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[33]		France
[31]		143,111

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[54] **TUBULAR HEAT EXCHANGER**
10 Claims, 13 Drawing Figs.

[52] U.S. Cl. 165/178,
285/158; 248/56

[51] Int. Cl. F28b 9/04

[50] Field of Search. 165/128;
16/2; 248/56; 285/158; 165/177, 172, 178

ABSTRACT: A tubular heat exchanger includes a plurality of heat exchange tubes mounted between two tube support plates having apertures to accommodate the ends of these tubes. A sealing sleeve is interposed between the end of each tube and the associated aperture, this sealing sleeve having at least one and preferably two external sealing zones adapted to seal against the edges of the aperture and at least one external sealing zone adapted to seal against the tube.

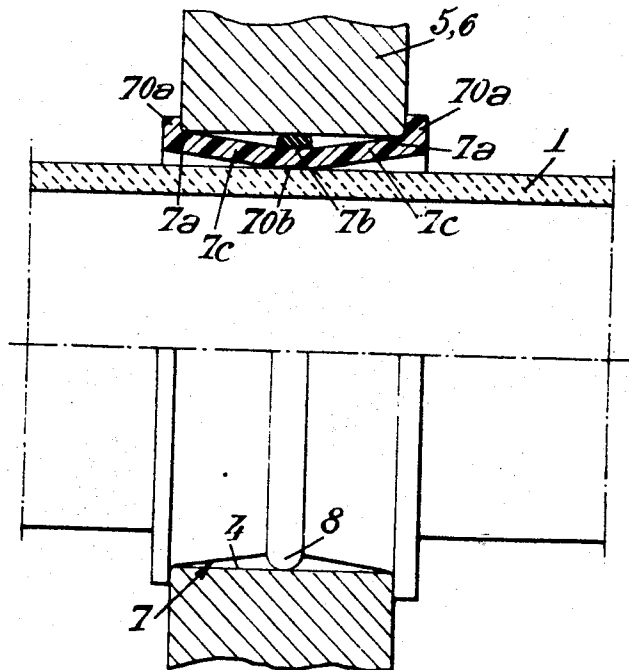


Fig.1.

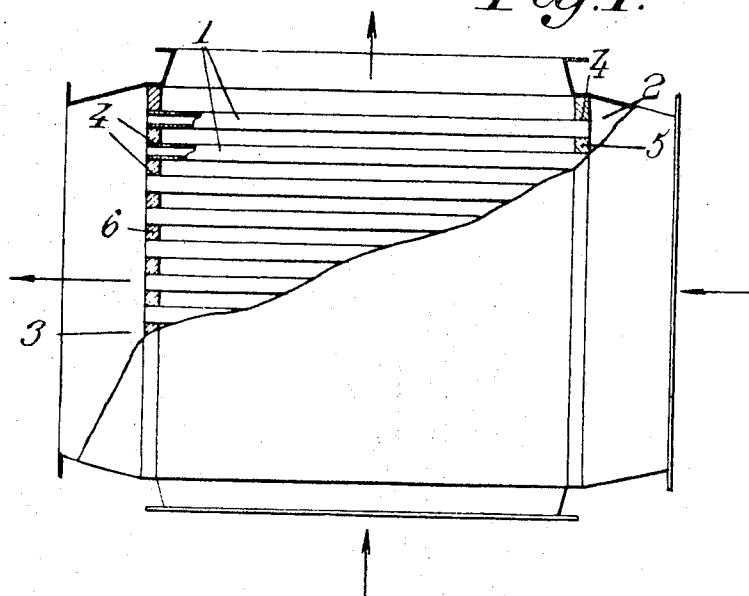


Fig.2.

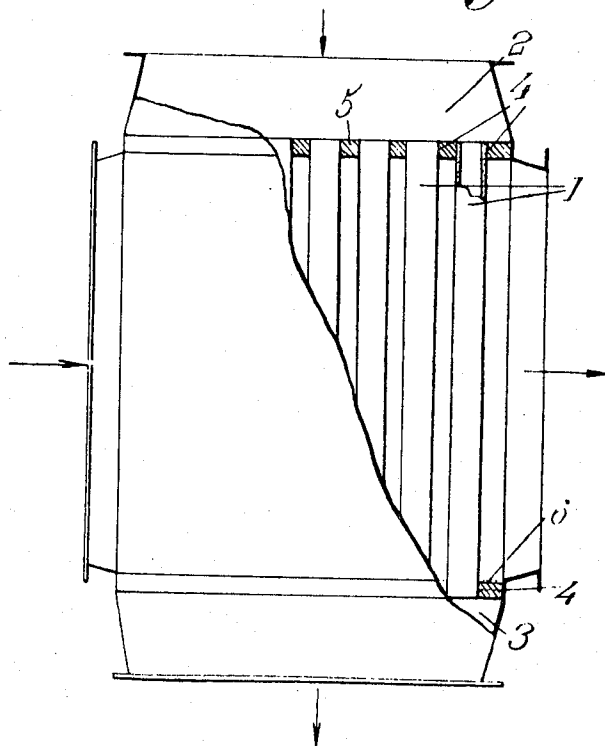


Fig. 4.

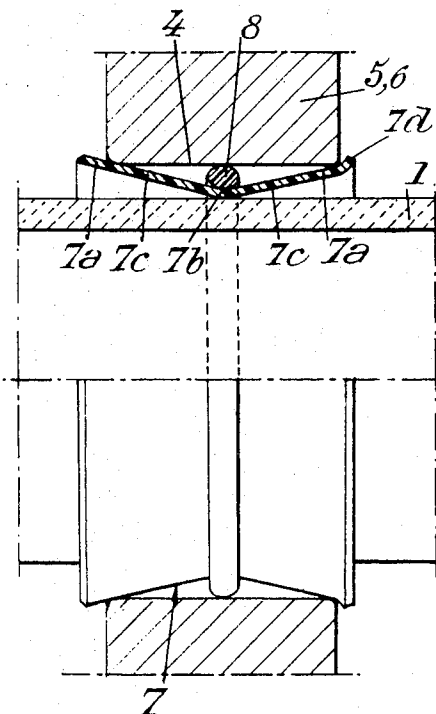


Fig. 5.

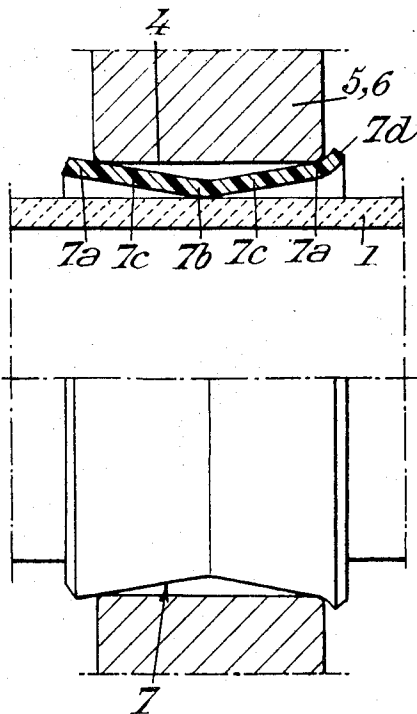
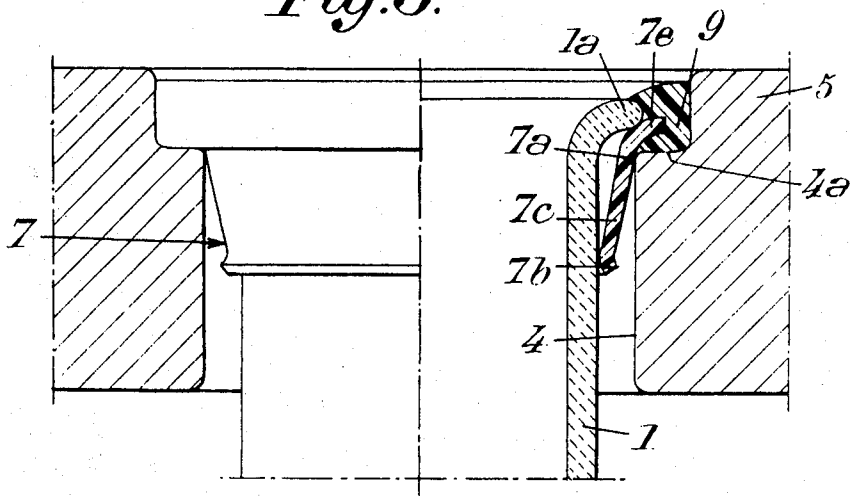


Fig. 3.



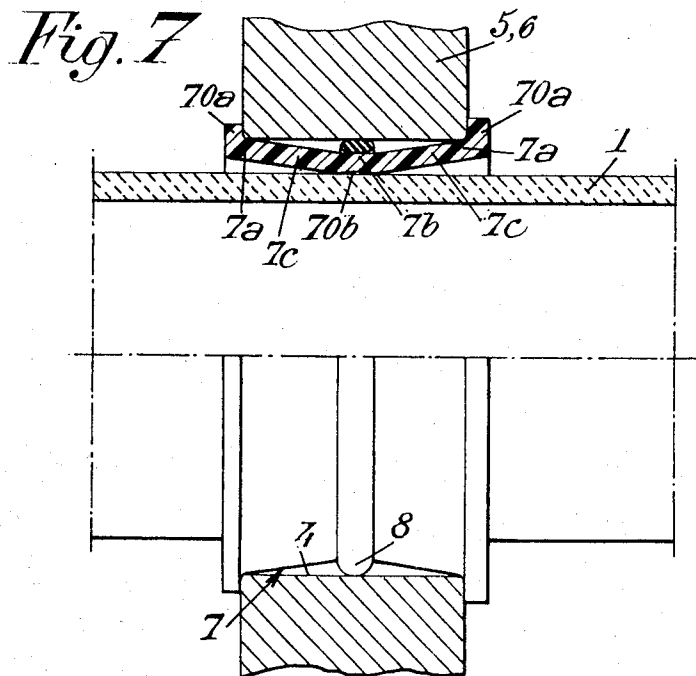
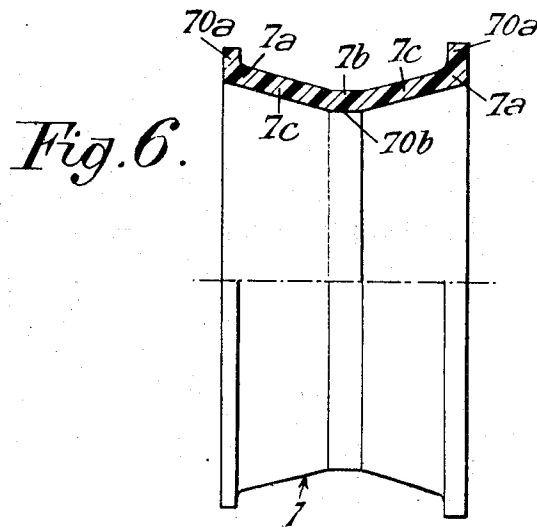


Fig. 8

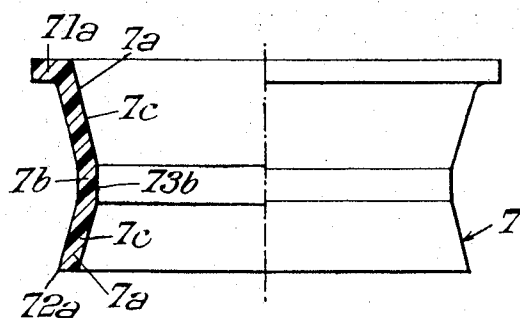


Fig. 9.

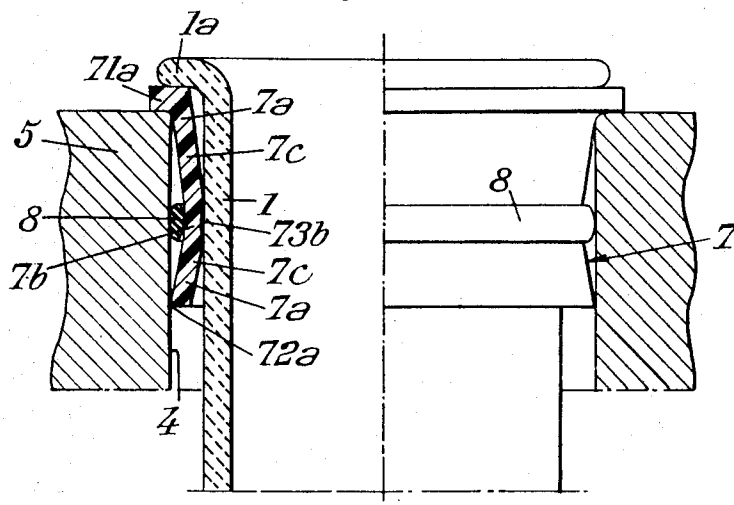


Fig 10

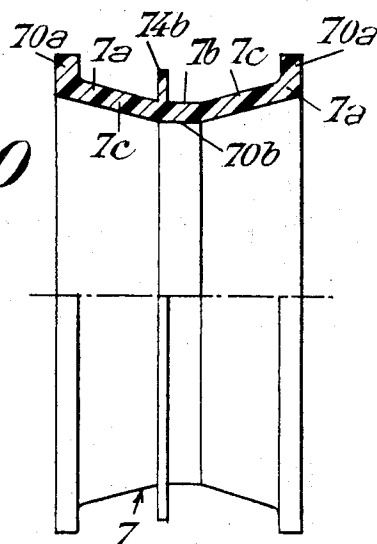
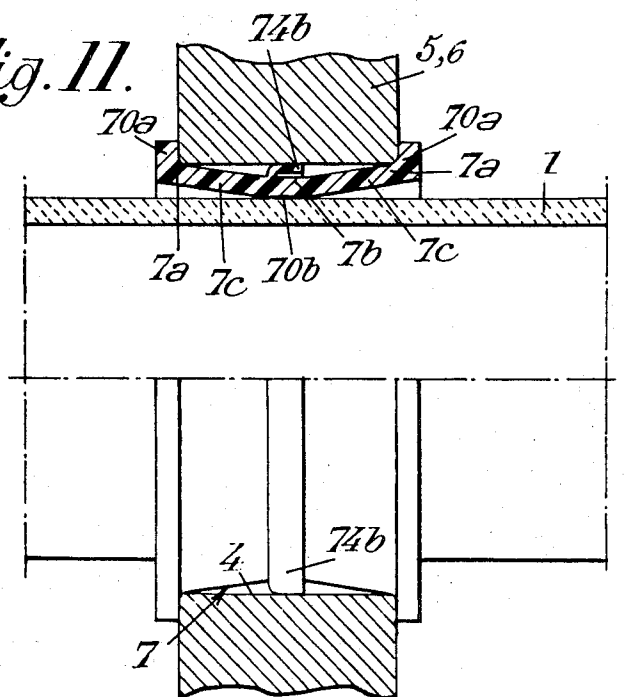
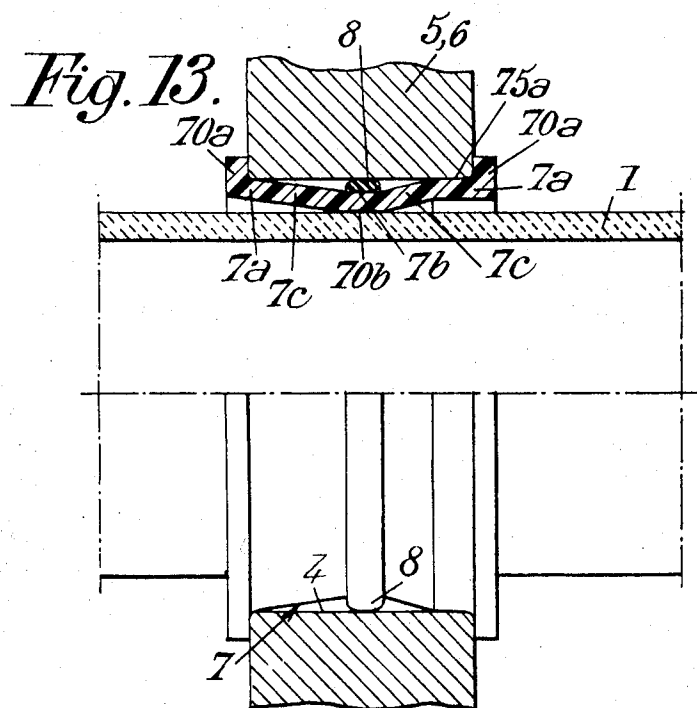
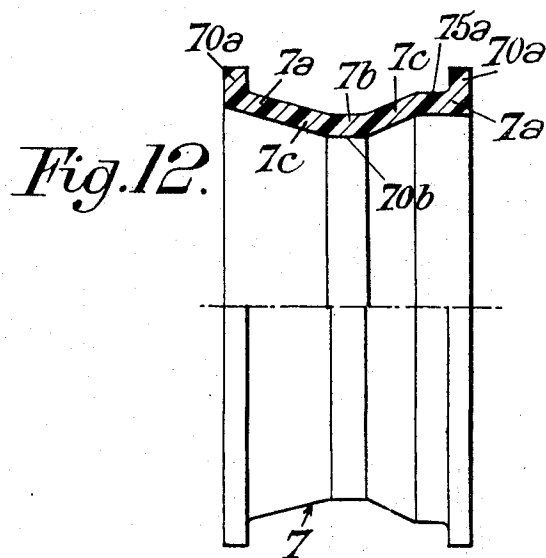


Fig. 11.





TUBULAR HEAT EXCHANGER

The invention concerns improvements in or relating to tubular heat exchangers. By the term "tubular heat exchanger" there is to be understood broadly the type of heat exchanger wherein a number of tubes, herein referred to as a nest of tubes, are arranged to extend, generally parallel to each other, between an inlet chamber and an outlet chamber, these tubes being traversed by one of the two fluids between which the thermal exchange takes place, while the other fluid circulates round the said tubes. The heat exchangers with which the present invention is concerned are of this general type, and moreover of the particular variety wherein the ends of each individual tube are mounted via sealing means in associated apertures in the walls of respectively the inlet chamber and the outlet chamber, where the two ends of the nest of tubes terminate. At this point it should be noted that the apertured walls of the inlet and outlet chambers will hereinafter be referred to as the tube inlet plate and the tube outlet plate respectively.

The invention is particularly though not exclusively concerned with tubular heat exchangers in which the nest of tubes is formed of a number of tubes each of a borosilicate glass, such as that known under the trade name PYREX, since it is with these that the invention best displays its advantages.

It is the object of this invention to provide improved tubular heat exchangers which will function better than some which hitherto have found widespread use, notably insofar as the sealing means interposed between the ends of each of the tubes and the appropriate tube inlet or outlet plates have mechanical characteristics which enable the operating play between each aperture and the corresponding tube to be compensated, as well as physical properties which endow the heat exchanger with a long operating life, the ability to withstand high temperatures, and to resist corrosion.

According to the invention there is provided a tubular heat exchanger of the kind described above, in which the sealing means interposed between the end of the tubes in the nest of tubes and the corresponding aperture in the tube inlet or outlet plate comprise a sealing sleeve of elastically-deformable material, having at least two axially displaced sealing zones linked by a connecting zone, one of said sealing zones being external of the sleeve and having a diameter such that when the sleeve is positioned in the associated aperture this external sealing zone contacts the edge of the aperture to effect a seal, and being also preferably adapted by means of a part facing the adjacent tube plate to form an axial stop determining the position of the sleeve in relation to said tube plate, another of said sealing zones being internal of said sleeve and having a diameter such that when the tube is inserted within the said sleeve this internal sealing zone embraces the tube to effect a seal.

With such sealing means it is possible especially by an appropriate choice of the axial area of the connecting zone to secure mechanical characteristics which enable the working play between each aperture and the associated tube to be compensated, and by using a material with the appropriate physical properties as the constituent material of the sleeve to endow the sleeve with long life, with the ability to withstand high temperatures, and with resistance to corrosion.

In one preferred embodiment of the invention, the sleeve has a single external sealing zone, and then includes only a single connecting zone. In another preferred embodiment of the invention, the sleeve has two external sealing zones and one internal sealing zone situated approximately equidistant from the two external sealing zones, and then includes two connecting zones.

To facilitate understanding of the invention it will now be further described with reference to the accompanying drawings, which show certain preferred embodiments of the invention, but of course are not intended limitatively. In the drawings:

FIGS. 1 and 2 show elevational views, partly cut away to reveal vertical cross-sectional views, of tubular heat exchangers

of the type susceptible of improvement in accordance with this invention;

FIG. 3 shows a view, partly in elevation and partly in cross section taken along the tube axis, of the tube, sealing means and tube plate of one preferred embodiment of the invention;

FIG. 4 shows a view, partly in elevation and partly in cross section taken along the tube axis, of the tube, sealing means and tube plate of another preferred embodiment of the invention;

FIG. 5 shows a view, similar to that given in FIG. 4, of a variant of the embodiment illustrated in FIG. 4;

FIG. 6 shows a view, partly in elevation and partly in cross section taken on the axis of a sleeve for use as the sealing means between a tube plate and a tube in a third embodiment of the invention, but not shown mounted in said tube plate;

FIG. 7 shows a similar view of the sleeve of FIG. 6, but now mounted in the tube plate;

FIG. 8 shows a view, partly in elevation and partly in cross section taken on the axis, of a sleeve for use as the sealing means between a tube plate and a tube in a fourth embodiment of the invention, but not shown mounted in the tube plate;

FIG. 9 shows a similar view of the sleeve of FIG. 8, but now mounted in the tube plate;

FIG. 10 shows a view, partly in elevation and partly in cross section taken on the axis of a sleeve for use as the sealing means between a tube plate and a tube in a fifth embodiment of the invention, but not shown mounted in the tube plate;

FIG. 11 shows a similar view of the sleeve of FIG. 10, but now mounted in the tube plate;

FIG. 12 shows a view, partly in elevation and partly in cross section taken on the axis, of a sleeve for use as the sealing means between a tube plate and a tube in a sixth embodiment of the invention, but not shown mounted in the tube plate; and

FIG. 13 shows a similar view of the sleeve of FIG. 12, but now mounted in the tube plate.

The general type of tubular heat exchanger with which the invention is concerned is shown in FIGS. 1 and 2. This tubular heat exchanger comprises a number of tubes 1, arranged parallel with one another to form a nest of tubes interconnecting an inlet chamber 2 and an outlet chamber 3. These tubes 1 are conveniently formed of a borosilicate glass such as that known under the name of PYREX, and in operation they are traversed by one of the two fluids between which the thermal exchange is to take place, while the other fluid circulates round the said tubes 1. As can be seen, the respective ends of each of the tubes 1 are inserted via sealing means (not shown in FIGS. 1 and 2) into a corresponding aperture 4 arranged respectively in a tube inlet plate 5 (constituting one wall of the tube inlet chamber 2) and in a tube outlet plate 6 (constituting one wall of the tube outlet chamber 3) at which the two ends of the nest of tubes terminate. Heat exchangers of this type are used for instance as preheaters in boilers; the hotter fluid passed into the exchanger being the combustion gases (and vapors) emerging from the boiler furnace, while the colder fluid entering the exchanger to be heated therein is the air needed to support combustion in said furnace. The heat exchanger shown in FIG. 1 is what may be termed a horizontal air heater, that is to say the nest of tubes in this heat exchanger is horizontally orientated, the combustion gases circulating round the tubes 1 while the air to be heated passes through the tubes 1. The heat exchanger shown in FIG. 2 is what may be termed a vertical heat exchanger, that is to say the nest of tubes in this heat exchanger is vertically orientated, the combustion gases passing through the tubes 1 while the air to be heated circulates round the tubes 1.

Before considering the improvements effected in this type of heat exchanger by means of this invention, it is important to bear two points in mind.

Firstly, the borosilicate glass tubes employed can be obtained at competitive prices only within quite large manufacturing tolerances. Thus, such a tube with a specified external diameter of 32 mm. can in fact have an external diameter

varying between 31 and 33 mm. Now the apertures 4 cut in the tube inlet plate 5 and the tube outlet plate 6 have identical diameters within very small manufacturing tolerances. The working play between each aperture 4 and the corresponding tube 1, which is therefore different in each case, must be compensated by the sealing means interposed between said tube 1 and said aperture 4.

Secondly, it is essential that under the working conditions of the heat exchanger, the sealing means must have as long a life as possible, which is dependent especially upon their ability to withstand high temperatures and to resist corrosion by very powerful chemical agents, such as sulfuric acid resulting from hydration of the sulfurous compounds coming from the combustion. Hydration always takes place, no matter whether the water originates from condensates of sulfurous compounds elsewhere in the cold regions of the heat exchanger or even from residues of water left over from the washing of the heat exchanger.

As can be seen in FIG. 3, and indeed also in subsequent FIGS., the sealing means which are interposed according to the invention between the end of the tube 1 and the aperture 4 in either the tube inlet plate 5 or the tube outlet plate 6 are constituted by a sealing sleeve 7 of elastically-deformable material, having at least two axially-displaced sealing zones 7a and 7b linked by a connecting zone 7c. At least one of these sealing zones 7a is external of the sleeve 7, and has such a diameter that when the sleeve 7 is positioned in the associated aperture 4, this external sealing zone 7a is pressed against the edge of the aperture 4 to ensure sealing. This external sealing zone 7a is also preferably as shown so arranged, with one part facing the adjacent tube plate 5 or 6, that it provides an axial stop which determines the position of the sleeve 7 in relation to said tube plate. At least one of the sealing zones 7b is internal of the sleeve 7, and has such a diameter that when the tube 1 is inserted into the sleeve 7 this internal sealing zone 7b embraces the tube 1 to ensure sealing.

It will be recognized that it is possible, by a suitable choice of the axial extent of the connecting zone 7c to confer mechanical characteristics on the sealing means which enable the considerable but variable degree of play between each aperture 4 and the corresponding tube 1 to be compensated. Equally, it can be appreciated that by choosing a material for the sleeve which has suitable physical properties it is possible to ensure that the sleeve 7 has the ability to withstand high temperatures and to resist corrosion, and thus to endow it with long life.

To achieve these objectives the axial size of the connecting zone 7c is preferably so chosen that this connecting zone 7c constitutes a truncated cone, the half-angle at the apex of which lies between 5° and 20°, and the sleeve 7 is preferably moulded from polymerized tetrafluoroethylene, for instance that known under the trade name TEFLON, or a material based on TEFLON and which can contain small quantities of certain additional substances.

This is illustrated in the embodiment of FIG. 3, in which the sleeve 7 has a single external sealing zone 7a and includes only a single connecting zone 7c. The external sealing zone 7a is here disposed on the side of the sleeve 7 from which the tube 1 has to be inserted. This embodiment of FIG. 3 it should be noted is more particularly intended to form the sealing means at the level of the upper tube plate in a heat exchanger with a vertical nest of tubes such as that illustrated in FIG. 2. If, as is generally the case, the combustion gases are passed through this exchanger from top to bottom, the upper tube plate then becomes the tube inlet plate 5. The sealing means at the level of the lower tube plate in a vertically arranged exchanger will best be a sleeve 7 of the type illustrated in FIGS. 4 and 5.

The external sealing zone 7a preferably has a flared extension 7e, reinforcing the effect of the axial stop provided by this external sealing zone against the tube inlet plate 5. Each of the tubes 1 in such a vertically-arranged heat exchanger has at its upper end an external flange or collar 1a, whose external diameter is preferably greater than the diameter of the aper-

ture 4. This collar 1a then rests under the weight of the tube 1 on that area of the sleeve 7 which is formed by the external sealing zone 7a and the flared extension 7e.

Advantageously the upper surface of the tube inlet plate 5 is then machined so that each aperture is surrounded by a recess 4a which will receive on the one hand the area of the sleeve 7 formed by the external sealing zone 7a and the flared extension 7e, and also on the other hand the collar 1a of the tube 1. Moreover, the rest of the recess 4a can if desired be wholly or partially filled in, so as to protect the ends of the tube 1 and of the sleeve 7, by a sealing joint 9 formed by a mastic or injected plastic material or by an annulus in the form of a plain ring made of plastic material. The plastic material can in both cases consist of or be based upon a copolymer of vinylidene fluoride and hexafluoropropylene, for instance the material known under the trade name of VITON.

Alternatively and advantageously the sealing means may be constructed in the manner of the embodiments illustrated in FIGS. 4 to 13, in which the sleeve 7 has two external sealing zones 7a, and an internal sealing zone 7b situated roughly halfway between the two external sealing zones 7a, this embodiment of sleeve then having two connecting zones 7c.

In the embodiment illustrated in FIG. 4, the thickness of the sleeve 7 is only slight, and a toroidal seam 8 is arranged belt-wise round the sleeve 7 at the level of the internal sealing zone 7b, this seam 8 being made of a material more easily deformable than the constituent material of the sleeve 7, such as VITON. By combining such a sleeve 7 with this toroidal seam 8 the composite article acquires mechanical characteristics as a whole which include the properties of deformability and elasticity of TEFLON, and the properties of deformability of VITON.

In the modified embodiment illustrated in FIG. 5, the thickness of the sleeve 7 is greater than in FIG. 4, and this sleeve 7 has mechanical characteristics determined solely by the properties of deformability and elasticity of TEFLON.

It should be noted that the embodiments illustrated in FIGS. 4 and 5 are both particularly intended for use as the sealing means in a heat exchanger with a horizontal nest of tubes, such as that illustrated in FIG. 10.

The external sealing zone 7a on the side from which the tube 1 is inserted will advantageously have a flared skirt 7d reinforcing the effect as on an axial stop of this external sealing zone 7a in coaction with the facing part of the tube inlet plate 5 or tube outlet plate 6.

It is convenient at this point to mention that it has been assumed above that the tubular heat exchanger consists only of a nest of tubes extending a tube inlet plate 5 and a tube outlet plate 6; but if the heat exchanger should also include one or more intermediate tube plates then sleeves analogous to those just described above can of course be used to support the tubes therein, although usually no sealing problem will arise with intermediate tube plates.

In the embodiment illustrated in FIGS. 6 and 7, the sleeve 7 has two external sealing zones 7a, and each of these includes a raised edge 70a extending radially outwards normal to the axis of the sleeve 7, the raised edge 70a of one of these two external sealing zones 7a having preferably a diameter and a thickness slightly less than the diameter and the thickness of the raised edge 70a of the other external sealing zone 7a. Also the axial distance separating these two raised edges 70a is slightly less than the thickness of the tube inlet plate 5 or tube outlet plate 6 in which the sleeve 7 is to be mounted. The internal sealing zone 7b is formed by a part 70b of the inner surface of the sleeve which is cylindrical (see FIG. 6) when the sleeve 7 is not mounted in the tube inlet plate 5 or tube outlet plate 6. However, as can be seen in FIG. 7, this cylindrical part 70b deforms, becoming slightly concave, when the sleeve 7 is mounted in the plate, because the axial distance separating the two raised edges 70a of the two external sealing zones 7a is slightly less than the thickness of the said tube plate 5 or 6. In this way sealing with the tube inlet plate 5 or tube outlet plate 6 is effected by means of the two raised edges 70a of the two

external sealing zones 7a which press thereagainst; and sealing with the tube 1 is effected by means of the two lips raised at each end of the deformed, slightly concave part 70b of the internal sealing zone 7b.

In this embodiment, the sleeve 7 is made of TEFLON and has only a slight thickness, but a toroidal seam 8 is arranged beltwise round the sleeve 7 at the level of the internal sealing zone 7b, this seam 8 being made of a material more easily deformable than the constituent material of the sleeve 7, such as VITON. The combination of such a sleeve 7 with this toroidal seam 8 imparts mechanical characteristics to the whole which comprise the properties of deformability and elasticity of TEFLON and the properties of deformability of VITON.

It should be pointed out that this embodiment of sleeve 7 may be mounted in the apertures 4 in the tube inlet 5 or tube outlet plate 6 by inserting into the aperture that side of the sleeve which is provided with the raised edge 70a having the smallest diameter and the smallest thickness.

In order further to illustrate the foregoing, certain dimensions (expressed in millimetres) will now be given relating to a heat exchanger according to the invention. These for example can be as follows:

Tube 1, external diameter: 32 ± 1 mm.

Apertures 4, diameter: 38 mm.

Tube plates 5 or 6, thickness: 20 mm.

Under these conditions, the sleeve 7, when unmounted, may be dimensioned as follows:

One of the two raised edges 70a, external diameter: 42 mm.

One of the two raised edges 70a, thickness: 2 mm.

The other raised edge 70a, external diameter: 41 mm.

The other raised edge 70a, thickness: 1.5 mm.

The two raised edges 70a, axial separation: 18.5 mm.

Part 70b, axial size: 3 mm.

Part 70b, internal diameter: 30 mm.

In the embodiment illustrated in FIGS. 8 and 9, the sleeve 7 has one external sealing zone 7a which serves as an axial stop, this zone having a raised edge 71a extending radially outwards normal to the axis of the sleeve 7, and another sealing zone 7a constituted by an external lip 72a which contacts the inside of the cylindrical wall of the aperture 4, since the axial distance separating the above-mentioned exterior lip 72a from the surface of the raised edge 71a which is in contact with the corresponding tube plate 5 or 6 is less than the thickness of the above-mentioned tube plate 5 or 6.

The internal sealing zone 7b is constituted by a part 73b of the inner wall of the sleeve 7 which is cylindrical when the sleeve 7 is not mounted between the tube inlet plate 5 or tube outlet plate 6 and the tube 1, but which is deformed becoming slightly concave when the sleeve 7 is mounted, because of the insertion of the tube 1 and the reaction caused in the sleeve 7 at the level of the exterior lip 72a when it comes into contact with the cylindrical wall of the aperture 4.

In this way sealing is achieved with the tube inlet plate 5 or tube outlet plate 6 by means of the raised edge 71a of one of the two external sealing zones 7a and by means of the external lip 72a of the other external sealing zone 7a; and with the tube 1 by means of the two lips raised at each end of the deformed, slightly concave part 73b of the internal sealing zone 7b.

It may here be noted that the sleeve 7, arranged as has just been described, is particularly suitable for use as the sealing means at the level of the tube inlet plate 5, thus in the upper tube plate, in a heat exchanger with a vertical nest of tubes, such as that shown in FIG. 2. In that case each tube 1 can then advantageously include, at its upper end, a collar 1a whose external diameter is preferably greater than the diameter of the aperture 4, this collar 1a then resting on the raised edge 71a.

In this embodiment, the sleeve 7 is made of TEFLON and has only a slight thickness, but a toroidal seam 8 is arranged beltwise around the sleeve 7 at the level of the internal sealing zone 7b, this seam 8 being made of a material more easily deformable than the constituent material of the sleeve 7, such as VITON. The combination of such a sleeve 7 with this toroidal seam 8 gives mechanical characteristics to the whole

ensemble which combine the properties of deformability and elasticity of TEFLON and the properties of deformability of VITON.

Such a sleeve 7 can be mounted in the apertures 4 of the tube inlet plate 5 by inserting thereinto the side thereof not provided with a raised edge 71a, that is to say the side having the exterior lip 72a, whose external diameter is equal to or only slightly greater than the diameter of the apertures 4.

In order further to illustrate what has been said above, certain dimensions (expressed in millimetres) will now be given, merely by way of example, relating to a heat exchanger according to the invention:

Tube 1, external diameter: 32 ± 1 mm.

Apertures 4, diameter: 38 mm.

Tube plate 5, thickness: 30 mm. or more.

Under these conditions, the sleeve 7, when unmounted, may have the following dimensions, expressed in millimetres:

Raised edge 71a, external diameter: 42 mm.

Raised edge 71a, thickness: 2 mm.

External lip 72a, external diameter: 38 mm.

Separation of the external lip 72a from the surface of the raised edge 71a intended to contact the tube plate 5 or 6, axial distance: 16.5 mm.

Part 73b, axial size: 3 mm.

Part 73b, internal diameter: 30 mm.

In the embodiment illustrated in FIGS. 10 and 11, the sleeve 7 has an internal sealing zone 7b which includes a flexible collar 74b extending radially outwards and having, when the sleeve 7 is unmounted, an external diameter slightly greater than the diameter of the associated aperture.

Thus, sealing is achieved at the level of the tube inlet plate 5 or tube outlet plate 6 by means of this flexible collar 74b, which is deformed and presses against the cylindrical inner wall of the aperture 4, the contact between the above-mentioned flexible collar 74b and the above-mentioned cylindrical inner wall being augmented by the pressure difference between the pressures prevailing on the two sides of the tube inlet plate 5 or tube outlet plate 6 under consideration.

This sleeve 7 advantageously has raised edges 70a at the level of the external sealing zones 7a, and a cylindrical part 70b at the level of the internal sealing zone 7b. Under these conditions the flexible collar 74b is preferably situated at the end of the cylindrical part 70b which is on the side of the external sealing zone 7a from which the insertion of the sleeve 7 into the aperture 4 takes place.

In order further to illustrate what has been said above, certain dimensions will now be given, though only by way of example, for the sleeve 7 when used in a heat exchanger having the same dimensions as those of the first-mentioned example save that the tube inlet plate 5 or tube outlet plate 6 have a thickness of 20 mm. These dimensions (expressed in millimetres) are as follows for the unmounted sleeve:

Raised edges 70a, external diameter: 42 mm.

Raised edges 70a, thickness: 2 mm.

Separation of two raised edges 70a, axial distance: 18 mm.

Part 70b, axial size: 3.7 mm.

Part 70b, internal diameter: 30 mm.

Flexible collar, 74b, external diameter: 39.2 mm.

In the embodiment illustrated in FIGS. 12 and 13, the sleeve 7 has two external sealing zones 7a, of which at least one includes a cylindrical bearing surface 75a, having an external diameter, when the sleeve 7 is unmounted, slightly greater than the diameter of the associated aperture 4. In this way sealing with the tube inlet plate 5 or tube outlet plate 6 is achieved by means of this cylindrical bearing surface 75a, which coacts with the cylindrical inner wall of the aperture 4. This has the advantage that the cylindrical inner wall frequently has a better surface condition than that of the external faces of the tube inlet plate 5 or tube outlet plate 6.

This sleeve 7 also advantageously includes raised edges 70a in the region of the external sealing zones 7a, and a cylindrical part 70b in the region of the internal sealing zone 7b.

Under these conditions, the sleeve includes a single cylindrical bearing surface 75a, situated in the region of that one of the external sealing zones 7a opposite the other one of these external sealing zones 7a by means of which the sleeve 7 is inserted into the aperture 4. The sleeve 7 is made of TEFLON and has only a slight thickness, but advantageously a toroidal seam 8 is disposed beltwise around the sleeve 7 in the region of the internal sealing zone 7b, this toroidal seam being made of an easily deformable material such as VITON.

In a variant of this embodiment of the invention (not illustrated) this sleeve can instead be provided with a flexible collar analogous to that illustrated in FIGS. 10 and 11.

In order further to illustrate what has just been said above, certain dimensions for the sleeve 7 will now be given, though only by way of example, for use in a heat exchanger of the same dimensions as those of the first-mentioned example, save that the tube inlet plate 5 or tube outlet plate 6 have a thickness of 20 mm. These dimensions (expressed in millimetres) relate to the unmounted sleeve, and are as follows:

Raised edges 70a, diameter: 42 mm.

Raised edges 70a, thickness: 2 mm.

Separation of the two raised edges 70a, axial distance: 18 mm.

Part 70b, axial size: 3.7 mm.

Part 70b, internal diameter: 30 mm.

Cylindrical bearing 75a, axial size: 3 mm.

Cylindrical bearing 75a, external diameter: 38.5 mm.

The advantages of the preferred forms of construction described and illustrated above when applied to tubular heat exchanges with glass tubes can be summarized as follows:

The sleeve interposed between each tube and the tube inlet and outlet plates makes it possible to compensate the working play existing between each aperture and the corresponding tube.

Sealing is effected in a lasting way between each tube and the tube inlet and outlet plates, whatever the conditions under which the exchanger is functioning.

The sleeve, when it is made of TEFLON as recommended, will perform its function without breakdown up to temperatures of 250° C.

This sleeve is resistant to the most powerful corrosive agents, such as concentrated sulfuric acid.

The sleeve has no porosity, and therefore does not accumulate corrosive agents, a fact which eliminates the risks that the tubes may be crushed or blocked-up by swelling and other modification of the mechanical properties of the sealing means, a problem encountered with classic sealing means.

The frictional forces between each tube and the sleeves are reduced to a minimum, and allow the tubes to expand freely in their longitudinal direction.

The mechanical connection between the tubes and the tube inlet and outlet plates is achieved without setting the tubes in place, which considerably reduces the risks of rupture of the tubes, since these are practically "articulated" into the respective tube plates.

The cost price of the sleeves is very low, especially if these sleeves are made from cylindrical sections, which are hot-deformed to give the desired shape.

The sleeve has characteristics which allow it to be mounted in the apertures of the tube inlet and outlet plates very simply.

The sleeve can be made in such a way that its axial size is notably less than the thickness of the tube inlet or outlet plates, which can lead to a very appreciable economy of material, especially in the case of the upper tube plate of a vertical exchanger, since this is generally very thick, of the order of twice the thickness of the lower tube plate.

I claim:

1. A tubular heat exchanger comprising an inlet chamber including an apertured tube inlet plate, an outlet chamber in-

cluding an apertured tube outlet plate, a nest of tubes extending between said tube inlet and outlet plates, each said tube having its ends mounted within apertures in respectively said tube inlet plate and said tube outlet plate, and sealing means mounted between each said tube end and the edges of its associated aperture to effect a seal between the tube and plate, and in which the sealing means comprises a sleeve constructed of elastically-deformable material and having three axially-displaced sealing zones, two of said sealing zones being external of said sleeve and having diameters such that when the sleeve is mounted in its associated aperture these external sealing zones each contact the plate around said aperture to effect a seal therewith, the other of said sealing zones being internal of said sleeve and having a diameter such that it tightly embraces the tube within the sleeve to effect a seal therewith, said internal sealing zone being intermediate and substantially equidistant from said external sealing zones and linked thereto by connecting zones, and in which each of the two external sealing zones includes a raised edge extending radially outwards normal to the axis of the sleeve, the axial distance separating these raised edges when the sleeve is unmounted being slightly less than the thickness of the associated tube plate, and in which the internal sealing zone is formed by a part of the inner surface of the sleeve which is cylindrical when the sleeve is unmounted but which deforms to become slightly concave when the sleeve is mounted in the associated plate, thus raising lips at each end of the deformed, slightly concave part of the inner surface to effect positive sealing between the sleeve and the associated tube.

2. A heat exchanger according to claim 1, in which the tubes in said plurality of tubes are formed of a borosilicate glass.

3. A heat exchanger according to claim 1, in which the connecting zones each form a truncated cone having a half-angle between 5° and 20°.

4. A heat exchanger according to claim 1, in which the sleeve is formed of a plastic material consisting at least predominantly of polymerized tetrafluoroethylene.

5. A heat exchanger according to claim 1, in which said sleeve formed of flexibly-thin material is surrounded externally by a toroidal seam disposed beltwise around the sleeve adjacent the internal sealing zone, said seam being formed of a material more easily deformable than the material constituting the sleeve.

6. A heat exchanger according to claim 1, in which one of said raised edges has an external diameter and a thickness slightly greater than the external diameter and thickness of the other of said raised edges.

7. A heat exchanger according to claim 6, in which the sleeve is mounted in its associated aperture by inserting therein the side of said sleeve having the raised edge of smallest external diameter and thickness.

8. A heat exchanger according to claim 1, in which said sleeve includes a flexible collar extending radially outwards therefrom adjacent the internal sealing zone and having an external diameter when the sleeve is unmounted slightly greater than the diameter of the associated aperture.

9. A heat exchanger according to claim 1, in which at least one of the two external sealing zones includes a cylindrical bearing surface having an external diameter when the sleeve is unmounted slightly greater than the diameter of the associated aperture.

10. A heat exchanger according to claim 9, in which said sleeve formed of flexibly-thin material is surrounded externally by a toroidal seam disposed beltwise around the sleeve adjacent the internal sealing zone, said seam being formed of a material more easily deformable than the material constituting the sleeve.