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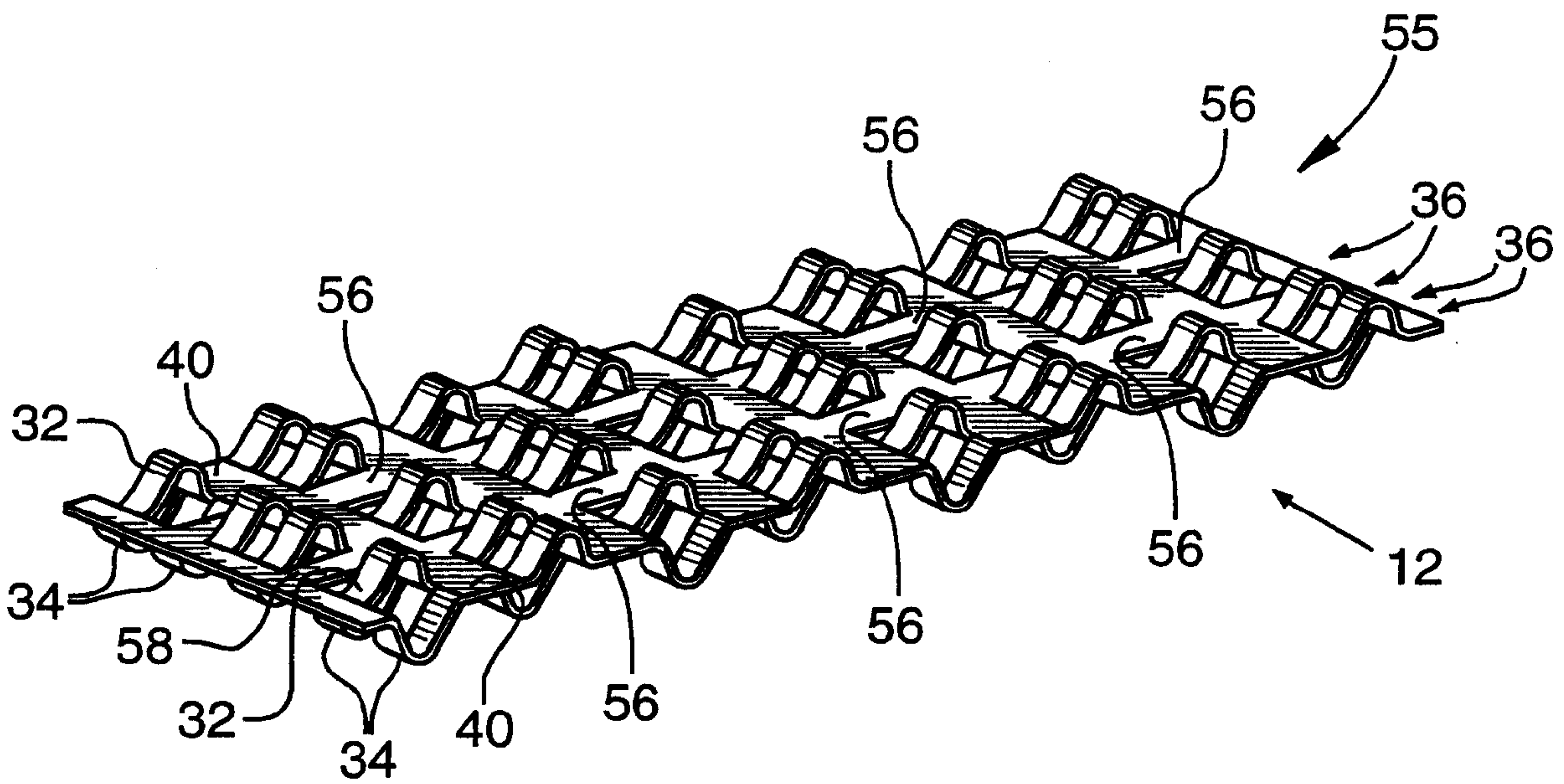


(57) Abrégé/Abstract:

A heat exchanger is disclosed of the type having stacked plate pairs with a turbulizer located inside each pair of plates. The turbulizer is of the expanded metal type having rows of convolutions. The convolutions are interrupted periodically to form non-convoluted pressure recovery zones located between or downstream of the convolutions. Also, the rows of convolutions can be spaced apart to provide longitudinal neutral zones between the rows of convolutions. The pressure recovery zones and longitudinal neutral channels reduce pressure drop in the heat exchanger without appreciably reducing heat transfer.

Abstract of the Disclosure

A heat exchanger is disclosed of the type having stacked plate pairs with a turbulizer located inside each pair of plates. The turbulizer is of the expanded metal type having rows of convolutions. The convolutions are interrupted periodically to form non-convoluted pressure recovery zones located between or downstream of the convolutions. Also, the rows of convolutions can be spaced apart to provide longitudinal neutral zones between the rows of convolutions. The pressure recovery zones and longitudinal neutral channels reduce pressure drop in the heat exchanger without appreciably reducing heat transfer.

HEAT EXCHANGER TURBULIZERS WITH INTERRUPTED CONVOLUTIONS

The present invention relates to heat exchangers, and in particular, to turbulizers used in plate type heat exchangers.

In heat exchangers made from multiple, stacked, plate pairs defining flow passages inside the plate pairs, it is common to use turbulizers located between the plates inside the plate pairs to enhance heat transfer, especially where a liquid, such as oil, passes through the plate pairs. These turbulizers are commonly in the form of expanded metal inserts and they have undulations or convolutions formed therein to create turbulence in the flow and in this way increase heat transfer in the heat exchanger.

While conventional turbulizers do increase heat transfer, a difficulty with these turbulizers is that they also increase flow resistance or pressure drop inside the heat exchanger. In fact, the flow resistance increases even more than the heat transfer gain produced by the turbulizer, because only a part of the increased turbulence caused by the turbulizer is effective in promoting heat transfer. The balance is wasted in inefficient eddies or vortices.

The present invention periodically interrupts the convolutions in the turbulizer to form non-convoluted pressure recovery zones located between the convolutions. Surprisingly, this substantially reduces the pressure drop caused by the turbulizer without appreciably reducing heat transfer.

According to one aspect of the invention, there is provided a turbulizer for a heat exchanger comprising a planar member having a plurality of parallel rows of convolutions formed therein. The convolutions are interrupted periodically to form non-convoluted pressure recovery zones located between the convolutions.

According to another aspect of the invention, there is provided a heat exchanger comprising a pair of back-to-back plates having joined peripheral edges and raised central portions defining a flow passage therebetween. The central portions define spaced-apart inlet and outlet openings. A turbulizer as described next above is located in the flow passage between the inlet and outlet openings.

Preferred embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is an exploded perspective view of a preferred embodiment of a plate type heat exchanger according to the present invention;

Figure 2 is an enlarged perspective view of a portion of the turbulizer used in the heat exchanger of Figure 1;

Figure 3 is an elevational view of a portion of the turbulizer of Figure 2 taken in the direction of arrow 3 in Figure 2;

Figure 4 is a plan view of the turbulizer of Figures 2 and 3;

Figure 5 is a perspective view of another embodiment of a turbulizer according to the present invention;

Figure 6 is an elevational view of a portion of the turbulizer of Figure 5 taken in the direction of arrow 6 in Figure 5;

Figure 7 is a plan view of the turbulizer shown in Figures 5 and 6;

Figure 8 is a perspective view of yet another embodiment of a turbulizer according to the present invention;

Figure 9 is an elevational view of a portion of the turbulizer of Figure 8 taken in the direction of arrow 9 in Figure 8;

Figure 10 is a plan view of the turbulizer shown in Figures 8 and 9;

Figure 11 is a perspective view of yet another embodiment of a turbulizer according to the present invention;

Figure 12 is an elevational view of a portion of the turbulizer of Figure 11 taken in the direction of arrow 12 in Figure 11;

Figure 13 is a plan view of the turbulizer shown in Figures 11 and 12;

Figure 14 is a perspective view of yet another embodiment of the present invention;

Figure 15 is a side elevational view of the turbulizer shown in Figure 14; and

Figure 16 is a plan view of the turbulizer shown in Figures 14 and 15.

Referring to Figure 1, a preferred embodiment of a heat exchanger according to the present invention is generally indicated by reference numeral 10. Heat exchanger 10 is formed of a plurality of plate pairs 12, each having an upper plate 14, a lower plate 16 and a turbulizer 18 located therebetween. Plates 14, 16 are arranged back-to-back and have joined peripheral edges 20. Plates 14, 16 also have raised central portions 22 which define a flow passage therebetween in which turbulizers 18 are located. Raised central portions 22 also define spaced-apart inlet and outlet openings 24, 26 for the flow of fluid, such as oil, through the plate pairs. When the heat exchanger is assembled, all of the inlet openings 24 are aligned and in communication forming an inlet header, and all of the outlet openings 26 are aligned and in communication forming an outlet header. Expanded metal fins 28 are located between the plate pairs for allowing another fluid, such as air to flow transversely through the plate pairs. The plates 14,16 that are in contact with fins 28 are spaced apart by raised end bosses 29 to make room for fins 28 between plate central portions 22.

The plates 14, 16 and the fins 28 can be any shape and configuration desired and are not, *per se* ,considered to be part of the present invention. In fact, plates 14, 16 can be formed with outwardly disposed dimples which mate in adjacent plate pairs in which case, fins 28 would not be used.

Referring next to Figures 2, 3 and 4, a preferred embodiment of a turbulizer 30 is shown which could be used as the turbulizer 18 in Figure 1. It will be appreciated that Figures 5, 8, 11 and 14 show other preferred embodiments of turbulizers. Any one of these could be used as the turbulizer 18 in the heat exchanger 10 shown in Figure 1. The turbulizers shown in Figures 2, 5, 8, 11 and 14 are just illustrations of sections or portions of the turbulizers. It will be appreciated that these turbulizers can be made in any length or width desired depending upon the manufacturing method. The turbulizers usually are stamped or roll-formed out of aluminum about 0.01 inches

(0.25 mm) thick. However, other materials and heavier or thinner materials can be used for the turbulizers as well.

Turbulizer 30 is a planar member having a plurality of convolutions 32, 34 formed therein. Convolutions 32, 34 are arranged in parallel rows. Where turbulizer 30 is elongate in shape, convolutions 32, 34 are arranged in parallel, longitudinal rows 36, and also in parallel transverse rows 38.

Convolutions 32, 34 are interrupted periodically to form non-convoluted pressure recovery zones 40 located between or downstream of the convolutions 32, 34 in each row of convolutions 36. In other words, the convolutions 32, 34 in each row are spaced-apart by pressure recovery zones 40, rather than being located contiguous to one another as is the case in conventional turbulizers.

Turbulizer 30 has a central plane containing pressure recovery zones 40 as indicated by arrow 42, and convolutions 32, 34 extend alternately above (convolutions 32) and below (convolutions 34) the central plane 42. Convolutions 32, 34 are in the form of bridges, and turbulizer 30 has a high pressure drop orientation in the direction of the bridges, or in the longitudinal direction, and a low pressure drop orientation in the direction passing under the bridges or the transverse direction. In the embodiment shown in Figure 2, the convolutions 32, 34 are interrupted in the high pressure drop direction by pressure recovery zones 40 located between or downstream of the convolutions. As seen best in Figure 4, the pressure recovery zones 40 are located in transverse rows or neutral channels 41 themselves.

When turbulizer 30 is used as the turbulizer 18 in heat exchanger 10 of Figure 1, fluid flows in the high pressure drop orientation or direction parallel to longitudinal rows 36 from inlet openings 24 to outlet openings 26. The fluid flows around and under or through convolutions 32, 34. This causes turbulence and reduces boundary layer growth increasing the heat transfer co-efficient. However, pressure recovery zones 40 allow for a pressure recovery to reduce flow resistance or pressure drop in the fluid passing from inlet openings 24 to outlet openings 26.

In turbulizer 30, convolutions 32, 34 are aligned in the low pressure drop or transverse direction. Also, pressure recovery zones 40 are aligned in the low pressure drop or transverse direction to form neutral channels 41. Pressure recovery zones 40 thus form continuous neutral channels 41 in the low pressure drop direction. These neutral channels 41 also provide areas that can be used to eject the turbulizer from the dies used to produce the turbulizer.

The width of the convoluted longitudinal rows 36 is preferably as narrow as is practical for tool design and maintenance purposes. For automotive cooling puroses, a preferred minimum width would be about 0.02 inches (0.5 mm). The maximum width should not exceed ten times the minimum. Typically, the maximum width would be about 0.2 inches (5 mm). The longitudinal length of pressure recovery zones 40 ranges from about 5% of the longitudinal or centerline to centerline spacing between convolutions 32, 34 to about 75% of the spacing between any two consecutive convolutions 32, 34. A preferable range would be between 0.02 inches (0.5 mm) to about 0.5 inches (1.25 cm), or about 40% to 50% of the centerline to centerline distance between longitudinally consecutive convolutions 32, 34.

The height of convolutions 32, 34 above or below the central plane 42 containing pressure recovery zones 40 depends upon the thickness of the material used for turbulizer 30. This height should not be less than the material thickness and typically ranges from this minimum to about 10 times the material thickness where aluminum is used for turbulizer 30. A good range is from 0.01 inches (0.25 mm) to 0.5 inches (1.25 cm).

The longitudinal length of convolutions 32, 34 is normally about 2 times the height of the convolutions. The height normally ranges from about 2 times the material thickness to about 20 times the material thickness. A good range is from 0.02 inches (0.5 mm) to about 1.0 inch (2.5 cm).

Referring next to Figures 5, 6 and 7, a turbulizer 45 is shown which is substantially similar to turbulizer 30 except as follows. In turbulizer 45, the convolutions 32, 34 are staggered in the low pressure drop or transverse direction. In other words, the convolutions 32 which extend above the central plane do not line up transversely with the convolutions 34 that extend below the central plane in the adjacent longitudinal rows 36. Convolutions 32, 34 in every other row of convolutions do line up, but they could be staggered as well if desired. The material thickness and dimensions of convolutions 32, 34 and pressure recovery zone 40 are similar to those of turbulizer 30 of Figure 2.

Referring next to Figures 8, 9 and 10, yet another embodiment of turbulizer 50 is shown wherein the convolutions are staggered in the low pressure drop or transverse direction. In turbulizer 50, all of the pressure recovery zones 40 are contained in a common reference plane 52 and all of the convolutions 54 extend in the same direction relative to this reference plane 52. In all other respects, turbulizer 50 is similar to turbulizers 30 and 45.

Referring next to Figures 11, 12 and 13, a turbulizer 55 is shown that is most similar to turbulizer 30 of Figure 2, except the convolutions 32, 34 are also interrupted in the low pressure drop direction to form further pressure recovery zones 56 located between some of the rows of convolutions 36. Actually, pressure recovery zones 56 extend longitudinally the full length of turbulizer 55 to form longitudinal neutral channels 58 in the high pressure drop or longitudinal direction of turbulizer 55. For manufacturing purposes, the width of neutral channels 58 preferably is about the same as the width of the rows of convolutions 36. In turbulizer 55, the convolutions 32, 34 are aligned in the low pressure drop or transverse direction, but they could be staggered as well. Where convolutions 32, 34 are aligned in the low pressure drop or transverse direction, it will be appreciated that pressure recovery zones 40 are aligned to give transverse neutral channels 59 in the low pressure drop direction, and pressure recovery zones 56 are aligned to give longitudinal neutral channels 58 in the high pressure drop direction. Where convolutions 32, 34 are staggered, only longitudinal neutral channels 58 would be formed. In all other respects, turbulizer 55 is similar to turbulizers 30, 45 and 50.

Referring next to Figures 14, 15 and 16, a turbulizer 60 is shown where the convolutions 32, 34 are interrupted only in the low pressure drop or transverse direction and only between some of the rows of convolutions 36. These interruptions make pressure recovery zones 61 in the form of longitudinal neutral channels 62. In all other respects, turbulizer 60 is similar to turbulizers 30, 45, 50 and 55.

Having described preferred embodiments of the invention, it will be appreciated that various modifications can be made to the structures described above. For example, the convolutions 32, 34 have been shown to be rounded with various curvatures. These convolutions can be any configuration, such as semi-circular, sinusoidal, trapezoidal or even V-shaped, if desired. In heat exchanger 10 shown in Figure 1, turbulizer 18 is shown to be orientated such that the flow is in the high pressure drop or longitudinal direction. However, the turbulizer could be rotated 90 degrees so that the flow from inlet 24 to outlet 26 is in the low pressure drop direction if desired. It will also be appreciated that the various features of turbulizers 30, 45, 50, 55 and 60 could be mixed and matched, or a combination of these features could be employed in the same turbulizer. Also, any given heat exchanger could have any one or a combination of the turbulizers described above. Other modifications to the structure described above will be apparent to those skilled in the art.

As will be apparent to those skilled in the art in the light of the foregoing disclosure, many alterations and modifications are possible in the practice of this invention without departing from the spirit or scope thereof. Accordingly, the scope of the invention is to be construed in accordance with the substance defined by the following claims.

CLAIMS:

1. A turbulizer for a heat exchanger comprising:

a planar member having a plurality of longitudinal parallel rows of convolutions formed therein, said convolutions being interrupted to form longitudinal neutral channels only between some of the adjacent longitudinal parallel rows of convolutions.

2. A turbulizer for a heat exchanger as claimed in claim 1 wherein the convolutions are in the form of bridges, the turbulizer having a high pressure drop orientation in the direction of the bridges and a low pressure drop orientation in the direction passing under the bridges.

3. A turbulizer for a heat exchanger as claimed in claim 2 wherein the convolutions are interrupted in the high pressure drop direction to form pressure recovery zones located between the convolutions.

4. A turbulizer for a heat exchanger as claimed in claim 2 wherein the convolutions are interrupted in the low pressure drop direction to form pressure recovery zones located between the rows of convolutions.

5. A turbulizer for a heat exchanger as claimed in claim 3 wherein the convolutions are aligned in the low pressure drop direction, the pressure recovery zones also being aligned to form neutral channels in the low pressure drop direction.

6. A turbulizer for a heat exchanger as claimed in claim 3 wherein the convolutions are staggered in the low pressure drop direction.

7. A turbulizer for a heat exchanger as claimed in claim 4 wherein the convolutions are aligned in the low pressure drop direction, the pressure recovery zones also being aligned to form neutral channels in the high pressure drop direction.

8. A turbulizer for a heat exchanger as claimed in claim 4 wherein the convolutions are staggered in the low pressure drop direction, the pressure recovery zones in the high pressure drop direction being aligned to form neutral channels in the high pressure drop direction.

9. A turbulizer for a heat exchanger as claimed in claim 3 wherein the convolutions are also interrupted in the low pressure drop direction to form further pressure recovery zones located between the convolutions in the low pressure rop direction.

10. A turbulizer for a heat exchanger as claimed in claim 9 wherein the convolutions are aligned in the low pressure drop direction, said pressure recovery zones and said further pressure recovery zones also being aligned to form neutral channels in both the low pressure drop and the high pressure drop directions.

11. A turbulizer for a heat exchanger as claimed in claim 4 wherein the convolutions are staggered in the low pressure drop direction, the pressure recovery zones being aligned to form neutral channels in the high pressure drop direction.

12. A turbulizer for a heat exchanger as claimed in claim 3 wherein the turbulizer has a central plane containing the pressure recovery zones, and wherein the convolutions in each row of convolutions extend alternately above and below the central plane.

13. A turbulizer for a heat exchanger as claimed in claim 3 wherein the turbulizer has a reference plane containing the pressure recovery zones, and wherein the convolutions all extend in the same direction relative to the reference plane.

14. A turbulizer for a heat exchanger as claimed in claim 6 wherein the turbulizer has a central plane containing the pressure recovery zones, and wherein the convolutions in each row of convolutions extend alternately above and below the central plane.

15. A turbulizer for a heat exchanger as claimed in claim 6 wherein the turbulizer has a reference plane containing the pressure recovery zones, and wherein the convolutions all extend in the same direction relative to the reference plane.

16. A turbulizer for a heat exchanger as claimed in claim 9 wherein the turbulizer has a central plane containing the pressure recovery zones, and wherein the convolutions in each row of convolutions extend alternately above and below the central plane.

17. A turbulizer for a heat exchanger as claimed in claim 7 wherein the turbulizer has a central plane containing the pressure recovery zones, and wherein the convolutions in each row of convolutions extend alternately above and below the central plane.

18. A heat exchanger comprising:

a pair of back-to-back plates having joined peripheral edges and raised central portions defining a flow passage therebetween; said central portions defining spaced-apart inlet and outlet openings; and a turbulizer as claimed in claim 3 located in the flow passage between the inlet and outlet openings.

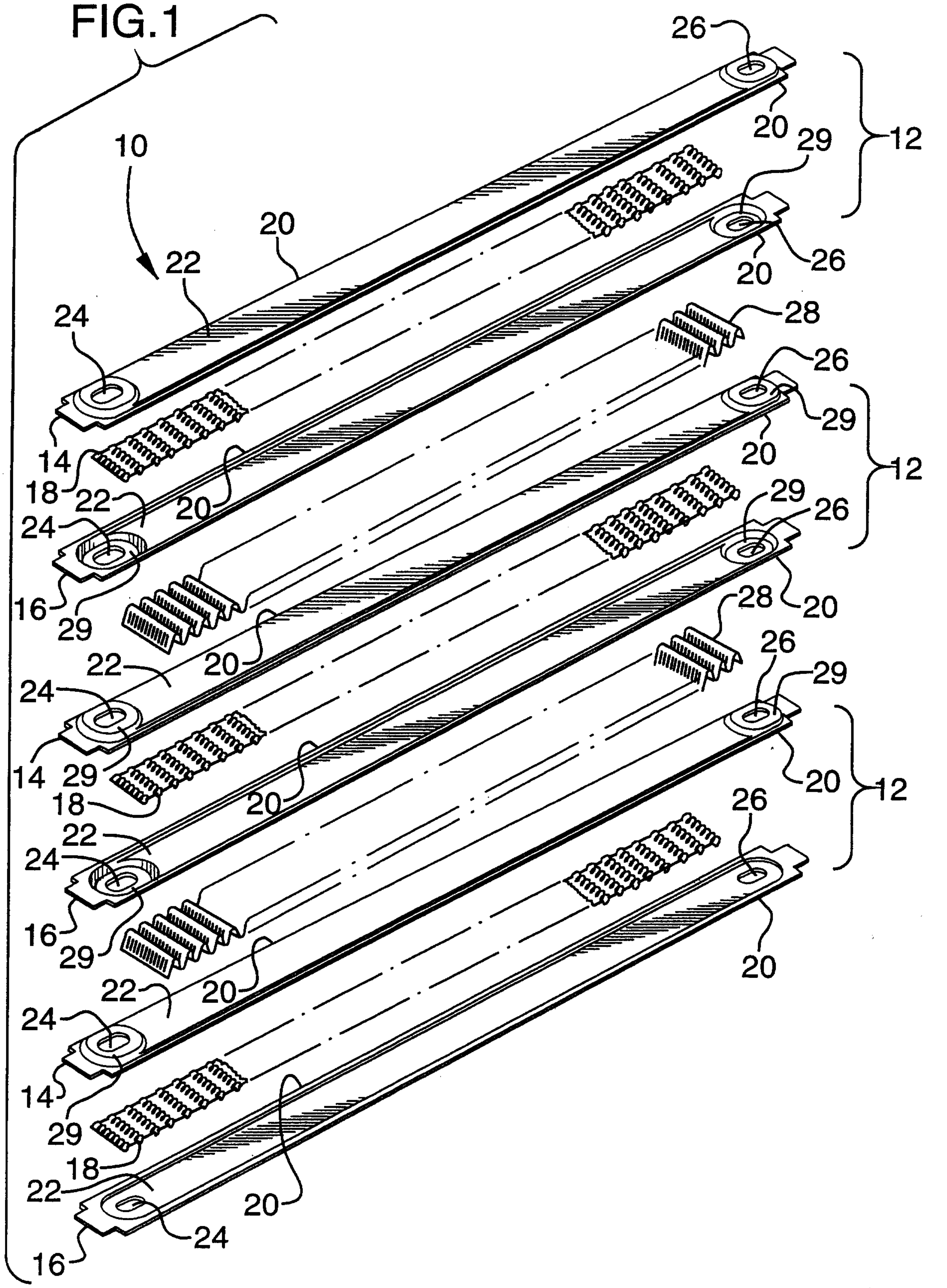
19. A heat exchanger comprising:

a pair of back-to-back plates having joined peripheral edges and raised central portions defining a flow passage therebetween; said central portions defining spaced-apart inlet and outlet openings; and a turbulizer as claimed in claim 7 located in the flow passage between the inlet and outlet openings.

20. A heat exchanger comprising:

a pair of back-to-back plates having joined peripheral edges and raised central portions defining a flow passage therebetween; said central portions defining spaced-apart inlet and outlet openings; and a turbulizer as claimed in claim 10 located in the flow passage between the inlet and outlet openings.

FIG.1



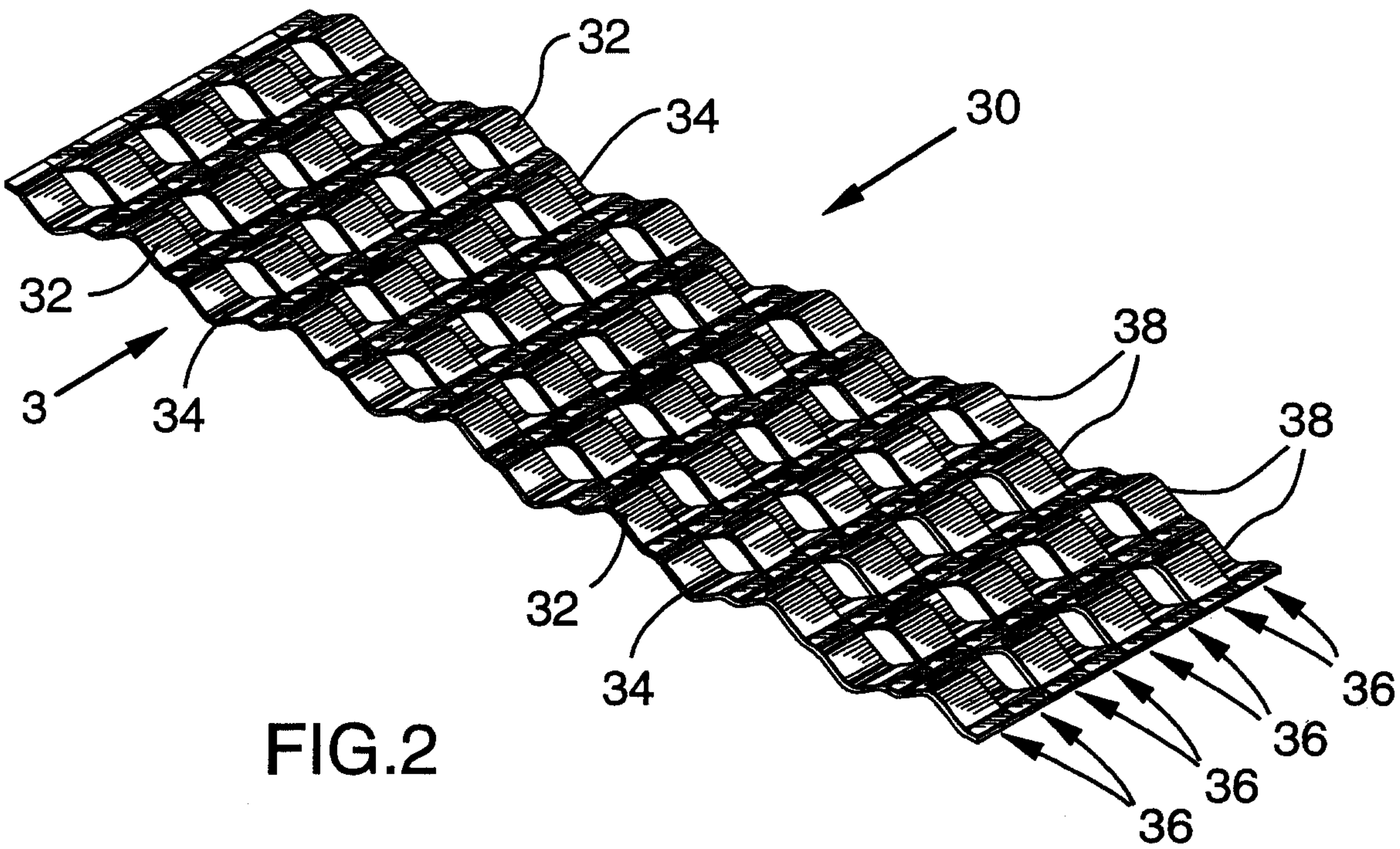


FIG.2

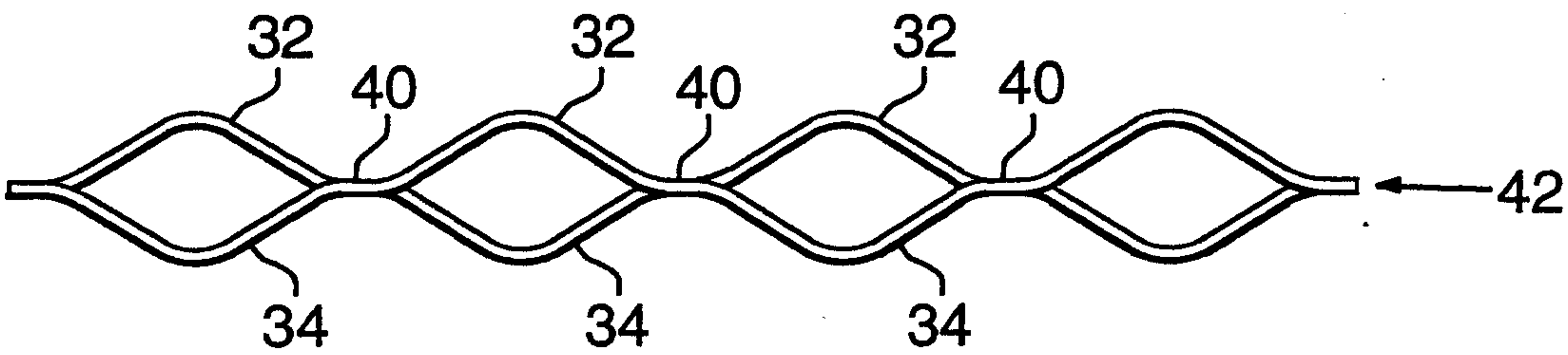


FIG.3

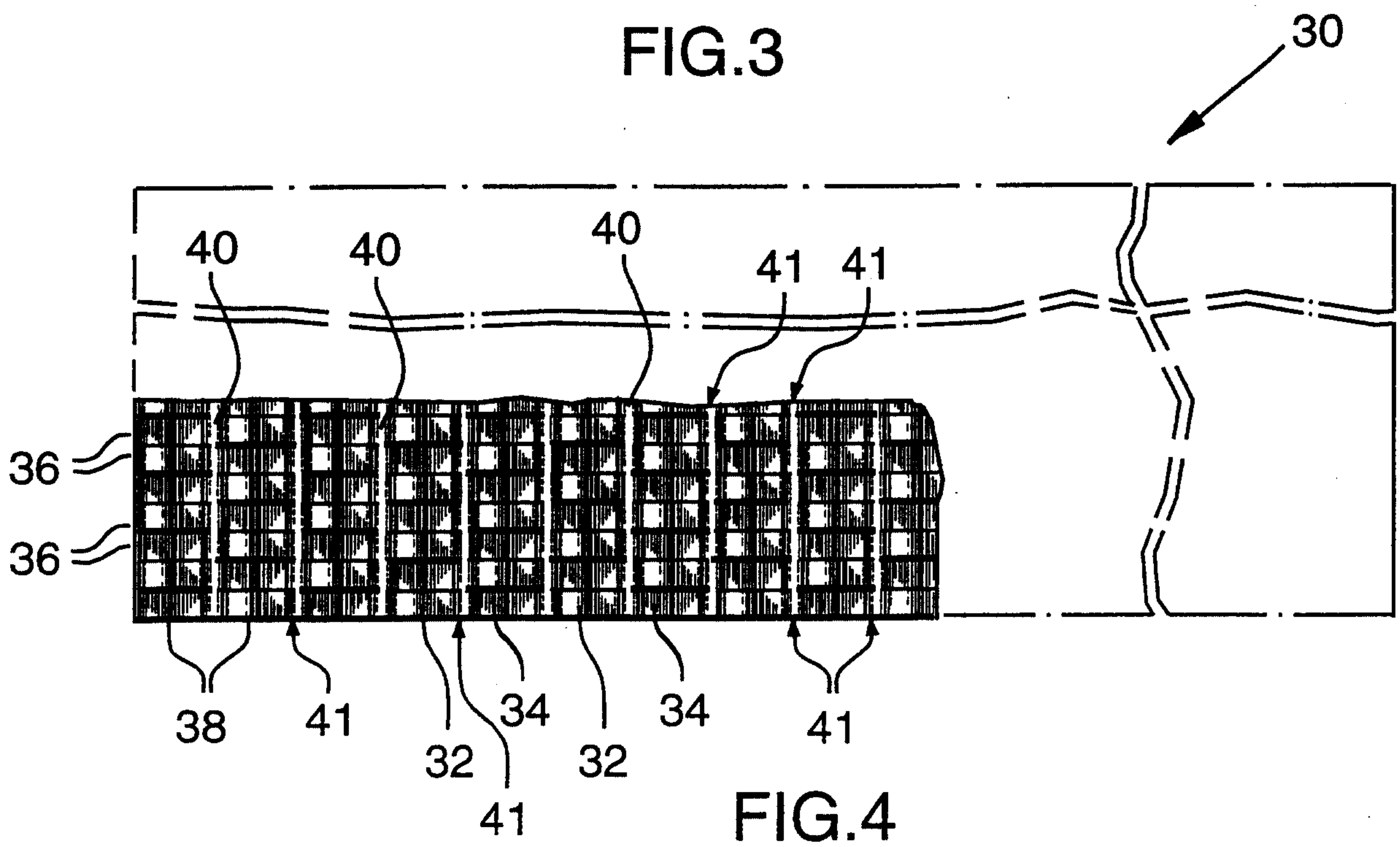


FIG.4

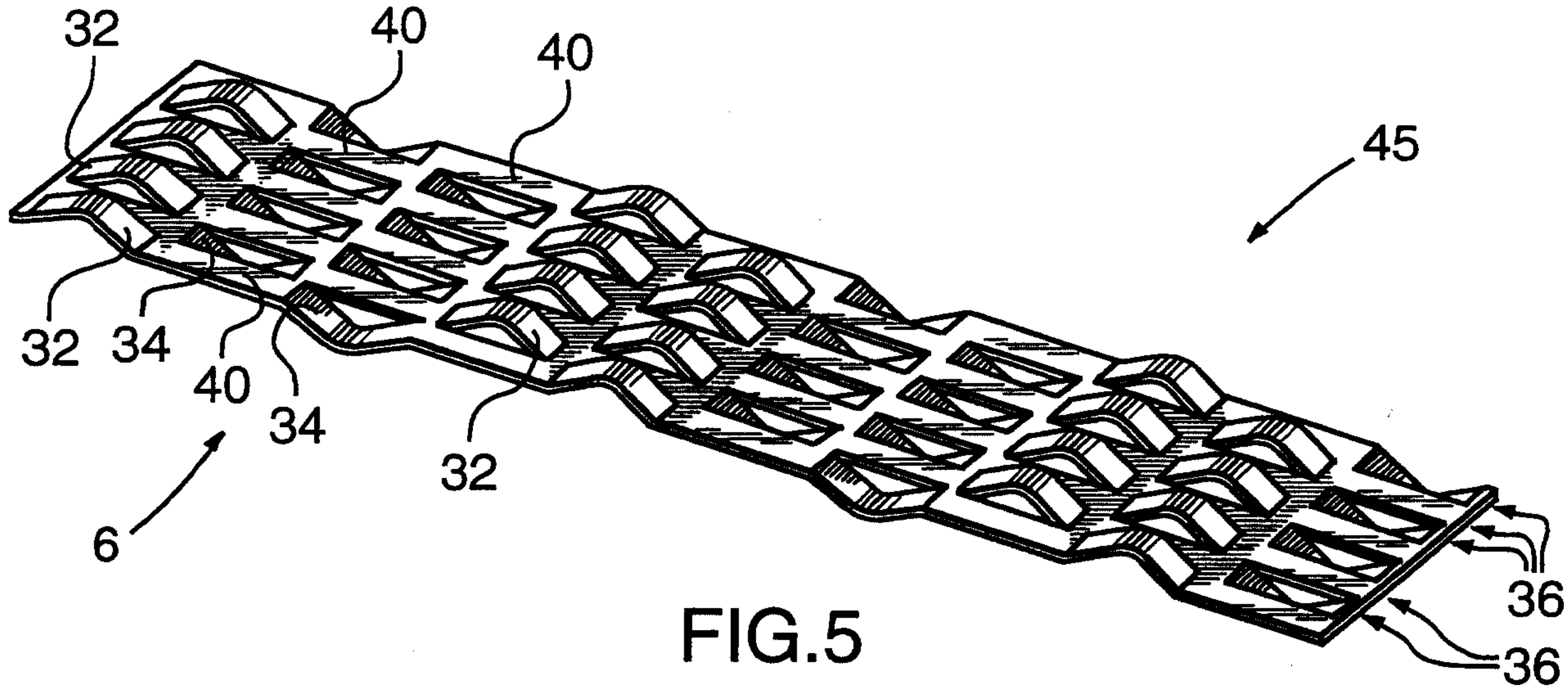


FIG.5

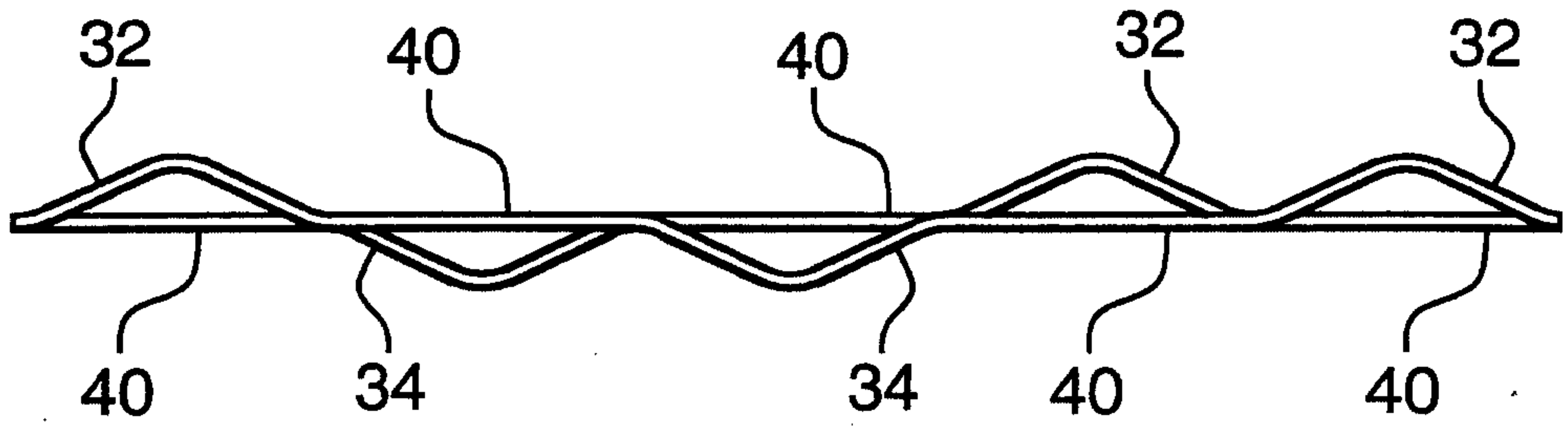


FIG.6

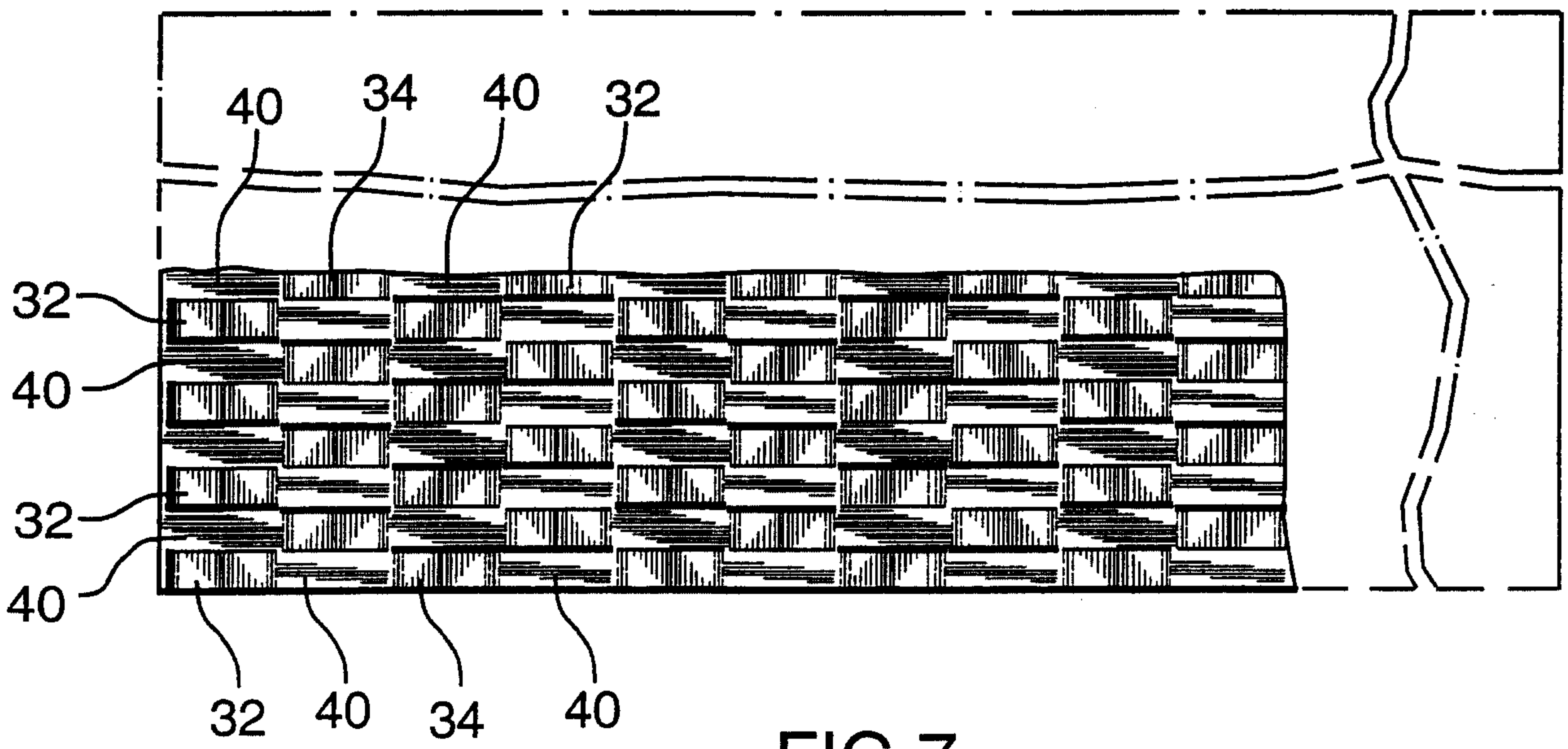


FIG.7

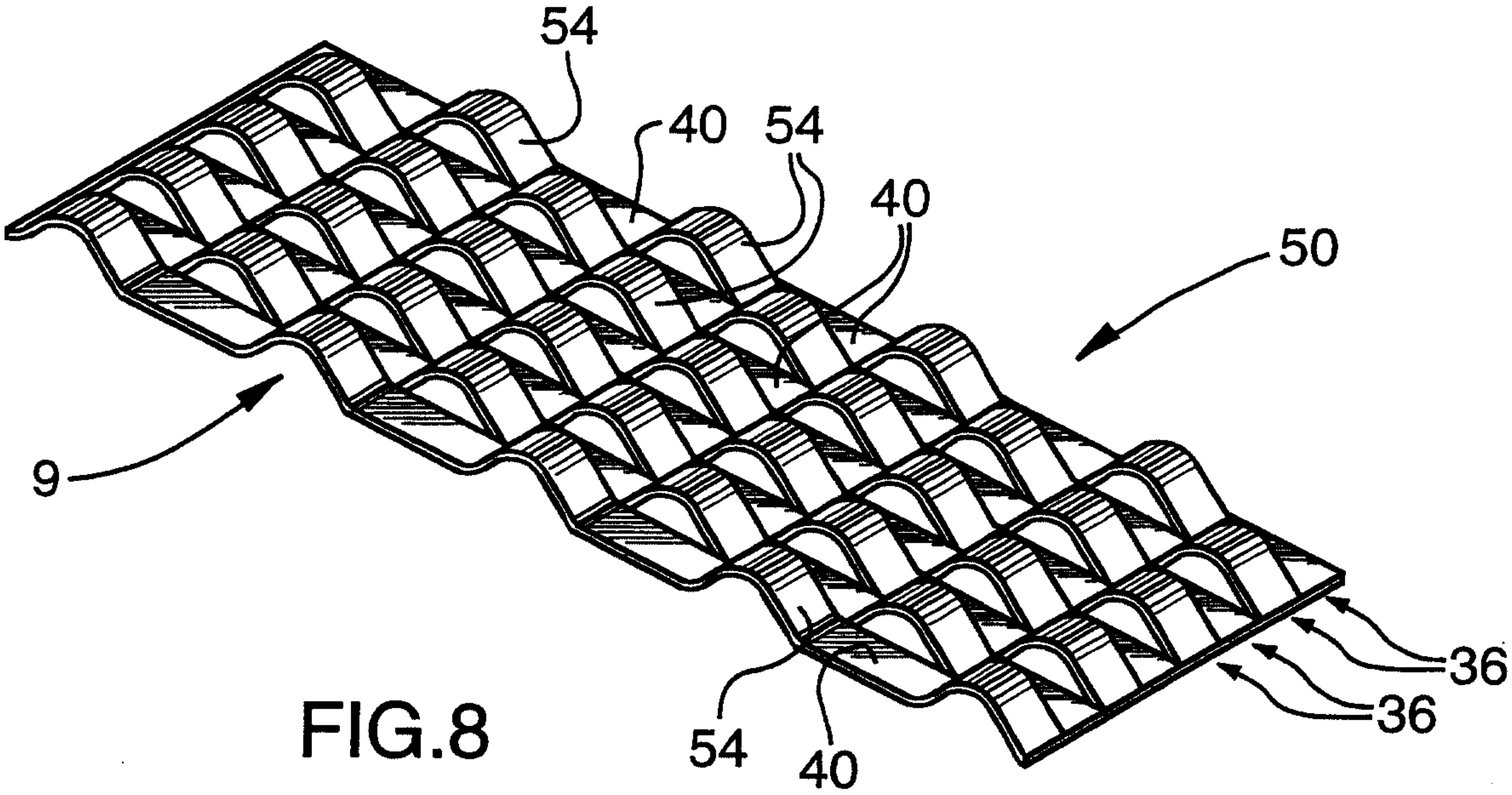


FIG.8

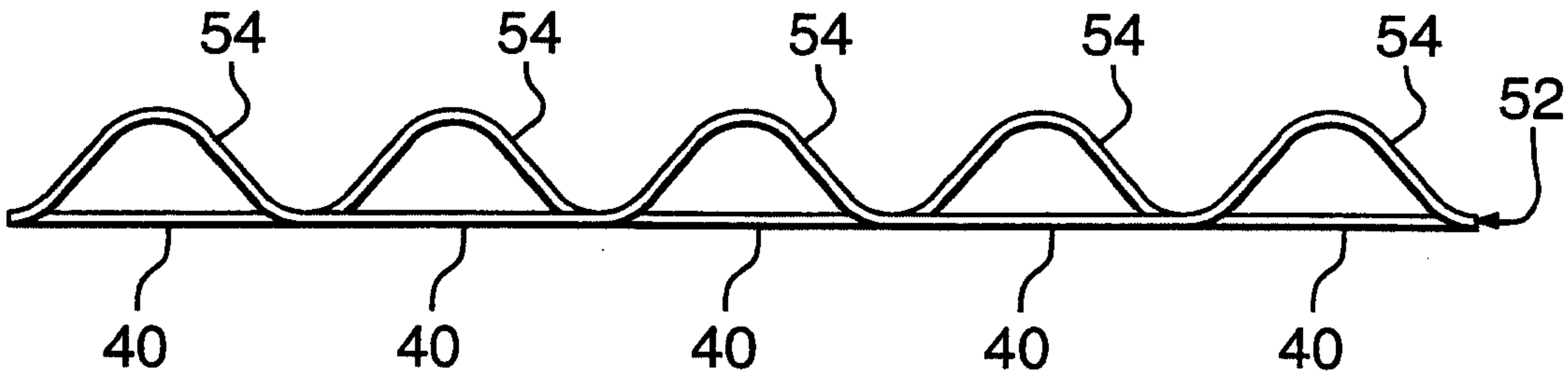


FIG.9

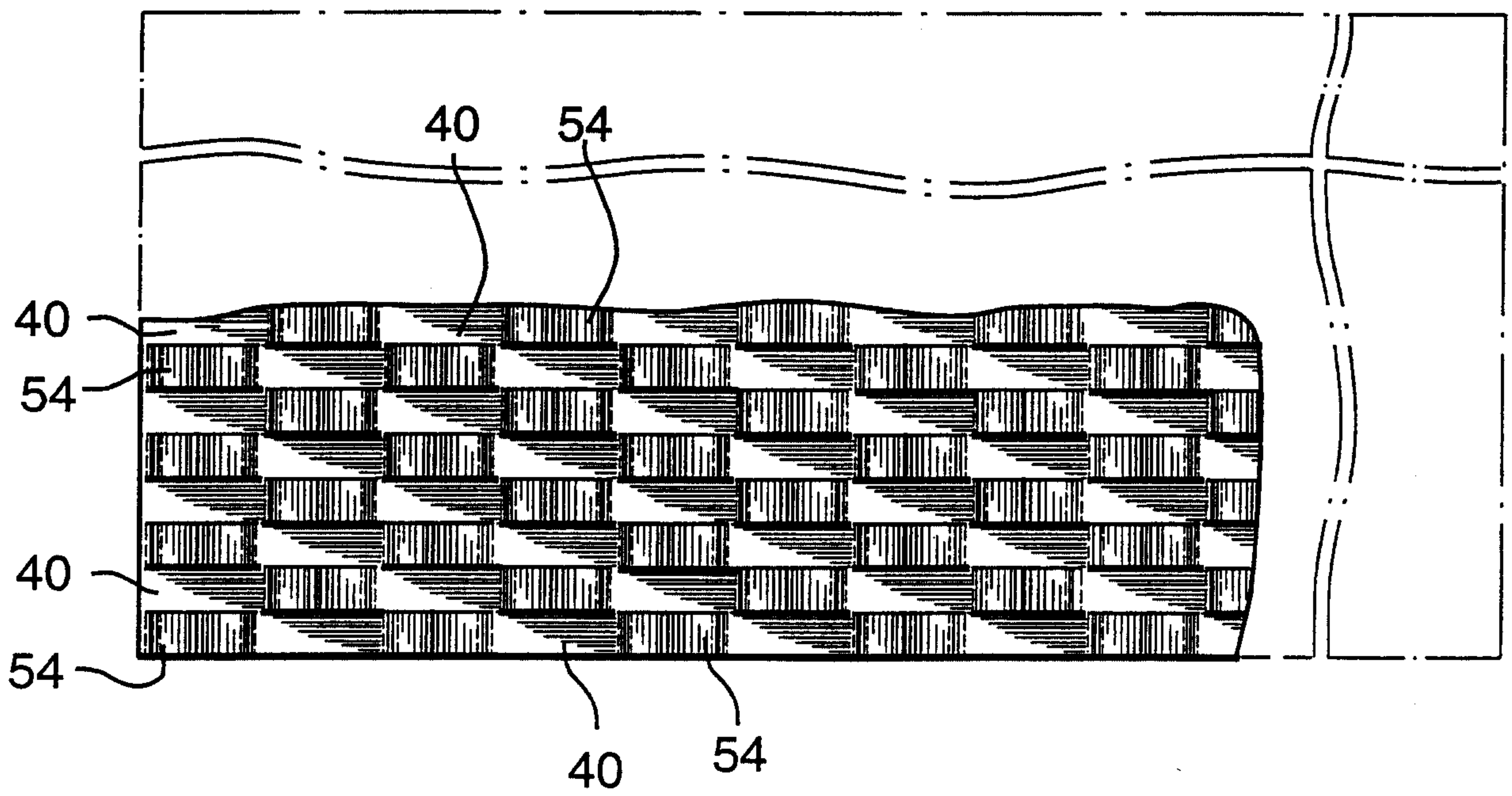


FIG.10

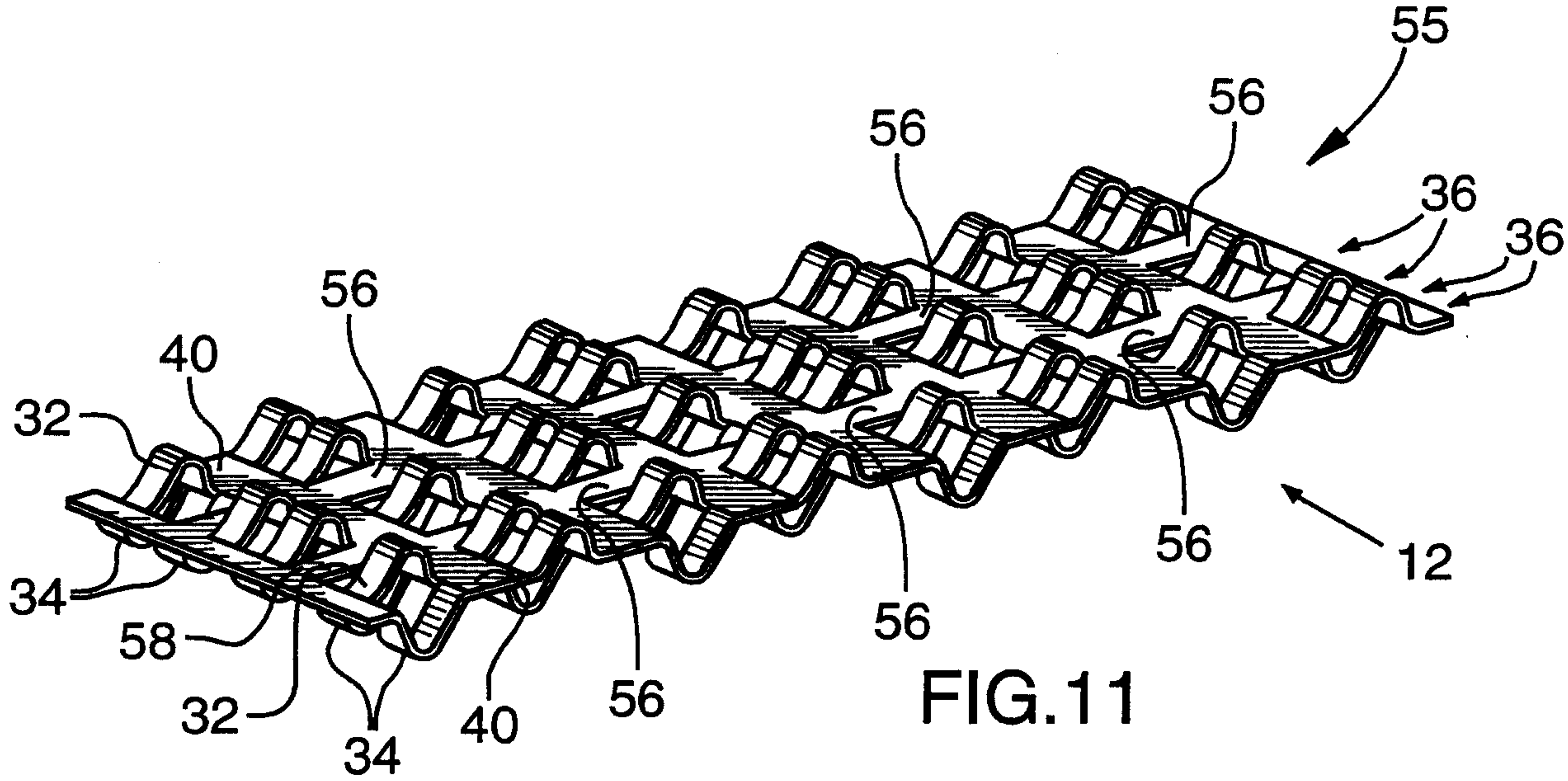


FIG.11

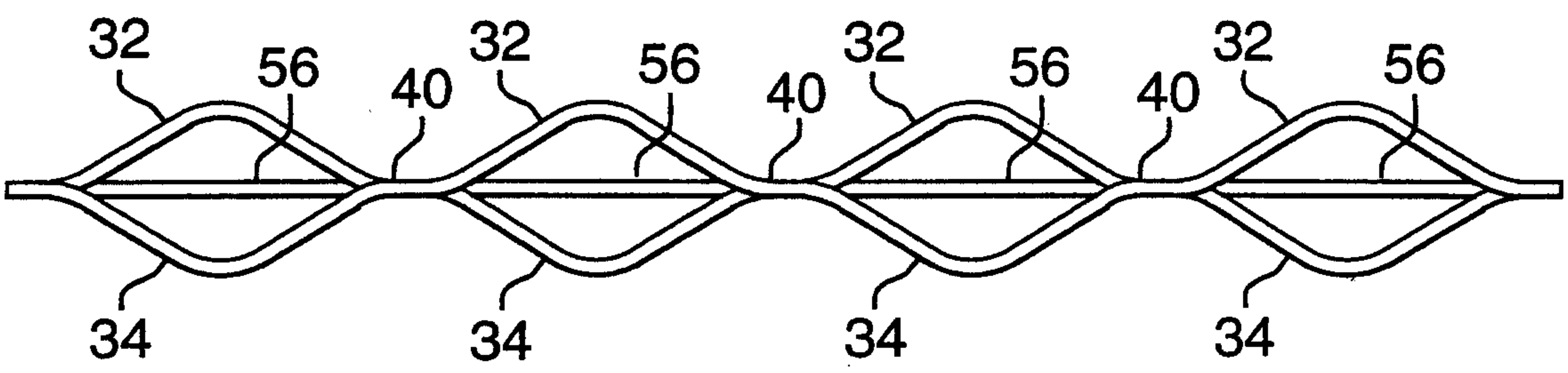


FIG.12

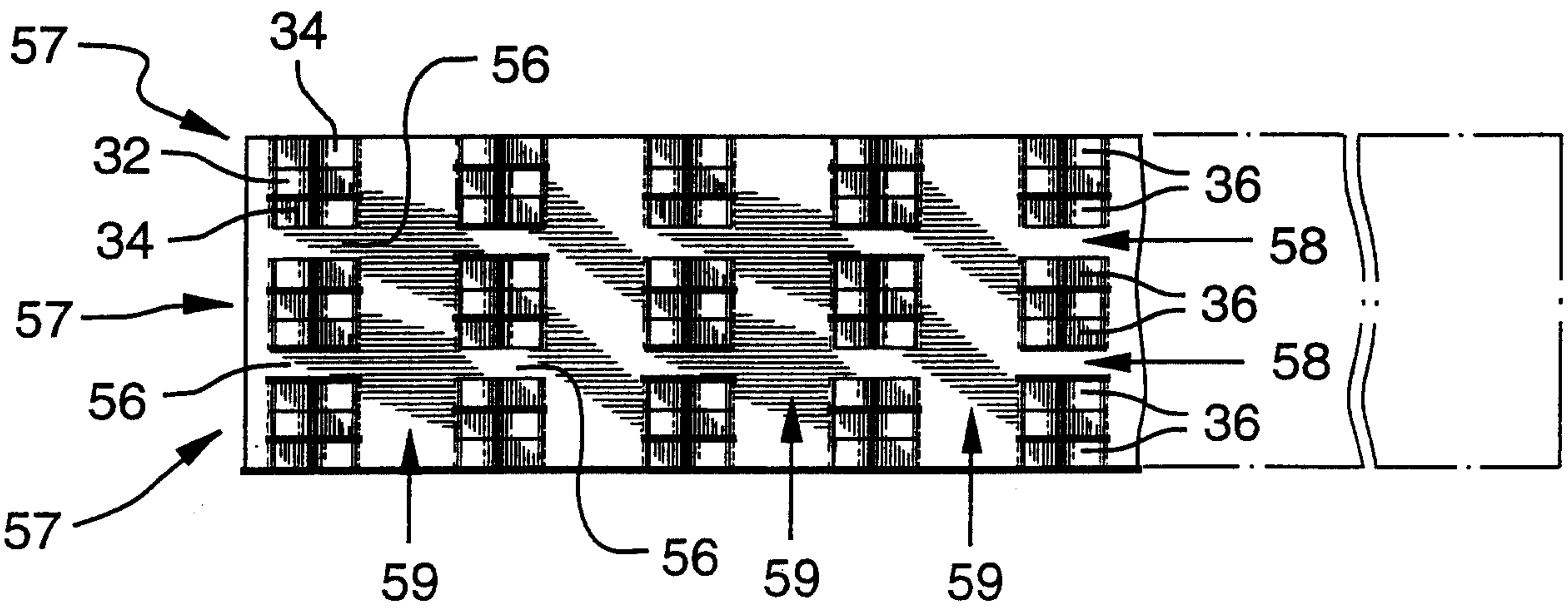


FIG.13

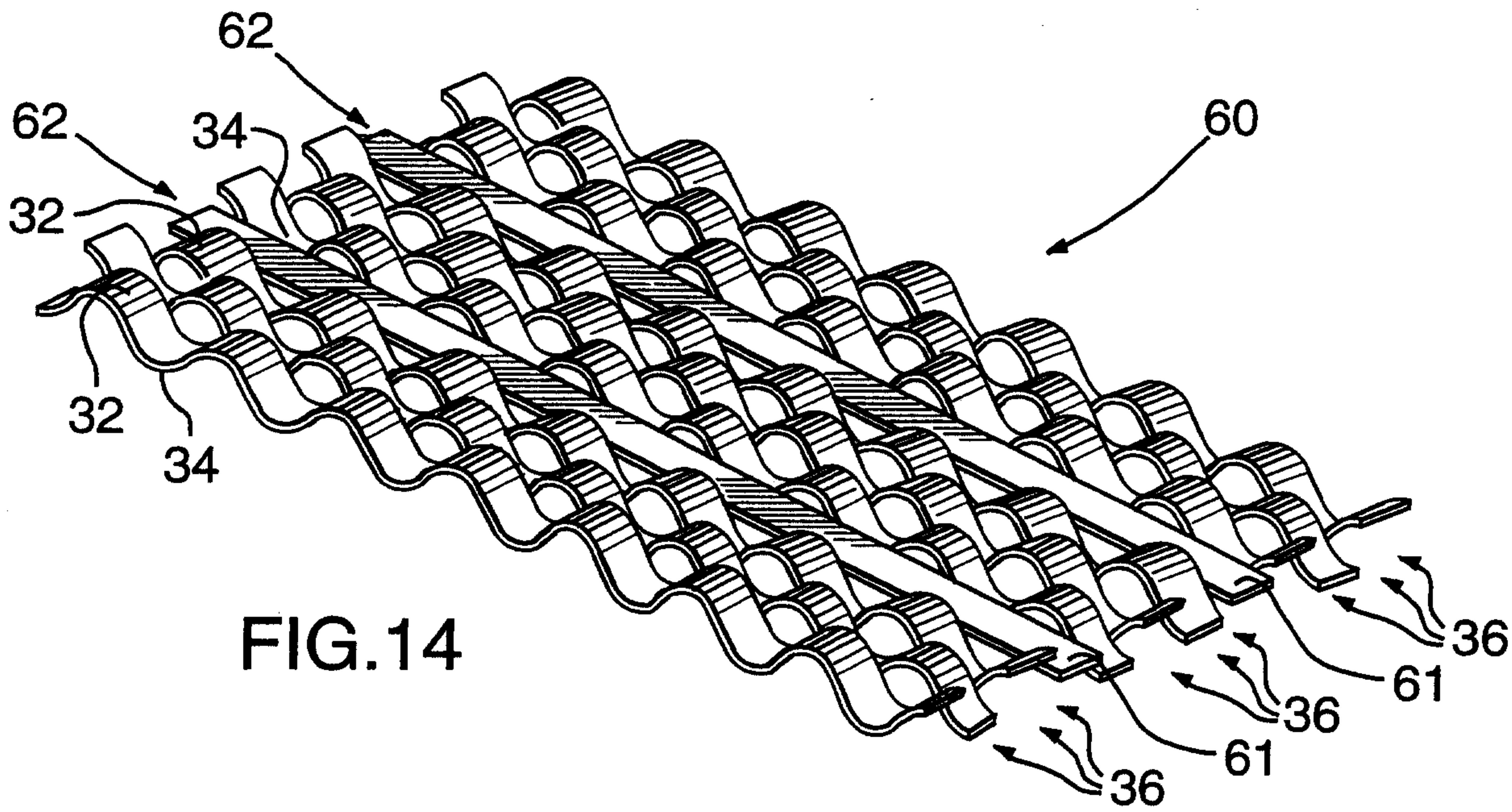


FIG.14

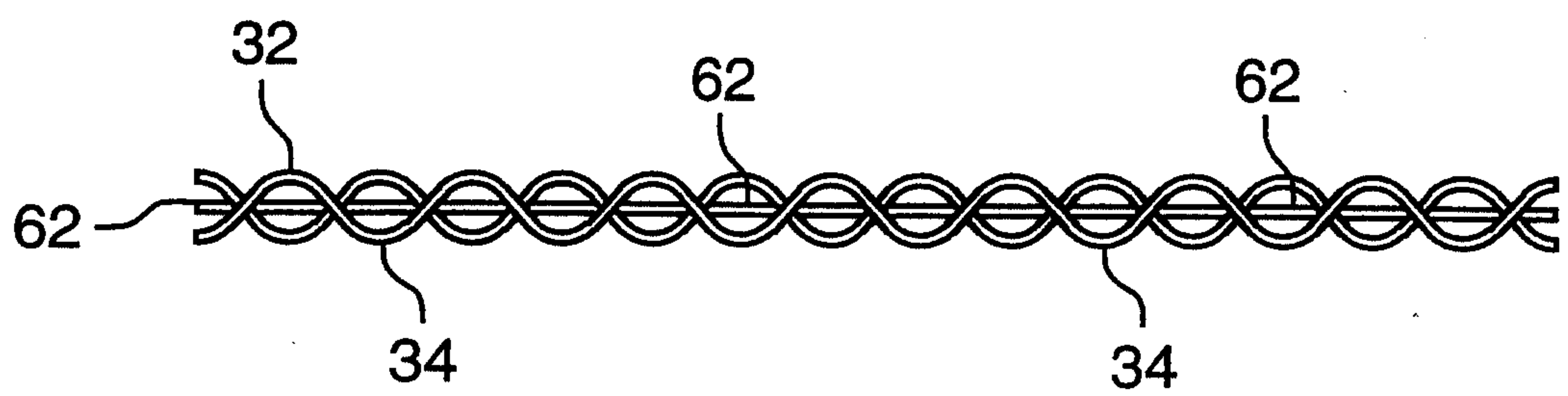


FIG.15

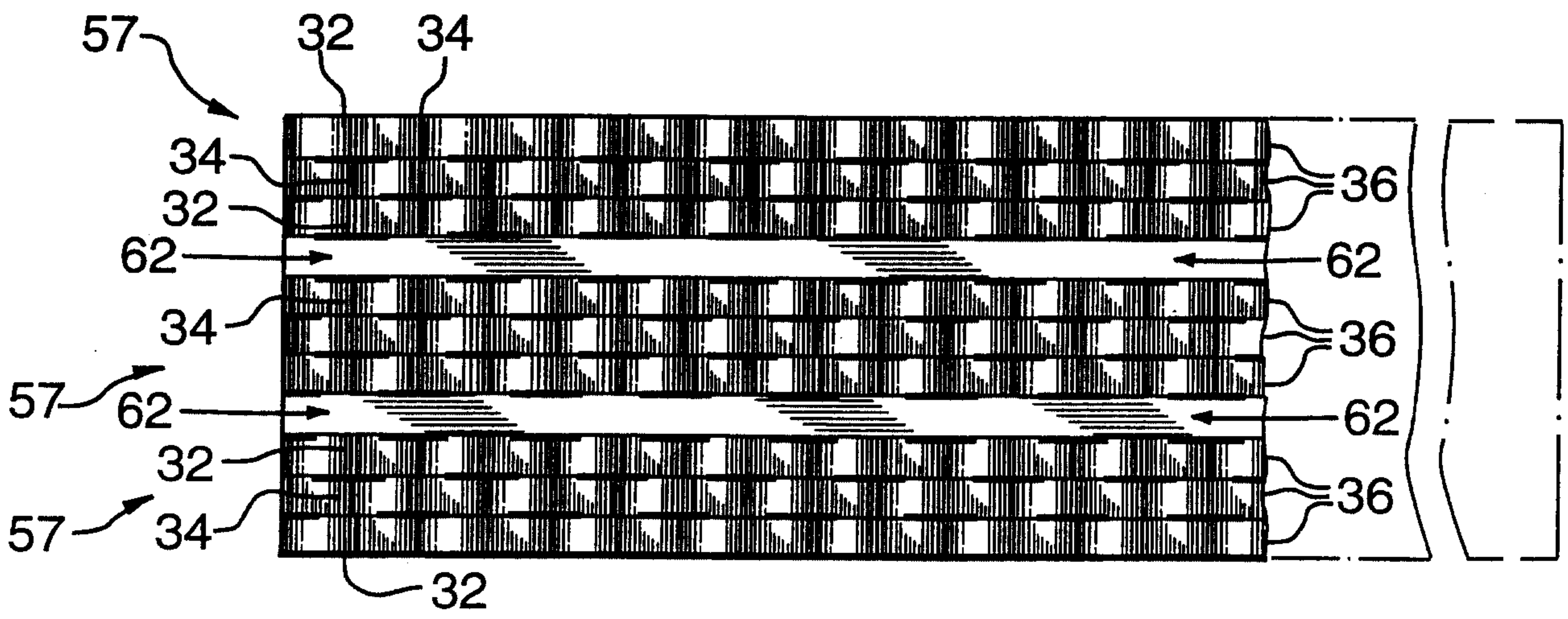
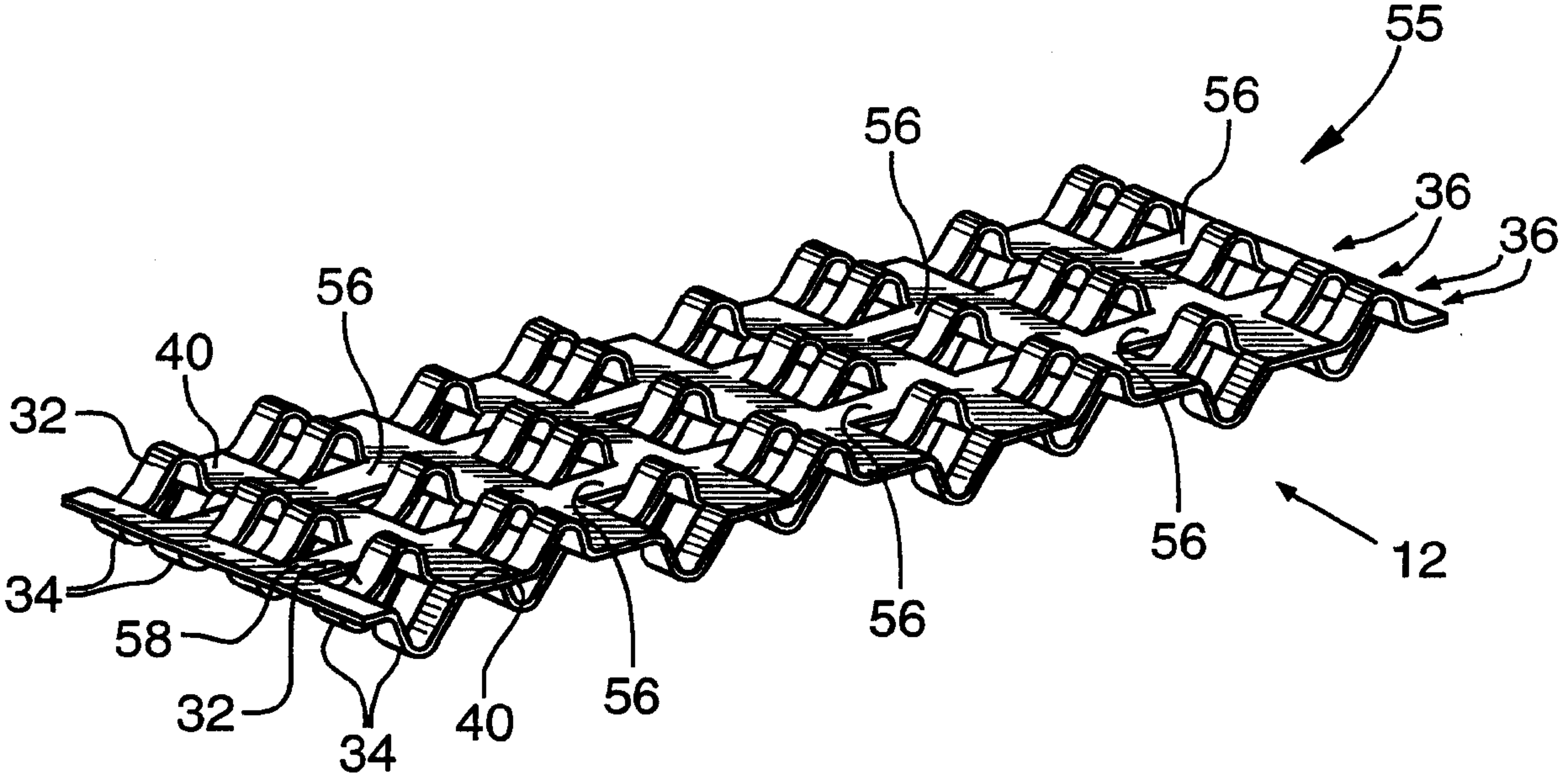


FIG.16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