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(54) **A method for fixing heat exchange elements to an end plate and a tool for conforming to a circular cross-section the end of a tube of oblong cross-section**

Verfahren zum Verbinden von Warmaustauscherelementen an einer Platte und Werkzeug zum Verformen des Rohrendes von einem länglichen Durchschnitt zu einem kreisförmigen Durchschnitt

Méthode pour la fixation des éléments d'un échangeur de chaleur à une plaque et outil pour déformer le bout d'un tube d'une section oblongue dans une section circulaire

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(73) Proprietor: **MAGNETI MARELLI CLIMATIZZAZIONE S.r.l.**
I-10046 Poirino (Torino) (IT)

(72) Inventors:
- **Parola, Andrea**
  I-10090 Rosta (Torino) (IT)
- **Michielon, Erminio**
  I-10028 Trofarello (Torino) (IT)
- **Dentis, Luigi**
  I-10095 Grugliasco (Torino) (IT)
- **Parrino, Maurizio**
  I-10135 Torino (IT)

(74) Representative: **Bosotti, Luciano et al**
I-10152 Torino (IT)

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Description

The present invention relates to the manufacture of heat-exchangers, particularly for motor vehicles, and is concerned with a method of fixing an end plate to a heat-exchange system including a plurality of tubes with elongate cross-sections, in which the ends of the tubes are shaped so as to have circular cross-sections before being inserted in sealing collars of circular cross-section disposed in respective holes in the end plate, and in which the tubes are fixed to the end plate by the radial expansion of their ends after they have been fitted in the sealing collars.

In a heat-exchanger of the type specified above, it is necessary to shape the ends of the tubes in order to achieve an effective and durable connection between the end plates and the ends of the tubes. Since the end plates serve for the attachment of the header tanks containing the liquid which circulates in the heat-exchange system, their connection to the ends of the tubes must be quite firm mechanically as well as being liquid-tight.

Experience has shown that, with tubes of elongate cross-section (particularly with a very high ratio between the maximum and minimum dimensions of the cross-section of the tube), it is very difficult to connect the ends of the tubes to the header plates in a mechanically firm and liquid-tight manner simply by the enlargement (expansion) of the ends of the tubes. In fact, in this case, a firm anchorage of the walls of the tubes, which extend parallel to the major axes of their cross-sections, is rather problematical. Thus, in spite of the enlargement of the ends of the tubes, there is a danger of the walls of the tubes breaking parallel to their major axes, making the mechanical connection and the sealing of the heat-exchanger insecure.

A method of shaping the end of a metal heat-exchanger tube of elongate cross-section to give it a circular cross-section is known from the French patent No. 2,462,215. The method described in this document consists of two steps, that is, one step in which the end of the tube undergoes radial compression, and another step in which a punch is force-fitted into the end. If the radial deformation is effected first, the end of the tube is compressed between two jaws which are movable perpendicular to the axis of the tube along the major axis of its cross-section. If the punch is force-fitted in the end of the tube first, the subsequent radial compression is effected by means of a bush with a flared end which is movable along the axis of the tube.

For practical purposes, the two-step method of shaping the ends of the tubes has various disadvantages. In particular, radial compression effected by jaws movable perpendicular to the axis of the tube cannot easily be used for heat exchangers with two or more rows of tubes, since it would require too much space between the rows. In the solution in which the radial deformation is effected by means of a bush slidable along the axis of the tube, difficulties are encountered in removing the tools from the ends of the tubes since, upon completion of the shaping, both the bush and the punch are coupled with the end of the tube at the same time. In any case, with the two-step shaping method, the shaping tools and machines are more complex than with a single-step shaping method.

In a method known from the British document No. 2,055,064 for shaping the end of a metal tube having an elongate cross-section to give it a circular cross-section, the shaping is effected in a single step by means of a punch having a cylindrical body which is force-fitted in the end of the tube. This solution is unsuitable for tubes with ratios of the order of 3:1 or more between their maximum and minimum diameters. Figure 10 of the appended drawings shows the configuration which a tube 1 with a ratio of the order of 3:1 between its extreme diameters would assume as a result of radial deformation from inside by means of a punch 2. The smaller-radius curves 3 tend to remain undeformed since they have greater rigidity than the rest of the wall. A more even circular cross-section could be achieved with the use of a larger-diameter punch but this would stretch the walls of the tube too much. This stretching would make it difficult to carry out the subsequent step in which the ends of the tubes are fixed to the sealing collars in the base plate by radial expansion. In fact, two successive steps which stretch the walls of the tube considerably increases the risk of the walls breaking. Moreover, larger diameters of the ends of the tubes necessitate more space between the rows of tubes in the exchanger system.

In order to overcome the aforementioned problems, the present invention provides for a method with the features of claim 1 respectively a tool with the features of claim 2.

In comparison with two-step shaping methods, the method of the invention is quicker, requires simpler tools, and involves a simplification of the machines which move the tools since the machines have to effect only one movement instead of the two movements needed for two-step methods.

In comparison with the solution which provides for the end of the tube to be expanded from the inside by means of a punch, there is the advantage that the excessive stretching of the walls of the tube, particularly with a high ratio between the maximum and minimum diameters of its cross-section, is avoided.

Further characteristics and advantages of the present invention will become clear in the course of the detailed description which follows with reference to the appended drawings, provided purely by way of non-limiting example, in which:

Figure 1 is a cross-section of a portion of a heat-exchange system during a stage of the method according to the invention,

Figure 2 is a section taken on the line II-II of Figure 1,

Figures 3 and 4 are views similar to Figure 1, showing another two steps of the method according to the invention,

Figure 5 is a plan view of a tool for shaping the ends of the tubes,

Figures 6 and 7 are sections taken on the lines VI-VI and VII-VII of Figure 5,

Figure 8 is a perspective view of the end of a tube shaped by the tool of Figure 5,

Figure 9 is a view taken on the arrow IX of Figure 8, and

Figure 10, which has already been commented upon above, is a schematic view showing the shaping of a tube by a method of the prior art.

With reference to the drawings, in Figures 1 and 2, a heat-exchange system, indicated 10, includes a plurality of tubes 12 having flat cross-sections each constituted by two straight lines 14 and two semicircular connecting portions 16. The maximum and minimum dimensions of the cross-section of each tube 12 are indicated a and b; the ratio a/b is of the order of 3:1. In the embodiment shown in the drawings, the tubes 12 are arranged in two parallel rows, 18, 20.

The tubes 12 are fixed to metal fins 22 disposed one above another along the longitudinal axes of the tubes 12. In known manner, the fins 22 have holes, with shapes corresponding to the profiles of the tubes 12, in which the tubes 12 are fitted with slight radial clearance. The tubes 12 are fixed to the fins 22, in known manner, by the expansion of the tubes 12.

After the tubes 12 have been fixed to the fins 22 to form the heat-exchange system 10, the ends 24 of the tubes are fixed to an end plate 26 (Figures 3 and 4) which constitutes the base wall of a header tank (not shown) for collecting the cooling liquid which circulates in the tubes 12. With reference to Figures 3 and 4, the end plate 26 has a plurality of holes 28 with circular cross-sections, in which sealing collars 30 of a gasket 32 of elastomeric material are disposed.

Before the ends 24 of the tubes 12 are fitted in the sealing collars 30, the ends 24 are shaped so as to have circular cross-sections by respective tools 34, shown in Figures 1 and 5-7. Each tool 34 is constituted by a metal body having a cavity 36 with an opening 38. At a distance e from the opening 38, along the axis of the cavity 36, the cross-section of the cavity 36 is circular. A portion 40 of the cavity 36 has a tapered wall which is inclined at 2-3° to the longitudinal axis of the cavity 36. The length of the portion 40 is equal to the desired length of the circular cross-sectioned end portion of each tube 12. At the end of the cavity 36 is a connecting portion 42 of radius R which gives the end edge of the tube a perfectly circular cross-section and makes it easier to fit in a hole in a sealing collar 30 by forming a kind of lead-in. The cavity 36 communicates with a hole 44 for fixing the tool 34 to a frame (not shown) which moves the tools 34 along the line indicated by the arrow 46 in Figure 1. The opening 38 has an oval cross-section the maximum dimension c which is slightly greater than the maximum dimension a of the cross-section of the undeformed tube 12. The minimum dimension, indicated d, of the opening 38 is equal to or greater than the maximum diameter of the circular cross-sectioned portion 40 of the cavity 36. The opening 38 is connected to the tapered portion 40 of the cavity 36 by means of a connecting region having two opposed surfaces 50 which, in use, exert gradual pressure on the walls 16 of the tube 12 which have the smallest radius of curvature.

The ends 24 of the tubes 12 are shaped by being force-fitted in the respective cavities 36 of the tools 34. The taper of the portion 40 of each cavity 36 facilitates the removal of the tools 34 upon completion of the shaping. Figure 8 shows the end of a tube 12 which has been shaped. The tool 34 causes no stretching of the material in the deformed region. Upon completion of the shaping, the perimeter of the end 24 is the same as or slightly shorter than the perimeter of the undeformed portion of the tube 12.

After the ends 24 of the tubes 12 have been shaped by the tools 34, the ends 24 are fitted in the cylindrical holes in the sealing collars 30 with radial clearance (see Figure 3). Punches 52 are then inserted in the ends of the tubes 12 to expand the ends 24 radially against the sealing collars 30. This expansion connects the tubes 12 to the end plate 26 mechanically and in a fluid-tight manner. During the expansion, the edges 24_a of the end 24 are turned over so as to improve the seal resulting from the expansion of the end 24.

The method of shaping the ends of the tubes has been described with reference to flat tubes but is intended also to be applicable to tubes having any elongate cross-section, such as, for example, oval, elliptical, ovoidal, or the like.

Claims

1. A method of fixing an end plate (26) to a heat-exchange system (10) including a plurality of tubes (12) with elongate cross-sections, in which the ends (24) of the tubes are shaped so as to have circular cross-sections before being fitted in sealing collars (30) of circular cross-section disposed in respective holes (28) in the end plate (26), and in which the tubes (12) are fixed to the end plate (26) by the radial expansion of their ends (24) after they have been fitted in the sealing collars (30), characterised in that the ends (24) of the tubes are shaped in a single step by radial compression from outside, applied by means of a hollow body (34) with a cavity (36) having a cross-section varying from elongate to circular, the hollow body being movable along the axis of the tube and formed so as to exert pressure on the walls (16)

of the tube (12) which have the smallest radius of curvature, and in that the ends of the tubes (24) are fitted in the sealing collars (30) without further deformation.

2. A tool for performing a method according to Claim 1, for shaping the end of a heat-exchanger tube to give it a circular cross-section, characterised in that it includes a unitary body (34) having an opening (38) which communicates with a cavity (36) the cross-section of which varies along its longitudinal axis, the cross-section of the cavity being elongate near the opening so as to contain the cross-section of the undeformed tube, and being circular a predetermined distance (e) from the opening (38) along the axis of the cavity.

3. A tool according to Claim 2, characterised in that the cross-section of the cavity near the opening (38) is oval and has a maximum dimension (c) greater than the maximum dimension (a) of the cross-section of the undeformed tube and a minimum dimension (d) which is equal to or greater than the diameter of the portion of the cavity (36) which has a circular cross-section.

4. A tool according to Claim 3, characterised in that the cavity (36) has a portion (40) with a tapered wall of a length, along the axis of the cavity, equal to the desired axial length of the circular cross-sectioned end portion of the tube.

Patentansprüche

1. Verfahren zur Befestigung einer Endplatte (26) an einem Wärmeaustauschsystem (10) umfassend eine Mehrzahl von Rohren (12) mit länglichem Querschnitt, bei dem die Enden (24) der Rohre so geformt werden, daß sie einen kreisförmigen Querschnitt aufweisen, bevor sie in dichtende, in entsprechenden Öffnungen (28) in der Endplatte (26) angeordneten Manschetten (30) mit kreisförmigem Querschnitt eingepaßt werden, und bei dem die Rohre (12) nach dem Einpassen in die dichtenden Manschetten (30) durch radiales Dehnen ihrer Enden (24) an der Endplatte (26) befestigt werden, dadurch gekennzeichnet, daß die Enden (24) der Rohre in einem einzigen Schritt durch radiales Pressen von außen geformt werden, welches mit Hilfe eines Hohlkörpers (34) mit einem Hohlraum (36) erfolgt, der einen von länglich bis kreisförmig varrierenden Querschnitt aufweist, wobei der Hohlkörper entlang der Achse des Rohres bewegbar und so geformt ist, daß er auf die Wände (16) des Rohres (12), die den kleinsten Krümmungsradius aufweisen, Druck ausübt, und daß die Enden der Rohre (24) in die dichtenden Manschetten (30) ohne weitere Verformung eingepaßt werden.

2. Werkzeug zur Durchführung eines Verfahrens gemäß Anspruch 1, zum Formen des Endes eines Wärmeaustauschrohres, um diesem einen kreisförmigen Querschnitt zu verleihen, dadurch gekennzeichnet, daß es einen einheitlichen Körper (34) mit einer Öffnung (38) umfaßt, die mit einem Hohlraum (36) in Verbindung steht, dessen Querschnitt entlang seiner Längsachse variiert, wobei der Querschnitt des Hohlraumes nahe der Öffnung länglich ist, sodaß er den Querschnitt des nicht verformten Rohres einschließt, und in einem vorbestimmten Abstand (e) von der Öffnung (38) entlang der Achse des Hohlraumes kreisförmig ist.

3. Werkzeug nach Anspruch 2, dadurch gekennzeichnet, daß der Querschnitt des Hohlraumes nahe der Öffnung (38) oval ist und eine maximale Dimension (c), die größer ist als die maximale Dimension (a) des Querschnittes des nicht verformten Rohres, und eine minimale Dimension (d) hat, die gleich oder größer ist als der Durchmesser jenes Bereiches des Hohlraumes (36), der einen kreisförmigen Querschnitt aufweist.

4. Werkzeug nach Anspruch 3, dadurch gekennzeichnet, daß der Hohlraum (36) einen Bereich (40) mit einer sich verjüngenden Wand aufweist, deren Länge, entlang der Achse des Hohlraumes, gleich ist der gewünschten axialen Länge des Endabschnittes des Rohres mit kreisförmigem Querschnitt.

Revendications

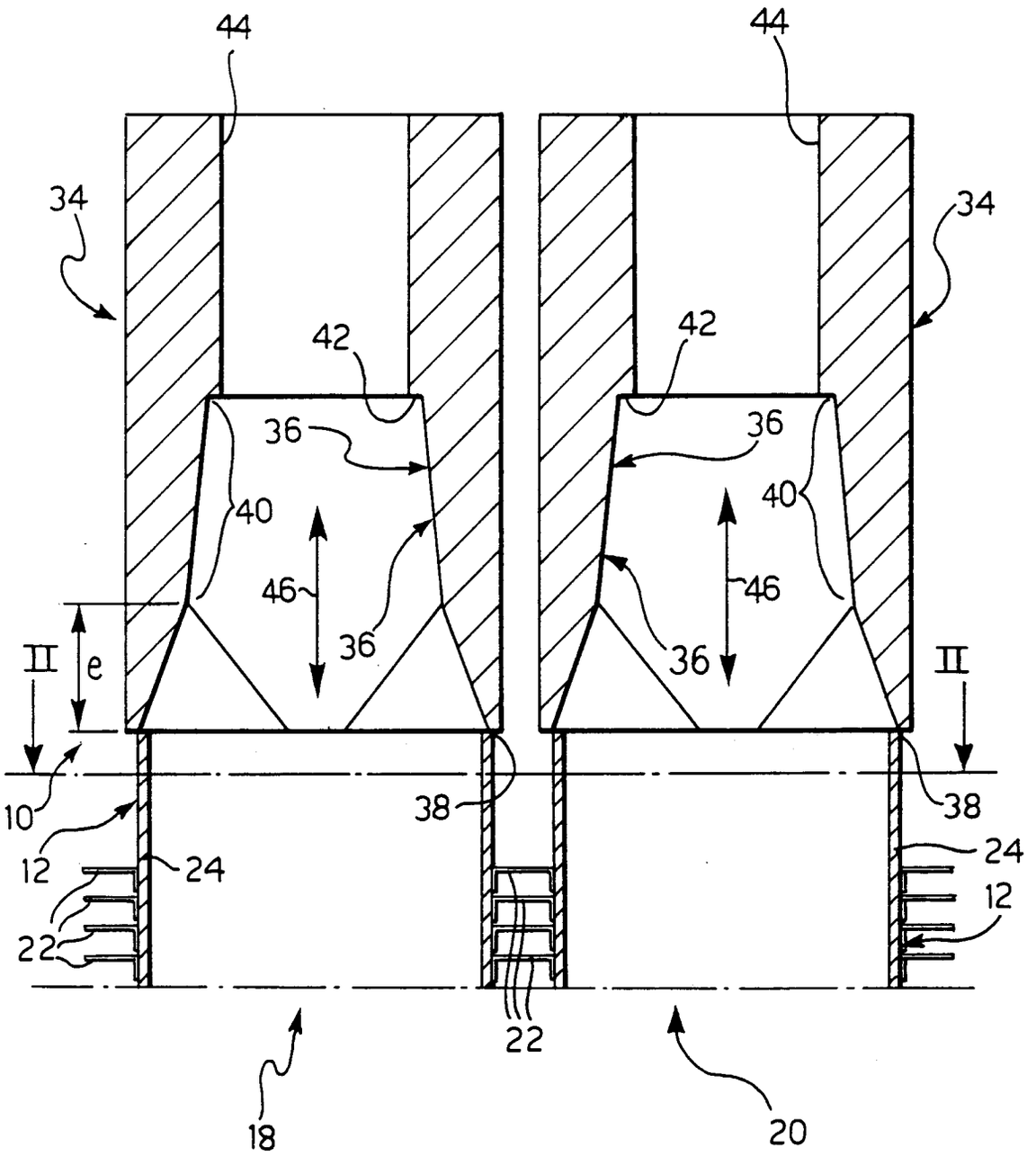
1. Procédé de fixation d'une plaque terminale (26) à un système d'échange de chaleur (10) comprenant une pluralité de tubes (12) à section allongée, dans lequel les extrémités (24) des tubes sont façonnées de manière à avoir une section circulaire avant d'être insérés dans des bagues d'étanchéité (30) à section circulaire disposées dans des trous respectifs (28) de la plaque terminale (26) et dans lequel les tubes (12) sont fixés à la plaque terminale (26) par dilatation radiale de leurs extrémités (24) après qu'ils ont été emboîtés dans les bagues d'étanchéité (30), caractérisé en ce que les extrémités (24) des tubes sont façonnées en une seule phase par compression radiale exécutée en agissant de l'extérieur, au moyen d'un corps creux (34) muni d'une cavité (36) ayant une section transversale qui varie d'une forme allongée à une forme circulaire, le corps creux pouvant être mis en mouvement selon l'axe du tube et étant formé de manière à exercer une pression sur les parois (16) du tube (12) qui ont le plus petit rayon de courbure, et en ce que les extrémités des tubes (24) sont emmanchées dans les bagues d'étanchéité (30) sans nouvelle déformation.

2. Outil pour la mise en oeuvre du procédé selon la revendication 1, servant à façonner l'extrémité d'un tube d'échangeur de chaleur pour lui donner une section circulaire, caractérisé en ce qu'il comprend un corps unitaire (34) ayant une ouverture (38) qui communique avec une cavité (36) dont la section varie le long de son axe longitudinal, la section de la cavité étant allongée dans le voisinage de l'ouverture de manière à contenir la section du tube non déformée et étant circulaire à une distance prédéterminée (e) de l'ouverture (38), mesurée le long de l'axe de la cavité.

3. Outil selon la revendication 2, caractérisé en ce que la section de la cavité dans le voisinage de l'ouverture (38) est ovale et a une dimension maximum (c) plus grande que la dimension maximum (a) de la section du tube non déformé et une dimension minimum (d) qui est égale ou supérieure au diamètre de la partie de la cavité (36) qui a une section circulaire.

4. Outil selon la revendication 3, caractérisé en ce que la cavité (36) a une partie (40) ayant une paroi à pente d'une longueur, mesurée le long de l'axe de la cavité, égale à la longueur axiale désirée de la partie d'extrémité à section circulaire du tube.

FIG. 1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34
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42
42
36
36
40
40
46
46
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36
II
e
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10
12
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38
38
24
12
22
22
18
20

FIG. 2

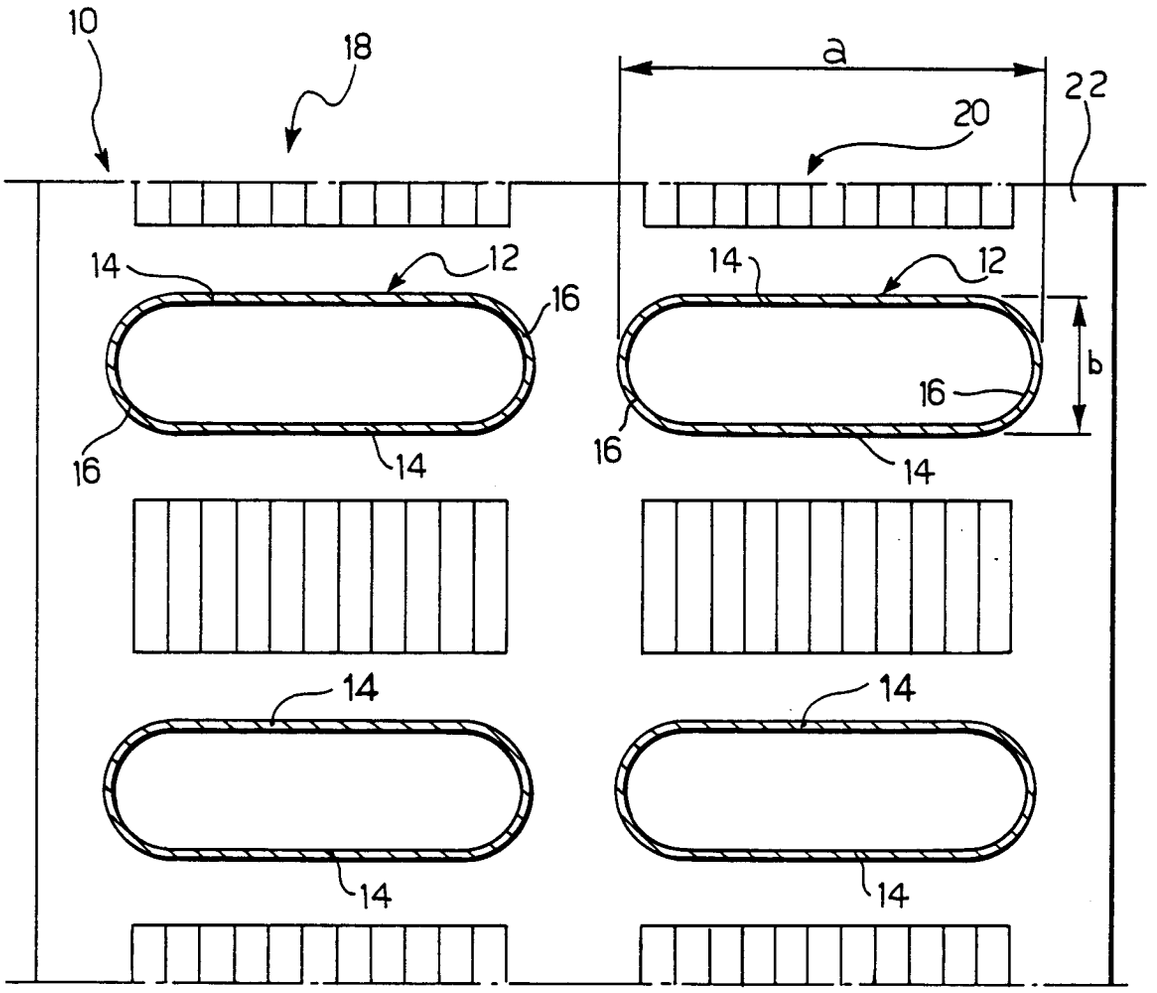
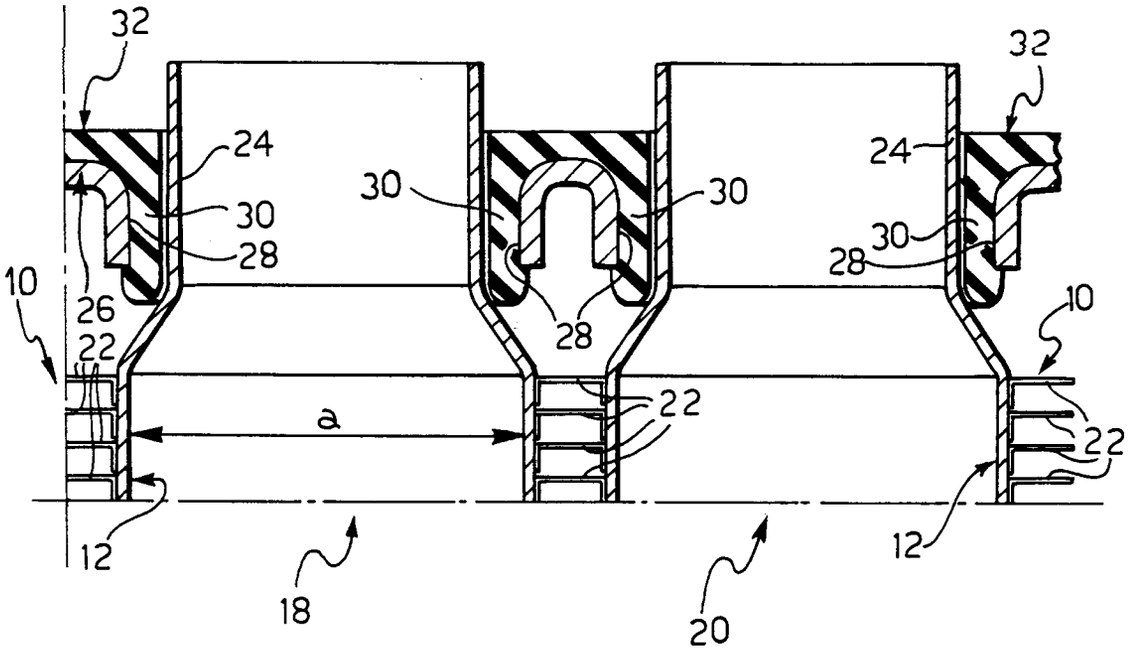


FIG. 3


32
24
30
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12
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30
28
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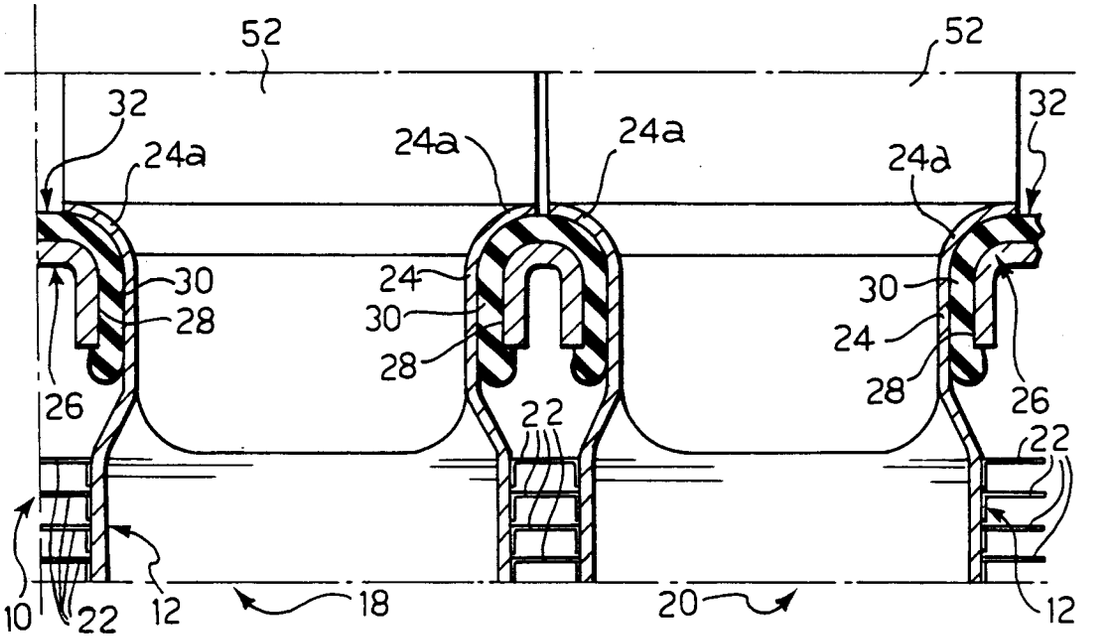
22
22
12

FIG. 4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20
12

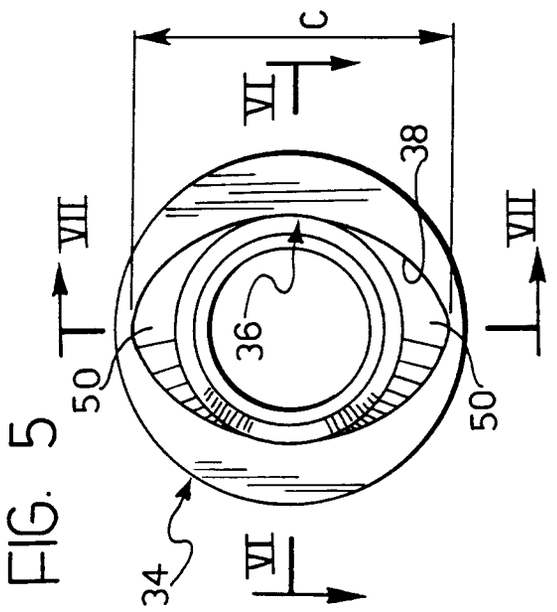

FIG. 5

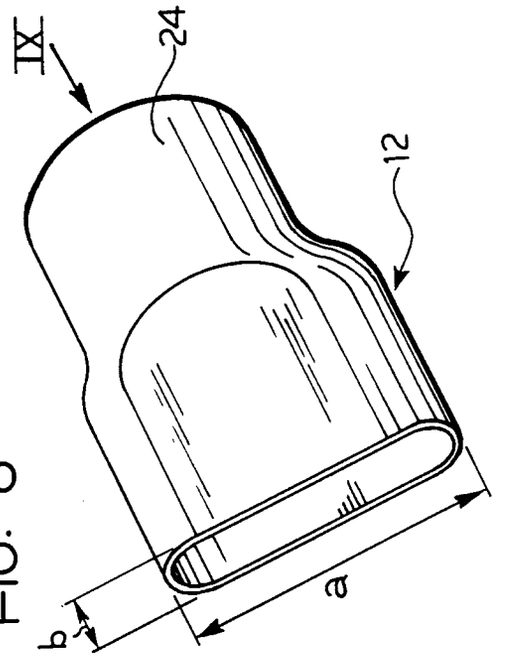

FIG. 8

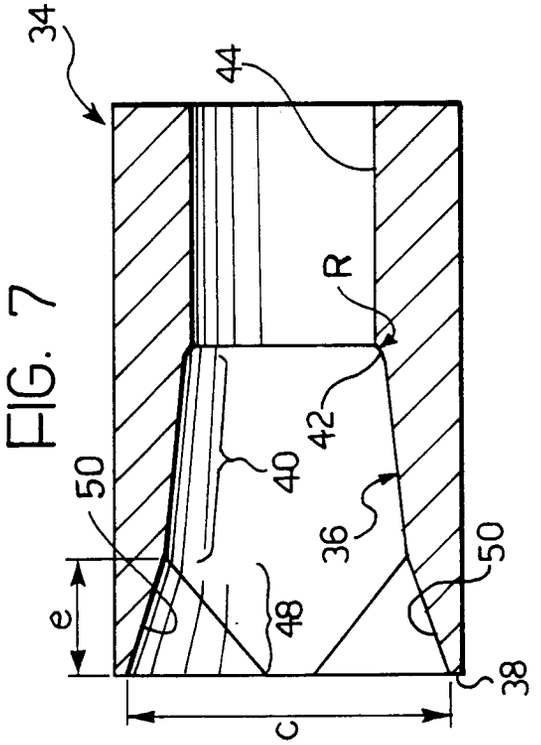

FIG. 7

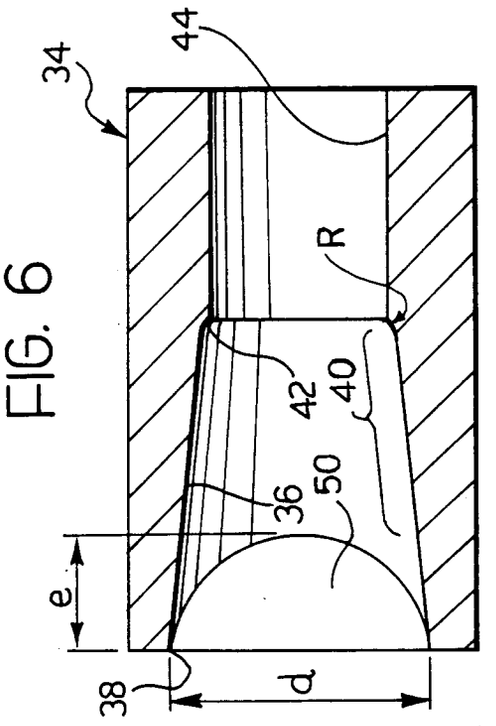

FIG. 6

FIG. 9

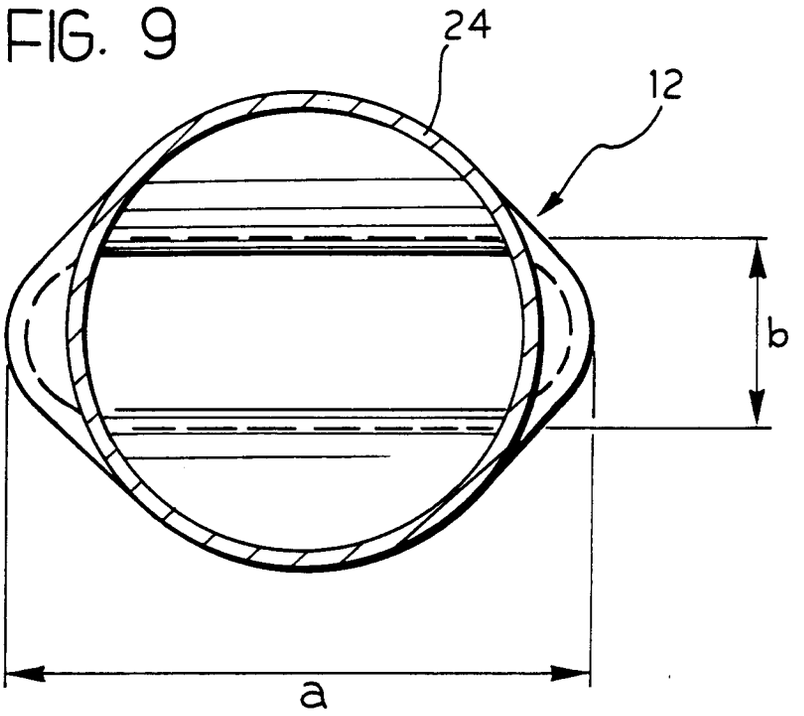

FIG. 10