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Energy Absorbing Carrier Tape

BACKGROUND

The present invention generally relates to packaging methods for electronic circuit components, particularly to improved carrier tapes for electronic circuit components, and specifically to improved carrier tapes for aiding in the non-contacting, electro-optical vision inspection of electronic circuit components located in the pockets and/or for electronic circuit components for protecting the electronic circuit components in the event that the reel of carrier tape is dropped.

A common packaging method for electronic circuit components such as microchips and utilized in robotic based board assembly is placement into pockets located at precise intervals on a carrier medium. Specifically, such pockets could be arranged in arrays of rows and columns in trays and, especially common for small resistors, capacitors, and memory boards for surface mount assembly of circuit boards, could be arranged in continuous columns in carrier tapes.

An example of such an electronic circuit component is the QFP and TQFP product which is a rectangular or square format, thin cross section package with leads extending from all four sides. The leads are spaced in close proximity in the neighborhood of .5 mm centers, are .2 mm wide by 1 mm long, and are "gull winged" in format. The leads are fragile and must be protected from harsh contact with the carrier tape during transport. Carrier tapes utilize pedestals to support the component in the pocket. Conventional carrier tape confines the body of the component by use of small ridges on or near the pedestals that nest under the gull wing shaped leads and next to the body such that the free ends of the leads of the component are spaced from and ideally do not engage the side walls of the pocket. This works well for centering the electronic circuit component in the pocket of the carrier tape.

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The IC industry conducts a drop test on the final packaging system which includes carrier tape, cover tape, reel, static control bag, "pizza" box and outer shipping box. It has been reported that 30% of the electronic circuit components sustain damage during drop testing using current tape technology. The mode of failure is lead bending resulting from the rapid deceleration of the electronic circuit components against the near vertical side wall of the carrier tape pocket after the electronic circuit components "jump" their restraining centering ridges. Specifically, in a drop test, the body of the electronic circuit component "jumps" the centering ridges and the leads of the electronic circuit component collide with the near vertical side walls of the carrier tape pocket. Once the body of the electronic circuit component has jumped the ridges, then the ridges can bend the leads. In a drop test of 3 feet, deceleration forces can range from 100 to 10,000 G's depending upon how much deformation one assumes takes place at the box versus at the carrier tape interface. It can be appreciated that the centering ridges of conventional carrier tape pockets do not protect the electronic circuit component from drop damage and in fact are a major source of component failure.

As part of the manufacture of electronic circuit components, the leads of the electronic circuit components are inspected for improper bends, out of specification configurations, and like abnormalities. This inspection can occur while the electronic circuit components have been removed from the pocket, but this is a time consuming and relatively expensive procedure. This inspection can also occur while the electronic circuit components are in the pocket but before the pockets are covered in a manner to avoid accidental falling of the electronic circuit components from the pocket. Such in the pocket inspection generally utilizes non-contacting, electro-optical vision systems having frame grabbers and clever algorithms to



compare the electronic circuit components in the pocket with a desired standard.

Although easier and less expensive to perform than out of the pocket inspection, in the pocket inspection results in the indication of many false rejections which require extra time for human inspection and override. Specifically, due to their placement out of center in the pocket or due to their shifting in the pocket due to movement of the pocket, the leads of the electronic circuit components can be located closely adjacent or abutting with the side walls of the pocket. Such leads can cause a reflection on the side walls which can not be differentiated from the actual lead by the electro-optical vision system and would then be considered as extra long leads. Since long leads would be a flaw in the manufacture of electronic circuit components, the inspection would indicate a rejection which typically stops operation until manually overridden by the operator. The manufacturers of electro-optical vision inspection systems have attempted to overcome this problem of the false indication of improper lead problems by various approaches such as but not limited to using point source lighting, using diffuse lighting, using polarizing or color filters, and the like. However, such attempts by manufacturers of electro-optical vision inspection systems have not been successful in overcoming this problem of the false indication of improper lead problems.

Thus, a need continues to exist in the field of in the pocket inspection of electronic circuit components for eliminating the false indication of lead problems as the result of the positioning of the leads in close vicinity to the side wall of the carrier pocket.

Further, a need continues to exist in the field of electronic circuit component packaging methods for carrier tape designed to absorb kinetic energy and protect the electronic circuit component from damage and especially



protecting the leads of the electronic circuit component from bending or crushing.

SUMMARY

This need and other problems in the field of packaging for electronic circuit components have been solved by providing, in the most preferred form, abutments formed on the side walls of a pocket for receiving an electronic circuit component for abutting with the free ends of the leads of the electronic circuit component for preventing engagement of the leads with the side wall and for optically dispersing reflection of the leads. Thus, inspection of the electronic circuit component can occur while the electronic circuit component is located within the pocket while the false indication of lead problems as the result of the positioning of the leads in close vicinity to the side wall of the pocket is eliminated.

In other aspects of the present invention, ramp portions in the side walls of the pocket of the carrier are inclined upwardly and outwardly and for engaging the free ends of the leads of the electronic circuit component when centered and supported in the pocket. In an aspect of the present invention, the electronic circuit component is supported in the pocket by a platform which is free of protrusions extending above the bottom of the body of the electronic circuit component. Thus, the electronic circuit component is free to slide on the platform to center itself in the pocket when positioned therein. Further, there is less tendency for leads to be bent or otherwise damaged in the event that external forces cause movement of the electronic circuit component on the platform.

In a further aspect of the present invention, the bottom of the pocket is sized smaller than the periphery of the body of the electronic circuit component and thus also of the pocket. The bottom of an upper pocket sandwiches the electronic circuit component against the platform of a lower pocket to clamp the electronic circuit



component in the lower pocket. Such clamping force resists movement of the electronic circuit component in the pocket in the event that external forces are placed on the carrier. Thus, the carrier is able to absorb kinetic energy and protect the leads of the electronic circuit component from bending or other damage. In an additional aspect of the present invention, the pocket bottom includes an undercut to prevent abutment of the pocket bottom with the front face of the carrier in the event that the upper pocket spans two, circumferentially adjacent, lower pockets and the thickness of the body of the electronic circuit component is such that a gap exists between the front face of the carrier and the top of the electronic circuit component.

It is thus an object of the present invention to provide a novel carrier for electronic circuit components such as microchips.

It is further an object of the present invention to provide such a novel carrier in the preferred form of a carrier tape.

It is further an object of the present invention to provide such a novel carrier preventing engagement of the leads with the side walls of the pockets of the carrier.

It is further an object of the present invention to provide such a novel carrier optically dispersing reflection of the leads.

It is further an object of the present invention to provide such a novel carrier minimizing the area contacted by the free ends of the leads in the pocket.

It is further an object of the present invention to provide such a novel carrier protecting the leads from bending or other damage during engagement with the side-walls of the pockets of the carrier.

It is further an object of the present invention to provide such a novel carrier which absorbs kinetic energy.

It is further an object of the present invention to provide such a novel carrier allowing the electronic



circuit component to center itself in the pocket by simply sliding on the support provisions.

It is further an object of the present invention to provide such a novel carrier which places a clamping force on the body of the electronic circuit component when the pockets are arranged in layers.

It is further an object of the present invention to provide such a novel carrier which supports the body of the electronic circuit component by provisions which are free of ridges or protuberances extending above the bottom of the body of the electronic circuit component.

These and further objects and advantages of the present invention will become clearer in light of the following detailed description of illustrative embodiments of this invention described in connection with the drawings.

#### DESCRIPTION OF THE DRAWINGS

The illustrative embodiments may best be described by reference to the accompanying drawings where:

Figure 1 shows a perspective view of a carrier tape according to the preferred teachings of the present invention, with an electronic circuit component being exploded therefrom.

Figure 2 shows a cross-sectional view of the carrier tape of Figure 1.

Figure 3 shows a diagrammatic view of a shadow of a lead on the pocket side wall of prior carrier tapes.

Figure 4 shows a diagrammatic view of a shadow of a lead on the pocket side wall of the carrier tape of Figure 1.

Figure 5 shows a perspective view of a carrier tape according to the preferred teachings of the present invention being wound on a reel, with an electronic circuit component being exploded therefrom.

Figure 6 shows a cross-sectional view of the carrier tape of Figure 5 according to section line 6-6 of Figure 5.



Figure 7 shows a cross-sectional view of the carrier tape of Figure 5 according to section line 7-7 of Figure 6.

Figure 8 shows a diagrammatic cross-sectional view of a portion of the carrier tape as wound on the reel of Figure 5 according to section line 8-8 of Figure 5.

Figure 9 shows a diagrammatic top view of the carrier tape of Figure 5 according to view line 9-9 of Figure 8.

All figures are drawn for ease of explanation of the basic teachings of the present invention only; the extensions of the Figures with respect to number, position, relationship, and dimensions of the parts to form the preferred embodiment will be explained or will be within the skill of the art after the following teachings of the present invention have been read and understood. Further, the exact dimensions and dimensional proportions to conform to specific force, weight, strength, and similar requirements will likewise be within the skill of the art after the following teachings of the present invention have been read and understood.

Where used in the various figures of the drawings, the same numerals designate the same or similar parts. Furthermore, when the terms "first", "second", "front", "back", "upper", "lower", "height", "width", "length", "thickness", "end", "side", "horizontal", "vertical", "longitudinal", "lateral", and similar terms are used herein, it should be understood that these terms have reference only to the structure shown in the drawings as it would appear to a person viewing the drawings and are utilized only to facilitate describing the invention.

#### DESCRIPTION

A carrier tape according to the preferred teachings of the present invention is shown in the drawings and generally designated 12. Carrier tape 12 generally includes a carrier medium in the preferred form of an elongated strip 14 made of semi-flexible, deformable material such as plastic and the like, with strip 14 including a front face 16 and a back face 18. A plurality



of longitudinally spaced, indexing holes 20 extend through strip 14 in input strips located parallel to and adjacent one or both edges of strip 14 in the most preferred form. Holes 20 serve as a finished product feature required by carrier tape 12 in the industry as set forth in Electronic Industries Association standards such as holes 20 can be 1.5 mm in diameter on 4 mm centers.

A plurality of pockets 22 are provided at precise intervals on the carrier medium and in the preferred form shown are longitudinally spaced in a column extending parallel to index holes 20 and the edges of strip 14 and recessed from face 16 and extending beyond face 18 of strip 14. Each pocket 22 includes side walls 24 and a bottom 26 generally parallel to faces 16 and 18 and located on the opposite side of face 18 than face 16. Bottom 26 includes suitable provisions 28 for positioning a product such as a microchip or like electronic circuit component within pocket 22 with the leads of the microchip not engaging bottom 26. A hole 30 of nominal size in the order of 1.5 to 2.0 mm diameter is typically formed in bottom 26 within provisions 28 per Electronic Industries Association standards. In the embodiment of Figures 1-4, side walls 24 extend at an acute angle up to 90° from face 18, with the leads of the microchip ideally not engaging side walls 24.

In the preferred embodiment shown, pockets 22 are of the type for receiving an electronic circuit component 32 in the form of a semiconductor I.C. device having a plurality of fine pitch leads 34 extending outwardly from the sides of its body 36, with leads 34 extending from two sides being shown in Figures 1-4 and from all four sides of body 36 being shown in Figures 5-9. Carrier tape 12 according to the preferred teachings of the present invention is especially adapted for components 32 having body 36 of a shape of a right parallelepiped and specifically of a square or a rectangle with a length to width ratio not exceeding a range of 1:1.3 or so, with QFP



and TQFP products being components 32 especially benefiting from the teachings of the present invention. Leads 34 are generally equally spaced along the sides of body 36 and extend from midway between the top and bottom of body 36. Leads 34 in the preferred form are gull wing shaped and terminate in free ends which are generally linear and parallel to the sides of body 36. The sides of body 36 can be chamfered or tapered at about 10° from the top and bottom to where leads 34 extend therefrom. However, it should be appreciated that component 32 can be of other forms, shapes, and the like according to the teachings of the present invention and that the teachings of the present invention are not limited to the particular form and shape of component 32 shown.

According to the teachings of the present invention as shown in Figures 1-4, side walls 24 have a shape corresponding to that of the free ends of leads 34 of component 32 received within pockets 22 and include a plurality of spaced abutments 38 extending generally into pockets 22. In the most preferred form, abutments 38 are integrally formed with pockets 22 at the same time that pockets 22 are formed in the carrier medium, with pockets 22 being formed using conventional carrier tape forming processes. Abutments 38 should be positioned on side walls 24 to be horizontally aligned with leads 34 of component 32 positioned on provisions 28 and in the preferred form can extend generally from adjacent face 18 to bottom 26 and in the most preferred form can extend to and be formed in bottom 26. Abutments 38 abut with the free ends of leads 34 of component 32 within pocket 22 for preventing engagement of leads 34 with side walls 24. The faces of abutments 38 extending into pockets 22 have a shape for optically dispersing any reflection of leads 34 thereon. In the preferred form, abutments 38 have a shape which minimizes the actual area contacted by the free ends of leads 34 and in the most preferred form have horizontal cross sections parallel to bottom 26 of pockets 22 of a



semicircular or V-shape. In particular, the horizontal length of the area of engagement by abutments 38 is considerably smaller than the horizontal length of the free ends of leads 34.

According to the teachings of the present invention as shown in Figures 1-4, the spacing and number of abutments 38 are such that the number of leads 34 which actually contact abutments 38 is minimized and such that abutments 38 will not cause bending or other damage to leads 34. In the most preferred form, a greater number of abutments 38 at a lesser spacing are provided on each side wall 24 than the number of leads 34 located on each side of component 32. Specifically, in the most preferred form where fourteen leads 34 extend from each side of component 32, eighteen abutments 38 are provided on each side wall 24, with the maximum width of abutments 38 at side wall 24 being generally equal to the widths of leads 34 and with the spacing between abutments 38 being equal and approximately 30% less than the spacing between leads 34. Thus, in the event that component 32 is slid towards one of side walls 24 while remaining generally parallel to side walls 24, some of the leads 34 will engage abutments 38 in some cases with their centers aligned but in most cases with the centers offset and some of the leads 34 will not engage any of abutments 38. As shown in Figure 2, with component 32 located generally centered between side walls 24 extending parallel to index holes 30, the center of first lead 34 from the left generally engages the center of the first abutment 38, the left corner of second lead 34 from the left generally engages the center of the second abutment 38, the third lead 34 from the left is positioned between and does not engage the third and fourth abutments 38, the right corner of the fourth lead 34 from the left generally engages the center of the fifth abutment 38, and so on. It should then be noted that leads 34 generally abut with the center of abutments 38 which because of their semicircular cross sections is at



the greatest spacing from side wall 24 and in particular do not extend to an extent less than the greatest spacing of abutments 38 from side wall 24. If the spacing between abutments 38 were such that the ends of leads 34 could extend between abutments 38 such as would be the case if abutments 38 were equally spaced apart at a spacing generally equal to the spacing between leads 34, then leads 34 could slide in an interfitting or gear-type relation with abutments 38 and be hooked between abutments 38 resulting in bending or damage of leads 34 if component 32 was moved relative to pocket 22. It can then be appreciated that abutments 38 can have other spacings and arrangements than equal spacing and still prevent an interfitting relation with leads 34 including but not limited to abutments 38 of variable spacings, groups of equally spaced abutments 38 at spacings different from other groups of abutments 38 which is not a whole number multiple of the spacings between abutments 38 in the groups, and the like.

It should further be appreciated that component 32 could have an offset relation to pocket 22 rather than a parallel relation to side walls 24 as shown in Figure 2. As an example, the front left lead 34 could engage one of the abutments 38 of the front side wall 24 and the rear right lead 34 could engage one of the abutments 38 of the rear side wall 24. But in any case, abutments 38 would prevent abutment of leads 34 with side walls 24, the area of engagement between leads 34 and abutments 38 which are actually engaged is minimized, and leads 34 do not have an interfitting relation with abutments 38 whatever the position of component 32 in pocket 22.

Now that the basic construction of carrier tape 12 according to the preferred teachings of the present invention has been set forth, the use of carrier tape 12 in a non-contacting, electro-optical vision inspection system can be explained. Prior to the present invention,



if leads 34 contacted or were closely adjacent side walls 24, the light necessary for operation of the inspection system caused the lead to have a reflection on side wall 24 as diagrammatically shown in Figure 3. The inspection system utilized the combined length of the actual length of the lead 34 together with the length of its reflection on side wall 24 as it could not detect the difference between the lead 34 and its reflection. Thus, during comparison with the standard component 32 desired, the inspection system would consider that the lead of component 32 in pocket 22 as being too long and indicate a rejection which in this example would be incorrect assuming that the actual length of the lead 34 was proper if its reflection was properly not considered. It would then be necessary for the operator to determine why the inspection system indicated a rejection and manually override the inspection system so that inspection of components 32 in the remaining pockets 22 of carrier tape 12 would continue.

Carrier tape 12 according to the teachings of the present invention prevents abutment of leads 34 with side walls 24. Particularly, engagement of some of the leads 34 of component 32 with abutments 38 hold the free ends of leads 34 spaced a sufficient distance from side walls 24 so that the end of leads can be detected as being separate from side walls 24. It should then be appreciated that the engagement of some of the leads 34 of component 32 with abutments 38 will cause the creation of reflections on abutments 38. However, carrier tape 12 allows the inspection system to detect the difference between leads 34 and their reflection on abutments 38 according to the teachings of the present invention. Particularly, Figure 4 shows a worse case scenario where the center of the lead 34 corresponds to the center of abutment 38. However, due to the minimal area of engagement between lead 34 and abutment 38 and the semicircular cross section of abutment 38, the reflection is in the form of a spike having a



width considerably less than the width of lead 34 as the remaining, major portions of the reflection of lead 34 is dispersed. Although such non-dispersed reflection would also be detected by the inspection system, the inspection system can utilize a process referred to as high frequency edge trimming or noise removal to electronically substract this spike of reflection from the end of lead 34 and thus compare the desired standard with the actual length of lead 34. Vision analysis software for electronically substracting this spike of reflection is offered at least by COGNEX Corporation in Boston, MA, USA. Thus, the false indication of lead problems as the result of detection of the reflection of leads 34 on abutments 38 and also side walls 24 is thereby eliminated.

In the preferred form shown in Figure 2, the distance between abutments 38 on opposite side walls 24 is greater than the distance between the free ends of leads 34 on opposite sides of component 32. Thus, if component 32 is centered in pocket 22, none of the leads 34 would engage abutments 38. However, abutments 38 could be formed having a distance between opposite side walls 24 generally equal to that of the distance between the free ends of leads 34 on opposite sides of component 32. Thus, abutments 38 would center component 32 in pockets 22. In that event, abutments 38 could be shaped to accentuate this additional function such as having increasing spacing from side walls 24 with decreasing distance from bottom 26 of pocket 22 such as having abutments 38 being semi-spherical in shape.

Additionally, although semicircular or V-shaped cross sections have been set forth for abutments 38 as advantageously reducing the area of engagement with leads 34, abutments 38 according to the teachings of the present invention could have other shapes such as semispherical as set forth above as well as other shapes including but not limited to having concave depressions at the engagement area of abutments 38 with leads 34.



Although carrier tape 12 has been shown as including a single column of pockets 22, it should be appreciated that pockets 22 could be arranged in more than one column to form pockets 22 in an array of columns and rows on carrier tape 12. Likewise, although the carrier in the preferred form is formed of semi-flexible, deformable material to form tape 12, pockets 22 could be formed in carriers of other mediums such as but not limited to trays.

In the most preferred form shown in Figures 5-9, provisions 28 are in the form of a pedestal generally including a planar platform 40 of a shape corresponding to but of a size smaller than the perimeter of the sides of body 36. In the most preferred form, hole 30 is formed in platform 40. Platform 40 is held at a parallel, elevated position above bottom 26 by an integral skirt 41 integrally extending between platform 40 and bottom 26. Skirt 41 in the most preferred form is frustopyramid in shape of an increasing size extending from platform 40, with skirt 41 extending at an obtuse angle in the order of  $105^\circ$  from platform 40. The lower edge of skirt 41 integrally secured to bottom 26 in the most preferred form is of a shape corresponding to but of a size smaller than the perimeter of the sides of body 36 and represents the minimum size of bottom 26 in directions both perpendicular and parallel to the direction of index holes 20.

However, provisions 28 can be of other forms than a single pedestal of a generally right parallelepiped or square shape as shown. As an example, provisions 28 could be in the form of first and second, spaced, parallel pedestals of generally rectangular shape. Such pedestals could be arranged with their long dimension arranged perpendicular to the direction of index holes 20. Hole 30 could be formed in bottom 26 intermediate such first and second pedestals. Platform 40 defined by the top surfaces of such first and second pedestals would be planar but would have an area which is not continuous and which is



substantially less than the area of the bottom of body 36 of component 32.

Component 32 is supported in pocket 22 by the bottom of body 36 abutting with platform 40 and located intermediate bottom 26 of pocket 22 and face 18. In the most preferred form, platform 40 and provisions 28 are free of ridges or similar protrusions extending above the bottom of body 36 of component 32 when supported on platform 40. Thus, component 32 is not confined by provisions 28 and generally is free to slide on platform 40 in any direction parallel to platform 40.

Side walls 24 extend from face 18 to bottom 26. In the most preferred form of Figures 5-9, side walls 24 each generally include a ramp portion 42 located at a position intermediate bottom 26 and face 18 corresponding to that of the free ends of leads 34. In the most preferred form, ramp portion 42 is inclined at an angle of 30° upwardly and outwardly from bottom 26. Further, in the most preferred form, the spacing between ramp portions 42 on opposite sides of provisions 28 is such that with component 32 centered in pocket 20 and with the bottom of body 36 flushly abutting with platform 40, all of the free ends of leads 34 will simultaneously engage ramp portions 42 of all four side walls 24. In the preferred form, ramp portions 42 do not extend in a single plane but specifically are arcuate in shape.

Side walls 24 further include transition portions between ramp portions 42 and face 18 and bottom 26. Specifically, in the preferred form, first transition portions 44 are located intermediate face 18 and ramp portions 42 and specifically extend from face 18 to the upper edges of ramp portions 42. Second transition portions 46 extend from bottom 26 to the lower edges of ramp portions 42. In the most preferred form, transition portions 44 are generally planar and are near vertical and extend at an angle up to 90° from face 18. Transition portions 44 provide the necessary depth to pocket 22 such



that the top of body 36 of component 32 supported on provisions 28 is located at or slightly below the plane of face 16 while minimizing the dimensions of pocket 22 than if the angle of incline of ramp portions 42 would have been continued up to face 18.

In the embodiment shown in Figures 5-9, transition portions 46 include an annular flange 48 having a frusto-pyramid shape of an increasing size extending from bottom 26. The upper edges of annular flange 48 integrally terminate in the inner edge of an annular ring 50 located parallel to and intermediate bottom 26 and platform 40. The lower edges of ramp portions 42 are integrally formed with a lip 52 extending slightly downward from the outer edge of annular ring 50. The lower edge of flange 48 has a shape corresponding to but of a size generally equal to or slightly smaller than the perimeter of the sides of body 36 and corresponding to but of a size smaller than pocket 22 at face 18. The upper edge of flange 48, lip 52, and transition portions 44 have a shape corresponding to but of a size larger than the perimeter of the sides of body 36 of component 32. The function of the configuration of transition portions 46 is to insure that during the manufacturing process, ramp portions 42 have the desired shape. Specifically, during forming, side walls 24 could simply extend generally vertically to bottom 26 in the event that the forming process did not have an approach to draw or force the molten material into the desired shape. The particular configuration of transition portions 46 as shown and described is an approach which insures the acceptable formation of ramp portions 42 during production. It can be realized that transition portions 46 can have other shapes and configurations and/or that other approaches can be utilized to obtain accurate formation of ramp portions 42 in the side walls 24 during fabrication of carrier tape 12. It should further be realized that side walls 24 including ramp portions 42 according to the teachings of the present invention can



have other configurations. As an example, side walls 24 could be configured not to have distinct regions such as between ramp portions 42 and transition portions 46 and 48 but rather to have a continuous shape such as being parabolic or hyperbolic in cross section. Similarly, side walls 24 could be configured to include a first frustopyramid shaped portion extending upwardly and outwardly from bottom 26 at an angle in the order of  $30^\circ$  and integrally terminating in a second frustopyramid shaped portion extending upwardly and outwardly at an angle in the order of  $57^\circ$  and which in turn integrally terminates in a tubular portion with near vertical walls. In this arrangement, the free ends of leads 34 with component 32 centered on provisions 28 could abut side walls 24 at the intersection of the first and second frustopyramid shaped portions. Similarly, ramp portions 42 could include planar, arcuate, combinations thereof, or other shapes according to the teachings of the present invention.

In the preferred form shown in Figures 5-9, bottom 26 is generally annular in shape and defined by and between the lower edges of flange 48 and of skirt 41. In the most preferred form, the portions of bottom 26 parallel to index holes 20 and intermediate the linear portions of bottom 26 extending perpendicular to the direction of index holes 20 include an undercut 54 extending generally parallel to bottom 26. Such linear portions of bottom 26 thus extend parallel to and adjacent to the opposing sides of body 36 extending perpendicular to the direction of index holes 20. Undercut 54 is spaced above bottom 26 a distance generally equal to the greatest acceptable spacing allowed by Electronic Industries Association standards between the top of body 36 of component 32 and face 16 and in the most preferred form is generally equal to 0.2 mm.

In the packaging method of the present invention, component 32 is lightly positioned and released in pocket



22. It should be realized that component 32 could be positioned off center in pocket 22 such as in a direction parallel to index holes 20 and to the right in Figure 6. The free ends of leads 34 on the right in Figure 6 would engage ramp portion 42 extending generally perpendicular to the direction of index holes 20 and above the position as shown, body 36 would not flushly abut with platform 40 but would abut along a line adjacent to the left edge of platform 40 in Figure 6, and the free ends of leads 34 on the left in Figure 6 would be spaced from side wall 24. Under gravitational forces and from such a position, the free ends of leads 34 would slide down ramp portion 42 to the position as shown. Due to the inclined nature of ramp portion 42, as leads 34 slide downwardly, leads 34 and component 32 are forced to the left and body 36 will move to flushly abut with platform 40. When body 36 flushly abuts with platform 40, the free ends of leads 34 on the opposite side of component 32 simultaneously abut with ramp portion 42 on the opposite side of pocket 22 in the most preferred form. It should be realized that component 32 will not have a tendency to continue to move to the left as to do so would require the free ends of leads 34 on the left side of Figure 6 to ride up ramp portion 42 and move against gravitational forces. Thus, pocket 22 according to the teachings of the present invention centers component 32 therein. If leads 34 of component 32 should not slide down ramp portion 42 until body 36 flushly abuts with platform 40 due to gravitational forces alone such as the result of frictional forces, the normal movement of carrier tape 12 after component 32 has been placed in pocket 22 should jostle component 32 sufficiently to cause leads 34 to slide down ramp portion 42 to thereby center component 32 in pocket 22.

Similarly, component 32 could be positioned off center in pocket 22 in a direction perpendicular to the direction of index holes 20 and to the right or left in Figure 7. In that situation, the free ends of leads 34 on the sides



of body 36 parallel to the direction of index holes 20 would engage and slide down the respective ramp portion 42 also extending parallel to the direction of index holes 20. Thus, pocket 22 would similarly center component 32 in a direction perpendicular to the direction of index holes 20. It should be realized that assuming component 32 has leads 34 extending from all four sides of body 36, pocket 22 according to the teachings of the present invention will center component 32 therein whether or not component 32 is off center in a direction parallel or perpendicular to the direction of index holes 20 or combinations thereof and whether or not the sides of body 36 of component 32 are arranged parallel or non-parallel to directions parallel or perpendicular to the direction of index holes 20. Further, it should be realized that the risk of bending leads 34 is minimal as generally several leads 34 will simultaneously engage side walls 24 so that the forces are spread out and not concentrated on a single or a few leads 34. Further, the forces involved are minimal and generally are limited to gravitational forces, with such forces typically being insufficient to bend or otherwise damage leads 34.

After components 32 are placed in pockets 22, a cover tape 56 of any desired type is suitably secured to face 16 of carrier tape 12. Carrier tape 12 including components 32 in pockets 22 covered by cover tape 56 is then conventionally wound on a reel 58. After wound on reel 58, reel 58 is placed within a static control bag and then into its individual "pizza" box. Several individual "pizza" boxes are then placed in an outer shipping box for storage and transport.

When wound on reel 58, carrier tape 12 has a configuration of an increasing spiral with bottoms 26 of pockets 22 of one wrap abutting with cover tape 56 of the wrap below. It should further be realized that the periphery of any particular wrap and thus the length of carrier tape 12 in any particular wrap increases from the



center of reel 58 outward. Thus, pockets 22 are not necessarily stacked on top of each other in a radial direction such as diagrammatically shown in the top two layers of Figure 8 but rather are often in an overlapping condition as diagrammatically shown in the bottom five layers of Figure 8. The relative position of pockets 22 between wraps then depends on numerous factors including but not limited to the radial spacing from the center of reel 58, the depth of pockets 22, the tension in wrapping carrier tape 12, and similar factors. The diagrammatic showing of Figure 8 represents several of the possible relative positions of pockets 22 in different layers of wrap.

One possibility is that pockets 22 are exactly radially aligned as illustrated in the fifth and sixth layers which are the top two layers of Figure 8. As the size of bottom 26 at the lower edge of skirt 41 is less than the periphery of the sides of body 36, bottom 26 of the top layer will abut with cover film 56 of the fifth layer. It should be understood that if a gap exists between the top of body 36 and cover tape 56 in the fifth layer, bottoms 26 of pockets 22 of the top layer will deflect cover tape 56 to engage the top of body 36 due to the winding tension placed on carrier tape 12 as it is being wound upon reel 58. Thus, body 36 and cover film 56 of the fifth layer is tightly sandwiched between platform 40 of the fifth layer and bottom 26 of pocket 22 of the sixth layer. Due to this sandwiching force, body 36 in the fifth layer is thereby clamped in position in pocket 22 to resist movement therein.

Another possibility is illustrated in the fourth and fifth layers of Figure 8 where the linear portion of bottom 26 of the fifth layer extending perpendicular to the direction of index holes 20 to the right in Figure 8 engages cover tape 56 intermediate the sides of body 36 of the fourth layer and the linear portion of bottom 26 to the left in Figure 8 engages cover tape 56 extending over



face 16 intermediate two adjacent pockets 22 of the fourth layer. Thus, body 36 and cover tape 56 of the fourth layer is tightly sandwiched between platform 40 of the fourth layer and the linear portion of bottom 26 of the fifth layer to the right in Figure 8. Due to this sandwiching force, body 36 in the fourth layer is thereby clamped in position in pocket 22 to resist movement therein. Similarly, body 36 in the second layer is clamped in position by the linear portions of bottom 26 of the third layer extending perpendicular to the direction of index holes 20 to the right in Figure 8.

Another possibility is illustrated in the third and fourth layers of Figure 8 where the linear portion of bottom 26 of the fourth layer extending perpendicular to the direction of index holes 20 to the right in Figure 8 engages cover tape 56 intermediate the sides of body 36 of one component 32 of the third layer and the linear portion of bottom 26 to the left in Figure 8 engages cover tape 56 intermediate the sides of body 36 of the next component 32 in the circumferentially adjacent pocket 22 to the left in Figure 8. It should be realized that body 36 of any particular pocket in the third layer of Figure 8 is engaged by the linear portions of bottom 26 extending perpendicular to index holes 20 of two different pockets 22 of the fourth layer. The purpose of undercuts 54 can now be explained. In particular, the portions of bottom 26 of pockets 22 of the fourth layer parallel to the direction of index holes 20 extends over the face 16 intermediate two adjacent pockets 22 of the third layer. In the event that bodies 36 have a height less than the distance between the top surface of platform 40 and face 16, it is necessary for the linear portions of bottom 26 extending perpendicular to index holes 20 to deflect cover tape 56 into pockets 22 of the third layer and thus be located below the level of cover tape 56 and face 16. Without undercuts 54, the portions of bottom 26 parallel to index holes 20 of the fourth layer would abut against



cover tape 56 and face 16 intermediate pockets 22 of the third layer which would act like a fulcrum and absorb part of the tension forces arising from winding carrier tape 12 in reel 58. Thus, undercuts 54 allow the linear portions of bottom 26 of a single pocket 22 in an upper layer to engage and apply a clamping force to two different components 32 in two circumferentially adjacent pockets 22 of the lower layer. It should be realized that undercuts 54 are not required in the event that bodies 36 have a height generally equal to the distance between the top surface of platform 40 and face 16 such that fulcrum situations do not arise and/or if the forces absorbed by carrier tape 12 between pockets 22 do not sufficiently detract from the clamping forces placed on components 32.

Another possibility is illustrated in the first and second layers which are the bottom two layers of Figure 8 where the linear portion of bottom 26 of the second layer extending perpendicular to the direction of index holes 20 to the right in Figure 8 engages cover tape 56 intermediate the sides of body 36 of one component 32 of the bottom layer and the linear portion of bottom 26 to the left in Figure 8 engages cover tape 56 intermediate component 32 in the circumferentially adjacent pocket 22 to the left in Figure 8 and face 16 intermediate the two adjacent pockets 22 of the bottom layer. It should be realized that the portions of bottom 26 extending parallel to the direction of index holes 20 would engage cover tape 56 and particularly undercuts 54 in the most preferred form and sandwich it against face 16 intermediate the two adjacent pockets 22 of the bottom layer and thereby prevent the linear portion of bottom 26 extending perpendicular to index holes 20 to the left in Figure 8 from extending into pocket 22 in a manner to engage leads 34 of component 32. It should also be realized that due to undercuts 54, cover tape 56 will be deflected from its plane extending over face 16 with cover film 56 thus being placed under tension and in the most preferred form



placing a clamping force against body 36 towards platform 40. Due to these forces, body 36 in the bottom layer is thereby clamped in position in pocket 22 to resist movement therein.

It should be appreciated that as components 32 are clamped in position on platforms 40 of their respective pockets 22 according to the teachings of the present invention, considerable force is required to move components 32 in pockets 22. Thus, in a drop test, the forces at which leads 34 collide with side walls 24 of pockets 22 is substantially less than if components 32 were not under a clamping force in pockets 22. Specifically, such collision forces should be sufficiently small to minimize or generally eliminate the possibility of bending or otherwise damaging leads 34.

In the event that forces are applied to component 32 which would tend to move component 32 in pocket 22 of the type of the present invention, several dynamics are involved. Specifically, due to the angle of incline of ramp portions 42, the free ends of leads 34 engage side walls 24 in a manner to flex leads 34. It should be appreciated that collectively, considerable force can be absorbed by leads 34 before bending or other damage to leads 34 occurs. Thus, pockets 22 of the present invention enhances the spring effect provided by leads 34 of component 32. Further, due to the incline of ramp portions 42, the height of the free ends of leads 34 increases as component 32 moves in a direction parallel to platform 40. Due to this increase in height, leads 34 place a force on body 36 to raise the respective side of body 36 from platform 40. In addition to the forces necessary to do this, force will be necessary to deflect cover tape 56 outwardly. In addition, according to the most preferred teachings of the present invention, the raising of body 36 from platform 40 is further resisted by the clamping force provided by being sandwiched by bottom 26 against platform 40. Thus, bending or other damage to



leads 34 of components 32 is minimized or generally eliminated when reel 58 is subjected to considerable outside forces such as would be present in a drop test.

Contrary to the conventional approach of attempting to position components 32 inside of pockets 22 in a manner such that leads 34 do not engage side walls 24, pockets 22 according to the preferred teachings of the present invention shown in Figures 5-9 are shaped such that leads 34 engage with side walls 24. In this regard, side walls 24 are configured in a manner such that the engagement therewith by leads 34 is in a controlled manner to center component 32 in pocket 22 and to absorb kinetic energy and protect leads 34 from damage as the result of reel 58 being subjected to outside forces such as encountered in a drop test. A major advantage of pocket 22 of the present invention is that provisions 28 can be formed by a platform 40 of a generally planar nature and specifically does not require any ridges or other protrusions which extend above the plane of the bottom of body 36 when supported by provisions 28 in pocket 22. Such ridges or protrusions were a major cause of lead damage in prior carrier tapes.

Thus since the invention disclosed herein may be embodied in other specific forms without departing from the spirit or general characteristics thereof, some of which forms have been indicated, the embodiments described herein are to be considered in all respects illustrative and not restrictive. The scope of the invention is to be indicated by the appended claims, rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are intended to be embraced therein.





CLAIMS

1. Carrier for electronic circuit components having a plurality of leads extending outwardly from a body, with the leads terminating in free ends and being spaced from each other, comprising, in combination: a pocket for receiving the electronic circuit component and including a side wall and a bottom, with the side wall having a shape corresponding to that of the free ends of the leads of the electronic circuit component received within the pocket; and means formed on the side wall for abutting with the free ends of the leads of the electronic circuit component within the pocket for preventing engagement of the leads with the side wall and for optically dispersing major portions of the reflection of the leads.

2. The carrier of claim 1 wherein the abutting means comprises a plurality of spaced abutments having a shape which minimizes the area contacted by the free ends of the leads of the electronic circuit component.

3. The carrier of claim 2 wherein the abutments have semicircular cross sections parallel to the bottom of the pocket.

4. The carrier of claim 2 wherein the spacings between the abutments are not equal to the spacings between the leads of the electronic circuit component for preventing the abutments from interfitting with the leads.

5. The carrier of claim 4 wherein the spacings between the abutments are equal.

6. The carrier of claim 5 wherein the number of abutments formed on the side wall of the pocket is greater than the number of leads extending outwardly from a side of the electronic circuit component corresponding to a length of the side wall of the pocket aligned with the side of the electronic circuit component on which the abutments are formed.

7. The carrier of claim 2 wherein the number of abutments formed on the side wall of the pocket is greater than the number of leads extending outwardly from a side of





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the electronic circuit component corresponding to a length of the side wall of the pocket aligned with the side of the electronic circuit component on which the abutments are formed.

8. The carrier of claim 2 wherein a plurality of pockets are provided at precise intervals on a carrier medium.

9. The carrier of claim 8 wherein the plurality of pockets are arranged at precise intervals in a column.

10. The carrier of claim 8 wherein the carrier medium is formed of semi-flexible material; and wherein the carrier further comprises, in combination: a plurality of longitudinally spaced, indexing holes extending through the carrier medium.

11. The carrier of claim 2 wherein the spacings between the abutments prevent the free ends of the leads from extending between the abutments.

12. The carrier of claim 1 wherein the abutting and optically dispersing means prevent an interfitting relation with the leads.

13. Carrier for electronic circuit components having a plurality of leads extending outwardly from a body, with the leads terminating in free ends and being spaced from each other, comprising, in combination: a pocket for receiving the electronic circuit component and including a side wall and a bottom, with the side wall having a shape corresponding to that of the free ends of the leads of the electronic circuit component received within the pocket; and means formed on the side wall for abutting with the free ends of the leads of the electronic circuit component within the pocket for preventing engagement of the leads with the side wall; wherein the abutting means comprises a plurality of spaced abutments having a shape which minimizes the area contacted by the free ends of the leads of the electronic circuit component; and wherein the spacings between the abutments are not equal to the spacings between the leads of the electronic circuit component for preventing the

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abutments from interfitting with the leads.

14. The carrier of claim 13 wherein the spacings between the abutments are equal.

15. The carrier of claim 14 wherein the number of abutments formed on the side wall of the pocket is greater than the number of leads extending outwardly from a side of the electronic circuit component corresponding to a length of the side wall of the pocket aligned with the side of the electronic circuit component on which the abutments are formed.

16. The carrier of claim 13 wherein the abutments have semicircular cross sections parallel to the bottom of the pocket.

17. The carrier of claim 13 wherein a plurality of pockets are provided at precise intervals on a carrier medium.

18. The carrier of claim 17 wherein the plurality of pockets are arranged at precise intervals in a column.

19. The carrier of claim 17 wherein the carrier medium is formed of semi-flexible material; and wherein the carrier further comprises, in combination: a plurality of longitudinally spaced, indexing holes extending through the carrier medium.

20. Carrier for electronic circuit components having a plurality of leads extending outwardly from at least first and second opposing sides of a body, with the body having a top and a bottom, with the leads having free ends, comprising, in combination: a carrier medium including a front face and a back face; and at least a first pocket for receiving the electronic circuit component, with the pocket including first and second side walls on opposite sides of the pocket and further including means for supporting the electronic circuit component in the pocket, with the supporting means being free of protrusions extending above the bottom of the body of the electronic circuit component when supported in the pocket, and with the side walls including ramp portions inclined upwardly and outwardly,

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with the free ends of the leads on the first and second sides of the body engaging with the ramp portions of the first and second side walls on opposite sides of the pocket when the electronic circuit component is centered in the pocket.

21. The carrier of claim 20 wherein the first and second side walls further include a transition portion extending at an angle up to 90° from the back face for providing the necessary depth to the pocket.

22. The carrier of claim 21 wherein the transition portion is located intermediate the back face and the ramp portion.

23. The carrier of claim 20 wherein the pocket includes a pocket bottom, with the bottom of the body being supported in the pocket by the supporting means intermediate the pocket bottom and the back face, with the pocket bottom having a minimum size in a direction between the first and second side walls which is smaller than the body between the first and second sides, with the size of the pocket bottom being smaller than the size of the pocket at the back face.

24. The carrier of claim 20 wherein the electronic circuit component has a periphery in the shape of a right parallelepiped and the body includes third and fourth opposing sides; wherein the pocket includes third and fourth side walls on opposite sides of the pocket, with the free ends of the leads on the third and fourth sides of the body engaging with the ramp portions on the third and fourth side walls on opposite sides of the pocket when the electronic circuit component is supported in the pocket by the supporting means and centered in the pocket.

25. The carrier of claim 24 wherein the pocket includes a pocket bottom, with the pocket bottom having a minimum size in a direction between the first and second side walls which is smaller than the body between the first and second sides and a minimum size in a direction between the third and fourth side walls which is smaller than the body between the third and fourth sides, with the size of the pocket

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bottom being smaller than the size of the pocket at the back face.

26. The carrier of claim 20 wherein the free ends of the leads on the first side of the body engage the ramp portion of the first side wall simultaneously as the free ends of the second side of the body engage the ramp portion of the second side wall when the electronic circuit component is centered in the pocket.

27. The carrier of claim 20 wherein the ramp portions are inclined at an angle in the order of 30° to the front and back faces.

28. The carrier of claim 20 wherein the ramp portions of each of the side walls do not extend in a single plane.

29. The carrier of claim 20 wherein the supporting means comprises a platform for abutting with the bottom of the body, with the platform being planar and of a size smaller than the perimeter of the bottom of the body.

30. The carrier of claim 29 wherein the platform has an area which is not continuous and which is substantially less than the bottom of the body.

31. Carrier for electronic circuit components having a plurality of leads extending outwardly from at least first and second opposing sides of a body, with the body having a top and a bottom, with the leads having free ends, comprising, in combination: a carrier medium including a front face and a back face; and at least a first pocket for receiving the electronic circuit component, with the pocket including first and second side walls on opposite sides of the pocket, with the pocket further including means for supporting the electronic circuit component in the pocket, with the pocket further including a pocket bottom, with the bottom of the body being supported in the pocket by the supporting means intermediate the pocket bottom and the back face, with the pocket bottom having a minimum size in a direction between the first and second side walls which is smaller than the body between the first and second sides, with the size of the pocket bottom being smaller than the

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size of the pocket at the back face such that when the carrier medium is stacked in an upper layer and a lower layer, the pocket bottom of the upper layer sandwiches the electronic circuit component against the supporting means in the pocket of the lower layer.

32. The carrier of claim 31 wherein the electronic circuit component has a periphery in the shape of a right parallelepiped and the body includes third and fourth opposing sides; wherein the pocket includes third and fourth side walls on opposite sides of the pocket, with the pocket bottom having a minimum size in a direction between the third and fourth side walls which is smaller than the body between the third and fourth sides.

33. The carrier of claim 31 wherein the supporting means comprises a platform for abutting with the bottom of the body, with the platform being planar and of a size smaller than the perimeter of the bottom of the body.

34. The carrier of claim 33 wherein the platform has an area which is not continuous and which is substantially less than the bottom of the body.

35. The carrier of claim 31 wherein the supporting means is free of protrusions extending above the bottom of the body of the electronic circuit component when supported in the pocket.

36. The carrier of claim 32 wherein the pocket bottom includes first and second linear portions extending parallel to the first and second side walls, with the pocket bottom being undercut between the first and second linear portions.

37. The carrier of claim 36 wherein the pocket bottom is annular shaped and includes third and fourth linear portions extending parallel to the third and fourth side walls.

38. The carrier of claim 31 wherein the pocket bottom includes first and second linear portions extending parallel to the first and second side walls, with the pocket bottom being undercut between the first and second linear portions.

39. The carrier of claim 31 wherein the carrier

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medium is made of semi-flexible, deformable material; and wherein the carrier medium is stacked by winding upon a reel.

40. Carrier for electronic circuit components having a plurality of leads extending outwardly from at least first and second opposing sides of a body, with the body having a top and a bottom, with the leads having free ends, comprising, in combination: a carrier medium including a front face and a back face; and at least a first pocket for receiving the electronic circuit component, with the pocket including first and second side walls, a pocket bottom, and means for supporting the electronic circuit component in the pocket, with the supporting means being free of protrusions extending above the bottom of the body of the electronic circuit component when supported in the pocket, with the first and second side walls located on opposite sides of the pocket, with the side walls including ramp portions inclined upwardly and outwardly from the pocket bottom, with the free ends of the leads on the first and second sides of the body engaging with the ramp portions of the first and second side walls on opposite sides of the pocket when the electronic circuit component is centered in the pocket, with the bottom of the body being supported in the pocket by the supporting means intermediate the pocket bottom and the back face, with the pocket bottom having a minimum size in a direction between the first and second side walls which is smaller than the body between the first and second sides, with the size of the pocket bottom being smaller than the size of the pocket at the back face such that when the carrier medium is stacked in an upper layer and a lower layer, the pocket bottom of the upper layer sandwiches the electronic circuit component against the supporting means in the pocket of the lower layer.

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