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(54) **Microchannel, flat tube exchanger with bent tube configuration**

(57) A heat exchanger assembly (20) includes a first header (22) having an inlet (26) and a second header (24) having an outlet (28) spaced parallel from each other. A plurality of tube members (30) having an ultimate strength (Us) and a width (w), extend between the first header (22) and the second header (24). The tube members (30) define a plurality of fluid passages (38) for the

flow of a liquid through the tube members (30) and between the first and second headers (22, 24). The tube members (30) extend through at least one bend having a bend radius (r) in the range of 50.00 mm to straight ( $\infty$ ) through angles between 0 and 100 degrees. A plurality of corrugated air fins (40) are brazed between adjacent tube members (30). The bends of the tube members (30) satisfy a bending formula  $(w/r)Us \leq 30$  mega Pascal.

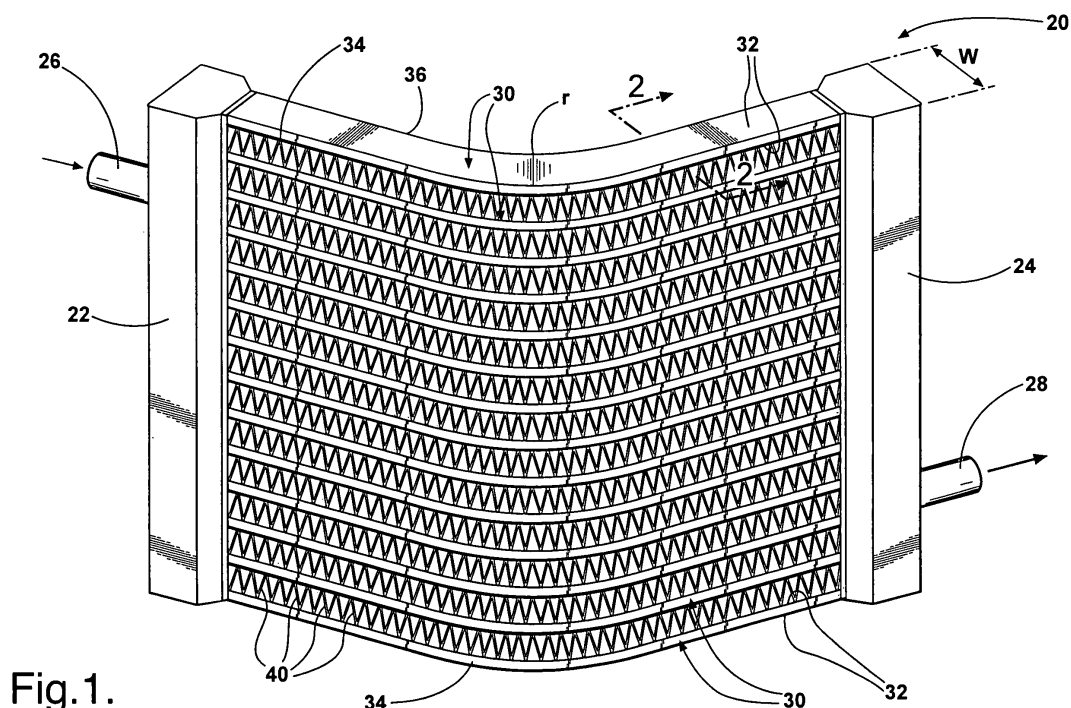


Fig. 1.

## Description

### TECHNICAL FIELD

**[0001]** The subject invention relates to a heat exchanger assembly for use in residential air conditioning units.

### BACKGROUND OF THE INVENTION

**[0002]** It is known in the prior art how to produce heat exchangers of the type having round, expanded tubes and flat, non brazed fins in various bent or non flat configurations, as shown in U.S. Patent 5,954,125 to Mantegazza et al. These configurations are often used in outdoor heat exchanger cabinets for residential applications, and may be fairly easily bent in L, V or U shaped configurations, in which various face portions remain flat and joined to other flat face portions across relatively sharp bends of up to ninety degrees.

**[0003]** It is also known in the prior art that brazed heat exchanger construction with flat, microchannel tubes and brazed, corrugated air fins are inherently more thermally efficient than older, expanded round tube and non brazed flat fin designs, but have not found wide acceptance as a replacement for the type of heat exchanger shown in the Mantegazza patent. One reason for this is the perceived difficulty or inability in bending relatively wide, flat microchannel tubes across equivalent bends. One way around this difficulty is disclosed in U.S. Patent 5,826,649 to Chapp et al. The Chapp patent avoids the problem by simply orienting the flat tubes vertically, and allowing them to remain straight and unbent. The round headers are instead bent into the desired shape, and oriented at the top and bottom of the core. However not all header designs will be so amenable to bending, and it may be desired to leave the headers vertical, straight, and unbent, which would necessitate either bending the flat tubes, or finding alternate ways to interconnect the various flat face portions of the core together.

**[0004]** It has been proposed to provide an essentially cylindrical core of two semi circular portions, both bent in a shallow and continuous curvatures, and joined together by box like headers as disclosed in U.S. Patent 4,443,921 to Allemandou. No sharp bends in the tube members are needed to create the semi circular shape of the core faces.

**[0005]** Although the prior art shows bends in heat exchanger assemblies of various configurations, there is a continuing need for heat exchanger assemblies having more efficient or alternative bending configurations as compared to the conventional heat exchanger assemblies.

### SUMMARY OF THE INVENTION

**[0006]** The invention provides a heat exchanger assembly for use in residential air conditioning units. The assembly includes a first header and a second header

spaced parallel from each other. A plurality of tube members extend between the first header and the second header. The tube members have a width (w) that is measured from a first nose of the tube member to a second nose of the tube member. The tube members define a plurality of fluid passages for the flow of a liquid through the tube members and between the first and second headers. The tube members have an ultimate strength (Us) and extend through at least one bend having a bend radius (r). A plurality of air fins are disposed between adjacent tube members for dissipating heat from the tube members. The invention is distinguished by the bends of the tube members satisfying a bending formula  $(w/r)Us \leq 30$  mega Pascal.

**[0007]** The subject invention also provides a method of manufacturing a heat exchanger assembly having a plurality of bent tube members for use in residential air conditioning units. The method includes preparing a straight condenser having a plurality of headers spaced parallel from each other and a plurality of tube members defining a plurality of flow passages extending between the headers and a plurality of air fins extending between the tube members. The method further includes brazing the joints between the headers and the tube members and between the tube members and the air fins. The method is distinguished by bending the straight condenser to at least one predetermined bend satisfying a bending formula  $(w/r)Us \leq 30$  mega Pascal, wherein w equals a width extending between semi-circular noses, r equals a bend radius, and Us equals the ultimate strength of the tube members.

**[0008]** Accordingly, the invention produces sharp bends of relatively wide and thin, flat microchannel extruded tube members with brazed, corrugated air fins.

### BRIEF DESCRIPTION OF THE DRAWINGS

**[0009]** Other advantages of the present invention will be readily appreciated, as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Figure 1 is perspective view of a heat exchanger embodying the subject invention;

Figure 2 is a cross-sectional view of a tube member taken along the line 2-2 of Figure 1; and

Figure 3 is top view of a heat exchanger embodying the subject invention.

### DESCRIPTION OF THE PREFERRED EMBODIMENTS

**[0010]** Referring to the Figures, wherein like numerals indicate corresponding parts throughout the several views, a heat exchanger assembly **20** is generally shown for use in residential air conditioning units in Figures 1-3.

**[0011]** The assembly **20** comprises a first header **22** and a second header **24** spaced parallel from each other.

The first header **22** includes an inlet **26** and the second header **24** includes an outlet **28** for the flow of a liquid through the assembly **20**. Although the headers **22**, **24** are illustrated as trapezoidal in cross-section, many different configurations may be used, including round and rectangular. A plurality of tube members **30** generally indicated extend between the first header **22** and the second header **24**. The tube members **30** have two parallel flat sides **32** that extend between semi-circular first and second noses **34**, **36**. The first nose **34** and the second nose **36** are spaced a width **w** from each other. The width **w** of the tube members **30** is in the range of 12.00 mm to 27.00 mm. The tube members **30** define a plurality of fluid passages **38** for the flow of a liquid through the tube members **30** and between the first and second headers **22**, **24**. As is well known in the art, the refrigerant may make multiple passes between the headers **22**, **24** by placing appropriate dividers or baffles in the headers **22**, **24**. The passages **38** are generally round in cross section, but may be any shape known in the art. The passages **38** have a diameter **d** in the range of .50 mm to 1.00 mm. The liquid will enter the assembly **20** through the inlet **26** of the first header **22**, move through the passages **38** of the tube members **30** to the second header **24**, and out of the assembly **20** through the outlet **28** of the second header **24**.

[0012] The tube members **30** extend through at least one bend having a bend radius **r** in the range of 50.00 mm to straight ( $\infty$ ) through angles between 0 and 100 degrees. The tube members **30** have an ultimate strength **Us** and are typically made of aluminum or aluminum alloys, but may be of any material known in the art, such as copper or copper alloys. The ultimate strength **Us** of the material being used can be found in several publications that list various properties of materials. One such publication is "Property of Aluminum Alloys: Tensile, Creep, and Fatigue Data at High and Low Temperatures" published by The Aluminum Association and ASM International.

[0013] The tube members **30** have an internal wall thickness **t<sub>i</sub>** between each of the passages **38** and the next adjacent one of the passages **38** in the range of .15 mm to .40 mm. The tube members **30** have an external wall thickness **t<sub>e</sub>** between each of the passages **38** and the flat sides **32** of the tube members **30** in the range of .15 mm to .40 mm. The tube members **30** have a nose thickness **t<sub>n</sub>** between each of the first and second noses **34**, **36** and the adjacent one of the passages **38** in the range of .15 mm to 1.00 mm.

[0014] A plurality of air fins **40** are brazed between two of the parallel flat sides **32** of adjacent tube members **30** for dissipating heat from the tube members **30**. The air fins **40** are corrugated.

[0015] The subject invention is distinguished by the bends of the tube members **30** satisfying a bending formula  $(w/r)Us \leq 30$  mega Pascal. The ratio of the width **w** of the tube members **30** to the bend radius **r** multiplied by the ultimate strength **Us** of the material used must be

less than 30 mega Pascal for a successful sharp bend.

[0016] By way of an example we calculate the dimensions of the tube member **30** with a width **w** = 12.00 mm and a bend radius **r** = 50.00 mm using the bending formula and the width **w** and bend radius **r** ranges set out above. In addition to width **w** and bend radius **r**, for the bending equation. Again, such a value can be obtained from "Property of Aluminum Alloys: Tensile, Creep, and Fatigue Data at High and Low Temperatures" published by The Aluminum Association and ASM International. For 3003 "O" temper aluminum, the ultimate strength **Us** was found to be 110 mega Pascal. When the values are plugged into the bending formula  $(12 \text{ mm}/50 \text{ mm})110 \text{ mega Pascal} \leq 30 \text{ mega Pascal}$ , a value of 26.4 mega Pascal  $\leq 30$  mega Pascal is obtained. The formula is satisfied and the tube member **30** with these values may be bent.

[0017] The subject invention also provides for a method of manufacturing a heat exchanger assembly **20** having a plurality of bent tube members **30** for use in residential air conditioning units. The method begins with the step of preparing a straight condenser. The condenser includes a plurality of headers **22**, **24** spaced parallel from each other, a plurality of tube members **30** defining a plurality of flow passages **38** extending between the headers **22**, **24**, and a plurality of air fins **40** extending between the tube members **30**. The method proceeds with the step of brazing the joints between the headers **22**, **24** and the tube members **30** and between the tube members **30** and the air fins **40**. The method is distinguished by bending the straight condenser to at least one predetermined bend satisfying a bending formula  $(w/r)Us \leq 30$  mega Pascal, wherein **w** equals a width **w** extending between semi-circular noses **34**, **36**, **r** equals a bend radius **r**, and **Us** equals the ultimate strength **Us** of the tube members **30** material. The method is more specific by establishing a range for the bend radius **r** of 50.00 mm to straight ( $\infty$ ) through angles between 0 and 100 degrees and a range for the width **w** of 12.00 mm and 27.00 mm.

[0018] Obviously, many modifications and variations of the present invention are possible in light of the above teachings. The invention may be practiced otherwise than as specifically described within the scope of the appended claims.

## Claims

1. A heat exchanger assembly (**20**) for use in residential air conditioning units comprising;

a first header (**22**) and a second header (**24**) spaced parallel from each other,  
a plurality of tube members (**30**) extending between said first header (**22**) and said second header (**24**) and having a width (**w**) from a first nose (**34**) to a second nose (**36**) and defining a

- plurality of fluid passages (38) for the flow of a liquid through said tube members (30) and between said first and second headers (22, 24), said tube members (30) extending through at least one bend having a bend radius (r), said tube members (30) having an ultimate strength (Us), and a plurality of air fins (40) disposed between adjacent ones of said tube members (30) for dissipating heat from said tube members (30), said bends of said tube members (30) satisfying a bending formula  $(w/r)Us \leq 30$  mega Pascal.
2. An assembly (20) as set forth in claim 1 wherein said bend radius (r) is in the range of 50.00 mm to straight ( $\infty$ ) through angles between 0 and 100 degrees.
  3. An assembly (20) as set forth in claim 2 wherein said width (w) of said tube members (30) is in the range of 12.00 mm to 27.00 mm.
  4. An assembly (20) as set forth in claim 3 wherein said tube members (30) include two parallel flat sides (32) extending between said semi-circular first and second noses (34, 36).
  5. An assembly (20) as set forth in claim 4 wherein said plurality of air fins (40) are corrugated and brazed between two of said parallel flat sides (32) of adjacent ones of said tube members (30) for dissipating heat from said tube members (30).
  6. An assembly (20) as set forth in claim 5 wherein said tube members (30) include an internal wall thickness ( $t_i$ ) between each of said passages (38) and the next adjacent one of said passages (38) in the range of .15 mm to .40 mm.
  7. An assembly (20) as set forth in claim 6 wherein said tube members (30) include an external wall thickness ( $t_e$ ) between each of said passages (38) and said flat sides (32) in the range of .15 mm to .40 mm.
  8. An assembly (20) as set forth in claim 7 wherein said tube members (30) include a nose thickness ( $t_n$ ) between each of said first and second noses (34, 36) and the adjacent one of said passages (38) in the range of .15 mm to 1.00 mm.
  9. An assembly (20) as set forth in claim 8 wherein said passages (38) are generally round in cross section.
  10. An assembly (20) as set forth in claim 9 wherein said passages (38) include a diameter (d) in the range of .50 mm to 1.00 mm.
  11. An assembly (20) as set forth in claim 10 wherein said tube members (30) are aluminum.
  12. A heat exchanger assembly (20) for use in residential air conditioning units comprising;
 

a first header (22) and a second header (24) spaced parallel from each other, a plurality of tube members (30) extending between said first header (22) and said second header (24) and having two parallel flat sides (32) extending between semi-circular first and second noses (34, 36) spaced a width (w) from said first nose (34) to said second nose (36) and defining a plurality of fluid passages (38) each being generally round in cross section for the flow of a liquid through said tube members (30) and between said first and second headers (22, 24), said tube members (30) extending through at least one bend having a bend radius (r) in the range of 50.00 mm to straight ( $\infty$ ) through angles between 0 and 100 degrees, said tube members (30) being of aluminum and having an ultimate strength (Us), said width (w) of said tube members (30) being in the range of 12.00 mm to 27.00 mm, said tube members (30) having an internal wall thickness between each of said passages (38) and the next adjacent one of said passages (38) in the range of .15 mm to .40 mm, said tube members (30) having an external wall thickness ( $t_e$ ) between each of said passages (38) and said flat sides (32) in the range of .15 mm to .40 mm, said tube members (30) having a nose thickness ( $t_n$ ) between each of said first and second noses (34, 36) and the adjacent one of said passages (38) in the range of .15 mm to 1.00 mm, said passages (38) having a diameter (d) in the range of .50 mm to 1.00 mm, and a plurality of air fins (40) being corrugated and brazed between two of said parallel flat sides (32) of adjacent ones of said tube members (30) for dissipating heat from said tube members (30), said bends of said tube members (30) satisfying a bending formula  $(w/r)Us \leq 30$  mega Pascal.
  13. A method for manufacturing a heat exchanger assembly (20) having a plurality of bent tube members (30) for use in residential air conditioning units comprising the steps of;
 

preparing a straight condenser having a plurality of headers (22, 24) spaced parallel from each other and a plurality of tube members (30) defining a plurality of flow passages (38) extending between the headers (22, 24) and a plurality of air fins (40) extending between the tube members (30),

brazing joints between the headers **(22, 24)** and the tube members **(30)** and between the tube members **(30)** and the air fins **(40)**, and bending the straight condenser to at least one predetermined bend satisfying a bending formula  $(w/r)U_s \leq 30$  mega Pascal and wherein  $w$  equals a width **(w)** extending between semi-circular noses **(34, 36)** and  $r$  equals a bend radius **(r)** and  $U_s$  equals the ultimate strength **(Us)** of the tube members **(30)**.

- 14.** A method as set forth in claim 13 wherein the bend radius **(r)** is in the range of 50.00 mm to straight ( $\infty$ ) through angles between 0 and 100 degrees.

- 15.** A method as set forth in claim 14 wherein the width **(w)** is in the range of 12.00 mm and 27.00 mm.

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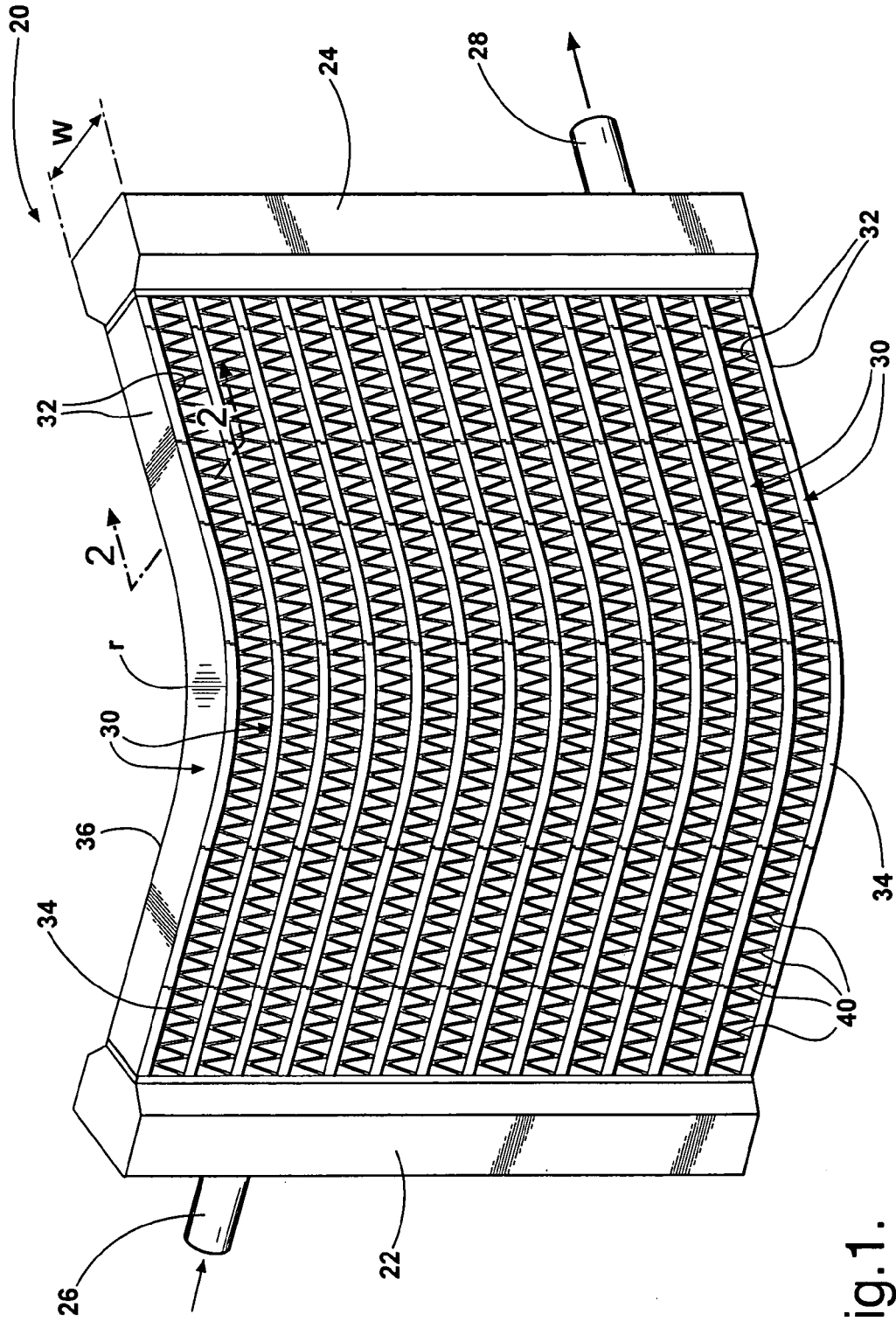
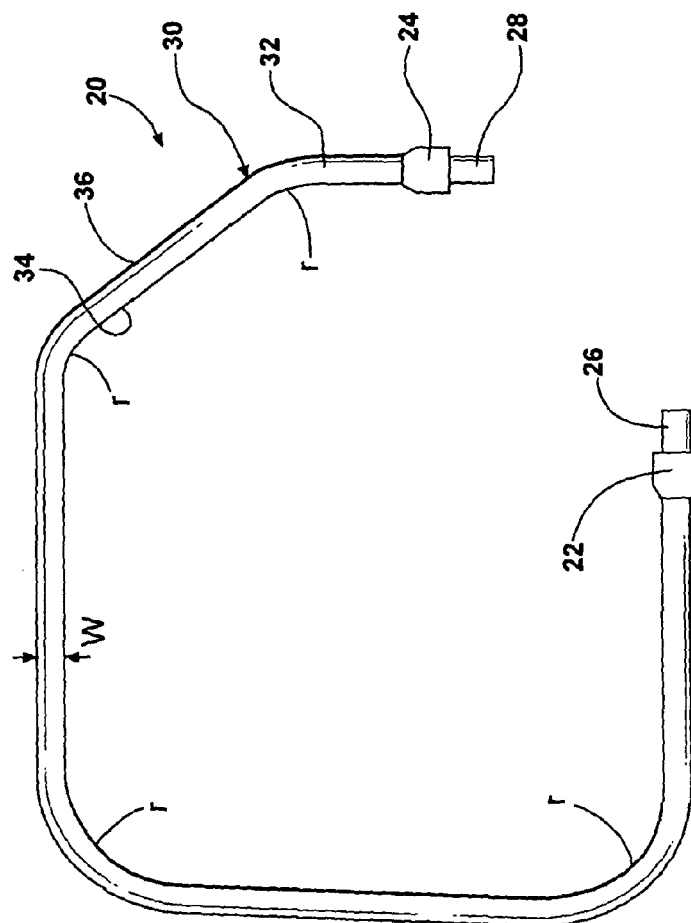
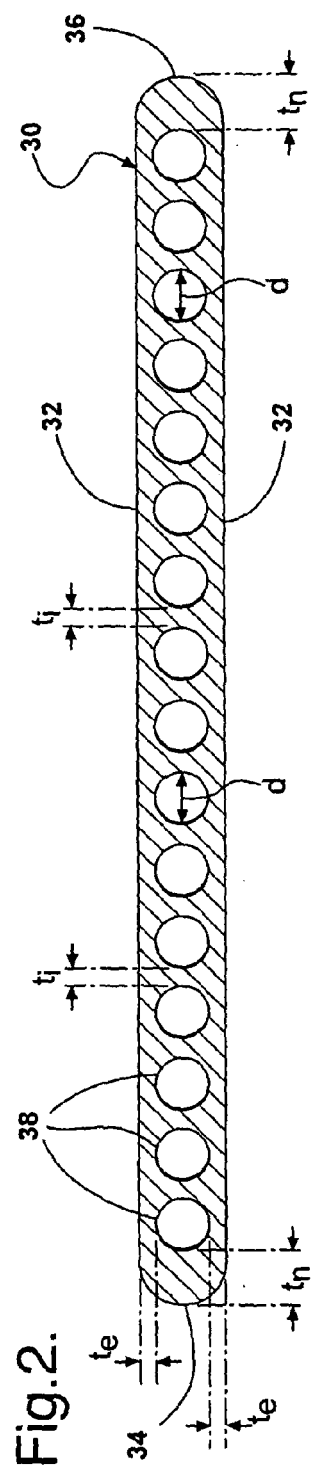


Fig. 1.



**REFERENCES CITED IN THE DESCRIPTION**

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