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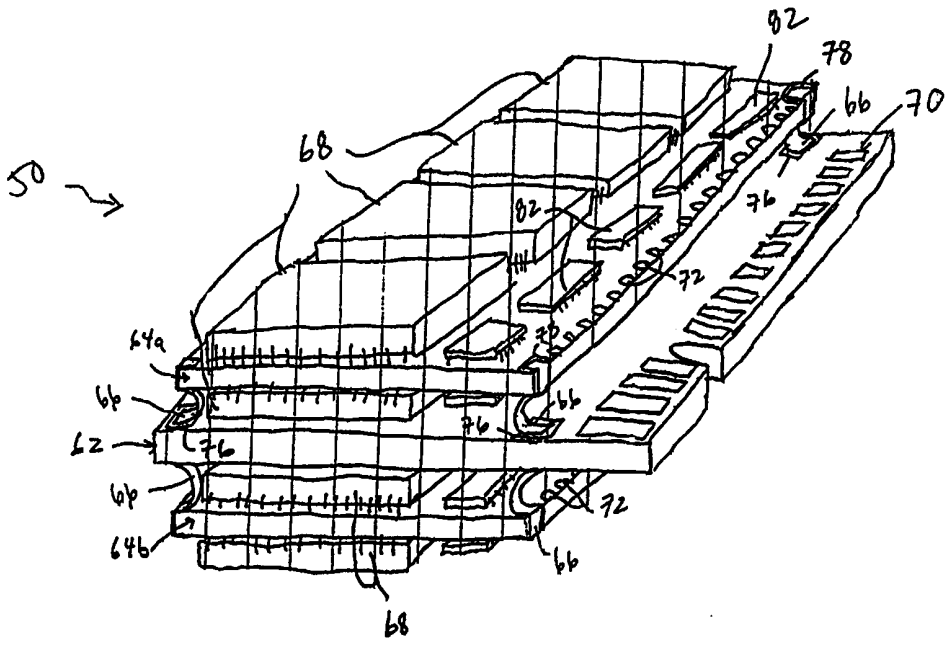

(57) Abstract

A module for insertion into an expansion slot of a computer includes a primary board (62) and a pair of auxiliary boards (64a, 64b). The auxiliary boards are mounted in a spaced relationship on respective sides of the primary board to define air paths between the boards. The air paths allow air to circulate between the boards. The auxiliary boards each have a trace (72) for electrically connecting the board to the primary board, and the primary board has a trace (70) for connecting chips (68) mounted thereon to an interface with the expansion slot. The traces of the auxiliary boards are substantially the same length. The trace of the primary boards is only slightly longer than the traces of the auxiliary boards.

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HIGH-DENSITY COMPUTER MODULES WITH STACKED PARALLEL-PLANE PACKAGING

CROSS-REFERENCE TO RELATED APPLICATION

This is a continuation-in-part of copending application 09/008,925, filed January 20, 1998. The entire content of this copending application is hereby incorporated by reference.

FIELD OF THE INVENTION

The present invention is directed to computer memory boards and, more particularly, to expansion modules for mounting in an expansion slot of a mother board of a computer.

BACKGROUND OF THE INVENTION

It is well known that in the electronics industry, particularly the personal computer industry, that the trend is to design products which are smaller, lighter, and more compact while maintaining or increasing power, speed, and memory capacity. In recent years, the computer industry has experienced the advent of the lap-top computer, the notebook computer, and now the palm-top computer. Although these computers are amazingly compact and lightweight, they are still incredibly powerful and fast. They are capable of running software applications that only in the recent past were able to be run on desk-top computers with large amounts of memory.

Personal computers (including desk-top, lap-top, notebook, and palm-top computers) include a mother board for controlling the operation of the computer. Personal computers are sold with a specified amount of memory, for example, 1.2 gigabytes (GB) of storage memory on a hard drive and 64 megabytes (MB) of random access memory (RAM). Many users upgrade the RAM of their computers. Accordingly, motherboards typically include standardized expansion slots in which a memory card may be inserted. The expansion slots may also receive cards for upgrading a particular function of the computer, such as cards for sounds, video, and graphics.

A dual in-line memory module (DIMM) connector is a standard industry connector for receiving a memory module. And in accordance with the "smaller-is-better" trend in the computer industry, many mother boards are equipped with only two DIMM connectors. As

such, in order to install a larger amount of memory in only two DIMM connectors, higher density memory modules have been developed.

One conventional technique for increasing the storage capacity of a memory module is to double the height of the module. To do so, two rows of memory chips are mounted on the memory module, essentially doubling the capacity of the module. However, there are two primary disadvantages of such a configuration. One disadvantage is the double height. The housing of the computer and the area around the mother board both need to be sufficiently large in order to accommodate this doubled size of the expansion, which runs contrary to the small-is-better design principle. Another disadvantage lies in different trace lengths. A trace is the electrical conductor which connects the chips to the edge connector or interface portion of the module. In the double-row configuration, one row of chips has one trace length, and the other row of chips has another trace length. The trace of the further row of chips is essentially twice as long as the closer row of chips from the edge connector. Accordingly, a signal traveling to the further rows of chips take about twice as long to arrive as the signal traveling to the closer row of chips. This arrangement requires the signal delay to be eliminated, which may be done by synchronizing the signals, which is difficult and expensive to accomplish. Alternatively, the trace of the closer row of chips may be physically doubled in length so that the signals arrive at the two rows at about the same time. Either solution results in a module which is limited in speed by the double-length trace.

Another conventional technique for increasing storage capacity of a memory module is to configure the double-height arrangement discussed above with a foldable portion such as an integral flex conductor. The module may then be folded in half, thereby reducing the height essentially by two. However, this foldable configuration still suffers from the drawback of the varying trace lengths. An additional drawback is created by the folded arrangement in that vertical air circulation is restricted. The components of the module produce heat, and under normal convection the heated air would rise and be drawn out of the computer by a fan. However, the folded portion of the module retains heat between the folded sections, which may cause the module to function improperly and errant.

Accordingly, in view of the foregoing, it is an object of the present invention to provide an expansion module which overcomes the disadvantages and drawbacks associated with conventional expansion modules.

It is another object of the present invention to provide a memory module which maximizes memory per unit volume of space which the memory module occupies.

It is yet another object of the invention to provide a high-density memory module which operates at the highest speed possible.

It is yet another object of the invention to provide a multiple-layer memory module with a minimized trace length.

It is yet another object of the present invention to provide a multiple-layer memory module with substantially equal trace lengths between layers.

It is a further object of the present invention to provide a multiple-layer memory module having boards that can be readily connected and disconnected from each other.

SUMMARY OF THE INVENTION

These and other objects are achieved by the apparatus of the present invention which provides a module for insertion into an expansion slot on a motherboard of a computer. Exemplary module maximizes the speed at which the module operates, maximizes chip density per expansion slot, and minimizes trace length. Although capable of performing all types of functions typical of expansion modules, the module of the present invention is particularly suitable for expanding the memory of a computer, either a desk-top, lap-top, notebook, or palm-top computer.

According to one aspect of the invention, an exemplary module includes a primary board with an interface portion for engaging with the expansion slot. The interface portion may be configured to engage with a conventional 168-pin dual in-line memory module (DIMM) connector, for example. At least one but preferably two auxiliary boards are mounted to respective sides of the primary board. The auxiliary boards are mounted with fasteners in a spaced relationship which defines an air path between each of the auxiliary boards and the primary board. Each of the auxiliary boards has a trace for electrically connecting the board to the primary board.

One of the advantages of the invention is that the air spaces allow air to circulate between the boards. Each of the boards may have a plurality of chips mounted thereon which generate heat when operating. In addition, the computer in which the module is inserted is a closed environment with many electronic components which also generate heat. As temperature increases, the speed of a chip decreases because of increased resistance. However, in accordance with the present invention, air is able to freely circulate between the boards, thereby either cooling the chips or at least providing adequate ventilation to prevent the ambient temperature from increasing undesirably.

Another aspect of the present invention focuses on the traces. In addition to the traces of the auxiliary board or boards, the primary board has a trace connecting the interface portion with any number of the chips that may be mounted thereon. The traces of the auxiliary boards have substantially the same length, which is only slightly longer than that of the trace of the primary board.

In contrast to conventional double-height arrangement in which one of the traces is essentially twice as long as the other trace, the traces of the module of the present invention are substantially the same length. This feature of equal trace length advantageously eliminates the need for synchronizing signals to different rows of chips. In addition, by way of example only, the module of the invention reduces trace length on average by about 20% to 50% over conventional arrangements or some other value consistent with operational parameters. The reduction in trace length results in a much faster operating module.

Another aspect of the present invention focuses on surface mount connectors, which are a specific type of fastener, that enable the auxiliary boards to be securely mounted to respective sides of the primary boards. One of the advantages of the surface mount connectors is the ease in which the auxiliary boards can be mounted and dismounted from the primary board, thus, reducing the time and costs of assembly. In addition, electrical failure verification and failure analysis can be readily performed by easily separating the auxiliary boards from the primary board and interfacing the individual boards with test equipment via the surface mount connectors.

Other aspects, features, and advantages of the present invention will become apparent to those persons having ordinary skill in the art to which the present invention pertains from the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of an exemplary embodiment of an expansion module of the present invention, particularly illustrating the expansion module mounted in an expansion slot of a mother board of a computer;

FIG. **2** is a perspective view of an exemplary expansion module of the present invention, illustrating a multiple-layer, parallel-plane configuration of boards;

FIG. **3A** is a side view of an auxiliary board of an expansion module of the invention, illustrating a plurality of chips mounted on a first side of the board;

FIG. **3B** is a view similar to that of FIG. **3A**, illustrating a plurality of chips mounted on a second side of the board;

FIG. **4** is a side view of a board of an exemplary expansion module of the invention, particularly highlighting a masked wiring arrangement of the board;

FIG. **5** is a cross-sectional view of an expansion module of the invention, particularly illustrating minimized trace lengths of auxiliary boards and a primary board of the module;

FIG. **6** is a cross-sectional view of an exemplary module of the invention, particularly illustrating open air paths defined between boards in a spaced relationship; and

FIG. **7** is an exploded perspective view of an alternative embodiment of an expansion module of the present invention, illustrating a plurality of surface mount connectors;

FIG. **8** is an exploded cross-sectional view of the expansion module illustrated in FIG. **7**;

FIG. **9A** is a side view of a primary board of the expansion module illustrated in FIG. **7**, illustrating a plurality of chips and surface mount connectors mounted on a first side of the primary board;

FIG **9B** is a view similar to that of FIG. **9A**, illustrating a plurality of chips and surface mount connectors mounted on a second side of the primary board;

FIG. **10A** is a side view of an auxiliary board of the expansion module illustrated in FIG. **7**, illustrating a plurality of chips mounted on a first side of the auxiliary board;

FIG. **10B** is a view similar to that of FIG **10A**, illustrating a plurality of chips and surface mount connectors mounted on a second side of the auxiliary board;

FIG. **11A** is a side view of the primary board of the expansion module shown in FIG. **7**, particularly highlighting a masked wiring arrangement of the first side of the primary board;

FIG. **11B** is a view similar to that of FIG. **11A**, illustrating a masked wiring arrangement on the second side of the primary board;

FIG. **12A** is a side view of the auxiliary board of the expansion module shown in FIG. **7**, particularly highlighting a masked wiring arrangement of the first side of the auxiliary board;

FIG. **12B** is a view similar to that of FIG. **12A**, illustrating a masked wiring arrangement on the second side of the auxiliary board;

FIG. **13A** is a top view of a male surface mount connector of the expansion module illustrated in FIG. **7**;

FIG. **13B** is a top view of a female surface mount connector of the expansion module illustrated in FIG. **7**;

FIG. **14** is a cross-sectional view of the expansion module illustrated in FIG. **7**, particularly illustrating minimized trace lengths of auxiliary boards of the module; and

FIG. **15** is a cross-sectional view of an expansion module illustrated in FIG. **7**, particularly illustrating open air paths defined between boards in a spaced relationship.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Referring to the drawings in more detail, in FIG. **1** an exemplary embodiment of a high-density, stacked parallel-plane module **50** and **150** of the present invention is illustrated. Exemplary module **50** and **150** is installable in a mother board **52** of a computer **54**. As known in the art, mother board **52** includes a main board **56** with a microprocessor **58** mounted thereon. Mother board **52** may include a plurality of additional semiconductor chips and electronic components operatively associated with microprocessor **58**, which additional chips and components are not shown in the drawings for clarity. Also not shown in the drawings are components and peripheral devices which may be configured with computer **52**, including a

monitor, input devices such as a keyboard and/or a mouse, network connections, output devices such as a printer, and so on.

Mother board **52** also includes at least one, but in general a plurality of expansion slots **60***a–l* in communication with microprocessor **58**. Expansion slots **60***a–l* may respectively receive add-on modules for performing particular functions. For example, a memory module may be inserted into one of the expansion slots **60** to increase the amount of memory of computer **54**. The expansion slots **60** are also known in the art as connectors. A 168-pin dual in-line memory module (DIMM) connector is an example of a standard expansion slot or connector commonly used in industry today. As computers become increasingly small and compact, particularly portable computers such as lap-top computers and now palm-top computers, many mother boards for desk-top computers are equipped with as few as two 168-pin DIMM connectors. As a referencing convention for this description, expansion slots (or connectors) are referenced generally by numeral **60**, with each particular expansion slot referenced specifically by alpha suffix *a*, *b*, ... *l*, respectively. This referencing convention will be utilized throughout this description for the expansion slots as well as for other plural elements of the present invention.

Referencing FIG. **2**, exemplary module **50** of the present invention includes a primary board **62** and at least one auxiliary board **64**. As exemplified in the embodiment shown in FIG. **2**, exemplary module **50** includes a pair of auxiliary boards **64***a* and **64***b*. Upon reading this description, those skilled in the art will appreciate that module **50** of the invention may include a plurality of auxiliary boards **64***a–m*. Auxiliary boards **64** are mounted to primary board **62** with fasteners **66**. As illustrated, auxiliary boards **64***a* and **64***b* are configured in a substantially spaced and parallel-plane relationship with respect to primary board **62**, with one of the auxiliary boards **64** being mounted on a first side of primary board **62** and the other auxiliary board **64** being mounted on a second side of primary board **62**. Such as relationship has a number of advantages, including ventilation, high density, reduced trace length, ease of manufacturing, which advantages will be discussed in more detail below. Exemplary boards **62** and **64** may be generally configured as printed circuit boards (PCBs) or printed wiring boards (PWBs), as known in the art. In addition to mechanically mounting auxiliary boards **64** to primary board **62**,

a number of fasteners **66** or each may also be conductive and serve as electrical connections, which will also be discussed in more detail below.

With additional reference to FIGS. **3A** and **3B**, each board **62** and **64** may include a plurality of chips **68***a–n* mounted on each side thereof. Each chip **68** may perform a particular function. For example, each chip **68** may be a memory chip so that exemplary module **50** is a high-density memory module. Exemplary primary board **62** includes an electrical interface portion **70** for connecting with one of the expansion slots **60**. With additional reference to FIG. **4**, each auxiliary board **64** includes edge pins **72** arranged generally around a periphery thereof. Chips **68** mounted on boards **62** and/or **64** communicate with pins **72** with traces **74**. Boards **62** and **64** may be configured with chips **68**, interface portion **70**, and pins **72** as known in the art of fabricating printed circuit boards. For example, each board **62** and **64** may be a multiple-layer glass epoxy configuration with interface **70** and edge pins **72** being formed by applying gold over nickel. Traces **74** may be applied by solder masks. Electrical connections between auxiliary boards **64** and primary board **62** may be made by fasteners **66** respectively mounted on pads **76** of primary board **62** and pads **78** of auxiliary boards **64**. Pads **76** of primary board **62** are electrically connected to interface portion **70** (which includes a plurality of standard edge connectors as known in the art). Pads **78** of auxiliary boards **62** are electrically connected to edge pins **72**.

With further reference to FIG. **1**, the art of chip fabrication allows microprocessor **58** to operate at increasing high speeds. For example, microprocessor **58** may operate on the order of hundreds of megahertz (MHz). Accordingly, if expansion module **50** is configured as a memory module, such as a synchronous dynamic random access memory (SDRAM), memory module **50** needs to operate at about 100 MHz or more. Switching times at 100 MHz are on the order of 10 nanoseconds (ns).

Electrical signals travel on traces **74** from pins **72** to chips **68**. A time (t) required for an electrical signal to travel from interface portion **70** to a chip may be determined by dividing a length (l) of a trace from interface portion **70** to the chip by a velocity (v) at which electrical signal travels, or $t = l / v$. As velocity v is substantially constant for the electrical signal (which is nearly equal to the speed of light), time t is substantially proportional to length l, with the length being the variable in the equation. In order to maximize the speed at which module **50** operates,

the time the electrical signals reach chips **68** needs to be minimized. To minimize the time, trace length *l* needs to be minimized. The velocity of the electrical signal will vary according to temperature, in that as temperature increases, velocity decreases, which will be discuss below.

With additional reference to FIG. **5**, trace length *l* may be defined as the total length of the electrical connection extending from the edge connectors of interface portion **70** of primary board **62** to one of the chips **68**. In accordance with this definition, auxiliary board **64***a* has a trace length l_a, and auxiliary board **64***b* has a trace length l_b, as shown by the dashed arrows. Exemplary module **50** is configured such that trace lengths l_a and l_b of auxiliary boards **64***a* and **64***b* are substantially equal. In addition, auxiliary trace lengths l_a and l_b are only slightly longer than a trace length l_p of primary board **62**, with the additional length being added by conductive fasteners **66**. In accordance with an exemplary embodiment of module **50**, primary trace length l_p may be increased by a small predetermined amount to be substantially equal to auxiliary trace lengths l_a and l_b. By way of example only, the trace lengths of the exemplary module **50** may be 20% less to up to 50% less than those of conventional modules, or some other value consistent with operational parameters.

It is preferred for fasteners **66** positioned along bottom edges of boards **62** and **64** (that is, near mother board **56**) to serve as electrical connectors for carrying the most significant or time-dependent electrical signals from mother board **56** to auxiliary boards **64** of module **50**. Fasteners **66** positioned along top edges of boards **62** and **64** (that is, along edges opposite to that at which interface portion **70** is disposed as shown in FIG. **2**) may serve as electrical connectors for carrying less time-dependent signals, such as power, ground, and address lines, for example.

As mentioned above, the velocity *v* at which an electrical signals travel along a trace **74** from a pin **72** to a chip **68**, and vice versa, is inversely proportional to temperature (T), that is, $v \propto (1 / T)$. Accordingly, if temperature T increases, then velocity *v* decreases and module **50** operates at a slower speed. To maximize the speed, temperature needs to be minimized, or at least maintained within a predetermined operating range or specification. With additional reference to FIG. **6**, module **50** is illustrated mounted in an expansion slot **60** of a mother board **56**. (Fasteners **66** are not illustrated for clarity.) In operation, chips **68** generate heat. If the generated heat is not ventilated, then the ambient temperature around module **50** will increase, thereby decreasing the speed of the module **50**.

According to the present invention, the spaced parallel-plane arrangement of module **50** defines an air path **80***a* between auxiliary board **64***a* and primary board **62** and an air path **80***b* between auxiliary board **64***b* and primary board **62**. Air paths **80** are open along top and bottom edges of boards **62** and **64**. As shown in FIG. **1**, fasteners **66** are relatively small and do not present substantial air blockage. Air paths **80** promote circulation and allow heat (which is shown by cursive arrows and reference **H**) to rise and escape. As discussed above, conventional modules have a closed flex conductor section extending along top edges of and between a pair of boards, which prevents air circulation and traps heat between the boards, thereby greatly increasing the ambient temperature at the module and, correspondingly, decreasing the speed. Increased temperature may also cause modules to malfunction and introduce errors.

Referencing FIG. **1** and **2**, one of the preferred commercial embodiments of exemplary module **50** is a memory module for augmenting existing memory of computer **54**. As such, chips **68** may be synchronous dynamic RAM (SDRAM) chips. Module **50** may also include a plurality of damping resistor packages **82** configured with the SDRAM chips. One of the advantages of the memory module embodiment of the present invention is that the amount of memory per module and memory per unit volume is maximized. For example, exemplary memory module **50** may include more than 256 MB for a standard 168-pin DIMM configuration. As the art of chip fabrication advances, it is obvious to those skilled in the art that more memory will be able to be included on module **50**.

Referring now to FIGS. **7** and **8**, an alternative embodiment of a high-density, stacked parallel-plane module **150** of the present invention is illustrated. Exemplary module **150** is installable in the mother board **52** of the computer **54** illustrated in FIG. **1**. Exemplary module **150** of the present invention includes a primary board **162** and at least one auxiliary board **164**. As exemplified in the embodiment shown in FIG. **7**, exemplary module **150** includes a pair of auxiliary boards **164***a* and **164***b*. Those skilled in the art will appreciate that module **150** of the invention may include a plurality of auxiliary boards **164***a-m*. Auxiliary boards **164** are mounted to primary board **162** with surface mount connectors **166** such as Fine Stack connectors available from AMP. As illustrated, auxiliary boards **164***a* and **164***b* are configured in a substantially spaced and parallel-plane relationship with respect to primary board **162**, with one of the auxiliary boards **164** being mounted on a first side of primary board **162** and the other auxiliary

board **164** being mounted on a second side of primary board **162**. Exemplary boards **162** and **164** may be generally configured as PCBs or PWBs. In addition to mechanically mounting auxiliary boards **164** to primary board **162**, the surface mount connectors **166** also serve as electrical connections, which will be discussed in more detail below.

With additional reference to FIGS. **9A** and **9B**, primary board **162** may include a plurality of chips **167***a-c* mounted within an opening thereof, and with additional reference to FIGS. **10A** and **10B**, auxiliary boards **164** may include a plurality of chips **168***a-n* mounted on each side thereof. Each chip **167** and **168** may perform a particular function such as a memory chip so that exemplary module **150** is a high-density memory module. Exemplary primary board **162** includes an electrical interface portion **170** for connecting with one of the expansion slots **60**.

Each surface mount connector **166** includes a male surface mount connector and a matching female surface mount connector which may be easily connected and disconnected. Primary board **162** may include five male surface mount connectors **166***a* on each side thereof with three of the male surface mount connectors **166***a* arranged in a single row along the top portion of the primary board **162** and the remaining two male surface mount connectors **166***b* arranged in a single row along the bottom portion of the primary board **162** adjacent to the electrical interface portion **170**. Chips **167** mounted on primary board **162** communicate with male surface mount connectors **166***a* by traces **174** as shown in FIGS. **11A** and **11B**. In addition, male surface mount connectors **166***a* are electrically connected to interface portion **170** of primary board **162**.

With additional reference to FIGS. **12A** and **12B**, each auxiliary board **164** includes five female surface mount connectors **166***b* which mechanically and electrically connect with the corresponding male surface mount connectors **166***a* of primary board **162**. Chips **168** mounted on each of the auxiliary boards **164** communicate with the female surface mount connectors **166***b* by traces **174** as shown in FIGS. **12A** and **12B**. Thus, auxiliary boards **164** and primary board **162** are electrically and mechanically connected by the male connectors **166***a* and female connectors **166***b*. It is noted that a primary board may comprise fewer or more than five male surface mount connectors on each side, and each auxiliary board may correspondingly comprise fewer or more than five female connectors. In addition, male surface connectors may be mounted on auxiliary boards and female surface mount connectors may be mounted on a primary board.

With additional reference to FIGS. **13A** and **13B**, both the male connectors **166***a* and female connectors **166***b* include a non-electrically conductive housing **176**. The housing **176** encloses a plurality of electrical contacts **178** which electrically connect the male connectors **166***a* to the female connectors **166***b*. A plurality of fingers **180** extend laterally and outwardly from the housing **176**. Presently, it is contemplated that the male connectors **166***a* and female connectors **166***b* each comprise forty electrically contacts **178** and forty fingers **180**. However, the number of contacts **178** and fingers **180** can range from twenty to eighty, or any other appropriate number. The fingers **180** are attached to the boards **162** and **164** by methods generally known in the art such as by soldering the fingers **180** to pads on the boards **162** and **164**. As discussed above in regards to the embodiment illustrated in FIG. **2**, each board **162** and **164** may be a multiple-layer glass epoxy configuration with traces **174** applied by solder masks.

The auxiliary boards **164** can be readily disconnected from the primary board **162** by simply separating the male connectors **166**a from their matching female connectors **166**b. By separating the boards **162** and **164**, the functionality of the boards **162** and **164** can be independently subjected to electrical failure verification and failure analysis. In addition, the electrical test equipment can be interfaced with each of the boards **162** and **164** via the surface mount connectors **166**. For example, the electrical test equipment can include a coupling which mates with the surface mount connector, thus, replacing the costly and time consuming method of testing boards with custom bed-of-nail test fixtures.

With further reference to FIGS. **7** and **8**, memory module **150** may further include fastening pins **182** which provide a secondary means of mechanically connecting the primary board **162** to the auxiliary boards **164**. Fastening pins **182** are particularly useful when the module **150** is exposed to harsh environmental conditions such as high frequency vibrations, high shock impacts, and thermal cycling. Each of the fastening pins **182** may be fitted and soldered into openings **184** formed in each corner of the of the boards **162** and **164**. It is noted that exemplary module **150** may comprise fewer or less than four fastening pins, and the pins may be secured to the boards **162** and **164** by other means such as an adhesive or other means generally known in the art.

With additional reference to FIG. **13**, trace length L may be defined as the total length of electrical connection extending from the edge connectors of interface portion **170** of primary

board **162** to one of the chips **168** on the auxiliary board **164**. In accordance with this definition, auxiliary board **164**a has a trace length L_a, and auxiliary board **164**b has a trace length L_b, as shown by dashed arrows. Exemplary module 150 is configured such that trace lengths L_a and L_b of auxiliary boards **164**a and **164**b are substantially equal.

It is preferred for surface mount connectors **166** positioned near the bottom edges of board **162** and **164** (that is, near mother board 56) to serve as electrical connectors for carrying the most significant or time-dependent electrical signals from mother board **56** to auxiliary board **164** of module **150**. Surface mount connectors **166** positioned near the top edges of boards **162** and **164** (that is, along edges opposite to that at which interface portion **170** is disposed as shown in FIG. **7**) may serve as electrical connectors for carrying less time-dependent signals, such as power, ground, and address lines, for example.

Referring now to FIG. **14**, module **150** is illustrated mounted in an expansion slot **60** of a mother board **56**. For the same reasons discussed above in regards to the embodiment illustrated in FIG. **2**, the spaced parallel-plane arrangement of module **150** is configured to promote circulation and allow heat (which is shown by cursive arrows and reference **H**) to rise and escape. The spaced parallel-plane arrangement defines an air path **180**a between auxiliary board **164**a and primary board **162** and air path **180**b between auxiliary board **164**b and primary board **162**. Air paths **180** are open along top and bottom edges of boards **162** and **164**, and the surface mount connectors are relatively small and do not present substantial air blockage.

The memory module **50** and **150** shown in FIG. **1** may have a thickness as defined from the outer or external side (i.e., the side not facing primary board **62**) of one of the auxiliary boards **64** to the outer side of the other auxiliary board **64** of less than about 0.5 inch but preferably less than about 0.325 inch. In addition, the memory module of the present invention may have an overall height as defined from the bottom edge to the top edge of primary board **62** of less than about one and a half inches but preferably less than about 1.40 inches.

Those skilled in the art will understand that the embodiments of the present invention described above exemplify the present invention and do not limit the scope of the invention to these specifically illustrated and described embodiments. The scope of the invention is determined by the terms of the appended claims and their legal equivalents, rather than by the described examples. In addition, the exemplary embodiments provide a foundation from which numerous alternatives

and modifications may be made, which alternatives and modifications are also within the scope of the present invention as defined in the appended claims.

CLAIMS

What is claimed is:

1. A module for mounting in an expansion slot of a mother board of a computer, said module comprising:

a primary board including an interface portion for engaging with the expansion slot;

an auxiliary board mounted to said primary board in a spaced relationship such that an air path is defined between said boards;

a plurality of surface mount connectors for mounting said auxiliary board to said primary board; and

a trace on said auxiliary board for electrically connecting said auxiliary board to said primary board.

2. The module of claim 1 wherein said primary board has a first side and a second side, said auxiliary board being mounted on said first side of said primary board;

said module further comprising:

a second auxiliary board mounted on said second side of said primary board in a spaced relationship such that an air path is defined between said boards;

a second trace on said second auxiliary board for electrically connecting said second auxiliary board to said primary board; and

an additional plurality of surface mount connectors for mounting said second auxiliary board to said primary board.

3. The module of claim 2 wherein said trace is substantially equal in length to said second trace.

4. The module of claim 2 wherein said plurality of surface mount connectors and said additional plurality of surface mount connectors include electrically conductive contacts for functioning as electrical connectors between said auxiliary boards and said primary board.

5. The module of claim 4 wherein said surface mount connectors and said additional surface mount connectors are connected to said traces.

6. The module of claim 1 wherein said interface portion is configured to be compatible with an industry standard memory module expansion slot.

7. The module of claim 2 wherein said surface mount connectors and additional surface mount connectors each include a male surface mount connector and a corresponding female surface mount connector, wherein said male connector mates with said female connector.

8. The module of claim 7 wherein said male connectors being directly attached to said first side and said second side of said primary board, and said female connectors being directly attached to a side of said auxiliary boards.

9. The module of claim 7 wherein each side of said primary board includes five said male connectors arranged in a first row and a second row, wherein said first row being adjacent to a top edge of said primary board and said second board being adjacent to a bottom edge of said primary board.

10. The module of claim 9 further comprising

a plurality of chips mounted to said auxiliary boards, said plurality of chips including memory chips;

one end of said trace connecting to at least one of said plurality of chips and the other end of said trace connecting to at least one of said plurality of surface mount connectors;

one end of said second trace connecting to at least one of said additional plurality of chips and the other end of said second trace connecting to at least one of said plurality of additional surface mount connectors and to at least one of said plurality of surface mount connectors and said second trace connecting to at least one of said plurality of chips; and

a plurality of additional chips mounted to said primary board

11. The module of claim 2 further comprising a fastening pin securing said primary board and said auxiliary boards together, wherein said fastening pin fits into apertures formed in each of said primary board and said auxiliary boards.

12. A computer comprising:

a mother board including an expansion slot; and

a memory module including:

a primary board including a plurality of integrated circuit chips, and an interface portion configured to be engaged with said expansion slot;

a pair of auxiliary boards mounted to respective sides of said primary board in a spaced relationship such that an air path is defined between each of said auxiliary boards and said primary board;

a plurality of additional integrated circuit chips connected to said auxiliary boards;

a plurality of surface mount connectors for mounting said auxiliary boards to said primary board, each of said surface mount connectors including a male surface mount connector and a matching female surface mount connector, wherein said male connector mates with said female connector with a friction fit; and

a trace for each said auxiliary board electrically connecting each said auxiliary board to said primary board.

13. The computer of claim 12 wherein said expansion slot is configured as a 168-pin dual in-line memory module (DIMM) connector.

14. The computer of claim 12 wherein each said trace of said auxiliary boards have substantially equal lengths.

15. The computer of claim 14 further including a fastening pin securing said primary board and said auxiliary boards together, wherein said fastening pin fits into apertures formed in each of said primary board and said auxiliary boards.

16. A method for increasing memory capacity of a computer, comprising the steps of:

(a) providing a computer including a mother board with an expansion slot;

(b) providing a memory module including:

a primary board including an interface portion configured to engage with the expansion slot of the computer, a plurality of chips including memory chips, and a trace connecting the interface portion with at least one of the chips;

an auxiliary board attached to the primary board in a spaced relationship such that an air path is defined between the boards, the auxiliary board including a plurality of chips including memory chips;

a plurality of surface mount connectors for mechanically and electrically connecting the auxiliary board to the primary board;

a trace on the auxiliary board connecting the surface mount connectors with at least one of the chips; and

(c) inserting the interface portion of the memory module into the expansion slot of said computer.

17. The method of claim 16 wherein the expansion slot is a 168-pin dual in-line memory module (DIMM) expansion slot, and the primary board has at least 200 megabytes of memory capacity.

18. The method of claim 16 wherein each of the surface mount connectors includes a male surface mount connector and a corresponding female surface mount connector, said male and female connectors mate to form a friction fit, and said male connector being attached to the primary board and the female connector attached to the auxiliary board.

19. The method of claim 16 further comprising the step of:

(d) arranging the surface mount connectors in a first row adjacent to a top edge of the primary board and auxiliary board; and

(e) arranging the surface mount connectors in a second row adjacent to a bottom edge of the primary board and auxiliary board.

20. The method of claim 16 further comprising the step of mechanically attaching the primary board and auxiliary board together by inserting a fastening pin through a hole in each of the primary board and auxiliary board.

21. A method of forming a memory module for mounting in an expansion slot of a mother board of a computer, comprising the steps of:

(a) providing a primary board including an interface portion for engaging with the expansion slot;

(b) providing an auxiliary board;

(c) providing a plurality of surface mount connectors for attaching the auxiliary board to the primary board in a spaced relationship such that an air path is defined between the boards; and

(d) forming a trace on the auxiliary board which connects the auxiliary board to the primary board.

22. The method of claim 21 further comprising the steps of:

(e) providing a plurality of additional surface mount connectors for attaching a second auxiliary board to the primary board in spaced relationship such that an air path is defined between the second auxiliary board and the primary board, wherein the auxiliary board is attached to a first side of the primary board and the second auxiliary board is attached to a second side of the primary board; and

(f) forming a second trace on the second auxiliary board which connects the second auxiliary board to the primary board.

23. The method of claim 22 wherein the trace is substantially equal in length to the second trace, the surface mount connectors are connected to the trace, and the additional surface mount connectors are connected to the second trace.

24. The method of claim 22 further comprising a plurality of chips attached to the auxiliary boards and a plurality of additional chips attached to the primary board, wherein the plurality of chips include memory chips.

25. A module for mounting in an expansion slot of a mother board of a computer, said module comprising:

a primary board including an interface portion for engaging with the expansion slot;

an auxiliary board mounted to said primary board in a spaced relationship such that an air path is defined between said boards;

a plurality of fasteners for mounting said auxiliary board to said primary board; and

a trace for electrically connecting said auxiliary board to said primary board.

26. A module as claimed in claim 25 wherein said primary board has a first side and a second side, said auxiliary board being mounted on said first side of said primary board;

said module further comprising:

a second auxiliary board mounted on said second side of said primary board in a spaced relationship such that an air path is defined between said boards; and

a second trace for electrically connecting said second auxiliary board to said primary board;

said plurality of fasteners including fasteners for mounting said second auxiliary board to said primary board.

27. A module as claimed in claim 26 wherein said trace connecting said auxiliary board to said primary board is substantially equal in length to said second trace connecting said second auxiliary board to said primary board.

28. A module as claimed in claim 26 wherein said plurality of fasteners includes conductive fasteners for functioning as electrical connectors between said auxiliary boards and said primary board.

29. A module as claimed in claim 28 wherein said conductive fasteners are connected to said traces.

30. A module as claimed in claim 25 wherein said interface portion is configured to be compatible with an industry standard memory module expansion slot.

31. A module as claimed in claim 30 further comprising a plurality of chips mounted to said boards, said plurality of chips including memory chips.

32. A module as claimed in claim 25 wherein each of said boards has a top edge and a bottom;

said interface portion being disposed along the bottom edge of said primary board.

33. A module as claimed in claim 32 wherein said air path is substantially open along the top edges of said boards.

34. A module as claimed in claim 25 wherein said primary board further includes:

a plurality of chips mounted thereon; and

a trace connecting said interface portion to at least one of said plurality of chips.

35. A module as claimed in claim 34 wherein said trace of said primary board has a length substantially equal to said trace connecting said auxiliary board with said primary board.

36. A computer comprising:

a mother board including an expansion slot; and

a memory module including:

a primary board including an interface portion configured to be engaged with said expansion slot;

a pair of auxiliary boards mounted to respective sides of said primary board in a spaced relationship such that an air path is defined between each of said auxiliary boards and said primary board;

a plurality of fasteners for mounting said auxiliary boards to said primary board; and

a pair of traces each for electrically connecting one of said auxiliary boards to said primary board.

37. A computer as claimed in claim 36 wherein said expansion slot is configured as a 168-pin dual in-line memory module (DIMM) connector.

38. A computer as claimed in claim 36 wherein said traces have substantially equal lengths.

39. A computer as claimed in claim 36 wherein said primary board further includes:

a plurality of chips mounted thereon; and

a trace connecting said interface portion with at least one of said plurality of chips.

40. A computer as claimed in claim 39 wherein each of said pair of traces has a length substantially equal to each other.

41. A computer as claimed in claim 40 wherein of said trace of said primary board has a length substantially equal to the length of said pair of traces.

42. A computer as claimed in claims 40 wherein said memory module has a thickness defined from an outer edge of one said auxiliary board to an outer edge of the other said auxiliary board of less than about 0.5 inch and a height defined from the bottom edge to the top edge of said primary board of less than about 1.5 inches

43. A method for increasing memory capacity of a computer, said method comprising the steps of:

providing a computer including a mother board with an expansion slot;

providing a memory module including:

a primary board including an interface portion configured to engage with the expansion slot of the computer, a plurality of chips including memory chips, and a trace connecting said interface portion with at least one of said chips;

an auxiliary board mounted to said primary board in a spaced relationship such that an air path is defined between said boards;

a plurality of fasteners for mounting said auxiliary board to said primary board; and

a trace for electrically connecting said auxiliary board to said primary board;

inserting said interface portion of said memory module into said expansion slot of said computer.

44. A method as claimed in claim 43 wherein:

said step of providing a computer comprises the step of providing a computer including a mother board with a 168-pin dual in-line memory module (DIMM) expansion slot; and

said step of providing a memory module comprises the step of providing a memory module including a primary board including a plurality of chips including memory chips with at least 200 megabytes of capacity.

AMENDED CLAIMS

[received by the International Bureau on 7 May 1999 (07.05.99);
original claim 29 cancelled;
original claims 1, 4, 12, 16, 21, 25, 26, 28, 36 and 43 amended;
remaining claims unchanged (11 pages)]

1. A module for mounting in an expansion slot of a mother board of a computer, said module comprising:

a primary board having a central region and an edge region, said edge region being defined by outer edges of the primary board, said central region being surrounded by said edge region, said edge region including an interface portion for engaging with the expansion slot;

an auxiliary board mounted to said primary board in a spaced relationship such that an air path is defined between said boards;

a plurality of surface mount connectors for mounting said auxiliary board to said primary board, wherein at least one of said plurality of surface mount connectors is disposed within said central region; and

a trace on said auxiliary board for electrically connecting said auxiliary board to said primary board.

2. The module of claim 1 wherein said primary board has a first side and a second side, said auxiliary board being mounted on said first side of said primary board;

said module further comprising:

a second auxiliary board mounted on said second side of said primary board in a spaced relationship such that an air path is defined between said boards;

a second trace on said second auxiliary board for electrically connecting said second auxiliary board to said primary board; and

an additional plurality of surface mount connectors for mounting said second auxiliary board to said primary board.

3. The module of claim 2 wherein said trace is substantially equal in length to said second trace.

4. The module of claim 2 wherein said plurality of surface mount connectors and said additional plurality of surface mount connectors electrically interconnect the auxiliary boards to the primary boards.

5. The module of claim 4 wherein said surface mount connectors and said additional surface mount connectors are connected to said traces.

6. The module of claim 1 wherein said interface portion is configured to be compatible with an industry standard memory module expansion slot.

7. The module of claim 2 wherein said surface mount connectors and additional surface mount connectors each include a male surface mount connector and a corresponding female surface mount connector, wherein said male connector mates with said female connector.

8. The module of claim 7 wherein said male connectors being directly attached to said first side and said second side of said primary board, and said female connectors being directly attached to a side of said auxiliary boards.

9. The module of claim 7 wherein each side of said primary board includes five said male connectors arranged in a first row and a second row, wherein said first row being adjacent to a top edge of said primary board and said second board being adjacent to a bottom edge of said primary board.

10. The module of claim 9 further comprising

a plurality of chips mounted to said auxiliary boards, said plurality of chips including memory chips;

one end of said trace connecting to at least one of said plurality of chips and the other end of said trace connecting to at least one of said plurality of surface mount connectors;

one end of said second trace connecting to at least one of said additional plurality of chips and the other end of said second trace connecting to at least one of said plurality of additional surface mount connectors and to at least one of said plurality of surface mount connectors and said second trace connecting to at least one of said plurality of chips; and

a plurality of additional chips mounted to said primary board

11. The module of claim 2 further comprising a fastening pin securing said primary board and said auxiliary boards together, wherein said fastening pin fits into apertures formed in each of said primary board and said auxiliary boards.

12. A computer comprising:

a mother board including an expansion slot; and

a memory module including:

a primary board including a plurality of integrated circuit chips, and an interface portion configured to be engaged with said expansion slot;

a pair of auxiliary boards mounted to respective sides of said primary board in a spaced relationship such that an air path is defined between each of said auxiliary boards and said primary board;

a plurality of additional integrated circuit chips connected to said auxiliary boards;

a plurality of surface mount connectors for mounting said auxiliary boards to said primary board, each said plurality of surface mount connectors including a male surface mount connector and a matching female surface mount connector, wherein said male connector mates with said female connector with a friction fit; and

a trace for each said auxiliary board electrically connecting each said auxiliary board to said primary board.

13. The computer of claim 12 wherein said expansion slot is configured as a 168-pin dual in-line memory module (DIMM) connector.

14. The computer of claim 12 wherein each said trace of said auxiliary boards have substantially equal lengths.

15. The computer of claim 14 further including a fastening pin securing said primary board and said auxiliary boards together, wherein said fastening pin fits into apertures formed in each of said primary board and said auxiliary boards.

16. A method for increasing memory capacity of a computer, comprising the steps of:

(a) providing a computer including a mother board with an expansion slot;

(b) providing a memory module including:

a primary board including an interface portion configured to engage with the expansion slot of the computer, a plurality of chips including memory chips, and a trace connecting the interface portion with at least one of the chips;

an auxiliary board attached to the primary board in a spaced relationship such that an air path is defined between the boards, the auxiliary board including a plurality of chips including memory chips;

a plurality of surface mount connectors for mechanically and electrically connecting the auxiliary board to the primary board, each of said plurality of surface mount connector comprising:

a plurality of surface mount connectors for mounting said auxiliary board to said primary board, wherein each said plurality of surface mount connectors comprises:

an electrically insulative housing;

a plurality of electrical contacts enclosed within said housing; and

a plurality of electrically conductive fingers electrically interconnected with said plurality of electrical contacts, said plurality of electrically conductive fingers extending outwardly from said housing; and

a trace on the auxiliary board connecting the surface mount connectors with at least one of the chips; and

(c) inserting the interface portion of the memory module into the expansion slot of said computer.

17. The method of claim 16 wherein the expansion slot is a 168-pin dual in-line memory module (DIMM) expansion slot, and the primary board has at least 200 megabytes of memory capacity.

18. The method of claim 16 wherein each of the surface mount connectors includes a male surface mount connector and a corresponding female surface mount connector, said male and female connectors mate to form a friction fit, and said male connector being attached to the primary board and the female connector attached to the auxiliary board.

19. The method of claim 16 further comprising the step of:

(d) arranging the surface mount connectors in a first row adjacent to a top edge of the primary board and auxiliary board; and

(e) arranging the surface mount connectors in a second row adjacent to a bottom edge of the primary board and auxiliary board.

20. The method of claim 16 further comprising the step of mechanically attaching the primary board and auxiliary board together by inserting a fastening pin through a hole in each of the primary board and auxiliary board.

21. A method of forming a memory module for mounting in an expansion slot of a mother board of a computer, comprising the steps of:

(a) providing a primary board having a central region and an edge region, the edge region being defined by outer edges of the primary board, the central region being surrounded by the edge region, the edge region including an interface portion for engaging with the expansion slot;

(b) providing an auxiliary board;

(c) providing a plurality of surface mount connectors for attaching the auxiliary board to the primary board in a spaced relationship such that an air path is defined between the boards, wherein at least one of the plurality of surface mount connectors is disposed within the central region; and

(d) forming a trace on the auxiliary board which connects the auxiliary board to the primary board.

22. The method of claim 21 further comprising the steps of:

(e) providing a plurality of additional surface mount connectors for attaching a second auxiliary board to the primary board in spaced relationship such that an air path is defined between the second auxiliary board and the primary board, wherein the auxiliary board is attached to a first side of the primary board and the second auxiliary board is attached to a second side of the primary board; and

(f) forming a second trace on the second auxiliary board which connects the second auxiliary board to the primary board.

23. The method of claim 22 wherein the trace is substantially equal in length to the second trace, the surface mount connectors are connected to the trace, and the additional surface mount connectors are connected to the second trace.

24. The method of claim 22 further comprising a plurality of chips attached to the auxiliary boards and a plurality of additional chips attached to the primary board, wherein the plurality of chips include memory chips.

25. A module for mounting in an expansion slot of a mother board of a computer, said module comprising:

a primary board including an interface portion for engaging with the expansion slot;

an auxiliary board mounted to said primary board in a spaced relationship such that an air path is defined between said boards;

a plurality of surface mount connectors for mounting said auxiliary board to said primary board, wherein each said plurality of surface mount connectors comprises:

an electrically insulative housing;

a plurality of electrical contacts enclosed within said housing; and

a plurality of electrically conductive fingers electrically interconnected with said plurality of electrical contacts, said plurality of electrically conductive fingers extending outwardly from said housing; and

a trace for electrically connecting said auxiliary board to said primary board.

26. A module as claimed in claim 25 wherein said primary board has a first side and a second side, said auxiliary board being mounted on said first side of said primary board, said module further comprising:

a second auxiliary board mounted on said second side of said primary board in a spaced relationship such that an air path is defined between said boards;

a second trace for electrically connecting said second auxiliary board to said primary board; and

a plurality of additional surface mount connectors for mounting said second auxiliary board to said primary board.

27. A module as claimed in claim 26 wherein said trace connecting said auxiliary board to said primary board is substantially equal in length to said second trace connecting said second auxiliary board to said primary board.

28. A module as claimed in claim 25 wherein said plurality of electrically conductive fingers from at least one of said plurality of surface mount connectors are connected to said trace.

29. (Cancelled)

30. A module as claimed in claim 25 wherein said interface portion is configured to be compatible with an industry standard memory module expansion slot.

31. A module as claimed in claim 30 further comprising a plurality of chips mounted to said boards, said plurality of chips including memory chips.

32. A module as claimed in claim 25 wherein each of said boards has a top edge and a bottom edge;

said interface portion being disposed along the bottom edge of said primary board.

33. A module as claimed in claim 32 wherein said air path is substantially open along the top edges of said boards.

34. A module as claimed in claim 25 wherein said primary board further includes:

a plurality of chips mounted thereon; and

a trace connecting said interface portion to at least one of said plurality of chips.

35. A module as claimed in claim 34 wherein said trace of said primary board has a length substantially equal to said trace connecting said auxiliary board with said primary board.

36. A computer comprising:

a mother board including an expansion slot; and

a memory module including:

a primary board including an interface portion configured to be engaged with said expansion slot;

a pair of auxiliary boards mounted to respective sides of said primary board in a spaced relationship such that an air path is defined between each of said auxiliary boards and said primary board;

a plurality of surface mount connectors for mounting said auxiliary boards to said primary board, wherein each said plurality of surface mount connectors comprises:

an electrically insulative housing having a slot;

a plurality of electrical contacts disposed in said slot; and

a plurality of electrically conductive fingers electrically interconnected with said plurality of electrical contacts, said plurality of electrically conductive fingers extending laterally and outwardly from said housing; and

a pair of traces each for electrically connecting one of said auxiliary boards to said primary board.

37. A computer as claimed in claim 36 wherein said expansion slot is configured as a 168-pin dual in-line memory module (DIMM) connector.

38. A computer as claimed in claim 36 wherein said traces have substantially equal lengths.

39. A computer as claimed in claim 36 wherein said primary board further includes:

a plurality of chips mounted thereon; and

a trace connecting said interface portion with at least one of said plurality of chips.

40. A computer as claimed in claim 39 wherein each of said pair of traces has a length substantially equal to each other.

41. A computer as claimed in claim 40 wherein of said trace of said primary board has a length substantially equal to the length of said pair of traces.

42. A computer as claimed in claims 40 wherein said memory module has a thickness defined from an outer edge of one said auxiliary board to an outer edge of the other said auxiliary board of less than about 0.5 inch and a height defined from the bottom edge to the top edge of said primary board of less than about 1.5 inches

43. A method for increasing memory capacity of a computer, said method comprising the steps of:

(a) providing a computer including a mother board with an expansion slot;

(b) providing a memory module including:

a primary board including an interface portion configured to engage with the expansion slot of the computer, a plurality of chips including memory chips, and a trace connecting said interface portion with at least one of said chips;

an auxiliary board mounted to said primary board in a spaced relationship such that an air path is defined between said boards;

a plurality of surface mount connectors for mounting said auxiliary board to said primary board, each of said surface mount connectors including a male surface mount connector and a matching female surface mount connector, wherein said male connector mates with said female connector with a friction fit; and

a trace for electrically connecting said auxiliary board to said primary board; and

(c) inserting said interface portion of said memory module into said expansion slot of said computer.

44. A method as claimed in claim 43 wherein:

said step of providing a computer comprises the step of providing a computer including a mother board with a 168-pin dual in-line memory module (DIMM) expansion slot; and

said step of providing a memory module comprises the step of providing a memory module including a primary board including a plurality of chips including memory chips with at least 200 megabytes of capacity.

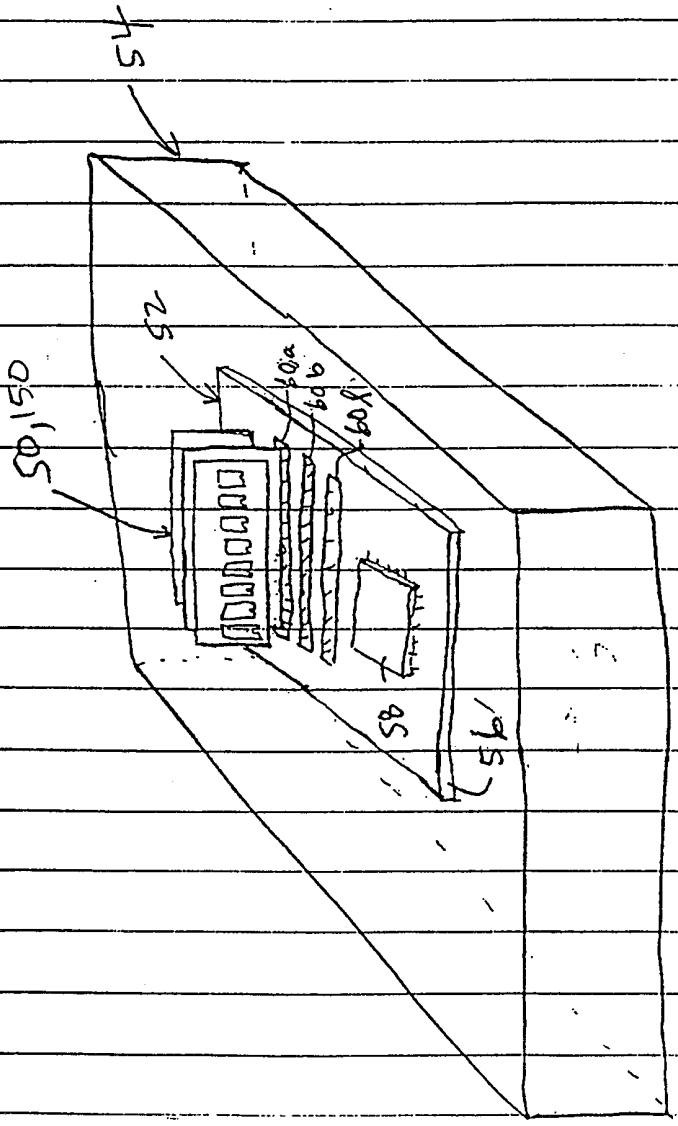

Fig. 1

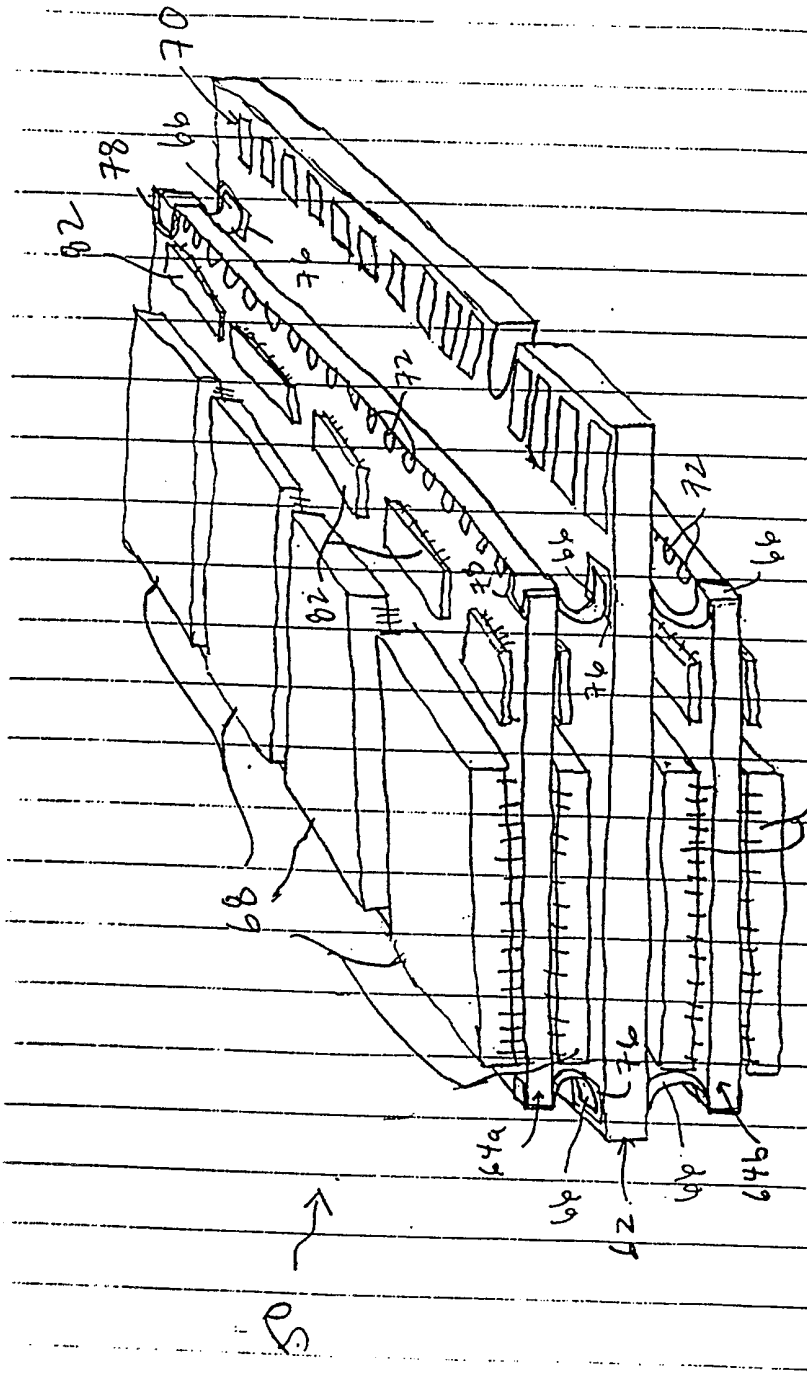
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FIG 1

FIG. 3A
SIDE 1

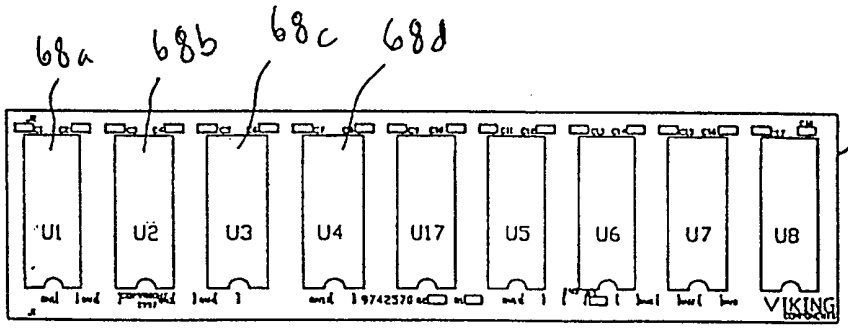
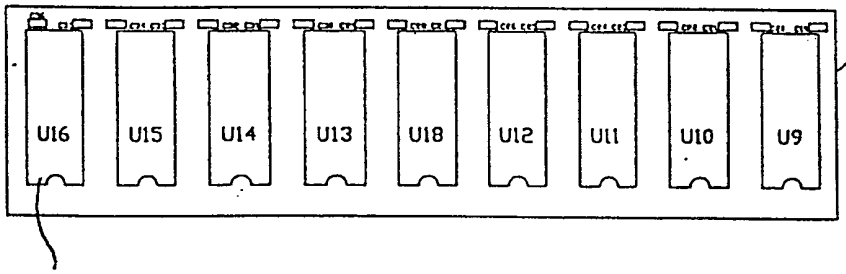


FIG. 3B
SIDE 2



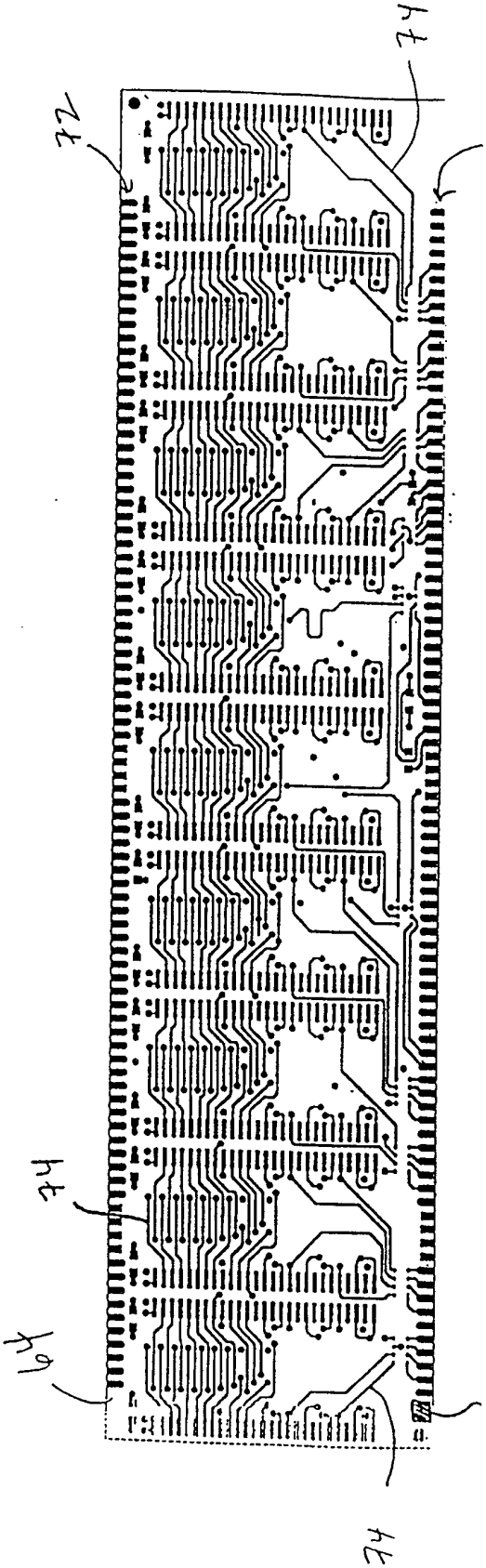


Fig. 4

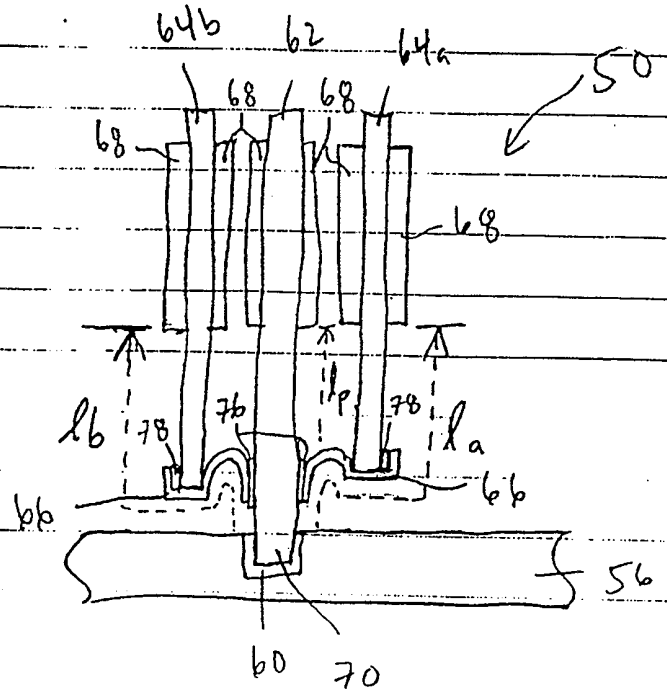


FIG. 5

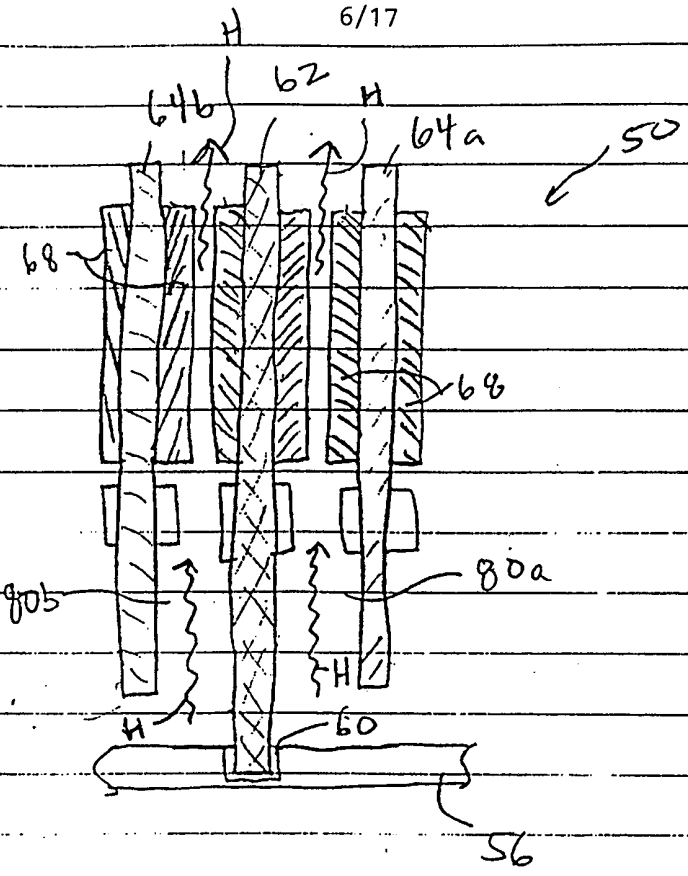


FIG. 6

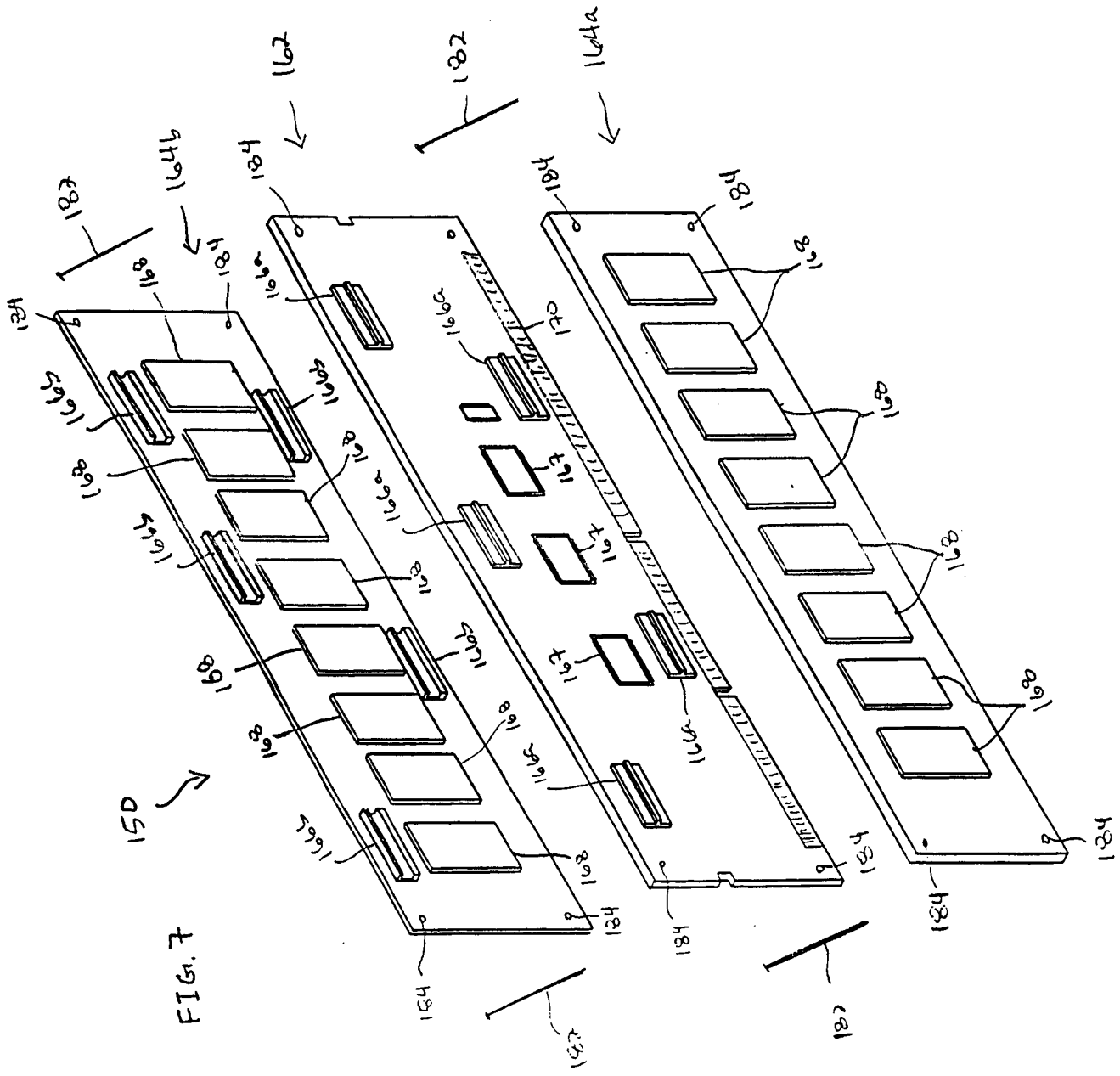
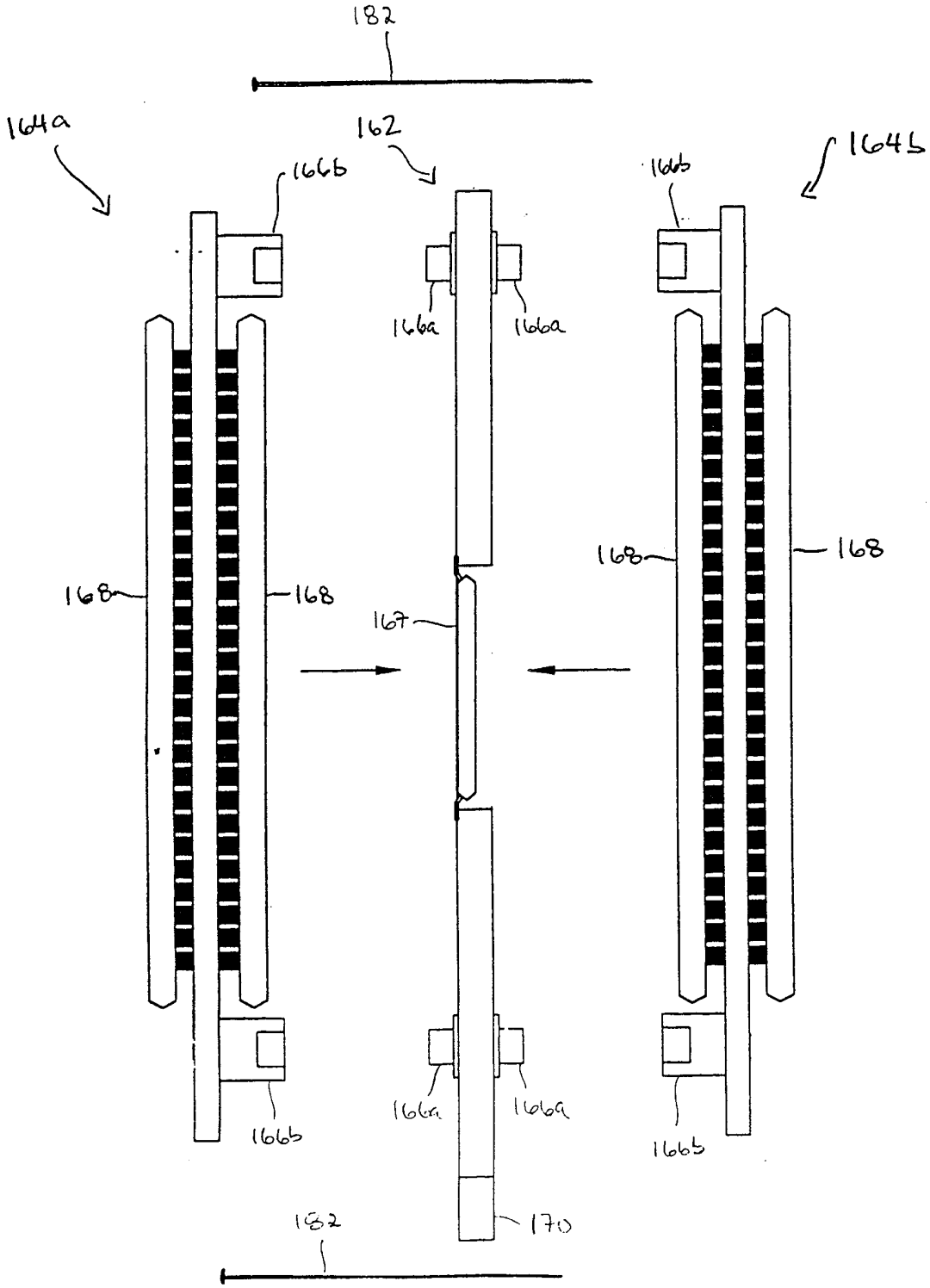


FIG. 7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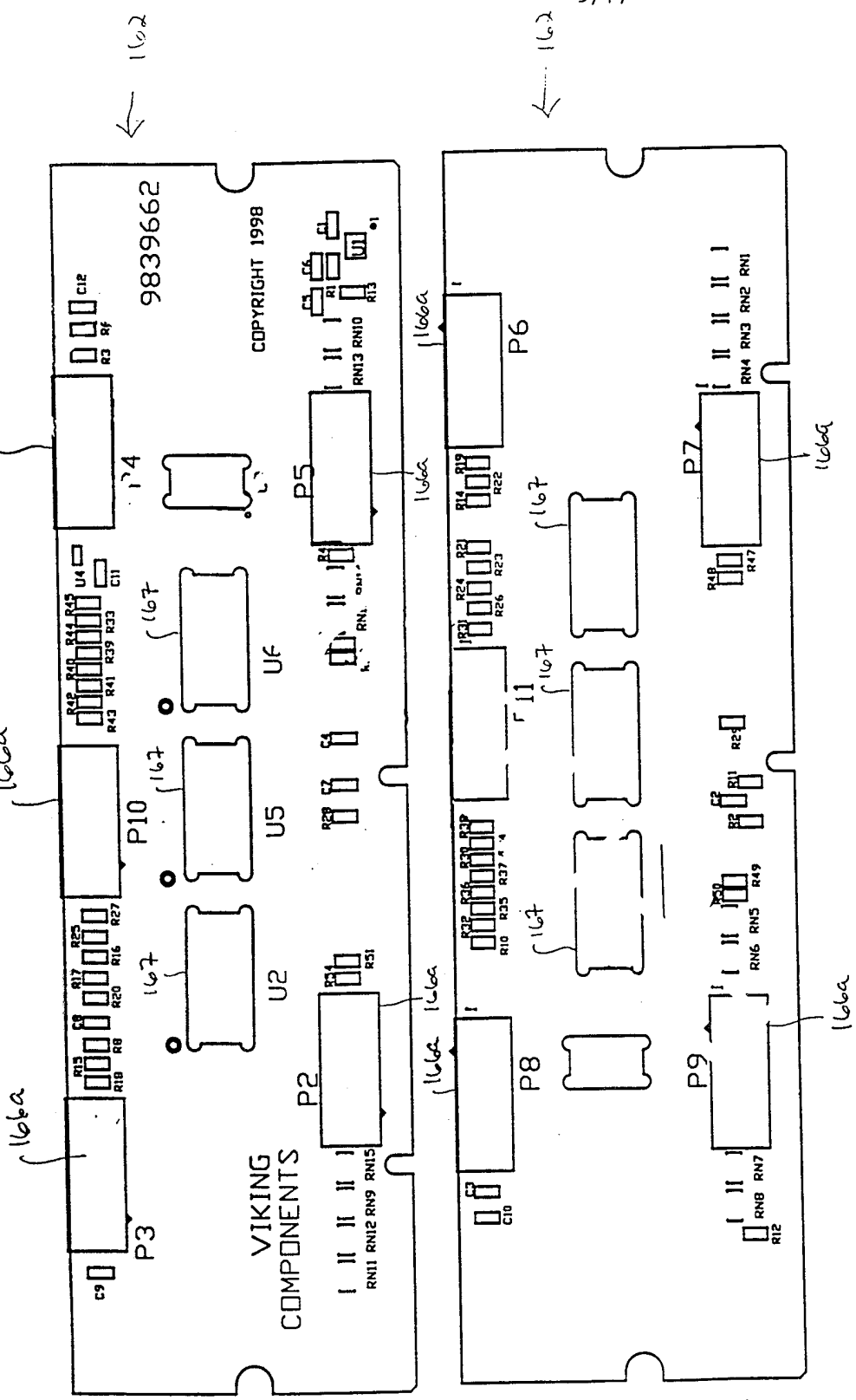

FIG. 9A SIDE1

FIG. 9B SIDE2

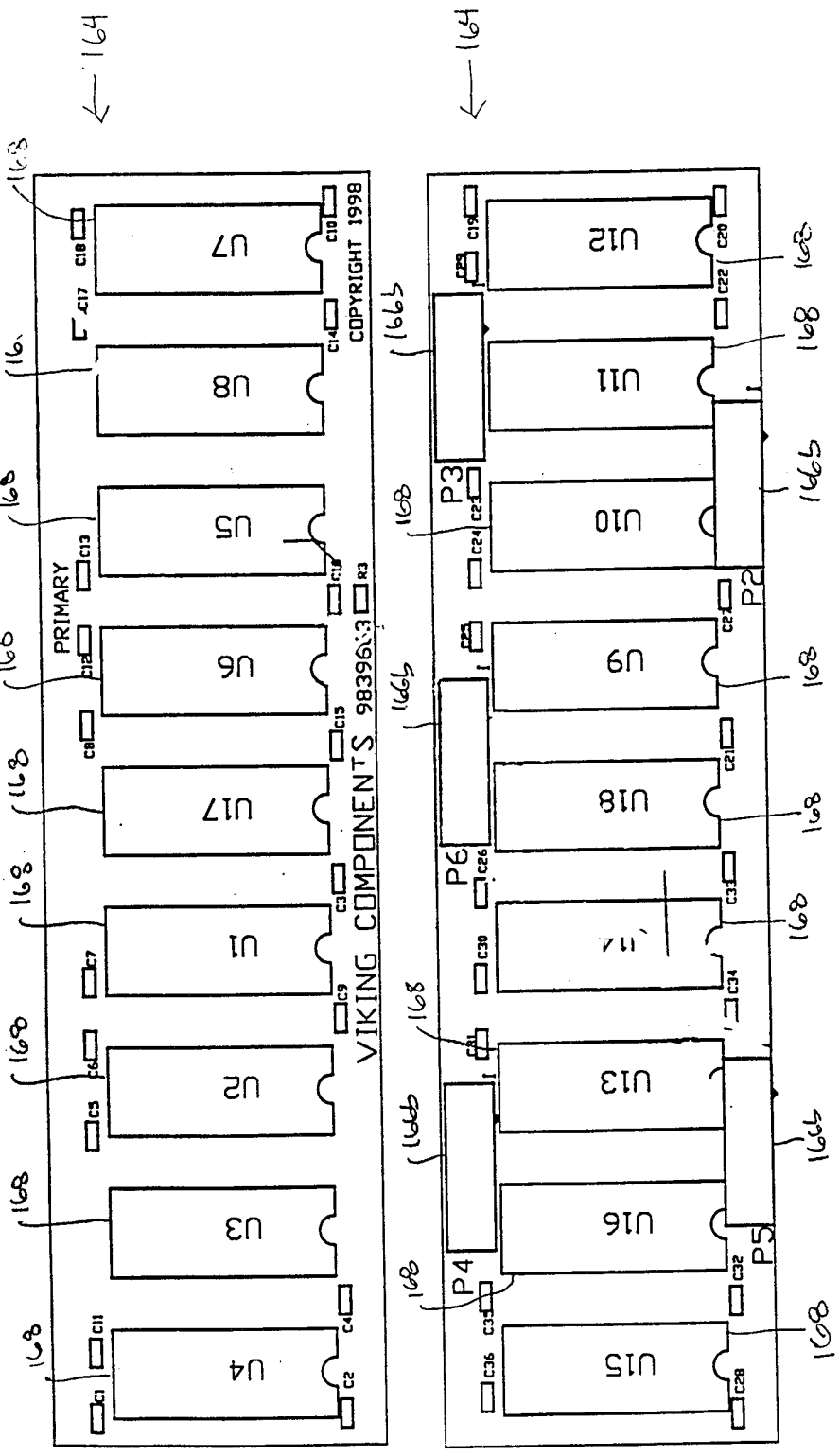

FIG. 10A SIDE 1

FIG. 10B SIDE 2

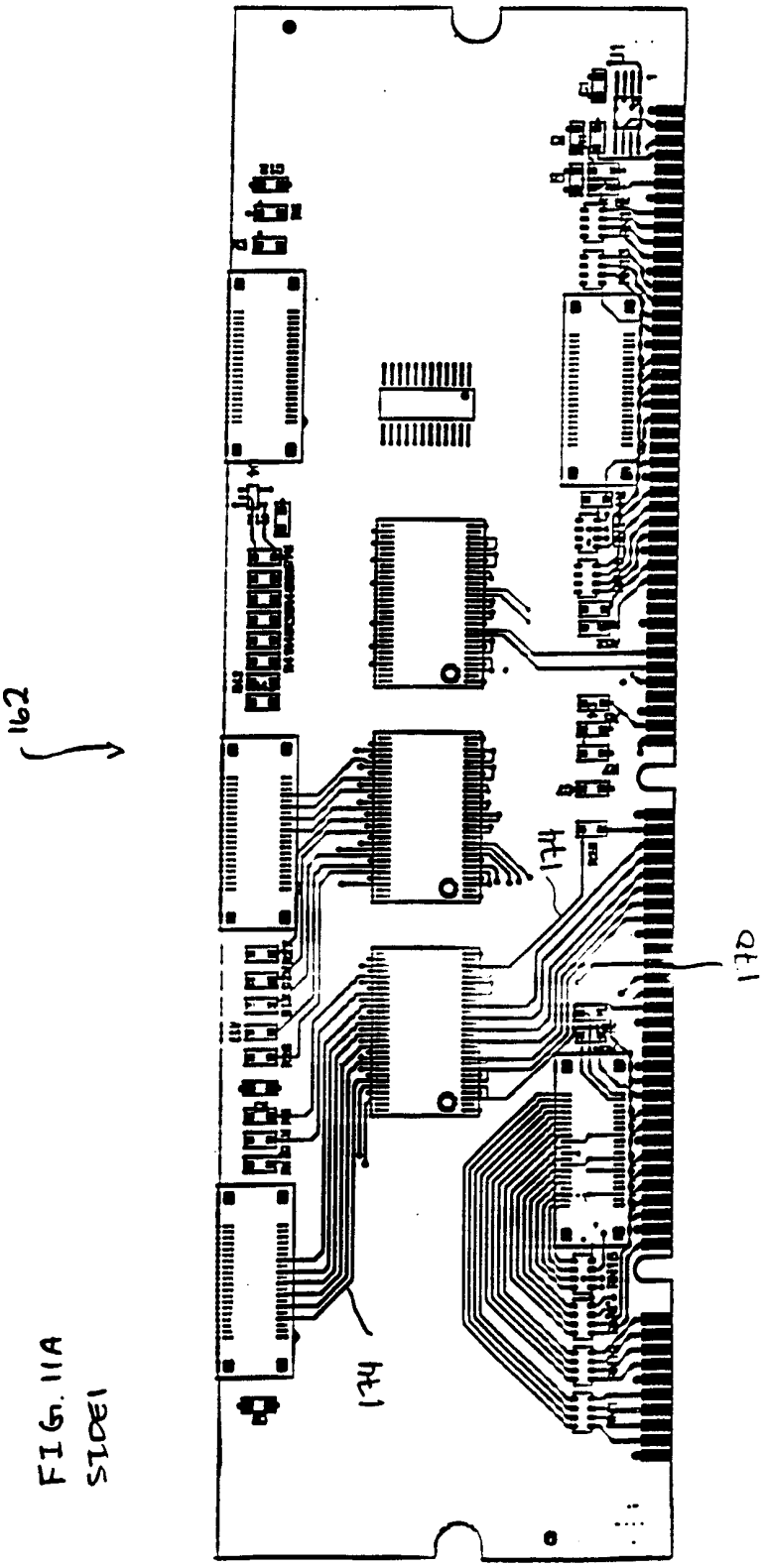

FIG. 11A

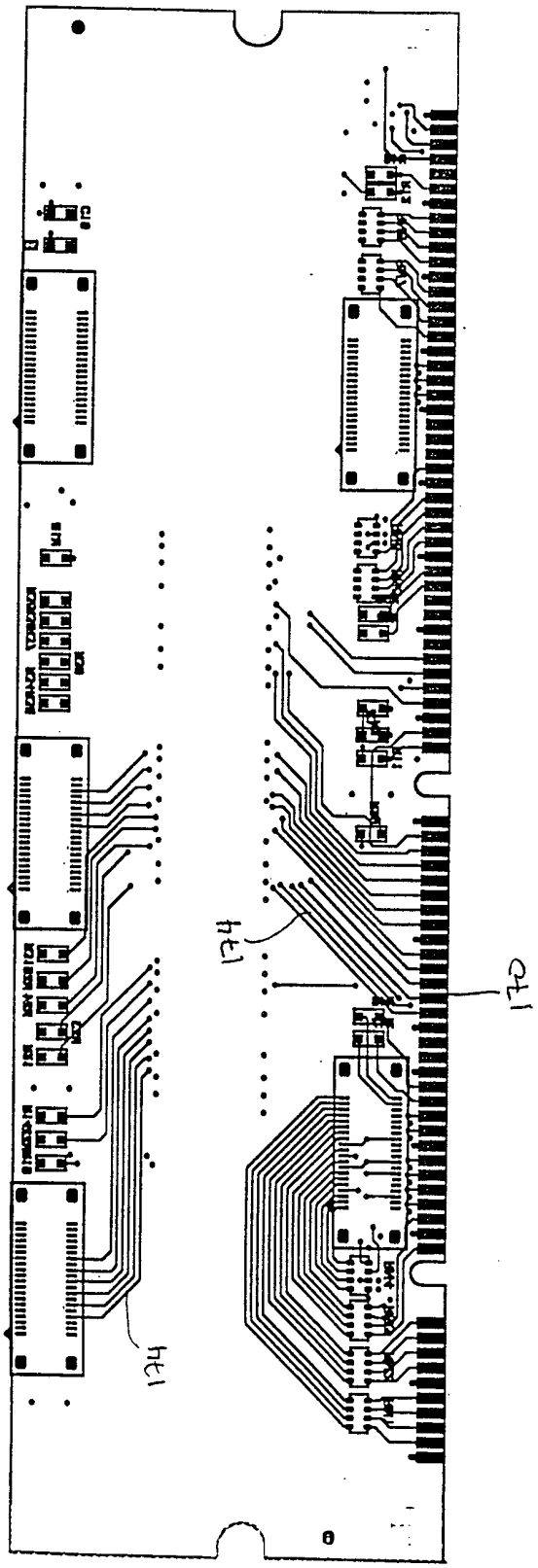

FIG. 11B

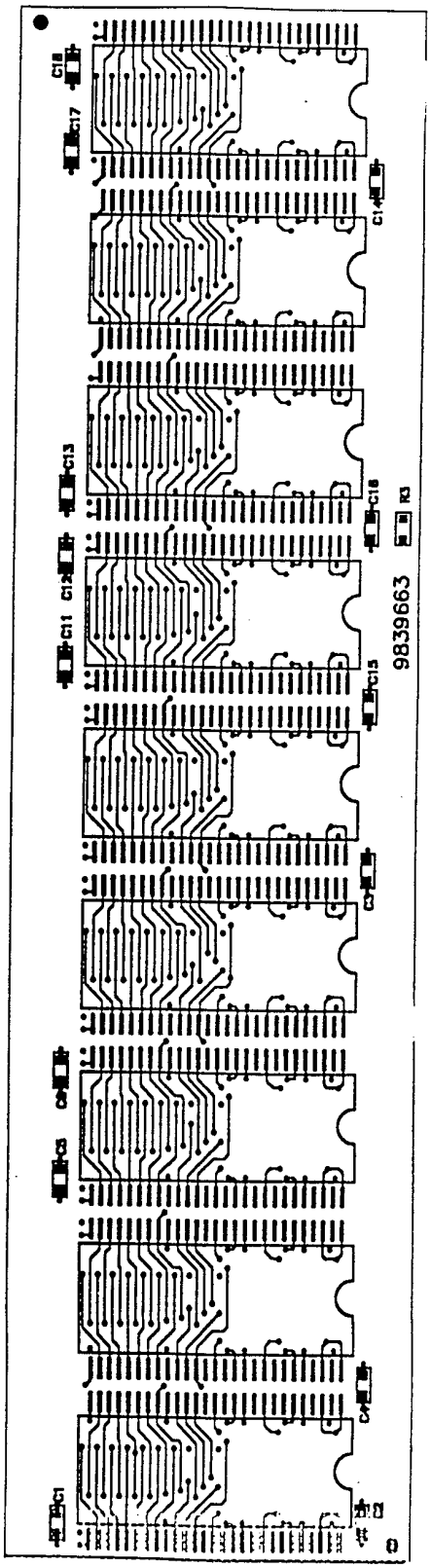

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FIG. 12A
SIDE 1

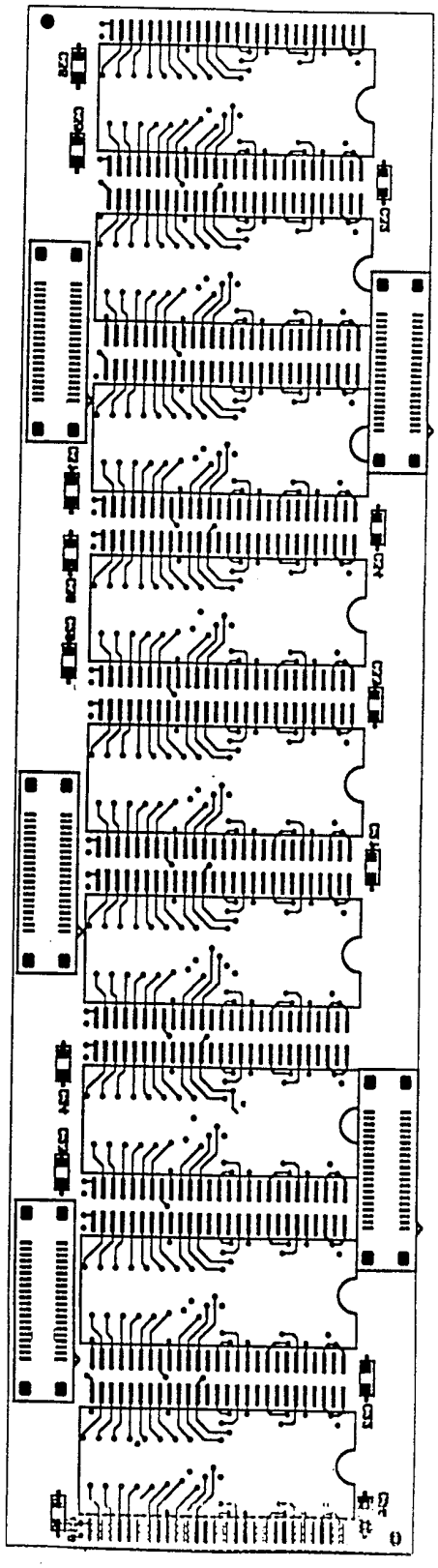

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FIG. 12B
SIDE 2

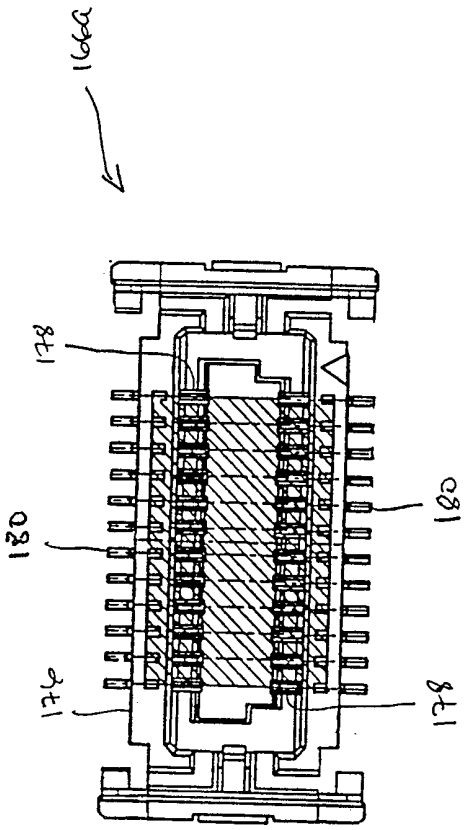

FIG. 12A

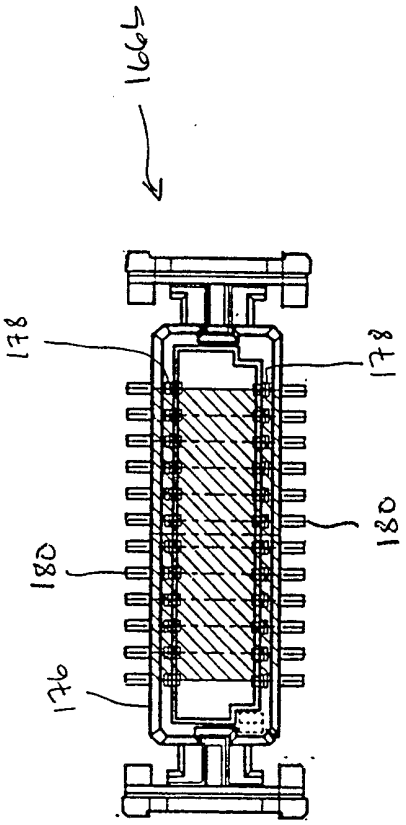

FIG. 13B

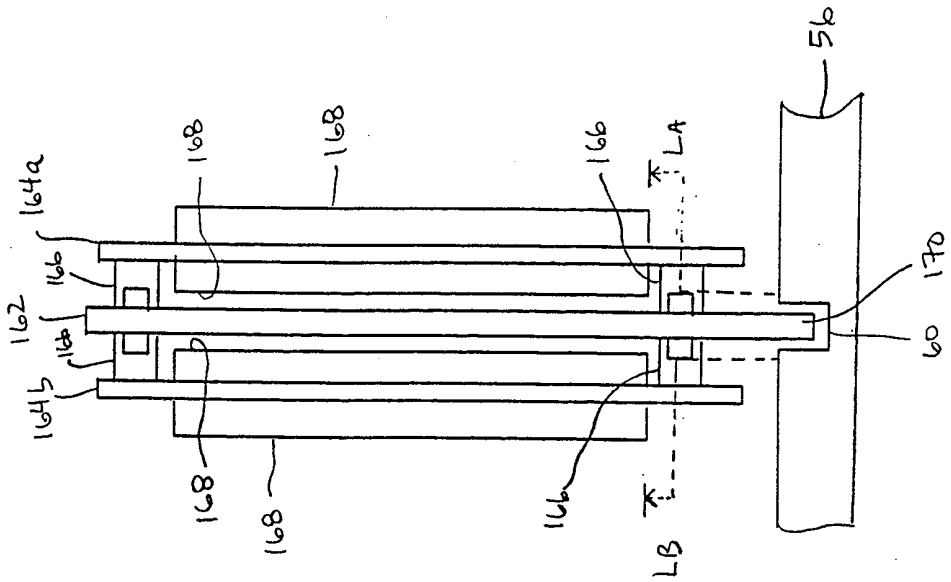

FIG. 14

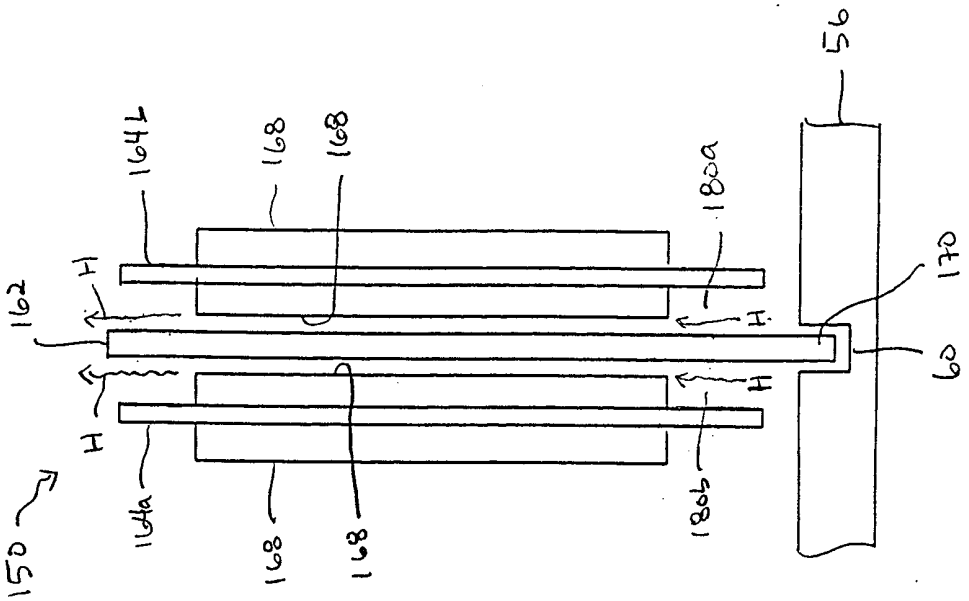

FIG. 15

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/01006

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :Please See Extra Sheet.
US CL :Please See Extra Sheet.
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)

U.S. : 174/260, 261; 257/685, 686, 690, 723, 724, 777; 361/735, 744, 760, 774, 784, 789, 790, 791, 803; 439/68, 69, 82, 83

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 practicable, search terms used)

APS, STN, IPSS II, GPIC, WEST, DERWENT

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 4-206765 A (MITSUBISHI ELECTRIC CORP.) 28 July 1992 (28.07.92), see figures 1-3 and 6.	1
X	JP 4-312992 A (MITSUBISHI ELECTRIC CORP.) 04 November 1992 (04.11.92), see figure 2.	1-44
X	JP 4-335561 A (MITSUBISHI ELECTRIC CORP.) 24 November 1992 (24.11.92), see figures 1-8.	1-44
X	GB 2,237,691 A (MITSUBISHI DENKI KABUSHIKI KALSHA) 05 August 1991 (05.08.91), see entire document.	1-44
X	US 5,191,404 A (Wu et al.) 02 March 1993 (02.03.93), see entire document.	1-44

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"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
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"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
"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)	"&"	document member of the same patent family
"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		

Date of the actual completion of the international search 15 MARCH 1999	Date of mailing of the international search report 15 APR 1999
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer DONALD A. SPARKS Telephone No. (703) 308-1756

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/01006

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2-235389 A (MITSUBISHI ELECTRIC CORP.) 18 September 1990 (18.09.90), see entire document.	1-44

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/01006

A. CLASSIFICATION OF SUBJECT MATTER:
IPC (6):

H01L 23/12, 23/34, 23/40; H01R 9/09; 13/08; 23/68, 23/70, 23/72; H05K 1/11, 1/14; 7/02, 7/10, 7/20

A. CLASSIFICATION OF SUBJECT MATTER:
US CL :

174/260, 261; 257/685, 686, 690, 723, 724, 777; 361/735, 744, 760, 774, 784, 789, 790, 791, 803; 439/68, 69, 82, 83