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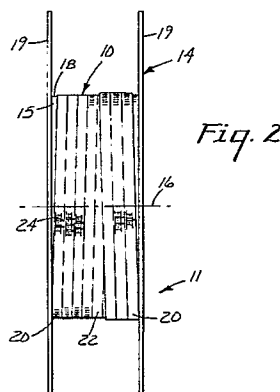
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**W-8000 München 2(DE)**(54) **Level wound reel of component carrier tape.**

(57) A combination of a length of component carrier tape (10) and a reel (14) having a hub (15) about which the component carrier tape (10) is helically level wound in layers with the wraps of carrier tape (10) in each layer being disposed edge to edge so that those wraps are displaced axially from each other by the width of the carrier tape (10), and with the opposite edges of wraps of carrier tape (10) in successive layers being angled in opposite directions with respect to the axis of the hub (15). The peripheral surface (18) of the hub (15) has a minimum diameter "D" determined by the formula:

$$D = \frac{2}{\pi} \sqrt{(7813)^2 - (7813 - W)^2}$$

where "W" is the width of the carrier tape (10) in millimeters so that the component carrier tape (10) should meet an industry camber specification despite cold flow which will occur in transition portions of the carrier tape (10) between the layers.

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Technical Field

The present invention relates to reels of component carrier tape (also called surface mount supplies carrier tape) of the type sent from the manufacturer of the carrier tape to a component manufacturer who  
 5 will unwind the carrier tape from the reel and fill it with components.

Background Art

Surface mount supplies carrier tape or component carrier tape is used to transport components (e.g.,  
 10 electrical components such as resistors, capacitors, or integrated circuits) from a component manufacturer to a different manufacturer that assembles the components into new products, typically by having automated assembly equipment sequentially remove components from the carrier tape and assemble them into to the new products. Such carrier tape is a polymeric strip that has been formed to have wall portions defining a series of identical pockets at predetermined uniformly spaced intervals along its length, which  
 15 pockets are shaped to closely receive identical components the tape is adapted to transport (e.g., which pockets could, for example, have rectangular or generally "I" or "T" shapes in the plane of the strip, and could have flat or rounded bottoms to accommodate the shape of the components), which strip normally also has through openings uniformly spaced along one side to receive a drive sprocket by which the strip can be driven and to provide indexing holes that can be used for accurately locating the pockets along the  
 20 tape with respect to assembly equipment. Typically, the carrier tape is manufactured in a first manufacturing location, wound on a reel and transported to the supplier of the components it is intended to transport. The component supplier unwinds the carrier tape from the reel, fills the pockets along the carrier tape with components, adheres a removable cover strip along the carrier tape over the component filled pockets, winds the component filled carrier tape with the attached cover strip onto a different typically smaller reel,  
 25 and sends it to the user who feeds it from the reel into the assembly equipment which removes the components.

An industry standard dictates that the carrier tape must have less than 1 millimeter non cumulative camber over a length of 250 millimeters. This means that when the carrier tape is unwound from the reel on which it is shipped to the component supplier and disposed on a planar surface, its elongate edges must  
 30 not deviate from being straight by more than 1 millimeter in any 250 millimeter length of the carrier tape. The component tape can easily be made to meet this specification. When the component tape is wound around a reel directly upon itself with the edges of all the wraps in a single plane for shipment to the component supplier (called "planetary winding" in the industry) it will remain generally as straight as it was when it was manufactured. Such planetary wound reels are limited in the amount of component tape they  
 35 can hold, however. Thus more than one year prior to the filing date of this application eight millimeter wide component tape shipped to component suppliers has been supplied level wound edge to edge on reels with 203.2 millimeter (8 inch) outside diameter cores and a width (i.e., 76.2 millimeter or 3 inch) between opposed flanges on the reel that was significantly greater than the width of the carrier tape (i.e., the component carrier tape was helically level wound around the 203.2 millimeter (8 inch) diameter peripheral  
 40 surface of the hub in layers with the wraps of carrier tape in each layer being disposed edge to edge so that those wraps are displaced axially from each other by the width of the carrier tape, and with the the opposite edges of wraps of carrier tape in successive layers being angled in opposite directions with respect to the axis of the hub). It has been found, however, that carrier tape supplied in this manner will not consistently meet the camber specification noted above, (even though the carrier tape as originally  
 45 manufactured met that specification), and thus such level winding has not been commercially successful.

Disclosure of Invention

The present invention provides a planetary wound reel of carrier tape that will consistently meet the  
 50 camber specification noted above, provided though the carrier tape as originally manufactured met that specification.

Applicant has recognized that the inability of eight millimeter wide component tape shipped to component suppliers level wound edge to edge on reels with 203.2 millimeter (8 inch) outside diameter cores to consistently meet the camber specification noted above (even though the carrier tape as originally  
 55 manufactured met that specification) was due to cold flow that occurs after the reel is level wound with the carrier tape in transition portions of the carrier tape adjacent the flanges of the reel in which the carrier tape changes its orientation with respect to the axis of the hub between successive layers of wraps, and has found a solution to that problem.

According to the present invention there is provided a combination of a length of component carrier tape and a reel of the type described above having a hub with a peripheral surface about which the component carrier tape is helically level wound in layers with the wraps of carrier tape in each layer being disposed edge to edge so that those wraps are displaced axially from each other by the width of the carrier tape, and with the the opposite edges of wraps of carrier tape in successive layers being angled in opposite directions with respect to the axis of the hub in which the peripheral surface of the hub has a minimum diameter "D" determined by the formula:

$$D = \frac{2}{\pi} \sqrt{(7813)^2 - (7813-W)^2}$$

where "W" is the width of the carrier tape in millimeters.

Such a hub diameter (e.g., about 226 millimeters (8.9 inches) for 8 millimeter wide component carrier tape) should allow the component carrier tape to normally meet the camber specification noted above despite cold flow which will occur in the transition portions of the carrier tape, as will be explained in greater detail below, and meeting that specification for 8 millimeter wide component carrier tape can be virtually assured through use of even a larger preferred 355.6 millimeter (14 inch) diameter reel hub.

#### Brief Description of Drawing

The present invention will be further described with reference to the accompanying drawing wherein like reference numerals refer to like parts in the several views, and wherein:

- Figure 1 is a perspective view of a combination according to the present invention of component carrier tape level wound on a reel;
- Figure 2 is an enlarged edge view of the component carrier tape level wound on the reel that is shown in Figure 1;
- Figure 3 is an enlarged fragmentary edge view of the component carrier tape level wound on the reel that is shown in Figure 1; and
- Figures 4 and 5 are schematic diagrams illustrating the development of a formula for the minimum diameter of a hub in the the reel of Figures 1, 2 and 3.

#### Detailed Description

Referring now to Figures 1, 2 and 3 of the drawing, there is shown a combination according to the present invention, designated by the reference numeral 11, which combination 11 generally comprises (1) a length of component carrier tape 10 having elongate edges and a uniform width between its edges; and (2) a reel 14 including a hub 15 having an axis 16, opposite axially spaced ends and a cylindrical peripheral surface 18 between its ends, and a pair of flanges 19, one fixed to the hub 15 at each of its ends and projecting radially from the hub 15, the flanges 19 having opposed inner surfaces spaced by a distance (e.g., 76.2 millimeters or greater) significantly greater than the width of carrier tape 10. The component carrier tape 10 is helically level wound around the peripheral surface 18 of the hub 15 in layers with the wraps of carrier tape 10 in each layer being disposed edge to edge so that those wraps are displaced axially from each other by the width of the carrier tape 10, with the the opposite edges of wraps of carrier tape 10 in successive layers being angled in opposite directions with respect to the axis 16 of the hub 15, and with transition portions 20 of the carrier tape 10 located adjacent the flanges 19 of the reel 14 in which transition portions 20 the carrier tape 10 changes its orientation with respect to the axis 16 of the hub 15 between successive layers of wraps. It has been found that cold flow will occur in the transition portions 20 of the carrier tape 10 shortly after the carrier tape 10 is level wound wound on the hub 15 of the reel 14 to cause camber in the carrier tape 10, and the present invention provides a sufficiently large diameter for the peripheral surface 18 of the hub 15 to minimize the amount of camber in the carrier tape 10 caused by such cold flow, as will be explained in greater detail below.

The carrier tape 10 is unitary, can be made to have a variety of uniform widths between its edges (e.g., 8, 12, 16, 24, 32 or 44 millimeters), and is made of a thin polymeric material (e.g., any thermoplastic crystalline or non crystalline material such as polyester, polycarbonate, polypropylene, styrene, butadiene, ABS plastic, etc. in the range of about 0.012 to 0.04 centimeter thick, and typically 0.025 centimeter thick) so that it is flexible. The carrier tape 10 comprises a strip like portion 22 defining a top surface for the tape

10, and wall portions defining a multiplicity of similarly shaped pockets 24 spaced along the carrier tape 10 and opening through its top surface. The wall portions may or may not include anti nesting shoulders for restricting entry of side wall portions defining the pockets 24 in one wrap of the carrier tape 10 on a reel into the pockets 24 in a wrap of carrier tape 10 beneath it as is described and claimed in U.S. Patent No. 4,898,275 issued February 6, 1990, the content whereof is incorporated herein by reference. The carrier tape 10 also has a conventional series of equally spaced and sized through openings 26 along one edge of the strip like portion 22 which will receive the teeth of a drive sprocket by which the carrier tape 10 may be driven through automated equipment which loads components into the pockets 24 or removes components from the pockets 24. Additionally, the carrier tape 10 has an opening generally centered in the bottom wall of each of the pockets 24 as is required by an industry standard to allow the presence of a component in a pocket 24 to be sensed, or to allow access for a probe that facilitates removal of a component from the pocket 24.

The hub 15 of the reel 14 is preferably a stiff hollow cylindrical tube of paper material, and the flanges 19 are preferably discs of a corrugated cardboard material attached to the ends of the hub 15 by a plurality of staples 28. The flanges 19 have central openings 30 around which are fastened the ends of a hollow cylindrical reinforcing journal tube 31 (also of paper material) extending between the flanges 19 and through which openings 30 and tube 31 a spindle may be positioned to rotatably support the reel 14. The flanges also have radially extending openings 32 that afford visual inspection of the amount of component carrier tape 10 remaining on the reel 14, and drive openings 33 adjacent the openings 30 in which an external drive member may be positioned to afford rotational driving engagement with the reel 14. The flanges 19 of the reel 14 are compressed around their peripheries to restrict engaging the edges of component carrier tape 10 being wound onto or off of the hub 15, and may also be compressed or creased along rectangularly disposed lines 34 ending in the openings 32 to afford bending portions of the flanges 19 away from the opposite flange 19 along the lines 34 to either afford visual inspection of the amount of component carrier tape 10 remaining on the reel 14, or to reduce the diameter of the reel 14 to facilitate its disposal, preferably to a recycler of paper products.

It can be estimated mathematically that in order for the component carrier tape 10 of width "W" in millimeters to be level wound on the hub 15 of the reel 14 in the manner illustrated and described with reference to Figures 1, 2 and 3 and so that cold flow that will occur in the transition portions 20 of the component carrier tape 10 adjacent the flanges 19 of the reel 14 will not cause the component carrier tape 10 to fail the industry standard described above (i.e., that the carrier tape 10 must have less than 1 millimeter non cumulative camber over a length of 250 millimeters) the peripheral surface 18 of the hub 15 should have a minimum diameter "D" determined by the formula:

$$D(\text{minimum}) = \frac{2}{\pi} \sqrt{(7813)^2 - (7813-W)^2}$$

The basis for this formula, described below, is illustrated in Figures 4 and 5.

Figure 4 illustrates a test length 250 millimeters long (which test length is designated as 2 times Z where Z is 125 millimeters long) of the component carrier tape 10 that is cambered in an arc to the maximum extent allowable under the industry specification described above (i.e., the camber Y is 1 millimeter). From the relationships illustrated Figure 4 it can be seen that R is the minimum radius that will still meet the industry standard described above, and that the following equations apply:

$$X + Y = R$$

$$X^2 + Z^2 = R^2$$

Solving these equations simultaneously for the illustrated conditions that Y = 1 millimeter (i.e., the maximum allowable value for camber in 250 millimeters of component carrier tape) and Z = 125 millimeter (i.e., one half of the 250 millimeter test length of component carrier tape represented by the cord of which Z is one half) results in a value for R of 7813 millimeters, which is the radius of the circle described by the outer edge of the test length of component carrier tape 10 illustrated in Figure 4, and the minimum radius of a circle that can be described by the outer edge of that test length for which the industry standard described above will be met.

In Figure 5 there is illustrated one flange 19 of the reel 14 and successive wraps designated Z1 and Z2 of the component carrier tape 10 in different layers joined by one of the transition portions 20 of the component carrier tape 10 that are curved to allow those wraps Z1 and Z2 to be angled in opposite directions with respect to the axis 16 of the hub 15, and which curvature will result from cold flow in the carrier tape 10 caused by such angling in opposite directions. From the relationships illustrated in Figure 5, which are essentially the same as those illustrated in Figure 4, it can be seen that the following equations also apply:

$$X + Y = R$$

$$X^2 + Z_1^2 = R^2$$

and that the value R of 7813 millimeters, (which is the minimum radius of a circle that can be described by the outer edge of the illustrated length of carrier tape 10 for which the industry standard described above will be met) will still be applicable. Solving these equations simultaneously for the conditions that Y = the width W of the carrier tape (i.e., when the component carrier tape 10 is wound on the peripheral surface 18 of the hub 15 edge to edge, the edge of the carrier tape 10 adjacent the flange 19 at the ends of the complete wraps Z1 and Z2 of carrier tape 10 will be displaced away from the flange 19 by an amount Y equal to the width W of the tape), and that Z<sub>1</sub> equals 0.5 πD will provide the formula

$$D(\text{minimum}) = \frac{2}{\pi} \sqrt{(7813)^2 - (7813-W)^2}$$

set forth above. It is recognized that the shape of the wraps designated Z1 and Z2 of the component carrier tape 10 in different layers and the transition portion 20 that joins them may not form a smooth circle, however, the approximation of a smooth circle is believed close enough for a valid approximation.

The use of reels 14 with the minimum diameter hubs 15 that can be determined by the above formula (e.g., about 226 millimeters (8.9 inches) for 8 millimeter (0.31 inch) wide component carrier tape; about 274 millimeters (10.8 inches) for 12 millimeter (0.47 inch) wide component carrier tape; about 317.5 millimeters (12.5 inches) for 16 millimeter (0.63 inch) wide component carrier tape; about 388.6 millimeters (15.3 inches) for 24 millimeter (0.94 inch) wide component carrier tape; about 449.6 millimeters (17.7 inches) for 32 millimeter (1.26 inch) wide component carrier tape; about 527.1 millimeters (20.7 inches) for 44 millimeter (1.73 inch) wide component carrier tape; and about 594.4 millimeters (23.4 inches) for 56 millimeter (2.2 inch) wide component carrier tape) would provide little margin for errors that might occur in level winding on the carrier tape 10 or for the approximation described above that is incorporated in the formula. Thus it is preferred to use a reel 14 that has a hub 15 diameter that is significantly above the minimum diameters indicated by the above formula, such as a reel 14 with a 355.6 millimeter (14 inch) diameter for either 8 or 12 millimeter wide component carrier tapes 10.

It is also useful to solve the formula

$$D = \frac{2}{\pi} \sqrt{(R)^2 - (R-W)^2}$$

to determine R in millimeters for the hub 15 diameter D selected for the reel 14 and the width W of the component carrier tape 10 wound on it, and to divide the value determined for R into the minimum radius R of 7813 millimeter determined as explained above with reference to Figure 4 to determine the percentage of that minimum radius to which the carrier tape will be subjected in the selected reel. From such a calculation it will be found that 8 millimeter wide carrier tape 10 wound on the peripheral surface 18 of a 355.6 millimeter (14 inch) diameter hub 15 will be subjected to a radius of curvature that is about 40 percent of the maximum radius to which it could be subjected and still be expected to meet the industry standard described above, which provides a good safety factor; and that 12 millimeter wide carrier tape 10 wound on the peripheral surface 18 of a 355.6 millimeter (14 inch) diameter hub 15 will be subjected to a radius of curvature that is about 60 percent of the maximum radius to which it could be subjected and still be expected to meet the industry standard described above, which also provides a good safety factor.

The present invention has now been described with reference to one embodiments thereof. It will be apparent to those skilled in the art that many changes can be made in the embodiment described without departing from the scope of the present invention. Thus the scope of the present invention should not be limited to the structure described in this application, but only by structures described by the language of the claims and the equivalents of those structures.

## Claims

1. In combination,

a length of component carrier tape (10) having elongate edges, and a uniform width between said edges; and

a reel (14) including a hub (15) having an axis (16), opposite axially spaced ends and a cylindrical peripheral surface (18) between said ends, and a pair of flanges (19), one fixed to said hub (15) adjacent each of said ends and projecting radially from said hub (15), said flanges (19) having opposed inner surfaces spaced by a distance significantly greater than the width of said carrier tape (10);

said component carrier tape (10) being helically level wound around the peripheral surface (18) of said hub (15) in layers with the wraps of carrier tape (10) in each layer being disposed edge to edge so that those wraps are displaced axially from each other by the width of the carrier tape (10), and with the opposite edges of wraps of carrier tape (10) in successive layers being angled in opposite directions with respect to the axis (16) of the hub (15);

said peripheral surface (18) of the hub (15) having a minimum diameter "D" determined by the formula:

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$$D = \frac{2}{\pi} \sqrt{(7813)^2 - (7813-W)^2}$$

where "W" is the width of the carrier tape (10) in millimeters.

2. A combination according to claim 1 wherein the width of said carrier tape (10) is 8 millimeters, and the diameter of said core is 355.6 millimeters (14 inches).

3. A combination according to claim 1 wherein the width of said carrier tape (10) is 12 millimeters, and the diameter of said core is 355.6 millimeters (14 inches).

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Fig. 1

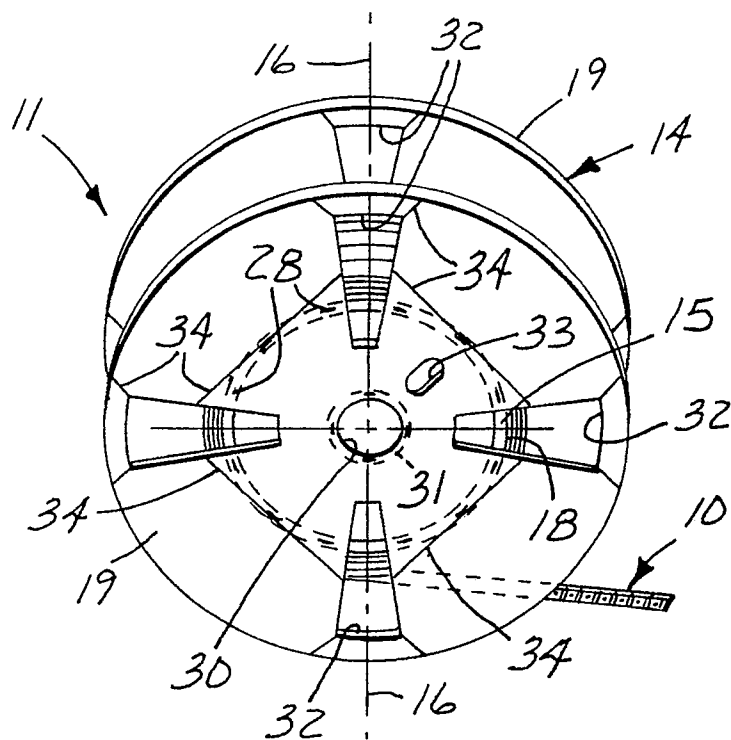
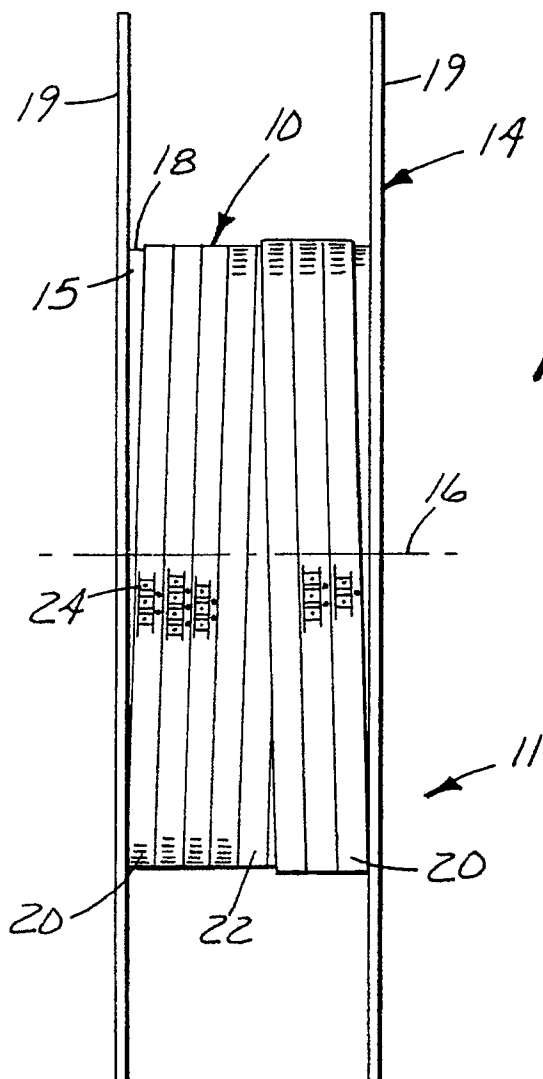
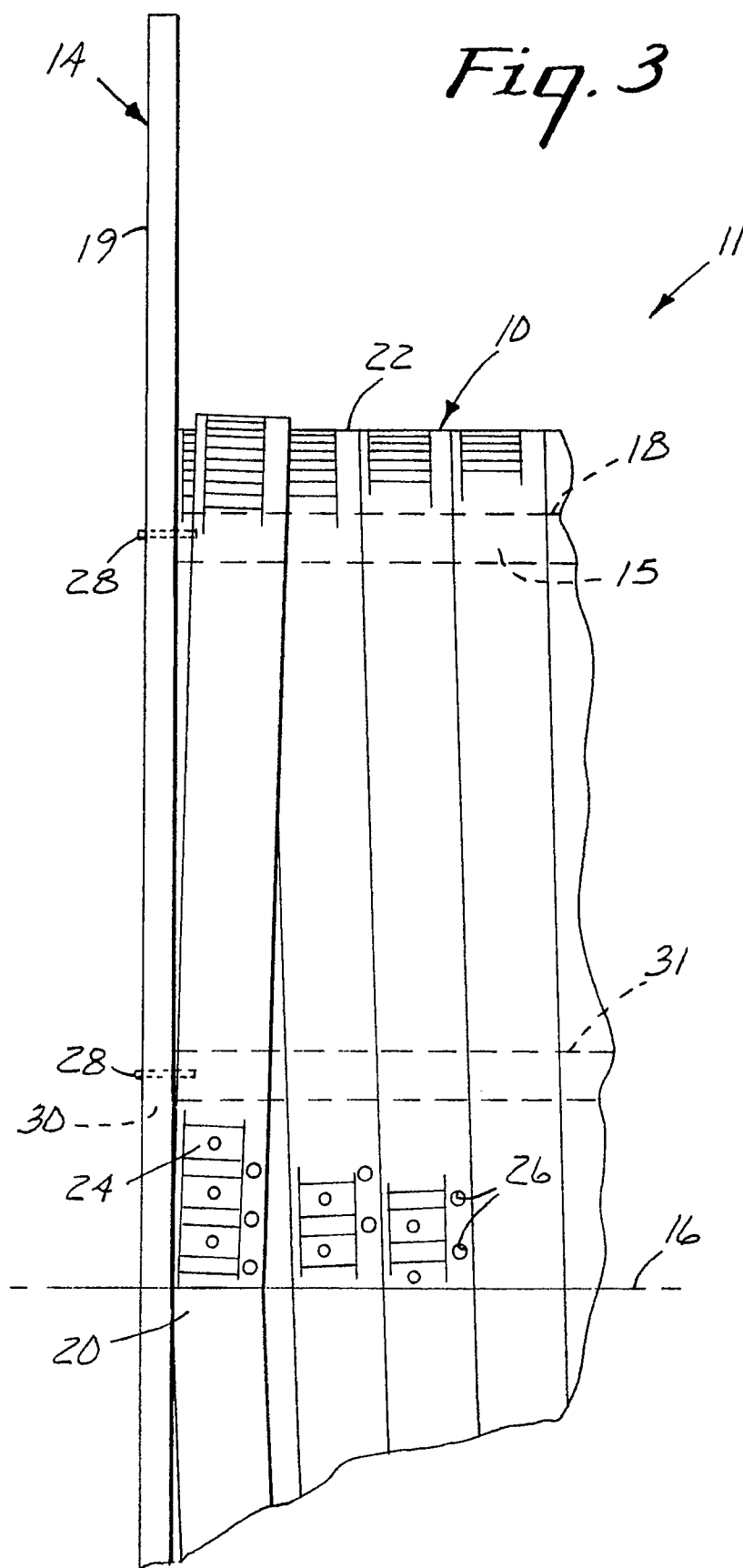
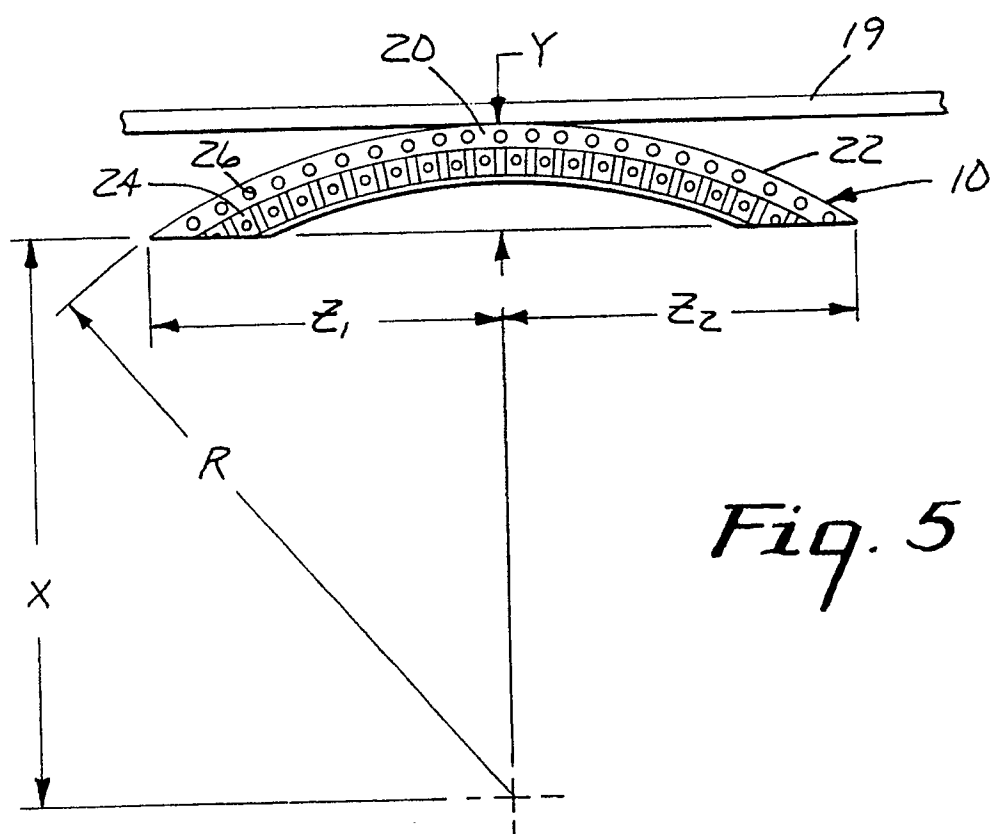
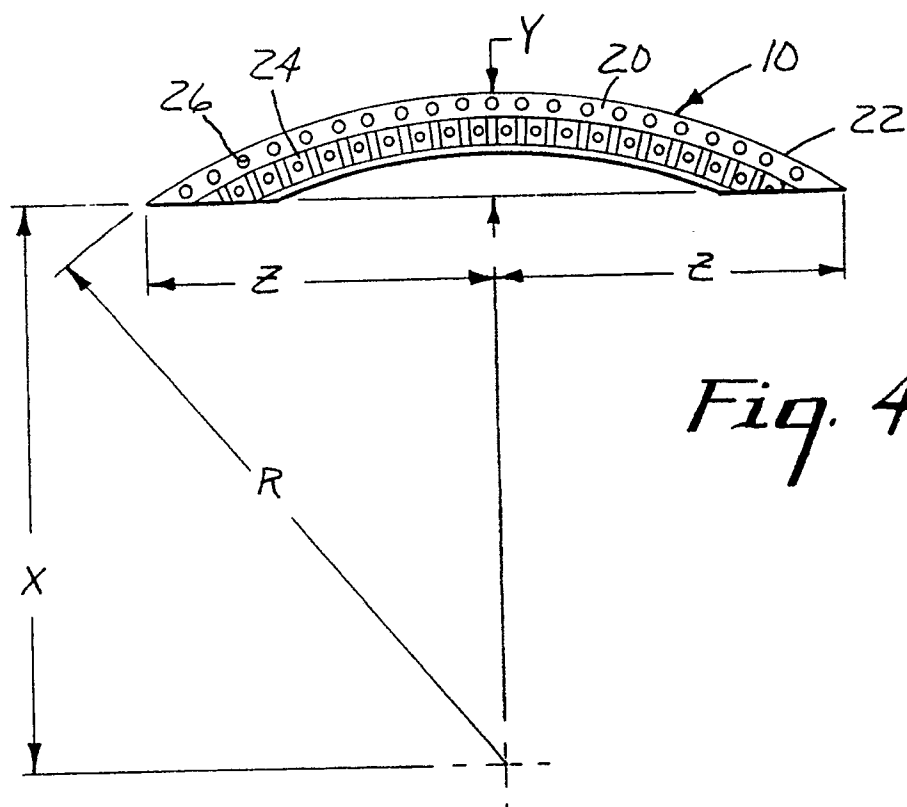


Fig. 2











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## EUROPEAN SEARCH REPORT

Application Number

**EP 90 31 3864**

DOCUMENTS CONSIDERED TO BE RELEVANT					
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)		
D,A	US-A-4 898 275 (T. SKRTIC et al.) -----		B 65 H 55/00		
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)		
			B 65 H B 65 D		
The present search report has been drawn up for all claims					
Place of search The Hague		Date of completion of search 21 June 91	Examiner GOODALL C.J.		
<table><tr><td><b>CATEGORY OF CITED DOCUMENTS</b> X: particularly relevant if taken alone Y: particularly relevant if combined with another document of the same category A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention</td><td>E: earlier patent document, but published on, or after the filing date D: document cited in the application L: document cited for other reasons ----- &amp;: member of the same patent family, corresponding document</td></tr></table>				<b>CATEGORY OF CITED DOCUMENTS</b> X: particularly relevant if taken alone Y: particularly relevant if combined with another document of the same category A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention	E: earlier patent document, but published on, or after the filing date D: document cited in the application L: document cited for other reasons ----- &: member of the same patent family, corresponding document
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