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(54) Semiconductor amplifying circuit and semiconductor electret condenser microphone

(57) Subject

To be resistant to effects of burst noise in semiconductor amplifying circuit and semiconductor electret condenser microphone.

Constitution

Comprising a voltage converting circuit 10 for receiving a weak signal  $\alpha$  and issuing this signal as a voltage signal  $\beta$ , and an amplifying circuit 20 for receiving the voltage signal  $\beta$  and amplifying and issuing this signal, the voltage converting circuit 10 and amplifying circuit 20 are formed in a same semiconductor chip C. That is, since the input terminal of the amplifying circuit 20 is concealed in the semiconductor chip C, burst noise hardly gets into the amplifying circuit 20.

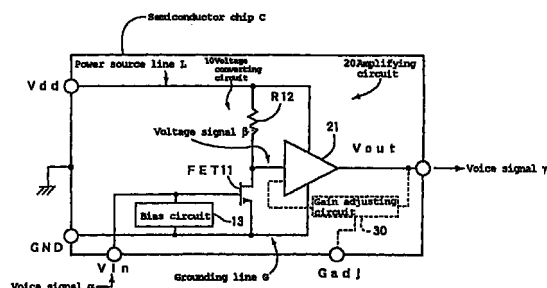


Fig. 1

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## Description

### TECHNICAL FIELD

[0001] The present invention relates to a semiconductor amplifying circuit resistant to effects of burst noise, and a semiconductor electret condenser microphone having the same circuit.

### PRIOR ART

[0002] The electret condenser microphones are widely used as the microphones of digital portable telephones and the like.

[0003] A conventional electret condenser microphone basically comprises, as shown in Fig. 10, a diaphragm 2, being a high polymer electret film, adhered to a ring 1, a back electrode 3 disposed opposite to the diaphragm 2, a spacer 4 interposed between the back electrode 3 and the ring 1 for opening a space between the diaphragm 2 and back electrode 3, a back electrode holder 5 for holding the back electrode 3, IC chips 61, 62 mounted on a printed circuit board 8, and a case 7 for accommodating them. In the diagram, reference numeral 9 is a front cloth.

[0004] A capacitor is formed of the diaphragm 2 and back electrode 3, and by making use of change of capacity of the capacitor by vibration of the diaphragm 2, the voice is converted into a voice signal, and this signal is amplified and issued. As the circuit for amplifying this signal, a semiconductor amplifying circuit as shown in Fig. 11 is widely used.

[0005] This circuit is composed of a voltage converting circuit A for converting the voice signal into a voltage signal, and issuing, and an amplifying circuit B for amplifying the voltage signal entered from the voltage converting circuit A, and issuing. The voltage converting circuit A is formed in the IC chip 61, and the amplifying circuit B is formed in the IC chip 62. In the diagram, Vdd denotes a supply voltage terminal, GND is a grounding voltage terminal, Vout1 is an output terminal of the voltage converting circuit A, and Vout is an output terminal of the amplifying circuit B.

[0006] In this prior art, however, the problem is that the semiconductor amplifying circuit is susceptible to effects of burst noise. That is, the radio frequency oscillator built in the digital portable telephone (TDMA system) is the source of burst noise (RF burst signal), and the burst noise radiated from the radio frequency oscillator gets into the power source line or wiring line, and a large burst component (burst operation frequency: 200 to 400 Hz) appears in the output signal of the semiconductor amplifying circuit. In particular, the input signal line of the amplifier circuit B is exposed, and the burst noise invading into this line is amplified by the amplifying circuit B, which poses a serious problem for reduction of noise in the electret condenser microphone, or the portable telephone itself.

[0007] If a noise blocking capacitor is provided in the output stage of the amplifying circuit B, it is effective for burst noise of low level, but it is not sufficient as noise countermeasure, and it gives an additional problem of increase in the number of parts from the viewpoint of reduction of cost.

[0008] The invention is created in the light of such background, and it is hence an object thereof to present a semiconductor amplifying circuit and a semiconductor electret condenser microphone resistant to effects of burst noise.

### SUMMARY OF THE INVENTION

[0009] The semiconductor amplifying circuit of the invention is a circuit for amplifying and issuing a weak signal, which comprises a voltage converting circuit for receiving the weak signal and issuing this signal as a voltage signal, and an amplifying circuit for receiving the voltage signal issued from the voltage converting circuit, and amplifying and issuing this signal, in which the voltage converting circuit and amplifying circuit are formed in a same semiconductor chip.

[0010] According to such constitution, since the input terminal of the amplifying circuit is concealed in the semiconductor chip, burst signal hardly gets into the amplifying circuit.

[0011] The voltage converting circuit preferably includes a junction type or MOS type FET of which source is grounded and gate receives the weak signal, and a resistance connected between the drain of the FET and a power source line for converting the drain current of the FET into a voltage and issuing as a voltage signal.

[0012] More preferably, the voltage converting circuit includes a junction type or MOS type first FET for receiving the weak signal at its gate with its source being grounded, a second FET having the source and drain connected between the drain of the first FET and a power source line for issuing the source voltage as a voltage signal, and a reference voltage generating circuit for receiving the supply voltage on the power source line, generating a reference voltage, and issuing to the gate of the second FET.

[0013] In such constitution, if the supply voltage is varied by the burst noise getting into the power source line or the like, although the source voltage of the second FET fluctuates, since the reference voltage fed into the gate of the second FET fluctuates at the same time, the degree of variation of the source voltage of the second FET is smaller than that of the supply voltage. Accordingly, if burst noise gets into the power source line or the like, the burst noise getting into the amplifying circuit is small.

[0014] The amplifying circuit preferably includes a gain adjusting circuit for adjusting the gain of this circuit from outside. This is because dispersion of characteristics of the voltage converting circuit can be absorbed by

the gain adjustment of the amplifying circuit.

**[0015]** More preferably, a capacitance for protection from surge formed by using a transistor is provided between the output of the amplifying circuit and the power source line and/or grounding line. Therefore, if a large burst component appears in the output of the amplifying circuit due to effects of burst noise, it can be blocked by the capacitance.

**[0016]** The semiconductor electret condenser microphone of the invention is a device, in which a capacitor is formed of a diaphragm and a back electrode, the voice is converted into a voice signal by making use of the change of capacity of the capacitor by vibration of the diaphragm, and this signal is amplified and issued, and any one of the semiconductor amplifying circuits mentioned above is used for amplifying the voice signal.

**[0017]** In the semiconductor electret condenser microphone, an electrode layer functioning as the back electrode is provided at the upper side of a semiconductor chip in which the semiconductor amplifying circuit is formed.

#### BRIEF DESCRIPTION OF THE DRAWINGS

##### **[0018]**

Fig. 1 is a circuit diagram for explaining an embodiment of a semiconductor amplifying circuit of the invention.

Fig. 2 is a circuit diagram showing a modified example thereof.

Fig. 3 is a schematic sectional view for explaining an embodiment of a semiconductor electret condenser microphone of the invention.

Fig. 4 is a schematic exploded perspective view of a case of the microphone.

Fig. 5 (A) is a schematic sectional view of the case, and (B) is a schematic bottom view of the case.

Fig. 6 is a schematic plan of a spacer layer of the microphone.

Fig. 7 is a schematic sectional view of a diaphragm of the microphone.

Fig. 8 is a circuit diagram showing an electric connection relation with the microphone in the circuit shown in Fig. 2.

Fig. 9 is a graph showing the relation between the level and frequency of burst noise contained in the voice signal issued from the semiconductor amplifying circuit.

Fig. 10 is a schematic sectional view for explaining a conventional electret condenser microphone.

Fig. 11 is a circuit diagram for explaining a conventional semiconductor amplifying circuit.

#### DESCRIPTION OF REFERENCE NUMERALS

##### **[0019]**

|    |          |                            |
|----|----------|----------------------------|
| 5  | 10       | Voltage converting circuit |
|    | 20       | Amplifying circuit         |
|    | C        | Semiconductor chip         |
|    | $\alpha$ | Voice signal               |
|    | $\beta$  | Voltage signal             |
| 10 | $\gamma$ | Voice signal               |

#### EMBODIMENTS OF THE INVENTION

**[0020]** Referring now to the drawings, an embodiment of the invention is described below. The semiconductor amplifying circuit in the illustrated example is a circuit for amplifying and issuing a weak voice signal  $\gamma$  detected by a semiconductor electret condenser microphone for a portable telephone, and it basically comprises, as shown in Fig. 1, a voltage converting circuit 10 for receiving a voice signal, and issuing this signal as a voltage signal, and an amplifying circuit 20 for receiving the voltage signal, amplifying this signal, and issuing as a voice signal  $\gamma$ . What is most characteristic of this semiconductor amplifying circuit is that the voltage converting circuit 10 and amplifying circuit 20 are formed in a same semiconductor chip C.

**[0021]** On the outer surface of the semiconductor chip C, there are provided a supply voltage terminal Vdd for feeding supply voltage, a grounding voltage terminal GND, an input terminal Vin for feeding voice signal  $\alpha$ , and an output terminal Vout for issuing voice signal  $\gamma$ . In the diagram, L denotes a power source line, and G is a grounding line (solid earth pattern). The constituent circuits are described below.

**[0022]** The voltage converting circuit 10 includes an FET 11 of which source is grounded and gate receives the voice signal  $\alpha$ , a resistance 12 connected between the drain of the FET 11 and the power source line L for converting the drain current of the FET 11 into a voltage, and issuing as a voltage signal  $\beta$ , and a bias circuit 13 for biasing the gate voltage of the FET 11 to 0 V. The FET 11 used herein is a junction type FET of N-channel depletion type, but a CMOS type FET may be also used. As the bias circuit 13, a diode or a giga-order resistance is used.

**[0023]** As the amplifying circuit 20, an operational amplifier 21 of high input impedance and low output impedance is used, and it is designed to generate a voice signal  $\gamma$  by amplifying the voltage signal  $\beta$  without inverting.

**[0024]** In thus constituted semiconductor amplifying circuit, the operation is described below. Since the gate circuit 13 is provided in the gate of the FET 11, the bias of the gate-source voltage  $V_{GS}$  of the FET 11 is 0 V. Supposing the drain current  $I_D$  of the FET 11 at  $V_{GS} = 0$  to be  $I_{DSS}$ , the relation between the  $I_{DSS}$  and the pinch-off voltage  $V_P$  of the FET 11 is as shown in the formula

below. In the formula,  $\beta$  is a constant determined by the gate size of the FET 11.

$$I_{DSS} = \beta \cdot V_P^2 \quad [\text{formula 1}]$$

At  $V_{GS} = 0$ , the relation between the voltage change  $\Delta V_{IN}$  of voice signal  $\alpha$  and the current change  $\Delta I_D$  of the drain current  $I_D$  of the FET 11 is expressed below.

$$\Delta I_D / \Delta V_{IN} = 2 \cdot I_{DSS} / V_P \quad [\text{formula 2}]$$

Hence,  $\Delta I_D$  is expressed as follows from formula 2 and formula 1.

$$\Delta I_D = -2 \cdot \Delta V_{IN} \cdot \beta \cdot V_P \quad [\text{formula 3}]$$

**[0025]** That is, when the voice signal  $\alpha$  is changed by  $\Delta V_{IN}$ , the drain current  $I_D$  of the FET 11 is changed by  $\Delta I_D$ . The input impedance of the operational amplifier 21 is very high and the drain current  $I_D$  flows into the resistance R12, the input voltage  $V_a$  of the operational amplifier 21 changes as follows. Herein, the resistance value of the resistance R12 is expressed as R.

$$\begin{aligned} \Delta V_a &= \Delta I_D \cdot R \\ &= -2 \cdot \Delta V_{IN} \cdot \beta \cdot V_P \cdot R \end{aligned} \quad [\text{formula 4}]$$

At  $V_{GS} = 0$ , since the drain current  $I_D$  of the FET 11 is  $I_{DSS}$ , the direct-current component of  $V_a$  is expressed as follows. The supply voltage is also expressed as  $V_{DD}$ .

$$\begin{aligned} V_a &= V_{DD} - R \cdot I_{DSS} \\ &= V_{DD} - R \cdot \beta \cdot V_P^2 \end{aligned} \quad [\text{formula 5}]$$

**[0026]** When the voice signal  $\alpha$  is fed into the voltage converting circuit 10, in the circuit, a voltage  $V_a$  proportional to the signal is generated. This is fed into the amplifying circuit 20 as voltage signal  $\beta$ , and a voice signal  $\gamma$  is generated.

**[0027]** In such semiconductor amplifying circuit, different from the prior art, since the input terminal of the amplifying circuit 20 is concealed in the semiconductor chip C, the burst noise originated from the radio frequency oscillator of the portable telephone hardly gets into the voltage signal  $\beta$ . As a result, if the voltage signal  $\beta$  is amplified by the amplifying circuit 20, the burst noise component contained in the voice signal  $\gamma$  after amplification is very small.

**[0028]** Incidentally, the parts used in the voltage converting circuit 10, in particular, the pinch-off voltage ( $V_P$ ) of the FET 11 differs in each product. The direct-current component of the voltage signal  $\beta$  is proportional to the square of the FET 11 pinch-off voltage ( $V_P$ ), and therefore the level of the voice signal  $\gamma$  fluctuates largely in each product. Since the voltage converting circuit 10 and amplifying circuit 20 are formed in a same

semiconductor chip C, it is impossible to adjust the level of the voice signal  $\gamma$  by the technique of selection of the parts.

**[0029]** As its countermeasure, a gain adjusting circuit 30 may be provided in the amplifying circuit 20 as indicated by dotted line in the diagram for adjusting the gain of the circuit from outside. This circuit is designed to adjust the feedback amount of the amplifying circuit 20 depending on the input voltage through the gain adjusting terminal  $G_{adj}$  provided on the outer surface of the semiconductor chip C, and change the gain of the amplifying circuit 20. It may be also designed to widen the input operation range of the amplifying circuit 20.

**[0030]** In the semiconductor amplifying circuit shown in Fig. 1, although it is very effective to the burst noise radiated from the radio frequency oscillator of portable telephone, it is not sufficiently effective to the incoming burst noise through the power source line L or grounding line G. If desired to control also the burst noise getting into the power source line L or the like, it is preferred to use the semiconductor amplifying circuit shown in Fig. 2.

**[0031]** What differs greatly from the circuit shown in Fig. 1 is the voltage converting circuit 10'. This circuit comprises an FET 11 grounded in the source and receiving a voice signal  $\alpha$  at the gate (corresponding to the first FET), an FET 13 having the source and drain connected between the drain of the FET 11 and a power source line L, and issuing a source voltage as a voltage signal  $\beta$  (corresponding to the second FET), and a reference voltage generating circuit 14 for receiving the supply voltage ( $V_{DD}$ ) on the power source line L, generating a reference voltage  $V_{ref}$ , and issuing to the gate of the FET 13. The FET 11 and FET 13 are manufactured in the same semiconductor manufacturing process, and the both FETs are identical in structure.

**[0032]** The connection relation between this circuit and the semiconductor electret condenser microphone is as shown in Fig. 8. This point is same as in the circuit shown in Fig. 1.

**[0033]** The reference voltage generating circuit 14 is designed to generate reference voltage  $V_{ref}$  by dividing the supply voltage ( $V_{DD}$ ) by resistance R141 and resistance R142.

**[0034]** Between the output of the amplifying circuit 20 and the power source line L and grounding line G, capacitances 41, 42 composed by using transistors are provided in each stage for protection from surge. The capacitances 41, 42 are composed of junction type FET of enhancement type, and are connected as shown in the drawing to increase the gate area, and the parasitic capacity is designed to be 2 pF or more. The other parts are exactly same as in the circuit shown in Fig. 1.

**[0035]** In thus constituted semiconductor amplifying circuit, the operation is described below. Same as in the circuit above, at  $V_{GS} = 0$ , the relation between the voltage change  $\Delta V_{IN}$  of voice signal  $\alpha$  and the current change  $\Delta I_D$  of the drain current  $I_D$  of the FET 11 is

expressed below. Herein,  $\beta_1$  is the constant determined by the gate size of FET 11.

$$\Delta I_D = -2 \cdot \Delta V_{IN} \cdot \beta_1 \cdot V_P \quad [\text{formula 6}]$$

When the drain current  $I_D$  of the FET 11 varies, the drain current  $I_D$  of the FET 13 changes similarly, but since the reference voltage  $V_{ref}$  is put into the gate of the FET 13, the gate-source voltage  $V_{GS}$  of the FET 13 changes depending on the drain current  $I_D$  of the FET 11. The relation between the two is as shown below. Herein,  $\beta_2$  is the constant determined by the gate size of FET 13.

$$\Delta I_D = -2 \cdot \Delta V_{GS} \cdot \beta_2 \cdot V_P \quad [\text{formula 7}]$$

Supposing the change of the input voltage of the operational amplifier 21 to be  $\Delta V_a$ , from formulas 6 and 7,  $\Delta V_a$  is expressed as follows.

$$\Delta V_a = (\beta_1/\beta_2) \cdot \Delta V_{IN} \quad [\text{formula 8}]$$

The direct-current component of  $V_a$  is expressed as follows.

$$V_a = V_{DD} - (V_{ref} + V_{GS}) \quad [\text{formula 9}]$$

**[0036]** Being set at  $V_{ref} = V_{DD}/2$ ,  $\beta_1 = \beta_2$ , the gate-source voltage  $V_{GS}$  of the FET 13 is zero. Accordingly, the voltage signal  $\beta$  and voice signal  $\gamma$  change about  $V_{DD}/2$ . Except for this point, the operation is basically same as in the circuit shown in Fig. 1. However, if burst noise gets into the power source line L or the like, large burst noise component does not appear in the voice signal  $\gamma$  owing to the reason explained below.

**[0037]** When  $V_{DD}$  fluctuates due to effects of burst noise,  $V_{ref}$  changes similarly depending on this fluctuation. However, as shown in formula 9, since  $V_{DD}$  and  $V_{ref}$  are reverse in polarity, if  $V_{DD}$  changes,  $V_a$  does not change so much. Moreover, if surge is put on  $V_{DD}$  due to burst noise, the surge is absorbed by the capacitances 41, 42 for surge protection. As a result, large burst noise component does not appear on the voice signal  $\gamma$ .

**[0038]** Incidentally, the portable telephone has a radio frequency oscillator in order to transmit and receive radio waves, and it was hitherto the source of burst noise, and had a serious effect on the electret condenser microphone. When the semiconductor amplifying circuit shown in Fig. 1 or Fig. 2 is used in the semiconductor electret condenser microphone shown in Fig. 5, since the semiconductor amplifying circuit itself is very strong against burst noise, the noise level can be lowered in the microphone and also in the portable telephone itself.

**[0039]** The semiconductor amplifying circuit shown in Fig. 1 and Fig. 2 can be similarly applied in the semiconductor electret condenser microphone shown in Fig. 3 through Fig. 7. The structure of this microphone is

described below while referring to the drawings.

**[0040]** As shown in Fig. 3, the microphone basically comprises a semiconductor chip 100 in which the semiconductor amplifying circuit shown in Fig. 1 or Fig. 2 is formed, an electrode layer 140 laminated on the surface of the semiconductor chip 100 through an insulating layer 130, an insulating layer 150 formed on the electrode layer 140, a diaphragm 200 attached to a ring 230, a spacer layer 170 interposed between the ring 230 and insulating film 150 for opening a space 180 between the diaphragm 200 and insulating film 150, and a case 300 for containing them.

**[0041]** The electrode layer 140 opposite to the diaphragm 200 functions as the back electrode 3 of the electret condenser microphone shown in Fig. 11. The diaphragm 200 is grounded according to the method described below, while the electrode layer 140 is connected to the wiring (not shown) formed on the insulating layer 130 and the electrode (input terminal  $V_{in}$ : not shown) formed on the surface of the semiconductor chip 100. In short, when the diaphragm 200 vibrates, the electric charge collected in the electrode layer 140 changes, and the voltage at this time is voice signal  $\alpha$ .

**[0042]** The case 300 has a case main body 310 forming a recess 330 in which the semiconductor chip 100 is fitted, and a lid 320 for closing the case main body 310.

**[0043]** The case 310 is formed by laminating four frame members as shown in Fig. 4, that is, a first layer 311, a second layer 312, a third layer 313, and a fourth layer 314. The first layer 311, second layer 312, third layer 313, and fourth layer 314 are set in equal overall dimensions, and when they are laminated, one nearly rectangular parallelepiped is formed. The first layer 311 is a conductive adhesive member, and the second layer 312, third layer 313, and fourth layer 314 are ceramics.

**[0044]** At the face side of the fourth layer 314 in the lowest layer, a grounding conductive layer 314B is formed by nickel plating or aluminum plating. At the face side and back side of two recesses 314C and 314D formed on the side of the fourth layer 314, a terminal conductive layer for signal output 314E and a terminal conductive layer for power source 314F are formed respectively.

**[0045]** In the center of the fourth layer 314, a recess 314A is formed as a back compartment 350. The size of the recess 314A is set smaller than the semiconductor chip 100 so that the semiconductor chip 100 may not get in.

**[0046]** In the center of the third layer 313 laminated on the fourth layer 314, an opening 313A is opened, and when the third layer 313 is laminated on the fourth layer 314, the conductive layer 314B of the fourth layer 314 is visible through the opening 313A of the third layer 313. At the face side of the third layer 313, except for the opening 313A, a grounding conductive layer 313B is formed by nickel plating or aluminum plating. The two recesses 313C and 313D formed on the side surface of

the third layer 313, and its face side and side surface side, a terminal conductive layer for signal output 313E and a terminal conductive layer for power source 313F are formed respectively. They are respectively connected to the terminal conductive layer for signal output 314E and terminal conductive layer for power source 314F of the fourth layer 314, respectively.

**[0047]** The opening 313A of the third layer 313 is set in a slightly larger size than the semiconductor chip 100 so that the semiconductor chip 100 may be fitted in.

**[0048]** In the center of the second layer 312 laminated on the third layer 313, an opening 312A larger than the opening 313A is formed, and when the second layer 312 is laminated on the third layer 313, the conductive layer 313B of the third layer 313 is visible through the opening 312A of the second layer 312. Moreover, on the surface of the second layer 312, three pads connected by an electrode layer 191 and a bonding wire 190 of the semiconductor chip 100 are formed.

**[0049]** These three pads are a grounding pad 312G for connecting the conductive layers 313B, 314B, a signal output pad 312E for connecting the terminal conductive layers for signal output 313E, 314E, and a power source pad 312F for connecting the terminal conductive layers for power source 313F, 314F. The grounding pad 312G is formed at a corner recess 312K, and the signal output pad 312E and power source pad 312F are formed at the face and backside of the two recesses 312C, 312D at the side, respectively.

**[0050]** In the center of the first layer 311 laminated on the second layer 312, an opening 311A larger than the opening 312A is opened.

**[0051]** As shown in Fig. 3, Fig. 4 and Fig. 5, the case main body 310 is formed by laminating and baking the first layer 311, second layer 312, third layer 313, and fourth layer 314. The one side of the recess 330 of the case main body 310 is formed in steps in the dimensional relation the opening 311A of the first layer 311, opening 312A of the second layer 312, and opening 313A of the third layer 313. Incidentally, it is also possible to form in a three-layer structure on the whole by integrating the second layer 312 and third layer 313.

**[0052]** As shown in Fig. 3, at the backside of the lid 320 for closing the case main body 310, a ring-shape protrusion 321 for pressing the ring 230 to which the diaphragm 200 is fitted is formed, and a sound hole 322 is opened near the center of the lid 320.

**[0053]** The semiconductor chip 100, insulating layer 130, electrode layer 140, insulating layer 150, and spacer layer 170 are formed by the known semiconductor process technology. The electrode layer 140 is made of aluminum, and the insulating layer 150 is TiN, which are formed by vapor deposition or the like. The spacer layer 170 is made of a polyimide resin, which is formed by etching or the like. As the electrode layer 140, when a material high in resistance to corrosion is used, the insulating layer 150 is not particularly required. In Fig. 3, reference numeral 110 is an element for composing the

voltage converting circuit 10 or the like formed in the semiconductor chip 100.

**[0054]** On the insulating film 150, a spacer layer 170 of a nearly ring shape is formed as shown in Fig. 6. In the spacer layer 170, a cut-off line 171 is formed as shown in the drawing. A space 180 and a back compartment 350 communicate with each other through the cut-off line 171 of the spacer layer 170 and a communication passage 360 (see Fig. 3).

**[0055]** As shown in Fig. 3, of the surface of the semiconductor chip 100, in the portion not laminated with the insulating layer 130 and others, electrodes 191 (only one shown in the drawing, corresponding to grounding voltage terminal GND, output terminal Vout, and supply voltage terminal Vdd) are formed, and these electrodes are electrically connected to the grounding pad 312G, signal output pad 312E, and power source pad 312F formed in the case main body 310 by using bonding wire 190 and others.

**[0056]** The diaphragm 200 is a high polymer electret FEP film 210 forming an electrode film 220 on one side as shown in Fig. 2. A nickel layer is evaporated in a thickness of about 400Å on the surface of the high polymer FEP film 210 of 5 μm to 12.5 μm in thickness, and the electrode film 220 is formed. The side not forming the electrode film 220, that is, the back side is polarized by corona irradiation or EB irradiation, and the electric charge is semipermanently charged in the high polymer FEP film 210, so that an electret is obtained.

**[0057]** Incidentally, as the electrode 220, aluminum may be evaporated in a thickness of about 40 nm (400Å), an insulating coat of polyimide or the like may be laminated to reinforce the environmental resistance. Alternatively, aluminum and nickel may be evaporated.

**[0058]** Such diaphragm 200 is fitted to the ring 230 of brass or stainless steel. The electrode film 220 on the diaphragm 200 is grounded through the grounding conductive layers such as the ring 230, lid 320 of the case 300, and case main body 310. The ring 230, lid 320, and case main body 310 are conductive to each other through a conductive adhesive material.

**[0059]** In the semiconductor electret condenser microphone having such structure, a capacitor is composed of the diaphragm 200 and electrode layer 140, and by making use of the change of capacity of the capacitor by vibration of the diaphragm 200, the voice is converted into a voice signal α. For amplifying the voice signal α, the semiconductor amplifying circuit in Fig. 1 or Fig. 2 is used. As compared with the electret condenser microphone shown in Fig. 10, the number of parts is smaller and the size is reduced, among other merits.

**[0060]** The semiconductor electret condenser microphone shown in Fig. 3 to Fig. 7 was placed in a PW (parallel wired) cell, the voice signal γ issued from the semiconductor amplifying circuit shown in Fig. 2 was measured by an FET analyzer in a 400 Hz burst electric field of 900 MHz and about 10 V/m (in continu-

ous wave). The graph of Fig. 9 (A) shows the measured result of the circuit. Fig. 9 (B) shows the measured result of the semiconductor amplifying circuit shown in Fig. 11 by using the same microphone. Similar characteristics were obtained also in the semiconductor amplifying circuit shown in Fig. 1.

**[0061]** In the conventional semiconductor amplifying circuit shown in Fig. 11, evident peaks were observed at 400 Hz and its higher harmonics. By fitting an external capacitor of 35 pF, the noise was not reduced. On the other hand, in the semiconductor amplifying circuit of the invention shown in Fig. 8, such noise peak was not detected. Similar results were obtained if measured in the 400 Hz burst electric field of 1900 MHz and about 10 V/m (in continuous wave). Hence, it was proved by experiment that no problem about RF burst noise occurs not only in the portable telephone but also in the PHS application.

**[0062]** The semiconductor amplifying circuit of the invention is applied not only in the semiconductor electret condenser microphone, but also in other uses. The voltage converting circuit and amplifying circuit are not limited in a specific circuit constitution as far as the same function is exhibited.

**[0063]** In the semiconductor electret condenser microphone of the invention, the capacitor is formed of diaphragm and back electrode, and the voice is converted into a voice signal by making use of the change of capacity of the capacitor by vibration of the diaphragm, and this signal is amplified, and any other constitution may be similarly applied as far as the same principle is exhibited.

**[0064]** In the semiconductor amplifying circuit of the invention, the voltage converting circuit for converting a weak input signal into a voltage signal, and the amplifying circuit for amplifying this voltage signal are formed in one same semiconductor chip, and therefore the signal input terminal of the amplifying circuit is concealed in the semiconductor chip, and burst noise hardly gets into the amplifying circuit. That is, since the amplifying circuit is resistant to effects of burst noise, it is a great merit for reducing the noise.

**[0065]** In the case of the semiconductor amplifying circuit of the invention, since the voltage converting circuit includes a junction type or MOS type FET of which source is grounded and gate receives the weak signal, and a resistance connected between the drain of the FET and a power source line for converting the drain current of the FET into a voltage and issuing as a voltage signal, if burst noise gets into the power source line or the like, the burst noise entering the amplifying circuit is small, and it is further resistant to effects of burst noise.

**[0066]** Further, in the case of the semiconductor amplifying circuit of the invention, since the gain adjusting circuit for adjusting the gain of the amplifying circuit from outside is provided, dispersion of characteristics of the voltage converting circuit can be absorbed by the

gain adjustment of the amplifying circuit. This is a great merit since the circuit can be adjusted easily.

**[0067]** In the case of the semiconductor amplifying circuit of the invention, moreover, since the capacitance for protection from surge formed by using a transistor is provided between the output of the amplifying circuit and the power source line and/or grounding line, if a large burst component appears in the output of the amplifying circuit due to effects of burst noise, it can be blocked by the capacitance. That is, without using an external capacitor, the noise can be reduced, the circuit of low noise can be obtained at low cost.

**[0068]** In the case of the semiconductor electret condenser microphone of the invention, since the semiconductor amplifying circuit mentioned above is used for amplifying the voice signal, the same merits as in the circuit mentioned above are obtained, and it is a great benefit for reducing the noise and lowering the cost.

## INDUSTRIAL APPLICABILITY

**[0069]** The semiconductor amplifying circuit and semiconductor electret condenser microphone of the invention can be used in the microphone of portable telephone and the like.

## Claims

1. A semiconductor amplifying circuit for amplifying and issuing a weak signal, comprising a voltage converting circuit for receiving the weak signal and issuing this signal as a voltage signal, and an amplifying circuit for receiving the voltage signal issued from the voltage converting circuit, and amplifying and issuing this signal, wherein the voltage converting circuit and amplifying circuit are formed in a same semiconductor chip.
2. The semiconductor amplifying circuit of claim 1, wherein said voltage converting circuit includes a junction type or MOS type FET of which source is grounded and gate receives said weak signal, and a resistance connected between the drain of the FET and a power source line for converting the drain current of the FET into a voltage and issuing as a voltage signal.
3. The semiconductor amplifying circuit of claim 1, wherein said voltage converting circuit includes a junction type or MOS type first FET for receiving said weak signal at its gate with its source being grounded, a second FET having the source and drain connected between the drain of the first FET and a power source line for issuing the source voltage as a voltage signal, and a reference voltage generating circuit for receiving the supply voltage on the power source line, generating a reference voltage, and issuing to the gate of the second FET.

4. The semiconductor amplifying circuit of claim 1, wherein said amplifying circuit includes a gain adjusting circuit for adjusting the gain of this circuit from outside.

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5. The semiconductor amplifying circuit of claim 1, wherein a capacitance for protection from surge formed by using a transistor is provided between the output of the amplifying circuit and the power source line and/or grounding line.

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6. A semiconductor electret condenser microphone wherein a capacitor is formed of a diaphragm and a back electrode, the voice is converted into a voice signal by making use of the change of capacity of the capacitor by vibration of the diaphragm, and this signal is amplified and issued, and the semiconductor amplifying circuit in any one of claims 1, 2, 3, 4 and 5 is used for amplifying said voice signal.

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7. The semiconductor electret condenser microphone of claim 6, wherein an electrode layer functioning as said back electrode is provided at the upper side of a semiconductor chip in which said semiconductor amplifying circuit is formed.

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Fig. 1

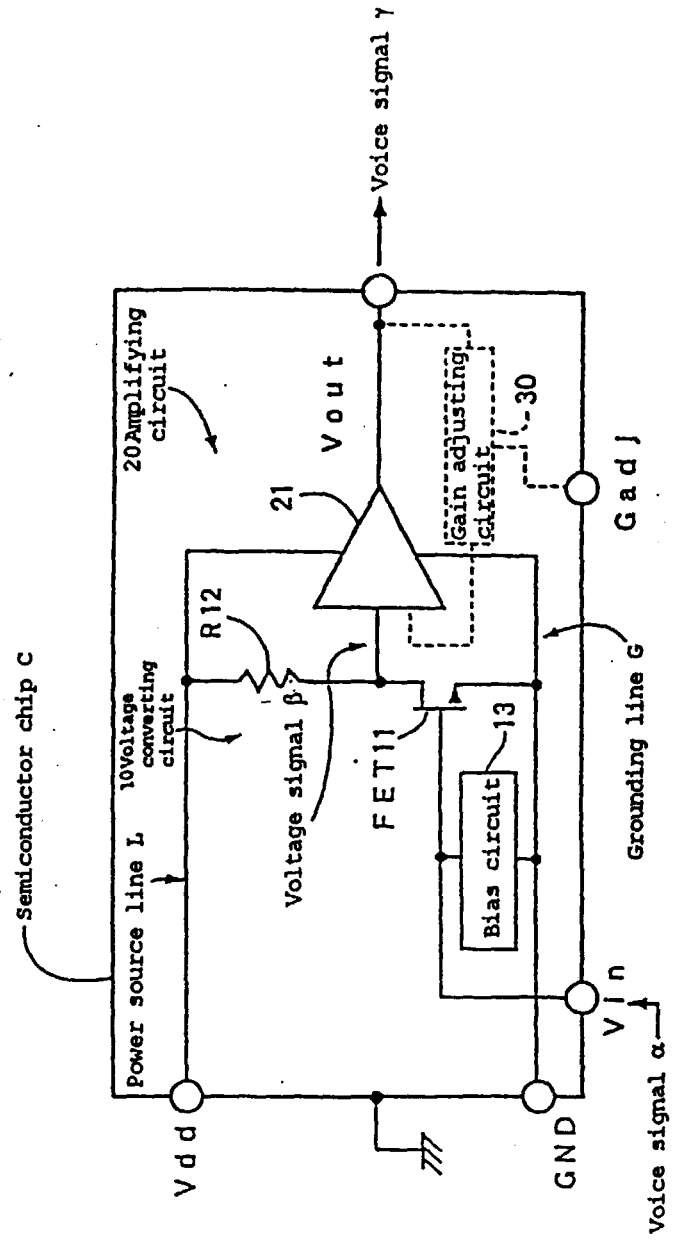


Fig. 2

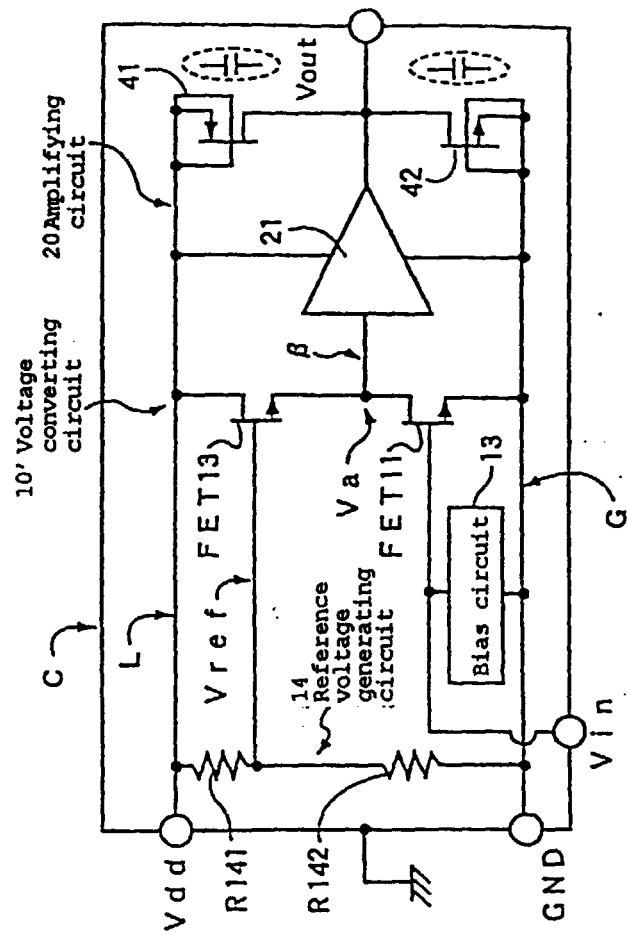


Fig. 3

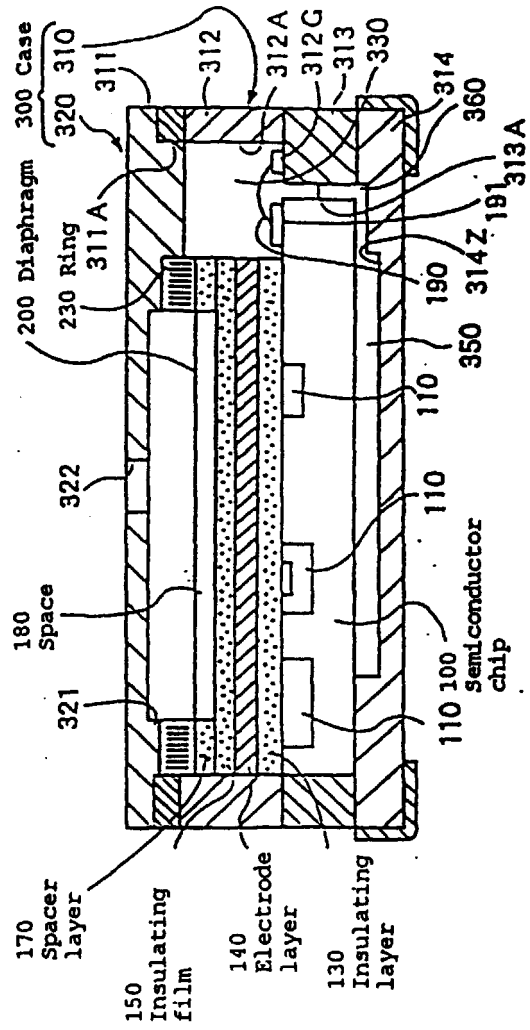


Fig. 4

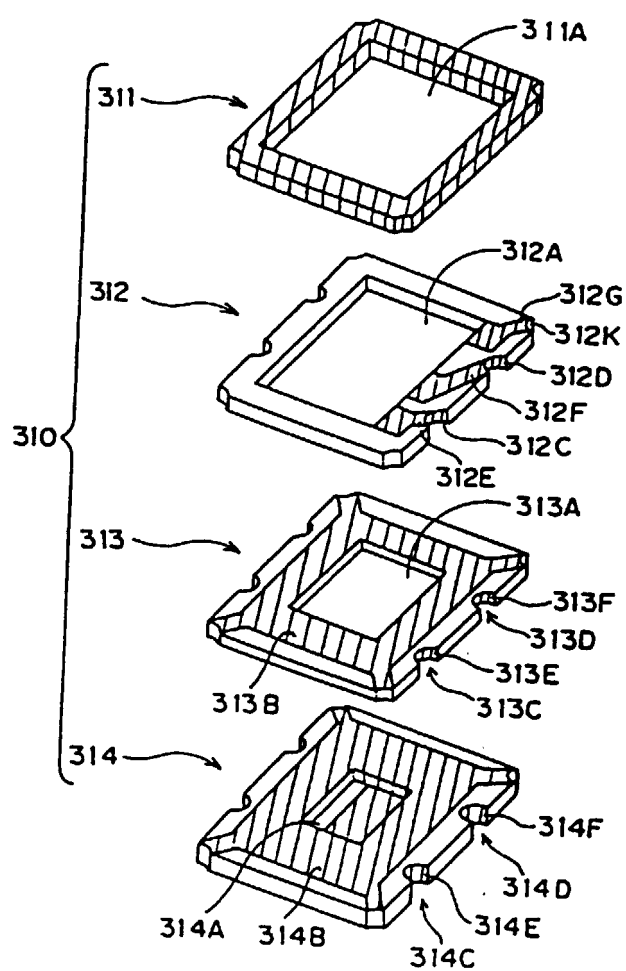


Fig. 5

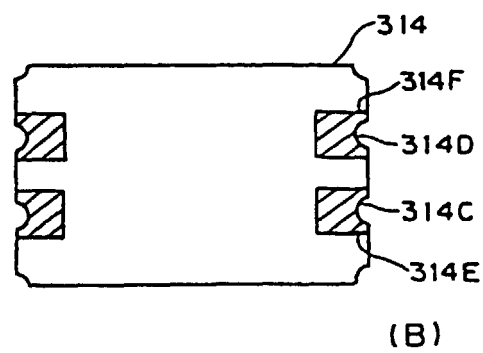
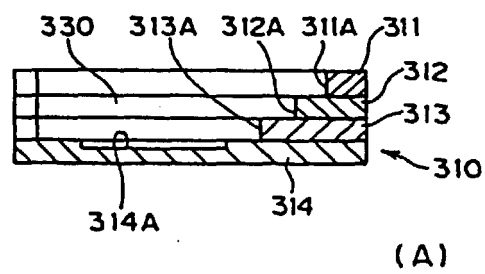


Fig. 6

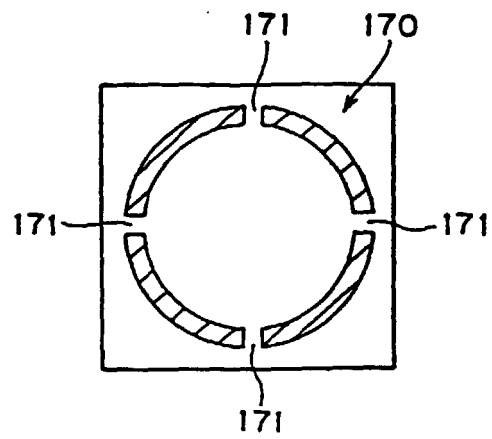


Fig. 7

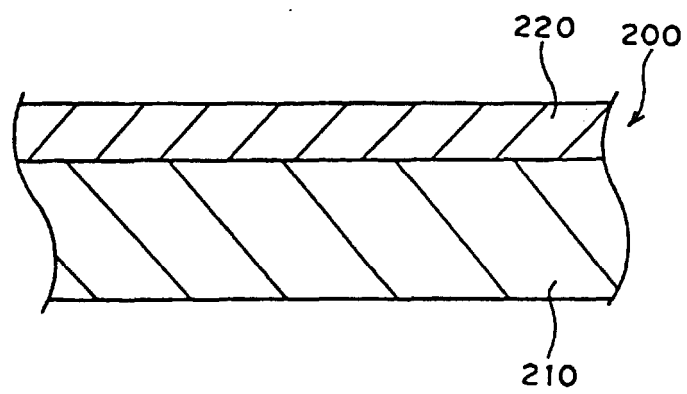


Fig. 8

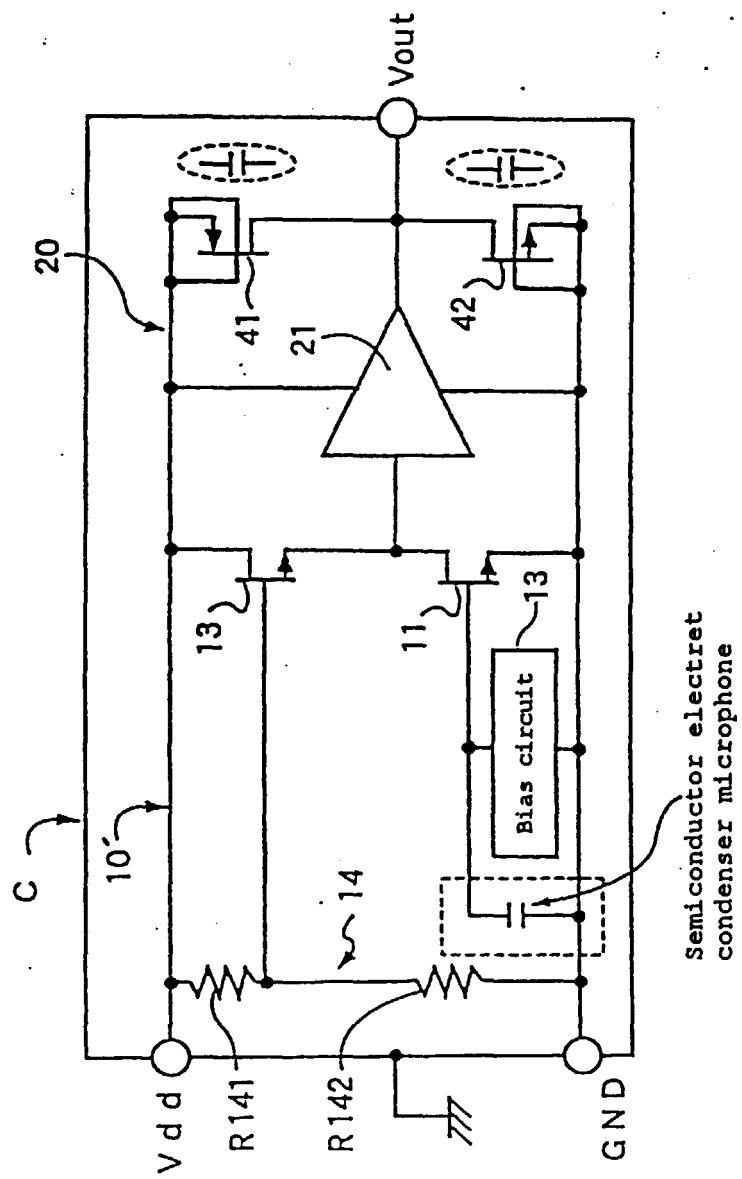
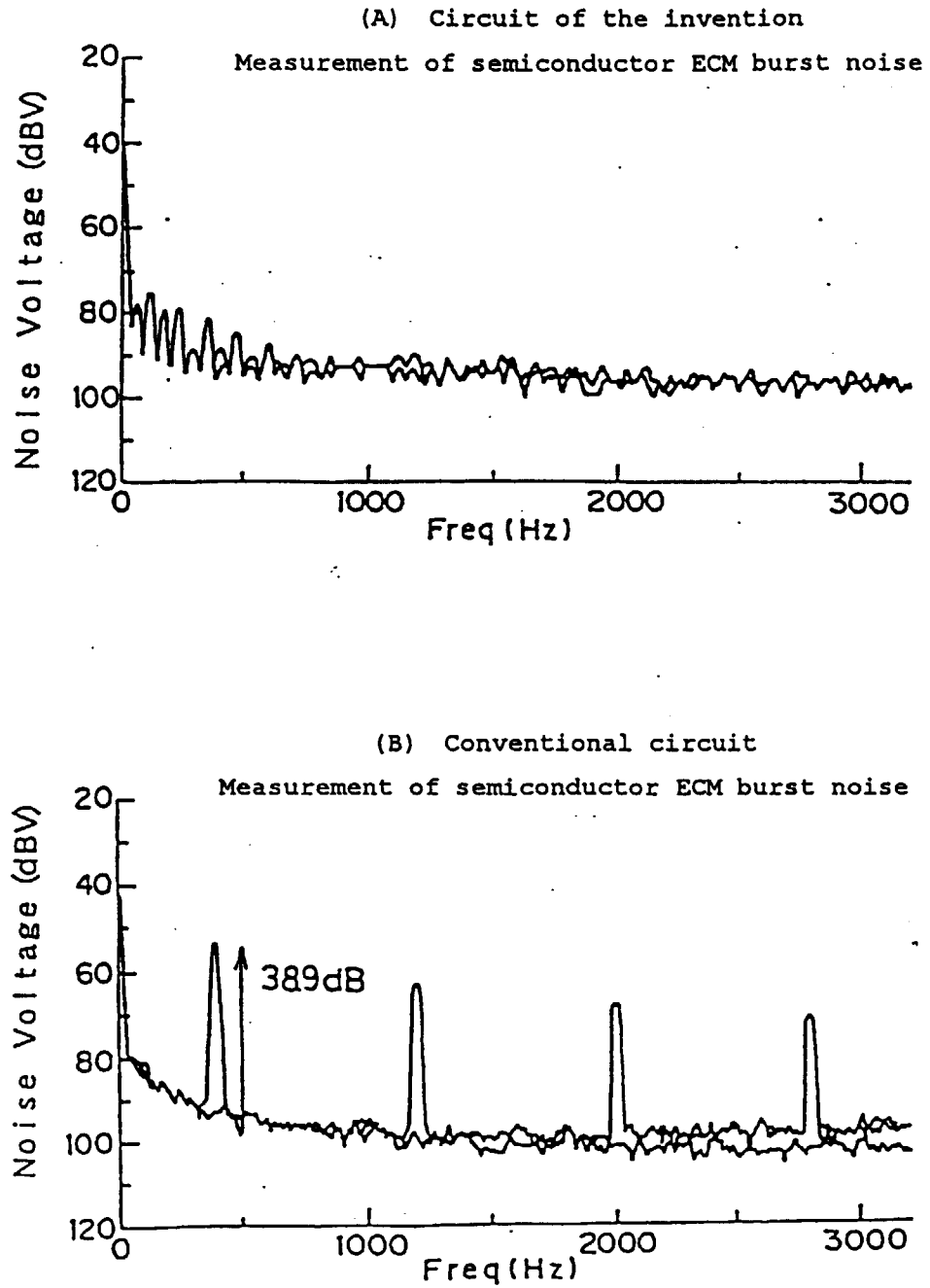




Fig. 9



F i g. 10

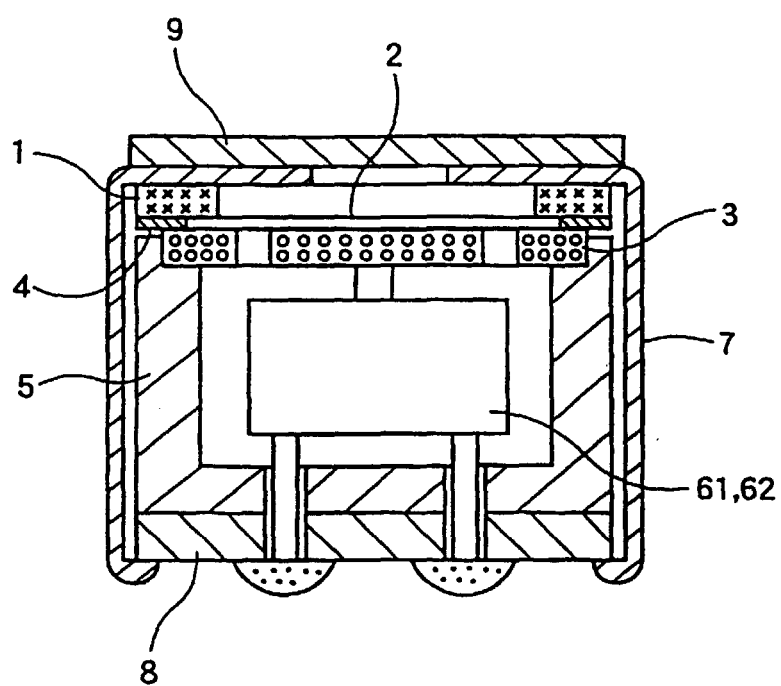


Fig. 11

