another jacket into the offtake chamber; spacing means serving to maintain the spacing of the tubes of each unit from one another and from associated jackets; inlet and discharge connections leading respectively to and from said manifolds and arranged to connect the various units in parallel; and means for movably sustaining said jackets at their upper ends upon the margins of corresponding openings in said partitioning means.

7. The combination defined in claim 6 in which the suspending means for the heat exchange units are mounted in said return chamber and engage said heat exchange units at the bends therein; and the inlet and discharge connections to the various manifolds take the form of individual curved tubes connected respectively to supply and discharge connections adjacent the furnace shell.

8. The combination defined in claim 6 in which the inlet and discharge connections to and from the various manifolds take the form of individual curved tubes connected respectively to supply and discharge connections, said individual curved tubes being so graduated in length that the length of the inlet connection plus the length of the flow path through the unit plus the length of the discharge connection is substantially uniform for all units.

EUGEN VILLIGER.

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