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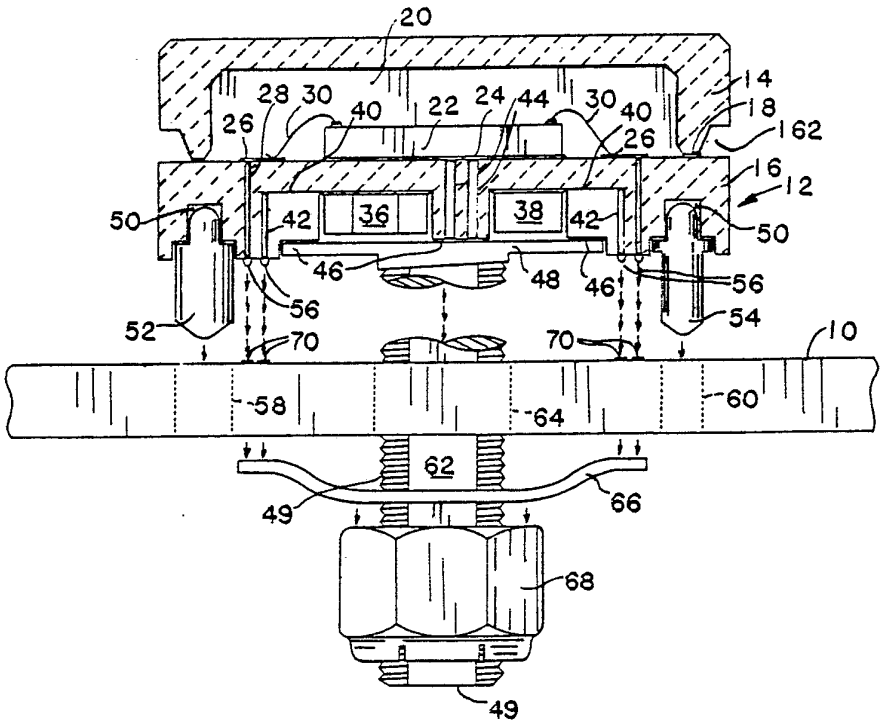

(57) Abstract

An electronic circuit component housing assembly (12) and a method for mounting it mechanically on a printed circuit (10), using a single mechanical fastener (49) to attach the circuit housing assembly (12) in a unique alignment with the printed circuit (10), and simultaneously using the fastener (49) to provide force to press physically compliant electrical contacts (56) included in the circuit housing assembly into electrical contact with terminal contact pads (70) on the printed circuit (10). The mechanical fastener (49) also acts as a thermal conductor. A multiple contact test probe assembly (180) mounts on the electronic circuit component housing (12).

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INTERCONNECTION MECHANISMS FOR ELECTRONIC COMPONENTS

TECHNICAL FIELD

The present invention relates to interconnection of electrical circuit components, and in particular to mounting of integrated circuits and similar electronic components in unitary housings on a printed circuit so as to assure reliable electrical connection in a reduced amount of printed circuit area and with increased contact density.

BACKGROUND ART

Various arrangements of electrical leads have been taught previously for enabling integrated circuit packages to be connected to printed circuits, as by soldering individual leads to the printed circuits or by clamping leads between a rigid separate body and contact pads on a printed circuit. The physical space required to permit soldering individual leads or clamping individual leads in place, however, presents certain shortcomings in applications where signals are intended to be transmitted at high frequencies and where there is high signal line density. Also, the length and impedance of individual conductors may be a factor in the circuit design. In such circuits, it becomes desirable, then, to reduce the size of circuits as much as possible, and, for the sake of reducing the cost of production and repair, it is desirable to provide simple and reliable means for connecting components to printed circuits.

The prior art has typically relied upon chip carriers to house electronic components, with such chip carriers being attached to printed circuits either through the use of conductive adhesives (such as reflowed solders or conductive epoxies) or through the use of a third, electrically conductive, and physically and electrically connective socketing part, which

resides between the printed circuit and the component housing.

The attachment of electronic component housings to the contact pads of printed circuits using socketing parts is a solderless approach to interconnecting the two units, however, in the prior art a third, physically independent, electrically conductive, mechanically and electrically connective part is required for this type of interconnection.

As an example, gull wing leads of an electronic component housing may be mated to the printed circuit contact pad using a compressible elastomer in a socket such that the rigid pressure bracket of the socket compresses the elastomer down upon the gull wing leads and physically and electrically mates the two contacts. Normally, all of such contacts have a high quality exterior finish with high electrical conductivity, such as by the use of gold, and are considered to have a reliable interconnection when a minimum pressure of approximately 8 to 16 grams is applied to the interface between the contacts. Such pressure has been provided in the past by, for example, corner screws which distribute the force across the socket's rigid pressure bracket such that the pressure at each lead is maintained at the required level.

A rigid insulating socket body, in other devices, retains an array of individual pin leaded spring contact sockets, wherein each contact houses a spring contact which mates, again under pressure, to the component housing pin lead. The socket itself, in such systems, is reflow soldered to the printed circuit contact pad, and conductivity between the component housing body and the printed circuit is again made by way of a component socket.

It is also desirable to provide a compatible electromagnetic environment to act as a suitable vehicle for the conveyance of electronic signals

between the printed circuit and the electronic components housed within a component housing, and to supply the signals internally to the electronic components in such a manner as to minimize the total area of circuit board required for the interconnection between the mounted component housing and the printed circuit on which it is mounted.

As the physical size of circuit components is reduced it becomes more and more difficult to make good electrical contact with individual circuit component leads. It is therefore important to provide for reliable electrical connection to the various electrical components located within a housing of reduced size.

Because individual leads previously have had to be connected, by the use of wires or conductive material desposited on flexible films appropriately clamped in place by separate structural members during installation of component housings, the size of conductors and connector pads previously has been larger than would be desired otherwise, in order that desired junctions may be accomplished without inadvertent electrical interconnections of electrical leads which are intended not to be connected to one another. As a result, currently used leads and pads have dimensions which are in many cases much larger than the size needed to carry the anticipated electrical loads.

Along with reduced component size, however, comes added difficulty in making contact for the testing of individual circuit elements.

What is needed, then, is an improved assembly for mounting electronic component housings on printed circuits, making installation simple, accurate, and reliable, and permitting installation of electronic components in a smaller space on a printed circuit than previously was required, while still leaving it possible to test the circuits contained and connected with the electronic components so mounted.

DISCLOSURE OF INVENTION

The present invention provides apparatus and a method for mounting electronic component housings or printed circuits and electrically connecting the components contained within such housings to the appropriate terminals provided on printed circuits, thus overcoming the above-mentioned shortcomings and drawbacks of the previously available ways of connecting electronic component housings to printed circuits.

In accordance with the present invention a housing for an electrical component assembly is mounted on a mechanical fastener, and cooperative alignment members are provided on the housing and a printed circuit on which it is to be mounted, to assure that the electronic component housing is aligned precisely with the printed circuit when the mechanical fastener is used to attach the electronic component housing to the printed circuit. Mechanically compliant electrical contacts are connected to the electronic circuit components held within the housing and are located about the periphery and interior of the face of the housing directed toward the printed circuit, so as to be properly aligned with mating conductor terminal pads provided in a planar array as part of the printed circuit. When the electronic component housing according to the present invention is mounted on the printed circuit accurate alignment and ample pressure are provided to assure reliable physical contact and resulting electrical contact between the circuits contained in the electronic component housing and those of the printed circuit, without the use of electrically conductive adhesives and without the use of physically independent sockets, clamps, and the like.

In order to minimize the total area required for the interface between the electronic circuit component housing and the printed circuit, the component mounting system of the present invention provides for

contacts on the electronic circuit component housing which interconnect with contact pads of the printed circuit, and which extend from beneath the electronic component housing, so that not all of the signal lines entering the component housing need to originate adjacent the edge of the component housing. This allows a smaller number of conductors to be more closely spaced at the edges of the housing and allows other conductors to enter the housing at the corner and interior portions which, as such, do not require significant additional area to be taken up by the component housing.

Only the critical signal lines are required to be brought from the outer edge of the component housing to the interconnection region near the edge of the electronic component, which is typically mounted centrally within the component housing, and thus the overall exterior dimensions of the housing are reduced due to the need to incorporate a lesser number of lines arrayed side by side.

The present invention also provides a mechanism for monitoring the electronic signals traveling between the printed circuit and electronic components housed within the component housing. This monitoring is accomplished by using a multiple contact probe attached to the component housing, the probe using compliant contacts to contact the electronic component housing and the printed circuit, to sense both a reference signal and the signals residing on the conductors radiating from beneath the attached component housing.

It is therefore a principal object of the present invention to provide an improved method for direct, non-permanent, electrical interconnection of electronic components with electrical circuits contained on mechanically supportive members on which the electronic component housings are to be mounted.

It is another important object of the present invention to provide for mounting electronic component housings on printed circuits in a manner which requires less physical space for removably mounting the electronic circuitry contained in a particular electronic component housing.

Yet another object of the invention is to provide electrical interconnection of electronic components with electrical circuits by providing the electrical components with compliant electrical contacts and a single fastener for applying compressive force so as to hold the contacts onto the electrical circuits.

A still further object of the present invention is to provide a compressive fastener having orientation means for ensuring proper alignment of electrical components with electrical circuits.

Yet another object of the present invention is to provide a test probe assembly for electrical components compressively connected to electrical circuits which may be electrically connected to such components, and take measurements therefrom, without interfering with the connection between the electrical components and the electrical circuits.

A further object of this invention is to provide a method for placing electrical resistors between circuit paths or contact points economically and using a minimum of space.

The foregoing and other objectives, features, and advantages of the invention will be more readily understood upon consideration of the following detailed description of the invention, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view of a portion of a printed circuit and an electronic circuit component housing embodying an interconnection mechanism according to the present invention.

FIG. 2 is a bottom plan view of the electronic circuit component housing shown in FIG. 1.

FIG. 3 is a top plan view of the portion of the printed circuit shown in FIG. 1, showing the mounting site which is available on the printed circuit to be occupied by the electronic component housing assembly shown in FIG. 1.

FIG. 4 is a top plan view of the electronic circuit component housing assembly shown in FIG. 1, without the lid of the housing.

FIG. 5 is a partially cut-away top plan view of a portion of the electronic circuit component housing as shown in FIG. 4, with a portion of an integrated circuit mounted thereon.

FIG. 6 is a top plan view, at a further enlarged scale, of a portion of the area of the electronic circuit component housing assembly shown in FIG. 5.

FIG. 7 is a side view of the portion of the electronic circuit component housing shown in FIG. 6.

FIG. 8 is a top plan view of the electronic circuit component housing and portion of a printed circuit shown in FIG. 1, with a circuit testing probe assembly in place on the electronic component housing.

FIG. 9 is a side elevational view of the electronic circuit component housing and probe shown in FIG. 8.

FIG. 10 is a sectional side view, taken along the line 10-10 of the electronic circuit component housing and probe shown in FIG. 8.

FIG. 11 is a sectional view of a portion of a printed circuit and an electronic circuit component housing mounted thereon which is another embodiment of the present invention.

FIG. 12 is a bottom plan view of the electronic circuit component housing shown in FIG. 11.

FIG. 13 is a sectional side view similar to that of FIG. 10, showing the electronic component housing shown in FIGS. 1-5, with an associated test probe of a second type in place thereon.

FIG. 14 is a sectional view of a portion of a printed circuit and an electronic circuit component housing mounted thereon which is a third embodiment of the present invention.

FIG. 15 is a bottom plan view of the electronic circuit component housing shown in FIG. 14.

FIG. 16 is a sectional side view similar to that of FIGS. 10 and 13, showing the electronic circuit component housing assembly of FIGS. 1-5, together with a circuit test probe attached thereto.

FIG. 17 is a bottom plan view of an electronic circuit component housing containing several electronic component assemblies and embodying the interconnection mechanism of the present invention.

FIG. 18 is a sectional side view of an exemplary assembly alignment device and an electronic circuit component housing similar to that shown in FIGS. 1-5, showing the manner of assembling the circuit component housing with its lid properly aligned with its base.

BEST MODE FOR CARRYING OUT

Referring now to FIGS. 1-4 of the drawings, in a first embodiment of the present invention, a portion of a printed circuit 10 is shown in side view, together with an electronic circuit component housing 12 embodying the interconnection mechanisms for electronic components according to the present invention. The electronic circuit component housing 12 includes a lid 14, which is hermetically attached to a base 16 by a hermetic seal 18 to define a cavity 20. The component housing base 16 and lid 14 may be made of a ceramic material such as alumina. The hermetic seal

18 may be formed of a fusible adhesive, as by soldering.

Within the cavity 20 is located an active electronic component such as an integrated circuit chip 22 mechanically attached to the upper side of the base member 16, using eutectic reflow solder 24 or other industry standard techniques.

The base 16 also includes horizontal electrical conductors 26 and vertical electrical conductors 28. The conductors 28 and 30 may be made by sintering refractory metal paste in the appropriate locations. Electrical conductors 30, typically fine wires, connect the various terminals of the integrated circuit chip 22 to respective ones of the horizontal conductors 26 in a conventional manner.

The base member 16 also defines cavities 32 and 34 on its lower side, for containment of other passive or active electronic components 36, 38. Additional horizontal conductors 40 and vertical conductors 42 are connected electrically to the components 36 and 38, and may be made in the same fashion as the horizontal and vertical conductors 26 and 28. Additional sintered refractory metal vertical conductors 44 are also provided, and may serve as thermal conductors to draw heat away from the integrated circuit chip 22 as necessary, as well as providing appropriate electrical connection between the chip 22 and the head 48.

The ceramic technology typically employed to construct the component housing base 16 is typically referred to as refractory metal multi-layer ceramic technology. In the construction of the base 16, multiple layers of green ceramic material are first shaped and punched with "via" holes, and refractory metal paste is then applied by screening. Following this process for each layer required, all of the layers are laminated together, shaped again, sintered, and plated as necessary with other conductive metals.

Finally, any parts which are to be attached to the component base 16 may be attached using conventional brazing techniques. In fabrication of the electronic circuit component housing 12 and its included electronic components 22, 36, and 38, the base 16 is inverted so that the components 36 and 38 may be placed within the cavities 32 and 34 to be connected with their respective conductors 40.

A hermetic seal area 46 surrounding the cavities 32 and 34 is then covered by a brazing preform, and the generally planar head 48 of a mechanical fastener such as a screw 49 is placed on top of the preform. It will be appreciated that the head 48 of the screw 49 thus serves as a bottom wall of the cavities 32 and 34 so that the hermetic seal area 46, when the head 48 is connected, as by brazing, to the base member 16, provides a hermetically sealed cavity to contain the electronic components 36 and 38. At this time, appropriate brazing preforms are placed in sockets 50 defined in the bottom side of the base member 16, and respective alignment pins 52 and a key alignment pin 54 are set atop the preforms within the sockets 50. Thereafter the component housing base is heated to braze the head 48 of the screw 49, and the alignment pins 52 and 54, to the base member 16. Each of the vertical conductors 28 and 42 is provided, in this embodiment of the invention, with a conductive compliant contact in the form of a nodule 56 located in the appropriate position upon the bottom side of the component housing base member 16. A preferred method of constructing these conductive compliant contact nodules 56 is to plate the exposed lower end portions of the refractory metal vertical conductors 28 and 42, also known as vias, with gold to form a generally hemispherical deposit of substantially pure gold, which is well suited for this application because of its softness, ductility, and conductivity. Each nodule is,

for example, in the form of a hemisphere about 0.008 inch in diameter, although the size is not critical so long as it is great enough to accomodate irregularities in the shapes of the base 16 and the printed circuit 10. Such nodules could be arrayed with spacing of 0.020 inch, center to center. Alternatively, nodules of conductive silicone material may be applied by screening them atop the lower end of each vertical conductor 28.

The horizontal electrical conductors 26 may be formed on the top side of the base 16 using a thin film deposition technique. Thereafter the integrated circuit chip 22 or other electronic component is attached to the deposited metal on the top side of the housing base 16 as will be described in greater detail subsequently. The ceramic component housing lid 14 is then aligned accurately with the base member 16 and attached to it, as by use of reflow solder to form the hermetic seal 18 described previously.

When the electronic circuit component housing 12 is complete, it may be attached to the printed circuit 10 by aligning the alignment pins 52 and the key alignment pin 54 with alignment apertures 58 and a key alignment aperture 60 defined in the structural portions of the printed circuit.

The screw 49 is a D-shank screw, including a flat side 62 which is useful as will be explained subsequently for alignment of the electronic circuit component housing 12 by automatic component installation machinery. An aperture 64 defined in the printed circuit 10 is, however, preferably circular because of the lower cost of producing a circular aperture. When the electronic circuit component housing 12 has been properly located on the printed circuit 10, a tensioning member, such as a spring washer 66, is placed on the shank of the screw 49 on the side of the printed

circuit 10 opposite the location of the circuit component housing 12, and a complementary member of the mechanical fastener, in this case a locknut 68, is assembled with the screw 49 and tightened so as to place the elongate shank portion of the screw 49 in tension, which is maintained by the elastic force provided by the spring washer 66.

Nodular shaped gold conductive compliant contacts such as the nodules 56 will make a reliable, mechanical and electrical interconnection with terminal contact pads 70, provided on the printed circuit 10, when compressed with a force of approximately 8 to 16 grams urging each nodule 56 contact toward the surface of the respective contact of the terminal pads 70. The mechanical fastener employed in accordance with the present invention provides compressive force distributed through the base member 16 of the electronic component housing 12 by way of the mechanical fastening device such as the screw 49, with the force being distributed laterally from the shank of the screw toward the nodules 56 by the head 48, so that the requisite force is provided at each of the contacts to provide electrical contact without the need to use conductive adhesives such as reflow solders, conductive epoxys, and the like. As a result, the electronic component housing 12 may be attached to or detached from the printed circuit 10 without the use of specialized equipment or facilities. In this manner the component housing 12 acts as its own base, while the printed circuit 10 acts as a socket in the traditional sense of receiving and electrically connecting the component housing 12, and the expense of a separate and independent socketing member separately mechanically fastened to the printed circuit to retain the electronic circuit component housing 12 is unnecessary. The compliant nature of each contact nodule 56 provided on the base member 16 permits the various nodules 56 to adjust to

the varying geometry of the printed circuit 10 on which the electronic circuit component housing 12 is mounted. Thus, although the conductive compliant nodule contacts 56 are small, they are required to adjust only to the relatively small amount of unevenness of the surface of the printed circuit 10 in the localized area of the mounting site covered by the electronic circuit component housing 12.

The force necessary to hold the compliant conductive electrical contacts against the surface of the terminal pads 70 is derived from the particular mechanical fastening device, which may comprise, instead of the threaded "D"-shank screw 49 shown in FIGS. 1 and 2, a threaded socket attached to the base member 16 and a complementary screw (not shown) which may be chosen in the appropriate length, depending upon the thickness of the printed circuit structure with which a particular electronic circuit component housing 12 is to be used. Because it is necessary to maintain at least a minimum amount of force on each of the conductive compliant contacts, to preserve the electrical integrity of the interface between the contacts of the electronic component housing 12 and the printed circuit terminal pads 70, it is important that the tensioning force storage member, such as the spring washer 66, be able to maintain and exert force to provide tension in the mechanical fastener over a span of time and throughout a range of temperatures, both to accommodate the thermal expansion characteristics of the entire interconnection system and to offset any relaxation that may occur as a result of deformation of the contacts themselves.

The alignment pins 52 and the key alignment pin 54, are preferably constructed to be of diameters nearly equal to those of the alignment apertures 58 and key alignment aperture 60, respectively, so that, when located at the extremities of the electronic circuit

component housing 12 the engagement of the pins with the respective apertures will minimize the possible misalignment of the conductive compliant nodules 56 with respect to the terminal pads 70. This is essential when a single mechanical fastening device, such as the screw 49, is used to attach the housing 12 to the printed circuit 10.

Referring particularly to FIG. 2, it may be seen that the nodules 56 may be arrayed in close proximity to one another about the periphery of the base member 16. Preferably, a plurality of DC contacts 72 are located about the alignment pins 52 and 54 in the corners of the base member 16. The interior-most row 74 of contacts are, for example, the reference contacts for the reference plane of a high frequency transmission line, while the outermost row 76 of contacts are preferably for the individual signal transmission line conductors.

At the center of the electronic circuit component housing 12, as shown in FIG. 2, is the screw 49. It will be appreciated that the head 48 of the screw 49 has a unique diagonal corner portion 78 oriented toward the key alignment pin 54, which is of a smaller diameter then the other alignment pins 52, and that the flat side 62 of the screw 49 has a particular orientation which is useful as mentioned previously to detect the orientation of the electronic circuit component housing 12 prior to its insertion into the printed circuit 10, so that appropriate automatic insertion equipment may be used for assembling the component housing 12 into the printed circuit 10 during production-scale fabrication of large electronic circuits. It will be appreciated that the alignment apertures might be provided in the base member 16 and the alignment pins 52 and 54 might be permanently installed in the printed circuit 10, or some of the pins might be located on the printed circuit 10 while

others are located on the base member 16. The object is to ensure that installation of the electronic circuit component housing 12 is possible only in a single orientation in which each of the compliant contact nodules 56 is properly aligned with the corresponding terminal pad 70 on the printed circuit 10.

FIG. 3 shows a portion of the printed circuit 10 including and surrounding the area which is covered by the electronic circuit component housing 12 when it is in place on the printed circuit 10. It will be appreciated that the several electrical conductors 80 extend perpendicularly away from the outer boundaries of the mounting site for the housing 12. The importance of this orientation will become apparent subsequently in connection with a test probe adapted for use in conjunction with the circuit component housing 12. It will be appreciated that the plurality of DC contacts 72 surrounding each of the alignment pins 52 and 54 will fall on a single electrical conductor terminal pad 82 surrounding each of the alignment apertures 58 and 60.

Referring particularly to FIG. 4, it will be seen that each of the connector conductors 30 leads from the integrated circuit chip 22 connect to a respective one of the conductors 26 located atop the base member 16.

Referring now to FIGS. 5, 6 and 7 a portion of the upper surface of the base member 16 and the integrated circuit chip 22 indicated by the broken line outline 84 in FIG. 4 is shown at an enlarged scale in FIG. 5, showing interconnection of the individual conductors 30 with various ones of the horizontal conductors 26 atop the base member 16. Preferably, the conductors 26 are, themselves, portions of a printed circuit forming the upper surface of the base member 16. In FIGS. 5 and 6, a portion of the integrated

circuit chip 22 has been cut away in the upper right-hand corner of the views shown, to expose portions of printed circuited conductors located beneath the integrated circuit chip 22. Location of these terminals beneath the integrated circuit chip 22 reduces the amount of space needed on the upper surface of the printed circuit 10 for the electronic circuit component housing. For example, such conductors may extend downwardly to a single common terminal 86 surrounding the aperture 64, as shown in FIG. 3.

Referring particularly to FIG. 6, a strip of resistive material, such as a thin strip 100 of NiChrome is deposited on the upper surface of the base member 16 as a straight line generally parallel with the nearby edge of the integrated circuit chip 22. The strip 100 of NiChrome is interrupted at various locations, as where the conductor 102 and the conductors 104 and 106 are located as shown in FIG. 6, but it is easier to deposit a single occasionally interrupted line extending peripherally about the intended location of the integrated circuit chip 22 then to deposit numerous short lines extending perpendicular to the edges of the integrated circuit 22. After the strip 100 is deposited on the base member 16, the conductors such as the horizontal conductors 26 and the conductors 102, 104, and 106 are deposited, so that the resistive NiChrome material of the strips 100 provides a resistive interconnection between those portions of the printed circuit interconnected by the deposited strips 100.

In each case the width of the gap determines the effective length, and thus the resistance value, of each portion of the resistive material, which is deposited in a strip of uniform width and thickness. The various conductors 30, as shown in FIG. 5 may be connected directly to one of the horizontal conductors 26, as at 108, where that particular conductor 26 is

thus made to be a controlled impedance signal line, interconnected with the surrounding deposited metal of a ground plane area 110, by a segment of the strip 100 extending from the conductor 26 to the base plane material 110 on either side of it. Alternatively, a conductor 30 may be connected as at 112 to a horizontal conductor 26 which is a non-controlled impedance signal line, entirely isolated from the ground plane area 110, as in the case of an active signal transmission line. At junction 114 a lead 30 extends from the integrated circuit chip 22 to a pad 116 which is resistively interconnected with the ground plane 110, while a jumper 118 also connects the nearest horizontal conductor 26 to the pad 116 to provide a controlled impedance signal line equivalent to that at 108, by again providing a resistive connection to the ground plane 110 by a pair of short segments of the deposited NiChrome resistive material of the strip 100. It will be appreciated that the total resistance between the pad 116 or the junction 108 and the ground plane 110 will be half the resistance of a single length of the strip 100 long enough to bridge the gap between the pad 116 and the closest portion of the ground plane conductor material, and that in designing the layout of the conductors deposited atop the base member 16, the resistance for each terminal may be determined by the width of the gap provided to be bridged by a particular portion or portions of a strip 100. In normal manufacturing practice, the NiChrome strips 100 would be deposited on the base member 16, while the printed circuit including the conductors 26, 102, 104, 106, and 110 would be deposited atop the strips 100 in electrical contact with them.

As may be seen with reference to FIG. 7, the bottom, or contacting side of the integrated circuit chip is electrically insulated from the printed circuit including the conductors 102, 104, 106 and the ground

plane 110 by a protective insulated layer 120, upon which is an additional conductive layer 122 whose dimensions closely correspond to those of the integrated circuit chip 22, so that the integrated circuit component 22 can be attached mechanically to the base member 16 by conventional attachment techniques such as eutectic attachment, reflow solder, or conductive epoxy, etc. Preferably, the protective electrically insulative layer 120 is of a material such as glass.

In order to obtain electrical connection with the circuitry contained within the electronic circuit component housing 12, a probe assembly 130 shown in FIGS. 8, 9 and 10 is provided for use in conjunction with the electronic circuit component housing 12. The probe assembly includes a set of four probe sections 132, 134, 136, and 138 each having an internal face configuration adapted to fit matingly against a corresponding face portion of the electronic circuit component housing 12, so that the probe assembly 130 surrounds the electronic circuit component housing 12 as shown in FIG. 8, with a respective set 140 of output leads extending from each of the probe sections 132, 134, 136, and 138 to provide connection to appropriate electronic testing and measuring equipment (not shown). A pair of elastic bands 142 and 144 under tension hold the probe sections snugly against the respective sides of the electronic circuit component housing 12, while the ends of adjacent probe sections abut against one another in diagonal surfaces which preferably include mating cavities 146 and protuberances 148, which permit the probe sections to pivot with respect to one another about their adjacent end portions. A pivot fulcrum, such as a rib 150, which may be continuous or interrupted, extends along an inner face 152, or attaching side, of each probe section, preferably aligned approximately vertically even with an upper elastic band 142. The rib 150 acts as a linear fulcrum about

which each probe section may be pivoted or rocked, with the rib 150 in contact with a respective generally vertical portion of the periphery of the lid 14 of the circuit component housing 12. An upper portion 154 of each probe section extends away from the printed circuit 10 above the rib 150, so that the respective upper portions 154 of each of the probe sections 132, 134, 136, and 138 may be pressed together manually, pivoting the probe sections with respect to one another about their ribs 150 and/or the pivotal joints defined by the cavities 146 and protuberances 148, urging the lower portions of the probe sections to part from one another against the tension in the elastic bands 142 and 144, to permit installation or removal of the probe assembly 130 with respect to the electronic circuit component housing 12. To aid further in installation of the probe assembly 130, each of the probe sections includes, preferably, a beveled or chamfered lower inner margin portion 158.

Located along the inner face 152 of each of the probe sections is a probe reference contact 160 having a shape adapted to fit between the upper surface of the base member 16 and a portion of the lid 14, preferably within a channel 162 defined by the shape of the lower marginal portion of the lid 14. Within the channel 162 a reference electrical potential is available, preferably through the electrically conductive material forming the hermetic seal 18, so that reference potential is available to be sensed through the probe reference contact 160. Along a lower margin 164, or tip, of each of the probe sections 132, 134, 136, and 138, are a plurality of compliant electrically conductive contact nodules 166, each similar to the nodules 56. The nodules 166 are connected electrically with respective conductors of the output lead set 140 of the respective one of the probe sections. Each of the nodules 166 is so located as to contact physically,

and thus electrically, a respective one of the electrical conductors 80 extending away from the electrical circuit component housing 12 as discussed with reference to FIG. 3.

When the probe sections 132, 134, 136, and 138 are squeezed toward one another and the probe assembly 130 is placed properly about the electronic circuit component housing 12, releasing one's grasp on the upper portions 154 permits the lower portions 156 of the probe sections to be drawn toward one another and the base member 16, and, with the probe reference contact members 160 located properly within the channels 162, the nodules 166 are drawn into physical and electrical contact with the proper ones of the electrical conductors 80 surrounding the electronic circuit component housing 12, permitting measurement of the various electrical signals available and thus enabling performance of the electronic components located within the electronic circuit component housing 12 to be evaluated.

There is an electrical reference contact pad 168 located within the channel 162 on a surface of either or each of the lid 14 and base 16. Pressure is developed against both the reference contact pad 168 and respective ones of the printed circuit conductors 80, etc., as a result of the attachment of the probe assembly 132 to the electronic circuit component housing 12. This force is supported by and transferred through the electrical circuit component housing body 12 and the mechanical fastener, such as the screw 49, which fastens the electronic circuit component housing 12 to the printed circuit 10.

An alternative embodiment of the interconnection system of the present invention is shown in FIGS. 11, 12, and 13, in which a printed circuit 180 is shown, together with an electronic circuit component housing 182 which is adapted for use therewith. The

electronic circuit component housing 182 includes a top portion 184, shown in section view in FIG. 11, which is molded together with a base portion 186. The base portion 186 encloses a head portion 188 of a mechanical fastener which extends downwardly through the bottom of the base portion 186 in a central location thereon. An integrated circuit chip 192 is attached to an upper surface of the head 188 by conventional electrically conductive adhesive means such as reflowed solder 194. A ring 196 of insulative material is adhesively attached to the upper surface 190 of the head 188, surrounding the integrated circuit chip 192. A conductive compliant lead frame 198 is attached adhesively to the upper side of the insulating ring 196. Preferably, the lead frame assembly 198 is attached to the insulative ring 196 in a flat condition. Therafter, additional electronic components, either active or passive in nature, such as the components indicated as 200 and 202 may be adhesively attached to the upper side of the lead frame assembly 198 using well-known techniques. The lead frame 198 is made, preferably, of a metal alloy such as a copper-nickel-tin alloy which has good conductivity and sufficient stiffness to be self-supporting and resilient.

The several terminals of the IC chip 192 are connected by respective conductors 204 to respective individual ones of the several leads 206 of the lead frame assembly 198, using conventional techniques for making the electrical connections. Similarly, the components 200 and 202 are connected electrically to respective ones of the individual leads 206. When this has been accomplished, the top 184 and base 186 are molded in place about the components mounted atop the head 188, preferably using a thermoplastic insulating material.

Thereafter, leads 206 are trimmed and bent to the shape shown in FIGS. 11 and 13, resulting in a

complex lead frame assembly including the head 180, the leads 206, and the insulator 196. Each of the individual leads 206 is trimmed so that its outer end 208 is able to fit around a convexly arcuate lower rim portion 210 of the base member 186 toward a channel 212 which limits the possible extent of travel of each lead 206. Dividers 214 are provided to maintain separation between the individual leads 206 to prevent them from coming into electrical contact with adjacent ones. The leads 206 are, for example, 0.005-0.018 inch thick and 0.0080.025 inch wide, and may be spaced at least as closely as to provide about 0.015 inch lateral separation.

Alignment pins 218 and a keying alignment pin 220, and corresponding alignment apertures 222 and a keying alignment aperture 224 are located, respectively, on the base member 186 and defined in the printed circuit 180, although their positions could be mixed or reversed as described previously in connection with the electrical circuit component housing 12 and printed circuit 10. When the alignment pins and apertures are properly mated, a contact portion 225 of each of the individual leads 206 is properly positioned to come into electrical contact with a corresponding terminal contact pad 226 of a respective conductor of the printed circuit 180. As with the conductors 80 of the printed circuit 10, the conductors 228 of the printed circuit 180 extend parallel with one another away from the mounting site of the electrical circuit component housing 182. When the ends 208 contact the bottom of the channel 212 an outward wiping movement of the contacts 225 against the terminal pads 226 occurs, contributing to good electrical contact.

An elongate portion, such as the "D" shank 230 is connected with the head 188 and extends through a hole 232 defined in the printed circuit 180, where a spring washer 234 and a locknut 236 perform the same

functions as described previously in connection with the spring washer 66 and locknut 68 of the electronic circuit component housing 12.

A probe assembly 240 is similar in function to the probe assembly 130, as shown in FIG. 13, and includes a probe section 242 adapted to mate with each indivdiual side of the electronic circuit component housing 12 uniquely to assure that the probe assembly 240 can mate in only one way with the electronic circuit component housing 12. Each probe section 242 defines a fulcrum in the form of a rib 244 located on an inner face or attaching side 246. An output lead set 248 extends from an upper portion 250 and elastic tension members 252 and 254 surround the probe sections 242 to hold them physically against the peripheral surfaces of the electronic circuit component housing 12, as in the probe assembly 130.

A probe reference contact 256 extends inwardly into the channel 160 defined between the lid 14 and the base 16 of the electronic circuit component housing 12, where a reference contact pad 168 may be provided, as described previously. Extending downwardly and arcuately outwardly about the tip or lower marginal rim portion 262 of each probe section 242 are a plurality of spring contacts 264 which are similar to the spring contacts 225 of the electronic circuit component housing 182. The spring contacts 264 are located in positions corresponding to the locations of the several conductors 80, so that when the probe assembly 240 is attached to the electronic circuit component housing 12 the spring contacts 264 are held in electrical contact with the conductors 80, making the various voltages detectable by means of the output lead set 248. As with the probe assembly 130, the probe assembly 240 is held with sufficient force toward the upper surface of the printed circuit 10 by tension forces carried by the fastener 49 attaching the

electronic circuit component housing 12 to the printed circuit 10.

A third embodiment of the electronic component interconnection mechanism according to the present invention is shown in FIGS. 14, 15, and 16, in which an electronic circuit component housing 282 is similar in many respects to the electronic circuit component housing 182, and is mounted on a printed circuit 280 in a similar fashion. A top portion 284, as is the top portion 184, is concurrently molded with a base portion 286 retaining a head 288 of a mechanical fastener as described previously in connection with the electronic circuit component housing 182. The head 288 includes an upper surface 290, and an integrated circuit chip 292, or another active electronic circuit assembly, is adhesively attached to the upper surface 290 by conventional means such as reflowed solder 294. A ring 296 of electrically insulating material is adhesively attached to the upper surface 290 and surrounds the integrated circuit chip 292.

The third interconnection mechanism, according to the present invention, resides in the provision the complex lead frame assembly of the electronic circuit component housing 282, which comprises a multi-layered "tape" lead frame 298 of flexible conductors including a plurality of closely-spaced individual conductors 300 deposited on a flexible supportive backing of sheet material 302, such as a polyimide plastic.

While this method of providing conductors in electronic circuits is well known as the tape automated bonding connection, in the present invention only one end of each of the conductors 300 is connected in the usual tape automated bonding method. Each of the several conductors 300 is connected either to a respective appropriately located terminal of the integrated circuit chip 292, or to respective conductors of other

electronic components, either passive or active, such as the components 304 and 306, which are adhesively attached atop the flexible tape conductors of the lead frame 298. As with the electronic circuit component housing 182, both the lid portion 284 and the base portion 286 are concurrently molded of thermoplastic material surrounding the head 288 and the components which are mounted thereon. Respective alignment pins 208 and a key alignment pin 210 are provided as a part of the form of the base 286, and corresponding alignment sockets 312, 314 are defined through the support strata of the printed circuit 280 to ensure proper orientation of the electronic circuit component housing 282 when it is installed upon the printed circuit 280.

Terminal contact pads 316 and associated conductors extending away from the contact pads 316, are provided as a part of the printed circuit on the upper surface of the printed circuit 280. The contact pads 316 are located to correspond with the locations of the individual compliant conductors 300 which extend downwardly along the peripheral surface of the base member 286. The supporting insulative flexible material of the sheet backing 302 extends inwardly beneath the base member 286, where it is held appropriately in position by the provision of appropriately located apertures 320 through which the alignment pins 308 and key alignment pin 310 extend to retain the sets of conductors 300 properly located with respect to the base 286 so that horizontal, downwardly facing portions of each of the conductors 300 are available in the form of compliant electrically conductive contact portions 322.

Arranged along the bottom surface of the base member 286, and held in place preferably by being molded in place with the dovetail interconnecting portions, are respective inner and outer resilient, elastomeric support members 324 and 326 which extend downward beneath the base member 286 below the height

of an alignment surface 328 surrounding each of the alignment pins 308 and key alignment pin 310 as a means of assuring that the electrical circuit component housing 282 assumes the proper location with respect to the upper surface of the printed circuit 280 in response to tightening of the locknut 330 on the elongate shank 332. Tightening the locknut 330 urges the spring washer 334 toward the opposite side of the printed circuit 280, placing the elongate shank 332 in tension and urging the electronic circuit component housing 282 into intimate contact against the upper surface of the printed circuit 280. When the elongate shank 332 is placed in tension, the force is distributed by the head 288 and urges the outer support elastomeric members 326 compressively toward the upper surface and the contact pads 316 on the printed circuit 280 urging the contact portions 322 of the compliant leads 300 into physical contact with sufficient force to provide reliable electrical contact between the contact portions 322 and the contact pads 316, thus electrically connecting the active and inactive components contained within the electrical circuit component housing 282 with the remainder of the electronic circuitry of the printed circuit 280. The amount of compression required depends on the material, and 20% compression, in the case of silicone rubber, is sufficient.

A third probe assembly 340 is provided with contacts of similar construction to that of the electronic circuit component housing 282. The probe assembly 340 is generally similar construction and operation with that of the previously described probe assemblies 130 and 240, except that it includes compliant electrically conductive contacts 342 of multi-layered flexible tape-supported construction similar to that of the conductors 300, flexible backing sheet 302, and contacts 322 described above in connection with the

electronic circuit component housing 282. A lower marginal portion 346 of each probe section 344, of which there is one for each side of the electronic circuit component housing 12, is provided with an elastomeric, compressible support portion 348 which is preferably molded in place along the lower marginal portion 346, so that each of the compliant contacts 342 is held in electrical contact with the respective conductor 80 extending outwardly away from the contact pads 72 surrounding the mounting site for the electronic circuit component housing 12.

The construction described above for each of the electrical circuit component housings 12, 182, and 282 provides compliant electrical contacts located appropriately close to one another to provide improved contact point density for easily mounting electronic circuit assemblies on printed circuits appreciably more densely than has previously been possible, making it possible to mount such components as integrated circuit chips in a space which may be as small as only 40% as large as that which would have been required to mount the same chip using previously employed interconnection and physical attachment systems, while also providing a path for conduction of thermal energy away from the active electronic components such as integrated circuit chips carried within the electronic circuit component housings. While the use of a single mechanical fastener has been disclosed in connection with attachment of single integrated circuit chips and associated discrete components, the mounting system and closely spaced compliant electrical contacts according to the invention can also be provided in a larger electrical circuit component housing 360, as shown in FIG. 17, where several integrated circuits, each mounted on a respective mechanical fastener 362 having a broad generally planar head 364 with an associated array of contacts 366, preferably of the deformable nodule type

used in the electrical circuit component housing 12, are provided with respect to each individual one of the several active circuit components and their associated discrete active and/or passive components. When several integrated circuit components, each mounted on a separate mechanical fastener 362, are provided on a single base member 365, it is necessary to provide only a single set of alignment pins 368 and a single orientation-enforcing key alignment pin 370. Alternatively, a similar mechanism, such as a non-symmetrical arrangement of the fasteners 362 may be used to ensure proper orientation of the multiple component assembly 360 on a printed circuit, with each of the many compliant individual contacts located properly with respect to respective contact pads on the printed circuit, and with an appropriate amount of compressive force provided by tension in the individual mechanical fasteners 362.

As shown in FIG. 18, the electronic circuit component housing 12 is preferably assembled most conveniently, so as to ensure accurate alignment and hermetic sealing of the lid 14 to the base 16, by the use of an assembly guide 380 which may, for example, be a crucible capable of being heated in an oven to provide the required temperature for fusing a eutectic sealing material or reflowed solder to form the hermetic seal 18 between the lid 14 and base 16. The assembly guide 380 includes parallel vertical sides 382, 384 defining a cavity 388 to receive the base portion 16 and lid 14 properly aligned with respect to one another, and with a lateral gap 386 great enough to permit a freely sliding movement of the base 16 into and out of the cavity 388. The lateral gap 386, however, must be small enough to assure alignment of the lid 14 to the base 16 within the limits of tolerance imposed by the small size of the electrical conductors 80 in order that the probe assembly 130 can

be properly aligned with the electrical conductors 80 when the rib 150 is held in contact with the lid 14 as previously described.

Depending upon the type of mechanical fastener used in conjunction with the electronic circuit component housing 12, a cavity 390 may need to be provided to receive a shank portion of a screw 49 in order to provide a stable location of the electronic circuit component housing 12 within the cavity 388. It should be noted that the alignment cavity 388 need not have continuous solid walls 382, 384 to accomplish the required alignment but need only constrain key portions of the outermost geometry of both the component housing lid 14 and the component housing base 16.

The terms and expression which have been employed in the foregoing specification are used therein as terms of description and not of limitation, and there is no intention in the use of such terms and expressions of excluding equivalents of the features shown and described or portions thereof, it being recognized that the scope of the invention is defined and limited only by the claims which follow.

I CLAIM:

1. A device for carrying electronic circuit components, comprising:

(a) a base member defining a contact side and an oppositely located upper side of said device;

(b) support means included in said base member for physically supporting an electronic circuit component;

(c) a tensionable fastener physically attached to said support means and extending away from said support means on said contact side of said device;

(d) a plurality of electrical conductors attached to said base member, at least some of said electrical conductors extending from said contact side to said upper side of said base member.

(e) a plurality of physically compliant electrical contacts arranged in a predetermined array on said contact side of said base member, each of said electrical contacts being connected with a respective one of said electrical conductors and each of said contacts including a nodule of electrically conductive material protruding away from said base member on said contact side of said device.

2. The device of claim 1 wherein said nodules are solid in structure.

3. The device of claim 1 wherein said nodules are of gold.

4. The device of claim 3 wherein said nodules are generally hemispherical in shape.

5. The device of claim 1 wherein said nodules are of electrically conductive elastomeric material.

6. The device of claim 5 wherein said nodules are generally hemispherical in shape.

7. The device of claim 5 wherein said elastomeric material is an electrically conductive silicone.

8. The device of claim 1 wherein said fastener and said base member include cooperative orienting means for aligning said fastener to said base member in a unique orientation and for thereafter indicating the orientation of said device during installation of the device in an electrical circuit.

9. The device of claim 1 wherein said fastener includes an interiorly threaded portion and an elongated exteriorly threaded portion removably mated therewith and extending away from said interiorly threaded portion.

10. The device of claim 1, including at least one thermal conductor extending through said base member from said fastener to said upper side of said base member.

11. The device of claim 10 wherein said thermal conductor is a column of metal extending through a corresponding bore defined within said base member.

12. The device of claim 1, including an alignment pin located on said contact side of said base member in a predetermined location with respect to said nodules and extending from said base member a distance greater than the distance said nodules protrude away from said base member.

13. The device of claim 12, including a plurality of said alignment pins, each having a respective predetermined location, different ones of said alignment pins having at least two different sizes.

14. The device of claim 1 wherein said contact side of said base member defines an alignment pin socket in a predetermined location with respect to said nodules.

15. The device of claim 14, including a plurality of said alignment pin sockets, each having a respective predetermined location, different ones of said alignment pin sockets being of at least two different sizes.

16. The device of claim 1 wherein said base member defines at least one cavity on said contact side thereof, respective ones of said electrical conductors extending into each said cavity, and said fastener being attached to said base member so as to close and hermetically seal said cavity between said fastener and said base member.

17. A device for carrying at least one electronic circuit component and electrically connecting it to a plurality of conductors of an electrical circuit, comprising:

(a) a base member defining a contact side and an oppositely-located upper side;

(b) a tensionable fastener fixedly connected to said contact side of said base member;

(c) a predetermined array of contacts located on said contact side proximate said fastener;

(d) a plurality of electrical conductors defined in said base member and electrically connected to respective ones of said contacts;

(e) a lid; and

(f) means for attaching said lid to said upper side of said base member and defining in cooperation with said upper side a hermetically sealed cavity between said lid and said upper side of said base member, at least some of said electrical conductors extending through said base member from said contact side into said cavity.

18. The device of claim 17 wherein said contact side of said base member defines at least one additional cavity, some of said electrical conductors connected to said contacts extending into said additional cavity.

19. The device of claim 17, including at least one thermal conductor extending through said base member from said fastener to said upper side of said base member.

20. The device of claim 17, including an alignment pin attached to said base member in a predetermined location with respect to said array of contacts.

21. The device of claim 20, including a pluraltiy of said alignment pins, each having a respective predetermined location, different ones of said alignment pins being of at least two different sizes.

22. The device of claim 17 wherein said fastener includes orienting means for aligning said fastener to said base member in a unique orientation and for thereafter indicating the orientation of said device during its installation in an electrical circuit.

23. The device of claim 17 wherein said fastener includes an interiorly threaded portion and an elongated exteriorly threaded portion removably mated therewith and extending away from said interiorly threaded portion.

24. The device of claim 17 wherein said contact side of said base member defines at least one alignment pin socket in a predetermined location with respect to said array of contacts.

25. The device of claim 24, including a plurality of said alignment pin sockets, each having a respective predetermined location, different ones of said alignment pin sockets being of at least two different sizes.

26. The device of claim 17, including an electronic circuit component fixedly connected mechanically to said upper side of said base member, at least some of said electrical conductors connected to said contacts being connected electrically to said electronic circuit component.

27. A device for carrying an electronic circuit component and electrically connecting it to a plurality of conductors of an electrical circuit, comprising:

(a) a tensionable fastener having a head portion;

(b) an upper surface defined on said head portion;

(c) a ring of electrically insulative material located on said upper surface;

(d) a plurality of flexible electrical conductors supported on a flexible supportive backing sheet, a plurality of said conductors each having a first end portion extending above and generally parallel with said upper surface of said head and spaced apart therefrom by said ring of insulative material;

(e) a molded housing including a base portion defining a bottom surface, said housing at least partially surrounding said head and said first end portions of said flexible electrical conductors; and

(f) an elastomeric support member fastened to said base portion, said flexible electrical conductors extending from said housing and being disposed adjacent said elastomeric support member and being exposed as downwardly disposed contacts located beneath said bottom surface.

28. The device of claim 27, including an alignment pin extending downwardly beneath said bottom surface, in a predetermined location with respect to a respective one of said contacts.

29. The device of claim 28, including a plurality of said alignment pins, different ones of said alignment pins being of at least two different sizes.

30. The device of claim 28 wherein said supportive backing sheet defines an aperture and said flexible electrical conductors are held in place along said elastomeric support member by said alignment pin extending through said aperture.

31. The device of claim 27 wherein said bottom surface includes an alignment surface, said elastomeric support member projecting downward beneath said base portion a predetermined distance with respect to said bottom surface.

32. The device of claim 27 wherein said fastener includes orienting means for aligning said fastener to said flexible electrical conductors in a unique orientation and for thereafter indicating the orientation of said housing during installation of said device in an electrical circuit.

33. The device of claim 27 wherein said fastener includes an interiorly threaded portion and an elongated exteriorly threaded portion removably mated therewith and extending away from said interiorly threaded portion.

34. A housing assembly for an electronic circuit component, comprising:

(a) a base member defining an electronic circuit component location area;

(b) a plurality of electrical circuit conductors extending radially away from said electronic circuit component location area;

(c) a plurality of electrical circuit conductors extending within said electronic circuit component location area and having portions thereof extending outwardly from within said electronic circuit component location area; and

(d) a discontinuous narrow strip of resistive material located on said base member proximate said electronic circuit component location area and interconnecting selected portions of respective ones of said electrical circuit conductors.

35. The housing of claim 34 wherein a majority of said plurality of electrical circuit conductors having portions extending outwardly from within said electronic circuit component location area are power conductors, and where said discontinuous narrow strip of resistive material provides connections having respective predetermined amounts of resistance between ones of said power conductors and other ones of said electrical circuit conductors.

36. The housing of claim 34 wherein said narrow strip of resistive material is of regular width and thickness and is interrupted at predetermined locations to provide different lengths of said narrow strip of resistive material to provide different resistance values between interconnected ones of said electrical circuit conductors.

37. A housing assembly for an electronic circuit component, comprising:

(a) a base member defining an electronic circuit component location area;

(b) a plurality of electrical circuit conductors located on said base member at least partially within said electronic circuit component location area and some thereof having portions thereof extending outwardly from within said electronic circuit component location area; and

(c) a discontinuous narrow strip of resistive material located on said base member within said electronic circuit component location area interconnecting selected ones of said electrical circuit conductors.

38. The housing of claim 37 wherein said narrow strip is of regular width and thickness and is interrupted at predetermined locations to provide different lengths and different numbers of electrically parallel lengths of said narrow strip of resistive material so as to provide different resistance values between different interconnected ones of said electrical circuit conductors.

39. In combination with an electrical circuit including a plurality of electrical circuit conductors located on a circuit support structure including a generally planar surface, a device for carrying an electronic circuit component and providing electrical connection between said electronic circuit component and said electrical circuit conductors, comprising:

(a) a base member having a contact side and an oppositely-located upper side;

(b) a plurality of contacts carried on said contact side of said base member in a predetermined pattern;

(c) a corresponding plurality of contact pads arranged in a pattern on said generally planar surface corresponding with said predetermined pattern of contacts and connected with respective ones of said electrical circuit conductors;

(d) a tensionable fastener fixedly connected with said base member and extending away from said base member in the direction of said contact side; and

(e) alignment pin and socket means, separate from said contacts and said contact pads, for assuring that said contacts of said predetermined pattern are properly aligned to make contact with said contact pads on said generally planar surface of said circuit support structure when said device is held in place thereon by said tensionable fastener.

40. The combination of claim 39 wherein said alignment pin and socket means includes at least one alignment pin mounted on one of said support structure and said base member, and a socket corresponding to each said alignment pin, defined in the other of said circuit support structure and said base member.

41. The combination of claim 39 wherein said alignment pin and socket means includes a plurality of alignment pins and corresponding sockets arranged so as to prevent insertion of said alignment pins except in a unique orientation of said base member with respect to said circuit support structure.

42. The combination of claim 39 wherein said alignment pin and socket means includes a plurality of alignment pins and corresponding sockets, at least one of said alignment pins and a corresponding socket being different from the remaining ones of said plurality.

43. A mounting device for carrying an electronic circuit component, comprising:

(a) a tensionable fastener having a head portion;

(b) an upper surface defined on said head portion; and

(c) a ring of electrically insulative material fixedly attached to said upper surface of said head portion so as to define a location for mounting an electronic circuit component on said head portion.

44. The device of claim 43, including a molded housing portion at least partially surrounding said head portion and defining a bottom surface of said mounting device.

45. The device of claim 44, including an alignment pin extending downwardly beneath said bottom surface generally parallel with said fastener.

46. The device of claim 45, including a plurality of said alignment pins wherein different ones of said plurality of alignment pins are of at least two different sizes.

47. The device of claim 43, including a plurality of electrical conductors, each having a first end portion extending above and generally parallel with said upper surface of said head and spaced apart therefrom by said ring of insulative material.

48. The device of claim 47, including a molded housing including a base portion defining a bottom surface, said housing at least partially surrounding said head and said first end portions of said electrical conductors.

49. The device of claim 48, including an alignment pin extending downward beneath said bottom surface.

50. The device of claim 49, including a plurality of said alignment pins, different ones of said plurality of alignment pins being of at least two different sizes.

51. The device of claim 43 wherein said fastener includes orienting means for indicating the orientation of said mounting device during its installation in an electrical circuit.

52. The device of claim 43 wherein said fastener includes an interiorly threaded portion and an elongated exteriorly threaded portion removably mated therewith and extending away from said interiorly threaded portion.

53. In combination with a mounting device for containing an electronic circuit component, said mounting device having a plurality of contacts electrically connected to respective electrical conductors of an electrical circuit and having a plurality of sides each including a face portion, an electrical probe assembly, comprising:

(a) a plurality of probe sections each adapted to fit on a respective side of said mounting device for containing an electronic circuit component and each of said probe sections having an internal face configuration adapted to fit matingly against a respective face portion of said mounting device;

(b) a plurality of physically compliant electrical contacts contained in at least one of said sections of said probe and located, respectively, in predetermined positions with respect to the respective face portion of said mounting device against which each such one of said probe sections is adapted to fit; and

(c) tensionable means associated with said probe for holding said probe in a predetermined position with respect to said mounting device.

54. The probe assembly of claim 53 wherein said tensionable means includes elastic bands surrounding said probe and urging said probe sections toward one another.

55. The probe assembly of claim 53, including a plurality of output leads attached to at least one of said probe sections in which said compliant contacts are contained, each of said output leads being connected electrically with a respective one of said compliant contacts.

56. The probe assembly of claim 53, including pivot means included in each of said probe sections for resting against the respective side of said mounting device and acting as a fulcrum about which said probe section is pivotable.

57. The probe assembly of claim 53 wherein at least some of said compliant contacts each include an electrically conductive nodule.

58. The probe assembly of claim 53 wherein some of said compliant contacts comprise a plurality of substantially parallel finger-like springs.

59. The probe assembly of claim 58, including means for limiting the freedom of movement of each of said finger-like spring contacts thereof.

60. The probe assembly of claim 53 wherein said contacts include a plurality of flexible electrical conductors supported on a flexible supportive backing sheet, portions thereof being exposed in the direction toward which said contact side of said device faces, and a compressible elastomeric support member supporting said backing sheet and said exposed portions of said conductors.

61. The probe assembly of claim 53 wherein at least one section thereof includes reference probe contact means for contacting a respective side of said mounting device.

62. The probe assembly of claim 61 wherein said reference probe contact means is adapted to fit within a groove defined on said side of said mounting device, said reference probe contact means being located between said pivot means and said compliant contacts.

63. The probe assembly of claim 61 wherein said mounting device includes a reference contact and said reference probe contact and said tensionable means are so located with respect to each other that said tensionable means provides the force required for maintaining electrical contact between said reference probe contact and said reference contact when said probe section is fitted against said respective side of said mounting device.

64. The probe assembly of claim 53 wherein said tensionable means and said compliant contacts are so located with respect to one another that said tensionable means provides the force required for maintaining electrical contact between said compliant contacts and said electrical conductors when said one of said probe sections is fitted against said face portion of a respective one of said sides.

65. In combination with an electrical circuit including a plurality of electrical circuit conductors electrically connected with respective contact pads located on a generally planar surface of a circuit support structure, a device for carrying an electronic circuit component and providing electrical connection

between said electronic circuit component and said electrical circuit conductors, comprising:

(a) a tensionable fastener having a head portion;

(b) an upper surface defined on said head portion opposite said downwardly extending portion;

(c) a ring of electrically insulative material located on said upper surface;

(d) a plurality of electrical conductors, each having a first end portion extending above and generally parallel with said upper surface of said head and spaced apart therefrom by said ring of insulative material;

(e) a molded housing including a base portion defining a bottom surface, said housing at least partially surrounding said head and said first end portions of said electrical conductors; and

(f) alignment pin means extending downwardly beneath said bottom surface for assuring that said device is properly aligned with said electrical circuit.

66. The device of claim 65, including a plurality of said alignment pins wherein different ones thereof are of at least two different sizes.

67. The device of claim 65, including a plurality of electrical contacts including finger-like spring members connected electrically to respective ones of said electrical conductors and extending substantially parallel with one another and exposed beneath said bottom surface of said base portion, each of said spring members having an end portion directed

inwardly beneath said base portion and an intermediately located arcuate contact portion protruding downwardly beneath said bottom surface.

68. The device of claim 67, including means for limiting the range of inward movement of said end portions of said finger-like spring members of said contacts and causing said arcuate contact portion of each of said spring members to move wipingly along a respective contact pad on said structural support member.

69. The device of claim 65 wherein said fastener includes an interiorly threaded portion attached to said head on a side thereof opposite said ring of insulative material, and an elongate exteriorly threaded portion removably mated therewith and extending away from said interiorly threaded portion.

70. The device of claim 65 wherein said fastener includes orienting means for indicating the orientation of said device during its installation in said electrical circuit.

71. In combination with an electrical circuit support structure having a generally planar surface and including at least one electrical circuit conductor located on said support structure and at least one electrical contact pad connected with said electrical circuit conductor of said circuit support structure, a device for carrying electrical circuit conductors and providing electrical connection between said device and said electrical conductor of said support structure, comprising:

(a) a base member defining a contact side;

(b) at least one electrical circuit conductor carried on said base member and residing at least in part on said contact side of said base member;

(c) at least one electrically conductive and physically deformable nodule contact connected electrically with said electrical circuit conductor of said base member; and

(d) at least one tensionable fastener urging said base member toward said circuit support structure and applying compressive force to said deformable nodule contact for assuring that electrical contact is maintained between said nodule contact and said electrical contact pad when said compliant nodule contact and said electrical contact pad are aligned with one another.

72. The device of claim 71 wherein said nodules are solid in structure.

73. The device of claim 71 wherein said nodules are generally hemispherical in shape.

74. The device of claim 71 wherein said nodules are of electrically conductive elastomeric material.

75. The device of claim 74 wherein said elastomeric material is an electrically conductive silicone.

76. The device of claim 71 wherein said nodules are of gold.

FIG. 1

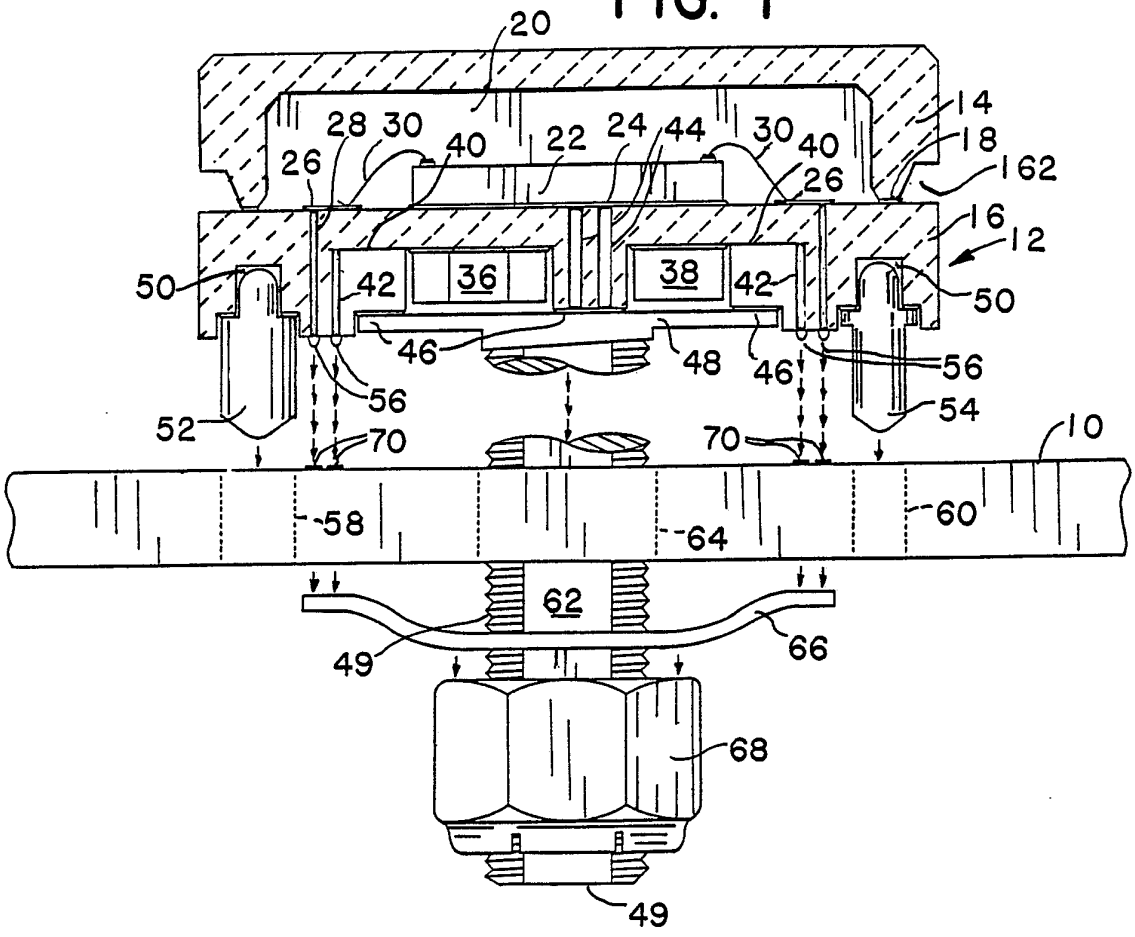
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FIG. 2

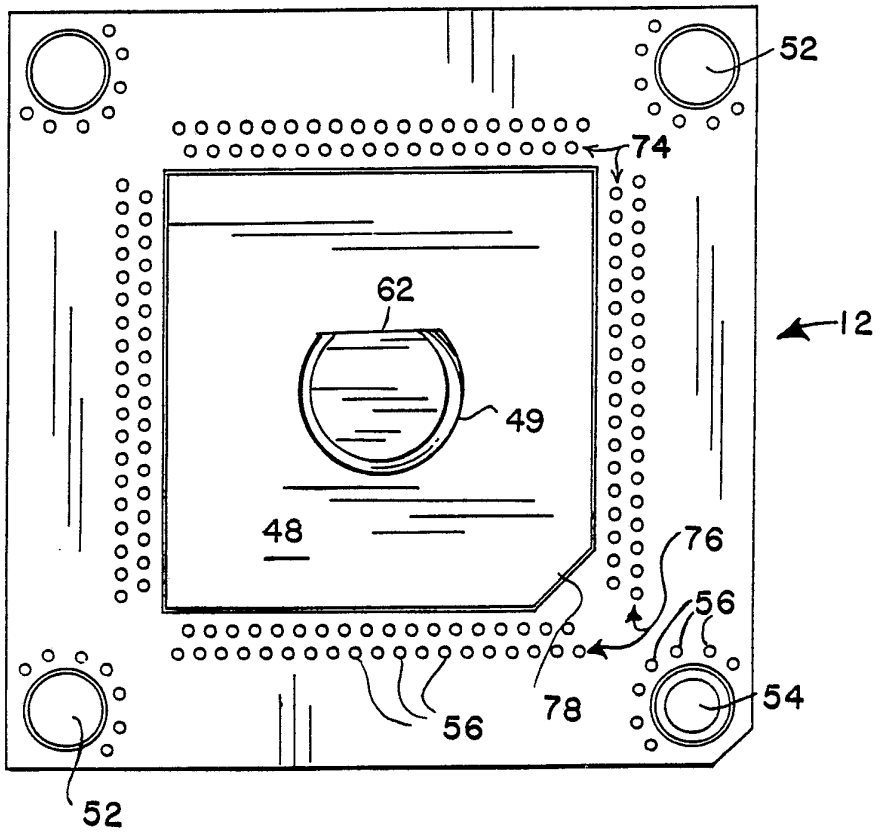
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FIG. 3

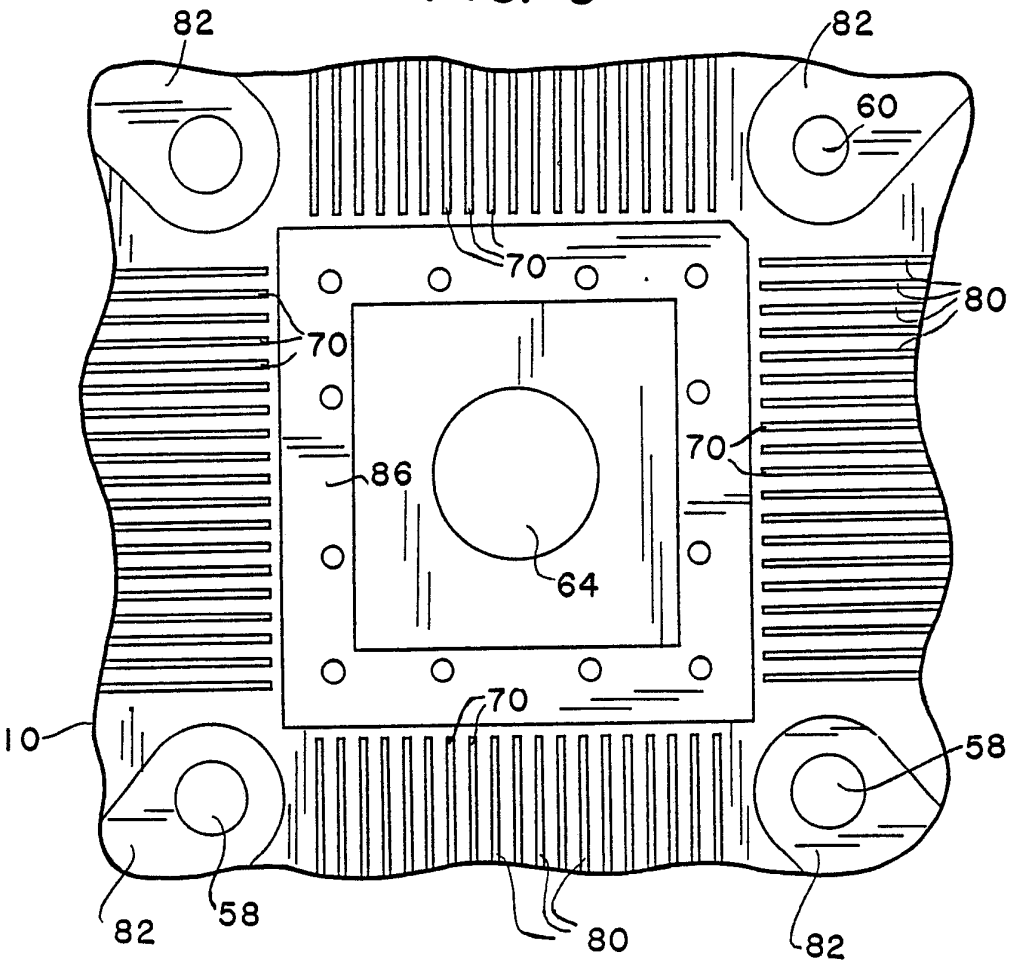

FIG. 4

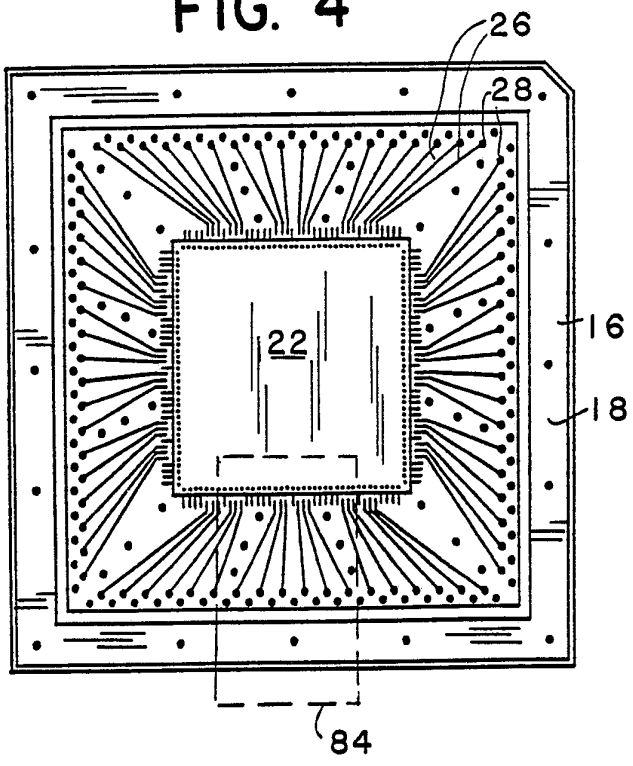

FIG. 6

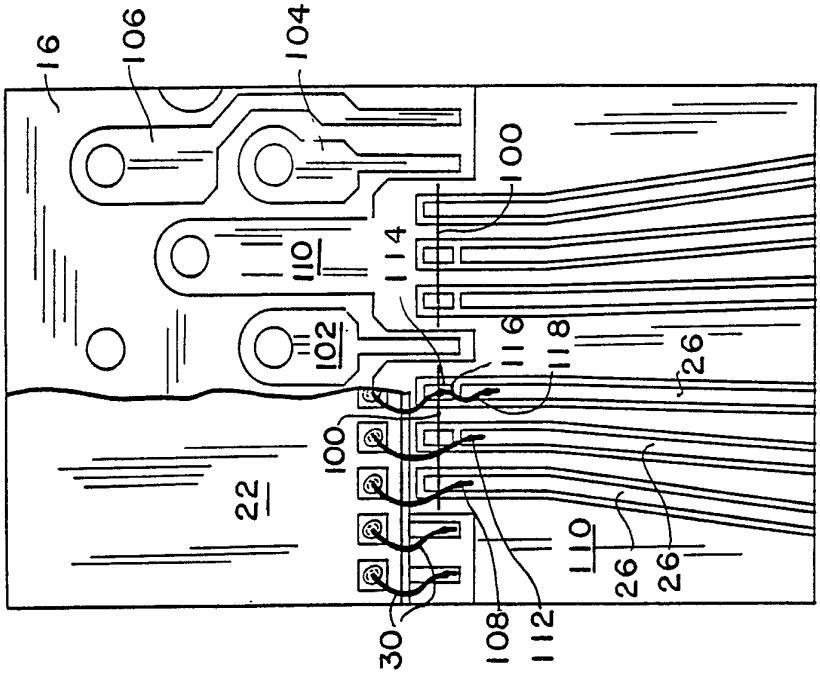
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FIG. 5

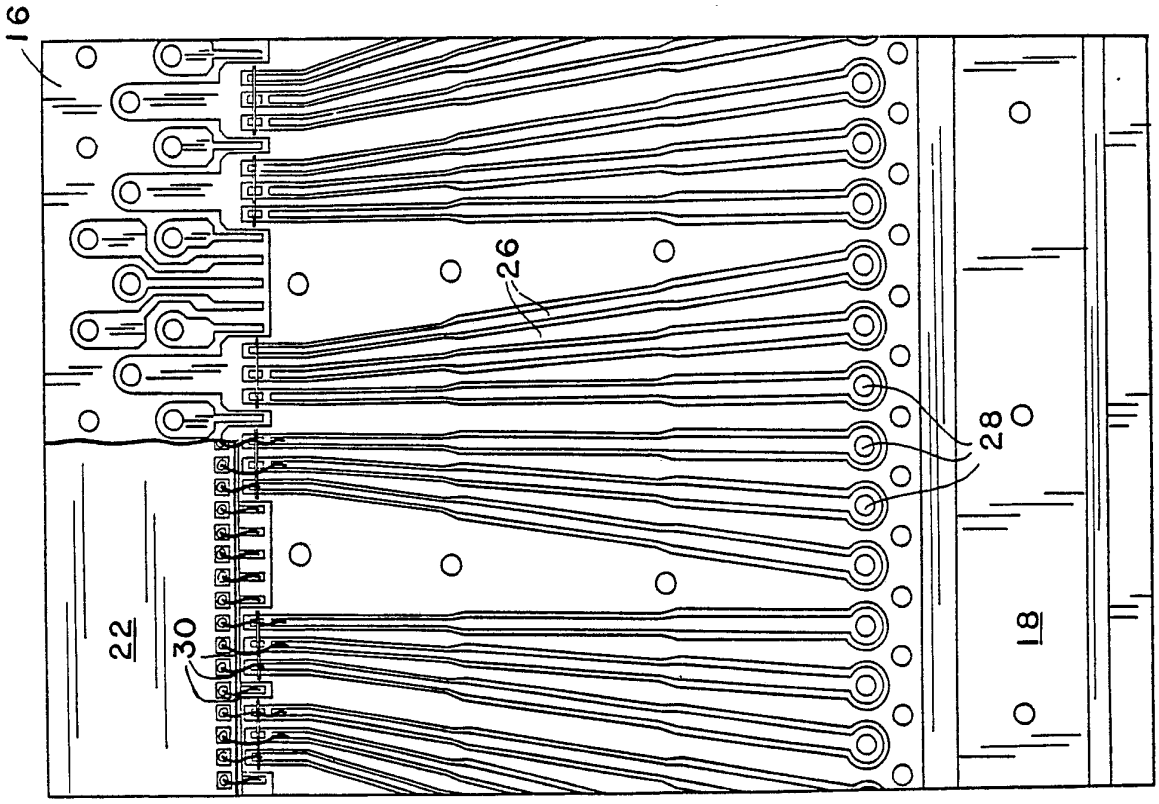
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FIG. 7

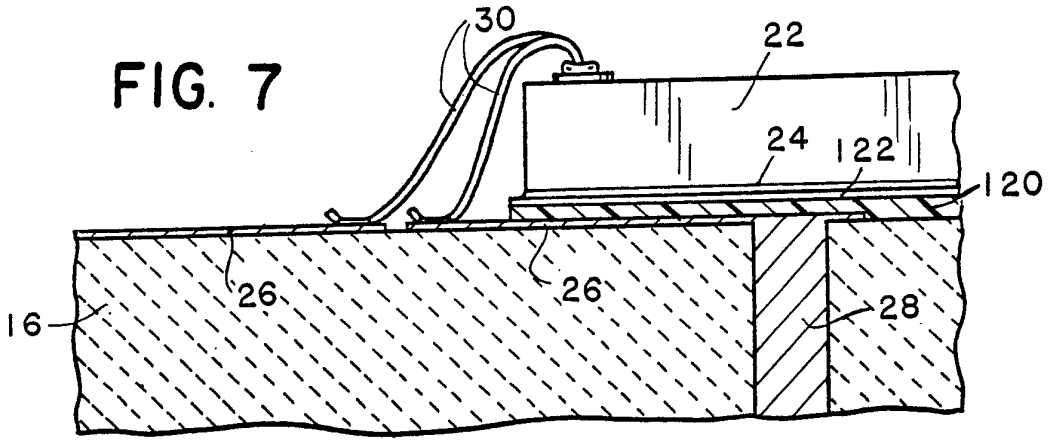
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FIG. 8

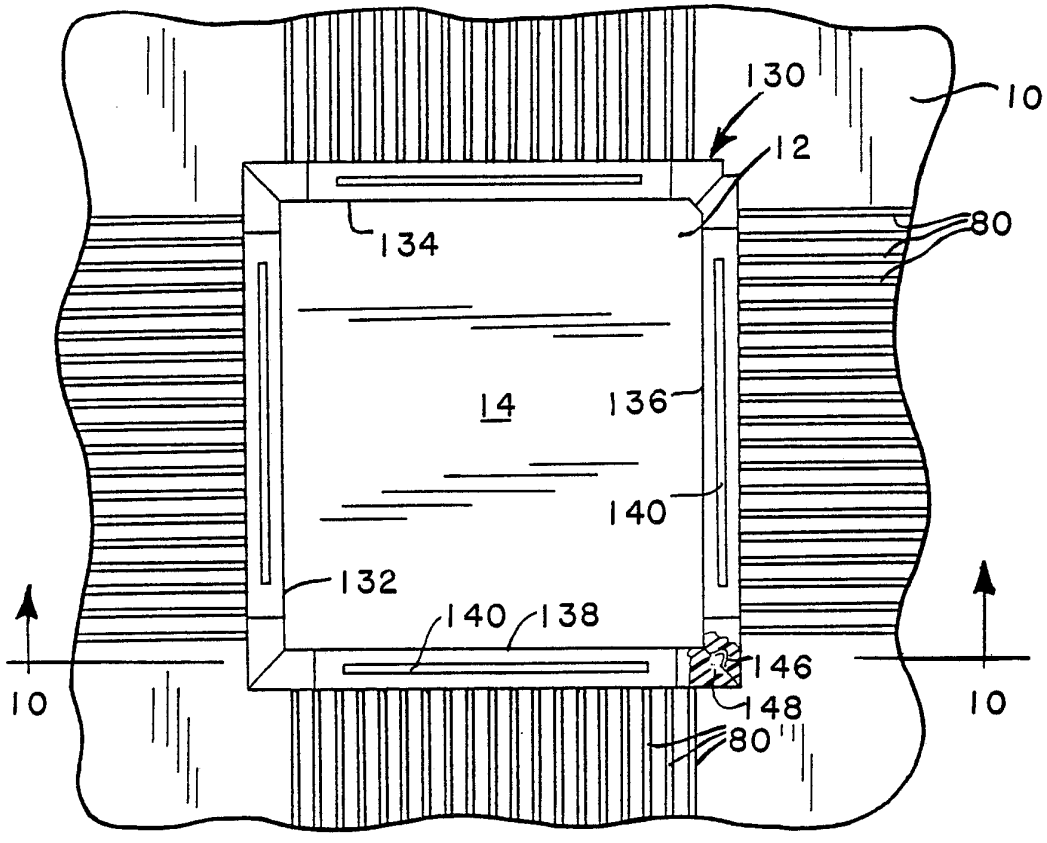
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FIG. 9

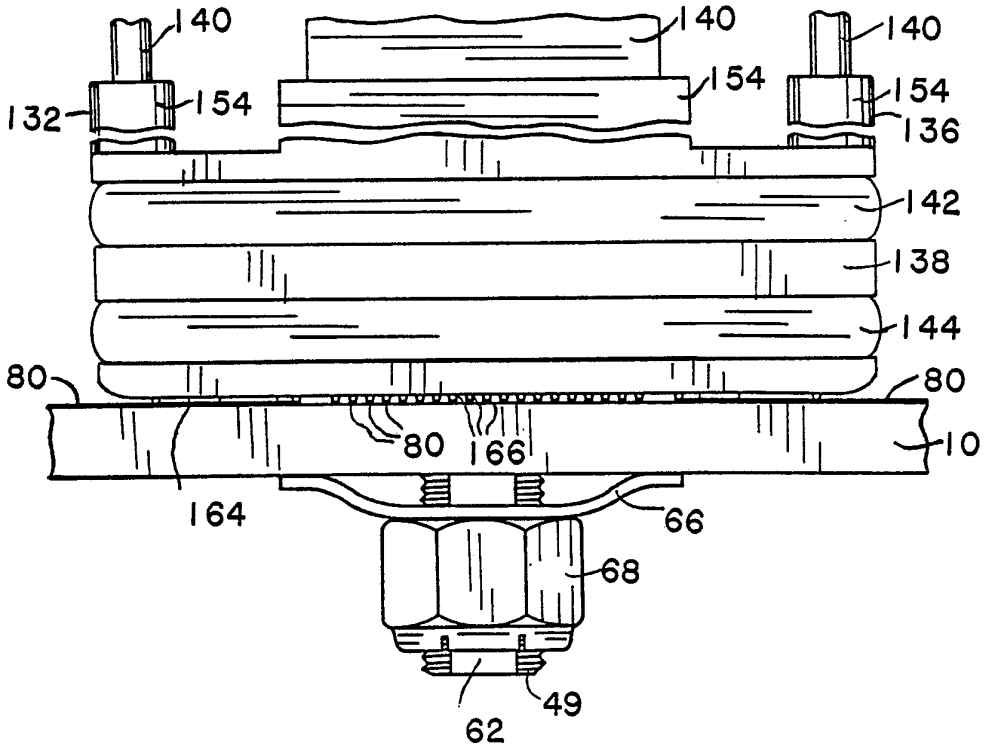
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FIG. 10

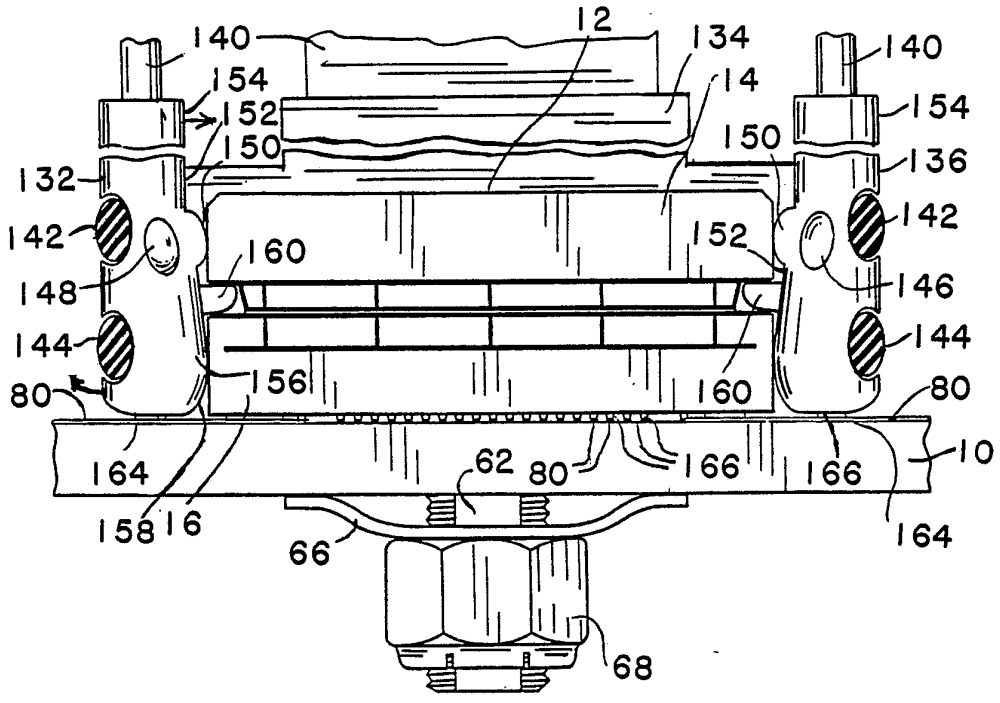
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FIG. 11

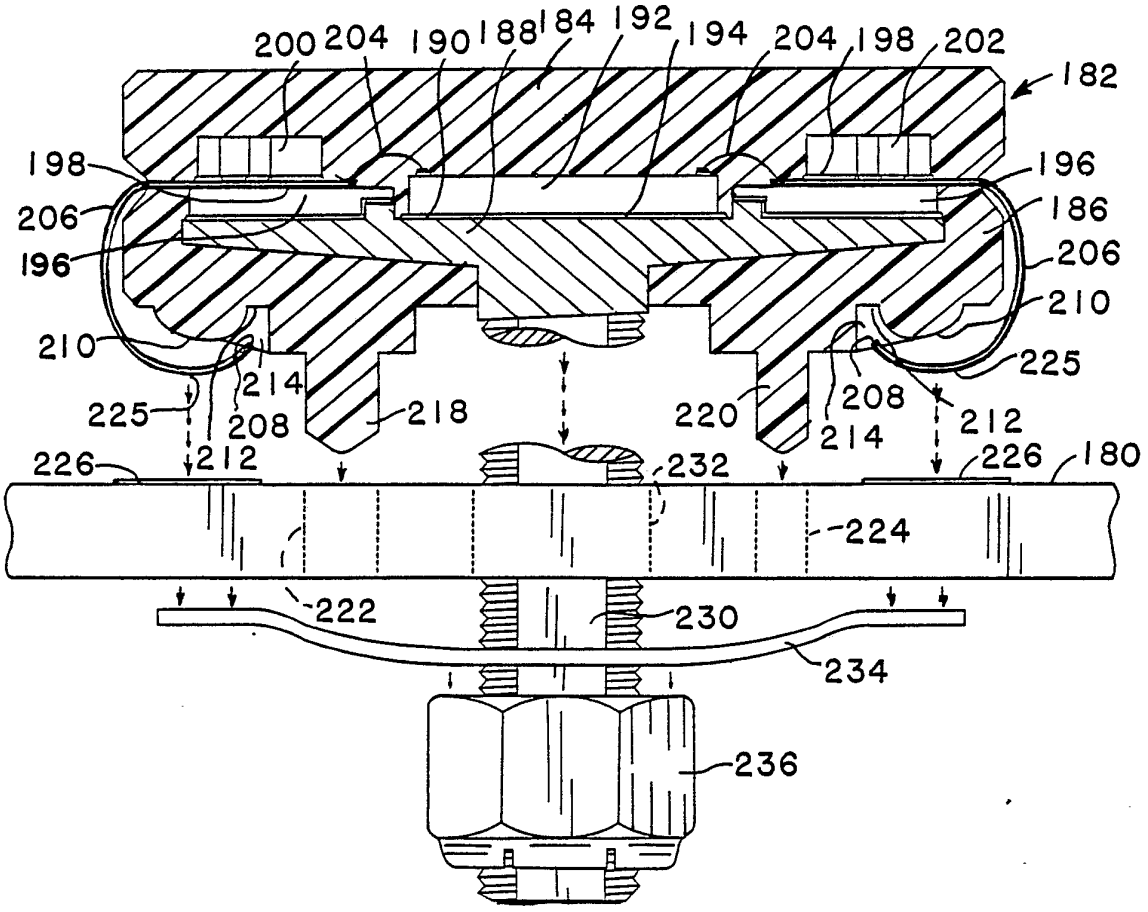
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FIG. 12

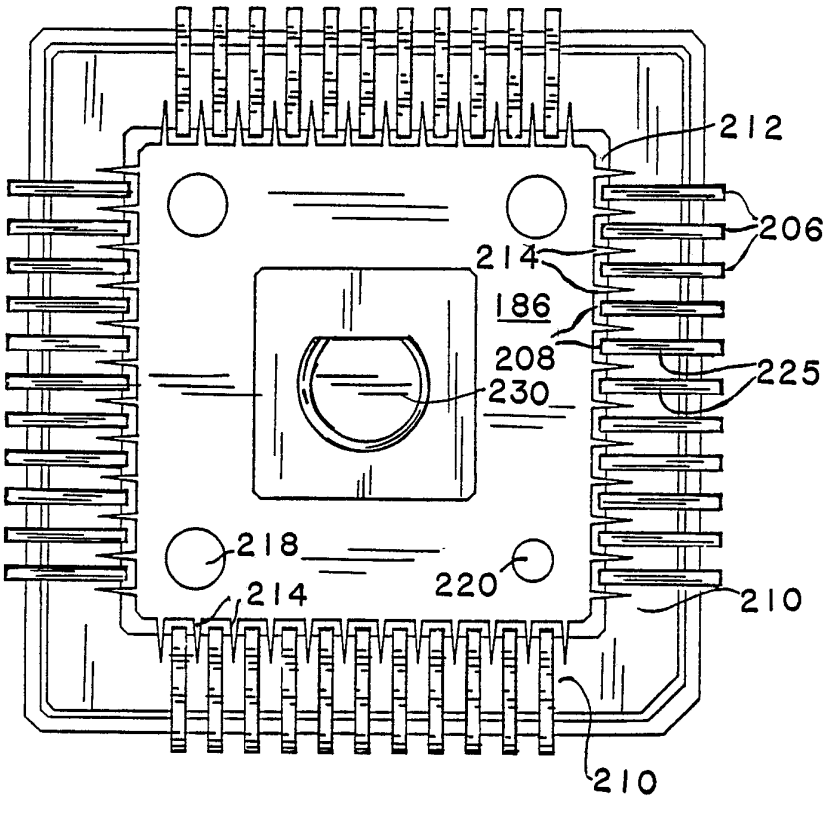
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FIG. 13

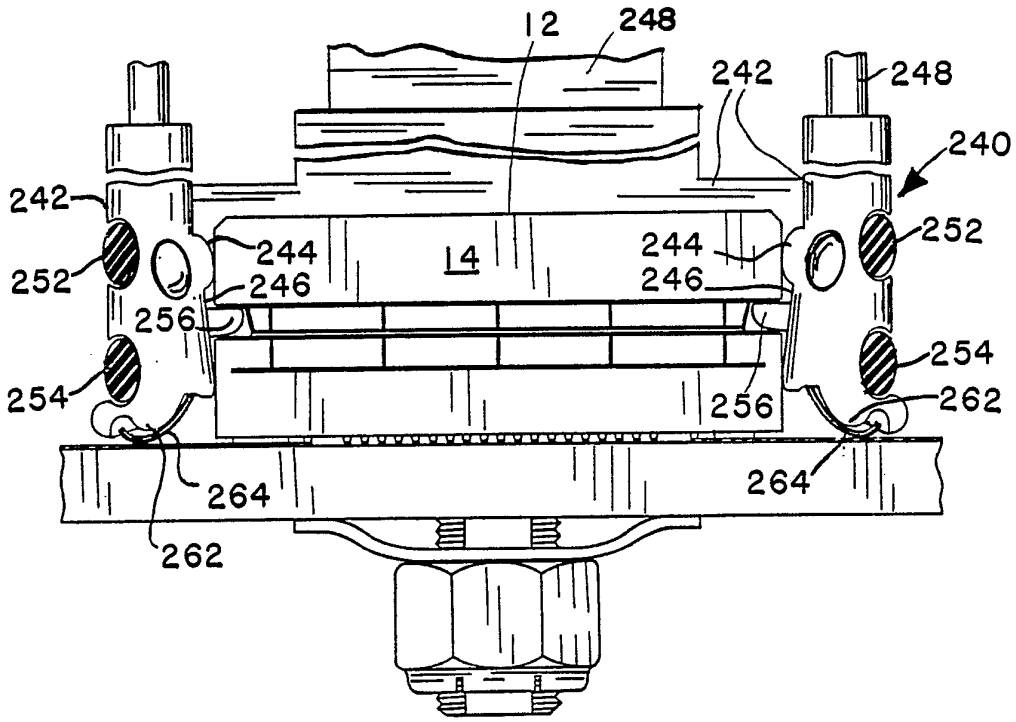
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FIG. 14

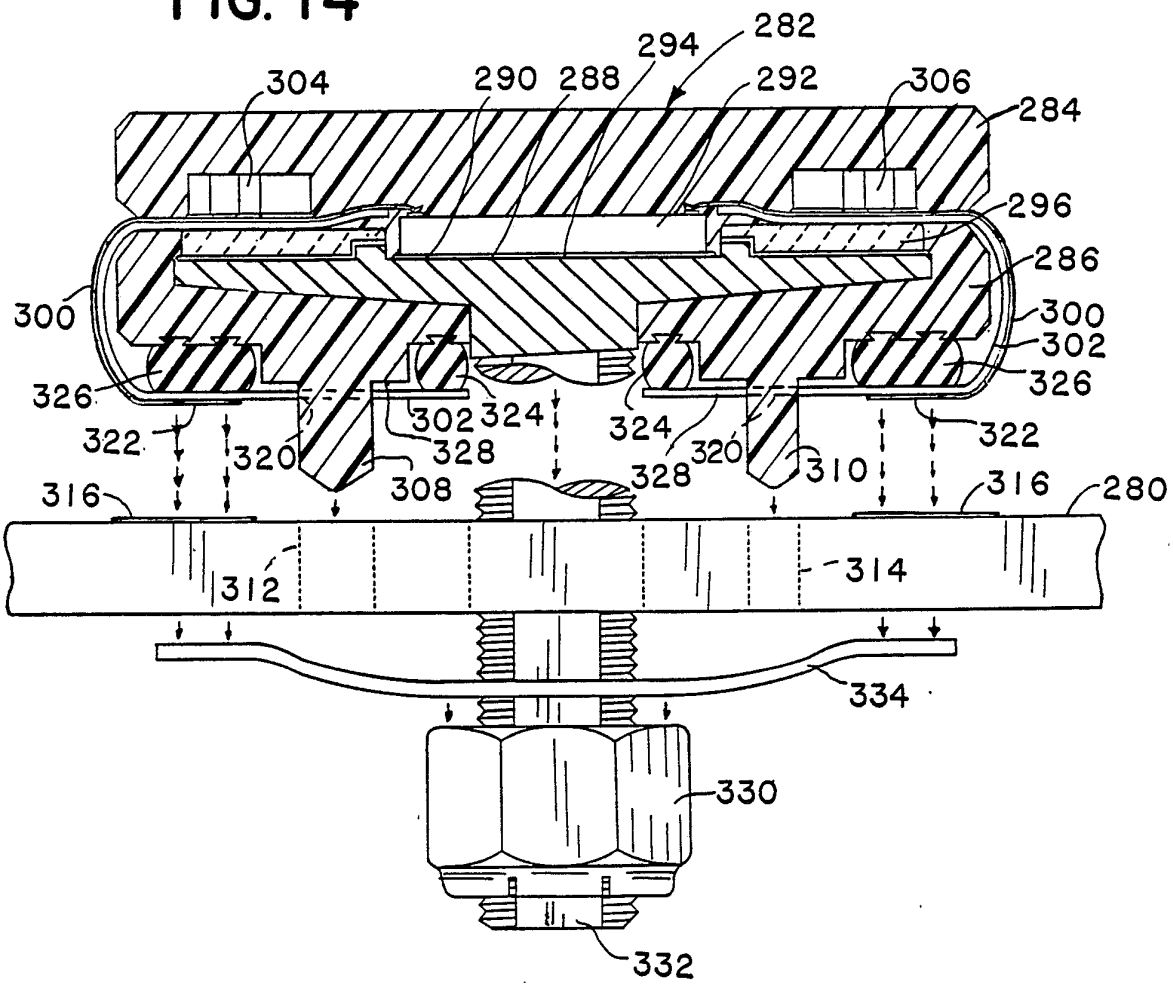
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FIG. 15

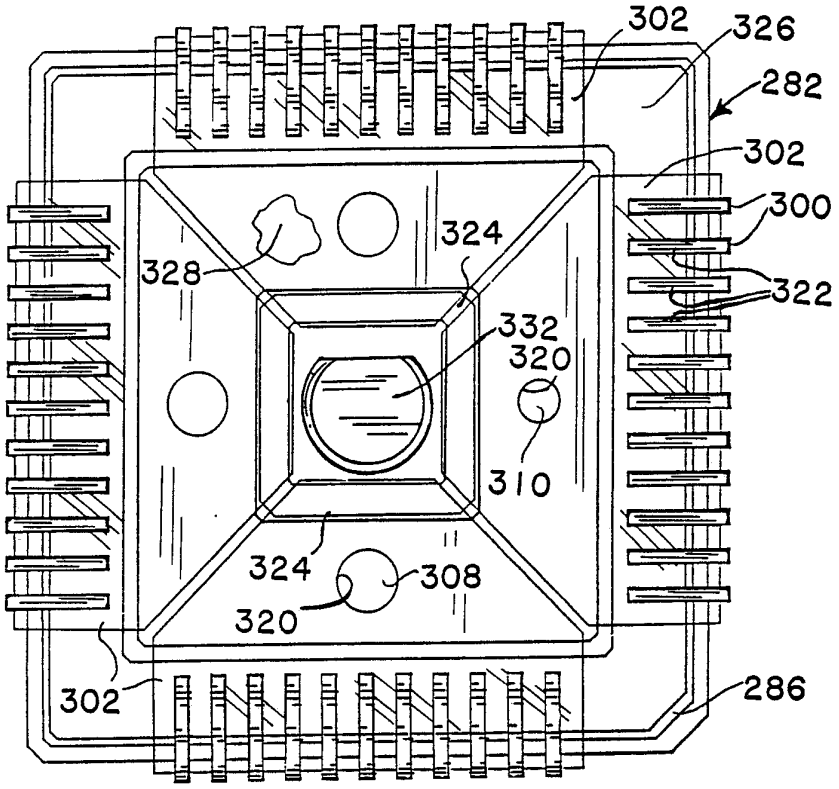
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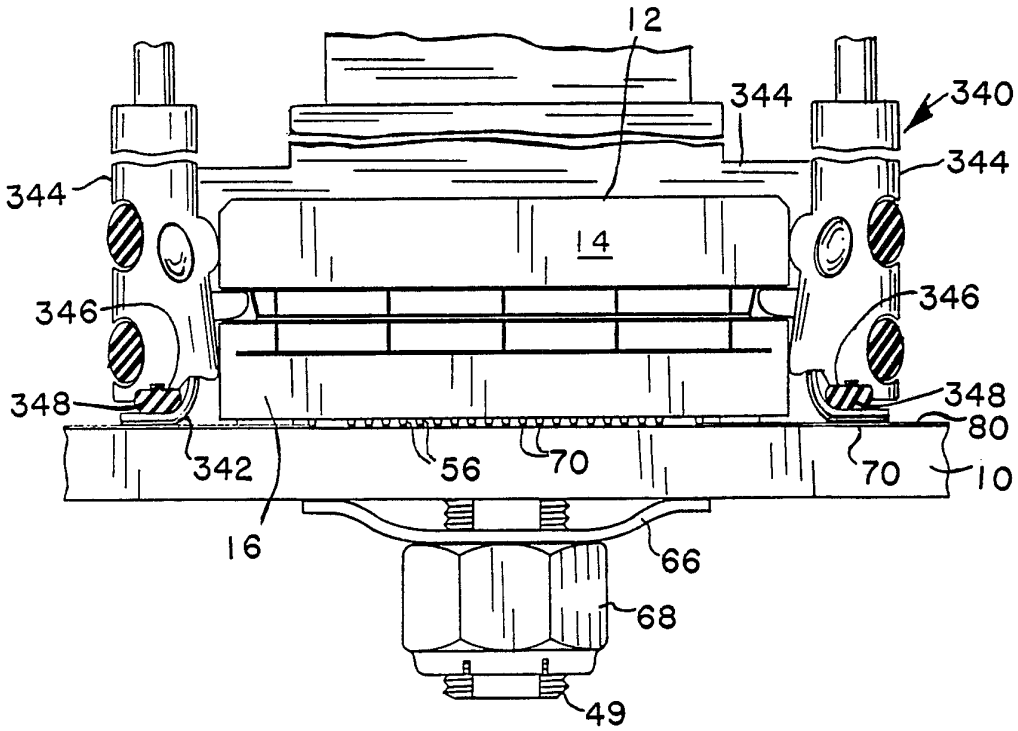
FIG. 16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INTERNATIONAL SEARCH REPORT

International Application No PCT/US87/02636

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(4) H05K 07/12
US 361/399

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S.	174/16HS; 52 FP;68.5; 338/128;357/81; 361/386;387;388;389;399;408;411 439/65 to 75 & 81

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
Y	US,A, 3,984,166 (HUTCHINSON) 05 October 1976 (See entire patent)	1 to 33,39 to 52,65 to 76
Y	US,A, 3,271,627 (MCDOUGAL) 06 September 1966 (See Figs 2,4 + Specification)	1 to 33,39 to 52,65 to76
Y	US,A, 4,358,173 (CONRAD) 09 November 1982 (See Assembly or Fig.7)	1 to 33,39 to 52,65 to 76
Y	US,A, 4,420,767 (HODGE) 13 December 1983 (See Figs. 3 & 4 along with specification)	1 to 33,39 to 52,65 to 76
Y	US,A, 3,971,610 (BUCHOFF) 27 July 1976 (See column 3 & 10 et. al. in.Figs)	2 to 7, 72 to 76
Y	GB,A, 991,649 12 May 1965 (See Figs. 2 & 3 + specification)	34 to 38
Y	US,A, 4,274,074 SAKAMOTO) 16 June 1981 (See 7a as in FIgs & Column 2)	34 to 38
Y	US,A, 2,758,256 (EISLER) 07 August 1956	34 to 38

* Special categories of cited documents: [15]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
24 November 1987	20 JAN 1988
International Searching Authority [1]	**Signature of Authorized Officer** [20]
ISA/US	Richard R. Kucia

Form PCT/ISA/210 (second sheet) (May 1986)

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

	(See column 3 & Figs)	
Y	US,A 4,591,896 (KIKUCHI) 27 May 1986 (See 5,6,8 in Figs. at Specification)	27 to 33,43 to 52,65 to 70
Y	US,A 4,624,303 (NIPPERT) 25 November 1986 (See 20 Fig. 1 et al.)	27,43,44,65
Y	US,A 4,266,267 (RUEGG) 05 May 1981 (See 13,17 in Figs & specification)	27,43,44,65
Y	US,A 3,487,267 (WINSTON) 30 December 1969 (See entire document)	18
Y	US,A 4,545,408 (ROBSSTH) 08 October 1985 (See entire document)	----

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [10]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers ....., because they relate to subject matter [12] not required to be searched by this Authority, namely:

2. ☐ Claim numbers ....., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [13], specifically:

VI. ☒ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [11]

This International Searching Authority found multiple inventions in this international application as follows:

Group I, Claims 1 to 33 & 39 to 76, drawn to a tensionable assembly.
Group II, Claims 34 to 38, drawn to a resistor circuit

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application. Telephone Practice

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.

Attachment to Form PCT/ISA/210, Part VI. 1.

Telephone Approval:

$140 payment approved by Mr. Donald B. Hansell on November 19, 1987 Group I; charge to Deposit Account No. 03-1550. Counsel advised that he has no right to protest for any group not paid for and that any protest must be filed no later than 15 days from the date of mailing of the search report (Form 210).

Reasons for holding lack of unity of invention:

The invention as defined by Group I (claims 1-33+39-76) is drawn to a tensionable assembly which is classified in Classes 361 and 339 and which bears no relationship whatsoever to the invention defined by Group II (claims 34-38) which is drawn to a resistor circuit and is classified in Class 338.

Time Limit for Filing a Protest

Applicant is hereby given 15 days from the mailing date of this Search Report in which to file a protest of the holding of lack of unity of invention. In accordance with PCT Rule 40.2 applicant may protest the holding of lack of unity only with respect to the group(s) paid for.