Gas-liquid heat exchanger and method for its manufacture

The tubular conduits (2) are essentially constituted by successive portions of a single conduit (8) which are connected with each other by means of connecting elbows (9) integrally formed in said conduit (8), while the fins (4) are provided with at least one substantially U-shaped seat (12) for housing the tubular conduits (2), the fins (4) being laterally connected with each other downstream of the tubular conduits (2) at an end portion (12b) thereof.
Description

Background of the invention

[0001] The present invention relates to a gas-liquid heat exchanger which is preferably but not exclusively employed in water heating apparatuses intended for both domestic use and utilization in residential areas.

[0002] The present invention relates, more particularly, to a gas-liquid heat exchanger as defined in the preamble of appended Claim 1.

[0003] The present invention also relates to an improved fin for gas-liquid heat exchangers, to a method for manufacturing the heat exchanger as defined above, as well as to a water heating apparatus incorporating the aforementioned heat exchanger.

Prior Art

[0004] In the field of gas-liquid or air-liquid heat exchangers, generally, and particularly in the field of gas-water heat exchangers for water or air-liquid heaters intended for room conditioning or refrigerating, one of the most felt needs is, at present, that of providing heat exchangers which are compact, light and have more and more limited costs and which may assure at the same time a high heat exchange efficiency.

[0005] For this purpose, tube heat exchangers are known, optionally provided with fins to increase the gas-liquid heat exchange efficiency, of the type comprising a housing shell, wherein are defined a gas flowpath extending along a transversal direction of the same and a hydraulic circuit comprising a plurality of tubular conduits for liquid circulation, extending in said shell along a direction, which is substantially perpendicular to the direction of the gas flow.

[0006] Thus, for example, European Patent application EP 0 831 281 describes a heat exchanger, wherein a plurality of unfinned tubes are housed between a pair of manifolds for distributing and collecting the liquid, to which manifolds the free end portion of each tube is connected.

[0007] Although substantially meeting the purpose, however, the gas-water heat exchangers of the prior art have a manufacturing cost which can not be further reduced owing to the manufacture and labor costs related to the need of providing a set of fittings between the tubular conduits and/or the ends thereof and the liquid distribution and collection manifolds, of assembling together the various parts of heat exchanger and lastly of rendering the same integral with each other.

Summary of the Invention

[0008] The technical problem underlying the present invention is, therefore, that of providing a gas-liquid heat exchanger having a lower cost with respect to the heat exchangers of the prior art having the same heating capacity, and showing at the same time features of reduced size and high heat exchange efficiency as required by the Standards adopted by the market.

[0009] According to a first aspect of the invention, the above problem is solved by a heat exchanger as defined in the characterizing portion of appended Claim 1.

[0010] The Applicant has, in fact, found out that the desired further cost reduction of manufacture of the heat exchanger may be achieved -obtaining a heat exchange efficiency which is substantially comparable with that of the most expensive heat exchangers of the prior art having a similar thermal capacity - thanks to the following measures:

- by integrally forming the tubular conduits of the exchanger into a single substantially coil-shaped conduit and provided with suitable connecting elbows which are integrally formed in the same conduit, and

- by optimizing the fluid dynamics of the gas phase during the passage of gases in the passages defined between the fins extending from the tubular conduits.

[0011] In particular, by laterally connecting the fins downstream of the tubular conduits at the end portion of their housing seat, it is advantageously possible to avoid undesirable gas by-passes into the free space existing downstream of the same tubular conduits, thus ensuring an excellent heat exchange between the gas flowing in the passages defined between the fins and the fins themselves.

[0012] In the following description and in the appended claims, the terms of: 'upstream' and of: 'downstream' will be used to indicate those parts of the heat exchanger which are touched upon first and, respectively, last by the gas flow which is crossing the heat exchanger itself.

[0013] Advantageously, in conformity with the present invention it is possible to provide a heat exchanger having both a high gas-liquid heat exchange efficiency and a high ratio between the heat exchange surface and the total volume; the equipment of the invention is therefore compact and thermodynamically efficient.

[0014] Conveniently, the gas passages defined between the fins extending from the tubular conduits are extending in the exchanger along a direction which is substantially perpendicular to the same tubular conduits, which are consequently transversally touched upon by the gas phase.

[0015] In this way, it is therefore advantageously possible to limit at minimum values the transversal sizes of the exchanger.

[0016] Preferably, said tubular conduits are parallel with each other and may lie both in the same plane or lie alternatively in parallel planes so as to have an alternation of staggered conduits which further reduces the width of the heat exchanger.

[0017] In this latter case, the distance between these
parallel planes can be established by an expert of the field to avoid interferences between the fins extending from adjacent conduits.

In a preferred embodiment of the invention, the fins are laterally connected with each other downstream of the tubular conduits by a couple of lips extending perpendicularly from each fin for a predetermined length along an end portion of the seat housing the tubular conduits.

Said lips have a predetermined suitable width capable to achieve a physical connection between a fin and the immediately adjacent one along the longitudinal direction of the heat exchanger. Preferably, the width of the lips is comprised between 1 and 8 mm and, more preferably, between 3 and 6 mm.

In the following description and in the appended claims, the term of: 'width' of a fin element is intended to indicate the extension of such element along a direction which is substantially perpendicular to the body of the same fin (i.e. substantially parallel to the longitudinal axis of tubular conduits).

In this way, it is advantageously possible to obtain, by suitably shaping the fins and after having joined the same together at a spaced relationship along the tubular conduits, a 'composite' substantially continuous closing wall capable to avoid undesirable gas by-passes into the free space existing downstream of the same tubular conduits.

Conveniently, said lips may be integrally formed in the fins by a conventional mass-production pressing operation to the full advantage of the desired reduction of production costs of the exchanger.

In an alternative embodiment of the invention, which is less desirable from the economical point of view, the fins may be laterally connected downstream of the tubular conduits by means of rectangular metal foils having an appropriate width or by means of U-shaped channels having a conveniently reduced thickness, inserted into the free space existing downstream of the tubular conduits and housed in the end portion of the housing seats of the same conduits.

Preferably, the housing seat of the tubular conduits is at least partly peripherally provided with a collar extending perpendicularly to the fin for a predetermined length. Still more preferably, the collar is extending perpendicularly to the fin for a predetermined length. Still more preferably, the collar is extending perpendicularly to the fin for a predetermined length. Still more preferably, the collar is extending perpendicularly to the fin for a predetermined length.

Conveniently, these gas passages are defined once the fins have been stably associated to the tubular conduits and, as described above, are extending along a direction which is substantially perpendicular to the longitudinal axis of the same tubular conduits.

Preferably, the heat exchanger of the invention comprises suitable means for spacing the fins in a pitch-wise manner, which means may be advantageously constituted by the aforementioned collars, lips or by appropriate spacers eventually integrally formed in the same fins.

Said means advantageously allows to define the width of said gas passages so as to achieve the desired fluid dynamics properties of gas flow which is crossing the heat exchanger.

Conveniently, the pitch between the fins may be selected by a skilled man in the art depending upon the pressure drop and the fluid dynamics properties of the gas flow which are required.

According to a preferred embodiment of the invention, furthermore, it is advantageously possible to ensure a suitable gas-tight seal both downstream and laterally with respect to the tubular conduits without the need of welding the lips and/or the side walls of a fin to the one which is immediately adjacent thereto.

This can be obtained by imparting to the lips and/or to the side walls of the fins a predetermined inclination with respect to the body of the same fins.

For the purposes of the invention, this inclination may preferably assume with respect to the body of the fins an angular value (\(\alpha_1\)) comprised between 90° and 105° as to the lips and an angular value comprised between 80° and 105° as to the side walls.

Preferably, the lips and/or the side walls of the fins form an angle (\(\alpha_1\) and \(\alpha_2\)) comprised between 96° and 100° with respect to the body of the fins, that is, they are substantially flared.
[0039] In this way, it is advantageously possible -
while assembling the exchanger - to appropriately ad-
just the pitch between the fins at a value which is slightly
lower than the width of the lips and/or of the side walls
so as to obtain a partial overlapping between the free
end of the lips and/or of the side walls and the lip and/
or the side wall of the adjacent fin.

[0040] Advantageously, furthermore, the regulation of
the pitch between the fins allows in turn to conveniently
regulate the efficiency of the heat exchanger, which is
substantially proportional to the number of fins, by bring-
ing the latter to the desired value.

[0041] In a further embodiment of the invention and
in the case where the exchanger is provided with a plu-
rality of parallel tubular conduits, the fins are provided
with a plurality of substantially U-shaped seats each
adapted to house one tubular conduit.

[0042] In this case and so as to further increase the
efficiency of the heat exchange between gas and fins,
the latter may be provided with at least one rib, formed
between the housing seats of adjacent tubular conduits,
and adapted to increase the turbulence of the gas flow-
ing into the gas passages defined between adjacent fins.

[0043] Preferably, the heat exchanger further com-
promises a couple of quick-connecting pipe fittings associ-
ated with the opposite free ends of the substantially coil-
shaped conduit.

[0044] The presence of quick-connecting pipe fittings
considerably facilitates the operations necessary to as-
so as to obtain a partial overlapping between the free
end of the lips and/or of the side walls and the lip and/or
the side wall of the adjacent fin.

[0045] According to a second aspect, the present in-
vention also relates to a fin for gas-liquid heat exchang-
ers as defined in appended claim 9 and illustrated in the
preceding parts of the present description.

[0046] According to a third aspect, the present inven-
tion relates to a water heating apparatus, for example a
boiler, which is characterized in that it comprises a heat
exchanger of the type described above.

[0047] According to a fourth aspect, the present in-
vention relates to a method for manufacturing a gas-liq-
uid heat exchanger of the type described above as de-
defined in appended claim 14.

[0048] Advantageously, the said method allows to
manufacture the gas-liquid heat exchanger of the present
invention by means of mass-production operat-
ing steps and with a minimum manpower intervention
therefore achieving the desired cost reduction of the
heat exchanger.

[0049] Preferably, the radial compression and expan-
sion steps of the tubular conduits are carried out by
means of cold plastic deformation using conventional
equipment.

[0050] Preferably, besides, the step of stably associ-
ating the fins with the tubular conduits is carried out by
means of a conventional braze welding using known
equipments and techniques.

[0051] In a further embodiment, the method of the in-
vention may comprise the additional step of associating
a couple of quick-connecting pipe fittings to the opposite
ends of the conduit in which the liquid flowpath is de-

[0052] By means of the method of the invention, it is
possible to manufacture an economical compact and
thermodynamically efficient heat exchanger by using a
simple technology at low cost and capable to ensure on
a large-scale the repeatability and reproducibility of the
performances of the heat exchangers produced.

Brief description of the drawings

[0053] Additional features and advantages of a gas-
liquid heat exchanger according to the present invention
will be better apparent from the following description of
a preferred embodiment thereof, attached herewith,
which shows some preferred but non limiting embodi-
ments thereof, with reference to the attached drawings.
In the drawings:

- Figure 1 is a perspective view of a gas-liquid heat
  exchanger according to a preferred embodiment of
  the present invention.

- Figure 2 is a perspective view, in enlarged scale, of
  a fin of the heat exchanger of Figure 1.

- Figure 3 is a top view, in enlarged scale, of some
details of the fin of Figure 2.

- Figures 4 to 8 illustrate in a schematic manner as
  many operating steps of a method for manufactur-
ing a gas-liquid heat exchanger according to the
  present invention.

- Figure 9 illustrates in a schematic manner a boiler
  incorporating the gas-liquid heat exchanger of Fig-
  ure 1.

Detailed description of the preferred embodiments
of the invention

[0054] In these figures, numeral 1 generally indicates
a gas-water heat exchanger for water heating appar-
tuses, in particular for use as heat exchanger for heating
primary warm water or water for room heating of a boiler
6 of conventional type schematically illustrated in Figure
9 and hereinafter described.

[0055] The heat exchanger 1 comprises a plurality of
tubular conduits 2, substantially rectilinear, having a lon-
gitudinal axis x-x extending along a first predetermined
direction and wherein a flowpath 3 for the water circula-
tion in the exchanger 1 is defined.

[0056] A plurality of fins 4 substantially parallel and
pitchwise spaced with respect to each other are extending outwardly of the tubular conduits 2, to which are stably associated for example by braze welding and are packed between closing plates 20, 21 associated with the tubular conduits 2 at opposite ends of the heat exchanger 1.

[0057] A plurality of gas passages 5, which allow gas to flow along a second direction y-y which is substantially perpendicular to the longitudinal axis x-x of the tubular conduits 2, is defined between the fins 4.

[0058] Preferably, the fins 4 are made of a suitable metal having good thermal conductivity properties such as copper.

[0059] In this embodiment of the invention, the gas flowing through the exchanger 1 in the gas passages 5 is essentially constituted by combustion gases coming from a burner 7 of the boiler 6 (Figure 9).

[0060] The tubular conduits 2 are essentially constituted by successive portions of a single substantially coil-shaped conduit 8, which portions are connected to each other by means of connecting elbows 9 integrally formed in the same conduit 8.

[0061] Preferably, the conduit 8 is also made of a suitable metal having good properties of thermal conductivity, such as for example copper.

[0062] Advantageously, the conduit 8 is provided at its opposite ends 8a, 8b with respective quick-connecting fittings 10a, 10b, in this example integrally formed at the same ends, adapted to facilitate the connecting operations with the hydraulic circuit of the boiler 6.

[0063] In this embodiment and as illustrated in more detailed in Figures 2 and 3, the fins 4 of the exchanger 1 comprise a suitably plate-shaped body 11 having an appropriate reduced thickness, for example comprised between 0.2 and 0.7 mm.

[0064] Conveniently, the body 11 of the fins 4 is provided with a plurality of seats 12, which are substantially U-shaped, for housing the tubular conduits 2.

[0065] Each of the seats 12 comprises:

- a first portion or bottom portion 12a having a shape substantially mating the shape of the tubular conduits and specifically designed to house and touch the latter, and

- a second portion or end portion 12b open downstream of the tubular conduits 2 and designed to allow the assembling of the fins 4 on the tubular conduits 2 as better illustrated hereinafter.

[0066] The end portion 12b of the seat 12 is defined, in particular, between essentially rectilinear portions of opposite branches of the substantially U-shaped seat 12 and formed in the body 11 of the fin 4 (Figure 2).

[0067] In this embodiment of the invention, the fins 4 are laterally connected with each other downstream of the tubular conduits 2 by means of a couple of lips 13a, b extending perpendicularly to each fin 4 substantially for the whole length of the end portion 12b of the seat 12.

[0068] Preferably, the lips 13a,b are integrally formed in the fins 4 and have a width 't1' equal to about 4 mm adapted to physically connect a fin 4 and the fin which is immediately adjacent along a direction which is parallel to the longitudinal axis x-x of the tubular conduits 2, which in this case coincides with the longitudinal direction of the exchanger 1.

[0069] In this embodiment of the present invention, the bottom portion 12a of the seat 12 is peripherally provided with a collar 14 extending perpendicularly to the fin 4 for a length which is substantially equal to the length of such a bottom portion, in this case substantially coinciding with the contact zone between the fin 4 and the tubular conduits 2.

[0070] Preferably, the collar 14 has a width 't1, c' equal to about 2 mm and is advantageously integrally formed with the lips 13a,b to which is connected without interruption.

[0071] The fins 4 of the exchanger 1 are also pack-connected with each other laterally and at opposite parts of the tubular conduits 2 by means of a couple of side walls 15a,b extending perpendicularly to opposite ends 4a,b of the fins 4.

[0072] Conveniently, the side walls 15a, b have a predetermined width adapted to allow a physical connection between a fin and the one which is immediately adjacent along a direction which is parallel to the longitudinal axis x-x of the tubular conduits 2, which in such a case coincides with the longitudinal direction of the exchanger 1. Preferably, the width 't1, s' of the side walls 15a, b is slightly higher than that of the lips 13a,b and is equal to about 5 mm.

[0073] In this way, the gas passages 5 defined between the fins 4 are substantially laterally closed in a gas tight manner so as to avoid undesirable gas bypasses into the free space existing downstream of the tubular conduits 2 (end portion 12b of the seat 12) and also to optimize the fluid dynamics of the gas flowing through the same.

[0074] Advantageously, furthermore, the lips 13a,b and the side walls 15a,b of the fins 4 are suitably pitchwise spaced with one another so as to define an appropriate width of the gas passages 5 and to achieve the desired fluid dynamics properties of the gas which crosses the heat exchanger.

[0075] Conveniently, the pitch between the fins 4 is in this embodiment equal to about 3.2 mm.

[0076] In this embodiment of the invention, the lips 13a,b and the side walls 15a,b of the fins 4 have a predetermined inclination with respect to the body 11 of the fins 4 with which they form angles α1, α2 each equal to about 98.5°.

[0077] Thanks to the ensuing flaring of the lips 13a,b and of the side walls 15a,b it is possible to assemble in packed way the fins 4 by carrying out a partial overlapping between the free end of the lips 13a,b and the side walls 15a, b and the lip 13a,b and side wall 15a,b of an...
In this way, it is advantageously possible to obtain a lateral closing of the passages 5 with suitable gastight sealing properties without carrying out any welding operation between the lips 13a,b and the side walls 15a,b of one fin 4 and the fin immediately adjacent.

Besides, in such a case it is advantageously possible to conveniently regulate within certain limits the pitch between the fins 4, thereby adjusting in turn the width of the gas passages 5 and, along therewith, the pressure drop and the fluid dynamics properties of the gas phase.

In order to increase the turbulence of the gas flowing in the gas passages 5 defined between the fins 4 and, therefore, the exchange efficiency of the exchanger 1, the fins 4 are also provided with a couple of substantially hemispherical ribs 16, 17 integrally formed in the body 11 between the housing seats 12 of adjacent tubular conduits 2.

Preferably, the ribs 16, 17 are integrally extending from the body 11 of the fin 4 on the same side of the lips 13a,b and side walls 15a,b.

Hereinafter, a method according to the invention for manufacturing the gas-liquid heat exchanger 1 previously described will be illustrated.

In an initial step of the method, the coil-shaped conduit 8 is provided by conventional operations of plastic deformation starting from a rectilinear conduit having an appropriate length.

In the conduit 8 are thus defined the substantially rectilinear tubular conduits 2 which are connected with each other by the connecting elbows 9 integrally formed in the conduit 8.

In a preferred embodiment of the method of the invention, the quick-connecting pipe fittings 10a,b are associated with or, preferably, integrally formed at the opposite ends 8a,b of the conduit 8 before or after said step of providing the tubular conduits 2.

Later on and as schematically illustrated in Figures 4 to 6, the tubular conduits 2 are laterally compressed for a portion of predetermined length so as to form in said portion opposite rectified sides 2a,b which are substantially parallel with each other.

Conveniently, such a rectification step may be carried out by means of cold plastic deformation equipment of conventional type, such as for example a press provided with a plurality of conveniently shaped jaws 18, between which abutting inserts 19 are positionable in a removable manner.

At the end of this step of partial rectification of the tubular conduits 2, the latter show rectified portions having opposite sides 2a,b which are substantially parallel with each other and having a width 'l' substantially equal to the opening defined at the end portion 12b of the seats 12 adapted to house the tubular conduits 2 (see Figure 7).

In a successive step, a plurality of fins 4 which are pitchwise spaced with respect to each other thanks to the partial overlapping of the lips 13a,b and of the side walls 15a,b is inserted onto the partially rectified portions of the tubular conduits 2.

Advantageously, in such operation the end portion 12b and the lips 13a,b constitute as many means for the guided sliding of the tubular conduits 2 adapted to facilitate the correct positioning of the latter in the bottom portion 12a of the seat 12 which is designed for their final housing.

The position of the tubular conduits 2 in the bottom portion 12a of the seat 12 is shown in dotted line in Figure 8.

In a successive step, the lateral expansion of the opposite sides 2a,b of the rectified portions of the tubular conduits 2 is carried out so as to impart to the sides 2a,b a shape substantially mating with that of the bottom portion 12a of the seat 12.

Preferably, this lateral expansion step of the tubular conduits 2 is carried out by means of plastic deformation, for example by hydroforming operations carried out by means of conventional equipment known in the art.

The position and the final configuration of the tubular conduits 2 are illustrated by a continuous line in Figure 8.

At this point, the fins 4 package-mounted on the tubular conduits 2 are permanently associated to the latter - after having inserted the closing plates 20 and 21 (if present) - by conventional braze welding operations, for example carried out into a furnace at a temperature comprised between 700° and 800° employing metal alloys suitable for the purpose such as for example copper/phosphorus alloys.

With reference to Figure 9, a boiler in which the gas-liquid heat exchanger described hereinabove may be installed will be illustrated.

Said boiler, generally indicated at 6, is a boiler of the so-called combined type and comprises a combustion module 22, in which are conventionally supported the burner 7 and the gas-water heat exchanger 1, which is transversally crossed by combustion gases G which are later evacuated through an exhaust hood 23.

The boiler 6 also comprises a primary hydraulic circuit 24 for the circulation of primary warm water or water for room heating comprising in turn:

- a conduit 25 for feeding to the exchanger 1 the primary water coming from the room heating plant (not shown);
- a circulating pump 26;
- a conduit 27 to draw the heated primary water from the exchanger 1;
- a three-way valve 28, and
- a couple of conduits 29, 30 having the task, respec-
tively, to feed the primary heated water from the exchanger 1 or again towards the room heating plant or towards a water-water heat exchanger or secondary exchanger 31 which is designed to produce sanitary warm water.

[0099] The primary hydraulic circuit 24 comprises a conduit 32 for the recirculation of the primary water which has flown through the secondary exchanger 31 back to the feeding conduit 25 of the primary exchanger 1 as well as an expansion tank 33 having the task of compensating the heat expansion of the primary water.

[0100] The boiler 6 also comprises a secondary hydraulic circuit 34 for the circulation of sanitary warm water comprising in turn:
- a conduit 35 to feed to the secondary exchanger 31 the sanitary cold water coming from the water distribution network;
- the three-way valve 28;
- the secondary exchanger 31;
- a conduit 36 to feed the sanitary heated water coming from the secondary exchanger 31 towards one or more drawing points external to the boiler 6.

[0101] The boiler 6 comprises a conduit 38 for feeding a suitable gas fuel, for example, methane gas to the burner 7 and a valve 38 having the task of intercepting the conduit 38 and thereby adjusting the gas flow rate fed to the same burner.

[0102] In a conventional way, said conduits 25, 29, 35, 36, 37 are provided with respective fittings 25', 29', 35', 36' and 37' adapted to allow their connection respectively to the room heating plant, to the water network, to the sanitary water tapping points and to the gas distribution network.

[0103] The operation of the boiler 6 described hereinabove, driven by an equipment known per se and not shown, is entirely conventional and shall not be illustrated in detail hereinafter.

[0104] In the operation of the gas-liquid heat exchanger 1 described hereinabove, the gas phase G - in this case constituted by the combustion gases generated by the burner 7 of the boiler 9 - flows with an ascending motion from bottom upwards along the y-y direction in the gas passages 5 defined between the fins 4.

[0105] During the crossing of the gas passages 5, the combustion gases lap the fins 4, which absorb part of their sensible heat.

[0106] Thanks to the presence of a lateral connection between the fins 4 downstream of the tubular conduits 2, the combustion gases can not by-pass the gas passages 5 and leave the exchanger 1 only after having entirely crossed the latter, effectively transmitting part of their own sensible heat to the fins 4.

[0107] A portion of the heat transmitted to the fins 4 is in turn conveyed by the latter, essentially by conduction, to the water for space heating which flows in the liquid flowpath 3 defined in the conduit 8, water which is therefore heated at the desired temperature.

[0108] After a plurality of repeated tests carried out with the exchanger 1 according to the invention, the Applicant has found out that the exchanger is capable to reach a heat exchange efficiency comparable to that of the known heat exchangers having an equal heating capacity, even if the present exchanger has a cost which is much lower than the exchangers of the prior art.

[0109] According to the above description, the advantages achieved by the present invention are immediately clear.

[0110] Among the latter mention may be made of the following advantages:
- possibility of having a heat exchanger which is of simple construction and which may be manufactured without using particularly expensive materials and particularly complicated processing operations and, therefore, a heat exchanger having costs which are lower than the costs nowadays obtainable on the market;
- possibility of achieving a high ratio between the heat exchange surface and the total volume, thereby accomplishing a compact and light exchanger which is at the same time thermodynamically efficient.

Claims

1. Gas-liquid heat exchanger comprising:

- a plurality of substantially rectilinear tubular conduits (2) having a longitudinal axis (x-x) extending along a first predetermined direction, and wherein a flowpath (3) for the liquid circulation in the exchanger (1) is defined;
- a plurality of fins (4) substantially parallel with each other extending outwardly of said tubular conduits (2);
- a plurality of gas passages (5) defined between said fins (4) so as to allow a gas flow along a second direction (y-y) substantially perpendicular to the longitudinal axis (x-x) of the tubular conduits (2);

characterized in that the tubular conduits (2) are essentially constituted by successive portions of a single conduit (8), said portions being connected with each other by connecting elbows (9) integrally formed in said conduit (8) and in that said fins (4) are provided with at least one substantially U-
shaped seat (12) for housing the tubular conduits (2) and are laterally connected with each other downstream of the tubular conduits (2) at an end portion (12b) of said seat (12).

2. Heat exchanger according to claim 1, wherein the fins (4) are provided at the end portion (12b) of the seat (12) for housing the tubular conduits (2) with a couple of lips (13a,b) extending perpendicularly to the fin (4) for a portion of predetermined length along said end portion (12b) of the seat (12) and having a predetermined width and wherein the fins (4) are laterally connected with each other downstream of the tubular conduits (2) by means of said lips (13a,b).

3. Heat exchanger according to claim 2, wherein the seat (12) for housing the tubular conduit (2) is at least partially peripherally provided with a collar (14) extending perpendicularly to the fin (4) and having a predetermined width, said collar (14) being connected to and integral with said lips (13a,b).

4. Heat exchanger as defined in anyone of claims 1-3, wherein the fins (4) are provided at opposite portions with a couple of side walls (15a, b) extending perpendicularly to the fin (4) and having a predetermined width and wherein the fins (4) are laterally connected with each other at opposite portions of the tubular conduits (2) by means of said side walls (15a, b).

5. Heat exchanger according to claim 1, further comprising means for pitchwise spacing the fins (4) with respect to each other.

6. Heat exchanger according to claim 4, wherein:
   - the lips (13a,b) of the fins (4) form an angle ($\alpha_1$) comprised between 90° and 105° with respect to the body of the fins (4), and
   - the side walls (15a, b) form an angle ($\alpha_2$) comprised between 80° and 105° with respect to the body of the fins (4).

7. Heat exchanger according to claim 1, wherein the fins (4) are provided with a plurality of substantially U-shaped seats (12) for housing the tubular conduits (2) and are provided with at least one rib (16, 17) formed between said seats (12) in the body (11) of the fins (4) so as to increase the turbulence of the gas flowing into said gas passages (5).

8. Heat exchanger according to claim 1, further comprising a couple of quick-connecting fittings (10a,b) associated to opposite ends of said conduit (8).

9. Fin (4) for gas-liquid heat exchangers comprising a plate-shaped body (11) provided with at least one seat (12) for housing a tubular conduit (2), wherein a flowpath (3) for the liquid circulation in the exchanger (1) is defined, characterized in that the seat (12) for housing the tubular conduits (2) is substantially U-shaped and is provided at an end portion (12b) thereof with a couple of lips (13a,b) having a predetermined width and extending perpendicularly to the fin (4) for a predetermined length of said end portion (12b).

10. Fin (4) according to claim 9, wherein the seat (12) for housing the tubular conduit (2) is at least partially peripherally provided with a collar (14) extending perpendicularly to the fin (4) and having a predetermined width, said collar (14) being connected to and integral with said lips (13a,b).

11. Fin (4) according to claim 9, wherein the plate-shaped body (11) is provided at opposite end portions with a couple of side walls (15a, b) extending perpendicularly to said body (11) and having a predetermined width.

12. Fin (4) according to claim 9, wherein the plate-shaped body (11) is provided with a plurality of substantially U-shaped seats (12) for housing the tubular conduits (2) and is provided with at least one rib (16, 17) formed in said body (11) between said housing seats (12).

13. Water heating apparatus comprising a heat exchanger according to anyone of claim 1-8.

14. A method for manufacturing a gas-liquid heat exchanger according to anyone of claim 1-8, characterized in that it comprises the steps of:
   - providing a conduit (8) having a predetermined length constituted by a plurality of cylindrical substantially rectilinear tubular conduits (2) connected with each other by means of connecting elbows (9) integrally formed in said conduit (8);
   - laterally pressing said cylindrical tubular conduits (2) along a portion of predetermined length so as to form in said portion rectified opposite sides (2a,b) substantially parallel with each other;
   - housing into the partially rectified portions thus obtained a plurality of fins (4) according to anyone of claims 9-12;
   - laterally expanding the rectified opposite sides (2a,b) of said portions so as to impart to said
portions a substantially elliptical cross-section having a shape substantially mating with the shape of a bottom portion (12a) of respective housing seats (12) formed in the fins (4);

- associating in a stable way the fins (4) to the tubular conduits (2).

15. Method according to claim 14, wherein said compression and lateral expansion steps of the tubular conduits (2) are carried out by means of plastic deformation.

16. Method according to claim 14, wherein the step of stably associating the fins (4) to the tubular conduits (2) is carried out by means of braze welding.

17. Method according to claim 14, further comprising the step of associating a couple of quick-connecting fittings (10a, b) to the opposite ends (8a, b) of said conduit (8).
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<td>US 1 972 706 A (ROBERT C. ENGELMAN) 4 September 1934 (1934-09-04)</td>
<td>9-11</td>
<td>F28D7/08</td>
</tr>
<tr>
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<td>* page 2, line 85 - page 3, line 11; figures 4-9 *</td>
<td>1-6,12, 14,15, 8,17</td>
<td>F28F1/32</td>
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<tr>
<td>Y</td>
<td>US 3 433 300 A (PASTERNAK STEPHEN F) 18 March 1969 (1969-03-18)</td>
<td>1-6,14, 15</td>
<td></td>
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<tr>
<td></td>
<td>* column 6, line 17 - column 8, line 52; figures 1-8 *</td>
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<tr>
<td>X</td>
<td>US 2 532 301 A (JAMES R. HAYWARD) 5 December 1950 (1950-12-05)</td>
<td>9,10</td>
<td></td>
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<td>* column 1, line 48 - column 3, line 8; figures *</td>
<td>1-3,6</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>US 2 540 339 A (RICHARD W. KRITZER) 6 February 1951 (1951-02-06)</td>
<td>1,9,14</td>
<td>F28F</td>
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<td></td>
<td>* column 1, line 55 - column 3, line 28; figures *</td>
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<td>* abstract; figure 2 *</td>
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<td></td>
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<tr>
<td>A</td>
<td>US 4 928 756 A (SHULL WILLIAM ET AL) 29 May 1990 (1990-05-29)</td>
<td>16</td>
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</tr>
<tr>
<td></td>
<td>* abstract; figures *</td>
<td></td>
<td></td>
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</table>

The present search report has been drawn up for all claims.

Place of search: THE HAGUE
Date of completion of the search: 1 March 2000
Examiner: Van Dooren, M

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<tr>
<th>Patent document cited in search report</th>
<th>Publication date</th>
<th>Patent family member(s)</th>
<th>Publication date</th>
</tr>
</thead>
<tbody>
<tr>
<td>US 1972706 A</td>
<td>04-09-1934</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 3546763 A</td>
<td>15-12-1970</td>
</tr>
<tr>
<td>US 5157941 A</td>
<td>27-10-1992</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td>US 2532301 A</td>
<td>05-12-1950</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td>US 2540339 A</td>
<td>06-02-1951</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td>US 4671212 A</td>
<td>09-06-1987</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td>US 4928756 A</td>
<td>29-05-1990</td>
<td>NONE</td>
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