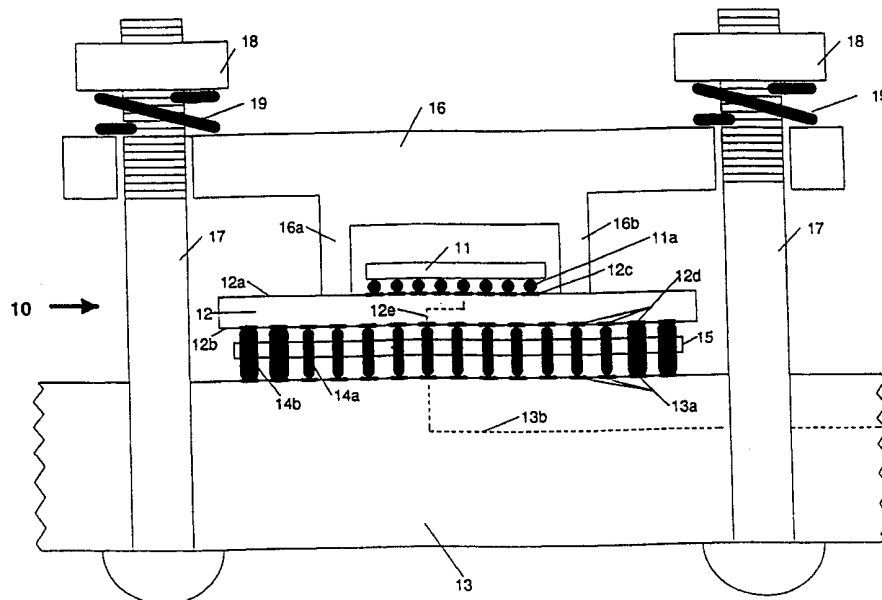




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(54) Title: INTEGRATED CIRCUIT MODULE HAVING SPRINGY CONTACTS OF AT LEAST TWO DIFFERENT TYPES FOR REDUCED STRESS, AND SUBASSEMBLY FOR SUCH MODULE



(57) Abstract

An electromechanical module (10) is comprised of an electronic component (11) that is attached to a substrate (12) which is bendable. Multiple springy contacts (14a and 14b) touch respective I/O pads (12d) on the substrate. A compressing mechanism (16-19) compresses the springy contacts against the I/O pads with forces that bend the substrate. The bending of substrate is reduced by including contacts of a first type (14a), each of which exert a relatively small force against its respective I/O pad; and contacts of a second type (14b), each of which exert a substantially larger force against its respective I/O pad.

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TITLE: INTEGRATED CIRCUIT MODULE HAVING SPRINGY
CONTACTS OF AT LEAST TWO DIFFERENT TYPES
FOR REDUCED STRESS, AND SUBASSEMBLY FOR
SUCH MODULE

BACKGROUND OF THE INVENTION:

This invention relates to integrated circuit modules and subassemblies of the kind which include springy contacts that are compressed to make electrical connections between two components.

5 In the prior art, an example of an integrated circuit module that uses compressed springy contacts to make electrical connections is disclosed in U.S. Patent 4,999,023 which is entitled "High Density Low Reactance Socket." There, in Figs. 2A and 2B, a springy
10 contact is indicated by reference numeral 15. This springy contact 15 is comprised of a wad of wire that is held by a sleeve 14.

In Figs. 2A and 2B of patent `023, the springy contact 15 is used to make an electrical connection
15 between an input/output pin 20 on a packaged integrated circuit chip and a signal line 32 on a printed circuit

board. This electrical connection is made by inserting the pin 20 into the sleeve 14 and pushing the pin against the springy contact 15.

When the pin 20 is pushed into the sleeve 14, the springy contact 15 is compressed parallel to the axis of the pin; and that causes the springy contact to expand perpendicular to the axis of the pin and press against the side wall of the sleeve 14. This establishes a low resistance electrical connection through the side wall of the sleeve 14 to the signal line 32.

Each springy contact 15 which is compressed exerts an opposing force against its corresponding input/output pin 20. Thus, as the total number of input/output pins 20 on a component increases, the total opposing force which is exerted on the component by all of the springy contacts 15 also increases.

As a numerical example, suppose that a component has one thousand input/output pins and each springy contact exerts an opposing force of two ounces. For that case, the total opposing force against the component is over one hundred pounds.

By increasing the total opposing force with which all of the springy contacts push against a component, a point can eventually be reached where the component will deflect or bend. If that occurs, mechanical stress is generated in the component; and this stress can produce permanent damage. For example, the stress can cause an immediate break in a microscopic signal line in or to the component; or, the stress can

weaken a joint in or to the component and thereby cause a long term reliability risk.

Accordingly, a primary object of the present invention is to provide an improved integrated circuit module which uses springy contacts to make electrical connections, and in which the above stress problem is overcome.

BRIEF SUMMARY OF THE INVENTION:

A particular embodiment of the present invention is an integrated circuit module which includes an integrated circuit chip that is soldered to one surface of a thin planar substrate. Multiple I/O pads are disposed on an opposite surface of this substrate; and a compressing mechanism within the module compresses multiple springy contacts respectively against the I/O pads with forces that bend the substrate.

In accordance with the present invention, the springy contacts are comprised of at least two different types, where each type of springy contact exerts a force of a different magnitude against its respective I/O pad. Also in accordance with the present invention, the different types of springy contacts are distributed in a pattern against the I/O pads such that the substrate is bent, in the critical region where the chip is soldered to the substrate, with a maximum deflection which is less than that which will occur if all of the springy contacts

exert the same magnitude force against its respective I/O pad.

The present invention is particularly useful where the compressing mechanism compresses the springy contacts by pushing on the one surface of the substrate in areas which do not align with all of the I/O pads. This can occur when the areas of the one surface on which the compressing mechanism can push are restricted by the presence of the chip and any other components on that surface. For example, the compressing mechanism could be restricted to pushing on the one surface in a narrow ring around the chip, while the opposite surface may be completely covered with rows and columns of the I/O pads.

In one embodiment, the different types of springy contacts are comprised of wads of wire having different wire thicknesses. Several alternative embodiments of the different types of springy contacts are also disclosed.

BRIEF DESCRIPTION OF THE DRAWINGS:

Fig. 1 shows an electromechanical module which constitutes one preferred embodiment of the present invention.

Fig. 2 shows the locations where various forces are applied to a substrate within the Fig. 1 module such that the bending of the substrate is reduced via the present invention.

Figs. 3A and 3B are schematic diagrams which illustrate the general concept of how bending is reduced in the substrate in Fig. 1 via the present invention.

Fig. 4 is a computer plot which illustrates in
5 detail how the substrate in Fig. 1 bends along a centerline, with and without the present invention.

Fig. 5 is a computer plot which illustrates in detail how the substrate in Fig. 1 bends along a diagonal line, with and without the present invention.

10 Fig. 6 is a computer plot which illustrates the chip attach shear stress which is generated by the bending in Fig. 4.

Fig. 7 is a computer plot which illustrates the chip attach shear stress which is generated by the
15 bending in Fig. 5.

Fig. 8 illustrates one embodiment of the springy contacts which are in the Fig. 1 module and exert some of the forces that occur in Fig. 2.

Fig. 9 illustrates a second embodiment of the
20 springy contacts which are in the Fig. 1 module and exert some of the forces that occur in Fig. 2.

Fig. 10 illustrates a third embodiment of the springy contacts which are in the Fig. 1 module and exert some of the forces that occur in Fig. 2.

25 Fig. 11 illustrates a fourth embodiment of the springy contacts which are in the Fig. 1 module and exert some of the forces that occur in Fig. 2.

Fig. 12 shows a modification in comparison to Fig. 2, to the locations where the forces are applied to
30 the substrate in the Fig. 1 module.

Fig. 13 shows an enlarged top view of a portion of a carrier, for the springy contacts of Figs. 8-11, which is one modification of a carrier in the Fig. 1 module.

5 Fig. 14 shows an enlarged side view of a portion of a carrier, for the springy contacts of Figs. 8-11, which is another modification of a carrier in the Fig. 1 module.

DETAILED DESCRIPTION:

10 Referring now to Fig. 1, an electromechanical module 10 which constitutes one preferred embodiment of the present invention will be described in detail. This electromechanical module 10 is comprised of several components 11-18, and each of those components is listed
15 and described below.

COMPONENT

DESCRIPTION

11 Component 11 is an integrated circuit chip which has multiple input/output terminals 11a. In Fig. 1, the input/output terminals 11a are shown as solder balls as an example.

12 Component 12 is a thin planar substrate which has a top surface 12a and a bottom surface 12b. All of the input/output terminals 11a of the

integrated circuit chip 11 are attached to respective I/O pads 12c on surface 12a of the substrate 12. Within the substrate 12 are a plurality of electrical conductors which connect the input/output terminals 12c to respective I/O pads 12d on the bottom surface 12b of the substrate 12. One such conductor is indicated by reference numeral 12e.

13..... Component 13 is a printed circuit board, and it has a plurality of I/O pads 13a that align with the I/O pads 12d on the substrate 12. Each I/O pad 13a is connected to a respective electrical conductor 13b (only one of which is shown) which lie within the printed circuit board 13.

14a and 14b.... Components 14a and 14b are springy contacts which are compressed to make electrical connections between the I/O pads 12d on the substrate 12 and the I/O pads 13a on the printed circuit board 13. A respective springy contact is provided for each of the I/O pads 12d. The springy contacts 14a and 14b are two different types. Each contact 14a exerts a relatively small force on

the I/O pads which it contacts; whereas each contact 14b exerts a relatively large force on the I/O pads which it contacts.

15..... Component 15 is a carrier which holds all of the springy contacts 14a and 14b such that they are aligned with the I/O pads 12d and 13a. This carrier 15 has two planar surfaces with multiple holes that extend from one surface to the other. The carrier 15 is made of an electrical insulator, such as plastic; and the springy contacts 14a and 14b are held in the holes of the carrier as shown in Fig. 1 by friction. Preferably, the springy contacts 14a and 14b in their uncompressed state extend past each planar surface of the carrier 15 by less than one-tenth of an inch.

16-19..... Components 16, 17, 18, and 19 together constitute a compressing mechanism which compresses the springy contacts 14a and 14b. Component 16 has four legs which surround the integrated chip 11 and rest on surface 12a of the substrate 12. Two of these legs are

indicated in Fig. 1 by reference numerals 16a and 16b. Each component 17 is a bolt which passes through a hole in the printed circuit board 13 and a hole in component 16. Each component 18 is a nut which screws onto one of the bolts 17. Each component 19 is a coil spring which fits onto one bolt 17 and is compressed by one nut 18.

One particular feature of the Fig. 1 electromechanical module is that the integrated circuit chip 11 and its substrate 12 can be easily removed and replaced. To remove the integrated circuit chip 11 and its substrate 12 from the Fig. 1 module, the nuts 18 are unscrewed from the bolts 17; components 19 and 16 are removed from the bolts 17; and the chip 11 together with the substrate 12 are lifted off of the springy contacts 14a and 14b. Then, to put another chip into the Fig. 1 module, that chip together with its substrate 12 are placed on the springy contacts 14a and 14b; component 16 is placed on the substrate 12 such that its legs surround the chip; the springs 19 are slipped onto the bolts 17; and the nuts 18 are tightened on the bolts 17 to a predetermined torque.

As the nuts 18 are tightened, the component 16 and the printed circuit board 13 move towards each other; and consequently, the springy contacts 14a and 14b get compressed into the holes of the carrier 15. Various forces are exerted on the substrate 12 by the legs of

component 16 and by the compressed springy contacts 14a and 14b; and the locations of these forces on the substrate 12 are illustrated in Fig. 2.

In Fig. 2, the location of the forces which are exerted on the substrate 12 by the legs of component 16 are indicated by four rectangles 16a', 16b', 16c' and 16d'. Leg 16a exerts the force in rectangle 16a'; leg 16b exerts the force in rectangle 16b'; etc. Likewise, in Fig. 2 the forces which are exerted on the substrate 12 by the springy contacts 14a and 14b are indicated by dots 14a' and x's 14b'. Each force at a dot 14a' is a relatively small force which is exerted by a springy contact 14a; and each force at an x 14b' is a relatively large force which is exerted by a springy contact 14b.

Due to all of the forces which are applied to the substrate 12 as shown in Fig. 2, that substrate will bend. However, by utilizing two types of springy contacts 14a and 14b which respectively exert a small force and a large force on the substrate 12, the maximum deflection of the substrate 12 beneath the chip 11 is less than that which will occur if all of the springy contacts exert the same magnitude force against the substrate. Consequently, the potential for damage to the chip and/or its connections due to stress is reduced.

The principle which causes this reduced deflection under the chip 11 is illustrated schematically in Figs. 3A and 3B. There, reference numeral 20 indicates a beam to which several forces F1, F1, and F3 are applied. This beam 20 represents the substrate 12 in Fig. 1; and the two forces F1 represent the forces which

are exerted by the legs 16a and 16b on the substrate 12. These two forces F1 are separated because the legs 16a and 16b in Fig. 1 are separated by the chip 11. Also in Figs. 3A and 3B, the forces F2 represent the small forces
5 which are exerted on the substrate 12 by the springy contacts 14a in Fig. 1; and the forces F3 represent the large forces which are exerted on the substrate 12 by the springy 14b of Fig. 1.

If only the forces F1 and F2 are applied to the
10 beam 20 as shown in Fig. 3A, the center of the beam is deflected upward relative to the points where the forces F1 touch the beam, and the ends of the beam are deflected downward relative to those same points. By comparison, when the forces F1, F2, and F3 are applied to the beam 20
15 as shown in Fig. 3B, the larger forces F3 have the effect of bending the ends of the beam upward. This, in turn, causes the center of the beam to be deflected less in the upward direction. Consequently, the peak deflection D' which occurs in the beam 20 of Fig. 3B is less than the
20 peak deflection D which occurs in the beam 20 of Fig. 3A.

To accurately determine the actual bending and actual stresses that occur in the substrate 12 of Fig. 1, a computer simulation was performed. The results of that simulation are shown in Figs. 4, 5, 6, and 7. All of the
25 parameters which were used to perform the simulation are listed below.

- 1) The substrate 12 was made of a printed circuit board material called FR4.

12

- 2) The size of the substrate 12 was 42.5 millimeters by 42.5 millimeters, and its thickness was 1.12 millimeters.
- 3) The I/O pads 12d were disposed on surface 12b of the substrate 12 in a 33 by 33 array.
- 4) The I/O pads 12d had a center to center spacing of 1.27 millimeters.
- 5) Each of the small force contacts 14a exerted a force of 1 ounce, or 0.28 Newtons, against the substrate 12.
- 6) Each of the large force contacts 14b exerted a force of 2 ounces, or 0.56 Newtons, against the substrate 12.
- 7) The integrated circuit chip 11 on surface 12a of the substrate 12 was 18.3 millimeters by 18.3 millimeters.
- 8) Component 16 had four spaced-apart legs which surround the integrated circuit chip 11 and press against surface 12a of the substrate 12.
- 9) Each leg of component 16 pushed against the substrate 12 in an area which was 1 millimeter wide and 25 millimeters long.
- 10) Each leg of component 16 was indented from an edge of the substrate 12 by 5 millimeters.

In Fig. 4, the "o" signs provide a plot of the deflections which occur along a line 12f in the substrate 12 during the above simulation. This line 12f in the substrate 12 is shown in Fig. 2. A deflection in Fig. 4 is positive if the deflected point is above the points where the legs 16a, 16b, etc. touch the substrate; otherwise the deflection in Fig. 4 is negative. For comparison purposes, the "+" signs in Fig. 4 provide a plot of the deflections which occur along the line 12f in the substrate 12 when the large force contacts 14b are replaced with the small force contacts 14a.

In Fig. 4, the deflections which are critical are those that occur under the integrated circuit chip 11. Those deflections occur where the distance x is less than $18.3 \div 2$ millimeters. For that region, the peak deflection shown by the "+" signs is about 0.042 millimeters; and, the peak deflection D' shown by the "o" signs is about 0.022 millimeters. Thus, by using the small force contacts 14a and the large force contacts 14b in accordance with the present invention, the peak deflection under the chip is reduced by roughly $(0.042 - 0.022) \div 0.042$, or about 47%.

Similarly, in Fig. 5, the "o" signs provide a plot of the deflections which occur along a line 12g in the substrate 12 during the above simulation. This line 12g in the substrate 12 is shown in Fig. 2. Here again, a deflection in Fig. 5 is positive if the deflected point is above the points where the legs 16a, 16b, etc. touch the substrate; otherwise the deflection in Fig. 5 is negative. Also in Fig. 5, the "+" signs provide a plot

of the deflections which occur along the line 12g in the substrate 12 when the large force contacts 14b are replaced with the small force contacts 14a.

Again in Fig. 5, the deflections which are
5 critical are those that occur under the chip 11 (i.e.- where x is less than $18.3 \div 2$ millimeters). There, the peak deflection shown by the "+" signs and the peak deflection shown by the "o" signs are approximately the same as that which occur in Fig. 4. Consequently, with
10 the present invention, the peak deflection under the chip is again reduced by about 47%

Inspection of Fig. 5 also shows that at the perimeter of the substrate, the deflection indicated by the "o" signs is actually larger than the deflection
15 indicated by the "+" signs. Thus when the large force contacts 14b are used with the small force contacts 14a, the deflection at the perimeter of the substrate is increased. However, this increased deflection at the perimeter of the substrate causes no damage because it
20 occurs far away from the integrated circuit chip.

In Fig. 6, the "o" signs provide a plot of the shear stress that is generated during the above simulation which occurs along the line 12f in the soldered joints between the substrate 12 and the
25 input/output terminals 11a of the integrated circuit chip 11. This shear stress is in units of Mega-Pascals (MPa); and it is generated by the deflections which are shown by the "o" signs in Fig. 4.

For comparison purposes, the "+" signs in
30 Fig. 6 provide a plot of the shear stress which occurs at

the same points as the "o" signs but under the condition where the large force contacts 14b are replaced with the small force contacts 14a. In Fig. 6, the peak shear stress shown by the "+" signs is roughly 6.0 MPa; 5 whereas the peak shear stress shown by the "o" signs is less than 4.0 MPa. Thus, with the present invention, the peak shear stress along line 12f in the solder joints between the substrate 12 and the input/output terminals 11a of the integrated circuit chip 11 is reduced by about 10 $(6.0-4.0) \div 6.0$, or 33%.

Similarly, in Fig. 7, the "o" signs provide a plot of the shear stress that is generated during the above simulation along the line 12g in the soldered joints between the substrate 12 and the input/output 15 terminals 11a of the integrated circuit chip 11. This shear stress is generated by the deflections which are shown by the "o" signs in Fig. 5.

For comparison purposes, the "+" signs in Fig. 7 provide a plot of the shear stress which occurs at the 20 same points as the "o" signs but under the condition where the large force contacts 14b are replaced with the small force contacts 14a. Inspection of Fig. 7 shows that the peak shear stress shown by the "+" signs is about 17 Mpa, and the peak shear stress shown by the "o" 25 signs is about 10.5 Mpa. Consequently, with the present invention, the peak shear stress along line 12g in the solder joints between the substrate 12a and the input/output terminals 11a of the integrated circuit chip 11 is reduced by about $(17-10.5) \div 17$ or 38%.

Turning now to Figs. 8-11, they show several embodiments of the springy contacts 14a and 14b. In Fig. 8, the springy contact 14a is comprised of a coil of wire which has a relatively small wire thickness T_1 , and the
5 springy contact 14b is comprised of a coil of wire which has a relatively large wire thickness T_2 . Due to these different thicknesses, the springy contact 14a exerts a relatively small force on the I/O pads which it contacts; whereas the springy contact 14b exerts a relatively large
10 force on the I/O pads which it contacts.

In Fig. 9, the springy contact 14a is comprised of a wad of wire which has a relatively small height H_1 ; and the springy contact 14b is comprised of a wad of wire which has a relatively large height H_2 . Each wad
15 includes one or more pieces of wire that are randomly bent and entangled into a springy mass. Due to the different heights of the springy masses, each contact 14a exerts a relatively small force on the I/O pad which it touches, whereas each contact 14b exerts a relatively
20 large force on the I/O pad which it touches.

As one modification, the springy contact 14a in Fig. 9 can be comprised of a coil of wire (as opposed to a wad of wire) which has the small height H_1 , and the springy contact 14b in Fig. 9 can be comprised of a coil
25 of wire which has the large height H_2 . Similarly, the springy contact 14a in Fig. 8 can be comprised of a wad of wire (as opposed to a coil of wire) which has the small wire thickness T_1 , and the springy contact 14b in Fig. 8 can be comprised of a wad of wire which has the
30 large wire thickness T_2 .

In Fig. 10, the springy contact 14a is comprised of an elastomer which is relatively pliant, and the springy contact 14b is comprised of a different elastomer which is relatively stiff. Due to the different elasticities E_1 and E_2 , the springy 14a exerts a relatively small force on the I/O pads which it contacts; whereas the springy contact 14b exerts a relatively large force on the I/O pads which it contacts.

In Fig. 11, the springy contact 14a is comprised of pogo-pin which includes a piston 14a-1 that pushes against a spring 14a-2 which has a relatively small spring constant. By comparison, the springy contact 14b in Fig. 11 is comprised of another pogo-pin which includes a piston 14b-1 that pushes against a spring 14b-2 which has a relatively large spring constant. Consequently, the springy contact 14a exerts a relatively small force on the I/O pads which it contacts, whereas the springy contact 14b exerts a relatively large force on the I/O pads which it contacts.

Several preferred embodiments of the present invention have now been described in detail. In addition, however, various changes and modifications can be made to those details without departing from the nature and spirit of the invention; and one such modification is shown in Fig. 12.

Fig. 12 is similar to Fig. 2 in that it shows the locations of the forces on the substrate 12 which are exerted by the springy contacts 14a and 14b and by the legs of component 16. However, one modification in Fig. 12 is that the component 16 has only two legs 16a and 16b

(rather than four legs) which exert forces on the substrate 12 in two rectangles 16a' and 16b'. Also, another modification in Fig. 12 is that the springy contacts 14a and 14b are arranged in a different pattern than that which occurs in Fig. 2, and this different pattern is indicated by the dots 14a' and the x's 14b'.

Due to all of the forces which are applied to the substrate 12 in Fig. 12, that substrate will bend. However, by utilizing the two types of springy contacts 14a and 14b which respectively exert the small force 14a and the large force 14b on the substrate 12, the maximum deflection of the substrate 12 under the chip 11 will again be less than that which will occur if all of the springy contacts exert the same magnitude force against the substrate. Why, this reduced deflection occurs will now be explained.

In Fig. 12, the two legs 16a and 16b on component 16 push downward in the rectangles 16a' and 16b'; whereas all of the springy contacts 14a which lie between those two legs push upward on the substrate at each of the dots 14a'. Consequently, the substrate 12 will bow upward between the two rectangles 16a' and 16b'; and, the remaining portion of the substrate 12 which lies to the left and right of the rectangles will be deflected downward.

To reduce the upward deflection of the substrate 12 between the two rectangles 16a' and 16b', the large force contacts 14b are interspersed with the small force contacts 14a on the periphery portion of the substrate 12 as shown in Fig. 12 by the x's 14b' and the

dots 14a'. Since the large force contacts 14b are mixed with the small force contacts 14a, the total upward force which is exerted on the periphery of the substrate is increased over that which would occur if all of the contacts were of the small force type. Consequently, the periphery portion of the substrate 12 is pushed further upward; and that in turn exerts a moment on the center portion of the substrate 12 which deflects if further downward.

10 In Fig. 12, the pattern of the small force springy contacts and large force springy contacts which is shown is just one example; and many other patterns could be used as an alternative. In particular, fewer large force contacts 14b can be used as the magnitude of the force which is exerted by each large force contact is increased relative to the magnitude of the force which is exerted by each small force contact 14a; and vice versa. By mixing the large force contacts and small force contacts in different permutations, the peak upward deflection of the substrate 12 between the legs 16a and 16b can be minimized. Preferably, the magnitude of the force which is exerted by each large force contact is at least 50% larger than the force which is exerted by each small force contact.

25 Also, as another modification, the number of different types of springy contacts which are employed can be more than two. For example, four different types of springy contacts can be used which respectively push against the substrate 12 with the force of 1 ounce, 30 2 ounces, 3 ounces, and 4 ounces. Preferably, for ease

of manufacturing, the number of different types of springy contacts is limited to less than ten.

Further, as still another modification the structure of the carrier 15 of the springy contacts in the Fig. 1 embodiment can be changed as shown in Figs. 13 and 14. In Fig. 13, a blown-up portion of the modified carrier is indicated by reference number 25. This modified carrier 25 is the same as the carrier 15 in Fig. 1 except that it includes a plurality of holes 26 which each hold four of the springy contacts 14a and/or 14b. One springy contact is held in a wide portion 26a of the hole; a second springy contact is held in another wide portion 26b of the hole; a third springy contact is held in another wide portion 26c of the hole; and a fourth springy contact is held in another wide portion 26d of the hole. By comparison, in the carrier 15 of Fig. 1, each hole in the carrier holds only a single springy contact.

As a related variation, the carrier 25 in Fig. 13 can be changed such that each hole 26 holds more than four springy contacts, or holds less than four springy contacts. This modification is made by simply increasing or decreasing the total number of the wide portions 26a-26d in each of the holes 26.

In Fig. 14, a blown-up portion of yet another modified carrier is indicated by reference numeral 35. This modified carrier 35 differs from the carrier 15 in Fig. 1 in that the springy contacts 14a and 14b project from only one planar surface 36a of the carrier.

To implement the Fig. 14 modification, the carrier 35 has holes 37 for holding the springy contacts 14a and 14b which start from the planar surface 36a but only extend part way through the carrier. Electrical
5 signals are transmitted to/from the springy contacts by microscopic conductors which run from the side walls of the holes to a terminal on the opposite planar surface 36b of the carrier, or to a terminal on the side of the carrier. Two such conductors are indicated by reference
10 numerals 38a and 38b.

Also, as another modification, the compressing mechanism shown in Fig. 1 can be replaced with any other mechanism that compresses the springy contacts 14a and 14b against respective I/O pads. Thus, the components
15 16-19 in Fig. 1 constitute just one particular embodiment of a compressing mechanism for the springy contacts.

Accordingly, since all of the above changes and modifications can be made to the preferred embodiments, it is to be understood that the invention is not limited
20 to the details of any one preferred embodiment but is defined the appended claims.

WHAT IS CLAIMED IS:

1. An electromechanical module which is comprised of:
 - an electronic component that is attached to a substrate which is bendable;
 - 5 multiple springy contacts that touch respective I/O pads on said substrate;
 - a compressing mechanism which compresses said springy contacts against said I/O pads with forces that bend said substrate; and,
 - 10 said springy contacts including contacts of a first type, each of which exert a relatively small force against its respective I/O pad; and contacts of a second type, each of which exert a substantially larger force against its respective I/O pad.
2. A module according to claim 1 wherein said different types of springy contacts are distributed in a pattern such that said substrate is bent, where said electronic component is attached, with a maximum
5 deflection which is less than that which will occur if all of said springy contacts exert said small force against its respective I/O pad.
3. A module according to claim 2 wherein said compressing mechanism has spaced-apart legs that push on said substrate around said electronic component.

4. A module according to claim 3 wherein said I/O pads are on said substrate both between and outside of said legs; and said second type of springy contacts push only on I/O pads which are outside of said legs.

5. A module according to claim 3 wherein said I/O pads are disposed on said substrate in a pattern of rows and columns, and where said second type of springy contacts are located at the perimeter of said pattern.

6. A module according to claim 3 wherein said electronic component is an integrated circuit chip.

7. A module according to claim 3 wherein said electronic component is attached to said substrate with microscopic solder connections that detach if said bend gets too large.

8. A module according to claim 1 wherein said compressing mechanism and all of said springy contacts push on said substrate such that said substrate is deflected in only one direction in a region where said electronic component is attached, and said second type of springy contacts are located such that they tend to deflect said region of said substrate in an opposite direction.

9. A module according to claim 8 wherein said springy contacts are held by a carrier which lies between said substrate and another member to which said compressing mechanism is attached.

10. A module according to claim 8 wherein said substrate is a printed circuit board.

11. A module according to claim 8 wherein said substrate is a ceramic substrate.

12. A module according to claim 1 wherein said first type contacts and said second type contacts are interspersed in a permutation which minimizes the maximum deflection of said substrate in a region where said
5 electronic component is attached.

13. An electromechanical subassembly which is comprised of:

a carrier having a body with a planar surface and multiple holes that extend from said planar surface
5 into said body;

a plurality of springy contacts which are held in said holes and extend past said planar surface; and,

said plurality of springy contacts including contacts of a first type which each exert a relatively
10 small opposing force when compressed to said planar surface, and contacts of a second type which each exert a substantially larger opposing force when compressed to said planar surface.

14. A subassembly according to claim 13 wherein each springy contact of said first type is comprised of a wad of wire having a relatively small wire thickness, and each springy contact of said second type is comprised of
5 a wad of wire having a larger wire thickness.

15. A subassembly according to claim 13 wherein each springy contact of said first type is comprised of a wad of wire having a relatively short height, and each springy contact of said second type is comprised of a wad
5 of wire having a taller height.

16. A subassembly according to claim 13 wherein each springy contact of said first type is comprised of a relatively pliable conductive elastomer, and each springy contact of said second type is comprised of a stiffer
5 conductive elastomer.

17. A subassembly according to claim 13 wherein each springy contact of said first type is comprised of a relatively pliable metal, and each springy contact of said second type is comprised of a stiffer metal.

18. A subassembly according to claim 13 wherein each springy contact of said first type is comprised of a piston which compresses a spring that exerts said small opposing force, and each springy contact of said second
5 type is comprised of a piston which compresses a spring that exerts said large opposing force.

19. A subassembly according to claim 13 wherein each springy contact of said first type is comprised of a coil of wire having a relatively small wire thickness, and each springy contact of said second type is comprised
5 of a coil of wire having a larger wire thickness.

20. A subassembly according to claim 13 wherein each springy contact of said first type is comprised of a coil of wire having a relatively short height, and each springy contact of said second type is comprised of a
5 coil of wire having a taller height.

21. A subassembly according to claim 13 wherein said plurality of springy contacts are limited to only said two different types.

22. A subassembly according to claim 13 wherein said small force and said large force differ from each other by at least 50%.

23. A subassembly according to claim 13 wherein said springy contacts include contacts of less than ten different types, each of which exert an opposing force of a different magnitude when compressed to said planar
5 surface.

24. A subassembly according to claim 13 wherein said holes extend through said body to another surface of said carrier, and said springy contacts extend past both surfaces.

25. A subassembly according to claim 13 wherein said holes extend into but not through said body.

26. A subassembly according to claim 13 wherein each one of said holes in said carrier holds only a single springy contact.

27. A subassembly according to claim 13 wherein each one of said holes in said carrier holds more than one springy contact.

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Fig. 1

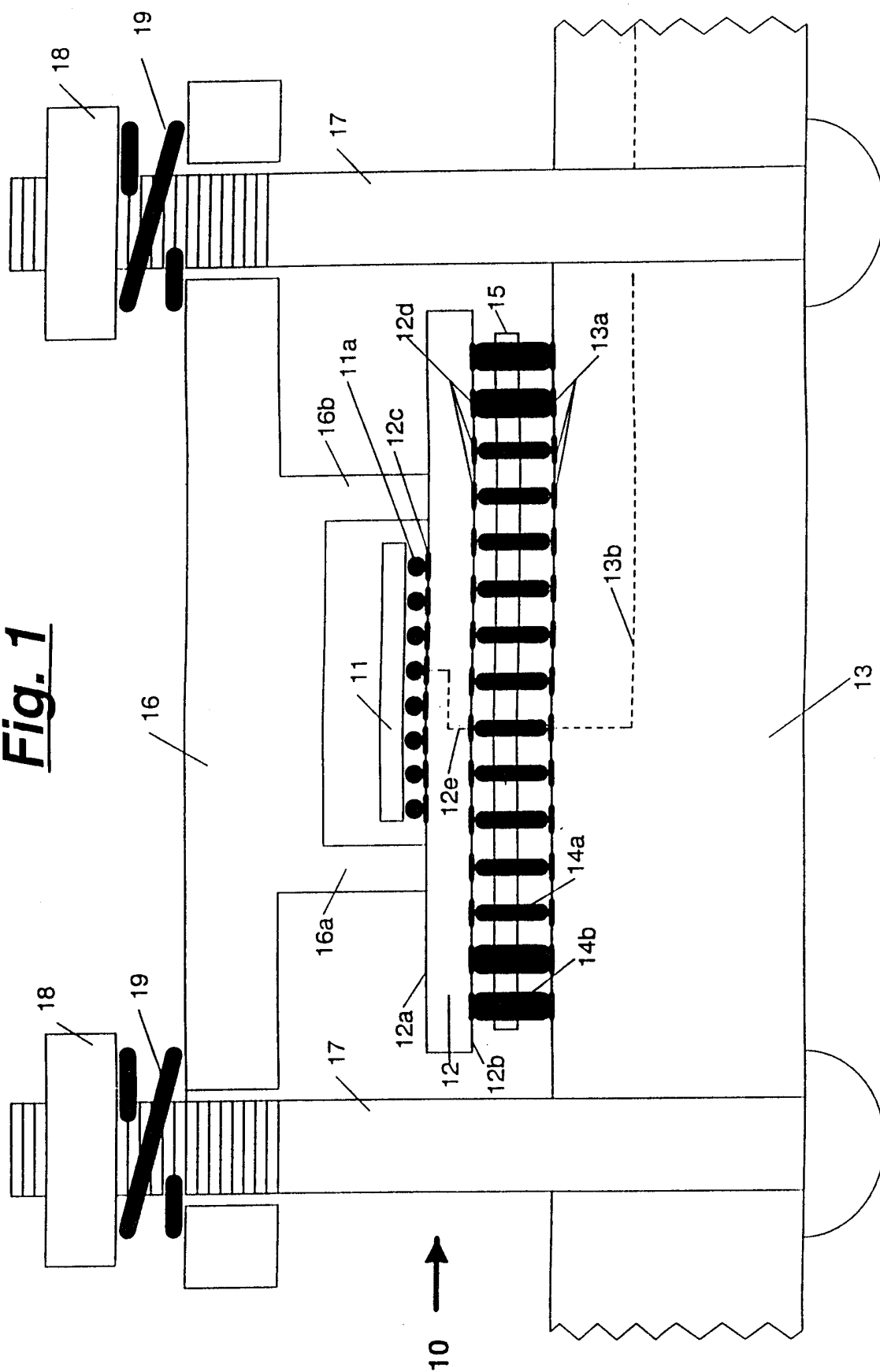


Fig. 2

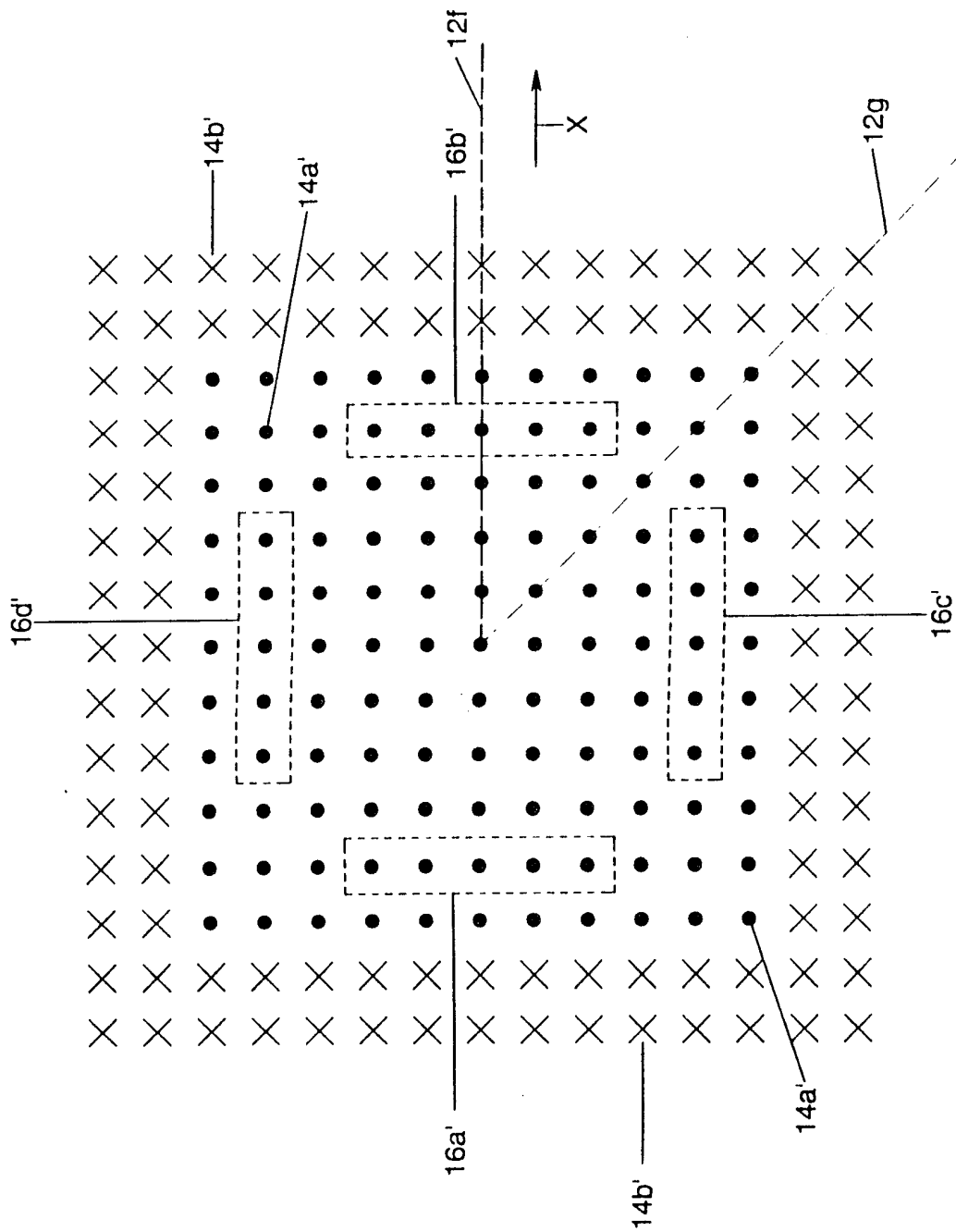
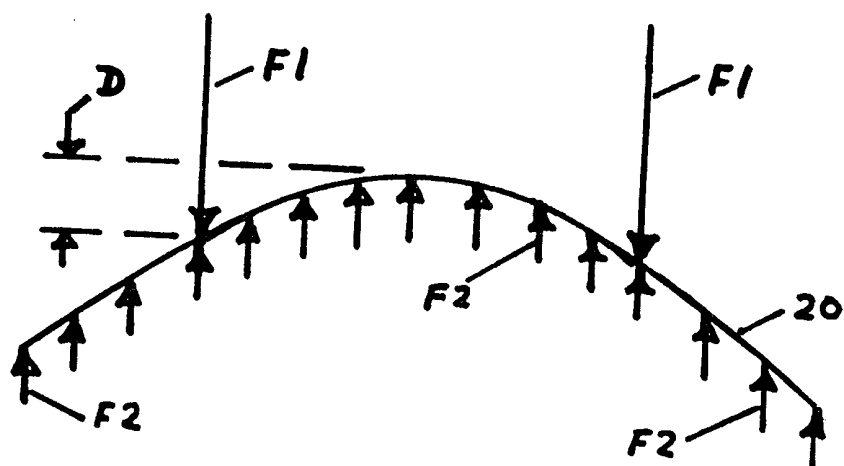
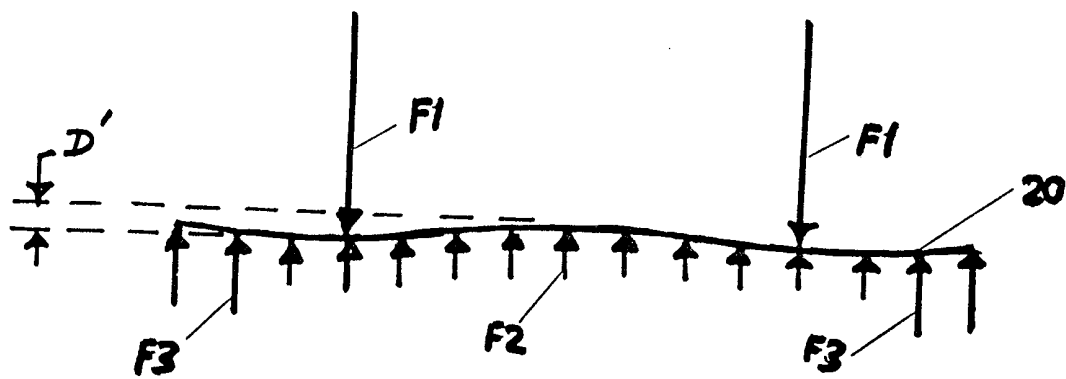
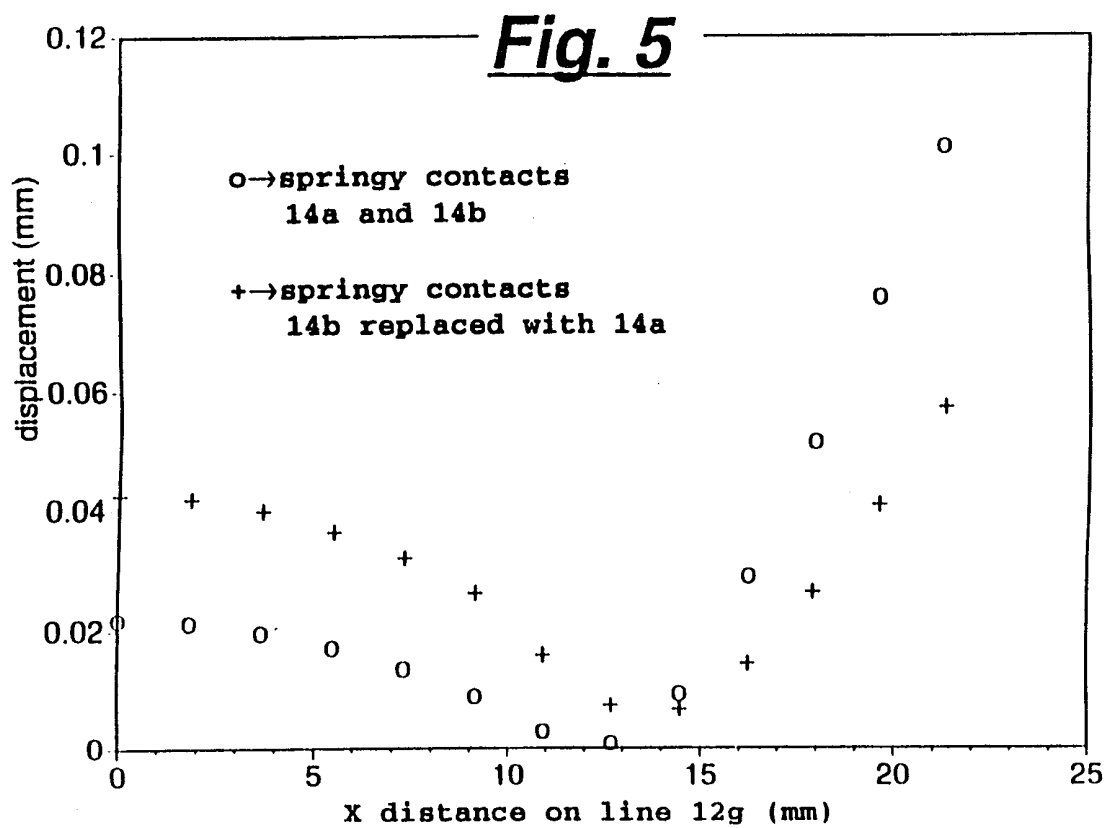
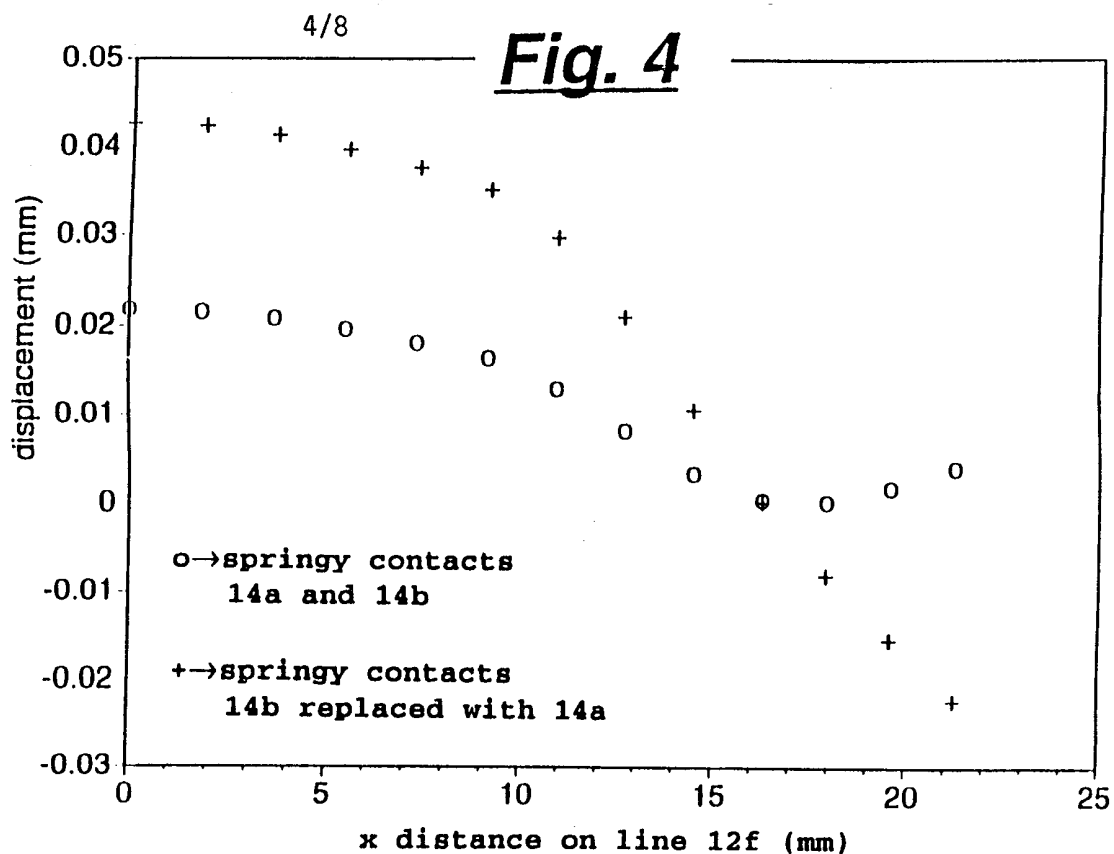


Fig. 3A**Fig. 3B**



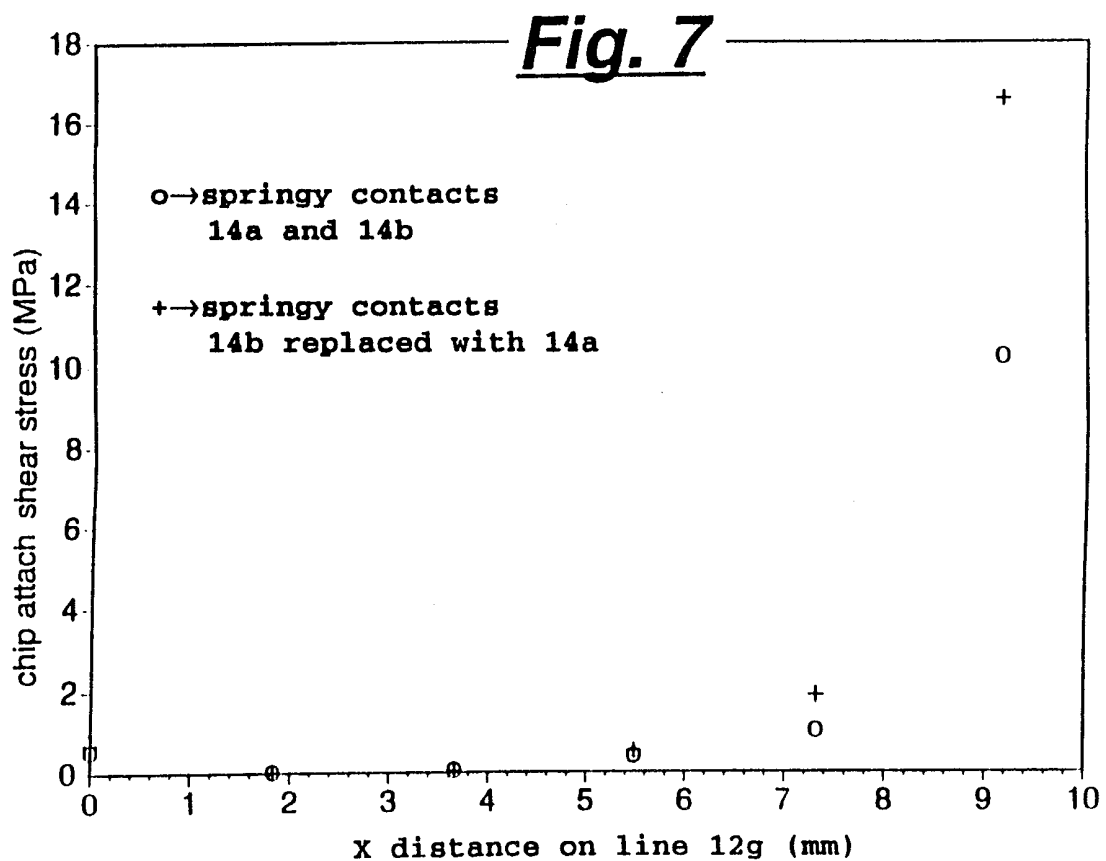
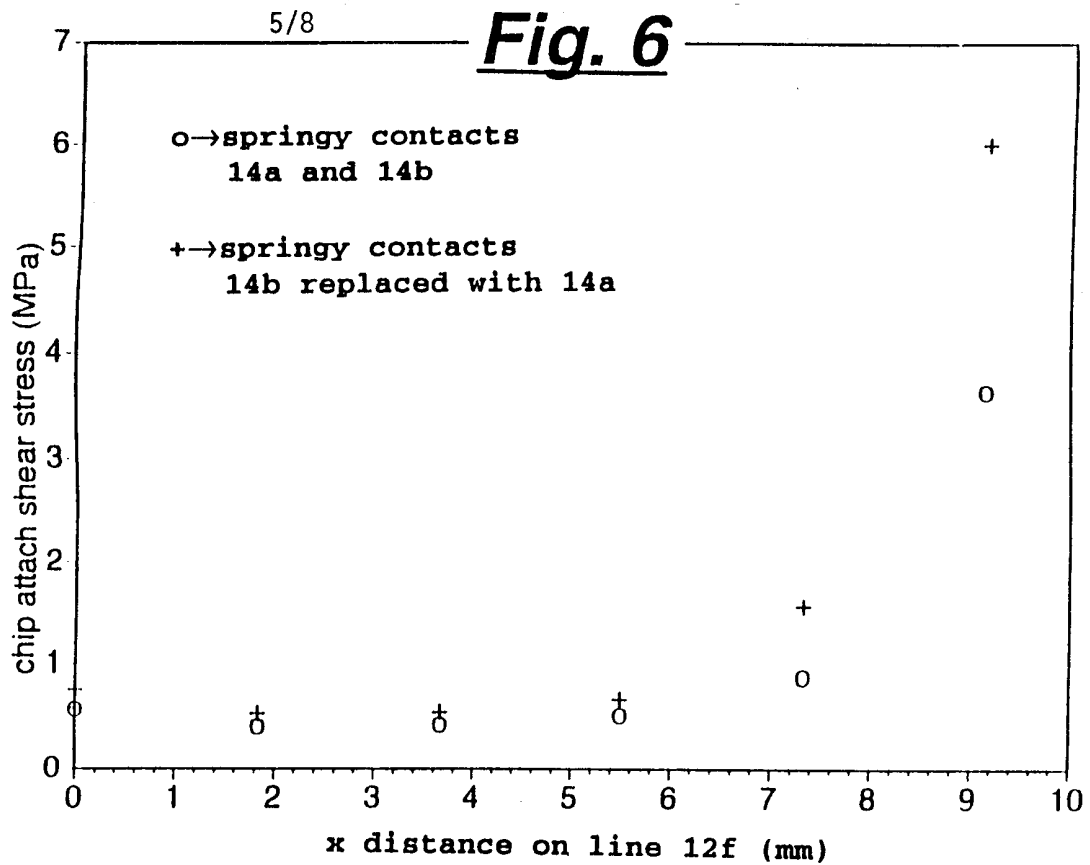


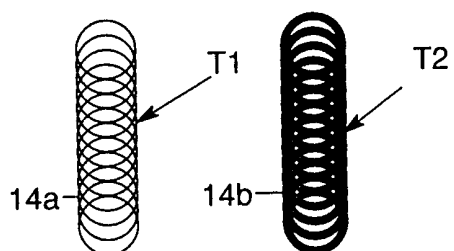
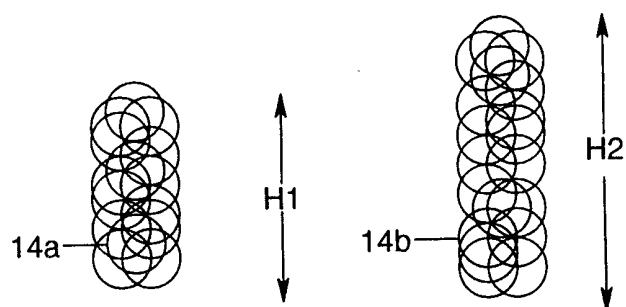
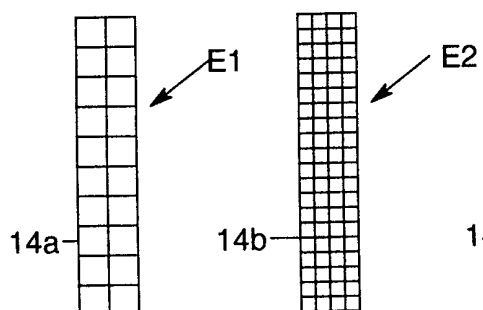
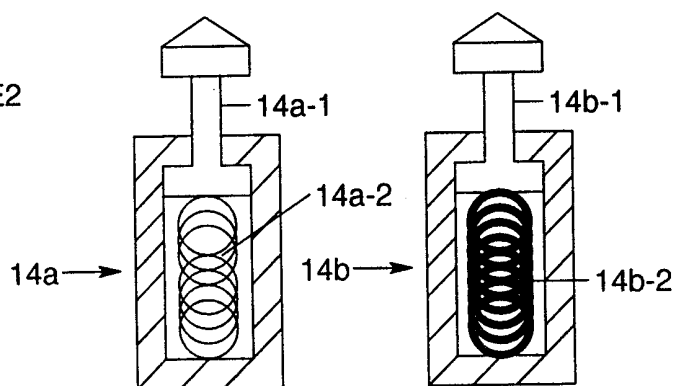
Fig. 8**Fig. 9****Fig. 10****Fig. 11**

Fig. 12

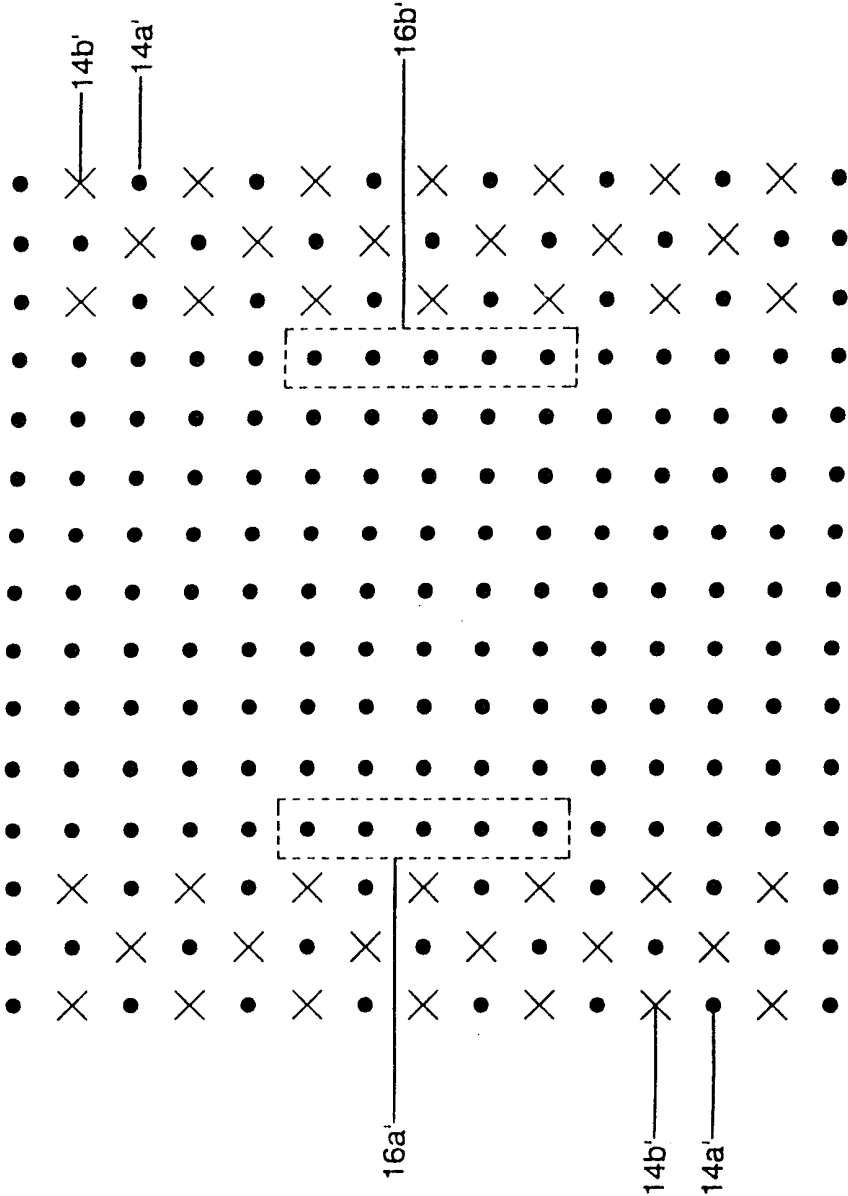
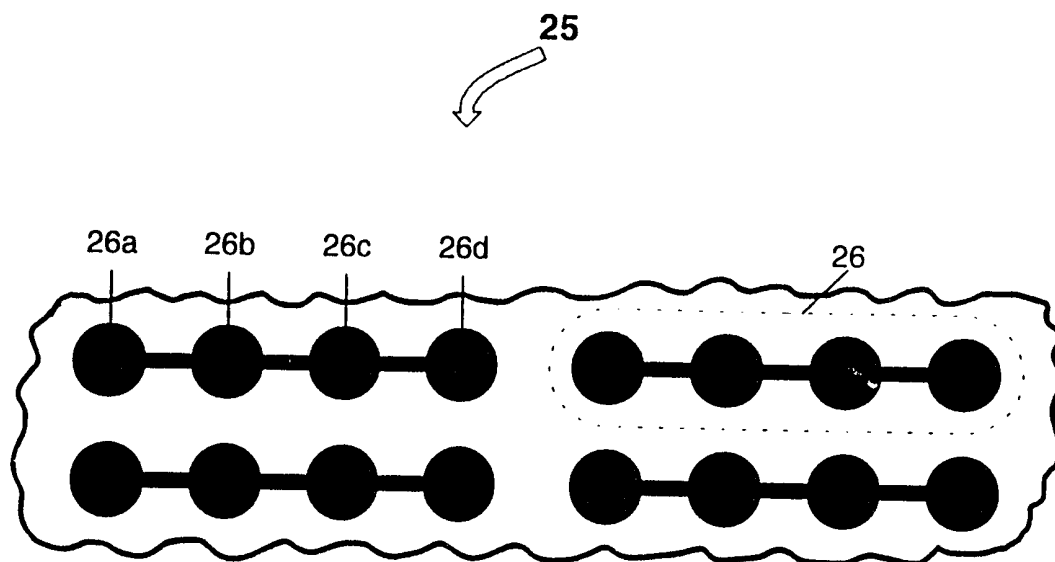
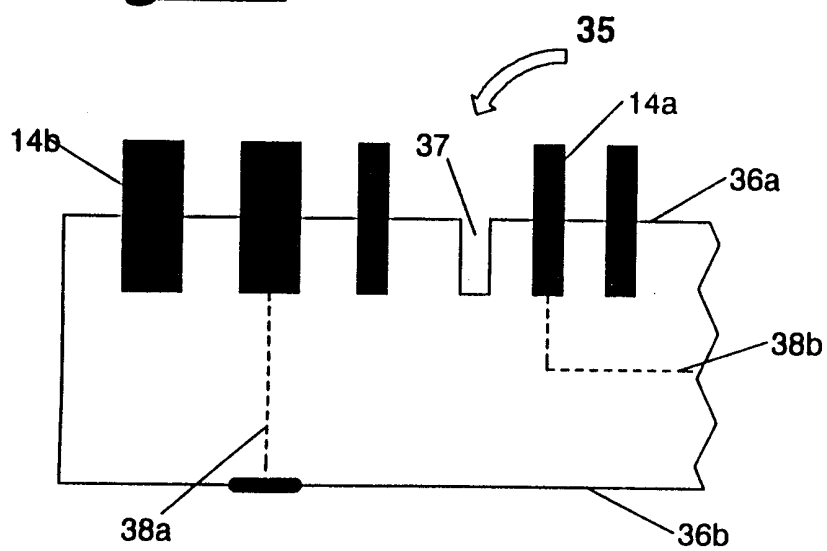


Fig. 13**Fig. 14**

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 99/15773

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H05K7/10 H01R13/18 H01R13/187

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H05K H01R H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 620 761 A (SMITH BRIAN M ET AL) 4 November 1986 (1986-11-04) figures 6-9 column 4, line 58 -column 6, line 29 ---	1-10, 12, 13, 19-24, 26
A	US 4 508 405 A (DAMON NEIL F ET AL) 2 April 1985 (1985-04-02) figures 1-3, 9 column 2, line 65 -column 4, line 6 column 5, line 17 - line 27 --- -/--	1-9, 12, 13, 18, 24, 26

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

30 September 1999

Date of mailing of the international search report

07/10/1999

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Polesello, P

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 99/15773

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 38 03 469 A (DIGATEC ELECTRONIC SYSTEMS) 17 August 1989 (1989-08-17) figures 1,4 column 5, line 21 - line 31 ----	1,2,6,8, 11-13, 20,23, 25-27
A	EP 0 717 471 A (IBM) 19 June 1996 (1996-06-19) figures 1,4 column 5, line 6 - line 37 column 6, line 52 -column 7, line 12 ----	1-3, 6-10,13, 14,17, 24-26
A	US 4 999 023 A (FROLOFF PHILIP P) 12 March 1991 (1991-03-12) cited in the application figure 3 column 2, line 19 -column 3, line 17 column 3, line 63 -column 4, line 4 -----	1-6,8, 10-18, 25,26

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