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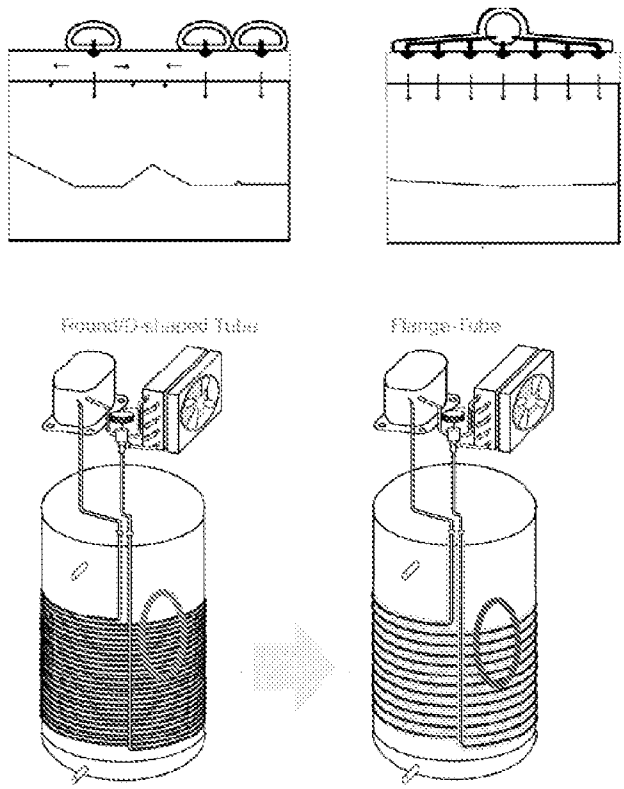
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(54) Title **A condenser tube, a method and an apparatus for heat exchange**

(56) References Cited: US 2138525 A, US 3384167 A, DE 760126 C, GB 803759 A, EP 2372284 A1

(57) Abstract

The present invention relates to a condenser tube profile (7), a method and an apparatus for heat exchange where a condenser tube profile (7) is applied for heat exchange purposes. The condenser tube profile (7) is made of aluminium or an aluminium alloy in an extrusion process, and a heat transfer medium is transported through one or more channels (12) arranged in the said tube profile (7). A substantial flat flange (10, 11) is integrated with the tube profile. The tube profile can be winded in a shape of a helix onto the outer surface of an object (8), that preferably has a cylindrical shape, and where the flat flange is arranged firmly onto the surface of the object. The invention also relates to a method for heat transfer (9) between a heat transfer medium flowing through such condenser tube and a liquid (4) in a tank as well as an apparatus such as a domestic water heater of steel or stainless steel provided with said heat transfer arrangement.



The present invention relates to a condenser tube, a method and an apparatus for heat exchange where a condenser tube is applied for circulation of a heat transfer medium for heat exchange purposes. More specific it relates to a condenser tube profile with one or more channels and of a certain shape, and that it can be wound in a helix manner outside a container or tank of metal for heat transfer purposes, for instance heating of domestic water.

Common technology used today is based on round, flattened round or D-shaped aluminium condenser tubes wrapped around a tank made of steel or stainless steel. Due to poor heat conductivity in steel/stainless steel the heat is not spread far from the contact point tube-to-tank. To transfer enough heating energy to the liquid (water) in the tank, the condenser tubes are wrapped close to each other and over a greater part of the tank. The length of the round/flattened/D-shaped condenser tube therefore needs to be rather long, often 50 - 60 meters. Due to this length, the crossflow area of the round/ flattened/D-shaped condenser tube therefore needs to be rather large not to introduce high pressure drop in the refrigeration cycle resulting in poor energy efficiency.

In the past, this solution has been good enough as HFC refrigerant gases have been available without GWP restrictions/quota regulations until now.

In CN211470775U there is disclosed a heat dissipating coil pipe on the outer surface of a tank body of a gas synthesis section where the cross-section of the coil pipe is omega shaped. Sealing gaskets are arranged between side plates on two sides of the coil pipe and the outer surface of the tank body so that cooling medium can be brought in contact with the outer surface of the tank. Each winding has a large pitch and is arranged with a large distance between each winding.

One other example of an omega shaped cooling condenser pipe is shown in CN107525311A. The omega shaped pipe is in most cases open and doesn't form a closed shape that can carry a pressurized medium without being welded or in other way joined to the wall of the tank. The closed tube design is described as produced by pressure casting or welding of a strip.

US2138525A discloses an evaporator for a refrigerator comprising, an extruded metal strip of relatively great length having a tubular portion and oppositely extending flanges thereon, said metal strip being fashioned into a plurality of coils, with the flanges of successive coils cooperating to form a solid wall.

US3384167A discloses an integral spiral wound wall-forming band for heat exchange comprising a

body having a conduit formed in its central portion, and inwardly internal complementary flange means on the opposite edges of said body for interlocking engagement with an adjacent section of the band, one of said flange means being substantially of inverted U-shape, the upper portion of the U being closed, the opposite side of said flange means being of an inverted L-shape.

DE760126C discloses an evaporator for refrigeration machines, in particular for compressors, which consists of sheet metal, in which grooves are pressed to form refrigerant channels, wherein a sheet metal strip forming only one refrigerant channel spirals into an evaporator body enclosing a freezer compartment and provided with a flat lower support surface for ice boxes.

The present invention is set forth and characterized in the independent claims, while the dependent claims describe other characteristics of the invention.

According to the present invention, the condenser tube can be made of aluminium or an aluminium alloy in a single extrusion process, having one or more channels. Further, the extruded tube profile is provided with an integrated flange at its periphery. The flange has a flat face against the tank. The big contact area between tube flange and tank minimizes the thermal contact resistance between flange tube and tank, hence optimizes the substantially one-dimensional heat transfer from flange tube to liquid inside the tank.

The cross-sectional shape of the condenser tube profile can be circular with a substantial flat flange and thus may have an omega shape but closed in shape. The substantially round channel shape with the flange integrated in its periphery can sustain internal pressure increase with minimum distortion of its shape and substantially without deformation of the flange, hence maintaining the good thermal contact between flange tube profile and tank. The flange can be thinner at its outer sides than in the vicinity of the channel(s) and thus having a slanting surface towards its longitudinal side edges.

By winding the condenser tube onto the outer surface of a tank for heating a fluid in a manner with windings of a pitch that brings the long sides of the flange close to each other or even to abut, a very efficient heat transfer can be obtained with a low amount of refrigerating medium necessary in the circulating circuit. One advantageous field of use for the condenser tube is that it can be arranged at the outer surface of a cylindrical tank for heating water for domestic use.

These and further advantages can be achieved by the invention according to the accompanying claims 1-11.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be further described in detail in the following by means of examples and with reference to the attached drawings 1-8 where:

Fig. 1 is a cross-section cut of a tank with a condenser tube at its outside and shows a State of the art technology used today based on round, flattened round or D-shaped tubes wrapped around a tank,

Fig. 2 is a cross-section cut of a tank with a condenser tube profile with one channel and further provided with a flange and being wrapped at the outside the tank, which is an embodiment according to the present invention,

Fig. 3 shows a condenser tube profile with a flange according to the present invention having one channel,

Fig. 4 shows a condenser tube profile with a flange according to the present invention and further provided with two channels,

Fig. 5 discloses means of connection the flange tube of Fig. 4 to a circuit,

Fig. 6 discloses a chart showing dimension ranges of various channels and flanges according to the invention,

Fig. 7a indicates the heat transfer in a heater applying a state-of-the-art D-shaped tube and in Fig 7 b there is indicated the heat transfer according to the present flange tube.

Fig. 8 briefly discloses a sanitary water heater applying round or D-shaped tube (left), and a flange tube according to the present invention (right).

DESCRIPTION OF THE INVENTION

Fig. 1 is a cross-section cut of a tank with a condenser tube at its outside and discloses the state-of-the-art technology used today based on round, flattened round or D-shaped tubes 1 wrapped around

a tank 2 made of steel or stainless steel (four windings shown). Due to poor heat conductivity in steel/stainless steel the heat is not distributed far from the contact point 3 tube-to-tank. To transfer enough heating energy to the water 4 in the tank, the tubes are wrapped close to each other 5 and over a greater part of the tank. The length of the round/D-shaped tube therefore needs to be rather long – often 50-60 meters. The crossflow area 6 of the round/flattened/D-shaped tube therefore needs to be rather large not to introduce high pressure drop in the refrigeration cycle resulting in poor energy efficiency. This results in a certain amount of heat transfer medium in the circuit.

Fig. 2 discloses two windings of a condenser tube profile 7 provided with a flange 10, 11 according to the present invention, made of aluminium or an alloy thereof and wrapped around a tank 8 made of steel or stainless steel. The tank may contain a body of water 4. The good heat conductivity properties of aluminium allow the heat to travel from the channel 12 to the flange 11 with a minimum of restriction between the parts as indicated by arrows 9.
As disclosed in Fig. 3, the flange 11' of the condenser tube profile 7' according to the present invention covers a larger area of the tank with full surface contact and therefore minimizes the effect of the poor heat conductivity in steel/stainless steel and in the contact between tank and flange.

The large width of the flange 11' associated with the condenser tube profile provided with channel 12' for a heat transfer medium allows that the number of wraps around the tank can be reduced and therefore the tubular part can be shortened significantly, for instance down to 18-23 meters. This corresponds to 2 to 3 times shorter than commonly used solutions. The condenser tube can be winded in shape of a helix and advantageously with a pitch such that the sides of the flange abuts each other throughout the whole length of the helix to be able to cover as much as possible of the surface of the tank.

Preferably, the aluminium or aluminium alloy is of a A3xxx or A1xxx type with ductility allowing that a condenser tube according to the invention can be formed in a convenient manner into a helix with planar abutment of its flange onto the cylindrical surface of the tank. The medium in the tank can be liquid, preferably water.

The radius (13) between the round part and the flange must be placed close to the outer diameter and have a certain size, preferably 0,5 mm to minimize heat transfer distance from refrigerant channel to outer tip of the flange. This design also serves to ease the extrusion process.

One technical effect of the significantly shorter tubular part provided by the invention is that it allows

a great reduction of the cross-sectional flow area without introducing an overall high pressure drop in the refrigeration cycle.

The flange condenser tube profile can be made much shorter and with a smaller inner diameter than that of the prior art, and thus enabling a reduction of the inner volume without compromising any functional parameters.

As a consequence, this allows low GWP (Global Warming Potential) gases such as Hydrocarbons to be used up to 150 gram system charge without getting into the grey zone between 150 and 500 gram where it is allowed, but with so complicated restrictions that almost no one will take the responsibility and therefore not a practical option.

Fig. 4 shows a condenser tube profile 7'' with a flange 11'' according to the present invention and further provided with two channels 12'', 12'''. This design may be provided by one extruded profile and allows that the cross-sectional flow area can be reduced.

Fig. 5 discloses means of connection the condenser tube profile 7'' with channels 12'', 12'' of Fig. 4 to a circuit that comprises a yoke formed tube with a main tube 16 having branches 17, 18.

Fig. 6 discloses a chart showing dimension ranges of various channels and flanges according to the invention;

where the relation between the inner diameter of the channel (ID) and the flange width (FW), (ID) : (FW) is in the interval (2mm - 6mm) : (20mm - 65mm,

or (FW), (ID) : (FW) is in the interval (2,5mm - 5mm) : (22,5mm – 60mm),

or (FW), (ID) : (FW) is in the interval (3mm - 4,5mm) : (22,5mm - 55mm).

Fig. 7a indicates the heat transfer in a heater applying a state of the art D-shaped tube and in Fig 7 b there is indicated the heat transfer according to the present flange tube. The arrows indicate the heat transfer and as can be seen from the illustration in Fig 7b the transfer of heat is very even.

Fig. 8 briefly discloses a sanitary water heater applying round or D-shaped tube (left), and a flange tube according to the present invention (right). It can be seen that the number of windings of the

tube is reduced significantly in the right illustration.

For instance, simply increasing the flange width 10 brings some Pro's and Con's:

| Pro's | Con's |
|---|---|
| - Fewer turns around tank results in reduced total tube length<br>- Reduced refrigerant charge<br>- Reduced pressure drop in refrigeration | - Longer way for the energy to travel to reach the tip of the flange<br>- Slight reduction of total heat transfer into the tank (to water) |

For instance, simply reducing the inner diameter 12 of the tube brings some Pro's and Con's:

| Pro's | Con's |
|---|---|
| - Reduced refrigerant charge | - Increased pressure drop in refrigeration system |

Conclusions from temporary test work:

Energy Efficiency (COP) can be increased to approx. 4,0 with system charge 150 g Propane (R290) in a typical Sanitary Hot Water Heat Pump system.

Energy Efficiency (COP) can easily be improved further with reduced inner diameter/wider flange (in combination with optimized/lower inner volume evaporator) and operate with max. 150 g Propane.

Further, according to the present invention there is a possibility to reduce the amount of material used for the condenser tube compared to the state of the art tube.

Round/D-shaped (ø10x1mm) 77 g/m x 55,6 meter => 4,29 kg/unit Flange-Tube (id ø5/Flange 25mm) 140 g/m x 23 meter => 3,22 kg/unit

The profile can be extruded in its full length and it can be coiled during production.

Claims

1. A condenser tube profile (7) made by an extrusion process of aluminium or an aluminium alloy and arranged outside an object (2) of a substantially cylindrical shape, wherein the condenser tube profile (7) is arranged for heat transfer between a heat transfer medium transported inside at least one channel (12) of said condenser tube, the channel having an inner diameter (ID), and a medium, preferably a liquid, contained in said object, wherein the tube profile (7) is winded onto the outer surface of the said object,
c h a r a c t e r i s e d i n t h a t
a substantially flat flange (11) with a flange width (FW) is integrated in parallel with a longitudinal direction of the condenser tube, where the flange is arranged in thermal contact with the outer surface of the said object (2), wherein the relation between the inner diameter (ID) of the channel (12) and the flange width (FW), (ID) : (FW), is in the interval (2 mm – 6 mm) : (20 mm – 65 mm).

2. A condenser tube according to claim 1, c h a r a c t e r i s e d i n t h a t
the condenser tube profile (7) is winded in the shape of a helix with a pitch where one side edge of the flange abuts the other.

3. A condenser tube according to claim 1, c h a r a c t e r i s e d i n t h a t
the object (2) is a tank made of steel or stainless steel.

4. A condenser tube according to claim 1, c h a r a c t e r i s e d i n t h a t
the condenser tube is provided with two channels (12'', 12''').

5. A condenser tube according to claim 1, c h a r a c t e r i s e d i n t h a t
the condenser tube profile (7) is extruded and coiled.

6. A condenser tube according to claim 1, c h a r a c t e r i s e d i n t h a t
the relation between the inner diameter (ID) of the channel (12) and the flange width (FW), (ID) : (FW) is in the interval (2,5mm - 5mm) : (22,5mm – 60mm).

7. A condenser tube according to claim 1, c h a r a c t e r i s e d i n t h a t
the relation between the inner diameter (ID) of the channel (12) and the flange width (FW), (ID) : (FW) is in the interval (3mm - 4,5mm) : (22,5mm - 55mm).

8. A method for heat transfer between a heat transfer medium and a medium, preferably a liquid, contained in a substantially cylindrical tank of steel or stainless steel (2), where a condenser tube profile (7) made by an extrusion process of aluminium or an aluminium alloy conducts the heat transfer medium in one or more channels (12), the channel having an inner diameter (ID), and is further arranged at the outside of the tank,

characterised in that

the condenser tube profile (7) is provided with a substantially flat flange (11) at the periphery of the condenser tube profile (7), with a flange width (FW), and where the sides of the flange are extending parallel to said condenser tube profile (7) in the longitudinal direction thereof, wherein the relation between the inner diameter (ID) of the channel (12) and the flange width (FW), (ID) : (FW), is in the interval (2 mm – 6 mm) : (20 mm – 65 mm), and wherein the flange (11) of the condenser tube is attached in firm contact with the tank (2) and where the condenser tube is winded as the shape of a helix.

9. A method according to claim 8, characterised in that

the condenser tube profile (7) is winded in a helix shape with a pitch where the one side of the flange abuts or substantially abuts the other.

10. An apparatus for heating domestic water, comprising a cylindrical tank (2) of steel or stainless steel for water to be heated, where a condenser tube profile (7) made by an extrusion process of aluminium or an aluminium alloy is fixed onto the outer surface of the tank for heating the water by a hot medium flowing through one or more channel(s) (12) of said condenser tube profile (7), the channel having an inner diameter (ID),

characterised in that

the condenser tube profile (7) is provided with a substantially flat flange (11) at its periphery, with a flange width (FW), the flange having side edges extending in parallel with said condenser tube profile, in the longitudinal direction thereof, wherein the relation between the inner diameter (ID) of the channel (12) and the flange width (FW), (ID) : (FW), is in the interval (2 mm – 6 mm) : (20 mm – 65 mm), and wherein the condenser tube profile is winded in the shape of a helix onto the surface of the tank (2) and attached in firm contact with it.

11. An apparatus according to claim 10,

characterised in that

the condenser tube profile (7) is winded in a helix shape with a pitch where the one side of the flange abuts or substantially abuts the other.

Krav

1. En kondensatorrørprofil (7) laget ved en ekstruderingsprosess av aluminium eller en aluminiumslegering og anordnet utenfor en gjenstand (2) med en hovedsakelig sylindrisk form, hvor kondensatorrørprofilen (7) er anordnet for varmeoverføring mellom et varmeoverføringsmedium transportert inne i minst én kanal (12) av kondensatorrøret, hvor kanalen har en indre diameter (ID), og et medium, fortrinnsvis en væske, inneholdt i gjenstanden, hvori rørprofilen (7) er viklet på den ytre overflaten av den nevnte gjenstanden,
k a r a k t e r i s e r t v e d a t
en hovedsakelig flat flens (11) med en flensbredde (FW) er integrert parallelt med en lengderetning av kondensatorrøret, hvor flensen er anordnet i termisk kontakt med den ytre overflaten av nevnte objekt (2), hvor forholdet mellom kanalens (12) indre diameter (ID) og flensbredden (FW), (ID) : (FW), er i intervallet (2 mm – 6 mm) : (20 mm – 65 mm).

2. En kondensatorrørprofil ifølge krav 1, k a r a k t e r i s e r t v e d a t kondensatorrørprofilen (7) er viklet i form av en spiral med en stigning hvor den ene sidekanten av flensen støter mot den andre.

3. En kondensatorrørprofil ifølge krav 1, k a r a k t e r i s e r t v e d a t objektet (2) er en tank laget av stål eller rustfritt stål.

4. En kondensatorrørprofil ifølge krav 1, k a r a k t e r i s e r t v e d a t kondensatorrørprofilen er utstyrt med to kanaler (12'', 12''')

5. En kondensatorrørprofil ifølge krav 1, k a r a k t e r i s e r t v e d a t kondensatorrørprofilen (7) er ekstrudert og kveilet.

6. En kondensatorrørprofil ifølge krav 1, k a r a k t e r i s e r t v e d a t forholdet mellom kanalens (12) indre diameter (ID) og flensbredden (FW), (ID) : (FW) er i intervallet (2,5 mm - 5 mm) : (22,5 mm – 60 mm).

7. En kondensatorrørprofil ifølge krav 1, k a r a k t e r i s e r t v e d a t forholdet mellom kanalens (12) indre diameter (ID) og flensbredden (FW), (ID) : (FW) er i intervallet (3mm - 4,5mm) : (22,5mm - 55mm).

8. En fremgangsmåte for varmeoverføring mellom et varmeoverføringsmedium og et medium, fortrinnsvis en væske, inneholdt i en hovedsakelig sylindrisk tank av stål eller rustfritt stål (2), hvor en kondensatorrørprofil (7) laget ved en ekstruderingsprosess av aluminium eller en aluminiumslegering leder varmeoverføringsmediet i én eller flere kanaler (12), kanalen har en indre diameter (ID), og er videre anordnet på utsiden av tanken,

k a r a k t e r i s e r t v e d a t

kondensatorrørprofilen (7) er forsynt med en hovedsakelig flat flens (11) ved periferien av kondensatorrørprofilen (7), med en flensbredde (FW), og hvor sidene av flensen strekker seg parallelt med kondensatorrørprofilens (7) lengderetning, hvor forholdet mellom kanalens (12) indre diameteren (ID) og flensbredden (FW), (ID): (FW), er i intervallet (2 mm – 6 mm) : (20 mm – 65 mm), og hvor kondensatorrørets flens (11) er festet i fast kontakt med tanken (2) og hvor kondensatorrøret er viklet i form av en spiral.

9. En fremgangsmåte ifølge krav 8, k a r a k t e r i s e r t v e d a t kondensatorrørprofilen (7) er viklet i en spiralform med en stigning hvor den ene siden av flensen støter mot eller hovedsakelig støter mot den andre.

10. Et apparat for oppvarming av husholdningsvann, omfattende en sylindrisk tank (2) av stål eller rustfritt stål for vann som skal varmes opp, hvor en kondensatorrørprofil (7) laget ved en ekstruderingsprosess av aluminium eller en aluminiumslegering er festet på den ytre overflaten av tanken for oppvarming av vannet med et varmt medium som strømmer gjennom én eller flere kanal(er) (12) av kondensatorrørprofilen (7), hvor kanalen har en indre diameter (ID),

k a r a k t e r i s e r t v e d a t

kondensatorrørprofilen (7) er forsynt med en hovedsakelig flat flens (11) ved sin periferi, med en flensbredde (FW), flensen har sidekanter som strekker seg parallelt med kondensatorrørprofilen, i dens lengderetning, hvor forholdet mellom kanalens (12) indre diameteren (ID) og flensbredden (FW), (ID) : (FW), er i intervallet (2 mm – 6 mm) : (20 mm – 65 mm), og hvor kondensatorrørprofilen er viklet i form av en spiral på overflaten av tanken (2) og festet i fast kontakt med den.

11. Et apparat ifølge krav 10,

k a r a k t e r i s e r t v e d a t

kondensatorrørprofilen (7) er viklet i en spiralform med en stigning hvor den ene siden av flensen støter mot eller hovedsakelig støter mot den andre.

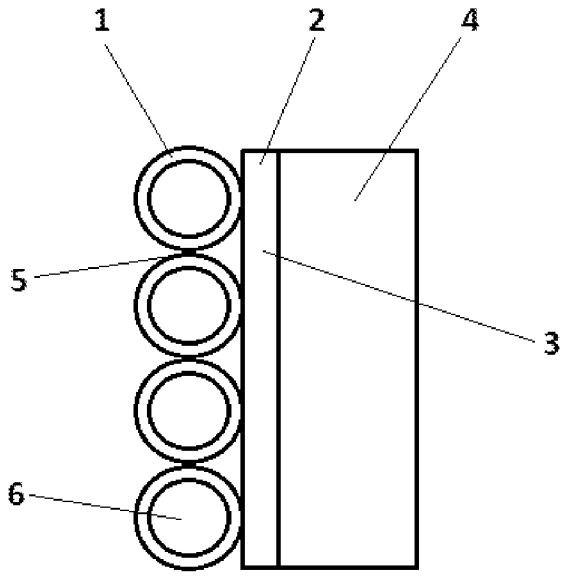



**Fig. 1**

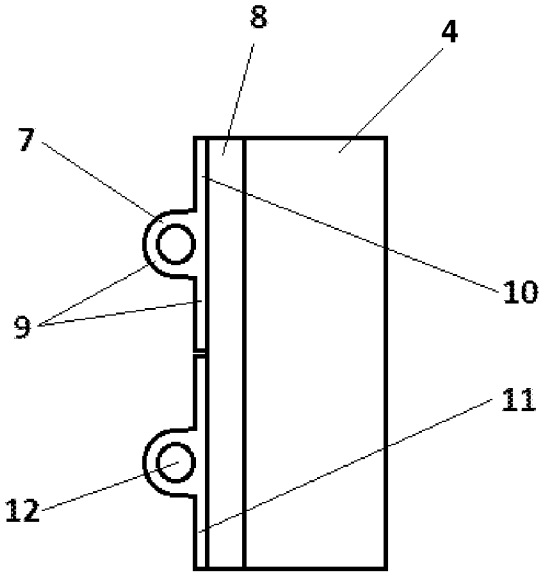



**Fig. 2**

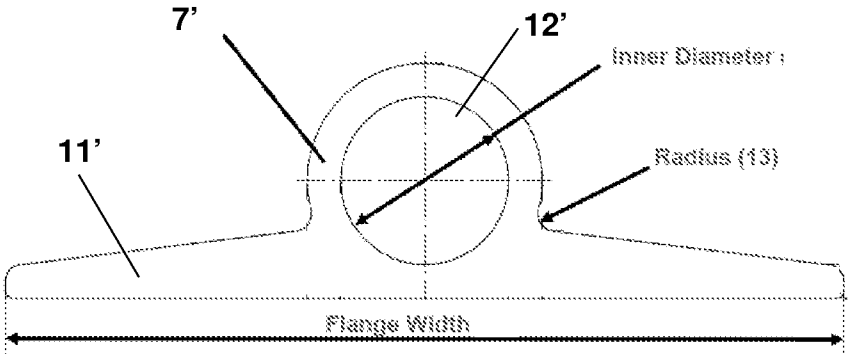



**Fig. 3**

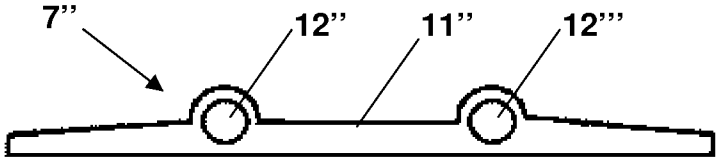



**Fig. 4**

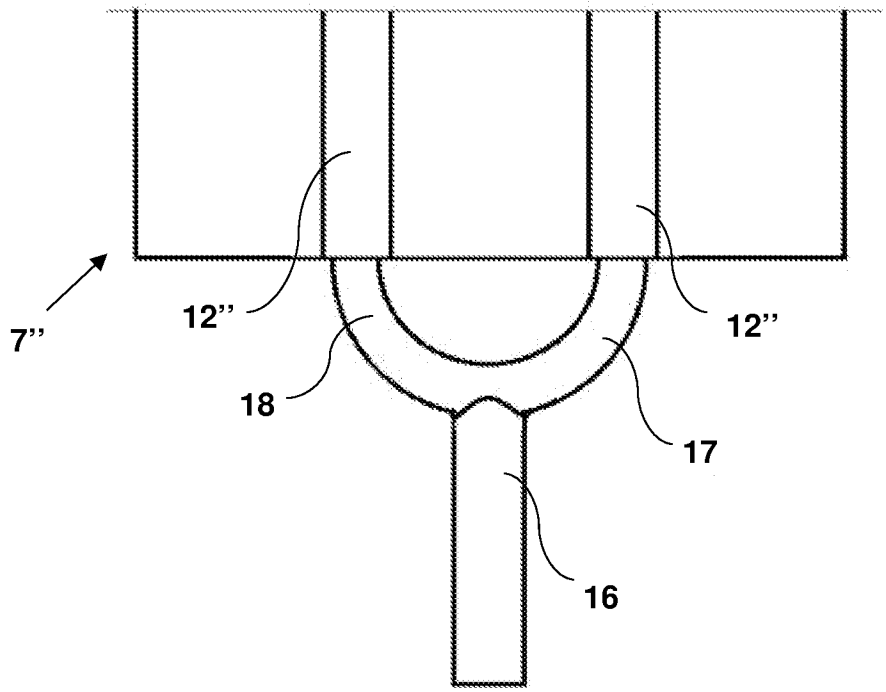

7''
12''
12''
18
17
16

**Fig. 5**

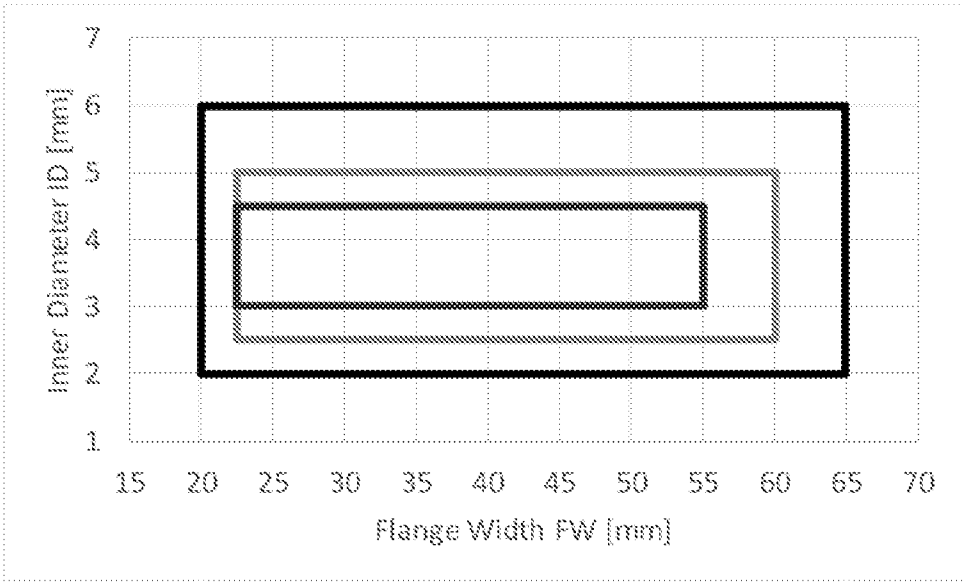

Inner Diameter ID [mm]
7
6
5
4
3
2
1
15
20
25
30
35
40
45
50
55
60
65
70
Flange Width FW [mm]

**Fig. 6**

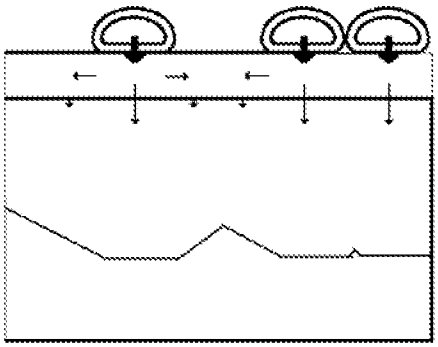


Fig. 7a

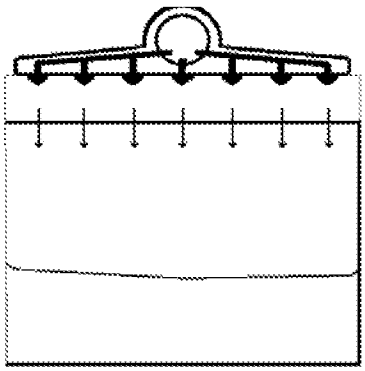


Fig 7b

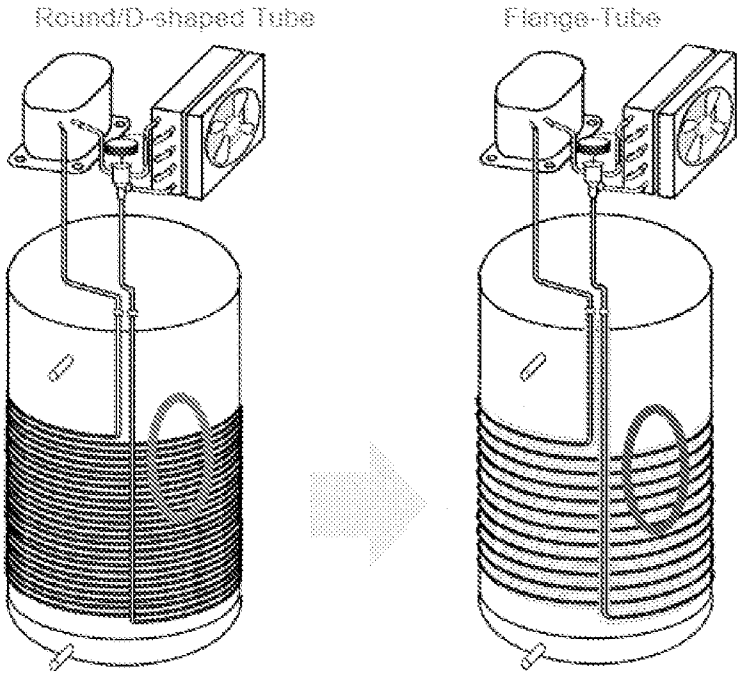



Fig. 8