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**Minervini**

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(54) **MINIATURE SILICON CONDENSER MICROPHONE**

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**H01L 23/12** (2006.01)  
**H04R 9/08** (2006.01)

(52) **U.S. Cl.** ..... **257/704**; 257/724; 381/355; 381/361

(58) **Field of Classification Search** ..... None  
See application file for complete search history.

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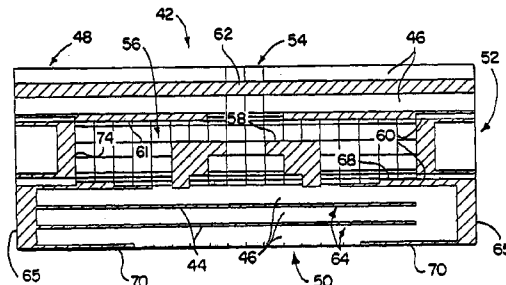
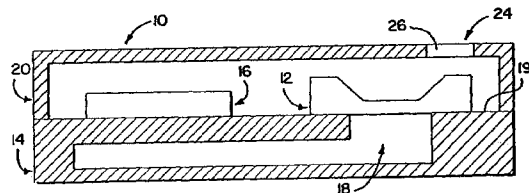
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(57) **ABSTRACT**

A silicon condenser microphone package includes a transducer unit, a substrate, and a cover. The substrate includes an upper surface transducer unit is attached to the upper surface of the substrate and overlaps at least a portion of the recess wherein a back volume of the transducer unit is formed between the transducer unit and the substrate. The cover is placed over the transducer unit and either the cover or the substrate includes an aperture.

**29 Claims, 11 Drawing Sheets**



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FIG. 1

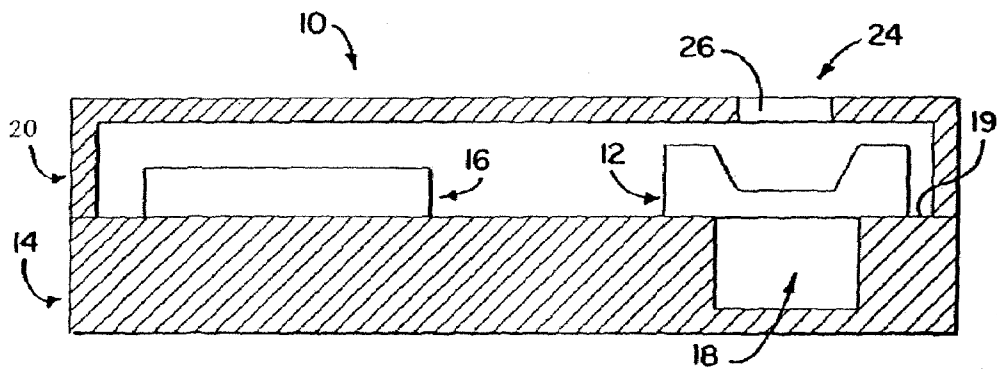


FIG. 2

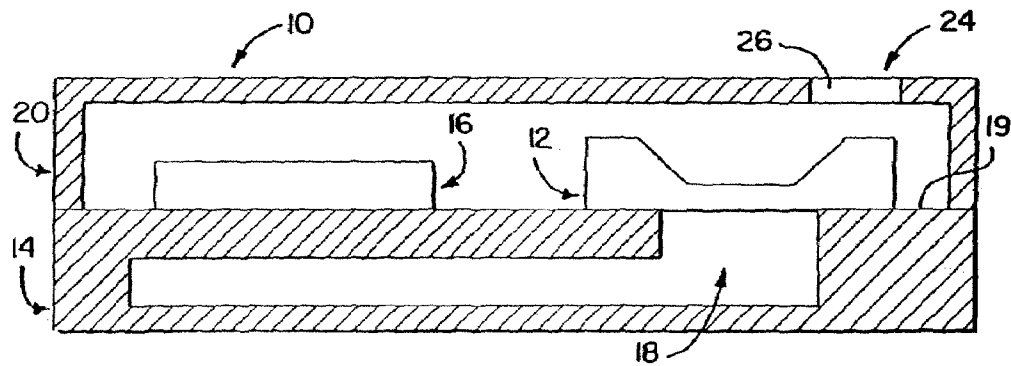


FIG. 3

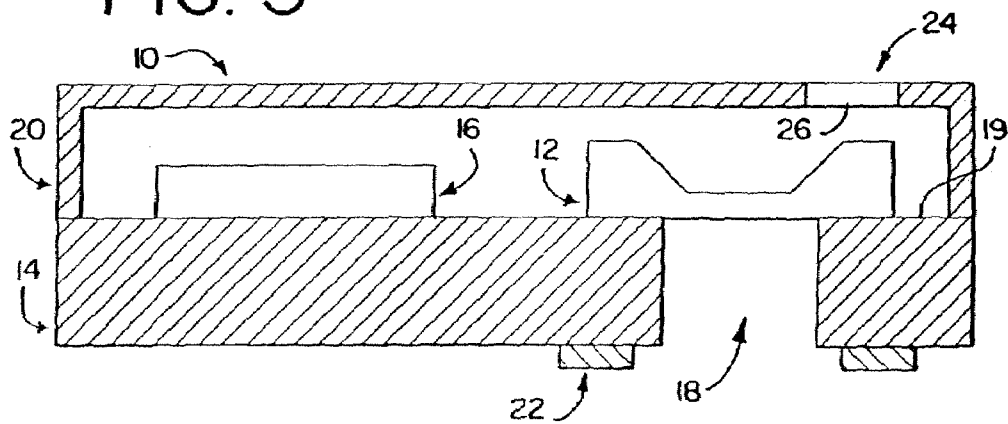


FIG. 4

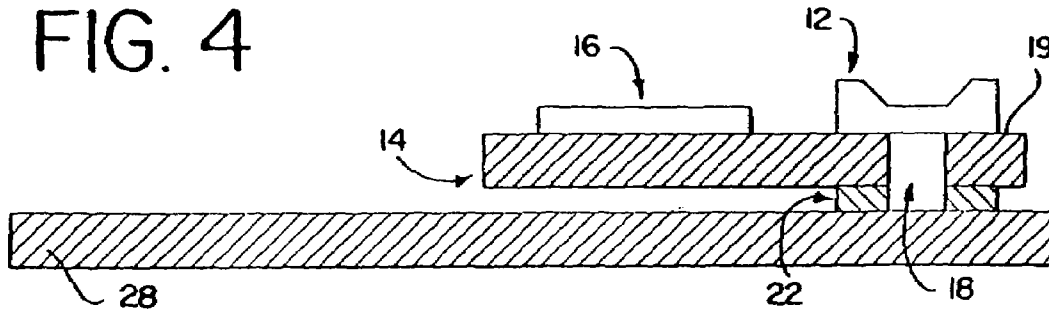


FIG. 5

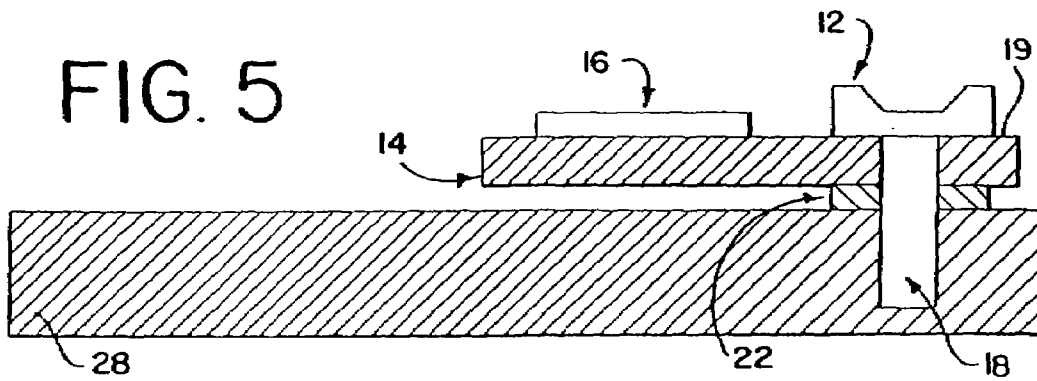
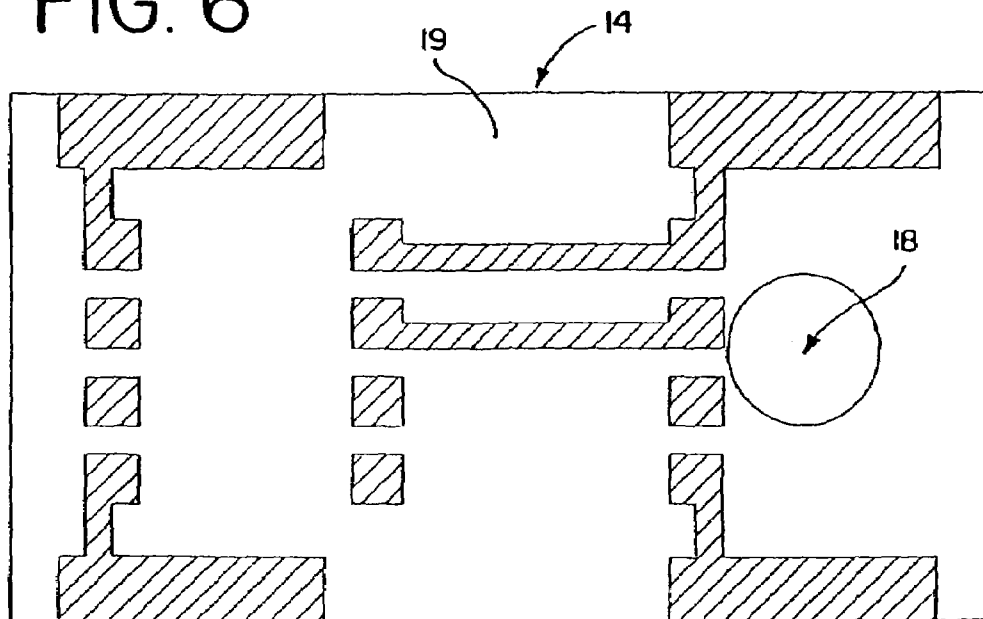


FIG. 6



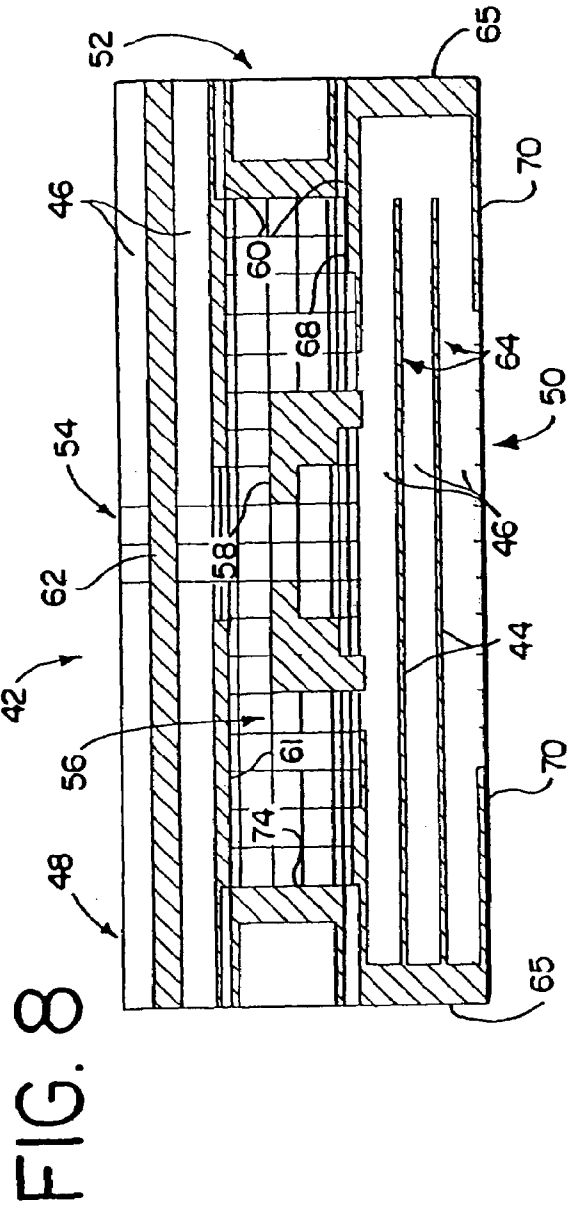
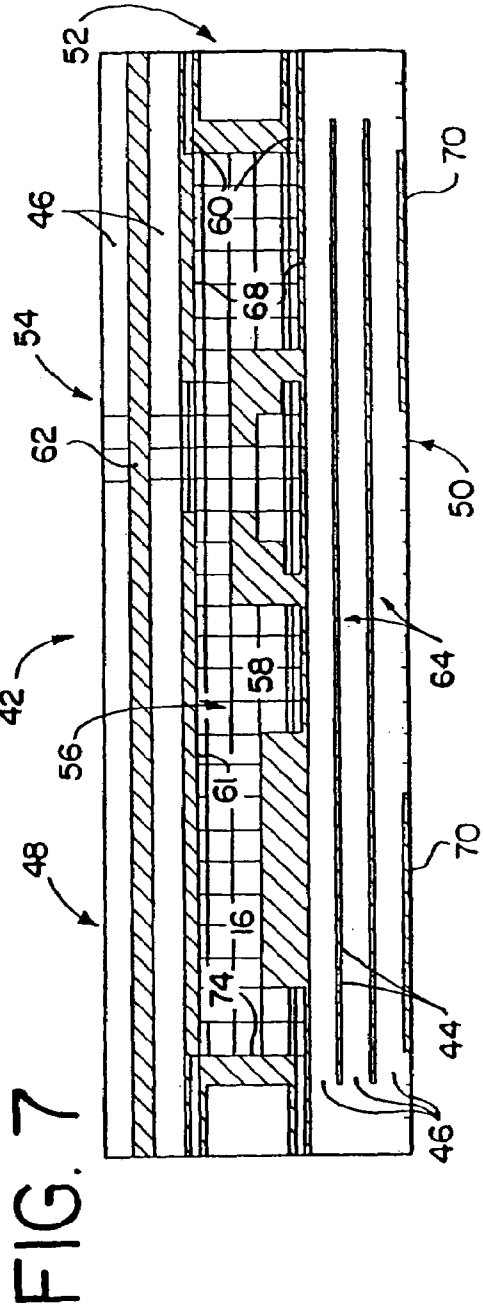


FIG. 9

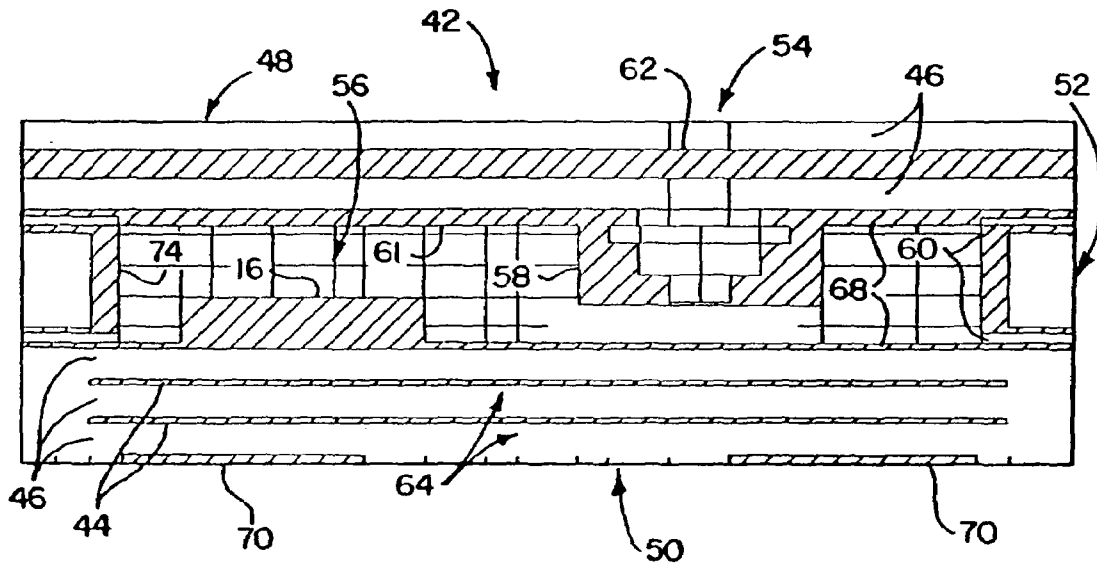


FIG. 10

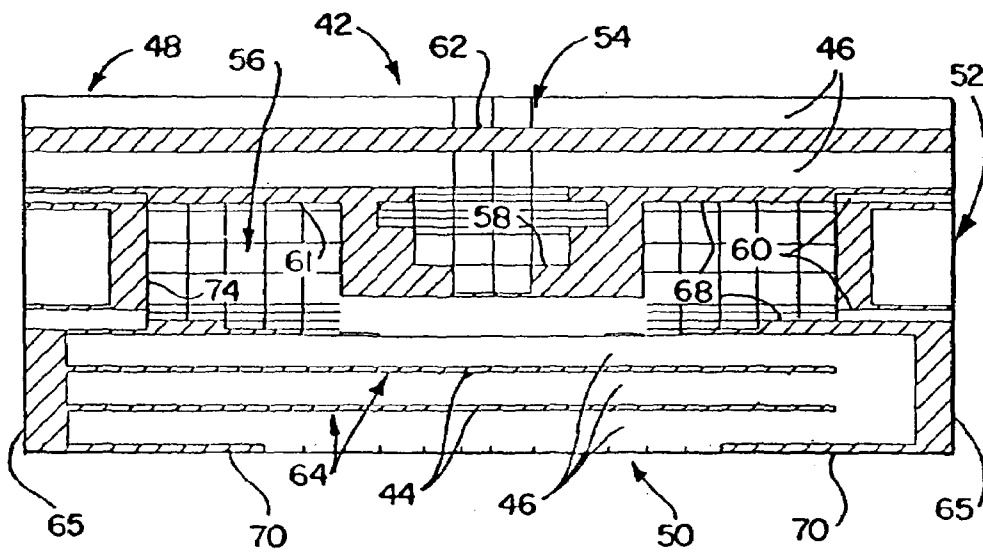


FIG. 11

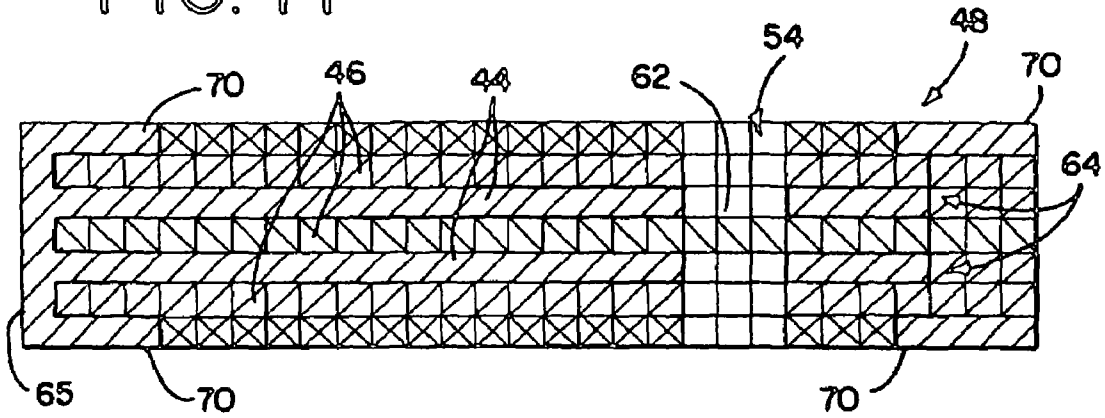


FIG. 12

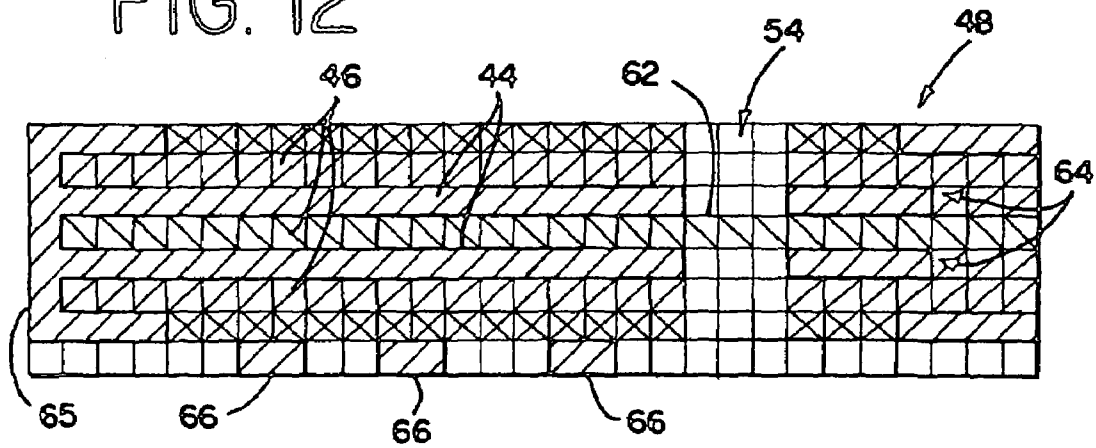


FIG. 13

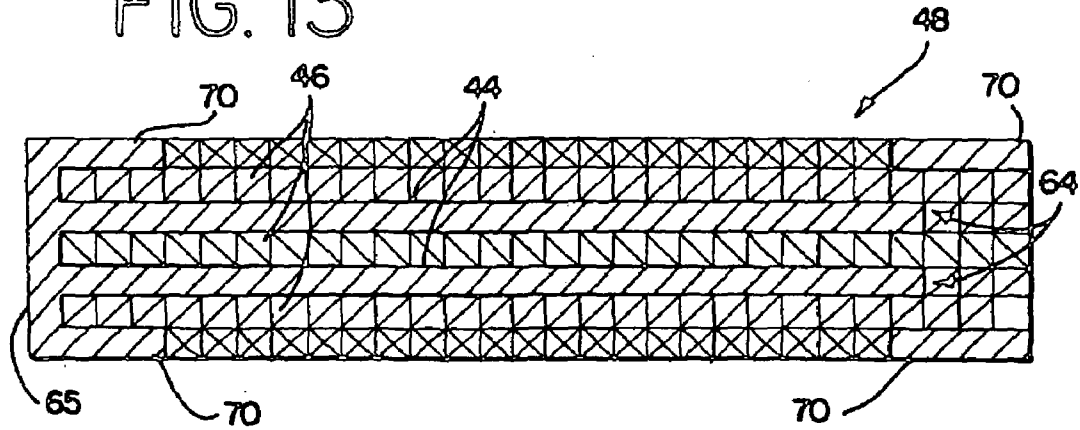


FIG. 14a

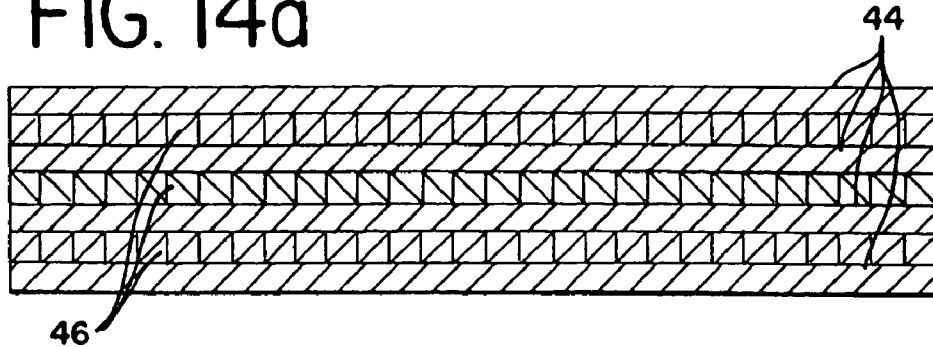


FIG. 14b

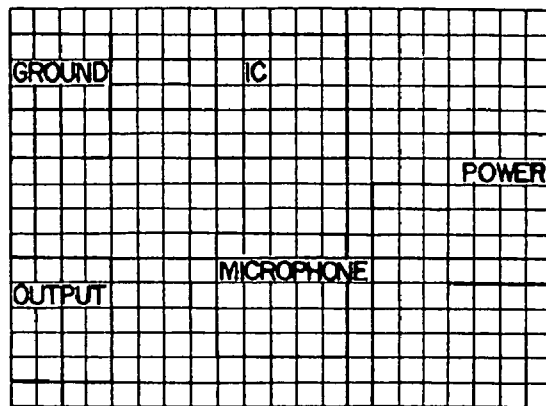


FIG. 14c

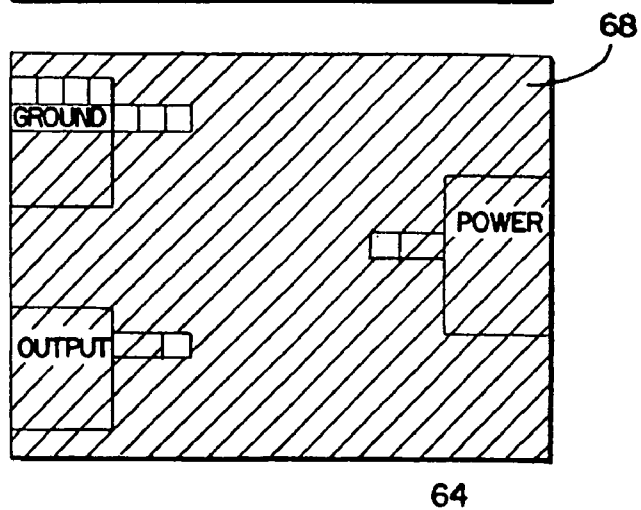


FIG. 14d

1



FIG. 15

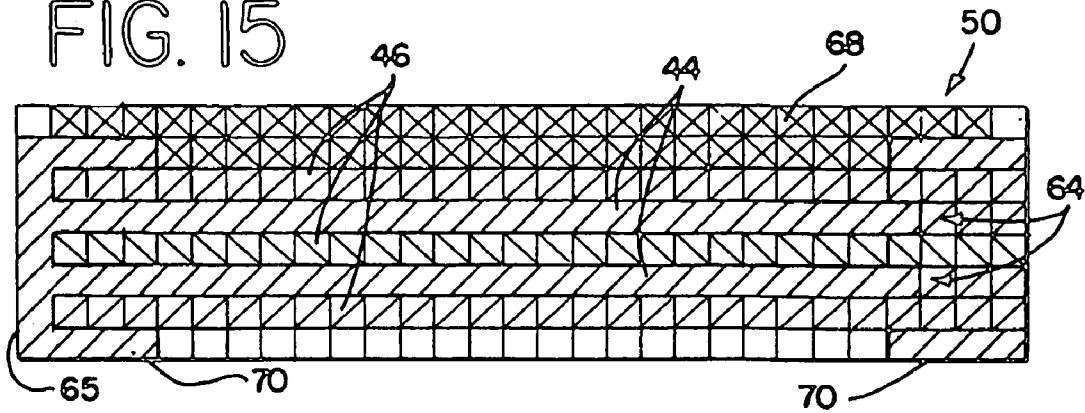


FIG. 16

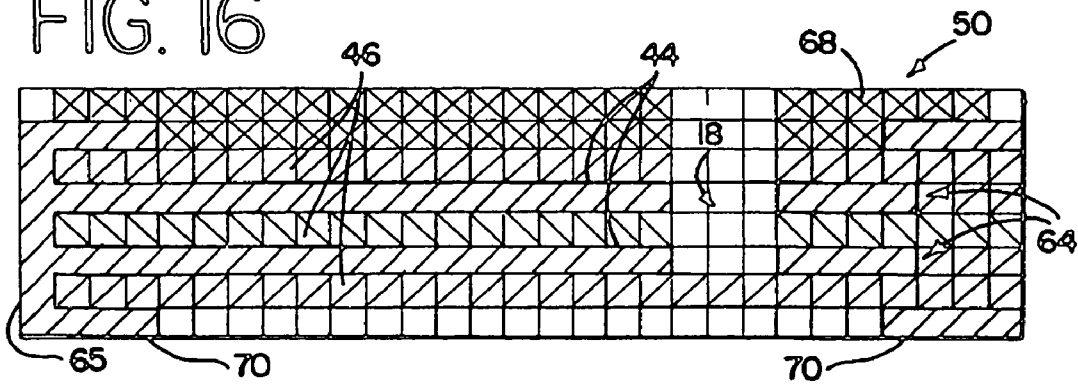


FIG. 17

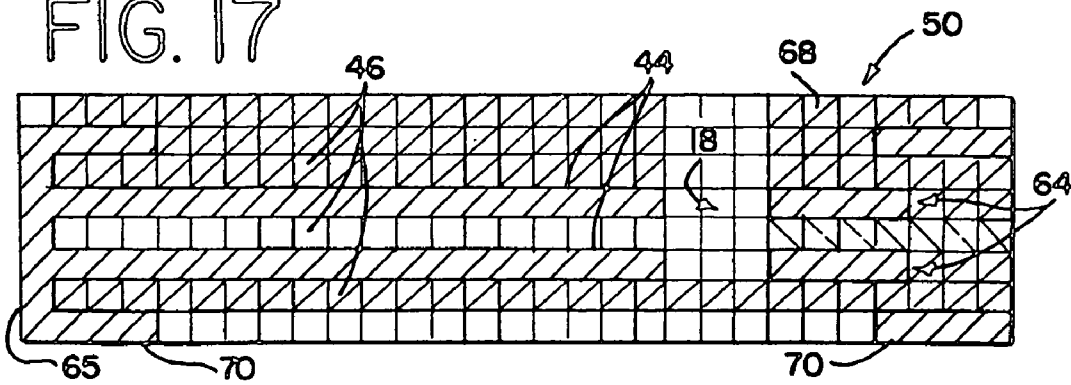


FIG. 18

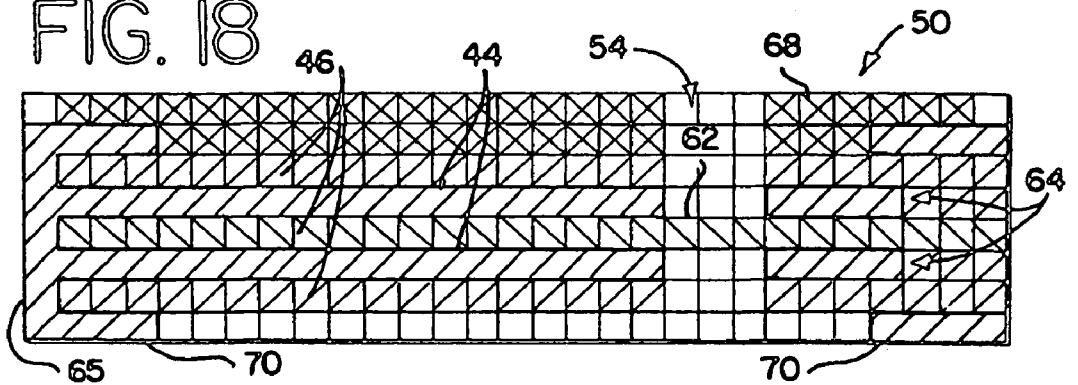


FIG. 19

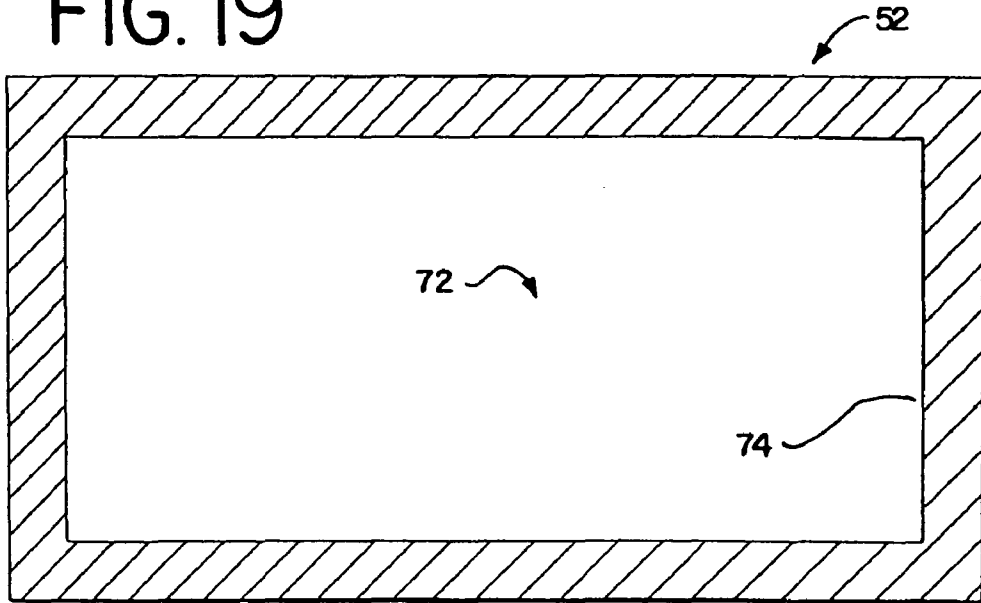


FIG. 20

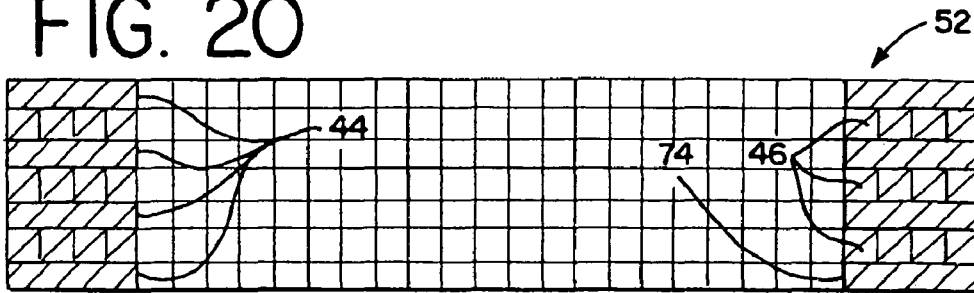


FIG. 21

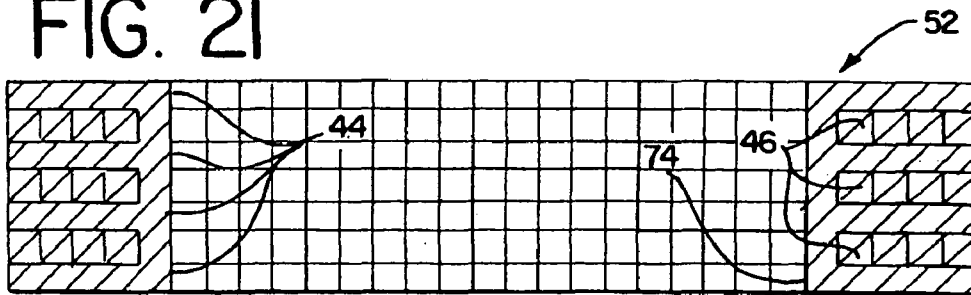


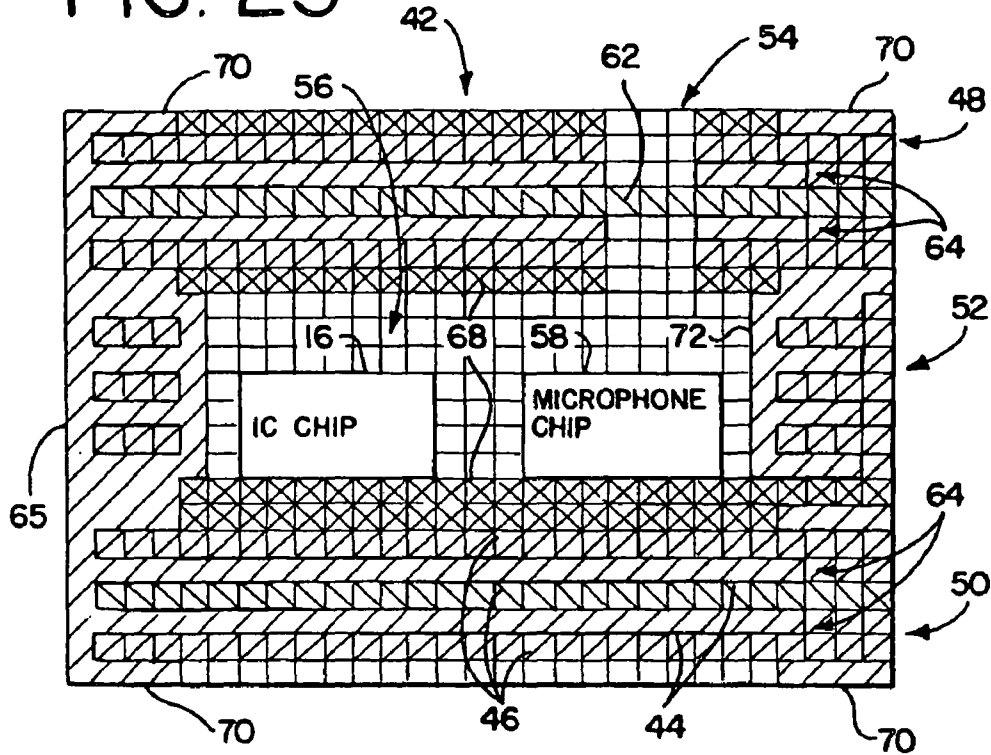
FIG. 22

44

74 46

52

# FIG. 23



# FIG. 24

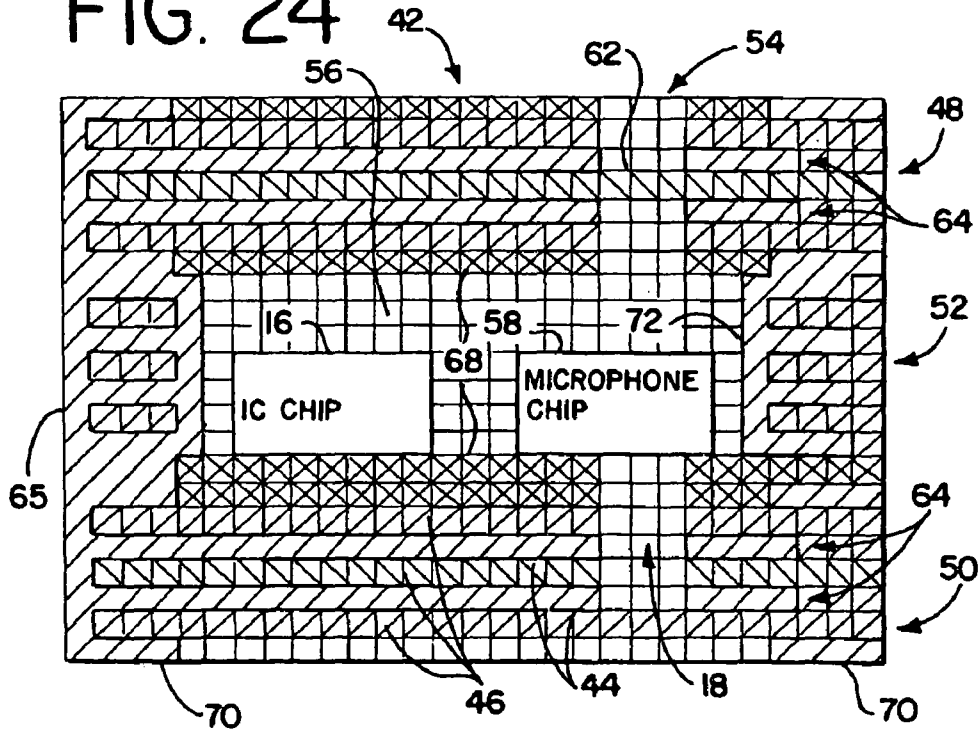


FIG. 25

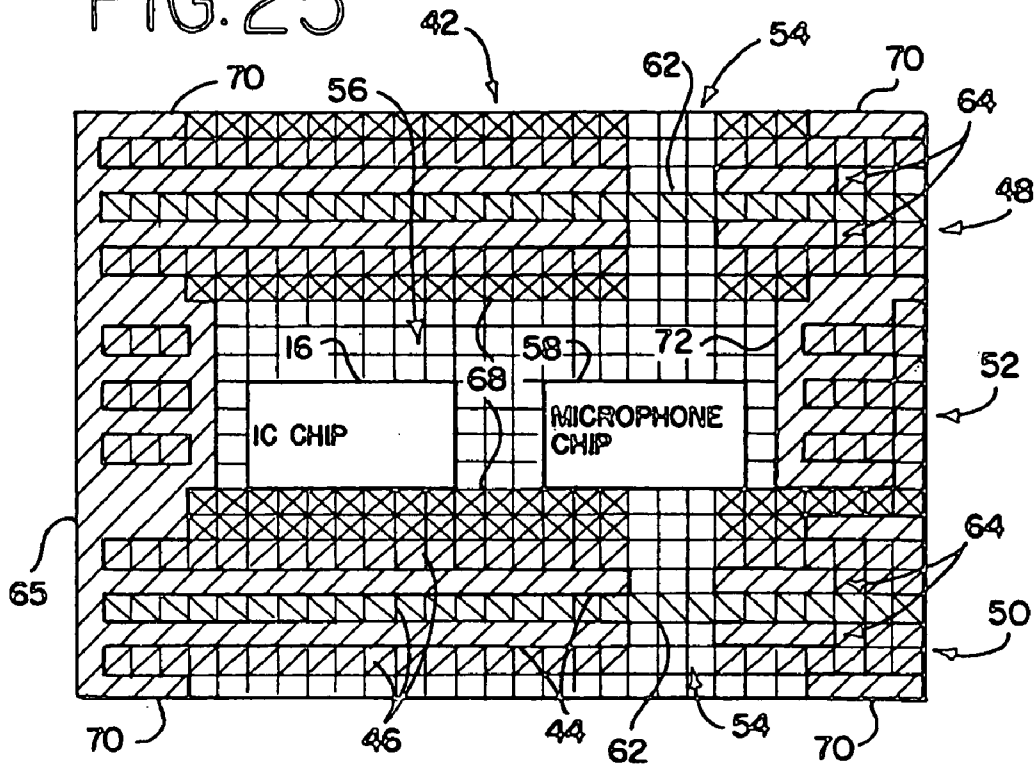


FIG. 26

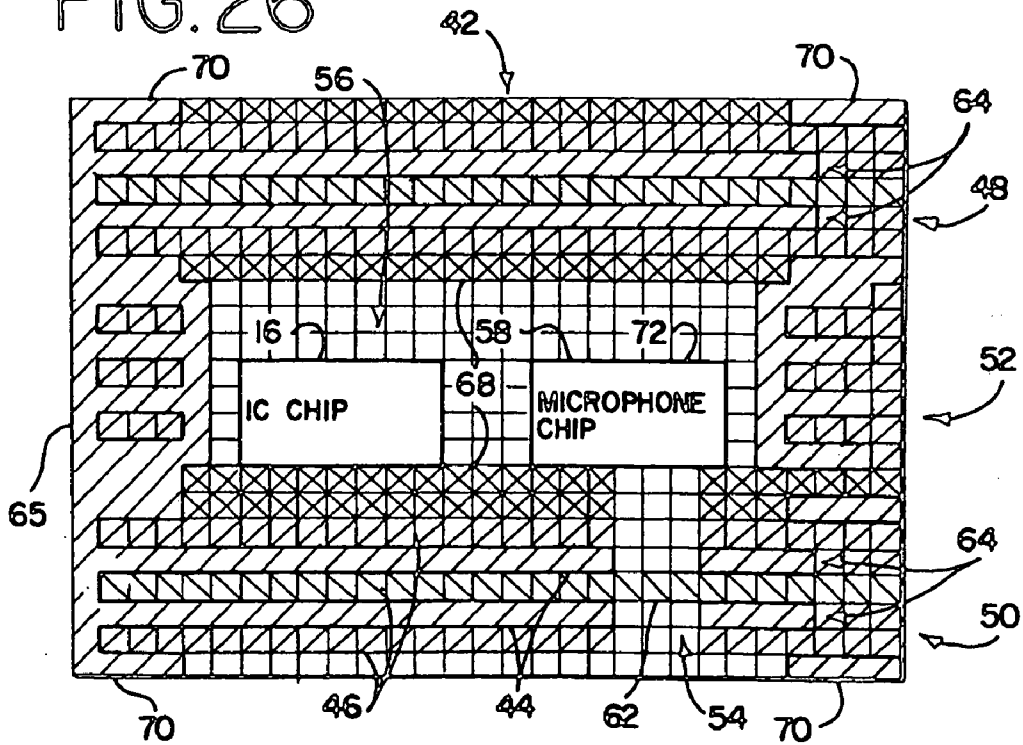


FIG. 27

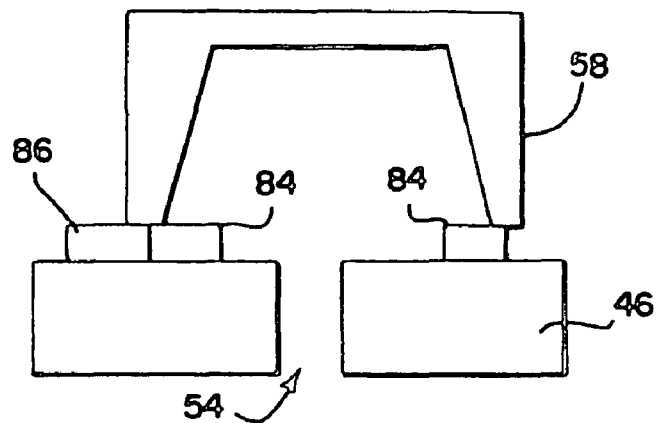


FIG. 28

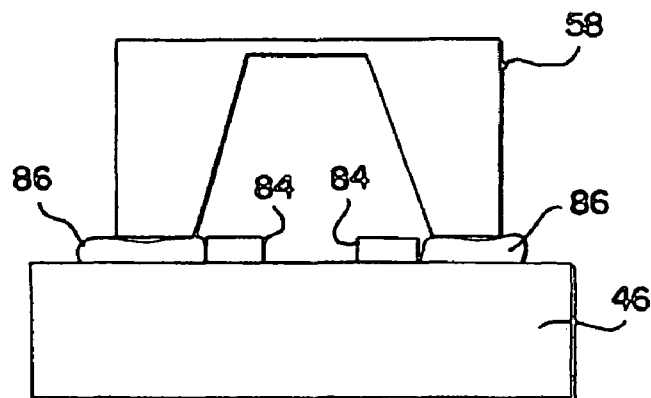
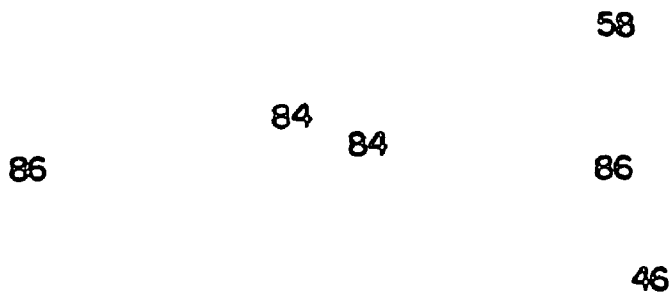


FIG. 29



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## MINIATURE SILICON CONDENSER MICROPHONE

### RELATED APPLICATION

This application is a division of U.S. application Ser. No. 09/886,854, filed Jun. 21, 2001, now U.S. Pat. No. 7,166,910, which claims the benefit of Provisional Patent Application Ser. No. 60/253,543 filed Nov. 28, 2000.

### TECHNICAL FIELD

The present invention relates generally to a housing for a transducer. More particularly, this invention relates to a miniature silicon condenser microphone comprising a housing for shielding a transducer produced on the surface of a silicon die. The silicon die must be packaged to produce a functional microphone of this type.

### BACKGROUND OF THE INVENTION

There have been a number of disclosures related to building microphone elements on the surface of a silicon die. Certain of these disclosures have come in connection with the hearing aid field for the purpose of reducing the size of the hearing aid unit. While these disclosures have reduced the size of the hearing aid, they have not disclosed how to protect the transducer from outside interferences. For instance, transducers of this type are fragile and susceptible to physical damage. Furthermore, they must be protected from light and electromagnetic interferences. Moreover, they require an acoustic pressure reference to function properly. For these reasons, the silicon die must be shielded.

Some shielding practices have been used to house these devices. For instance, insulated metal cans or discs have been provided. Additionally, DIPS and small outline integrated circuit (SOIC) packages have been utilized. However, the drawbacks associated with manufacturing these housings, such as lead time, cost, and tooling, make these options undesirable.

### SUMMARY OF THE INVENTION

The present invention is directed to a silicon condenser microphone package which allows acoustic energy to contact a transducer which provides the necessary pressure reference while at the same time protects the transducer from light, electromagnetic interference, and physical damage. A silicon condenser microphone package comprises a transducer, a substrate, and a cover. The substrate has an upper surface with a recess formed therein. The transducer is attached to the upper surface of the substrate and overlaps at least a portion of the recess so that a back volume of the transducer is formed between the transducer and the substrate. The cover is placed over the transducer and includes an aperture adapted for allowing sound waves to reach the silicon condenser transducer.

Other features and advantages of the invention will be apparent from the following specification taken in conjunction with the following drawings.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of a first embodiment of a silicon condenser microphone of the present invention;

FIG. 2 is a cross-sectional view of a second embodiment of a silicon condenser microphone of the present invention;

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FIG. 3 is a cross-sectional view of a third embodiment of a silicon condenser microphone of the present invention;

FIG. 4 is a cross-sectional view of the third embodiment of the present invention affixed to an end user circuit board;

FIG. 5 is a cross-sectional view of the third embodiment of the present invention affixed to an end user circuit board in an alternate fashion;

FIG. 6 is a plan view of a substrate to which a silicon condenser microphone is fixed;

FIG. 7 is a longitudinal cross-sectional view of a microphone package of the present invention;

FIG. 8 is a lateral cross-sectional view of a microphone package of the present invention;

FIG. 9 is a longitudinal cross-sectional view of a microphone package of the present invention;

FIG. 10 is a lateral cross-sectional view of a microphone package of the present invention;

FIG. 11 is a cross-sectional view of a top portion for a microphone package of the present invention;

FIG. 12 is a cross-sectional view of a top portion for a microphone package of the present invention;

FIG. 13 is a cross-sectional view of a top portion for a microphone package of the present invention;

FIG. 14a is a cross-sectional view of a laminated bottom portion of a housing for a microphone package of the present invention;

FIG. 14b is a plan view of a layer of the laminated bottom portion of FIG. 14a;

FIG. 14c is a plan view of a layer of the laminated bottom portion of FIG. 14a;

FIG. 14d is a plan view of a layer of the laminated bottom portion of FIG. 14a;

FIG. 15 is a cross-sectional view of a bottom portion for a microphone package of the present invention;

FIG. 16 is a cross-sectional view of a bottom portion for a microphone package of the present invention;

FIG. 17 is a cross-sectional view of a bottom portion for a microphone package of the present invention;

FIG. 18 is a cross-sectional view of a bottom portion for a microphone package of the present invention;

FIG. 19 is a plan view of a side portion for a microphone package of the present invention;

FIG. 20 is a cross-sectional package view of a side portion for a microphone package of the present invention;

FIG. 21 is a cross-sectional view of a side portion for a microphone package of the present invention;

FIG. 22 is a cross-sectional view of a side portion for a microphone package of the present invention;

FIG. 23 is a cross-sectional view of a microphone package of the present invention;

FIG. 24 is a cross-sectional view of a microphone package of the present invention;

FIG. 25 is a cross-sectional view of a microphone package of the present invention;

FIG. 26 is a cross-sectional view of a microphone package of the present invention;

FIG. 27 is a cross-sectional view of a microphone package of the present invention with a retaining ring;

FIG. 28 is a cross-sectional view of a microphone package of the present invention with a retaining wing; and

FIG. 29 is a cross-sectional view of a microphone package of the present invention with a retaining ring.

DETAILED DESCRIPTION OF THE  
PREFERRED EMBODIMENTS

While this invention is susceptible of embodiments in many different forms, there is shown in the drawings and will herein be described in detail preferred embodiments of the invention with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the broad aspect of the invention to the embodiments illustrated.

The present invention is directed to microphone packages. The benefits of the microphone packages disclosed herein over microphone packaging utilizing plastic body/lead frames include the ability to process packages in panel form allowing more units to be formed per operation and at much lower cost. The typical lead frame for a similarly functioning package would contain between 40 and 100 devices connected together. The present disclosure would have approximately 14,000 devices connected together (as a panel). Also, the embodiments disclosed herein require minimal "hard-tooling." This allows the process to adjust to custom layout requirements without having to redesign mold, lead frame, and trim/form tooling.

Moreover, these embodiments have a better match of thermal coefficients of expansion with the end user's PCB since this part would typically be mounted on FR-4 which is the same material used by end users. The present designs may also eliminate the need for wire bonding that is required in plastic body/lead frame packages. The foot print is typically smaller than that would be required for a plastic body/lead frame design since the leads are formed by plating a through-hole in a circuit board of which one half will eventually form the pathway to the solder pad. In a typical plastic body/lead frame design, a gull in which the leads are disposed, widen the overall foot print.

Now, referring to FIGS. 1-3, three embodiments of a silicon condenser microphone package 10 are illustrated. The silicon microphone package 10 generally comprises a transducer 12, e.g. a silicon condenser microphone as disclosed in U.S. Pat. No. 5,870,482 which is hereby incorporated by reference, a substrate 14, an amplifier 16, a back volume or air cavity 18 which provides a pressure reference for the transducer 12, and a cover 20. The substrate 14 is typically formed of FR-4 material which may be processed in circuit board panel form, thus taking advantage of economies of scale in manufacturing. FIG. 6 is a plan view of the substrate 14 showing the back volume 18 surrounded a plurality of terminal pads.

The back volume 18 may be formed by a number of methods, including controlled depth drilling of an upper surface 19 of the substrate 14 to form a recess over which the silicon condenser microphone is mounted (FIG. 1); drilling and routing of several individual sheets of FR-4 and laminating the individual sheets to form the back volume 18 which may or may not have internal support posts (FIG. 2); or drilling completely through the substrate 14 and providing a sealing ring 22 on the bottom of the device that will seal the back volume 18 during surface mounting to a user's "board" 28 (FIGS. 3-5). In this example, the combination of the substrate and the user's board 28 creates the back volume 18. The back volume 18 is covered by the transducer 12 (MEMS device) which is "bumpbonded" and mounted face down. The boundary is sealed such that the back volume 18 is "air-tight".

The cover 20 is attached for protection and processibility. The cover 20 contains an aperture 24 which may contain a sintered metal insert 26 to prevent water, particles and/or

light from entering the package and damaging the internal components inside; i.e. semiconductor chips. The aperture 24 is adapted for allowing sound waves to reach the transducer 12.

Referring to FIGS. 4 and 5, the final form of the product (shown without the cover 20) is a silicon condenser microphone package 10 which would most likely be attached to an end user's PCB 28 via a solder reflow process. FIG. 5 illustrates a method of enlarging the back volume 18 by including a chamber 32 within the end user's circuit board 28.

Another embodiment of a silicon condenser microphone package 40 is illustrated in FIGS. 7-10. In this embodiment, a housing 42 is formed from layers of materials, such as those used in providing circuit boards. Accordingly, the housing 42 generally comprises alternating layers of conductive and non-conductive materials 44, 46. The non-conductive layers 46 are typically FR-4 board. The conductive layers 44 are typically copper.

In the embodiment illustrated, the housing 42 includes a top portion 48 and a bottom portion 50 spaced by a side portion 52. The housing 42 further includes an aperture or acoustic port 54 for receiving an acoustic signal and an inner chamber 56 which is adapted for housing a transducer unit 58, typically a silicon die microphone or a ball grid array package (BGA). The top, bottom, and side portions 48, 50, 52 are electrically connected, for example with a conductive adhesive 60. Each portion may comprise alternating conductive and non-conductive layers of 44, 46.

The chamber 56 includes an inner lining 61. The inner lining 61 is primarily formed by conductive material. It should be understood that the inner lining may include portions of non-conductive material, as the conductive material may not fully cover the non-conductive material. The inner lining 61 protects the transducer 58 against electromagnetic interference and the like, much like a faraday cage.

In the various embodiments illustrated in FIGS. 7-10 and 23-26, the portions of the housing 42 that include the aperture or acoustic port 54 further include a layer of material that forms an environmental barrier 62 over or within the aperture 54. This environmental barrier 62 is typically a polymeric material formed to a film, such as a polytetrafluoroethylene (PTFE) or a sintered metal. The environmental barrier 62 is supplied for protecting the chamber 56 of the housing 42, consequently, the transducer unit 58 within the housing 42, from environmental elements such as sunlight, moisture, oil, dirt, and/or dust.

The environmental barrier layer 62 is generally sealed between two layers of conductive material 44. When the environmental barrier layer 62 is sandwiched between two layers of conductive material 44, it may act as a capacitor (with electrodes defined by the metal) that can be used to filter input and output signals or the input power. The environmental barrier layer 62 may further serve as a dielectric protective layer when in contact with the conductive layers 44 in the event that the conductive layers also contain thin film passive devices such as resistors and capacitors.

In addition to protecting the chamber 56 from environmental elements, the barrier layer 62 allows subsequent wet processing, board washing of the external portions of the housing 42, and electrical connection to ground from the walls via thru hole plating. The environmental barrier layer 62 also allows the order of manufacturing steps in the fabrication of the printed circuit board-based package to be modified. This advantage can be used to accommodate different termination styles. For example, a double sided

## 5

package can be fabricated having a pair of apertures **54** (see FIG. **25**), both including an environmental barrier layer **62**. The package would look and act the same whether it is mounted face up or face down, or the package could be mounted to provide directional microphone characteristics.

Referring to FIGS. **7**, **8**, and **11-13**, the transducer unit **58** is generally not mounted to the top portion **48** of the housing. This definition is independent of the final mounting orientation to an end user's circuit board. It is possible for the top portion **48** to be mounted face down depending on the orientation of the transducer **58** as well as the choice for the bottom portion **50**. The conductive layers **44** of the top portion **48** may be patterned to form circuitry, ground planes, solder pads, ground pads, and plated through hole pads. Referring to FIGS. **11-13**, there may be additional alternating conductive layers **44**, non-conductive layers **46**, and environmental protective membranes **62** as the package requires. Alternatively, some layers may be deliberately excluded as well. The first non-conductive layer **46** may be patterned so as to selectively expose certain features on the first conductive layer **44**.

FIG. **11** illustrates an alternative top portion **48** for a microphone package. In this embodiment, a connection between the layers can be formed to provide a conduit to ground. The top portion of FIG. **11** includes ground planes and/or pattern circuitry **64** and the environmental barrier **62**. The ground planes and or pattern circuitry **64** are connected by pins **65**.

FIG. **12** illustrates another embodiment of a top portion **48**. In addition to the connection between layers, ground planes/pattern circuitry **64**, and the environmental barrier **62**, this embodiment includes conductive bumps **66** (e.g. Pb/Sn or Ni/Au) patterned on the bottom side to allow secondary electrical contact to the transducer **58**. Here, conductive circuitry would be patterned such that electrical connection between the bumps **66** and a plated through hole termination is made.

FIG. **13** illustrates yet another embodiment of the top portion **48**. In this embodiment, the top portion **48** does not include an aperture or acoustic port **54**.

Referring to FIGS. **7**, **8** and **14-18**, the bottom portion **50** is the component of the package to which the transducer **58** is primarily mounted. This definition is independent of the final mounting orientation to the end user's circuit board. It is possible for the bottom portion **50** to be mounted facing upwardly depending on the mounting orientation of the transducer **58** as well as the choice for the top portion **48** construction. Like the top portion **48**, the conductive layers **44** of the bottom portion **50** may be patterned to form circuitry, ground planes, solder pads, ground pads and plated through hole pads. As shown in FIGS. **14-18**, there may be additional alternating conductive layers **44**, non-conductive layers **46**, and environmental protective membranes **62** as the package requires. Alternatively, some layers may be deliberately excluded as well. The first non-conductive layer **46** may be patterned so as to selectively expose certain features on the first conductive layer **44**.

Referring to FIGS. **14a** through **14d**, the bottom portion **50** comprises a laminated, multi-layered board including layers of conductive material **44** deposited on layers of non-conductive material **46**. Referring to FIG. **14b**, the first layer of conductive material is used to attach wire bonds or flip chip bonds. This layer includes etched portions to define lead pads, bond pads, and ground pads. The pads would have holes drilled through them to allow the formation of plated through-holes.

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As shown in FIG. **14c**, a dry film **68** of non-conductive material covers the conductive material. This illustration shows the exposed bonding pads as well as an exposed ground pad. The exposed ground pad would come in electrical contact with the conductive epoxy and form the connection to ground of the side portion **52** and the base portion **50**.

Referring to FIG. **14d**, ground layers can be embedded within the base portion **50**. The hatched area represents a typical ground plane **64**. The ground planes do not overlap the power or output pads, but will overlap the transducer **58**.

Referring to FIG. **15**, an embodiment of the bottom portion **50** is illustrated. The bottom portion **50** of this embodiment includes a solder mask layer **68** and alternating layers of conductive and non-conductive material **44**, **46**. The bottom portion further comprises solder pads **70** for electrical connection to an end user's board.

FIGS. **16** and **17** illustrate embodiments of the bottom portion **50** with enlarged back volumes **18**. These embodiments illustrate formation of the back volume **18** using the conductive/non-conductive layering.

FIG. **18** shows yet another embodiment of the bottom portion **50**. In this embodiment, the back portion **50** includes the acoustic port **54** and the environmental barrier **62**.

Referring to FIGS. **7-10** and **19-22**, the side portion **52** is the component of the package that joins the bottom portion **50** and the top portion **48**. The side portion **51** may include a single layer of a non-conductive material **46** sandwiched between two layers of conductive material **44**. The side portion **48** forms the internal height of the chamber **56** that houses the transducer **58**. The side portion **52** is generally formed by one or more layers of circuit board material, each having a routed window **72** (see FIG. **18**).

Referring to FIGS. **19-22**, the side portion **52** includes inner side wall **74**. The inner side walls **74** are generally plated with a conductive material, typically copper, as shown in FIGS. **20** and **21**. The side wall **74** are formed by the outer perimeter of the routed window **72** and coated/metallized with a conductive material.

Alternatively, the side wall **74** may be formed by many alternating layers of non-conductive material **46** and conductive material **44**, each having a routed window **72** (see FIG. **19**). In this case, the outer perimeter of the window **72** may not require coverage with a conductive material because the layers of conductive material **44** would provide effective shielding.

FIGS. **23-26** illustrate various embodiments of the microphone package **40**. These embodiments utilize top, bottom, and side portions **48**, **50**, and **52** which are described above. It is contemplated that each of the top, bottom, and side portions **48**, **50**, **52** embodiments described above can be utilized in any combination without departing from the invention disclosed and described herein.

In FIG. **23**, connection to an end user's board is made through the bottom portion **50**. The package mounting orientation is bottom portion **50** down connection from the transducer **58** to the plated through holes is made by wire bonding. The transducer back volume **18** is formed by the back hole (mounted down) of the silicon microphone only. Bond pads, wire bonds and traces to the terminals are not shown. A person of ordinary skilled in the art of PCB design will understand that the traces reside on the first conductor layer **44**. The wire bonds from the transducer **58** are connected to exposed pads. The pads are connected to the solder pads via plated through holes and traces on the surface.



In FIG. 24, connection to the end user's board is also made through the bottom portion 50. Again, the package mounting orientation is bottom portion 50 connection from the transducer 58 to the plated through holes are made by wire bonding. The back volume 18 is formed by a combination of the back hole of the transducer 58 (mounted down) and the bottom portion 50.

In FIG. 25, connection to the end user's board is also made through the bottom portion 50. Again, the package mounting orientation is bottom portion 50 connection from the transducer 58 to the plated through holes are made by wire bonding. With acoustic ports 54 on both sides of the package, there is no back volume, This method is suitable to a directional microphone.

In FIG. 26, connection to the end user's board is made through the top portion 48 of the bottom portion 50. The package mounting orientation is either top portion 48 down or bottom portion 50 down. Connection from the transducer 58 to the plated through holes is made by flip chipping and trace routing. The back volume 18 is formed by using the air cavity created by laminating the bottom portion 50 and the top portion 48 together. Some portion of the package fabrication is performed after the transducer 58 has been attached. In particular, the through hole formation, plating, and solder pad definition would be done after the transducer 58 is attached. The protective membrane 62 is hydrophobic and prevents corrosive plating chemistry from entering the chamber 56.

Referring to FIGS. 27-29, the portion to which the transducer unit 58 is mounted may include a retaining ring 84. The retaining ring 84 prevents wicking of an epoxy 86 into the transducer 58 and from flowing into the acoustic port or aperture 54. Accordingly, the shape of the retaining ring 84 will typically match the shape of the transducer 58 foot print. The retaining ring 84 comprises a conductive material (e.g., 3 mil. thick copper) imaged on a non-conductive layer material.

Referring to FIG. 27, the retaining ring 84 is imaged onto a non-conductive layer. An epoxy is applied outside the perimeter of the retaining ring 84, and the transducer 58 is added so that it overlaps the epoxy 86 and the retaining ring 84. This reduces epoxy 86 wicking up the sides of the transducer's 58 etched port (in the case of a silicon die microphone).

Alternatively, referring to FIG. 28, the retaining ring 84 can be located so that the transducer 58 does not contact the retaining ring 84. In this embodiment, the retaining ring 84 is slightly smaller than the foot print of the transducer 58 so that the epoxy 86 has a restricted path and is, thus, less likely to wick. In FIG. 29, the retaining ring 84 is fabricated so that it contacts the etched port of the transducer 58.

The following tables provide an illustrative example of a typical circuit board processing technique for fabrication of the housing of this embodiment.

TABLE 1

Materials			
Ma- terial	Type	Component	Note
1	0.5/0.5 oz. DST Cu 5 core FR-4	Bottom Portion (Conductive Layers 1 and 2; Non- Conductive Layer 1)	
2	0.5/0.5 oz. DST Cu 5 core FR-4	Bottom Portion (Conductive Layers 3 and 4; Non- Conductive Layer 2)	

TABLE 1-continued

Materials			
Ma- terial	Type	Component	Note
3	106 pre-preg		For Laminating Material 1 and Material 2 Afterward
4	0.5/0.5 oz. DST Cu 40 Core FR-4	Side Portion	Metallized Afterward
5	Bare/0.5 oz. Cu 2 core FR-4 (2 pieces)	Top Portion (Each Piece Includes 1 Conductive and 1 Non-Conductive Layer)	
6	Expanded PTFE	Environmental Barrier	

2: Processing of Materials (Base Portion Material 1)

Step	Type	Description	Note
1	Dry Film Conductive Layers		
2	Expose	Mask Material 1 (Lower Conductive Layer).	Forms Ground Plane on Lower Conductive Layer
3	Develop		
4	Etch Cu		No Etching on Upper Conductive Layer
5	Strip Dry Film		

TABLE 3

Processing of Materials Bottom Portion Material 2)

Step	Type	Description	Note
1	Dry Film Conductive Layers		
2	Expose	Mask Material 2 (Upper Conductive Layer)	Forms Ground Plane on Upper Conductive Layer
3	Develop		
4	Etch Cu		No Etching on Lower Conductive Layer
5	Strip Dry Film		

TABLE 4

Processing of Materials 1, 2, and 3 (Form Bottom Portion)

Step	Type	Description	Note
1	Laminate	Materials 1 and 2 Laminated Using Material 3	
2	Drill Thru Holes	Drill Bit = 0.025 in.	
3	Direct Metallization/Flash Copper	Plates Thru Holes	
4	Dry Film (L1 and L4)		
5	Expose	Mask Laminated Materials 1 and 2 (Upper and Lower Conductive Layers)	Forms Traces and Solder Pads
6	Develop		

TABLE 4-continued

<u>Processing of Materials 1, 2, and 3 (Form Bottom Portion)</u>			
Step	Type	Description	Note
7	Electrolytic Cu	1.0 mil	
8	Electrolytic Sn	As Required	
9	Strip Dry Film		
10	Etch Cu		
11	Etch Sn		
12	Insert Finishing Option Here	NG Option (See Table Below)	NG Option for Proof of Principle
13	Dry Film (cover lay) on Upper Conductive Layer Only	2.5 mil	Minimum Thickness on Upper Conductive Layer
14	Expose	Mask Laminated Materials 1 and 2 (upper and lower)	This mask defines an area on the upper conductive layer that will receive a dry film solder mask (cover lay). The bottom layer will not have dry film applied to it. The plated through holes will be bridged over by the coating on the top.
15	Develop		
16	Cure		Full Cure
17	Route Panels	Route Bit = As Required	Forms 4" x 4" pieces. Conforms to finished dims

Table 5 describes the formation of the side portion 52. This process involves routing a matrix of openings in FR-4 board. However, punching is thought to be the cost effective method for manufacturing. The punching may done by punching through the entire core, or, alternatively, punching several layers of no-flow pre-preg and thin core c-stage which are then laminated to form the wall of proper thickness.

After routing the matrix, the board will have to be electroless or DM plated. Finally, the boards will have to be routed to match the bottom portion. This step can be done first or last. It may make the piece more workable to perform the final routing as a first step.

TABLE 5

<u>Processing of Material 4 (Side Portion)</u>			
Step	Type	Description	Note
1	Route./Punch	Route Bit = 0.031 in.	Forms Side Portion
2	Direct Metallization/Flash Cu	0.25 mil minimum	Forms Sidewalls on Side Portion
3	Route Panels		

Table 6 describes the processing of the top portion. The formation of the top portion 48 involves imaging a dry film cover layer or liquid solder mask on the bottom (i.e. conductive layer forming the inner layer. The exposed layer of the top portion 48 will not have a copper coating. It can be processed this way through etching or purchased this way as a one sided laminate.

A matrix of holes is drilled into the lid board. Drilling may occur after the imaging step. If so, then a suitable solder mask must be chosen that can survive the drilling process.

TABLE 6

<u>Processing of Top Portion</u>			
Step	Type	Description	Note
1	Dry Film	Conductive Layer	
2	Expose	Mask Bare Layer	Form Conduction Ring
3	Develop		
4	Cure		
5	Drill Matrix of Holes	Drill Bit = 0.025 in.	Acoustic Ports
6	Laminate	PTFE (Environmental Barrier) Between 2 Pieces of Material 5	Forms Top Portion

TABLE 7

<u>Processing of Laminated Materials 1 and 2 with Material 4</u>			
Step	Type	Description	Note
1	Screen Conductive Adhesive on Material 4		
2	Laminate	Bottom Portion with Side Portion	Forms Bottom Portion with Side Portion (spacer)
3	Add Transducer Assembly	Silicon Die Microphone and Integrated Circuit	

TABLE 8

<u>Processing of Laminated Materials 1, 2, and 4 with Material 5</u>			
Step	Type	Description	Note
1	Screen Conductive Adhesive on Top Portion		
2	Laminate	Bottom Portion and Side Portion with Top Portion	Forms Housing
3	Dice		

TABLE 9

<u>Finishing Option NG (Nickel/Gold)</u>			
Step	Type	Description	Note
1	Immersion Ni	(40-50, μ-in)	
2	Immersion Au	(25-30, μ-in)	

TABLE 10

<u>Finishing Option NGT (Nickel/Gold/Tin)</u>			
Step	Type	Description	Note
1	Mask L2	(using thick dry film or high tack dicing tape)	
2	Immersion Ni	(40-50, μ-in)	
3	Immersion Au	(25-30, μ-in)	
4	Remove Mask on L2		
5	Mask L1	(using thick dry film or high tack dicing tape) bridge over cavity created by wall	
6	Immersion Sn	(100-250, μ-in)	
7	Remove Mask on L1		

TABLE 11

<u>Finishing Option ST (Silver/Tin)</u>	
Step	Type
1	Mask L2 (using thick dry film or high tack dicing tape)
2	Immersion Ag (40-50 μ-in)
3	Remove Mask on L2
4	Mask L1 (using thick dry film or high tack dicing tape) bridge over cavity created by wall
5	Immersion Sri (100-250 μ-in)
6	Remove Mask on L1

While specific embodiments have been illustrated and described, numerous modifications come to mind without significantly departing from the spirit of the invention, and the scope of protection is only limited by the scope of the accompanying claims.

What is claimed is:

1. A surface mountable package for containing a transducer, the transducer being responsive to sound pressure levels of an acoustic signal to provide an electrical output representative of the acoustic signals, the surface mountable package comprising:

at least a first member and a second member and a chamber being defined by the first member and the second member, the transducer being attached to a surface formed on one of the first member or the second member and the transducer residing within the chamber;

the surface being formed with at least one patterned conductive layer, the patterned conductive layer being electrically coupled to the transducer; an outside surface of the surface mountable package comprising a plurality of terminal pads electrically coupled to the patterned conductive layer;

a volume being defined by the transducer and one of the first member or the second member, the volume being acoustically coupled to the transducer; and

one of the first member or the second member being formed to include an aperture, the aperture configured to permit the passage of an acoustic signal to the transducer.

2. The surface mountable package of claim 1, wherein the first member comprises a substrate and the second member comprises a cover coupled to the substrate to define the chamber.

3. The surface mountable package of claim 1, the volume including a recess formed in the surface.

4. The surface mountable package of claim 1, the volume including a hole through one of the first member or the second member containing the surface.

5. The surface mountable package of claim 1, the surface mountable package being secured to a substrate of a device, the chamber in communication with a cavity formed in the device substrate.

6. The surface mountable package of claim 1, the aperture being acoustically coupled to a first side of the transducer and the volume being acoustically coupled to a second side of the transducer.

7. The surface mountable package of claim 1, the aperture being formed in the respective one of the first member and the second member, the surface being formed on the respective one of the first member and the second member and the transducer being attached to the surface completely covering the aperture.

8. The surface mountable package of claim 1, the aperture being formed in the respective one of the first member and the second member, the surface being formed on the respective one of the first member and the second member and the transducer being attached to the surface adjacent to the aperture.

9. The surface mountable package of claim 1, the aperture being formed in the respective one of the first member and the second member, the surface being formed on the respective other one of the first member and the second member and the aperture is acoustically coupled by the chamber to the transducer.

10. The surface mountable package of claim 1, the aperture is formed in the respective one of the first member and the second member, the surface is formed on the respective one of the first member and the second member and the transducer is attached to the surface leaving the aperture uncovered by the transducer, wherein the aperture is coupled to the transducer via the chamber.

11. The surface mountable package of claim 1, the aperture is formed in each of the first member and the second member.

12. The surface mountable package of claim 1, the aperture is formed in the second member, the surface is formed on the first member and the aperture is coupled to the transducer via the chamber; and the volume includes a recess formed in the first member.

13. The surface mountable package of claim 1, the aperture is formed in the respective one of the first member and the second member, the surface is formed on the respective one of the first member and the second member and the transducer is attached to the surface covering the aperture and a sealing ring is disposed about and surrounding the aperture, the sealing ring providing a seal between the transducer and the surface.

14. The surface mountable package of claim 1, the surface mountable package being secured to a surface of a device, a sealing ring disposed about and surrounding the aperture on an outside surface of the surface mountable package, the sealing ring providing a seal between the surface mountable package and the surface of the device.

15. The surface mountable package of claim 1, the patterned conductive layer comprising a plurality of terminal pads, the terminal pads providing an electrical connection between the transducer within the volume and an exterior of the surface mountable package.

16. The surface mountable package of claim 1, a metalized region being formed on an exterior surface of the surface mountable package, the metalized region being electrically coupled to the patterned conductive layer.

17. The surface mountable package of claim 1, one or both of the first member and the second member including a shield against electromagnetic interference.

18. The surface mountable package of claim 1, the first member including a first conductive portion, the second member including a second conductive portion, an electromagnetic interference shield being formed by the coupling of the first conductive portion and the second conductive portion.

19. The surface mountable package of claim 18, the first conductive portion comprising a conductive layer formed in the first member and the second conductive portion comprising a conductive layer formed in the second member.

20. The surface mountable package of claim 1, the first member comprising a printed circuit board.

21. The surface mountable package of claim 1, a third member being disposed between the first member and the

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second, the first member, the second member and the third member defining the chamber.

22. The surface mountable package of claim 1, a barrier being disposed within the aperture.

23. The surface mountable package of claim 22, wherein the barrier has acoustic properties.

24. The surface mountable package of claim 23, wherein the barrier forms an environmental protective barrier.

25. The surface mountable package of claim 1, the aperture being formed in the respective one of the first member and the second member, the surface being formed on the respective other one of the first member and the second member, the aperture being coupled to the transducer via the chamber and a passage being formed in the respective other

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one of the first member and the second member, the passage being coupled to the transducer.

26. The surface mountable package of claim 25, wherein the passage comprises a portion of an acoustic port.

27. The surface mountable package of claim 25, wherein a barrier is disposed within the passage.

28. The surface mountable package of claim 1, wherein the volume includes a portion of the chamber.

29. The surface mountable package of claim 1, wherein the acoustic signal is coupled to the transducer via the chamber.

\* \* \* \* \*