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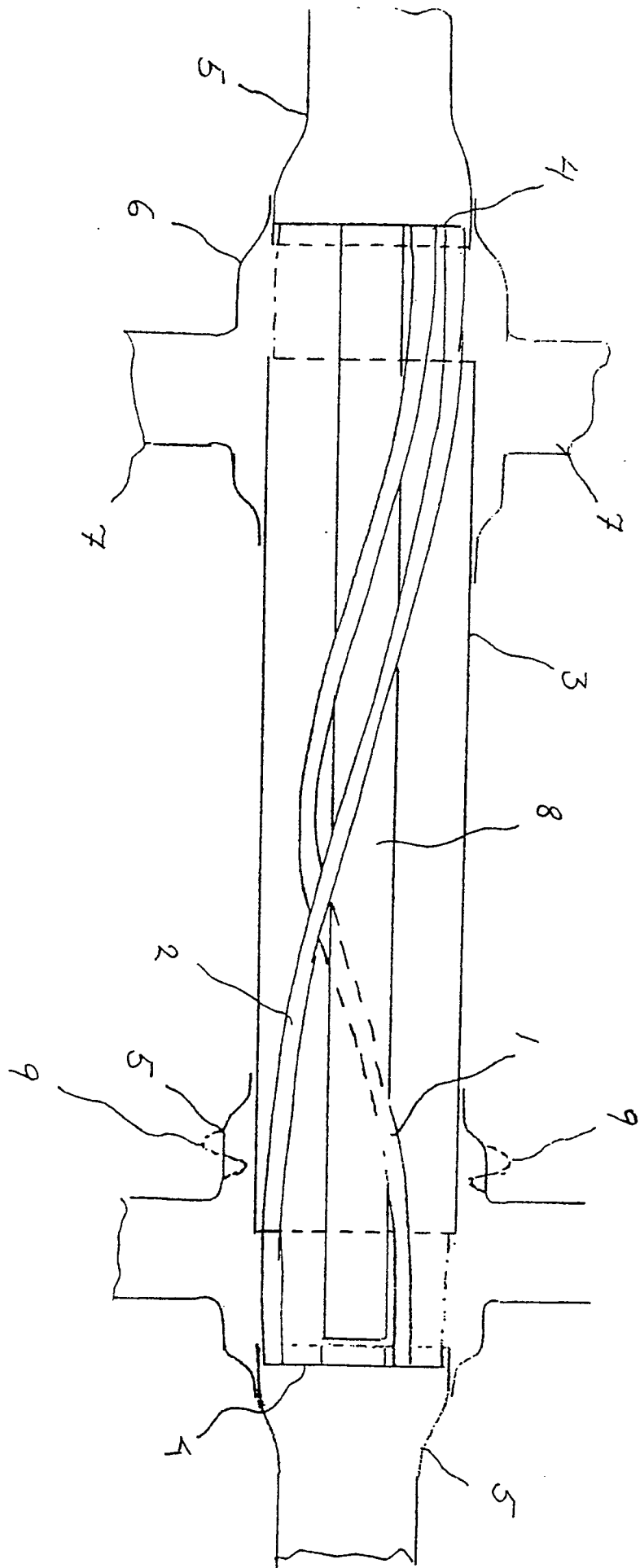
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Heat exchanger and a method for its fabrication.

Heat exchanger including progressively angled or over their length slightly spirally wound tubes (1, 2) extending between two tube plates (4). The tubes (1 and 2) are arranged in two concentric circles and the tubes of the different circles are given differing progression so that the same tube length can be used in the different concentric circles of the tubes. The tubes (1, 2) are corrugated over their length and the rings of tubes are in close contact with each other. In the end of the tubes the tube plates (4) are achieved by widening the ends of the pipe so that they come in contact with each other, whereafter the ends are soldered to each other. The tube bundle is surrounded by a tight fitting shell (3) and wide surrounding connections (5, 6) allowing the heat exchanger to be easily coupled in series parallel etc. (Fig 1).

Fig 1



HEAT EXCHANGER AND A METHOD FOR ITS FABRICATION

This invention is related to heat exchangers of the kind that includes pipes or tubes extending between two tube plates, and with one fluid streaming inside the tubes and another outside the tubes. The tube package or heat exchanger core is surrounded by a shell.

One problem at heat exchanger of this kind is that the tubes when heated will expand causing considerable tension in the tubes, tube plates and the shell. This is sometimes enhanced further by the use of different materials for tubes and shell. These tensions in turn will shorten the life span of the heat exchanger.

In order to diminish these tensions it is known to arrange the tubes with angular progression between the two plates, in other words slightly spirally or helical, as is for instance shown in the US patent 1,655,086. The helical shape or angular progression will provide a resilience to the core and the tension will be reduced. However these heat exchangers have a tendency to become rather expensive to make due to the great number of steps and the necessary manual labor for each heat exchanger.

The object of the invention is to provide a heat exchanger with an angular progression for the tubes that can be fabricated comparatively simple and with a minimum of manual labor. It is also the object of the invention to provide a space efficient heat exchanger, this since heat exchangers of this type, that is with more or less straight tubes and tube plates in each end tend to be less space efficient than other types, and for many appliances they become unpractically long.

This object is achieved by using tubes corrugated in their length direction over their entire length but for the ends. This will improve flow on the outside of the tubes so much that they can be in contact with each other all the way. The corrugations will improve turbulence in- and outside of the tubes and will also improve heat transfer.

Another object of the invention is also to provide a simple fabrication method for this type of heat exchanger. This is achieved by arranging straight tubes ring- or cylinderwise and then turning each entire cylinder or ring of tubes in one simultaneous motion. Preferably the heat exchanger is constituted by several concentric rings of tubes, that can be turned in the same direction or in different directions. Preferably each ring is turned separately beginning with the innermost ring. In order to have tubes with identical length and thus identical inner flow resistance the inner tube circles have a greater progression or turning angle than the outer ones. When the rings of tubes are turned the diameter of the tube circles tend to diminish and a good grip is therefor achieved for the inner circle on a center core tube and for the

outer circles on the inner ones. In this way a very compact packing of the tubes in the heat exchanger can be achieved in a simple manner and it should perhaps also be mentioned that this package will even hold together of its own accord when released from the machine that turns the tube circles.

When the tube package or core has been fabricated the end of the bundle are machined to the desired shape (normally flat). The tubes are then in their ends expanded so that no space will be left between them and the tubes can then be welded or soldered to each other so that a tube plate is achieved. Expansion and soldering can be carried out ringwise or simultaneous or in a close timed sequence.

In fabrication the tubes can be located on two rings of axially directed pins each tube ring at a turn and when each tube in a ring is in place it is turned and given its intended angular progression at the same time as the length is correspondingly reduced and then the next circular set of pins is used to set up the next layer etc. The locating of the tubes can be done by hand or by a simple robot. The demands on precision in fabrication is reduced in relation to the known art and the inventive method will thus provide a cost efficient fabrication method and a space efficient heat exchanger.

Further advantages and characteristics of the invention are apparent from the following description of preferred embodiments shown in the drawings. Fig 1 shows schematically a heat exchanger in accordance with the invention, fig 2 the tube plate end of a tube bundle, fig 3 shows schematically a coupling scheme of heat exchangers in accordance with the invention used in a device at a municipal heating network and figs 4 and 5 shows the compact actual arrangement of the device, and fig 6 shows an embodiment of the tube as used in the invention.

The heat exchanger shown in fig 1 and 2 includes two concentric circles of corrugated tubes, where the inner tubes have been designated by 1 and the outer by 2. The tubes 1 and 2 are in their ends widened as is shown for some tubes 1¹ and 2¹ in dashed lines so that they contact each other and they are soldered to each other, constituting a tube plate. In each end of the heat exchanger a distributing/collecting connection 5 is arranged over the two plates 4 transporting the medium that is to be led through the tubes to and from these. The tubes or rather the bundle of tubes are further surrounded over a greater part of their length by a shell 3. The shell 3 is in its ends provided with connections 6 surrounding the shell and in turn provided with connections 7 for the medium that is to stream around the tubes inside the shell. As is apparent from fig 1 the shell 3 extends a short distance into the connections 6. In this way the entering/leaving

medium will be distributed around the tube bundle more efficiently than if the shell only had extended to the connections 6. This in turn reduces the risk of internal heat differences and thereby caused tensions.

In fig 1 only one tube of each circle of tubes have been shown in order clearly to depict the angular progression or helical shape of the tubes. The tubes are not only helical in different directions but also the pitch is somewhat different for each circle. In the shown example the inner tube 1 has been turned more than the outer one in order to secure that the tube lengths of the tubes 1 and 2 can coincide so that the flow resistances inside the tubes are the same.

The arrangement of the tubes will secure a good turbulence around the tubes and since tubes will enter on one location in one tube plate and come out at another location in the other tube plate possible laminations in the entrance flow will effectively be broken up, also enhancing performance.

Since it would be difficult to provide tubes in the centre with a sufficient turning in order to achieve the necessary resilience and length of the tubes a blind tube 8 is located in the centre. The only object of this is to fill up a certain space in the heat exchanger and it can be connected either via a tube plate to the inner medium or being provided with openings towards the outer medium surrounding the tubes. The blind tube 8 is however only fastened to one tube plate so that the possible movements of the heat exchanger core are not hindered by this tube.

The heat exchanger tubes 1 and 2 are when fabricated turned ringwise. The tubes are corrugated lengthwise (see fig 7) or perhaps one should say profiled crosswise by being compressed laterally in alternating directions (preferably by 90°), giving an alternating flattening of the tubes. This improves the turbulence inside the tubes and contributes to an increased heat exchange. The flow conditions outside the tubes will be improved by this and in particular the flow resistance for the outer medium will be reduced.

When turning each ring of the heat exchanger tubes a stable shape will be achieved for each ring and if one starts with the inner ring this will contract and grip efficiently around the centre blind tube and the consecutive outer ring of tubes 2 will be contracted and press against the inner ring of tubes 1. Tools turning the tubes or rather the rings of tubes will while turned move axially the same distance whereas the turning angle will differ. The tools used can however with very small alterations be used for several different tubes of heat exchangers and lengths of heat exchangers. Preferably the different rings are turned in alternating directions. By turning the rings separately the total torque that has to be applied is kept at a low level and the tools can be made simpler.

Since the different rings of tubes in a heat exchanger core are only to be given such an angular

progression that the same length is achieved despite different diameter the machinery for turning the rings of tubes can be controlled so as to turn each ring until a preset intended final length of the core is reached. In this way one does not have to calculate the progression angle but instead the final length controls the degree of progression for each ring of tubes.

A ring of tubes turned in the above indicated way will even without an inner core be stable so if one so wishes the different rings could be fabricated separately and then brought together. Since the ring of tubes contract on turning the ends of the tubes will have a larger diameter than the tube bundle and therefor before soldering the tubes to each other the ends of the tube bundle is compressed to the diameter of the bundle so that a close fitting, by pass preventing shell can be used.

With the shown construction of the shell 3 and the connections 6 the connection 6 can be used to bypass the heat exchanger with yet another heat exchanger since a flow across and through the connections 6 past the tubes will have very little influence on the efficiency of the heat exchangers. This will in turn facilitate the building of very compact heat exchanger centrals, as they for instance are used in individual houses in a municipal heating network, and this will be shown in figs 3, 4 and 5, and described below.

The bellowlike dashed part 9 between the shell 3 and the connection 5 further improves the resilience so that the heat exchanger can cope even better with possible heat tensions that can result between the tube bundle and the heat exchanger shell and the connections of this.

At the use of tubes with angular progression as is above described the axial tensions between the tubes and the shell are efficiently eliminated.

Within the frame of the invention one can also allow the blind tube to be fully free floating without being connected either to one or the other of the tube plates.

At turning of the concentric circles of tubes these do not need to be guided over their length but at the turning of a circle of tubes a more or less automatic straightening of the bundle is achieved.

In order to connect the rings of tubes to a tube plate mandrels of a suitable shape are pressed into the tubes. This can be done in one step or in consecutive steps for instance one step for each ring to a configuration as shown at 1' and 2' in fig 2. The tubes are widened over a sufficient stretch to allow for the solder to give a good connection. This soldering can be carried out by a robot. Since copper is the most commonly used material this shapening of the tube ends will not constitute any problem. In case the different rings of tubes are angled or turned separately and then mounted together of course also the shaping of the ends can take place before the different layers of

tubes are mounted together, but preferably it can be carried out on the tube core as a unit. The mandrels used to widen the tubes are preferably prismatically chamfered or diminishing towards their front end in order to give a soft shapening of the tubes. The turning of the tubes as well as the shapeing of their ends can be carried out by hydraulic, mechanical or other means.

In figs 3-5 an embodiment of a heating device based on the invention is shown for the use in the separate houses in a municipal heating network. The exchanger device mainly is constituted of four heat exchangers as described above. Two of these heat exchangers 20, 21 are coupled in series and with an opposed flow direction for both of them for the heating of the water in the heating system of the house. The other two heat exchangers 22 and 23 are used to heat the hot water going to taps in the houses. An additional connection allows circulation of the hot water in the house, securing that hot water is swiftly obtained at each tap in the house.

As is obvious from fig 3 the use of the heat exchangers as described above and in accordance with the invention give a rather simple total layout of the device. In figs 4 and 5 is further shown how really compact this device becomes when the heat exchangers are placed close to each other. The resulting device is compact and provided only with a minimum of outlets and inlets simplifying the mounting thereof and also reducing the risk of mistakes.

From the above example it is apparent how easily the heat exchanger according to the invention can be coupled in parallel or series in adaption to different capacity requirements etc.

Claims

1. Method of fabricating a heat exchanger of the kind that includes tube plates and between these tubes with an angular progression **characterized in** that the tubes are arranged in rings and that each ring of concentric tubes is turned independent to its intended angular progression.
2. Method according to claim 1, **characterized in** that the concentric rings of tubes are turned in consecutive steps beginning with the inner ring.
3. Method according to claim 1 or 2, **characterized in** that the tubes in different rings are turned over different angles so that tubes with the same length can be used in all the circles.
4. Method according to one of the previous claims, **characterized in** that the tubes of consecutive rings are turned in alternating directions.
5. Method according to any of the previous claims, **characterized in** that before turning of the inner circle of tubes a central blinde tube is arranged.
6. Method according to claim 1, **characterized in** that the tubes before subjected to mounting in circles are corrugated in their length direction so that alternating flat parts are obtained.
7. Method according to any of the previous claims, **characterized in** that after turning of the tubes the ends of these are reshaped so that they will border closely to each other without any greater space between them and that they are then soldered together to constitute the tube plates.
8. Method according to any of the previous claims, **characterized in** that after the turning of the circles of tubes the ends of the circles are compressed radially, reducing the distance between the tubes and conforming the ends of the rings with the bundles general diameter which is diminished when the rings are turned.
9. Heat exchanger **characterized in** that this it is fabricated in accordance with any of the previous claims.
10. Heat exchanger device **characterized in** that it is fabricated in accordance with the description in connection to the figs 4 and 5.
11. Heat exchanger **characterized in** that it includes tube plates and between theses tubes with an angular progression, that are corrugated in their length direction so that alternating flat portions are obtained and that the tubes in each tube plate are arranged in concentric rings.
12. Heat exchanger in accordance with claim 11 **characterized in** that the tubes in the different rings are wound in alternateing directions.
13. Heat exchanger according to claim 11 **characterized in** that in the centre is arranged a blinde pipe around which the first layer or ring of tubes is wound.
14. Heat exchanger **characterized in** that neighbouring rings are in contact with each other.
15. Heat exchanger of the kind that includes tube plates and between these tubes with an angular progression, **characterized in** that the tubes are arranged in rings of concentric tubes and that the ends of the tubes are shaped so as closely to boarder to each other and soldered to each other, so that in this way the tube plates are fabricated

from the ends of the tubes themselves.

16. Heat exchanger device intended for the use in houses coupled to a municipal heating net work, **characterized in** that it is constituted by four heat exchangers that include pipes extending between tube plates and that the connections for the medium streaming around the tubes is som wide around the shell surrounding the tube bundle that it can be used to connect several heat exchangers in parallel, and that two heat exchangers are coupled in series and used to heat the water going to the radiators, whereas the other two heat exchangers are used to heat up the water going to the hot water taps of the house, these two heat exchangers also being coupled in series.

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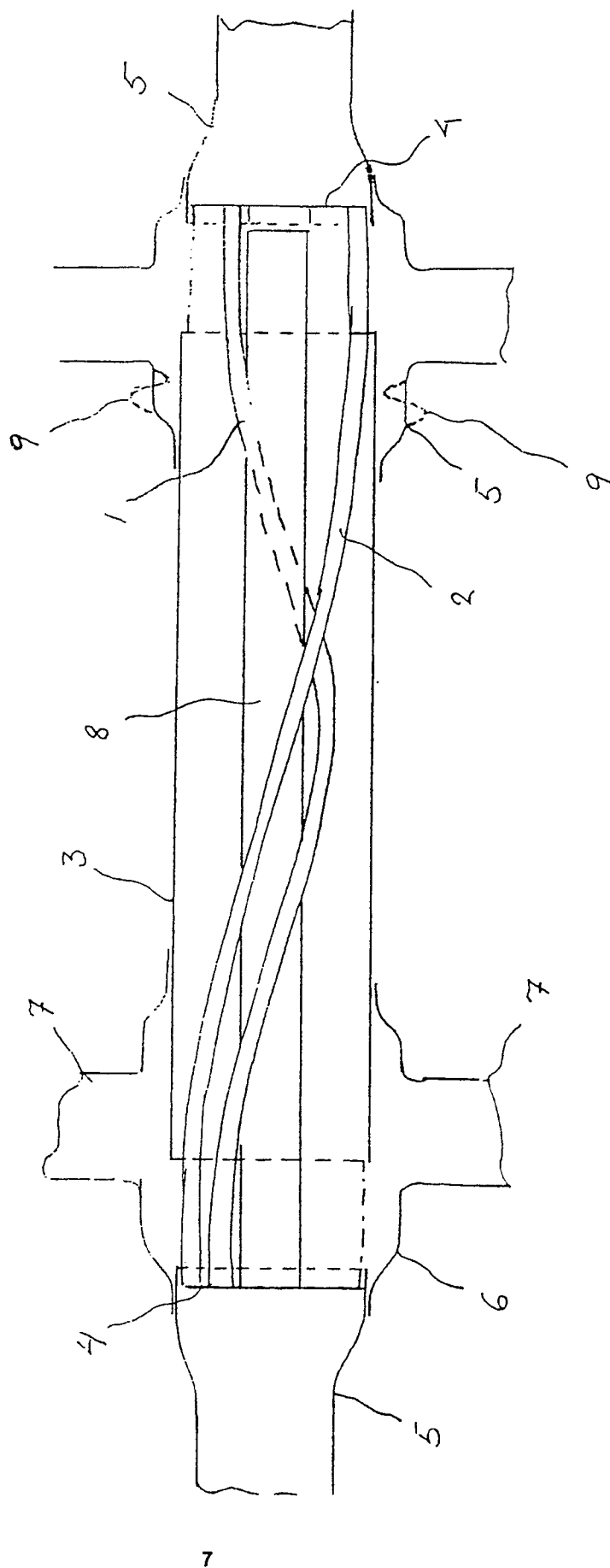
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Fig 1



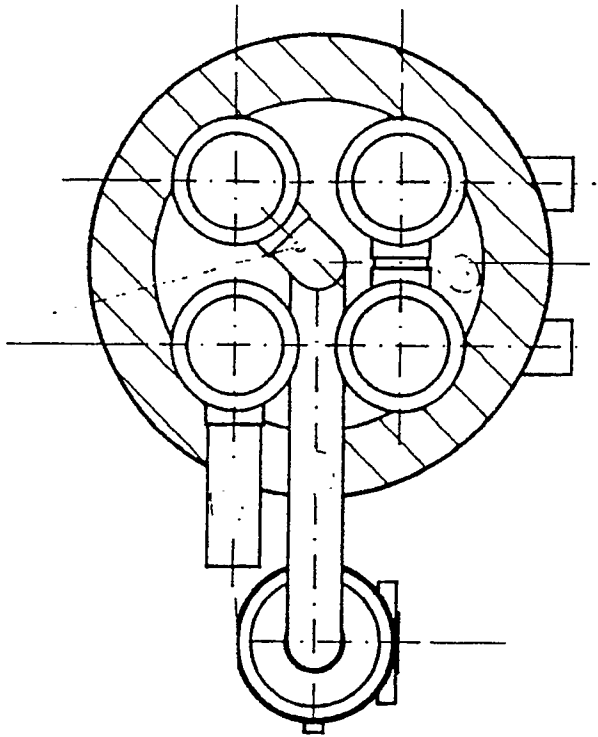


Fig 4

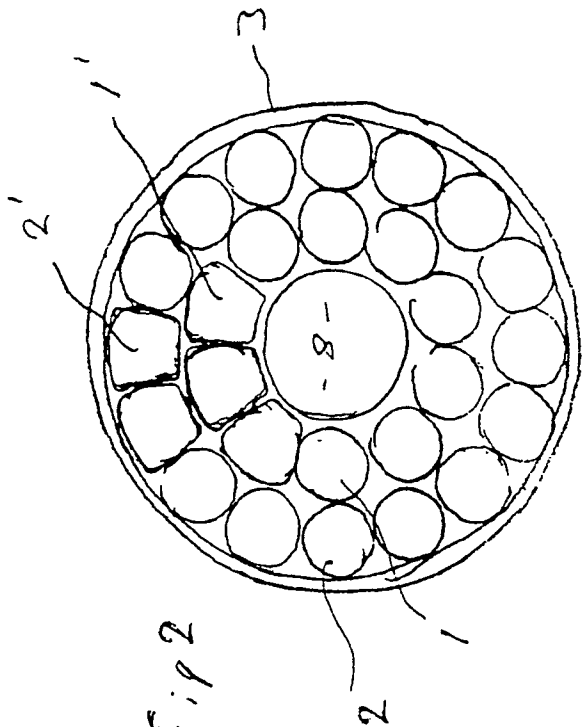


Fig 2

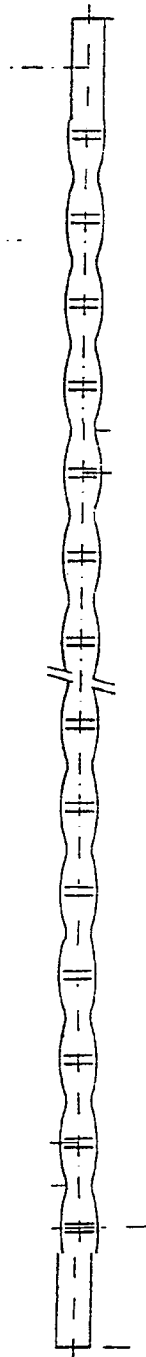


Fig 6

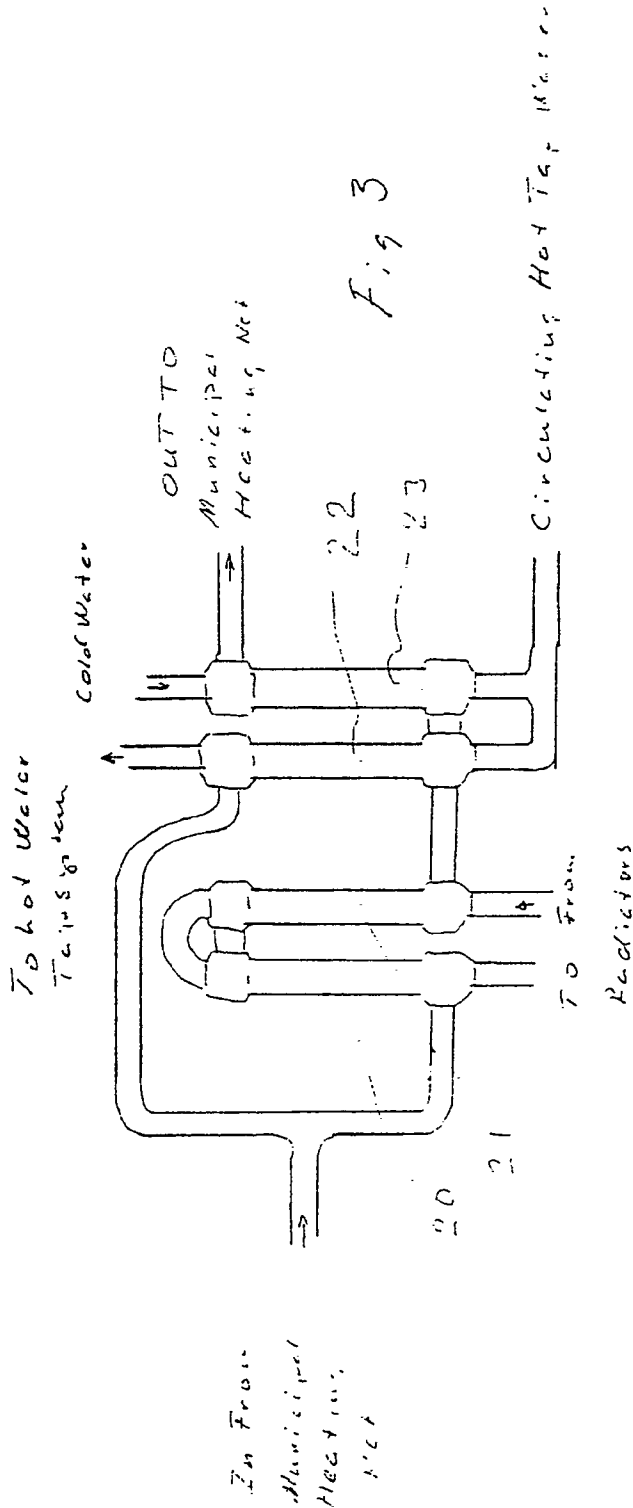


Fig 5

