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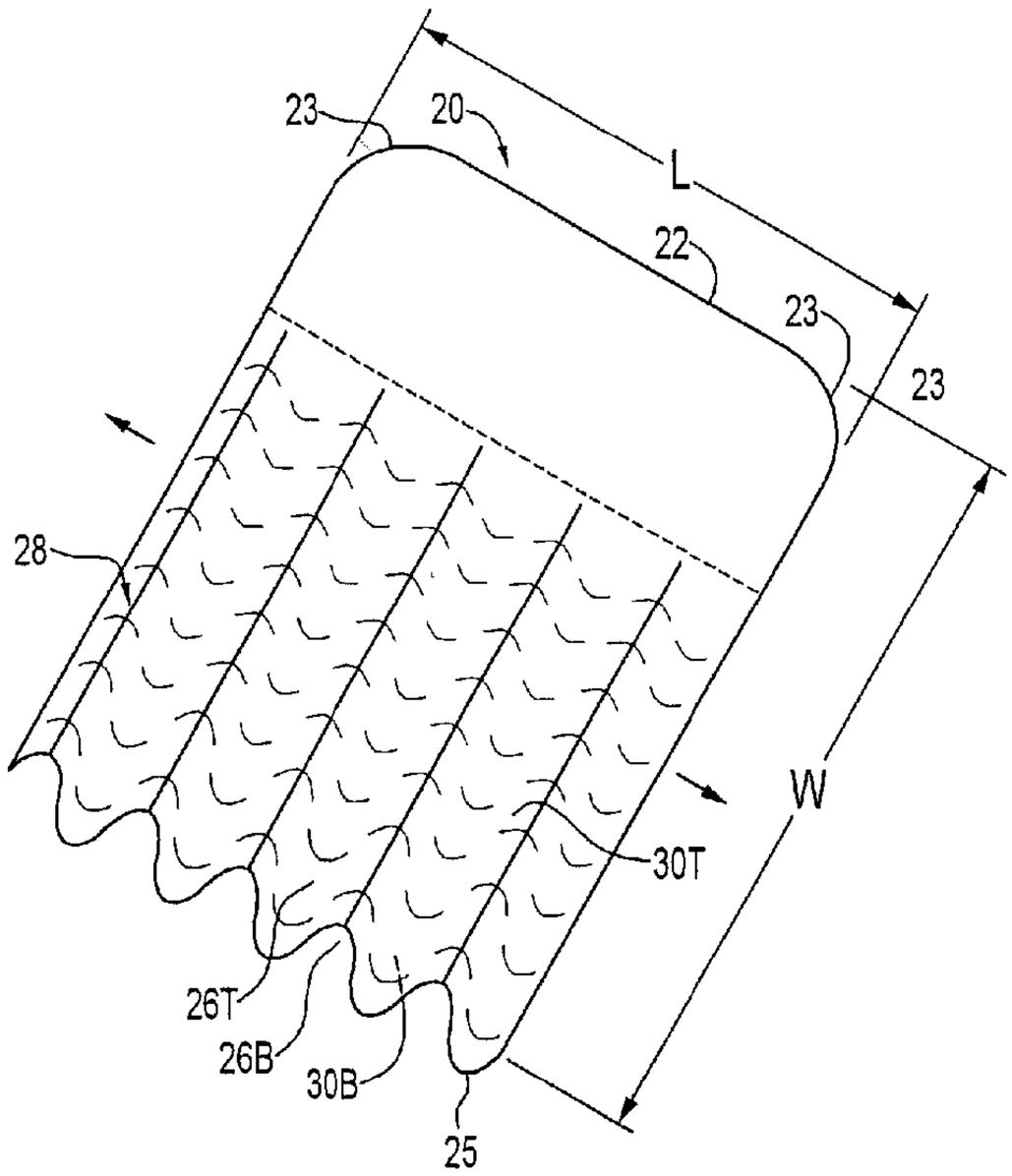
(54) Titre : LES DE REPARATION DE TOIT ET METHODE DE REMISE A NEUF DES TOITS EN BOIS
(54) Title: ROOF REPAIR STRIPS AND METHOD FOR REFURBISHING WOODEN ROOFS



(57) Abrégé/Abstract:
Repair strips can be inserted between courses of shakes or shingles in a wooden shake or shingle roof. The repair strip has a thin upper edge for insertion into the interface between two courses of shakes or shingles. A lower part of the repair strip is structured to provide air channels on one or both of its top and bottom faces. Gripping members may be provided to hold the repair strips in place.

Abstract of the Disclosure

Repair strips can be inserted between courses of shakes or shingles in a wooden shake or shingle roof. The repair strip has a thin upper edge for insertion into the interface between two courses of shakes or shingles. A lower part of the repair strip is structured to provide air channels on one or both of its top and bottom faces. Gripping members may be provided to hold the repair strips in place.

ROOF REPAIR STRIPS AND METHOD FOR REFURBISHING WOODEN ROOFS

Technical Field

[0001] The invention relates to roofing for buildings and particularly to the field of roofing with wooden shingles or shakes.

Background

[0002] Wooden shingles and shakes are a popular roofing material. Shingles and shake roofs can be very aesthetically pleasing roofs. Such roofs also tend to keep a building cooler than do roofs of asphalt shingles. Over time, exposure to the weather can damage shingles or shakes. For example, shingles or shakes may become cracked. A crack can present a path for water to leak through the roof.

[0003] There are ways to repair roofs in which a few individual shakes or shingles have become cracked. However, these ways require that all of the individual shingles or shakes which need repair can be identified. This is not always easy. Further, the process of removing and repairing a damaged shingle or shake can harm nearby shingles or shakes, especially if the roof is old.

[0004] As an alternative to removing and repairing damaged shingles, it is known to insert a piece of sheet metal between shingles to repair a leaky roof. However, the sheet metal creates a moisture barrier that interferes with natural evaporation of water from the roof, and can act as a point of condensation when the temperature changes.

[0005] It is wise to replace a roof before the roof begins to leak. Over time, leaking can damage the structure of a building. Replacing a roof can be very expensive. Where a building has an attractive shake or shingle roof, the building owner has a choice of replacing the shakes or shingles with new shakes or shingles or switching to another (often less attractive looking) roofing system. One difficulty in making this decision is that some of the wooden shingles and shakes available on the market are made from poorer quality wood which is not as long lasting as high quality shingles and shakes which were more readily available in the past.

[0006] There is a need for roofing systems and methods which provide building owners with additional roofing options.

Summary of the Invention

[0007] This invention provides repair strips which can be inserted between the courses of wooden shingles or shakes. The repair strips may be used to repair an existing roof, thereby avoiding the need to replace the roof. The repair strips may also be built into a new roof to make the new roof longer lasting, even if the shingles or shakes are of inferior quality. Use of the repair strips preserves the attractive appearance of wooden roofs.

[0008] One aspect of the invention provides repair strips for use in repairing or building wooden shake or shingle roofs. The repair strips comprise elongated waterproof bodies having upper and lower edges. The body is thin at the upper edge and tapers to a thickness greater than a

thickness of the upper edge in its parts toward the lower edge. The bodies may be made of sheet metal or plastic, for example.

[0009] Other aspects of the invention include:

- methods for repairing roofs which involve inserting repair strips into the interfaces between successive courses of wooden shakes or shingles; and,
- roofs which comprise a plurality of courses of overlapping wooden shingles or shakes; and a plurality of repair strips located in successive interfaces between a number of successive ones of the courses. Each of the repair strips overlaps with another one of the repair strips in an adjacent one of the interfaces.

[0010] Further aspects of the invention and features of specific embodiments of the invention are described below.

Brief Description of the Drawings

[0011] In drawings which illustrate non-limiting embodiments of the invention,

Figure 1 is a section through a prior art shingle roof;

Figure 2 is an isometric view of a roof repair strip according to one embodiment of the invention;

Figure 2A is a side elevation of the roof repair strip of Figure 2;

Figures 2B through 2D illustrate various alternative configurations for corrugations;

Figure 3 is a section through a shingle roof structure like that of Figure 1 equipped with repair strips as shown in Figure 2;

Figure 3A is a cross section in the plane 3A-3A through the structure of Figure 3;

Figures 4A through 4F show a number of alternative structures which provide air channels;

Figures 5A through 5C show a number of alternative structures for a gripping means;

Figure 6 is a partial isometric view of a repair strip having end portions that can be interlocked with end sections of horizontally adjacent repair strips;

Figure 6A is a cross section through a pair of horizontally adjacent repair strips as shown in Figure 5 with their end portions interlocked; and,

Figure 7 is a cross section through a pair of horizontally adjacent repair strips according to an alternative embodiment of the invention having end portions configured to prevent water leaking between the repair strips; and,

Figure 8 is a cross section through a roof in which repair strips **20** have been nailed into place during construction of the roof.

Description

[0012] Throughout the following description, specific details are set forth in order to provide a more thorough understanding of the invention. However, the invention may be practiced without these particulars. In other instances, well known elements have not been shown or described in detail to avoid unnecessarily obscuring the invention. Accordingly, the specification and drawings are to be regarded in an illustrative, rather than a restrictive, sense.

[0013] Figure 1 shows a prior art shingle roof construction of one type in association with which the repair strips of the invention may be used. Roof **10** is built on a base of transversely-oriented strapping **12** which are attached to rafters **14**. Shingles **16** are nailed through into strapping **12** with nails **17**. Shingles **16** are applied in horizontally extending rows or "courses" **18**. Each shingle **16** covers the nails **17** of the course below. A layer of roofing paper **19** is typically provided between shakes **16** and strapping **12**. Roofing paper **19** is typically also provided under each course **18**. Roofing paper **19** acts as a gasket to prevent fine particles (such as snow) from entering into the attic space under roof **10**, but roofing paper **19** alone will not prevent water from getting through roof **10**. If one of shingles **16** becomes cracked, there is a possibility that water will leak through roof **10**.

[0014] Figures 2 and 2A show a roof repair strip **20** according to an embodiment of the invention. Repair strips **20** can be inserted between courses **18** of shakes or shingles in a roof made of wooden shakes or shingles to improve the roof. Figures 3 and 3A show the repair strips **20** of Figure 2 in place between courses of shakes in a portion of a shingle roof like that shown in Figure 1.

[0015] Repair strip **20** has a width *W*. The desired width *W*, depends upon the length of the shingles or shakes in the roof to be repaired. As shown in Figure 3, repair strips **20** are wide enough that they overlap by a small distance ***O*** when they are in place between vertically adjacent courses of shakes or shingles. Preferably, repair strips **20** project

past the lower edges of the shakes or shingles in the course above them by a small distance ***P***. The exact size of distances ***O*** and ***P*** is not critical. ***O*** is typically in the range of 1 inch to 3 inches. ***P*** is typically in the range of 0 to 4 inches.

[0016] For example, a repair strip **20** for use in repairing a roof made with 18 inch long shakes would typically have a width ***W*** of approximately 10 inches. A repair strip **20** for use in repairing a roof made with 24 inch long shingles would typically have a width ***W*** of approximately 13 inches.

[0017] Repair strips **20** can be inserted between courses **18** of an existing roof **10** by sliding them into the interfaces between shingles **16** from below. Each repair strip **20** is inserted until its upper edge **22** is nearly at nails **17** of the course **18** above the repair strip **20**.

[0018] Repair strips **20** may be supplied in any convenient length ***L***. ***L*** is typically several times wider than individual shingles **16**. For example, repair strips **20** may have lengths ***L*** of 3 feet, 4 feet or 5 feet or some other convenient lengths in the range of 2 to 6 feet. It is not necessary that all repair strips **20** have the same length. In some alternative embodiments of the invention, repair strips **20** are supplied in long lengths (for example in a roll) and can be cut on site to any desired lengths.

[0019] Repair strips **20** are made of a material which is impermeable to water, non rusting and stiff enough to permit repair strips

20 to be slid between courses of shingles or shakes as described above. The material may be, for example, sheet aluminum, coated sheet steel, a high-quality plastic resistant to ultraviolet light, or the like. Repair strips **20** preferably have a number of additional features. The repair strip **20** of Figure 2 demonstrates a number of these features. These features may be present in any combination. Different embodiments of the invention have other combinations of these features.

[0020] Repair strip **20** is tapered in cross section. Upper edge **22** is thin so that it can be easily introduced into an interface between courses **18**. Upper edge **22** preferably has rounded corners **23** to aid in insertion into interface by reducing the chance that strip **20** will catch on shingles **16**. Upper edge **22** may also have a rounded cross section, as shown in Figure 2A.

[0021] A lower portion **24** of repair strip **20** is thicker than upper edge **22**. In example embodiments of the invention, the thickness **T1** adjacent upper edge **22** is in the range of about 0.02 to 0.1 inches while the thickness **T2** of lower portion **24** adjacent lower edge **25** is in the range of about 0.1 inches to about 0.5 inches.

[0022] Lower portion **24** is contoured to define air channels **26** on at least one of, and preferably on both of, its top surface **30T** and its bottom surface **30B**. In the embodiment of Figure 2, topside air channels **26T** and bottomside air channels **26B** are defined by corrugations **28** in lower portion **24**. Corrugations **28** may be formed by stamping, for example. Corrugations **28** may be tapered in the transverse direction (i.e.

the direction from lower edge **25** toward upper edge **22)** so that forming corrugations **28** also provides the feature that repair strips **20** are tapered, as described above. Corrugations **28** are beneficial in that they make repair strip **20** stiffer in relation to bends about axes that cross the corrugations. A non-corrugated region extends along upper edge **22**.

[0023] The precise shapes of corrugations **28** are not important. Corrugations **28** may be rounded, as shown in Figures 2 and 3A or in any of a variety of other configurations. Figures 2B through 2D, show various possible configurations for corrugations **28**. Where repair strips **20** are formed from a ductile material, such as aluminum, repair strips **20** may be made, for example, by stamping.

[0024] As shown in Figure 3A, channels **26T** permit air to flow between repair strip **20** and the shingles **16** of an upper course **18A**. Channels **26B** permit air to flow between repair strip **20** and the shingles **16** of a lower course **18B**. The air permits shingles **16** to dry out if they become damp. This extends the life of shingles **16**.

[0025] Channels **26T** and **26B** (collectively, channels **26**) are preferably wide enough that water does not tend to be retained in the channels by capillary action. In an example embodiment of the invention, channels **26** are at least 3/16 inches wide. Channels **26** are preferably on the order of 1/4 inch across to 3/4 inch across. In the illustrated embodiment, topside channels **26T** extend to lower edge **25**. Topside channels **26T** could be modified or removed in the portion of repair strip

20 which is exposed without significantly affecting the function of repair strip **20**.

[0026] Figures 4A through 4F show portions of some alternative repair strips **20** (identified individually as **20A** to **20E**) having different constructions of lower portion **24** to provide air channels **26**. It is to be understood that repair strips **20A** through **20E** are tapered in cross section such that the area adjacent lower edge **25** is thicker than the area adjacent upper edge **22**, as discussed above.

[0027] In Figure 4A, repair strip **20A** has topside channels **26T** defined between transversely-extending ridges **40** on top surface **30T**. Ridges **20** taper in height above top surface **30T** in the transverse direction. Bottomside channels **26B** could optionally be formed (indicated in dashed outline in Figure 4A) by providing similar ridges **40A** on bottom surface **30B**. Repair strip **20A** may be injection molded in plastic, for example.

[0028] Figure 4B shows a repair strip **20B** wherein an array of sawtooth-like projections **42** provide air channels **26**. Projections **42** may project from either or both of top surface **30T** and bottom surface **30B**. In the illustrated embodiment, projections **42** have a sharp corner **43**. Corners **43** are defined at the intersection of a gently sloping upward edge **44U** and a more steeply sloping lower edge **44L**. In the illustrated embodiment, projections **42** are generally triangular. When repair strips **20B** are installed between courses **18**, corners **43** act as gripping means by digging into the adjacent shingle **16** to resist pulling out of repair strip

20B. The height of projections **42** above top surface **30T** may be less for those of projections **42** which are closer to top edge **22** than it is for those projections **42** which are closer to lower edge **25**. Projections **42** may be oriented to direct water flowing down strip **20B** toward the middle of strip **20B**, for example by positioning projections **42** near the edges of strip **20B** at an angle such that water is directed away from the edges of strip **20B**, as shown in Figure 4F, which is a top view of strip **20B**. The embodiments of Figures 2 and 4B may be combined to form another embodiment, wherein sawtooth-like projections **42** of Figure 4B project from corrugations **28** of Figure 2.

[0029] Figure 4C shows a repair strip **20C** wherein an array of rounded projections **46** provide air channels **26**. Projections **46** may be formed on either one or both of top surface **30T** and bottom surface **30B**. The height of projections **46** above top surface **30T** may be less for those of projections **46** which are closer to top edge **22** than it is for those projections **46** which are closer to lower edge **25**.

[0030] Figure 4D shows a repair strip **20D** wherein air channels **26** are provided by a coarse mesh **48** affixed to a surface **30** of strip **20D**. A lower edge **49L** of mesh **48** is folded over so that mesh **48** is thicker in its parts near lower edge **25** than in its parts toward upper edge **22**.

[0031] Figure 4E shows a repair strip **20E** wherein air channels **26** are provided by a separate piece **50** having projections **52** that is affixed to a sheet **54** of waterproof material.

[0032] Repair strips **20** may be colored, especially in their lowermost projecting portions **60** (Figure 3) to match the color of the shingles or shakes **16**.

[0033] Repair strips **20** may be held in place between courses **18** by friction in roofs where courses **18** are close enough together. Repair strips **20** may also include gripping means for preventing repair strips **20** from slipping downward out from between courses **18** after they have been installed. The gripping means may take any of a variety of forms. The gripping means may comprise an adhesive material applied near upper edge **22**. The adhesive material may be a material that bonds to wooden shingles **16** with moisture. The adhesive material may be covered by a protective strip which is removed immediately prior to installation of strip **20**. Figure 4B illustrates a configuration wherein corners **43** constitute gripping means. Figures 5A through 5C show repair strips **20** having various gripping means.

[0034] As shown in Figure 5A, a gripping means may comprise a tab **64** located close to upper edge **22**. Tab **64** is bent to toward lower edge **25** and forms an acute angle with top surface **30T**. Tab **64** has a corner **65** that digs into the face of a shingle to hold a repair strip **20** in place.

[0035] Figure 5B shows a gripping means comprising an alternative tab **66** that is formed by making a V-shaped cut in the material of repair strip **20** near upper edge **22**. Tab **66** functions in the same manner as tab

64. A repair strip **20** may have tabs **64** and/or **66** projecting on the side of either or both of top surface **30T** and bottom surface **30B**.

[0036] Figure 5C shows a cross section of a gripping means comprising protrusions **68** extending upwardly and downwardly in alternating fashion. Protrusions **68** have spikes **69** extending outwardly therefrom.

[0037] Repair strips **20** provide a building owner with the option of repairing, instead of replacing, a wood shake or shingle roof that is becoming unreliable. It is not necessary to repair an entire roof. The owner has the option of repairing only a small area of the roof. Further, the roof does not need to be removed to make the repairs. The repairs can even be accomplished when it is raining (subject to the need to always work safely on roofs and to take suitable precautions to avoid slipping and falling while working on a roof). Further, repairs can be done incrementally. One could start by repairing the areas of a roof which have become the most badly deteriorated and then repair other areas of the roof as time or budget permit.

[0038] A roof repair can be accomplished simply by inserting repair strips **20** between adjacent courses of shingles or shakes in the area to be repaired. The gripping means hold the repair strips in place once they have been inserted. Repair strips **20** are easy to insert because they have a thin upper edge **22** and they are quite stiff. Once installed, repair strips **20** overlap with one another (see Figure 2) and provide a barrier against the entry of water through the roof. Even if a shake in the course **18**

above a repair strip becomes cracked or penetrated by a hole, water leaking through the shake falls onto the repair strip **20** and is carried downward to lower edge **25**. Since repair strips **20** overlap with one another in the vertical direction, the shingles or shakes need not be relied upon to be waterproof at all in a repaired section of a roof. The appearance of the roof is not substantially changed by the insertion of repair strips **20**. Only a narrow projecting portion of each repair strip **20** is exposed to view. This portion may be color matched to the existing shingles or shakes so that it is not overly noticeable.

[0039] The ends of horizontally adjacent repair strips **20** between the same courses may also overlap with one another so that water cannot leak through a roof between the repair strips. As shown in Figure **3A** this may be accomplished by overlapping one or two corrugations on an end of a repair strip **20** with corrugations on the end of a neighboring repair strip **20**.

[0040] Figures 6 and 6A illustrate an alternative repair strip **20F** which has optional interlocking end parts **70** and **72**. End part **70** is folded over to form a U-shaped channel **73** facing top surface **30T**. End part **72** is folded over to form a U-shaped channel **75** facing lower surface **30B**. As shown in Figure 6A, two adjacent repair strips **20** may be installed with the folded over part of end part **72** in channel **73** and the folded over part of end part **70** in channel **75**. The end parts are thereby joined in a loose lap seam. This seam is not required for structural strength. It merely stops water from flowing between the two repair strips **20F**.

[0041] Figure 7 shows an alternative arrangement for preventing the flow of water between two repair strips **20G**. Each repair strip **20G** has an upturned end portion **80** and a down turned end portion **82**. Repair strips **20G** are installed with down turned end portion **82** overlapping upturned end portion **80**.

[0042] It is not mandatory that repair strips **20** be used only for repairing roofs. Repair strips **20** may be integrated in a new wood shingle or wood shake roof. Where repair strips **20** are used in a newly constructed roof they may be inserted as described above or, in the alternative, they may be nailed into place in the roof using nails **88**, as shown in Figure 8. Repair strips **20** may include indicia on their top surfaces **30T** indicating desirable locations for inserting nails **88** to affix repair strips **20** to a roof.

[0043] Using repair strips **20** in the construction of a new roof can extend the lifespan of the roof even if a lower grade of wooden shakes or shingles is used to make the roof. The roof has the attractive appearance of a wooden shake or shingle roof but the repair strips provide insurance against leaks. Further, most of any rain or hail falling on the roof hits the exposed shakes or shingles. Thus the sound made by falling rain or hail is muted.

[0044] Moss will sometimes grow on wooden shakes and shingles. Moss holds moisture and can degrade a wooden roof. Exposed lower portions of repair strips **20** may optionally be coated with zinc or another

moss-retardant to prevent moss from growing on the repaired section of a roof.

[0045] Where a component (e.g. a structure, member, part etc.) is referred to above, unless otherwise indicated, reference to that component (including a reference to a "means") should be interpreted as including as equivalents of that component any component which performs the function of the described component (i.e., that is functionally equivalent), including components which are not structurally equivalent to the disclosed structure which performs the function in the illustrated exemplary embodiments of the invention.

[0046] 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. For example:

- In some embodiments of the invention, repair strips **20** may project significantly farther to the weather than is illustrated in the accompanying drawings. Repair strips **20** could even completely cover wooden shakes or shingles **16**. If repair strips **20** are wide enough, they may be nailed down even when they are not being applied as part of a new roof. In this case, the nails should be inserted at locations where they will be covered by overlying repair strips **20**. The nails may be inserted through an overlying shake or shingle to pass through the repair strip **20**.

Accordingly, the scope of the invention is to be construed in accordance with the substance defined by the following claims.

WHAT IS CLAIMED IS:

1. A repair strip for use in repairing or building a wooden shake or shingle roof, the repair strip comprising an elongated waterproof body having upper and lower edges, the body being thin at the upper edge and tapering to a thickness greater than a thickness of the upper edge in its parts toward the lower edge wherein the repair strip is configured to permit insertion of the repair strip, upper edge first, between existing courses of wooden shakes or shingles on a roof.

2. A repair strip according to claim 1 wherein a region extending along the body adjacent to the lower edge is corrugated.

3. A repair strip according to claim 2 wherein the region is corrugated with corrugations which are tapered in height, the corrugations being larger in their parts closest to the lower edge and smaller in their parts closest to the upper edge.

4. A repair strip according to claim 2 or 3 comprising a non-corrugated region extending along the upper edge.

5. A repair strip according to claim 1 wherein at least one of a top surface and a bottom surface of the repair strip is contoured to define a plurality of air channels in a region of the surface extending along the repair strip adjacent to the lower edge.

6. A repair strip according to claim 5 wherein the top surface and the bottom surface of the repair strip are both contoured to define air channels in a region of the surface extending along the repair strip adjacent to the lower edge.

7. A repair strip according to claim 5 comprising a plurality of ridges projecting from the body in the region of the surface, the ridges extending generally transversely on the body wherein the air channels are defined between adjacent ones of the ridges.

8. A repair strip according to claim 7 wherein the ridges are tapered in height, the ridges being taller in their parts closest to the lower edge and shorter in their parts closest to the upper edge.

9. A repair strip according to claim 5 comprising a plurality of projections on the surface in the region, wherein the air channels are defined between the projections.

10. A repair strip according to claim 9 wherein the projections are sawtooth-like and extend generally transversely on the body.

11. A repair strip according to claim 9 wherein the projections are oriented to direct water away from edges of the repair strip.

12. A repair strip according to claim 9 wherein the projections comprise points oriented toward the lower edge of the body to

resist pulling out of the repair strip from between courses of wooden shakes or shingles.

13. A repair strip according to claim 2 comprising a plurality of projections on the surface in the region.

14. A repair strip according to claim 3 comprising a plurality of projections on the corrugations.

15. A repair strip according to any one of claims 1 to 14 comprising gripping means on the body for holding the repair strip in place between courses of wooden shakes or shingles.

16. A repair strip according to claim 15 wherein the gripping means comprises adhesive material applied to a region of the repair strip along the upper edge.

17. A repair strip according to any one of claims 1 to 14 comprising a plurality of tabs projecting from the body and disposed along the upper edge, the tabs having edges oriented toward the lower edge of the body to resist pulling out of the repair strip from between courses of wooden shakes or shingles.

18. A repair strip according to claim 17 wherein the tabs include a first plurality of tabs projecting on a top side of the body and a second plurality of tabs projecting on a bottom side of the body.

19. A repair strip according to claim 17 wherein the tabs are triangular and each project at an acute angle to the body.

20. A repair strip according to any one of claims 1 to 19 comprising a first interlocking end part on a first end of the body and a second interlocking end part on a second end of the body opposed to the first end wherein the first interlocking end part of the repair strip can be interlocked with the second interlocking end part of a horizontally adjacent second repair strip to prevent leakage of water therebetween.

21. A repair strip according to claim 20 wherein the first interlocking end part comprises a U-shaped channel extending along the first end of the repair strip.

22. A repair strip according to claim 1 wherein the body comprises a metal sheet.

23. A method for repairing a roof comprising overlapping courses of wooden shakes or shingles, the method comprising inserting repair strips according to claim 1 in interfaces between the courses of shakes or shingles.

24. A method according to claim 23 wherein the repair strips comprise gripping means for holding the repair strip in place between courses of wooden shakes or shingles and the method comprises

inserting the repair strips until the gripping means engage the wooden shakes or shingles of the roof.

25. A method according to claim 24 comprising overlapping the repair strips inserted in vertically adjacent interfaces of the roof.

26. A method according to claim 25 comprising leaving a portion of each of the repair strips exposed.

27. A method according to claim 26 comprising overlapping horizontally adjacent ones of the repair strips.

28. A wooden shake or shingle roof comprising:

a plurality of courses of overlapping wooden shingles or shakes;

a plurality of repair strips according to claim 1, the repair strips located in successive interfaces between a number of successive ones of the courses, each of the repair strips overlapping with another one of the repair strips in an adjacent one of the interfaces.

29. A roof according to claim 28 wherein each of the repair strips is nailed through an underlying one of the shakes or shingles into a wooden member.

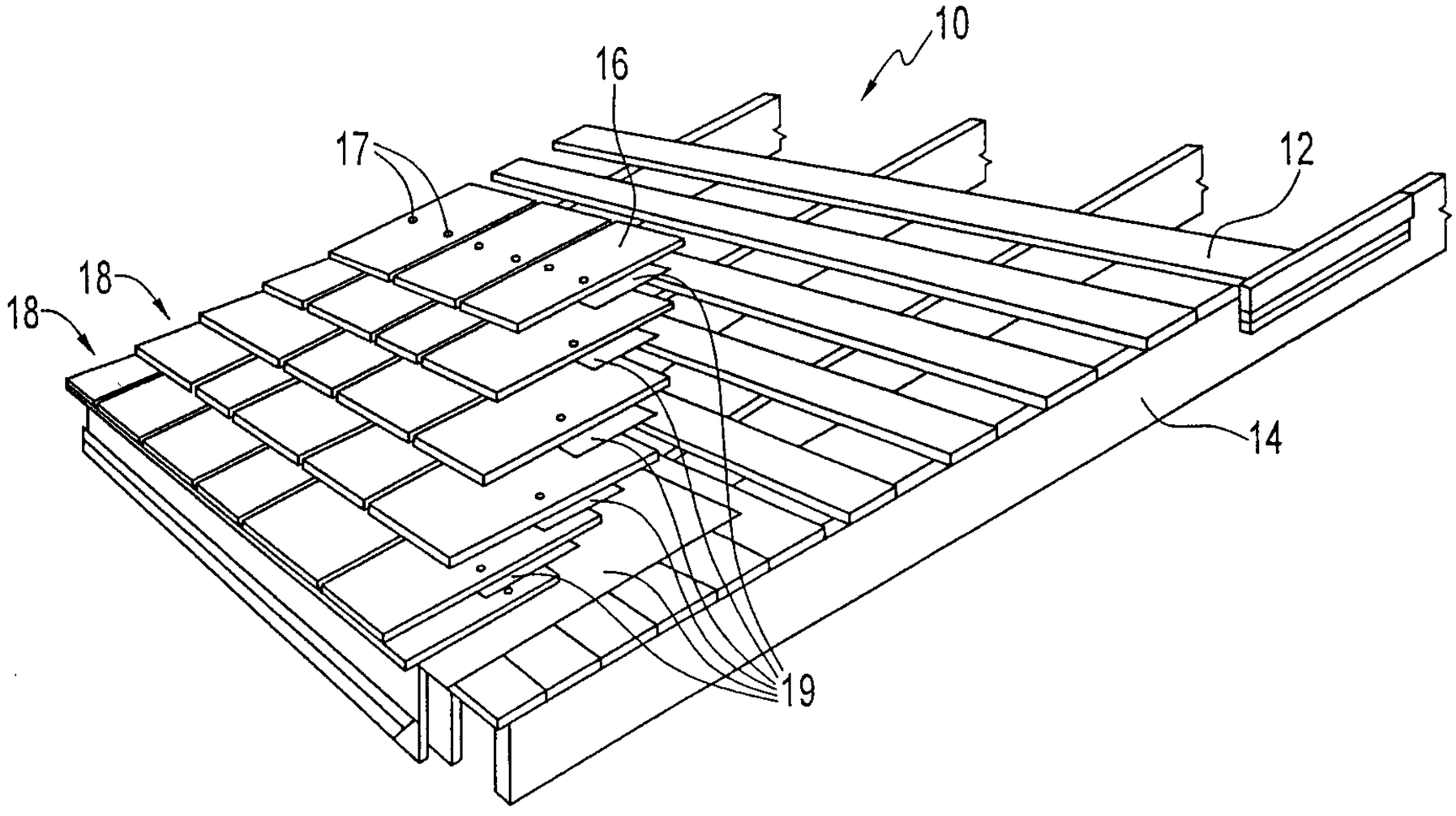


FIG. 1 (PRIOR ART)

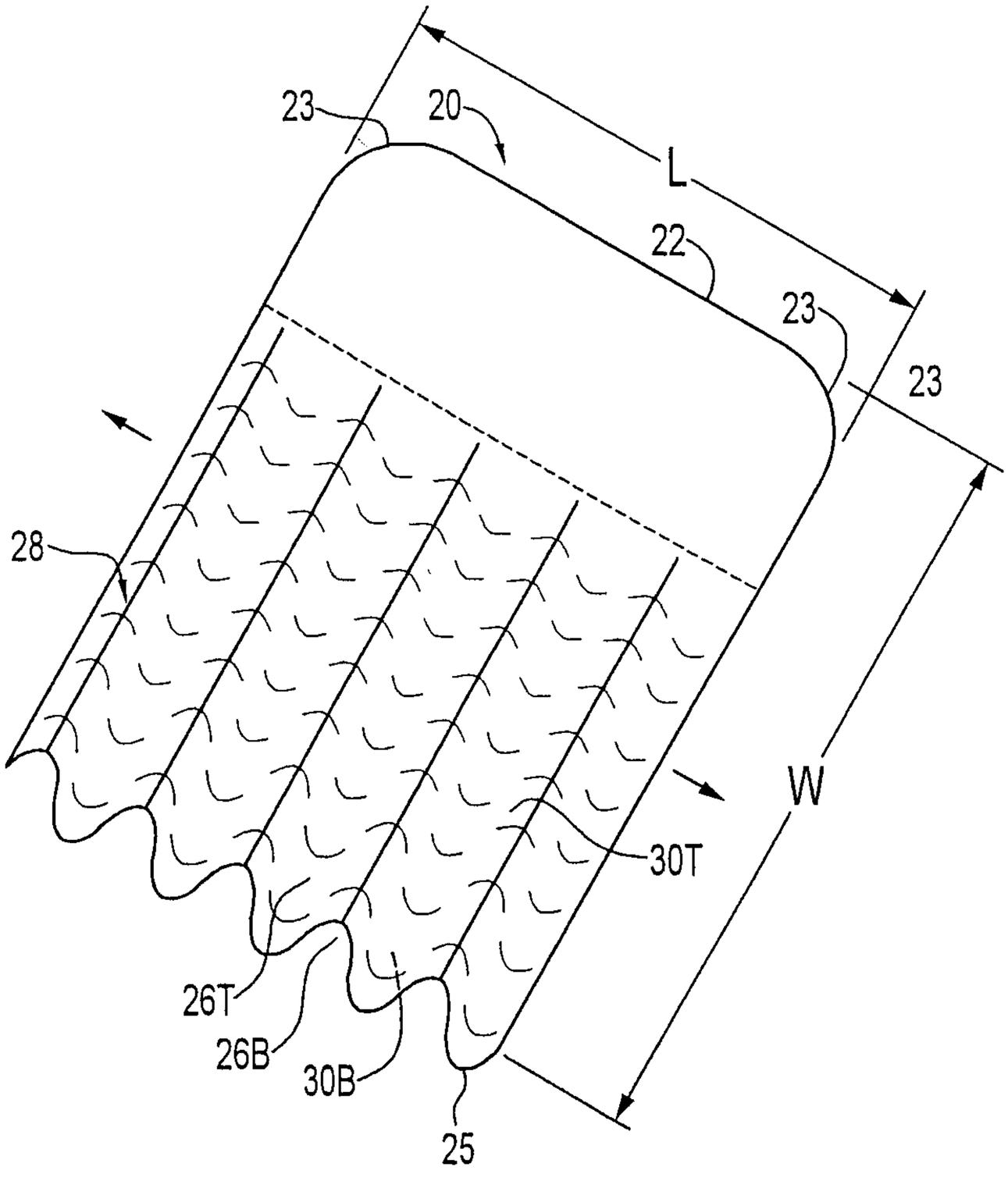


FIG. 2

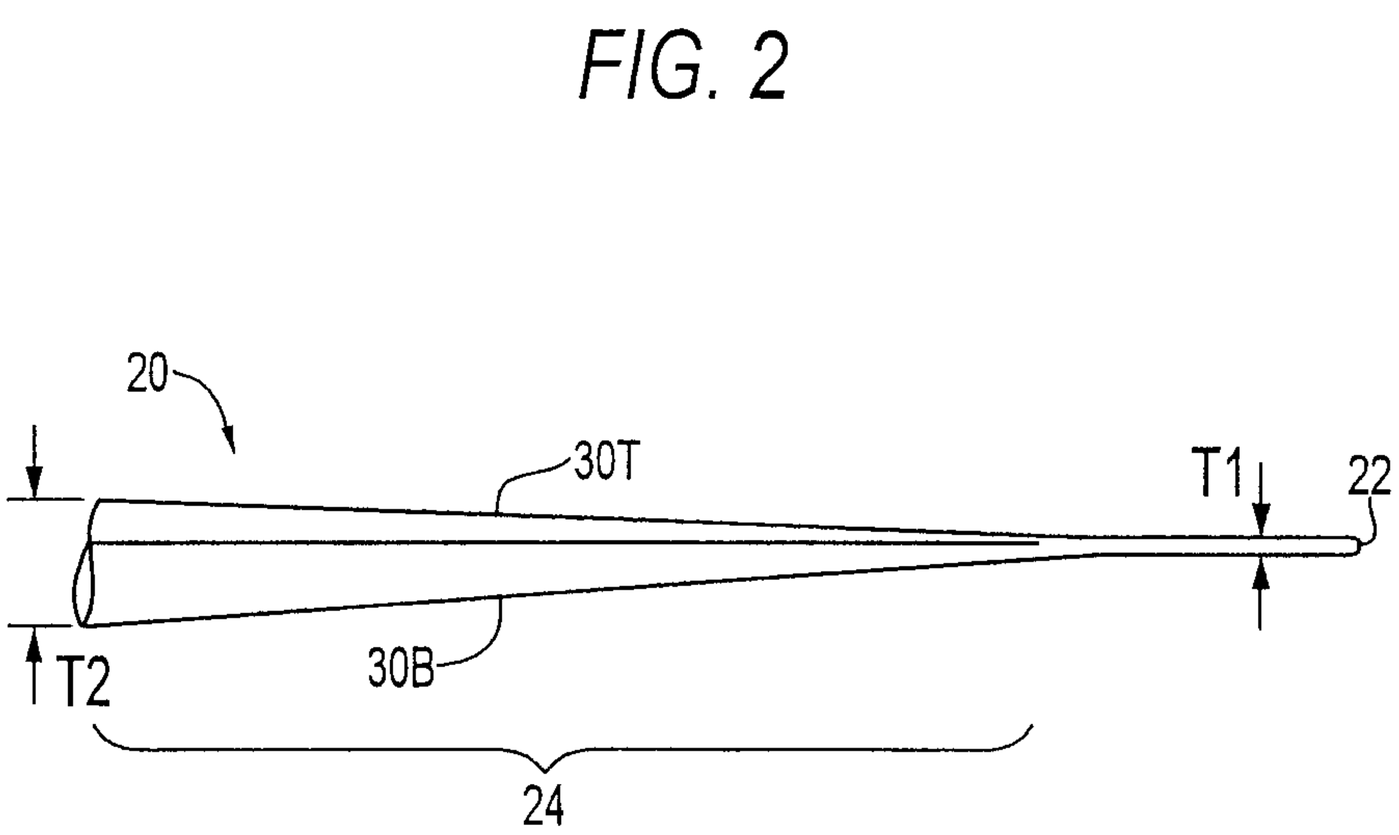


FIG. 2A

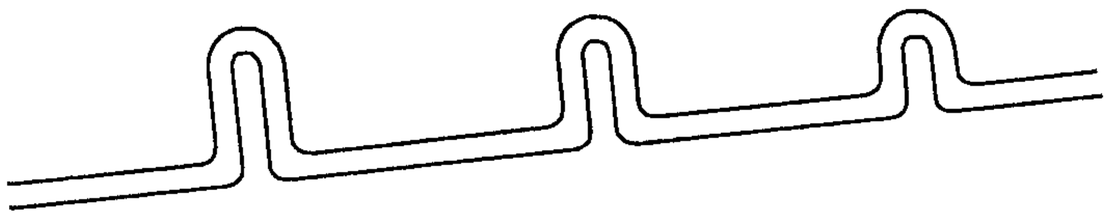


FIG. 2B

FIG. 2C

FIG. 2D

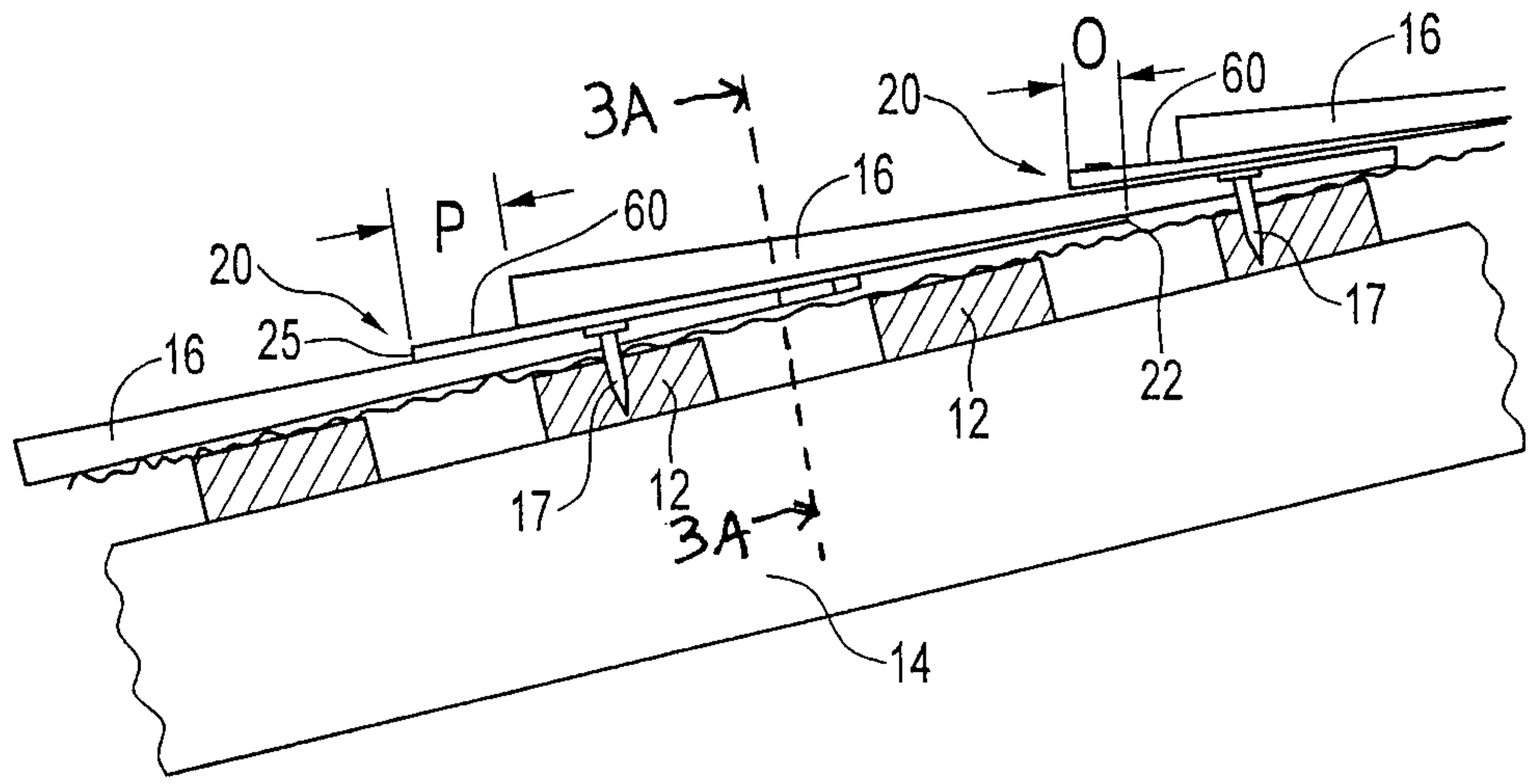

3A
P
60
16
20
O
60
16
20
25
16
17
12
22
12
17
3A
14

FIG. 3

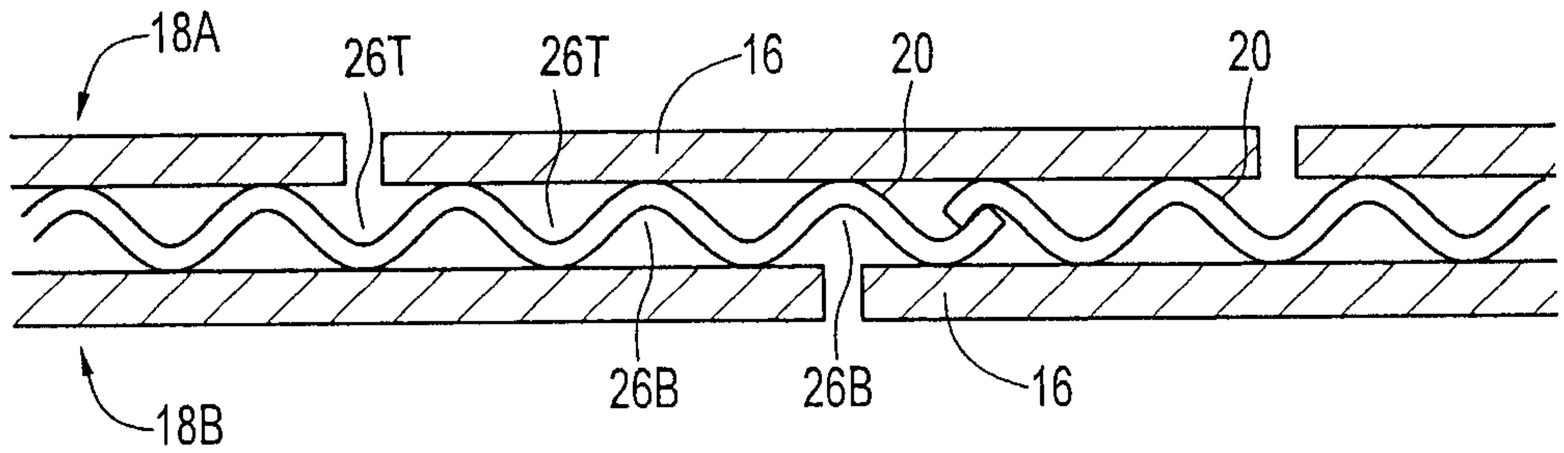

18A
26T
26T
16
20
20
26B
26B
16
18B

FIG. 3A

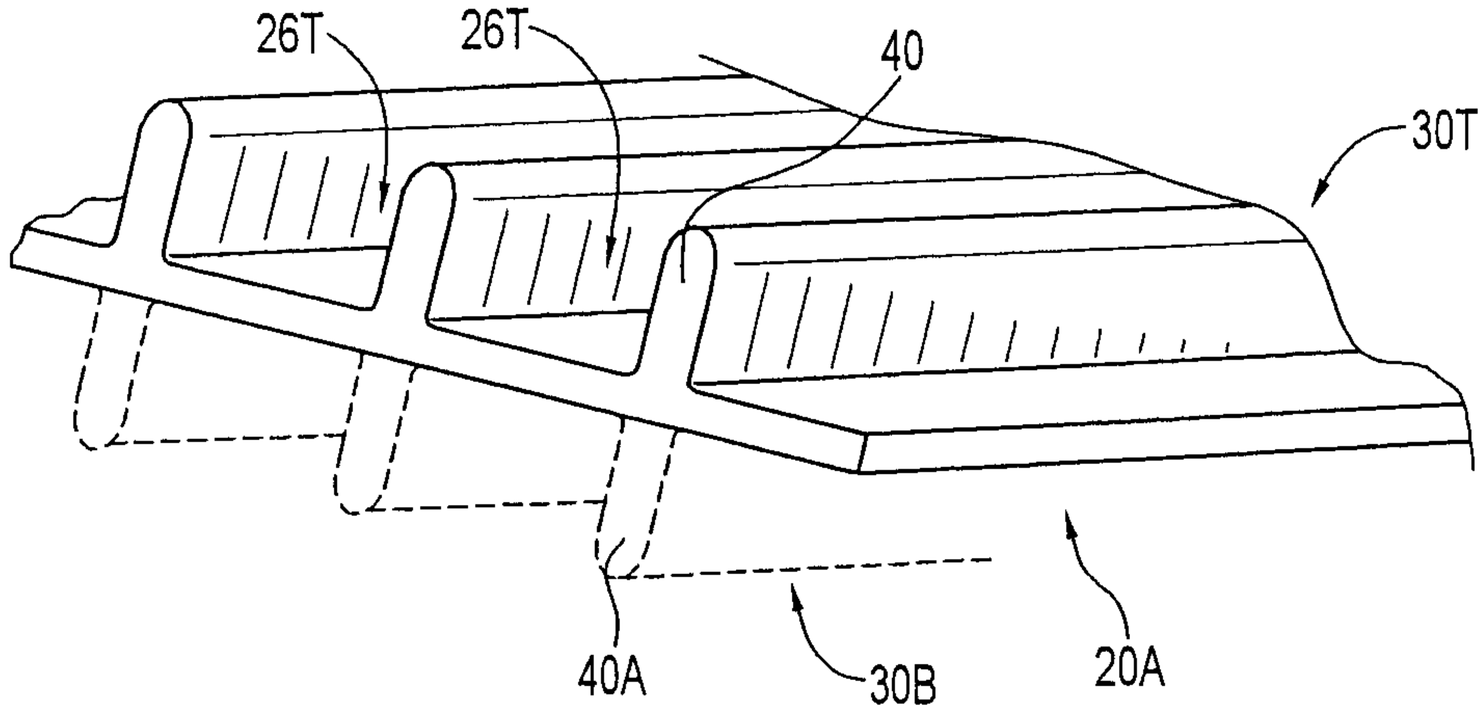


FIG. 4A

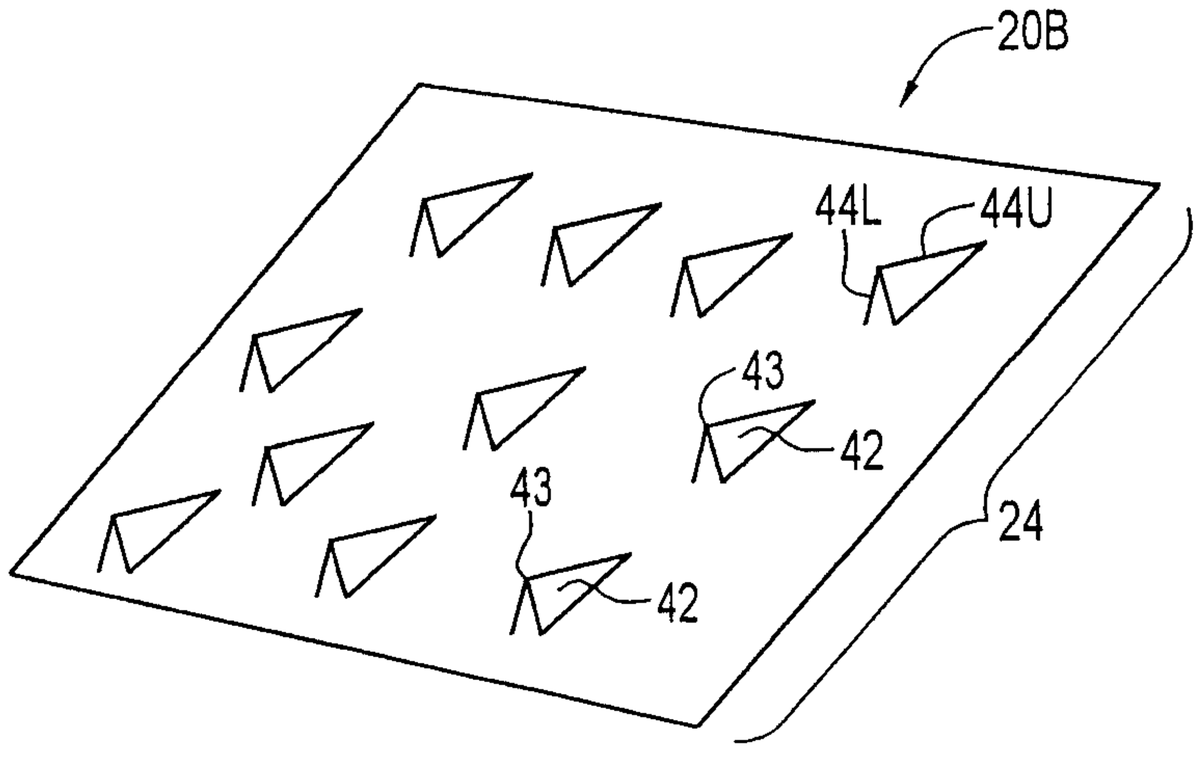


FIG. 4B

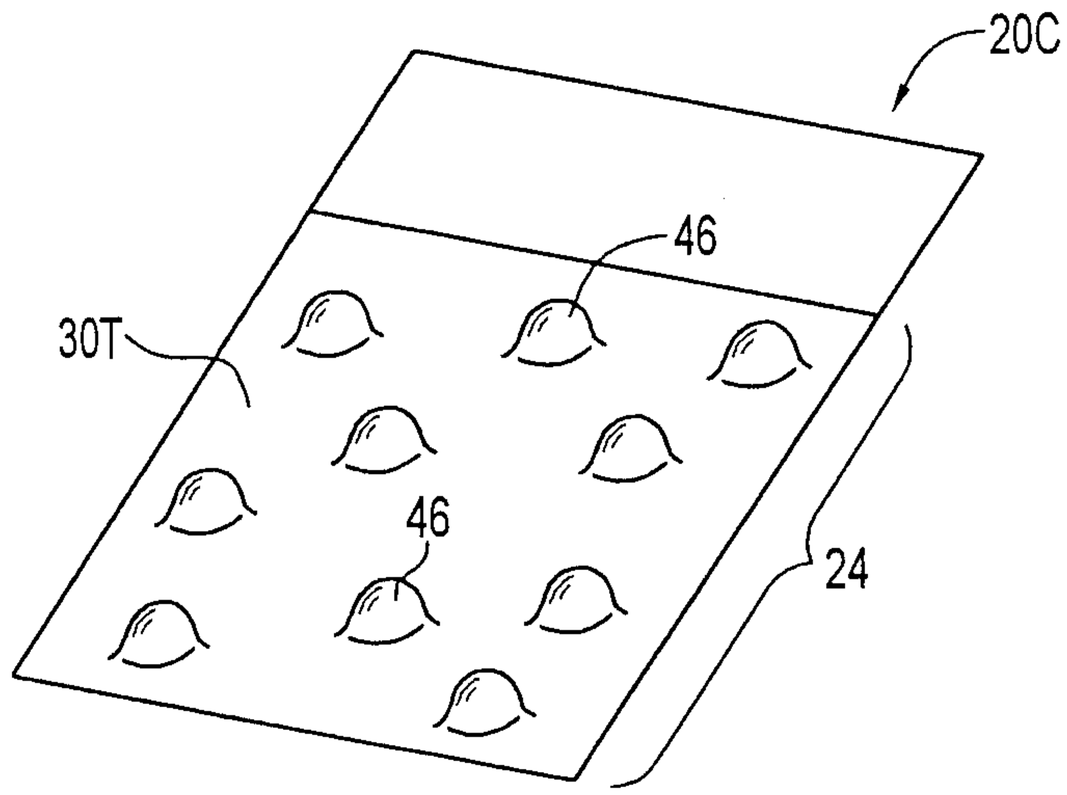


FIG. 4C

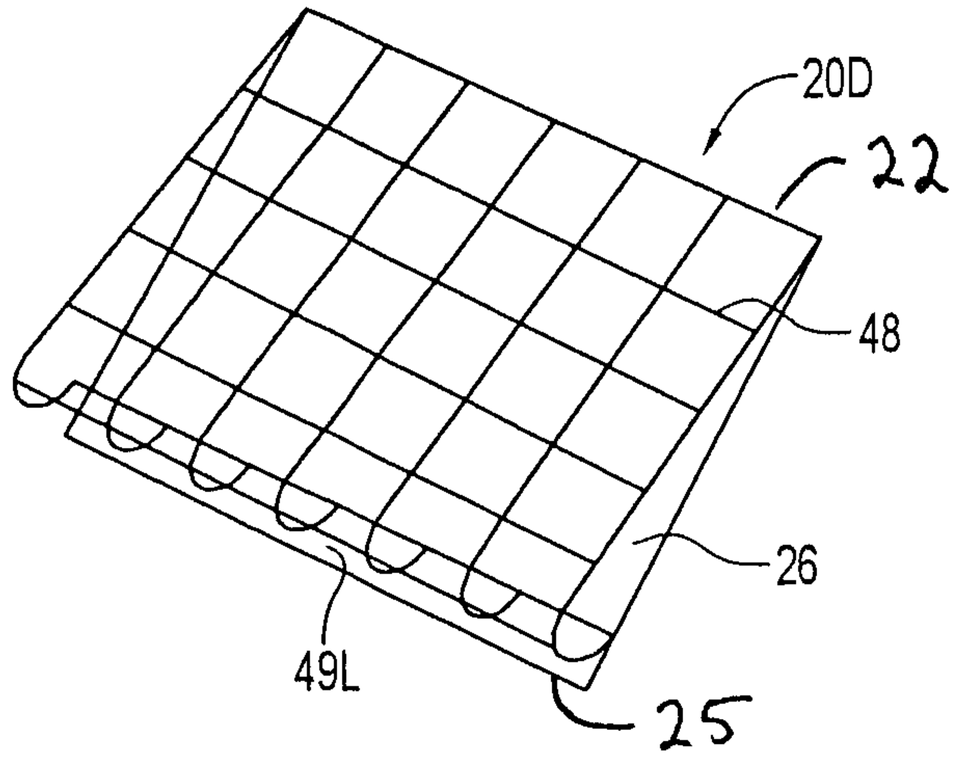


FIG. 4D

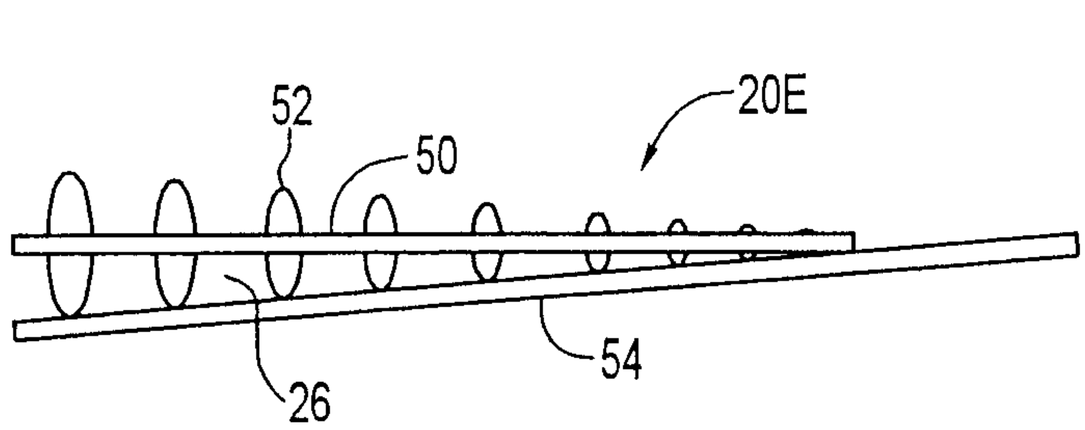


FIG. 4E

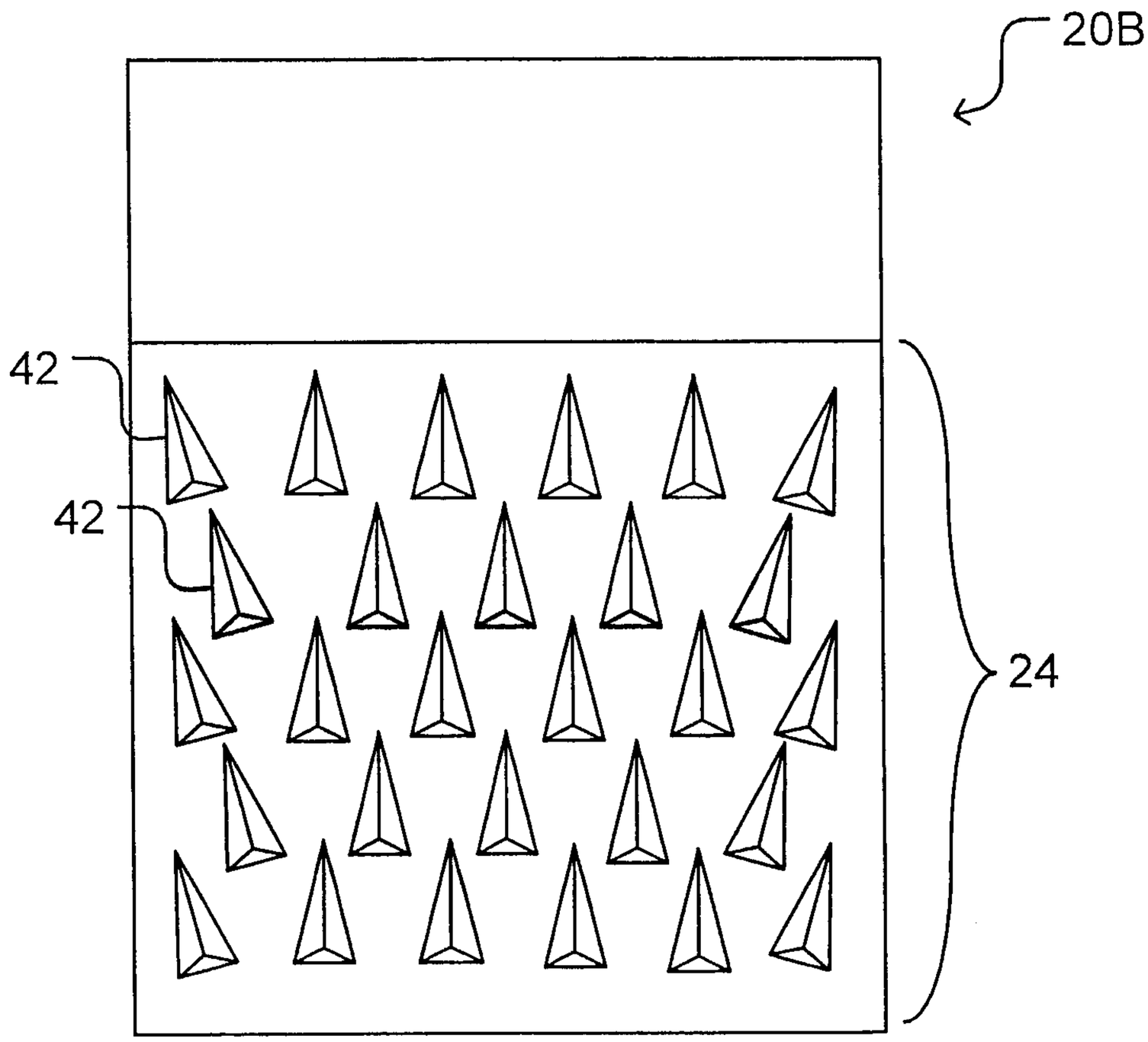


FIG. 4F

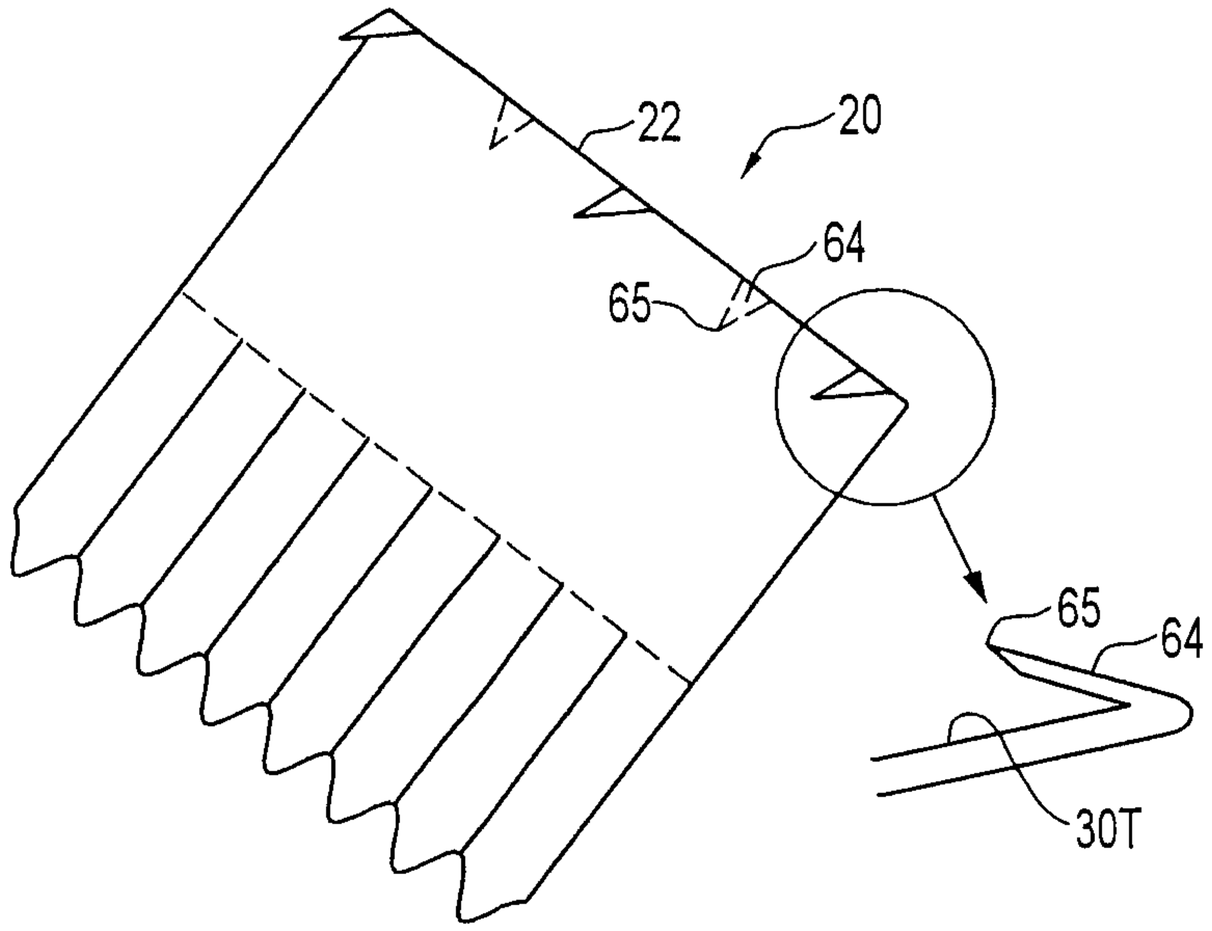


FIG. 5A

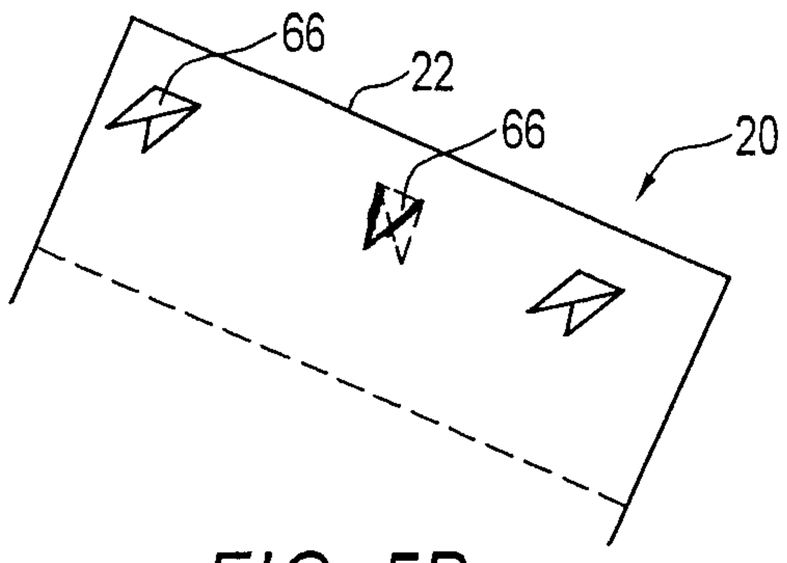


FIG. 5B

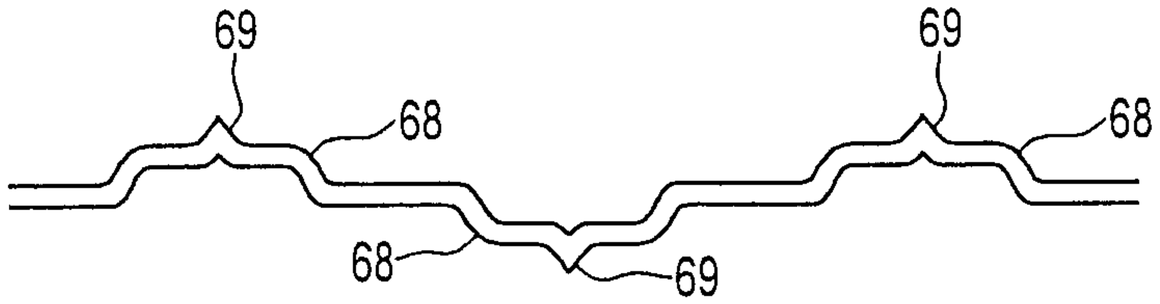


FIG. 5C

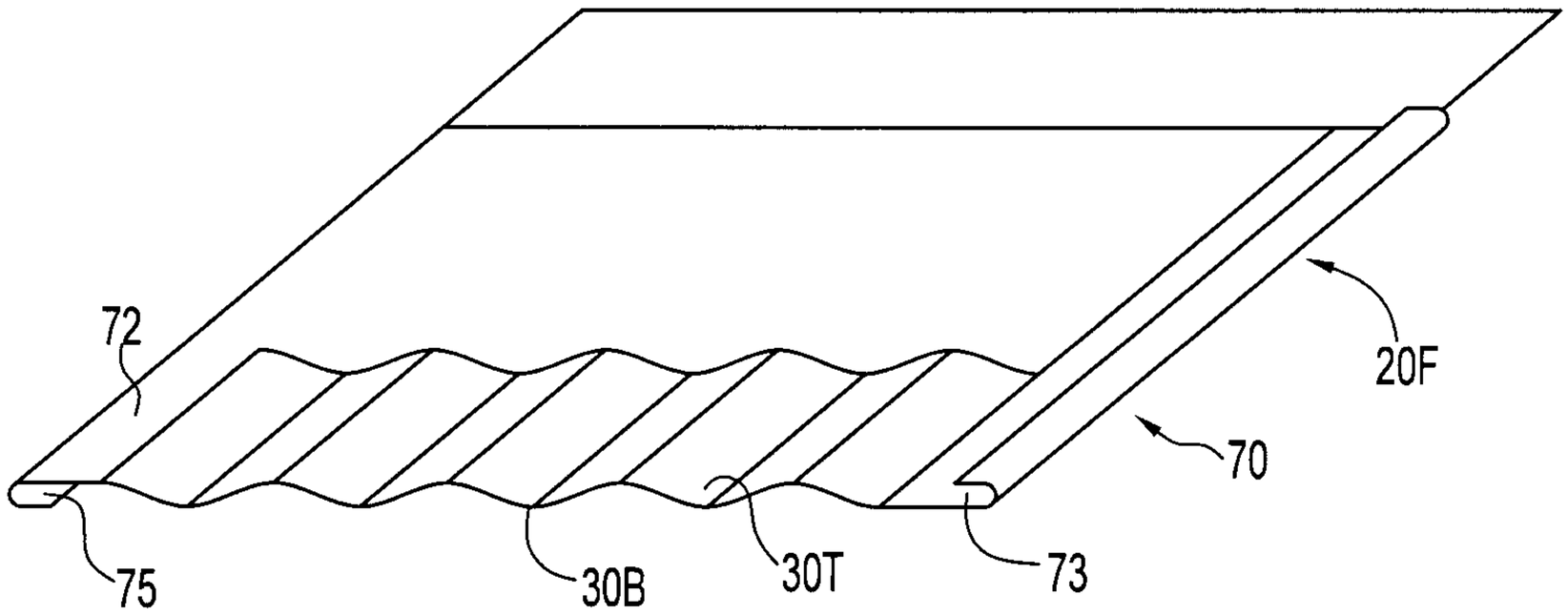


FIG. 6

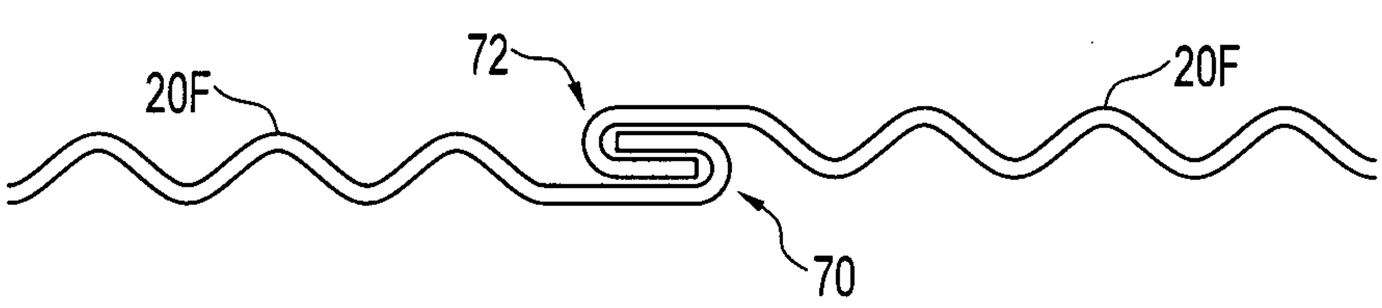


FIG. 6A

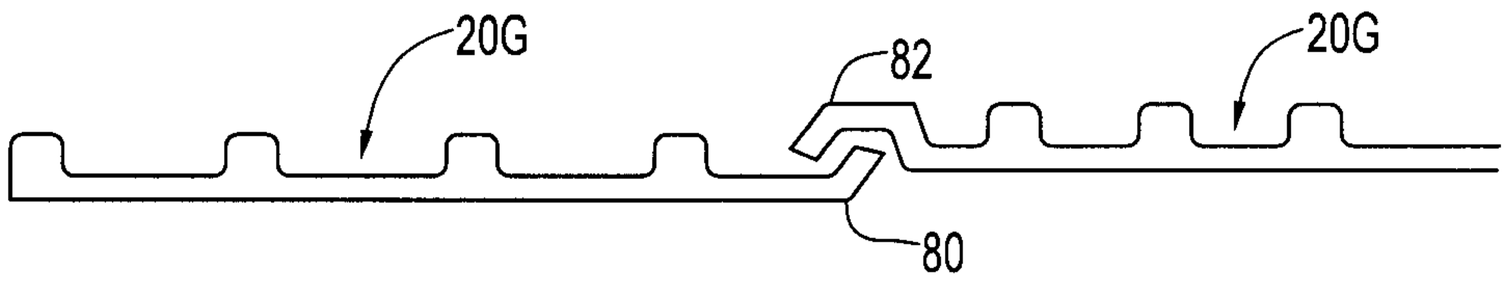


FIG. 7

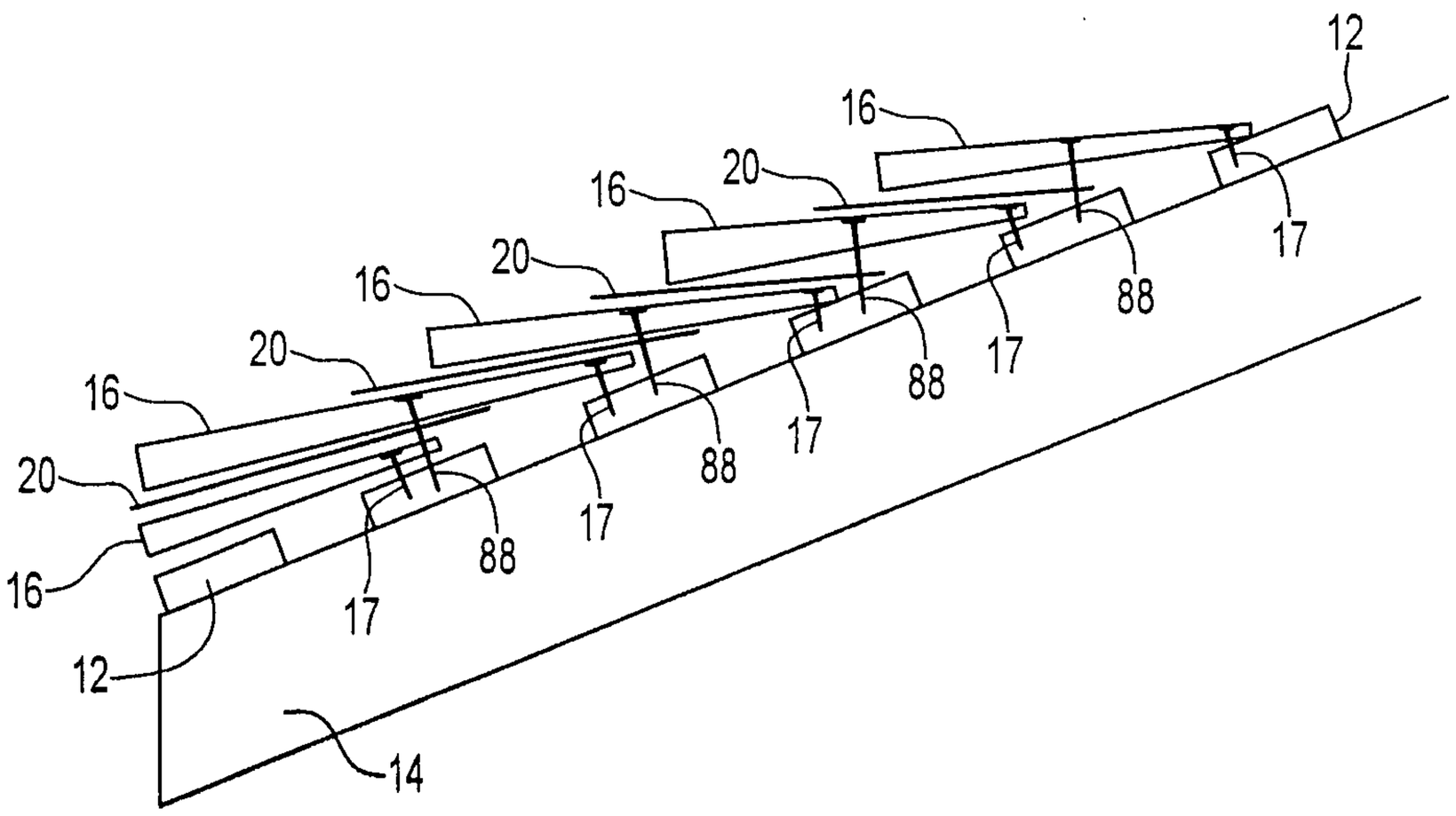
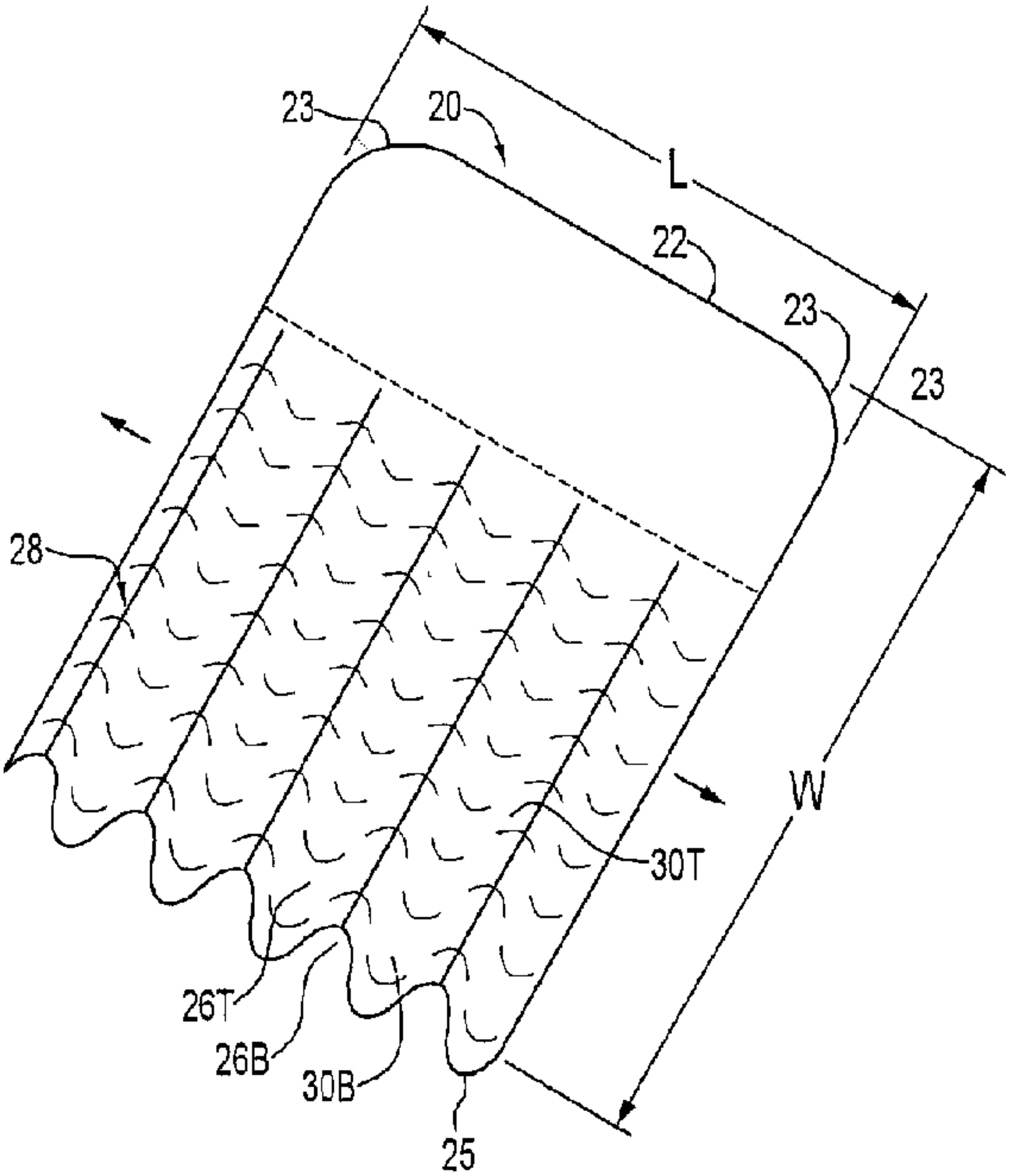


FIG. 8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