



REPLACED SHEETS SG

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BACKGROUND OF THE INVENTION

The present invention generally relates to non-reciprocal circuit elements and a method of manufacturing them, and more particularly, the improved construction of non-reciprocal circuit elements to be adopted as high-frequency parts of a microwave band such as isolators, circulators, and a method of manufacturing them.

Generally, non-reciprocal circuit elements such as isolators, circulators or the like have such a function as the attenuation is hardly effected in the transmission direction of signals, and the attenuation becomes larger in an opposite direction to it. The non-reciprocal circuit elements are adopted in a transmission circuit portion of a mobile transmission appliance such as portable telephone, automobile telephone or the like to be used in, for example, a UHF band. Non-reciprocal circuit elements to be adopted in the mobile communication appliance is demanded to be smaller in size and lighter in weight, considering the uses thereof. Conventionally the methods of intensively disposing central electrodes and matching circuits on one basic plate are variably proposed. The construction of such a non-reciprocal circuit element will be described hereinafter.

(1) First Prior Art

Fig. 56 and Fig. 57 are views showing the construction in a first example (hereinafter referred to as a first prior art) of the conventional circulator. Especially,



Fig. 56 is a perspective view of the essential portions thereof, and Fig. 57 is a sectional view thereof. Three sets of central electrodes 2a, 2b are disposed at given angle intervals so that they may not come into contact against one another, and may not cross with respect to one another, as shown in Fig. 56, on the surface of the dielectric basic plate 1 of ceramic or the like. Three sets of central electrodes 2c, 2d are disposed at given angle intervals, so that they may not come into contact against one another, and may not cross with respect to one another similarly, on the reverse face of the dielectric basic plate 1 of ceramic. The respective central electrodes 2a, 2b are respectively connected with the respective central electrodes 2c, 2d of the reverse face corresponding through a through hole 5. Three capacity electrodes 3 are formed integrally with the central electrodes 2a, 2b around the respective central electrodes 2a, 2b on the surface of the dielectric basic plate 1. An earthing electrode 4 is formed integrally with the central electrodes 2c, 2d around the respective central electrodes 2c, 2d on the reverse face of the dielectric basic plate 1. The respective capacity electrodes 3 become opposite to the earthing electrode 4 with the dielectric basic plate 1 being existed between them so as to constitute a capacitor for matching circuit use.

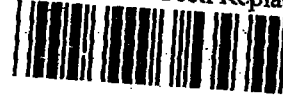
As shown in Fig. 57, the dielectric basic plate 1



is accommodated into the interior of a metallic made yoke 7. An earth plate 8 is disposed in the lower portion of the dielectric basic plate 1 in contact with the earth electrode 4 on the reverse face of the dielectric basic plate 1. An
5 concave portion is provided in the central portion of the earth plate 8 with a ferrite plate 6 being engaged into the concave portion. The ferrite plate 6 is positioned in the lower portion of the respective central electrodes so as to help the inductive coupling of the respective central
10 electrodes. A magnet 9 is fixed onto the inner ceiling face of the yoke 7. The magnet 9 applies a direct current magnetic field with respect to each of the central electrodes.

(2) Second Prior Art

Fig. 58 and Fig. 59 show the construction of a
15 second example (hereinafter referred to as a second prior art) of the conventional circulator. Especially, Fig. 58 is a perspective view of the essential portions thereof, and Fig. 59 is a sectional view thereof. An earth electrode 4 is formed as shown in Fig. 58 on the reverse face of an dielec-
20 tric basic plate 1 such as ceramic or the like. Three electrode film of pattern shapes 10 and two insulating sheets 11 are alternately formed by the repetition of printing and co-firing operations to be sintered on the surface of the dielectric basic plate 1. Each of the electrode films of
25 pattern shapes 10 has a central electrode portion 20 and a



capacity electrode portion 30. One end of each of the central
central electrodes 20 is connected with the earth electrode
4 on the reverse face respectively through a through hole 5.
Each of the capacity electrode portions 30 is opposite to the
5 earth electrode 4 with the dielectric basic plate 1 being
existed therebetween so as to constitute a capacitor for
matching circuit use.

The sectional construction of a second prior art is
similar to the sectional construction of the above described
10 first conventional art as shown in Fig. 59.

(3) Third Prior Art

Fig. 60 and Fig. 61 are views showing the construction of a third example (hereinafter referred to as to
a third prior art) of the conventional circulator. Especially,
15 Fig. 60 is a perspective view of the essential portions thereof, and Fig. 61 is a sectional view thereof. Electrode films of pattern shapes 10a, 10b and 10c are respectively formed by the printing operation on the surfaces of the dielectric basic plates 1a, 1b and 1c of a ceramic or
20 the like. The earth electrodes 4a, 4b and 4c are respectively formed by the printing operation on the reverse face of the dielectric basic plates 1a, 1b and 1c. The electrode films of pattern shapes 10a, 10b and 10c respectively include central electrode portions 20a, 20b and 20c, capacity
25 electrode portions 30a, 30b and 30c, earth electrode portions

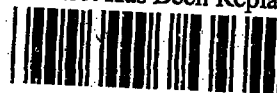


40a, 40b and 40c. The dielectric electrode basic plates 1a, 1b and 1c are individually fired, and thereafter are adhered under pressure into a multi-layer basic plate. The earth electrode portions 40a, 40b, 40c, and earth electrodes 4a, 4b, 4c are connected with respect to one another through through holes 6. Each of the capacity electrode portions 30a, 30b and 30c respectively become opposite to the earth electrodes 4a, 4b and 4c with the dielectric basic plates 1a, 1b and 1c being existed therebetween so as to constitute a capacitor for matching circuit use.

The sectional construction of a third prior art is almost similar to the sectional construction of the above described first prior art as shown in Fig. 61.

(4) Fourth Conventional Art

Fig. 62 through Fig. 64 are views showing the construction of a fourth example (hereinafter referred to as to a fourth prior art) of the conventional circulator. Especially Fig. 62 is an explosive perspective view seen from the top side thereof. Fig. 63 is an explosive perspective view seen from below. Fig. 64 is a sectional view thereof. Referring now to Fig. 62 through Fig. 64, a central electrode, and a capacitor for matching circuit use and so on are formed on the dielectric basic plate 1' as in the above described first through third prior arts. Input, output terminals 80a, 80b, 80c formed on the surface of the dielectric basic plate



1' are connected with the one side electrode of each capacitor for matching circuit use. The earth terminals 80d, 80e, 80f are connected with the earth electrode 4 formed on the reverse face of the dielectric basic plate 1'. A case 71 composed of resin moldings is selected into an approximately "H" character in sectional shape with a through hole 70a for inserting a magnet 9 being formed in the central portion thereof. A dielectric basic plate 1' is disposed in the lower side concave portion 70c of the case 71. A ferrite plate 6 and an earth plate 8 are disposed further under the dielectric basic plate. A metallic made magnetic yoke 72 is engaged into the upper, lower concave portions 70b, 70c of the case 71 so as to have a magnet 9, a dielectric basic plate 1', a ferrite plate 6 and an earth plate 8 existed therebetween. Thereafter, the magnetic yoke 72 is fixed to the case 71. External connecting terminals 71b, 71c, 71d are formed on the one side side face of the case 71, and external connecting terminals 71a, 71e, 71f are formed on the other-way side face. The respective external connecting terminals 71a through 71f go round onto the reverse face of the case 71 as shown in Fig. 63 and Fig. 64, thereafter, extend through the interior of the case 71 and are exposed onto the ceiling face of the lower side concave portion 70c of the case 71. The input, output terminals 80a through 80c respectively come into contact against the external connecting terminals 71a through 71c.



The earth terminals 80d through 80f respectively come into contact against the external connecting terminals 71d through 71f.

5 According to the construction of the above described fourth prior art, the circulator can be mounted on the eternal circuit basic plate without a bothersome wiring operation. Namely, the respective external connecting terminals 71a through 71f have only to be soldered onto the circuit basic plate with the case 71 being placed on the external circuit
10 basic plate. The fourth prior art is capable of surface mounting operation onto the circuit basic plate in this manner.

The first through fourth prior arts described hereinabove have such various problems as described herein-
15 after.

(1) First Prior Art Problem

a. Through holes are required without fail for a crossing operation so that the respective central electrodes may not be short-circuited with respect to one another, thus resulting
20 in complicated construction and higher cost.

b. Width of the central electrode has to be made narrower in order to prevent the short-circuiting operation among the central electrodes. Therefore, the loss at the central electrode increases, thus resulting in deteriorated electric
25 characteristics.



5 c. The capacity electrodes 3 are disposed around the respective central electrodes 2a, 2b. Area of the capacity electrodes 3 has to be made larger in order to obtain necessary capacity values so that the construction of the whole elements is made larger in size.

10 d. Twice co-firing steps to be sintered, namely, a co-firing step to be sintered of a dielectric basic plate 1, and a co-firing step to be sintered of an electrode printed on the dielectric basic plate 1 are required, thus resulting in complicated manufacturing step and longer manufacturing time..

e. A wiring operation is required between the dielectric basic plate and the circuit basic plate in the mounting operation on the external circuit basic plate, thus resulting in complicated and troublesome mounting operation..

15 (2) Second Prior Art Problem

20 a. Capacity electrode portions 30 are disposed around the respective central electrode portions 20. Area of the capacity electrode portions 30 has to be made larger so as to obtain the necessary capacity value, thus resulting in larger size in the whole element.

b. The co-firing step to be sintered of the respective electrode films of pattern shapes 10 and the respective insulating sheets 11 are repetitively required to be effected, thus resulting in complicated manufacturing step and longer manufacturing time.

25



c. A wiring operation is required between the dielectric basic plate and the circuit basic plate in the mounting operation on the external circuit basic plate, thus resulting in complicated and troublesome mounting operation.

5 (3) Third Prior Art Problem

a. The capacity electrodes 30a through 30c are disposed around the respective central electrodes 20a through 20c. Area of the capacity electrodes 30a through 30c has to be made larger in order to obtain the necessary capacity value so that
10 the construction of the whole element is made larger in size.

b. The co-firing step to be sintered for each of the respective dielectric basic plates 1a through 1c is repetitively required to be effected, thus resulting in complicated manufacturing step and longer manufacturing time.

15 c. Connecting locations are so more that reliability is inferior.

d. It is difficult to make thinner each of the dielectric basic plates 1a through 1c. Therefore, the thickness of the whole element becomes larger and the intervals between the
20 central electrodes located on the lower layer and the upper layer become too far, so that the mutual electric equivalent property (balance) of the central electrodes are deteriorated.

e. A wiring operation is required between the dielectric basic plate and the circuit basic plate in the mounting
25 operation of non-reciprocal circuit element on the external



circuit basic plate, thus resulting in complicated and troublesome mounting operation.

(4) Fourth Prior Art Problems

5 a. Similar problems to the above described first through third prior arts are caused due to the construction of the dielectric basic plate 1' and the respective electrode films of pattern shapes to be formed on it.

10 b. Although such troublesome wiring operation as in the first through third prior arts becomes unnecessary because of possible surface mounting, the input, output terminals 80a through 80f on the dielectric basic plate 1' have to be soldered to the external connecting terminals 71a through 71f of the case 71 so as to increase the assembling steps, thus becoming higher in cost. As there is a risk of disengaging
15 the soldered portions or melting them with heating, the reliability is lowered.

c. As the number of the parts is more, the elements become larger in size, thus becoming higher in price.

SUMMARY OF THE INVENTION

20 Accordingly, the present invention has been developed with a view to substantially eliminating the above discussed problems provided in the above described first through fourth prior arts, and has for its essential object to provide improved non-reciprocal circuit elements.

25 Another important object of the present invention:



is to provide improved non-reciprocal circuit elements which are smaller in size, lower in price, higher in reliability and easier to manufacture, and a method of manufacturing them.

5 In accomplishing these and other objects, according to one preferred embodiment of the present invention, there is provided a non-reciprocal circuit element which is extremely small in attenuation degree in the transmission direction of the signal, and extremely larger in attenuation degree in a direction opposite to it. A plurality of
10 electrode films of pattern shapes are disposed in lamination within one dielectric basic plate, so that internal circuits are disposed with microwave.

In such construction, the smaller size and higher performance of the whole element are designed by the lami-
15 nating disposition of a plurality of electrode films of pattern shapes within one dielectric basic plate. Namely, as the internal circuit disposed conventionally in plane can be disposed with microwave within the dielectric basic plate, the circuit area of the whole element can be made smaller. As the
20 respective electrode films of pattern shapes can be crossed without mutual contact within the interior of the dielectric basic plate, the insertion loss can be reduced without requirement of the narrower central electrode width as in the first prior art. As the construction is integral, suf-
25 ficiently larger strength can be retained even if the



arrangement is made with the intervals among the respective electrode films of pattern shapes are made extremely close. As a result, the electric symmetrical property among the respective central electrodes can be maintained in better condition.

The present invention is characterized in that the electrode pattern includes one central electrode pattern or more, one capacitor electrode pattern or more, one earth electrode pattern or more, and in the interior of the dielectric basic plate, the capacitor electrode films of pattern shapes and the earth electrode films of pattern shapes are alternately disposed with dielectrics being existed among them, the respective capacitor electrode films of pattern shapes are connected in common and connected with the corresponding central electrode films of pattern shapes, and the respective earth electrode films of pattern shapes are connected in common, so that one matching circuit capacity or more are disposed in lamination between the central electrode films of pattern shapes and the earth electrode films of pattern shapes.

In such construction, the capacitor electrode films of pattern shapes and the earth electrode films of pattern shapes are alternately disposed with dielectrics being inserted therebetween, the respective capacitor electrode films of pattern shapes are connected in common and are



connected with the corresponding central electrodes films of pattern shapes, further one matching circuit capacitor or more are disposed in lamination between the central electrode films of pattern shapes and the earth electrode films of pattern shapes by the common connection between the respective earth electrode films of pattern shapes. Capacity value necessary as the matching circuit can be retained with smaller circuit area so that the smaller size of the whole element can be designed.

The present invention is a non-reciprocal circuit element which is extremely small in attenuation degree in the transmission direction of the signals and extremely large in attenuation degree in a direction opposite to it. The non-reciprocal circuit element comprises one dielectric basic plate to be formed by the integration of a plurality of fired dielectric green seats adhered under pressure in lamination, a plurality of electrode films of pattern shapes to be formed by the co-firing to be sintered with the dielectric green sheets and to be disposed in lamination within the dielectric basic plate, a plurality of external connecting terminals to be formed by the co-firing to be sintered with the dielectric green sheet, to be connected with the given electrode films of pattern shapes and to be disposed so that an exposing operation is effected on the outer periphery of the dielectric basic plate, whereby the internal circuit and the external



connecting terminals to be connected with it become integrated with the dielectric basic plate and become disposed with microwave.

5 In such construction, a plurality of external
connecting terminals connected with a plurality of electrode
films of pattern shapes disposed in lamination and a plurality
of external connecting terminals connected with the given
electrode films of pattern shapes are fired simultaneously
with a plurality of dielectric green sheets pressed under
10 pressure in lamination and are integrated with one dielectric
basic plate so as to design smaller size of the elements
lower cost, higher reliability and simplified operation of the
assembling steps. As not only the electrode films of pattern
shapes, but also the external connecting terminals are also
15 integrated on one dielectric basic plate, the number of the
parts can be considerably reduced and the smaller size of the
element can be made. As the number of assembling steps is
reduced, the cost can be lowered. As the connecting location
with the soldering operations can be considerably reduced, the
20 reliability can be improved. As the internal circuit
conventionally disposed in plane can be disposed with
microwave within the dielectric basic plate, the circuit area
of the whole element can be reduced. As the respective
electrode films of pattern shapes can be crossed without
25 mutual contacting within the dielectric basic plate, the



insertion loss can be reduced without narrower width of the central electrode as in the first conventional art. As the construction is integral, sufficiently larger strength can be retained even if the arrangement is made with the intervals among the respective electrode films of pattern shapes are made extremely close. As a result, the electric symmetrical property among the respective central electrodes can be maintained in better condition. As the dielectric basic plate, the respective electrode films of pattern shapes, and the respective external connecting terminals are formed at the same time in one co-firing step to be sintered, the manufacturing time can be considerably shortened.

The present invention is characterized in that a dielectric basic plate has one side main surface and the other-way main surface. A first concave portion for engaging a magnet for direct current magnetic field applying use is formed on the one side main surface.

In such construction, a compacter non-reciprocal circuit element is provided by the formation of a first concave portion for engaging a magnet for direct current magnetic field applying use on one side main surface of the dielectric basic plate.

The present invention has characteristics in that a dielectric basic plate has one side main surface and the other-way main surface. A second concave portion for engaging



a ferrite plate for inductive coupling of the inner circuit is formed in the other main surface.

5 In such construction, a second concave portion for engagement of the inductive coupling ferrite plate of the internal circuit is formed in the other-way main surface of the dielectric basic plate so that a non-reciprocal circuit element which is compacter and lower in price can be obtained.

10 The present invention is a method of manufacturing non-reciprocal circuit elements which are extremely smaller in attenuation degree in the transmitting direction of the signal and extremely larger in attenuation degree in a direction opposite to it. This method comprises steps of a laminating step of adhering under pressure in lamination a plurality of dielectric green sheets with given electrode
15 films of pattern shapes being formed respectively on them so as to obtain the green sheet laminating bodies, a co-firing step to be sintered of co-firing to be sintered the green sheet laminating bodies so as to integrate one dielectric basic plate. A non-reciprocal circuit element is obtained
20 with inner circuits being disposed in lamination with microwave within one dielectric basic plate.

In such construction, a plurality of dielectric green sheets with given electrode films of pattern shapes being formed on each of them are fired collectively after
25 being adhered under pressure in lamination so as to be



integrated in one dielectric basic plate. As the dielectric basic plate and the internal circuit are simultaneously formed by one co-firing step to be sintered, the manufacturing time can be considerably reduced.

5 The present invention is characterized in that the central electrodes and the dielectric basic plates are formed in the same time by one co-firing step to be sintered.

10 In such construction, the central electrodes and the dielectric basic plates are formed at the same time by one co-firing step to be sintered.

15 The present invention is characterized in that the central electrode, a matching circuit to be connected with it, a dielectric basic plate are formed at the same time by one co-firing step to be sintered. In such construction, a central electrode, a matching circuit to be connected to it, a dielectric basic plate are formed at the same time by one co-firing step to be sintered.

BRIEF DESCRIPTION OF THE DRAWINGS

20 These and other objects and features of the present invention will become apparent from the following description taken in conjunction with the preferred embodiment thereof with reference to the accompanying drawings, in which;

25 Fig. 1 is a perspective view of the essential portions of a circulator in accordance with a first embodiment of the present invention;



Fig. 2 is a sectional view of a circulator in accordance with the first embodiment of the present invention;

Fig. 3 shows illustrating views for illustrating the manufacturing step of a dielectric basic plate to be used in one embodiment of the present invention, showing the condition of a ceramic green sheet before the lamination and co-firing operations to be sintered;

Fig. 4 is a top face view of a first ceramic green sheet;

Fig. 5 is a top face view of a second ceramic green sheet;

Fig. 6 is a top face view of a third ceramic green sheet;

Fig. 7 is a top face view of a fourth ceramic green sheet;

Fig. 8 is a top face view of a fifth ceramic green sheet;

Fig. 9 is a top face view of a sixth ceramic green sheet;

Fig. 10 is a top face view of a seventh ceramic green sheet;

Fig. 11 is a top face view of an eighth ceramic green sheet;

Fig. 12 is a top face view of a ninth ceramic green sheet;



Fig. 13 is a top face view of a tenth ceramic green sheet;

Fig. 14 is a top face view of an eleventh ceramic green sheet;

5 Fig. 15 is a top face view of a twelfth ceramic green sheet;

Fig. 16 is a top face view of a thirteenth ceramic green sheet;

10 Fig. 17 is a top face view of a fourteenth ceramic green sheet;

Fig. 18 is a bottom face view of the fourteenth ceramic green sheet;

15 Fig. 19 is an explosive perspective view of a circulator in accordance with a second embodiment of the present invention;

Fig. 20 is a sectional view of a circulator in the second embodiment of the present invention;

20 Fig. 21 is a perspective view of the essential portions of a circulator in accordance with a third embodiment of the present invention;

Fig. 22 is a sectional view of a circulator in accordance with a third embodiment of the present invention;

25 Fig. 23 shows illustrating views for illustrating a manufacturing step of a dielectric basic plate to be used in the third embodiment of the present invention, showing the



laminating relation of the ceramic green sheet before the co-firing operation to be sintered;

Fig. 24 is a top face view of a first ceramic green sheet;

5 Fig. 25 is a top face view of a second ceramic green sheet;

Fig. 26 is a top face view of a third ceramic green sheet;

10 Fig. 27 is a top face view of a fourth ceramic green sheet;

Fig. 28 is a top face view of a fifth ceramic green sheet;

Fig. 29 is a top face view of a sixth ceramic green sheet;

15 Fig. 30 is a top face view of a seventh ceramic green sheet;

Fig. 31 is a top face view of an eighth ceramic green sheet;

20 Fig. 32 is a top face view of a ninth ceramic green sheet;

Fig. 33 is a top face view of a tenth ceramic green sheet;

Fig. 34 is a top face view of an eleventh ceramic greens sheet;

25 Fig. 35 is a top face view of a twelfth ceramic

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green sheet;

Fig. 36 is a top face view of a thirteenth ceramic green sheet;

Fig. 37 is a top face view of a fourteenth ceramic green sheet;

5

Fig. 38 is a top face view of a fifteenth ceramic green sheet;

Fig. 39 is a top face view of a sixteenth ceramic green sheet;

10

Fig. 40 is a top face view of a seventh ceramic green sheet;

Fig. 41 is a top face view of an eighteenth ceramic green sheet;

Fig. 42 is a top face view of a nineteenth ceramic green sheet;

15

Fig. 43 is as top face view of a twentieth ceramic green sheet;

Fig. 44 is a top face view of a twenty first ceramic green sheet;

20

Fig. 45 is a top face view of a twenty second ceramic green sheet;

Fig. 46 is a top face view of a twenty third ceramic green sheet;

25

Fig. 47 is a top face view of a twenty fourth ceramic green sheet;



Fig. 48 is a top face view of a twenty fifth ceramic green sheet;

Fig. 49 is a top face view of a twenty sixth ceramic green sheet;

5 Fig. 50 is a top face view of a twenty seventh ceramic green sheet;

Fig. 51 is a top face view of a twenty eighth ceramic green sheet;

10 Fig. 52 is a top face view of a twenty ninth ceramic green sheet;

Fig. 53 is a top face view of a thirty ceramic green sheet;

Fig. 54 is a top face view of a thirty first ceramic green sheet;

15 Fig. 55 is a top face view of a thirty second ceramic green sheet;

Fig. 56 is a perspective view of the essential portions of a circulator in accordance with a first conventional art;

20 Fig. 57 is a sectional view of a circulator in accordance with the first conventional art;

Fig. 58 is an explosive perspective view of the essential portions of a circulator in accordance with a second conventional art;

25 Fig. 59 is a sectional view of a circulator in



accordance with the second conventional art;

Fig. 60 is a perspective view of the essential portions of a circulator in accordance with a third conventional art;

5 Fig. 61 is a sectional view of a circulator in accordance with the third conventional art;

Fig. 62 is an explosive perspective view of the essential portions seen from the top side of a circulator in accordance with a fourth conventional art;

10 Fig. 63 is an explosive perspective view seen from the reverse side of a circulator in accordance with the fourth conventional art; and

Fig. 64 is a sectional view of a circulator in accordance with the fourth conventional art.

15 DETAILED DESCRIPTION OF THE INVENTION

Before the description of the present invention proceeds, it is to be noted that like parts are designated by like reference numerals throughout the accompanying drawings.
(First Embodiment)

20 Fig. 1 through Fig. 18 are views showing the construction of a circulator in accordance with a first embodiment of the present invention. Especially Fig. 1 is a perspective view of the essential portions of a circulator. Fig. 2 is a sectional view of a circulator. Fig. 3 is a
25 perspective view for illustrating a manufacturing step of a



dielectric basic plate. Fig. 4 through Fig. 18 are plan views showing an electrode pattern in each ceramic green sheet. One embodiment of the present invention will be described hereinafter with reference to these Fig. 1 through Fig. 18.

5 As shown in Fig. 1 and Fig. 2, a dielectric basic plate 100 is accommodated in the interior of a metallic made yoke 7. An earth plate 8 is disposed under the dielectric basic plate 100, with the earth plate 8 being in contact against the earth electrode 4 on the reverse face of the
10 dielectric basic plate 100. A concave portion is provided in the central portion of the earth plate 8, with a ferrite plate 6 being engaged into the concave portion. The ferrite plate 6 is positioned in the lower portion of each central electrode so as to help the inductive coupling of each central elec-
15 trode. A magnet 9 is secured to the internal ceiling face of the yoke 7. The magnet 9 applies a direct current magnetic field with respect to each central electrode.

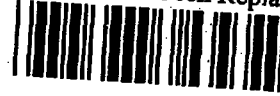
 The above described dielectric basic plate 100 is collectively fired and composed as shown in Fig. 3 after a
20 plurality of ceramic green sheets 101 through 114 with given electrode films of pattern shapes being formed respectively on them are laminated, and adhered under pressure. The ceramic green sheets are thin type (normally of several 10 μ or so) of sheet shaped member having flexibility to be
25 obtained by, for example, an extrusion molding with ceramic



powder unfired or temporarily fired being mixed, kneaded with an organic solvent which is a binder. A material having Q high in high frequency region and high ϵ_r (for example, $\epsilon_r = 20$ through 100), for example, dielectric material of MgTiO_3 - CaTiO_3 series, ZrO_2 - SnO_2 - TiO_2 series, BaTi_4O_9 series, $\text{Nd}_2\text{Ti}_2\text{O}_7$ - (BaPbTiO_3 - TiO_2 series is used as a ceramic green sheet material. The formation of the respective electrode pattern is formed by, for example, printing, evaporating operations and so on with Pd, Pt and so on in terms of sintering temperature of the dielectric material. The respective ceramic green sheets 101 through 114 are fused, integrated after collective co-firing operation to be sintered into one dielectric basic plate 100.

As shown in Fig. 4, Fig. 6, Fig. 8. Fig. 10, Fig. 12, Fig. 16, earth electrode films of pattern shapes 401, 403, 405, 407, 409, 413 on the same form are formed respectively on the surfaces of the ceramic green sheets 101, 103, 105, 107, 109, 113. As shown in Fig. 18, an earth electrode pattern 414 on the same form as the respective earth electrode films of pattern shapes is formed on the reverse face of the ceramic green sheet 114. As shown in Fig. 5, Fig. 7, Fig. 9, Fig. 11, Fig. 17, capacity electrode films of pattern shapes 302a through 302c, 304a through 304c, 306a through 306c, 308a through 308c, 314a through 314c on the same form are formed respectively on the surfaces of ceramic green sheets 102, 104,

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106, 108, 114.

Electrode films of pattern shapes 710, 711, 712 on approximately the same form are formed respectively on the surfaces of the ceramic green sheets 110, 111, 112. Respective electrode films of pattern shapes 710 through 712 are disposed each being shifted at an angular interval of 120° with respect to one after. The electrode pattern 710 includes a central electrode portion 210, a capacity electrode portion 310, an earth electrode portion 410, a wiring portion 810. The electrode pattern 711 includes a central electrode portion 211, a capacity electrode portion 311, an earth electrode portion 411, a wiring portion 811. An electrode pattern 712 includes a central electrode portion 212, a capacity electrode portion 312, an earth electrode portion 412, a wiring portion 812. Capacity electrode portions 310, 311, 312 are respectively connected with one end of the central electrode portions 210, 211, 212. Earth electrode portions 410, 411, 412 are respectively connected with the other end of the central electrodes 210, 211, 212. Capacity electrode portions 310, 311, 312 are respectively drawn out so far as the end portions of the ceramic green sheets 110, 111, 112 through the wiring portions 810, 811, 812.

Capacity electrode films of pattern shapes 302a, 304a, 306a, 308a, 314a and the capacity electrode portion 310 are connected with each other through a through hole 5a.



Capacity electrode films of pattern shapes 302b, 304b, 306b, 308b, 314b and the capacity electrode portion 311 are connected with each other through a through hole 5b. The capacity electrode films of pattern shapes 302c, 304c, 306c, 308c, 314c and the capacity electrode 312 are connected with each other through a through hole 5c. The earth electrodes films of pattern shapes 401, 403, 405, 407, 409, 413, 414 and the earth electrode portions 410, 411, 412 are connected with each other through through holes 5d, 5e, 5f.

In such construction as described hereinabove, the capacity electrode pattern 302a forms a first capacitor by the opposition between the earth electrode films of pattern shapes 401 and 403. The capacity electrode pattern 304a forms a second capacitor by the opposition between the earth electrode films of pattern shapes 403 and 405. The capacity electrode pattern 306a forms a third capacitor by the opposition between the earth electrode films of pattern shapes 405 and 407. The capacity electrode pattern 308a forms a fourth capacitor by the opposition between the earth electrode films of pattern shapes 407 and 409. Capacity electrode 310 forms a fifth capacitor by the opposition between the earth electrodes portions 409 and 411. The capacity electrode pattern 314a forms a sixth capacitor by the opposition between the earth electrode films of pattern shapes 413 and 414. The first through sixth capacitors for constituting a matching circuit



are connected in parallel between one end of the central electrode portion 210 and the earth, and are inserted. This is because the respective one side electrodes 302a, 304a, 306a, 308a, 310, 314a of the first through sixth capacitors are connected with one end of the central electrode portion 210 in common through a through hole 5a. The respective other-way electrodes 401, 403, 405, 407, 409, 411, 412, 413, 414 of the first through sixth capacitors are commonly connected with the earth through through holes 5d, 5e, 5f. Similarly, six capacitors for matching circuit use are connected in parallel and inserted between the central electrode portion 211 and the earth, and six capacitors for matching circuit use are connected in parallel and are inserted between the central electrode portion 212 and the earth.

As a plurality of capacitors connected in parallel are laminated and disposed between the one end of the respective central electrode portions 210 through 212 and the earth as described hereinabove, the capacity value necessary as the matching circuit can be retained with small circuit area. Accordingly, the construction of the whole element can be made smaller in size. In the above described embodiment, the co-firing operation to be sintered of the dielectric basic plate, the central electrode, the matching circuit can be completed by one co-firing step to be sintered so that the



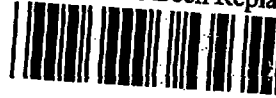
manufacturing step is simplified, and the manufacturing time can be considerably reduced. As a plurality of ceramic green sheet are integrated on one dielectric basic plate 100 by the co-firing operation to be sintered in the above described embodiment, the thickness of the respective ceramic green sheet, namely, the interval among the respective central electrode portions 210 through 212 can be extremely narrowed without strength problem. As a result, the electrical symmetry of the respective central electrode portions 210 through 212 can be made better.

As shown in Fig. 1, side face electrodes 800a, 800b, 800c are formed on the side face of the dielectric basic plate 100. The side face electrode 800a is connected with the wiring portion 810 of Fig. 13, the side face electrode 800b is connected with the wiring portion 811 of Fig. 14, the side face electrode 800c is connected with the wiring portion 812 of Fig. 15. In the respective ceramic green sheets, blank portions 401a, 403a, 405a, 407a, 409a, 411a, 412a, 413a, 414a are formed, on the earth electrode pattern or the earth electrode portion, so as to surround the periphery of the side face electrode 800a. Blank portions 401b, 403b, 405b, 407b, 409b, 410b, 412b, 413b, 414b are formed so as to surround the periphery of the side face electrode 800b. Blank portions 401c, 403c, 405c, 407c, 409c, 410c, 411c, 413c, 414c are formed so as to surround the periphery of the side face



electrode 800c. A blank portion 8a is formed on the earth plate 8 so as to surround the periphery of the side face electrode 800a. A blank portion 8b is formed so as to surround the periphery of the side face electrode 800b. A
5 blank portion 8c is formed so as to surround the periphery of the side face electrode 800c. The short circuiting operation among the respective side face electrodes and the respective earth electrode films of pattern shapes, the respective earth electrode portions and the earth plate 8 are prevented.

10 An operation of a circulator shown in Fig. 1 and Fig. 2 will be described hereinafter. When a high frequency signal is inputted into the side face electrode 800a, a high frequency magnetic field to be caused around the central
15 electrode portion 210 is rotated by a given angle by the direct current magnetic field from the magnet 9 so as to cause an induced current in, for example, the right-hand adjacent central electrode portion 211 by the inductive coupling through the ferrite plate 6. The high frequency signal to be
20 inputted from the side face electrode 800a is transmitted to the right-hand adjacent side face electrode 800b, but is not transmitted to the left-hand adjacent side face electrode 800c. A high frequency signal to be inputted from the side
25 face electrode 800b is transmitted to the right-hand adjacent side face electrode 800c, but is not transmitted to the left-hand adjacent side face electrode 800a. A high frequency



signal to be inputted from the side face electrode 800c is transmitted to the right-hand adjacent side face electrode 800a, but is not transmitted to the left-hand adjacent side face electrode 800b.

5 A circulator shown in Fig. 1 and Fig. 2 can be used as an isolator if a terminal resistor is connected between any one of wiring portions or the side face electrode (for example, a wiring portion 812 or a side face electrode 800c) and the earth. In this case, the isolator transmits a high
10 frequency signal only in one side direction from the remaining one side side face electrode (for example, a side face electrode 800a) to the remaining other-way side face electrode (for example, a side face electrode 800b).

(Second Embodiment)

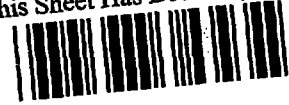
15 Fig. 19 and Fig. 20 shows views each showing the construction of a circulator in accordance with a second embodiment of the present invention. Especially, Fig. 19 is an explosive perspective view of a circulator and Fig. 20 is a sectional view of a circulator. The other embodiment of the
20 present invention will be described hereinafter with reference to Fig. 19 and Fig. 20.

 In the drawings, a dielectric basic plate 100' is collectively fired, integrated after a plurality of ceramic green sheets with given electrode films of pattern shapes
25 being formed respectively on them are adhered under pressure



in lamination as in the dielectric basic plate 100 shown in Fig. 1. The connection among the respective capacity electrode films of pattern shapes and the respective capacity electrode portions in the dielectric basic plate 100' are effected through the side face electrodes 800a through 800c without provision of the through holes. Capacity electrode films of pattern shapes 302a, 304a, 306a, 308a, 314a shown in Fig. 5, Fig. 7, Fig. 9, Fig. 11, Fig. 17 and the capacity electrode portion 310 shown in Fig. 13 are respectively provided with wiring portions, and are composed to be exposed on the side face corresponding to the side face electrode 800a. Similarly, the capacity electrode films of pattern shapes 302b, 304b, 306b, 308b, 314b and the capacity electrode portion 311 shown in Fig. 14 are provided respectively with the wiring portions, and are composed so as to be exposed on the side face corresponding to the side face electrode 800b. The capacity electrode films of pattern shapes 302c, 304c, 306c, 308c, 314c and the capacity electrode portion 312 shown in Fig. 15 are respectively provided with wiring portions, and are composed so as to be exposed on the side face corresponding to the side face electrode 800c. Blank portions are provided so as to surround the peripheries of the side face electrodes 800a through 800c on the earth electrode films of pattern shapes 401, 403, 405, 407, 409, 413, 414 and the earth electrode portions 410, 411, 412 on the dielectric basic plate

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100' so as to prevent the short-circuiting operation among the respective capacity electrode films of pattern shapes and the respective capacity electrode portions.

5 The connections of the earth electrode films of pattern shapes 401, 403, 405, 407, 409, 413, 414 and the earth electrode portions 410, 411, 412 are effected through the side face electrodes 800d through 800f without provision of the through holes as in the connection of the capacity electrode pattern and the capacity electrode. The respective side face
10 electrodes 800a through 800c, and 800d through 800f go round the surface of the dielectric basic plate 100' so as to effect the connections among the input, output terminals 71a through 71c and the connecting terminals 71d through 71f formed on the case 71. The surface electrodes 80a through 80c, and 80d
15 through 80f are formed respectively on the surface of the dielectric basic plate 100'.

 A case 71 composed of resin moldings is selected into approximately "H" character shape in the sectional shape with a through hole 70a for inserting a magnet being formed
20 in the central portion thereof. The dielectric basic plate 100' is disposed in the concave portion 70c on the lower side of the case 71, and further a ferrite plate 6 and an earth plate 8 are disposed under it. A metallic made magnetic yoke 72 is engaged into the upper, lower concave portions 70b, 70c
25 of the case 71 with the magnet 9, the dielectric basic plate



100', the ferrite plate 6 and the earth plate 8 being existed therebetween. Thereafter, the yoke 72 is secured to the case 71.

5 Input, output terminals 71b, 71c and the earth terminal 71d are formed on one side side face of the case 71. An input, output terminal 71a and the earth terminals 71e, 71f are formed on the other-way side face. (In Fig. 19, as the other-way side face of the case 71 is hidden, the input, output terminal 71a and the earth terminals 71e, 71f are not
10 shown.) The respective input, output terminals 71a through 71c and the earth terminals 71d through 71f extend into the interior of the case 71 as shown in Fig. 20 and are exposed to the ceiling face of the concave portion 70c on the lower side of the case 71. The surface electrodes 80a through 80c
15 are respectively in contact with the input, output terminals 71a through 71c. The surface electrodes 80d through 80f are respectively in contact with the earth terminals 71d through 71f.

20 A circulator shown in Fig. 19 and Fig. 20 constructed as described hereinabove functions as in a circulator shown in Fig. 1 and Fig. 2, and can be used as an isolator.

In the embodiment shown in Fig. 19 and Fig. 20, the connections among the respective capacity electrode films of pattern shapes and the respective capacity electrode portions,
25 and the connections among the respective earth electrode films



of pattern shapes and the respective earth electrode portions are designed to be effected with the use of the side face electrode. As in the embodiment shown in Fig. 1 and Fig. 2, these connections can be effected with the through holes.

5 As a plurality of electrode films of pattern shapes are adapted to be disposed in lamination within one dielectric basic plate in accordance with the invention of the above described embodiment, the smaller size and higher performance of the whole element can be intended. As the internal circuit
10 disposed conventionally in plane can be disposed with microwave within the dielectric basic plate, the circuit area of the whole elements can be made smaller in size. As the respective electrode films of pattern shapes can be crossed without mutual contact within the interior of the dielectric
15 basic plate, the insertion loss can be reduced without the requirement of the narrower width of the central electrode. As the construction is integral, sufficiently larger strength can be retained if the interval among the respective electrode films of pattern shapes are extremely narrowed. Therefore,
20 the electric symmetry among the respective central electrodes is retained in a better condition.

 As one capacitor for matching circuit use or more can be disposed in lamination between the central electrode pattern and the earth electrode pattern in accordance with the
25 invention of the above described embodiment, the capacity



value necessary as the matching circuit can be retained in small circuit area and the size of the whole element can be made smaller.

5 As a plurality of dielectric green sheets are fired collectively and are integrated into one dielectric basic plate after a plurality of dielectric green sheets are adhered under pressure in lamination with given electrode films of pattern shapes being formed on them in accordance with the invention of the above described embodiment, the dielectric
10 basic plate and the inner circuit can be formed with one co-firing step to be sintered and the manufacturing time can be considerably shortened.

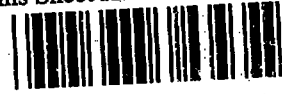
(Third Embodiment)

15 Fig. 21 through Fig. 55 are views showing the construction of a circulator in accordance with one embodiment of the present invention. Especially, Fig. 21 is a perspective view of the essential portions of the circulator. Fig. 22 is a sectional view of the circulator. Fig. 23 is a perspective view showing the lamination relation of the ceramic green sheet before the co-firing operation to be
20 sintered thereof. Fig. 24 through Fig. 55 are plan views showing the electrode films of pattern shapes in the respective ceramic greens sheets. A third embodiment of the present invention will be described with reference to the Fig. 21
25 though Fig. 55.



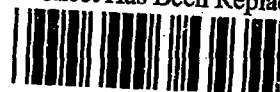
As shown in Fig. 21 and Fig. 22, circular concave portion 2100a is formed in the surface central portion of the dielectric basic plate 2100, and a circular concave portion 2100b is formed in the reverse face central portion. A stage difference concave portion 2100c is formed on the reverse face of the dielectric basic plate 2100. External connecting terminals Ta through Tf are formed on the side face of the dielectric basic plate 2100. A magnet 9 is engaged with the concave portion 2100a, and is secured to the dielectric basic plate 2100 with binding or the like. A ferrite plate 6 is engaged with the concave portion 2100b and is secured to the dielectric basic plate 2100 with bonding or the like. The metallic made magnetic yoke 72 is engaged with the dielectric basic plate 2100 so as to exist the magnet 9 and the ferrite plate 6 therebetween. As the magnetic yoke 72 is engaged into the stage difference concave portion 200c on the reverse face of the dielectric basic plate 200 at this time, the height of the formed portion of the external connecting terminals Ta through Tf becomes higher than the height of the surface of the magnetic yoke 72 on the reverse face of the dielectric basic plate 2100. This makes the surface mounting operation possible to effect onto the circuit basic plate.

The above described dielectric basic plate 200 is collectively fired and composed as shown in Fig. 23 after a plurality of ceramic green sheets 201 through 232a, 232b with



given electrode films of pattern shapes being formed are laminated, and adhered under pressure. The ceramic green sheets are thin type (normally of several 10 μ or so) of sheet shaped member having flexibility to be obtained by, for example, an extrusion molding with ceramic powder unfired or temporarily fired being mixed, kneaded with an organic solvent which is a binder. A material having Q high in high frequency region and high ϵ_r (for example, $\epsilon_r = 20$ through 100), for example, dielectric material of MgTiO_3 - CaTiO_3 series, ZrO_2 - SnO_2 - TiO_2 series, BaTi_4O_9 series, $\text{Nd}_2\text{Ti}_2\text{O}_7$ - $(\text{BaPb})\text{TiO}_3$ - TiO_2 series is used as a ceramic green sheet material. The formation of the respective electrode pattern is formed by, for example, printing, evaporating operations and so on with Pd, Pt and so on in terms of sintering temperature of the dielectric material. The respective ceramic green sheets 201 through 232 are fused, integrated after collective co-firing operation to be sintered into one dielectric basic plate 200.

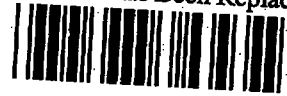
As shown in Fig. 24 through Fig. 29, circular through holes 201a through 206a are formed in the respective central portions in approximately square shaped ceramic green sheets 201 through 206. When the ceramic green sheets 201 through 206 have been laminated, these through holes 201a through 206a form a concave portion 200a for receiving the magnet 9. Or the surface of the ceramic green sheet 201, electrodes Xa, Xd, Xb are formed near the left-hand side, and electrodes Xe, Xc,



Xf are formed near the right-hand side.

As shown in Fig. 30, Fig. 32, Fig. 34, Fig. 36, Fig. 38, Fig. 42, Fig. 44, earth electrode films of pattern shapes 407, 409, 411, 413, 415, 419, 421 on the same shape are formed respectively on the surfaces of the ceramic green sheets 207, 209, 211, 213, 215, 219, 221. As shown in Fig. 31, Fig. 33, Fig. 35, Fig. 37, Fig. 43, capacity electrode films of pattern shapes 308a through 308c, 310a through 310c, 312a through 312c, 314a through 314c, 320a through 320c on the same form are formed respectively on the surfaces of ceramic green sheets 208, 210, 212, 214, 220.

Electrode films of pattern shapes 716, 717, 718 on approximately same form are formed respectively on the surfaces of the ceramic green sheets 216, 217, 218. Respective electrode films of pattern shapes 716 through 718 are disposed each being shifted at an angular interval of 120° with respect to one after. The electrode pattern 716 includes a central electrode portion 216, a capacity electrode portion 316, an earth electrode portion 416, a wiring portion 816. The electrode pattern 717 includes a central electrode portion 217, a capacity electrode portion 317, an earth electrode portion 417, a wiring portion 817. An electrode pattern 718 includes a central electrode portion 218, a capacity electrode portion 318, an earth electrode portion 418, a wiring portion 818. Capacity electrode portions 316, 317, 318 are respec-



tively connected with one end of the central electrode portions 216, 217, 218. Earth electrode portions 416, 417, 418 are respectively connected with the other end of the central electrodes 216, 217, 218. Capacity electrode portions 316, 317, 318 are respectively drawn out so far as the end portions of the ceramic green sheets 216, 217, 218 through wiring portions 816, 817, 818.

Capacity electrode films of pattern shapes 308a, 310a, 312a, 314a, 320a and the capacity electrode portion 317 are connected with each other through a through hole 5a. Capacity electrode films of pattern shapes 308b, 310b, 312b, 314b, 320b and the capacity electrode portion 317 are connected with each other through a through hole 5b. The capacity electrode films of pattern shapes 308c, 310c, 312c, 314c, 320c and the capacity electrode 317 are connected with each other through a through hole 5c. The earth electrode films of pattern shapes 407, 409, 411, 413, 415, 419, 421 and the earth electrode portions 416, 417, 418 are connected with each other through through holes 5d, 5e, 5f.

When such ceramic green sheets 210 through 224 as described hereinabove have been laminated, the capacity electrode pattern 308a forms a first capacitor by opposition between the earth electrode films of pattern shapes 407 and 409. The capacity electrode pattern 310a forms a second capacitor by the opposition between the earth electrode films



of pattern shapes 409 and 411. The capacity electrode pattern 312a forms a third capacitor by the opposition between the earth electrode films of pattern shapes 411 and 413. The capacity electrode pattern 314a forms a fourth capacitor by the opposition between the earth electrode films of pattern shapes 413 and 415. The capacity electrode portion 316 forms a fifth capacitor by the opposition between the earth electrode pattern 415 and the earth electrode portion 417. The capacity electrode pattern 320a forms a sixth capacitor by the opposition between the earth electrode films of pattern shapes 419 and 421. These first through sixth capacitors for composing the matching circuit are connected in parallel between one end of the central electrode portion 216 and the earth, and are inserted. This is because the respective one side electrodes 308a, 310a, 312a, 314a, 316, 320a are connected with one end of the central electrode portion 216 in common through a through hole 5a. The respective other-way electrodes 407, 409, 411, 413, 415, 417, 419, 421 of the first through sixth capacitors are connected with the earth in common through the through holes 5d, 5e, 5f. Similarly, six capacitors for matching circuit use are connected in parallel between the central electrode portion 217 and the earth, and are inserted, and the six capacitors for matching circuit use are connected in parallel between the central electrode portion 218 and the earth, and are interposed. As a plurality



of capacitors connected respectively in parallel are laminated, disposed among one end of the respective central electrode portions 216 through 218 and the earth, capacity value necessary as the matching circuit can be retained with small
5 circuit area. Accordingly, the construction of the whole element can be made smaller in size.

Approximately same shaped earth electrode films of pattern shapes 222 through 226 are formed on the surface of the ceramic green sheets 222 through 225 and the reverse face of
10 the ceramic green sheet 226 as shown in Fig. 45 through Fig. 49. Through holes 222a through 226a are formed in the central portions of the respective ceramic green sheets 222 through 226. The through holes 222a through 226a form the concave portion 200b for receiving the ferrite plate 6 - when the
15 ceramic green sheets 222 through 226 have been laminated. The earth electrode films of pattern shapes 222 through 226 are connected with the above described earth electrode films of pattern shapes 407, 409, 411, 413, 515, 419, 421 and the earth electrode portions 416 through 418 are connected through the
20 through holes 5d through 5f and also, are connected with one another through the through holes 5d through 5j.

Four earth electrode films of pattern shapes 222 through 225 are provided between the earth electrode pattern 221 and the earth electrode pattern 226 and further, four
25 through holes 5g through 5j are increased in number as



described hereinabove so as to effect connecting operations among the respective earth electrode films of pattern shapes 222 through 226. The reasons why the connections are effected are as follows. Namely, a ferrite plate 6 is mounted as described in the concave portion 200b to be formed by the through holes 222a through 226a, and many high frequency magnetic fields are caused by high frequency signals flowing through the respective central electrode portions 216 through 218 on the periphery of the ferrite plate 6. Therefore, the periphery of the ferrite plate 6 becomes an environment for high frequency induced current to be easier to flow. Assume that a connecting operation is effected between the earth electrode pattern 221 and the earth electrode pattern 226 only by three through holes 5d through 5f under such environment, impedance between the earth electrode pattern 221 and the earth electrode pattern 226 is increased by increase in the resistance component and the impedance component, thus resulting in larger loss. The resistance component and the impedance component are reduced with the increased provision of the through holes 5g through 5j, thereby reducing the impedance. The capacity components are caused in parallel with through holes 5d through 5j by the disposition of four earth electrode films of pattern shapes 222 through 225 between the earth electrode pattern 221 and the earth electrode pattern 226, whereby the reduction of the high



frequency impedance is further reduced.

Band shaped ceramic green sheets 227a through 232a are laminated near the left-hand side, and band shaped ceramic green sheets 227b through 232b are laminated near the right hand side on the reverse face of the ceramic green sheet 22 as shown in Fig. 50 through 55. Electrodes Ya, Yd, Yb are formed on the reverse face of the ceramic green sheet 232a and the electrodes Ye, Yc, Yf are formed on the reverse face of the ceramic green sheets 232b. These ceramic green sheet 227a through 232a and ceramic green sheets 227b through 232 form a stage difference concave portion 200c for receiving the magnetic yoke 72 when they have been laminated.

The above described ceramic green sheets 201 through 232a, 232b are laminated, and thereafter are adhered under pressure into a ceramic green sheet laminated body. Continuously a copper electrode composed of copper paste or the like is printed with pressure film on three locations on the left side face of the ceramic green sheet laminated body and on three locations on the right side face, whereby external connecting terminals Ta through Tf are formed. Although the copper paste is protruded onto the surface of the ceramic green sheet 201 and the reverse face of the ceramic green sheets 232a, 232b in the pressure film printing step, the protruded portion is absorbed and equalized by electrode Ya through Yf formed on the surface of the ceramic green sheet



201 and the electrodes Ya through Yf formed on the ceramic green sheets 232a, 232b. Namely, if the copper paste is protruded onto the surface of the ceramic green sheet 201 and is protruded onto the reverse faces of the ceramic green sheets 232a, 232b by the pressure film printing operation, the area of the protruded portion is generally smaller than the areas of the above described electrode Xa through Xf and Ya through Yf. Therefore, in the respective external connecting terminals Ta through Tf, the area of the extruded onto the surface of the ceramic green sheet 201 becomes equal respectively to the area of the electrodes Xa through Xf. The area of the portion extruded onto the reverse faces of the ceramic green sheets 232a, 232b becomes respectively equal to the area of the electrodes Ya through Yf. As the area of the electrode Xa though Xf are mutually equal, and the area of the electrode Ya through Yf becomes also equal with respect to one another, the area of the portion extruded onto the surface of the ceramic green sheet 201 become equally equal, and also, the areas of the portion extruded onto the reverse faces of the ceramic green sheets 232a, 232b become equal with respect to each other in the respective external connecting terminals Ta though Tf. As a result, the electric symmetry can be maintained properly without the provision of inequality in the area of the respective external connecting terminals Ta through Tf on the surface of the ceramic green sheet 201 and



the reverse face of the ceramic green sheets 232a, 232b.

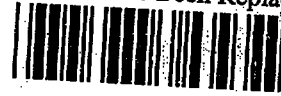
The above described ceramic green sheet laminated bodies are collectively fired. As a result, the respective ceramic greens sheets are fused, integrated into one dielectric basic plate 200. At this time, the respective electrode films of pattern shapes and the respective external connecting terminals are also integrated into dielectric basic plate 200. After the co-firing step to be sintered, a Ni plating portion is effected on the surfaces of the respective external connecting terminals Ta through Tf so as to prevent the copper electrode, which becomes the foundation of the external connecting terminals Ta through Tf at the soldering operation, from being diffused during the soldering operation. A Sn plating operation is effected upon the above described Ni plating so as to improve the soldering property of the respective external connecting terminals Ta through Tf.

As the dielectric basic plate, central electrode, matching circuit and the external connecting terminal can be fired at the same time by one co-firing step to be sintered in the present embodiment, the manufacturing step is simplified and the manufacturing time can be considerably contracted. As not only the central electrode, the matching circuit, but also the external connecting terminal is also integrated into the dielectric basic plate 200, the number of the parts can be reduced as compared with the conventional circulator



and the size can be made smaller. As the ferrite plate 6 can be accommodated in the concave portion 200b formed on the reverse face of the dielectric basic plate 200 in the circulator in the present embodiment, the magnetic yoke 72 comes into direct contact with the earth pattern 426 (see Fig. 49) formed on the reverse face of the dielectric basic plate 200. Therefore, in the conventional circulator, the earth plate 8 (for example, see Fig. 57) which was required can be made unnecessary, the number of the components can be further reduced, and the size can be made much smaller. In the present embodiment, a problem can not be caused in terms of strength even if the respective ceramic green sheets is made extremely thinner in thickness, because a plurality of ceramic green sheets can be integrated into one dielectric basic plate 200 by the co-firing to be sintered thereof. As a result, the interval among the respective central electrode portions 216 through 218 can be made extremely made narrower, and the electric symmetrical property of the respective central electrode portions 216 through 218 can be improved.

Blank portions 407a, 409a, 411a, 413a, 415a, 417a, 418a, 419a, 421a, 422a, 423a, 424a, 425a, 426a are formed, so as to surround the periphery of the external connecting terminal Ta, on the earth electrode pattern or the earth electrode portion in the given ceramic green sheet. Blank portions 407b, 409b, 411b, 413b, 415b, 416b, 418b, 419b, 421b,



422b, 423b, 424b, 425b, 426b are formed so as to surround the periphery of the external connecting terminal Tb, blank portions 407c, 409c, 411c, 413c, 415c, 416c, 417c, 419c, 421c, 422c, 423c, 424c, 425c, 426c are formed so as to surround the periphery of the external connecting terminal TC. These blank portions prevents the short-circuiting between the external connecting terminals Ta through Tc which become input, output terminals, and the respective earth electrode films of pattern shapes and the respective earth electrode portions. As the external connecting terminals Td through Tf are earth terminals, such blank portions as described hereinabove are not provided on theses peripheries.

The circulator in the present embodiment constructed as described hereinabove is placed on the external circuit basic plate (not shown), and the external connecting terminals Ta through Tf are soldered directly with the connecting terminal on the circuit basic plate side. Accordingly, the circulator in the present embodiment can be mounted on the surface onto the external circuit basic plate, thus making it unnecessary to have the troublesome wiring operation.

The operation of the circulator shown in Fig. 21 and Fig. 22 will be described. When the high frequency signal is inputted into the external connecting terminal Ta, the high frequency magnetic field to be caused round the central electrode portion 216 is rotated by the given angle by the



direct current magnetic field from the magnet 9 so as to cause the induced electric current in, for example, the right-hand adjacent central electrode portion 217 by the inductive coupling through the ferrite plate 6. The high frequency signal to be inputted from the external connecting terminal Ta is transmitted to the right-hand adjacent external connecting terminal Tb, but are not transmitted to the left-hand adjacent external connecting terminal Tc. Similarly, the high frequency signal to be inputted from the external connecting terminal Tb is transmitted to the right-hand adjacent external connecting terminal Tc, but are not transmitted to the left-hand adjacent external connecting terminal Ta. The high frequency signal to be inputted from the external connecting terminal Tc is transmitted to the right-hand adjacent external connecting terminal Ta, but is not transmitted to the left-and adjacent external connecting terminal Tb.

The circulator shown in Fig. 21 and Fig. 22 can be used as an isolator if the terminal resistor is connected between any one of the wiring portions or the external connecting terminal (for example, the wiring portion 818 or the external connecting terminal Tc). In this case, the isolator transmits the high frequency signal only in one side direction to the the remaining other external connecting terminal (for example, external connecting terminal Tb) from



the remaining one side external connecting terminal (for example, external connecting terminal Ta).

Although the connection among the respective capacity electrode films of pattern shapes and the respective capacity electrode portions, and the connections among the respective earth electrode films of pattern shapes and the respective earth electrode portions are adapted to be effected with the use of the through holes in the embodiments shown in Fig. 21 through Fig. 55, these connections may be effected with the use of the side face electrodes.

As is clear from the forgoing description, according to the inventions in the above described embodiments, a plurality of electrode films of pattern shapes and a plurality of external connecting terminals for constructing the central electrodes and the matching circuits are fired simultaneously with a plurality of dielectric green sheets adhered under pressure in lamination and are integrated with one dielectric basic plate, so that smaller size, lower cost, higher reliability of the elements and the simplification of the assembling steps can be designed. As not only the central electrodes and the matching circuits, but also the external connecting terminal are integrated into one dielectric basic plate, the number of the components can be considerably reduced, and the size of the elements can be made smaller. As the number of the assembling steps becomes less by the



reduction in the number of the components, the cost can be reduced. The connecting locations by the soldering operation and so on are reduced considerably, the reliability is improved. As the internal circuits which were disposed conventionally on plane can be arranged with microwave within the dielectric basic plate, the circuit area of the whole element can be reduced. As the respective electrode films of pattern shapes can be crossed without mutual contact within the dielectric basic plate, the insertion loss can be reduced without the requirement of making the width of the central electrode narrower as in the first conventional art. As the construction is integral, sufficiently larger strength can be retained even if the arrangement is made with the intervals among the respective electrode films of pattern shapes are made extremely close. As a result, the electric symmetrical property property among the respective central electrodes can be maintained in better condition. As the dielectric basic plate, the respective electrode films of pattern shapes, and the respective external connecting terminals are formed at the same time in one co-firing step to be sintered, the manufacturing time can be considerably shortened.

According to the invention of the above described embodiment, a compacter non-reciprocal circuit element is provided by the formation of a first concave portion for engaging a magnet for direct current magnetic field applying



use on one side main surface of the dielectric basic plate.

According to the invention in the above described embodiment, a second concave portion for engagement of the inductive coupling ferrite plate of the internal circuit is formed on the other-way main surface of the dielectric basic plate so that a non-reciprocal circuit element which is compacter and lower in price can be obtained. As the magnetic yoke can be used as an earth plate used with the conventional non-reciprocal circuit element, the number of the parts is reduced, and a non-reciprocal circuit element which is much smaller in size and lower in price can be obtained.

Although the present invention has been fully described by way of example with reference to the accompanying drawings, it is to be noted here that various changes and modifications will be apparent to those skilled in the art. Therefore, unless otherwise such changes and modifications depart from the scope of the present invention, they should be construed as included therein.



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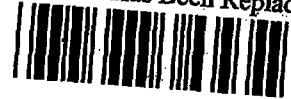
What is claimed is:

1. A non-reciprocal circuit element which is extremely small in attenuation degree in the transmission direction of the signals, and extremely larger in attenuation degree in a direction opposite to it, characterized in that a plurality of electrode films having pattern shapes are provided integrally through dielectric material within one dielectric substance, so that the circuit constituted in combination of the electrode films having patterns shapes are arranged within the dielectric substrate.

2. A non-reciprocal circuit element described in accordance with the claim 1, where the electrode films of pattern shapes include one central electrode pattern or more, one capacitor electrode pattern or more, one earth electrode pattern or more, and in the interior of the above described dielectric basic plate, the capacitor electrode films of pattern shapes and the earth electrode films of pattern shapes are alternately disposed with dielectrics being existed among them, the respective capacitor electrode films of pattern shapes are connected in common and connected with the corresponding central electrode films of pattern shapes, and the respective earth electrode films of pattern shapes are connected in common, so that one matching circuit capacity or more are disposed in lamination among the central electrodes films of pattern shapes and the earth electrode films of



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pattern shapes.

3. A non-reciprocal circuit element which is extremely small in attenuation degree in the transmission direction of the signals and extremely large in attenuation degree in a direction opposite to it, comprising one dielectric basic plate to be formed by the integration of a plurality of fired dielectric green sheets adhered under pressure in lamination, a plurality of electrode films of pattern shapes to be formed by the co-firing to be sintered with the dielectric green sheets and to be disposed in lamination within the dielectric basic plate, a plurality of external connecting terminals to be formed by the co-firing to be sintered with the dielectric green sheets and to be connected with the given electrode films of pattern shapes and to be disposed so that an exposing operation is effected on the outer periphery of the dielectric basic plate, so that the internal circuits and the external connecting terminals to be connected with them become integral with the dielectric basic plate and are disposed.

4. A non-reciprocal circuit element described in accordance with the claim 3, where the dielectric basic plate has one side main surface and the other-way main surface, a first concave portion for engaging a magnet for direct current magnetic field applying use is formed on the one side main surface.

5. A non-reciprocal circuit element described in



accordance with the claim 3, where the dielectric basic plate has one side main surface and other side main surface, a second concave portion for engaging a ferrite plate for inductive coupling use of the internal circuit on other side main surface.

5 6. A method of manufacturing non-reciprocal circuit elements which are extremely smaller in attenuation degree in the transmission of the signals and extremely larger in attenuation degree in a direction opposite to it, comprising the steps of adhering under pressure in lamination a plurality of dielectric green sheets with given electrode films of pattern shapes being formed respectively on them so as to obtain the green sheet laminating bodies, of co-firing to be sintered the green sheet laminating bodies so as to integrate them on one dielectric basic plate, so that a non-reciprocal circuit element can be obtained with inner circuits being disposed in lamination with microwave within the one dielectric basic plate.

15 7. A method of manufacturing non-reciprocal circuit elements described in accordance with the claim 6, having a step of forming the central electrodes and the dielectric basic plates at the same time by the one co-firing step to be sintered.

20 8. A method of manufacturing non-reciprocal circuit elements described in accordance with the claim 6, having a

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step of forming a central electrode, a matching circuit to be connected with it and the dielectric basic plate at the same time by the one co-firing step to be sintered.

9. A non-reciprocal circuit element substantially as hereinbefore described with reference to Figures 1 to 55 of the accompanying drawings.

10. A method of manufacturing non-reciprocal circuit elements substantially as hereinbefore described with reference to Figures 1 to 55 of the accompanying drawings.

Figure (s) to accompany abstract

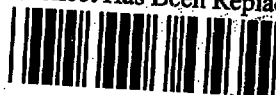
ABSTRACT

NON-RECIPROCAL CIRCUIT ELEMENTS AND METHOD THEREOF

Non-reciprocal circuit elements, wherein a plurality of ceramic green sheets (101 to 114) through with given electrode films of pattern shapes being formed respectively on them are collectively fired and integrated into one dielectric basic plate (100) after they have been adhered under pressure in lamination, and a plurality of electrode films of pattern shapes are laminated within one dielectric basic plate, so that the internal circuit of the central electrode, the matching circuit and so on are disposed with microwave, resulting in that they can be smaller in size, higher in performance and easier to manufacture.

Figure 1.

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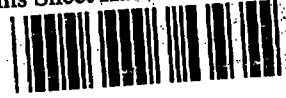
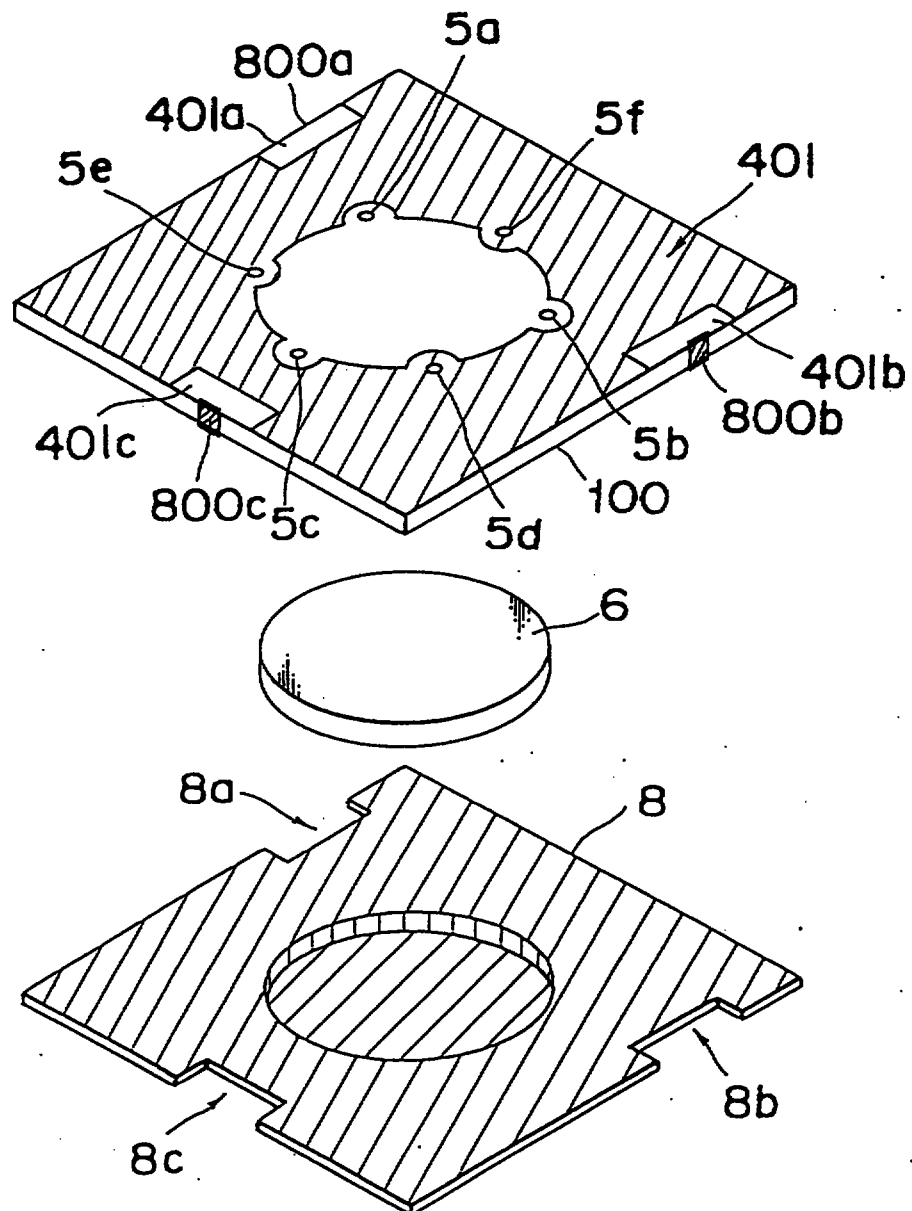


Fig. 1





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Fig. 2

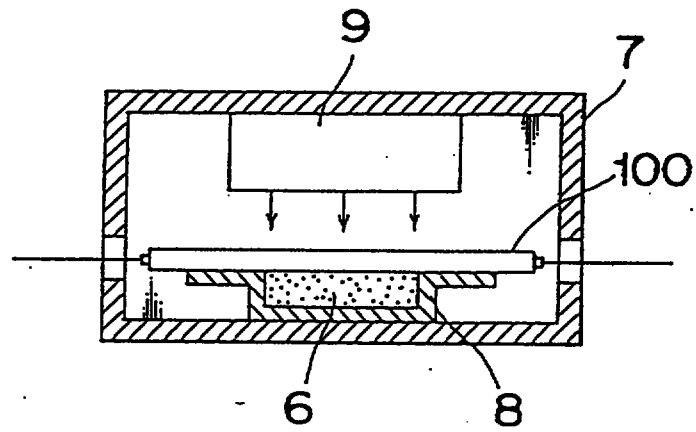
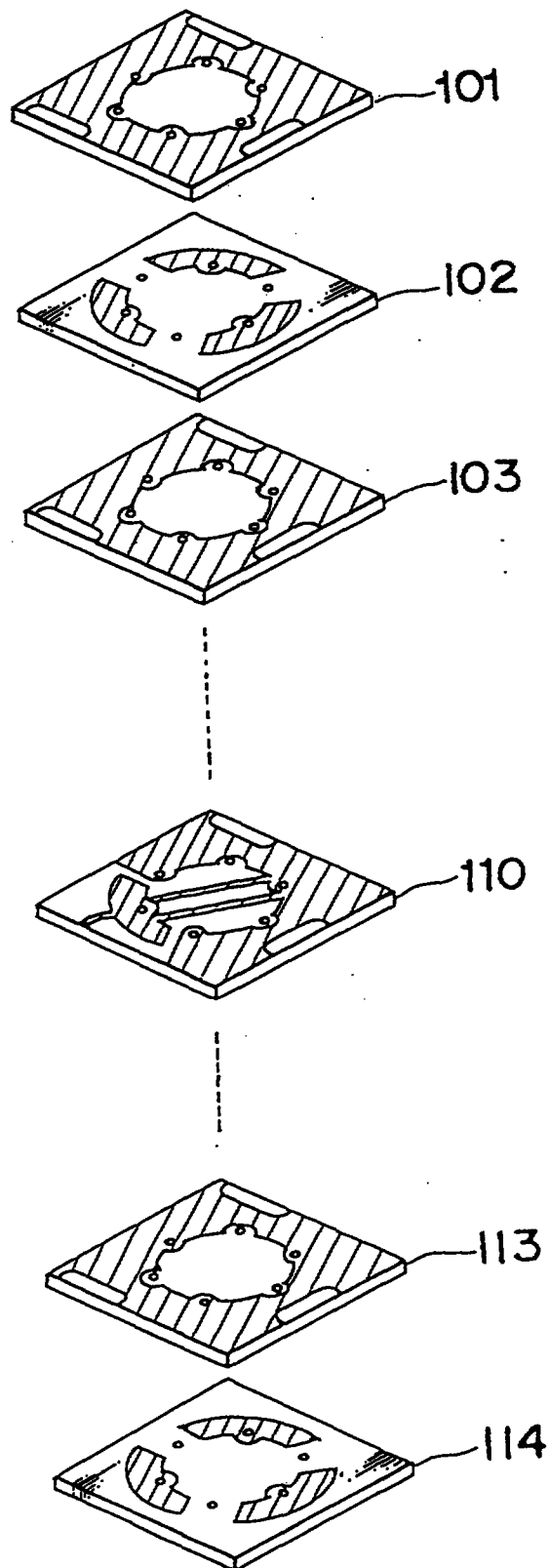


Fig. 3





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Fig. 4

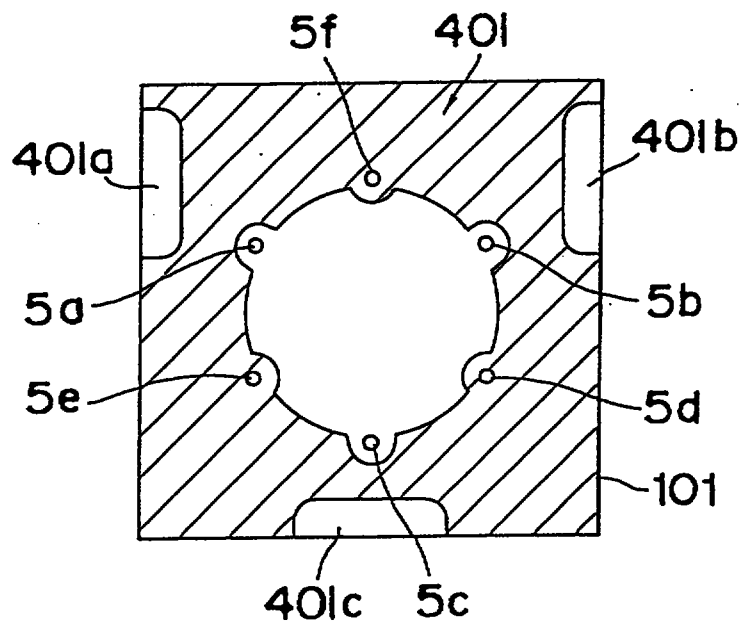
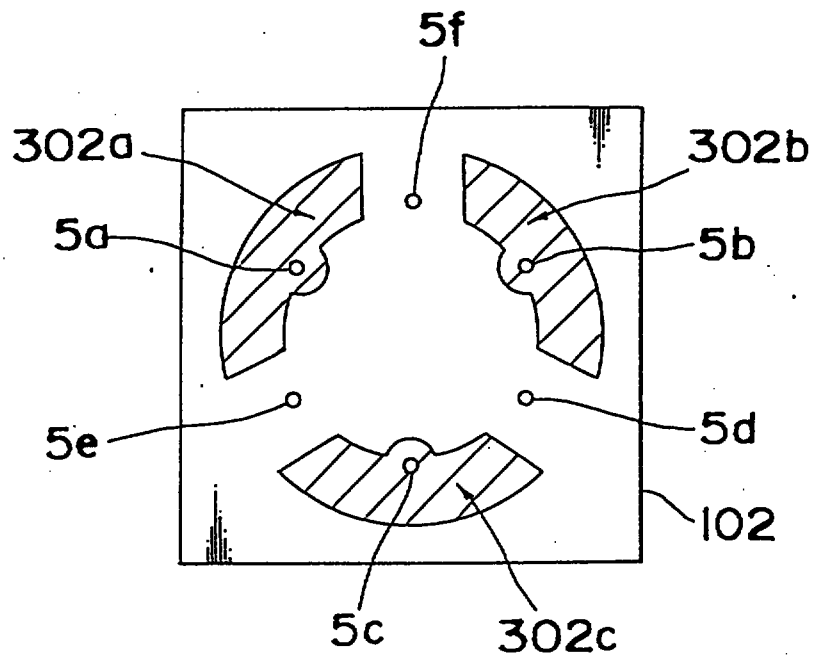


Fig. 5



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Fig. 6

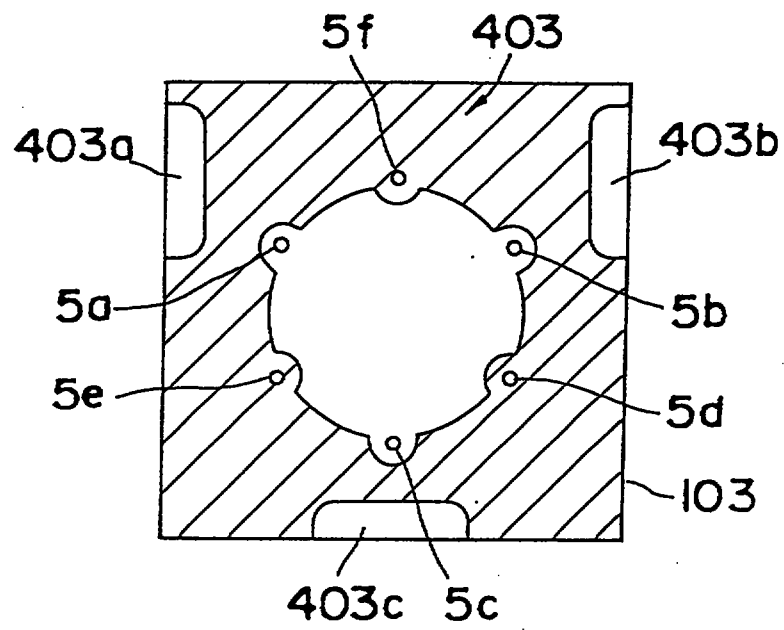
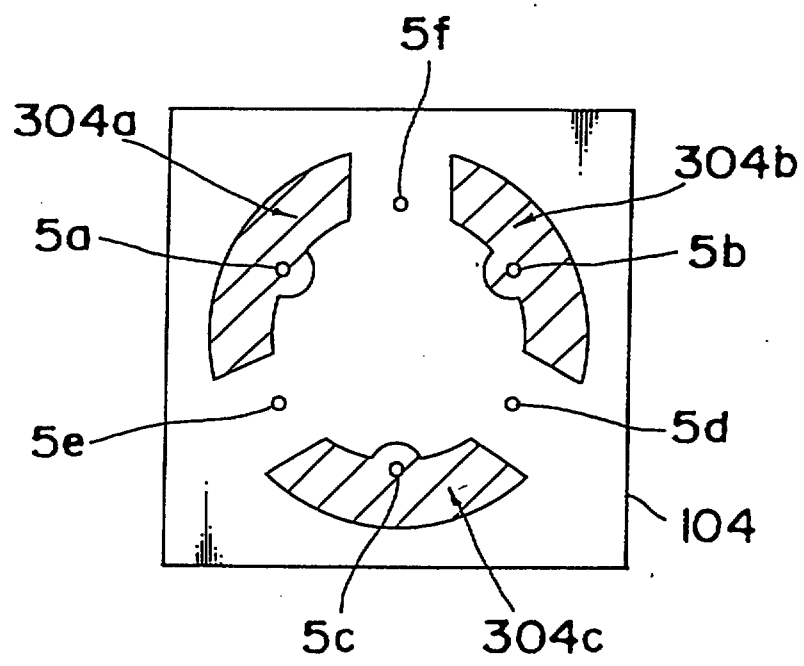


Fig. 7



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Fig. 8

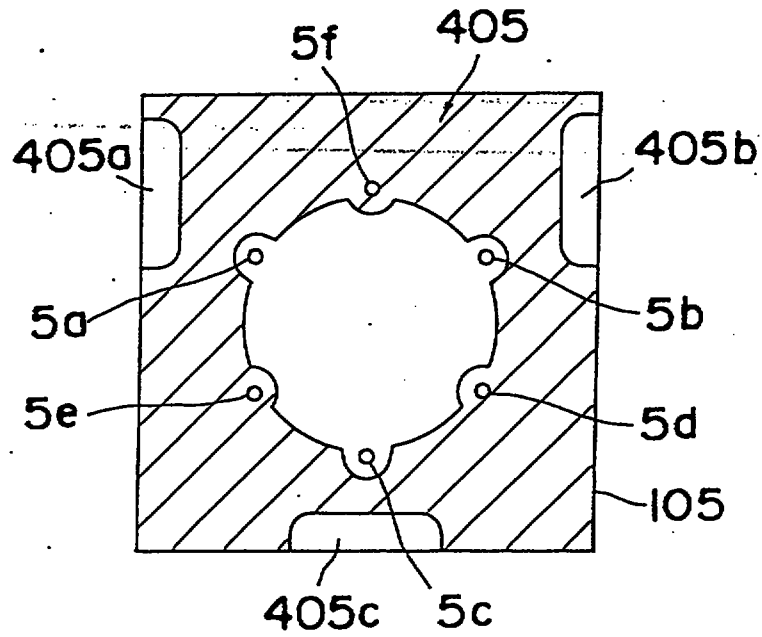
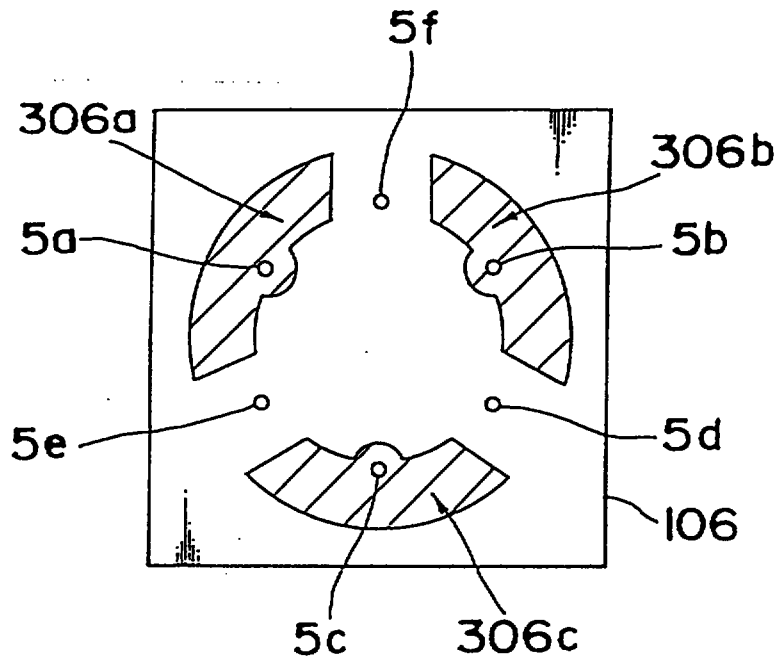


Fig. 9



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Fig. 10

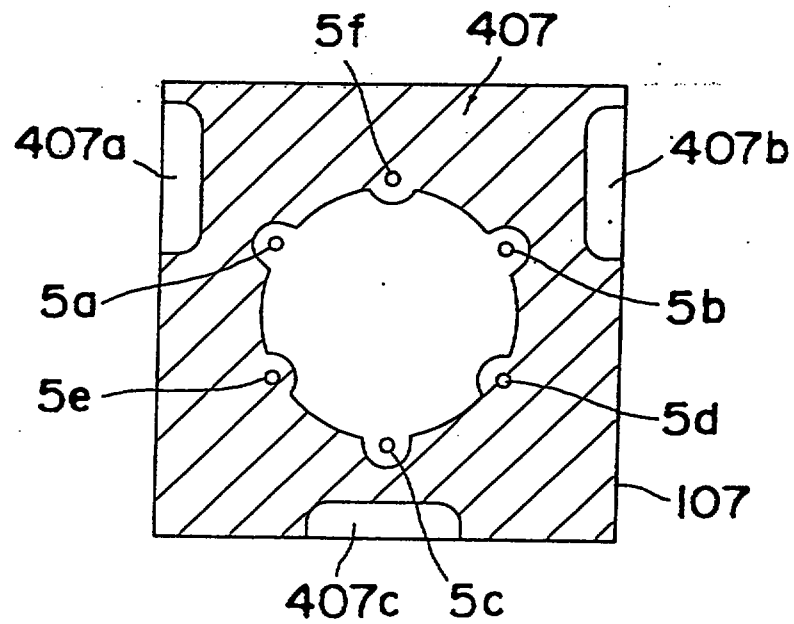
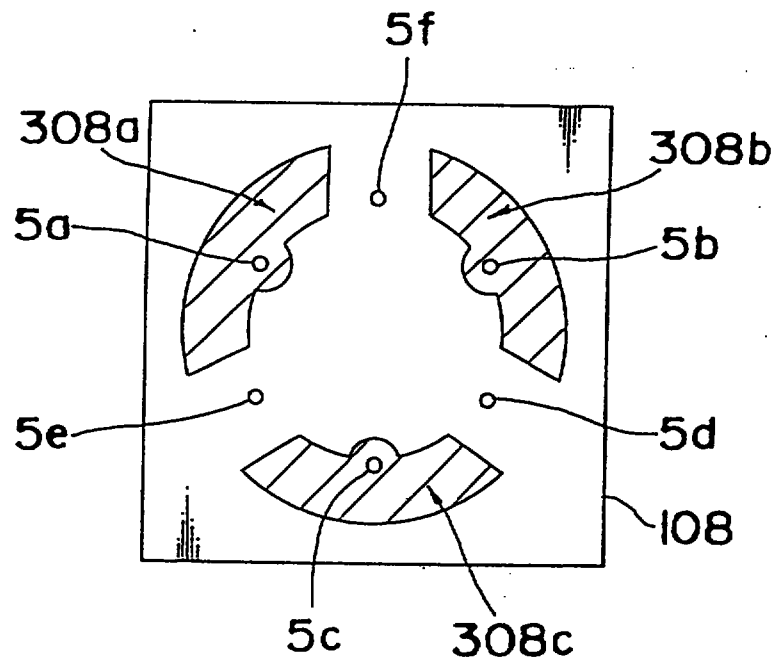


Fig. 11



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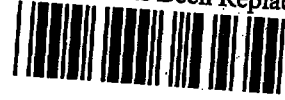


Fig. 12

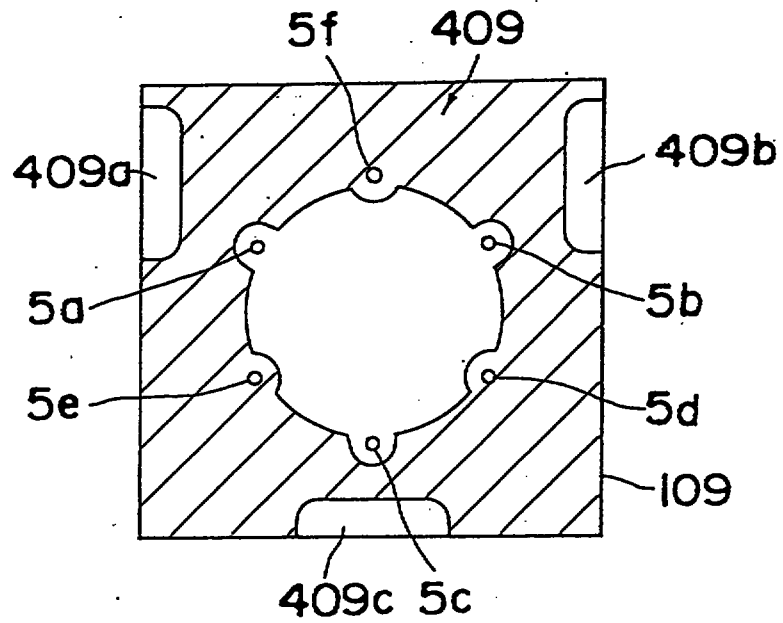
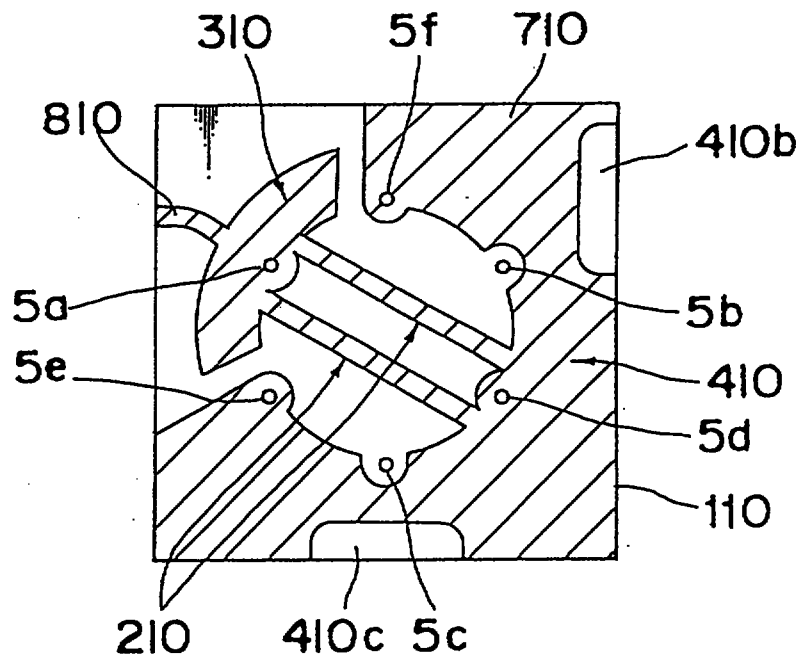


Fig. 13



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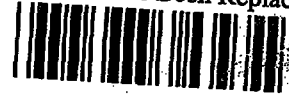


Fig. 14

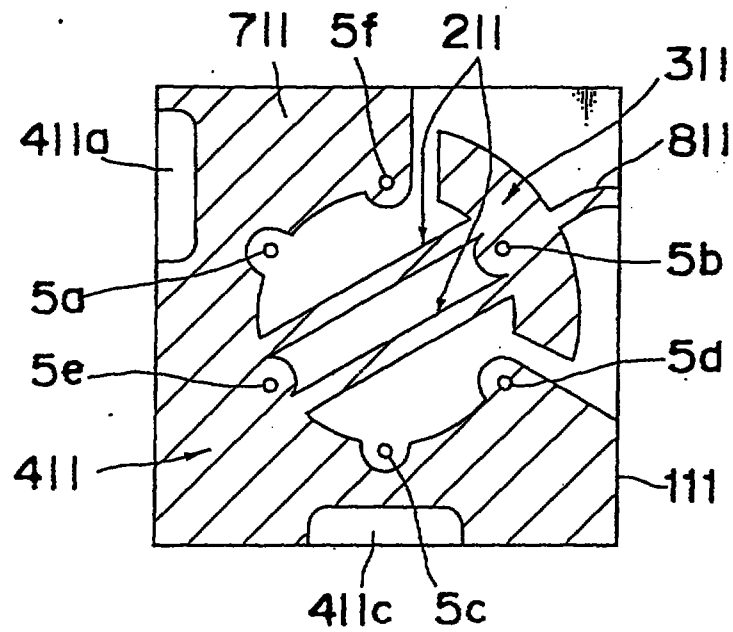
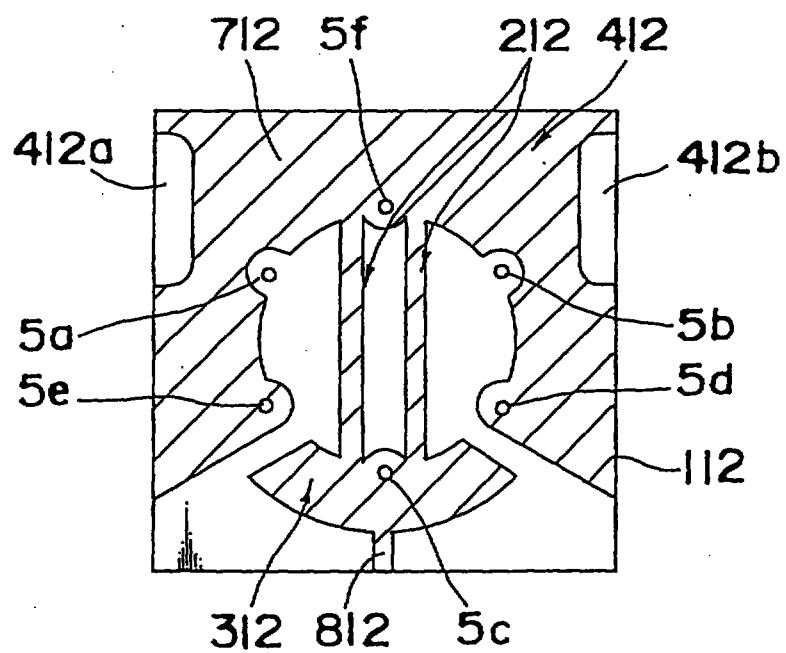


Fig. 15



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Fig. 16

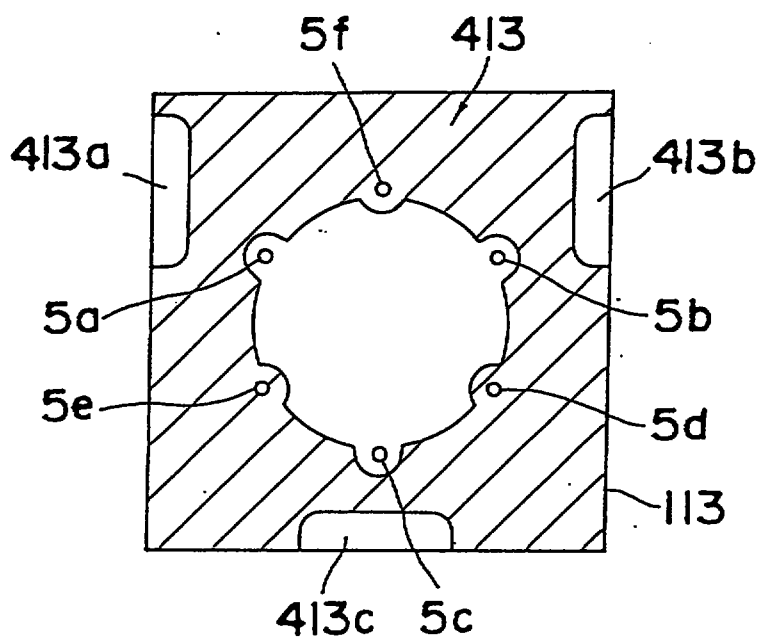
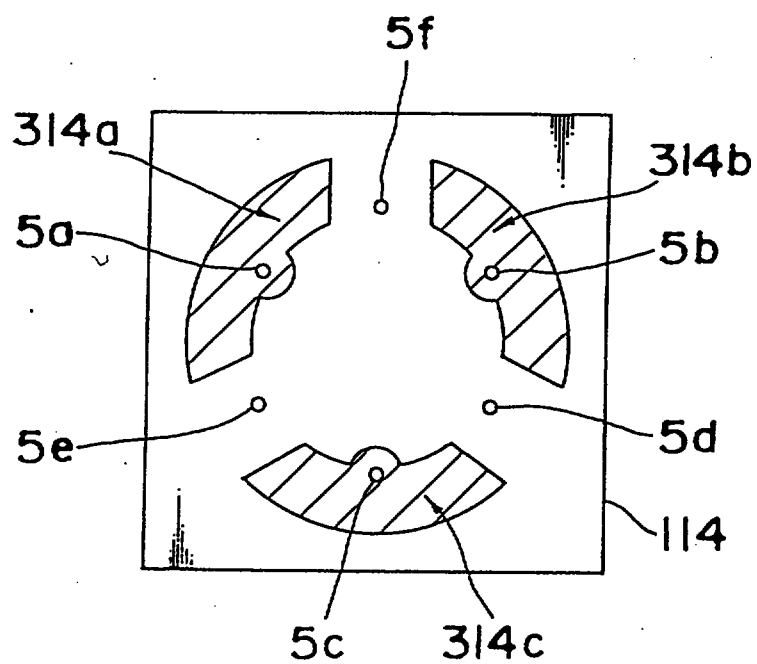


Fig. 17



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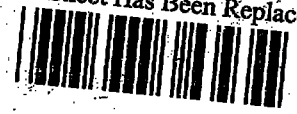
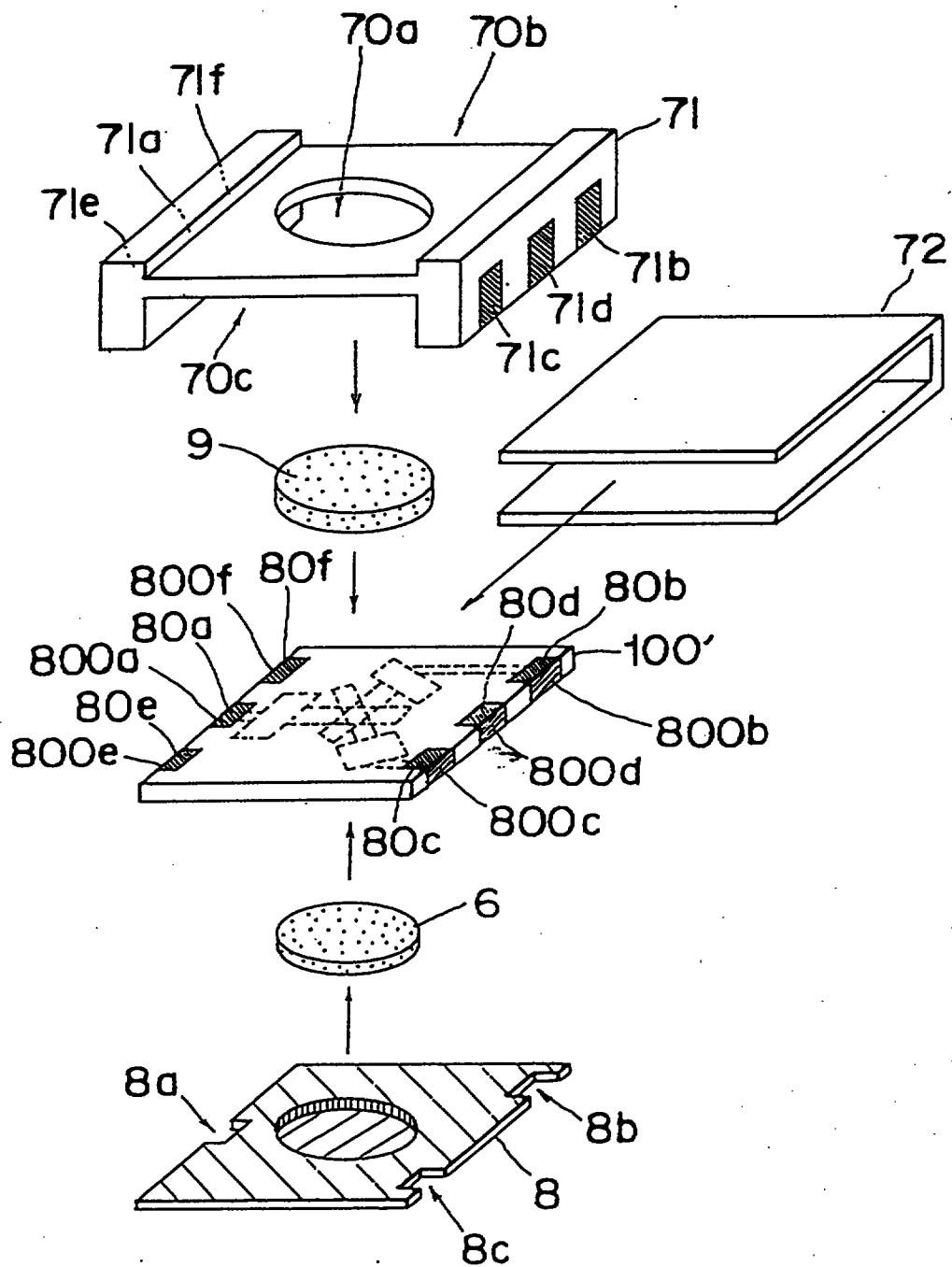


Fig. 19



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Fig. 20

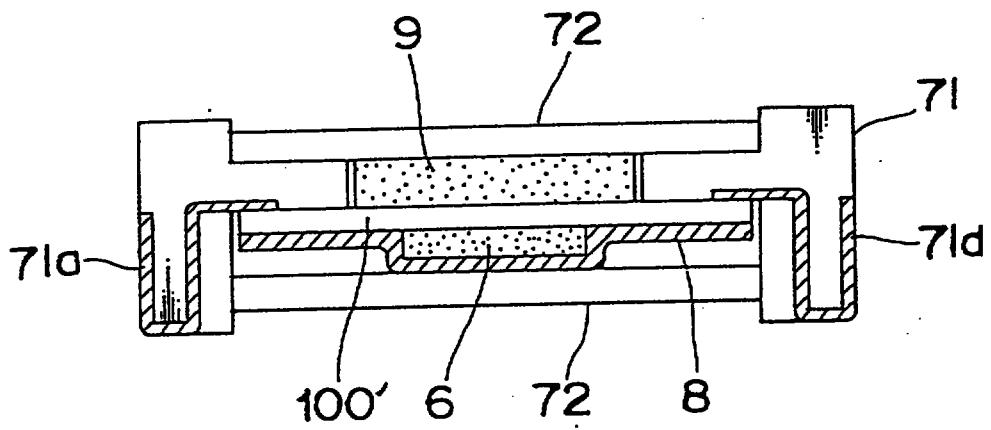


Fig. 21

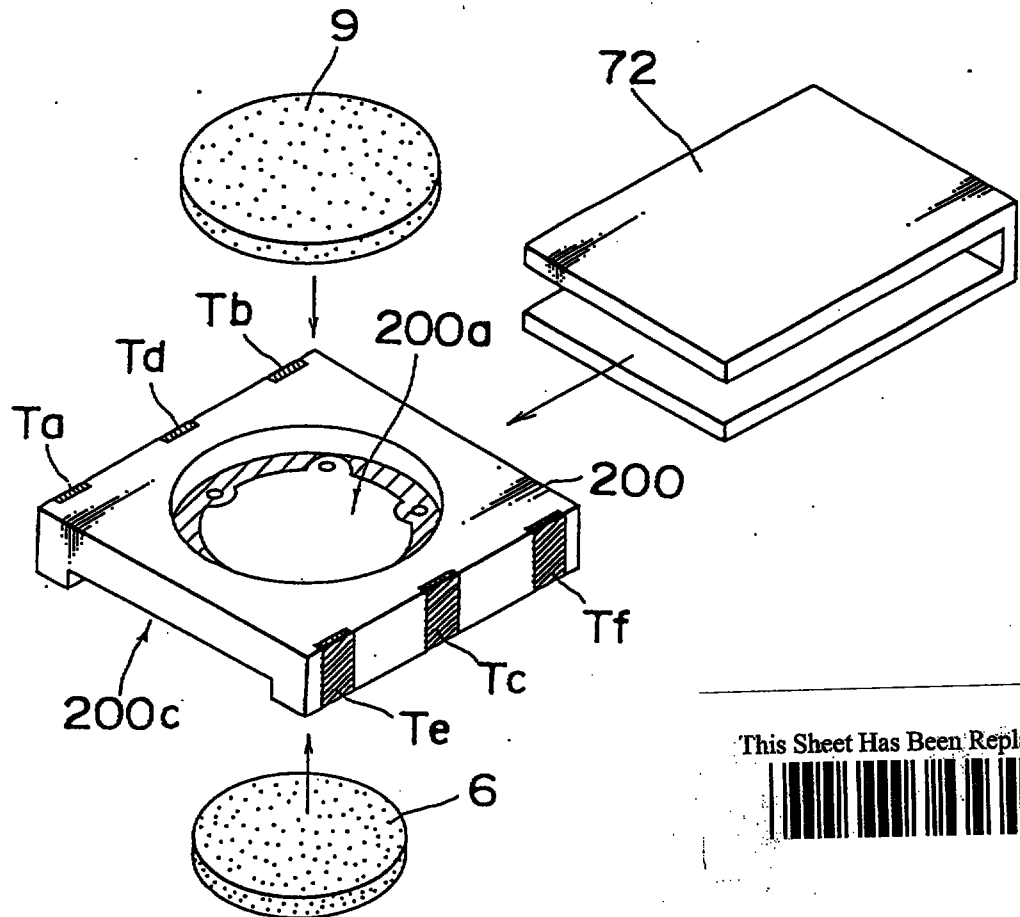
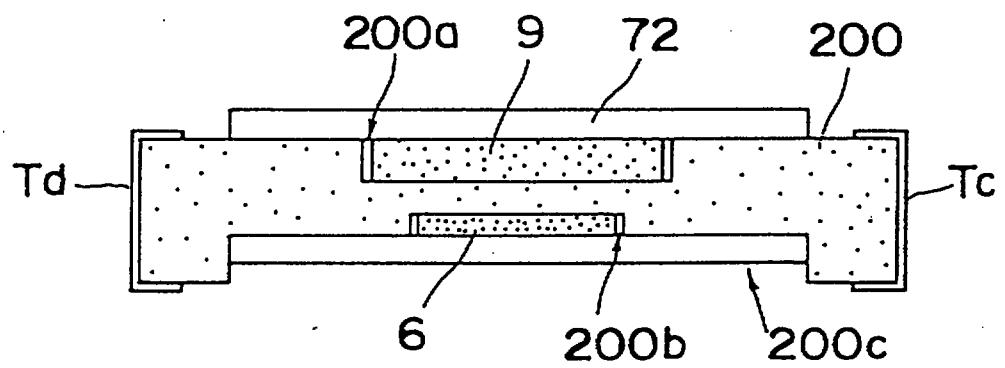


Fig. 22



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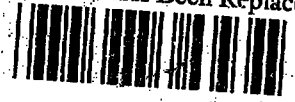
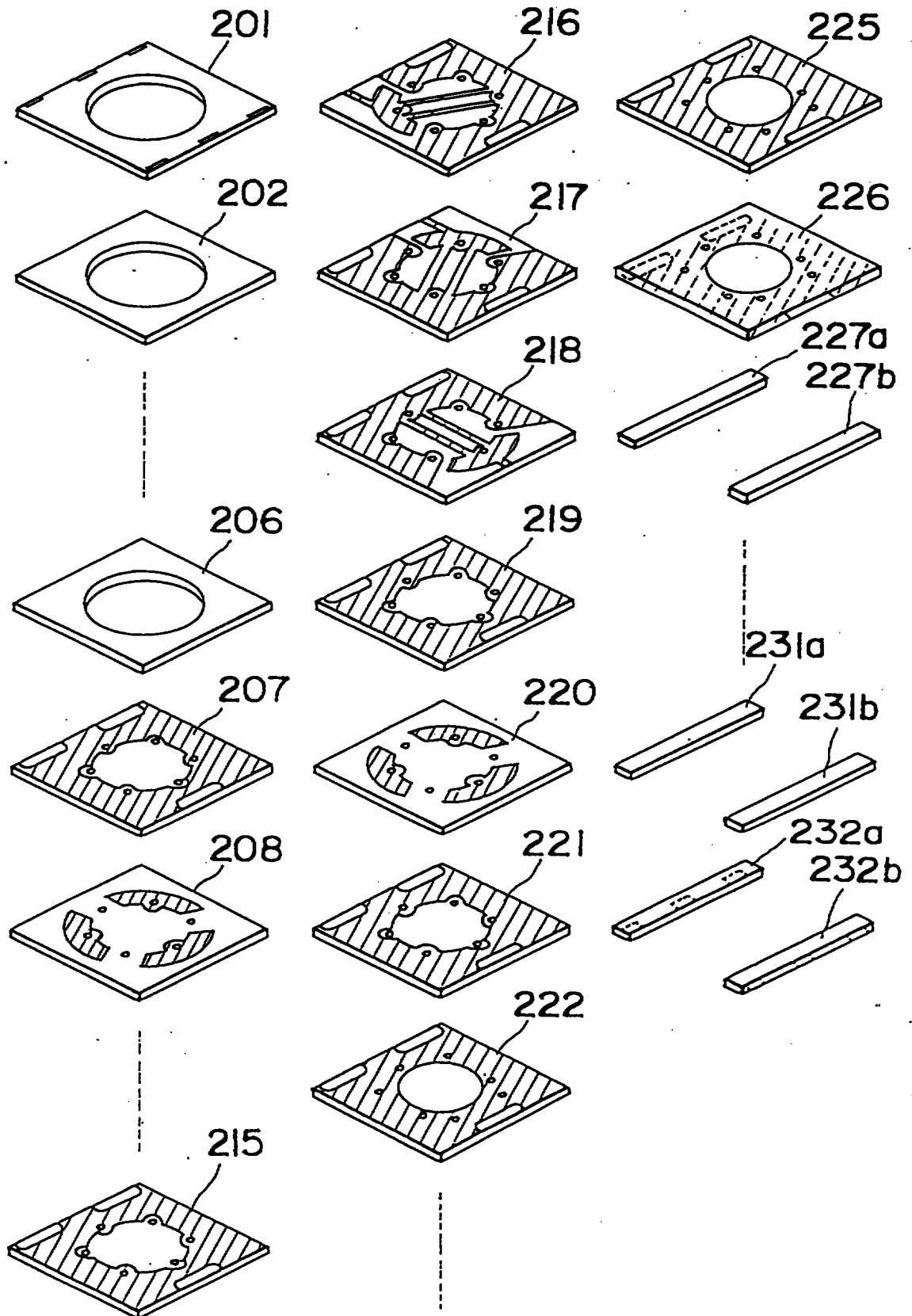
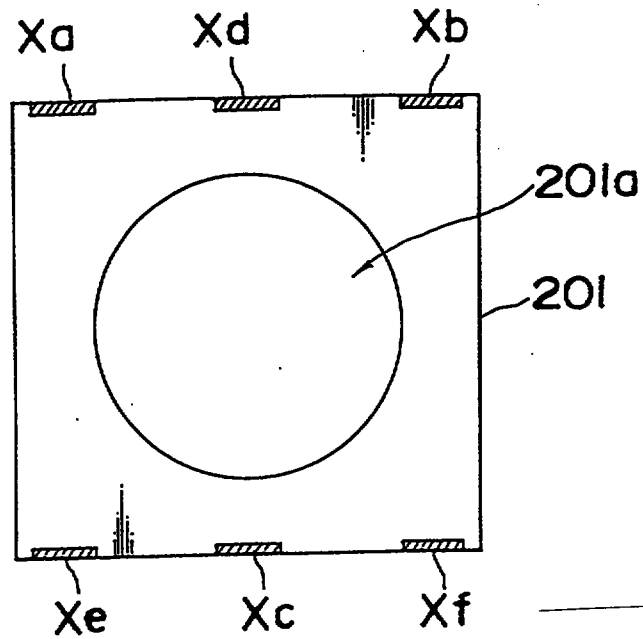


Fig. 23



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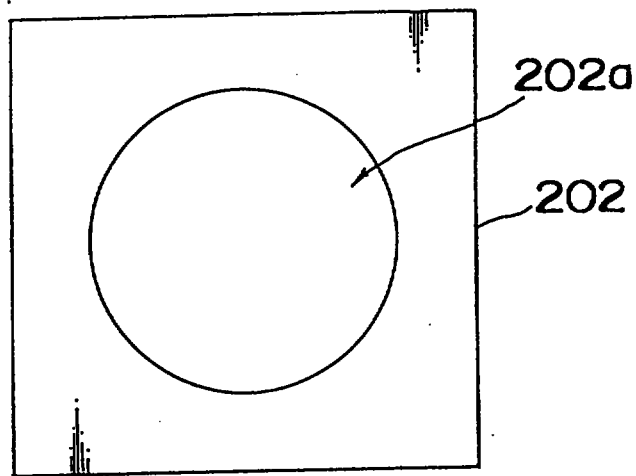
Fig. 24



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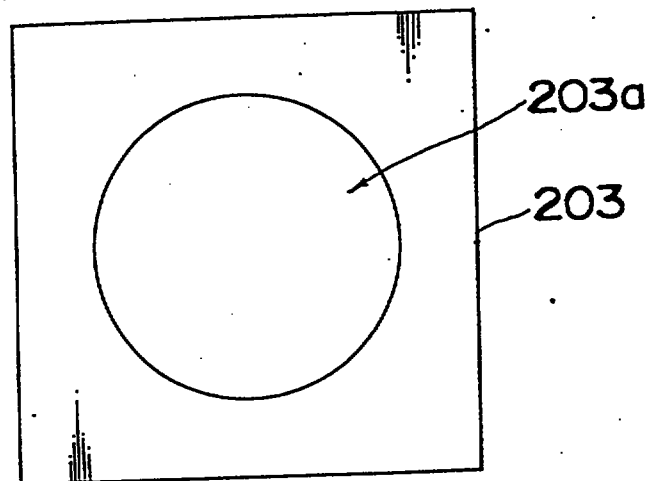


Fig. 25



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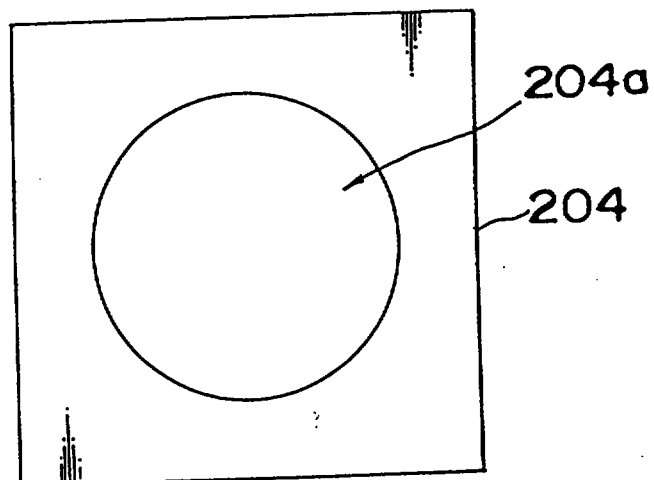
Fig. 26



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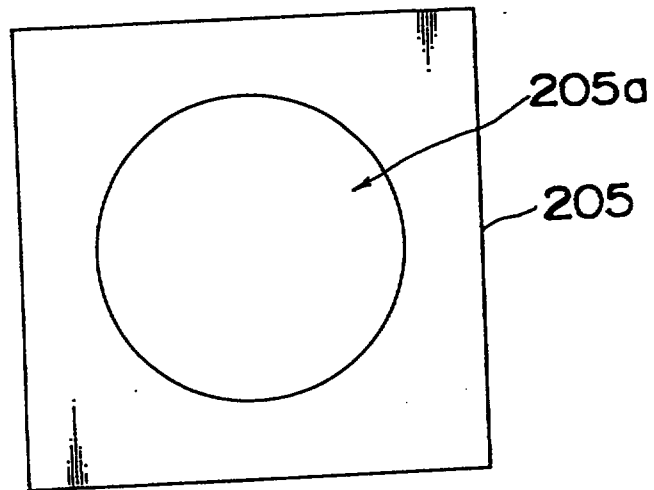


Fig. 27



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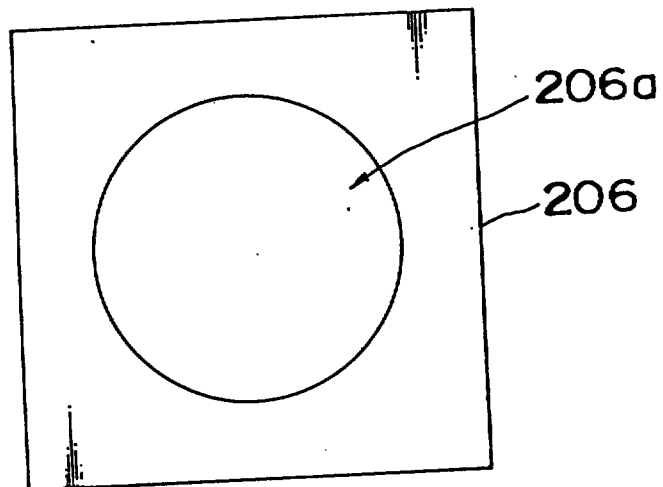
Fig. 28



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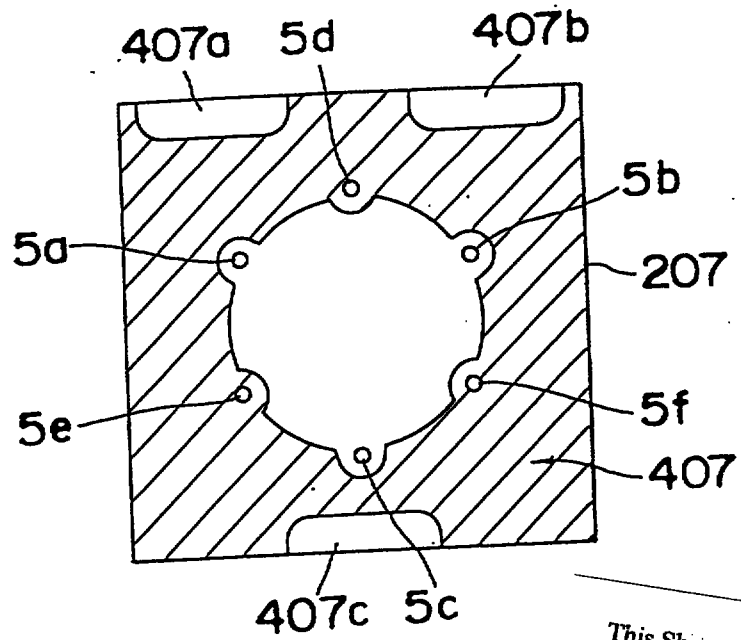


Fig. 29



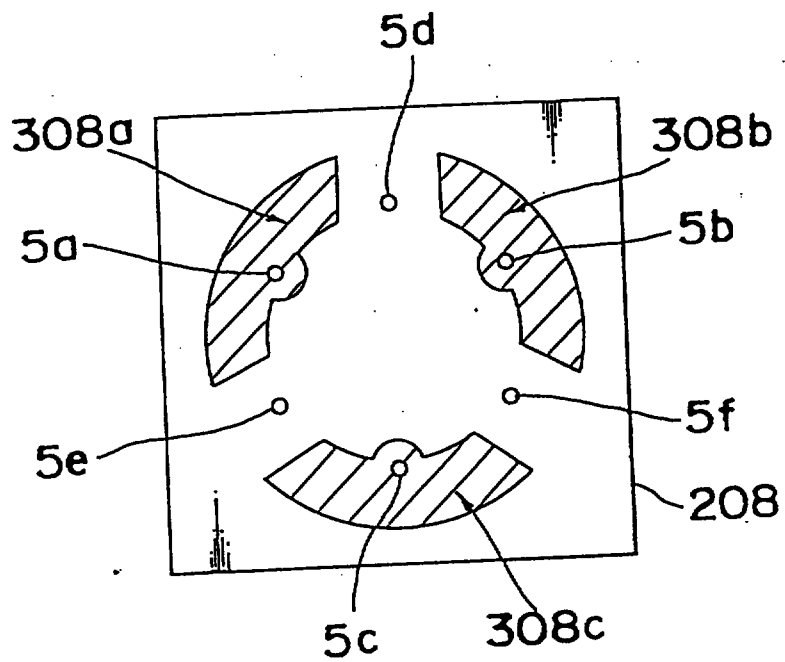
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Fig. 30



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Fig. 31



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Fig. 32

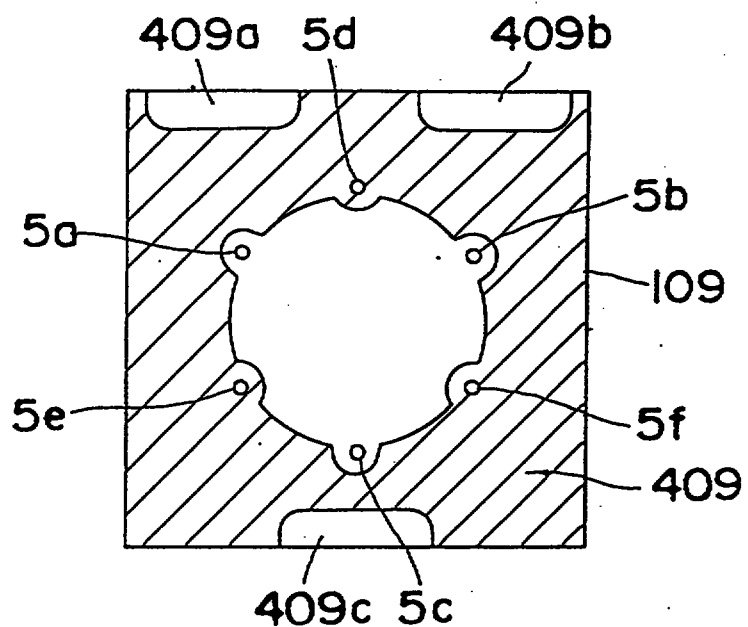
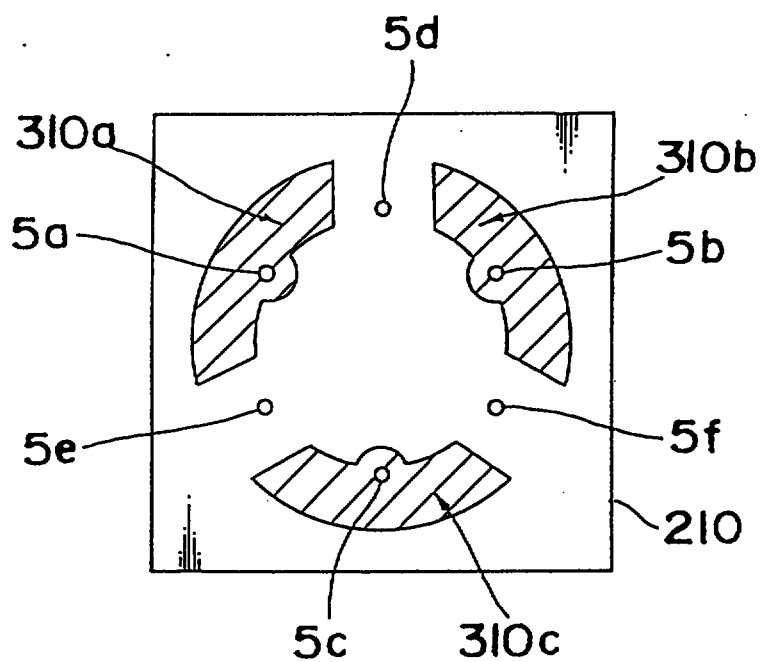


Fig. 33



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Fig. 34

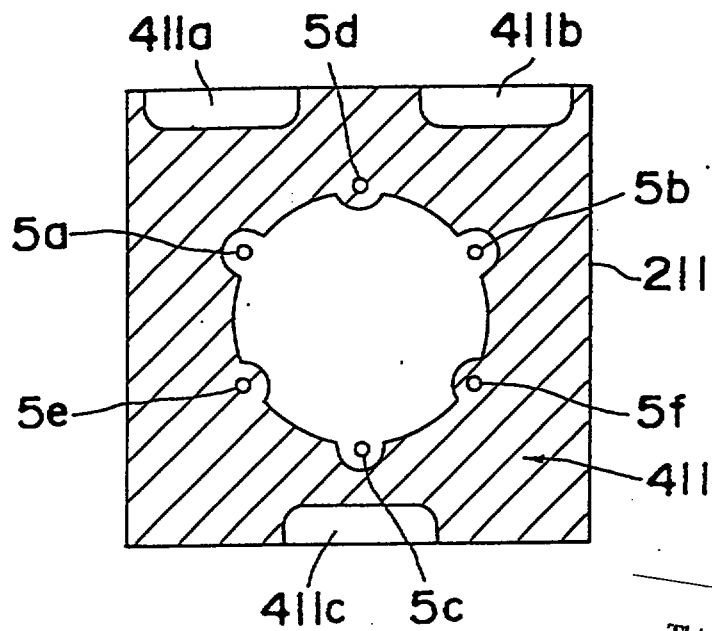
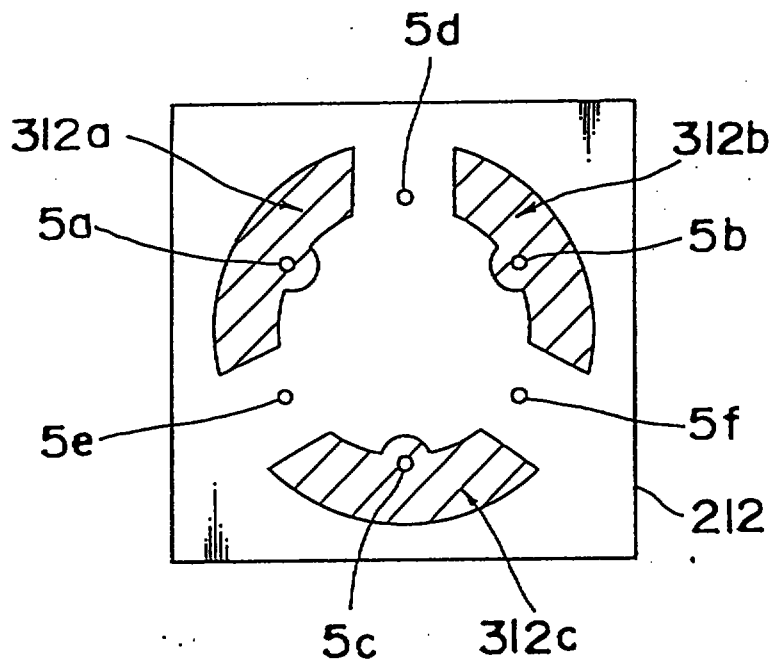


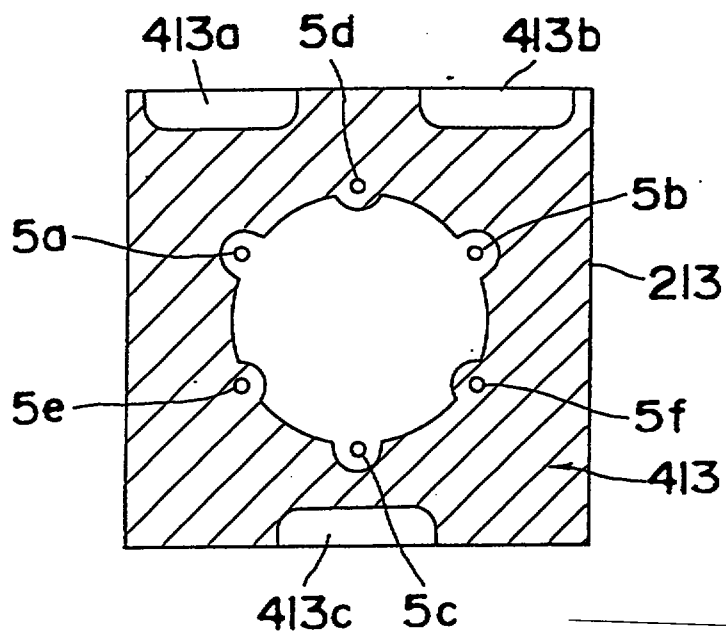
Fig. 35



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Fig. 36



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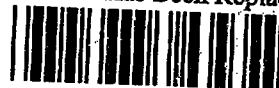


Fig. 37

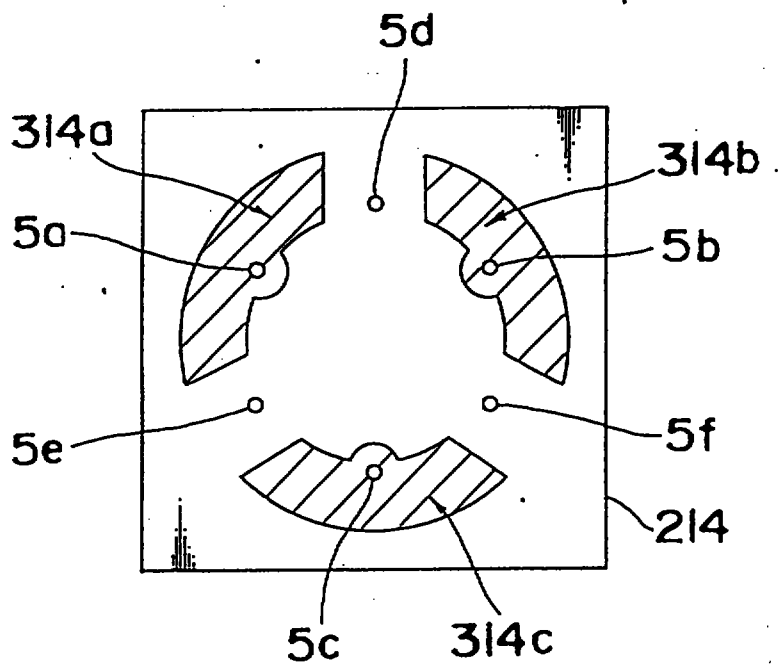
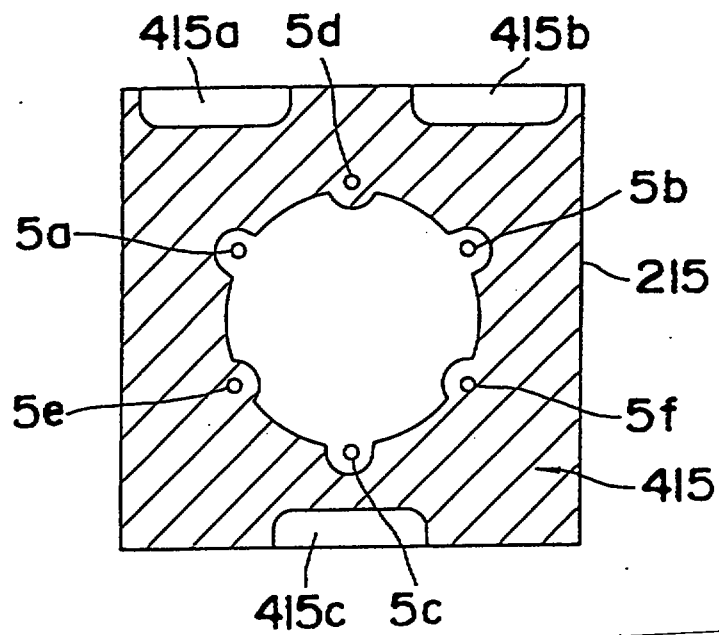


Fig. 38



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Fig. 39

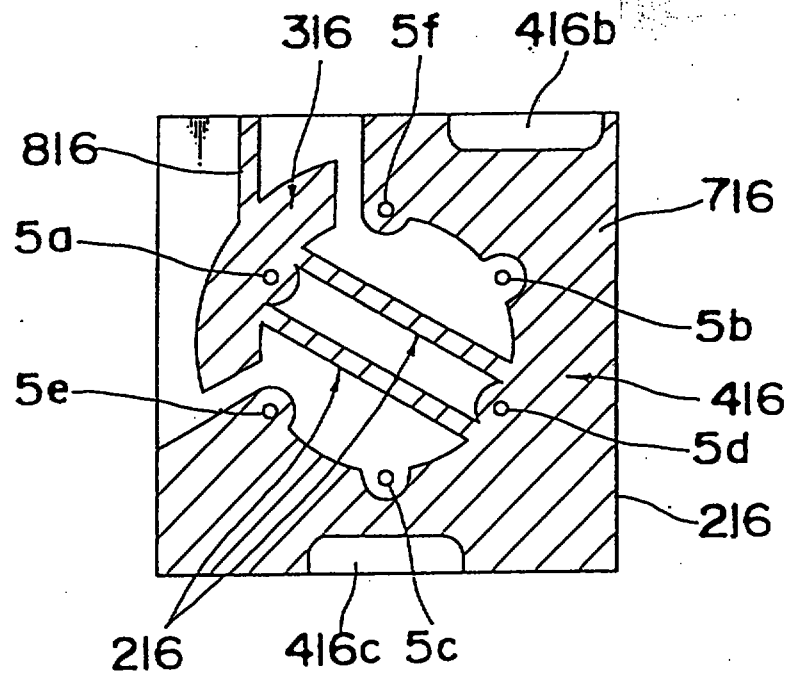
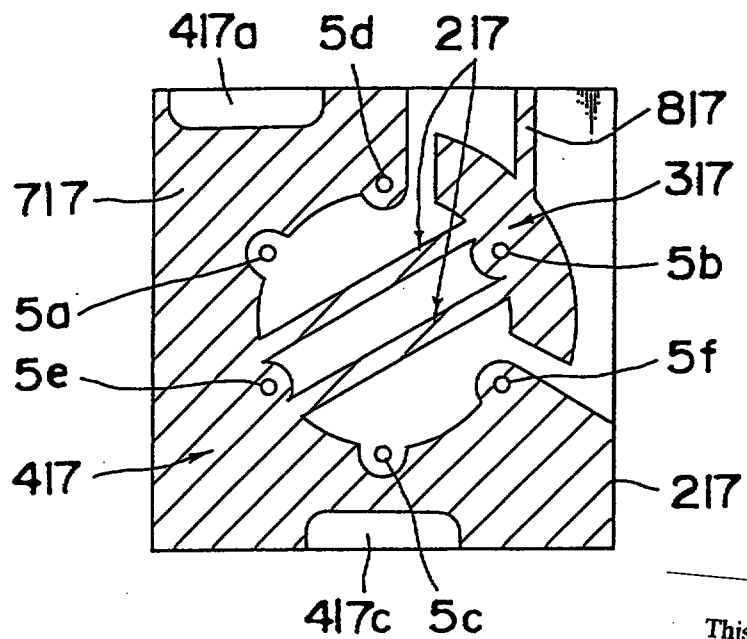
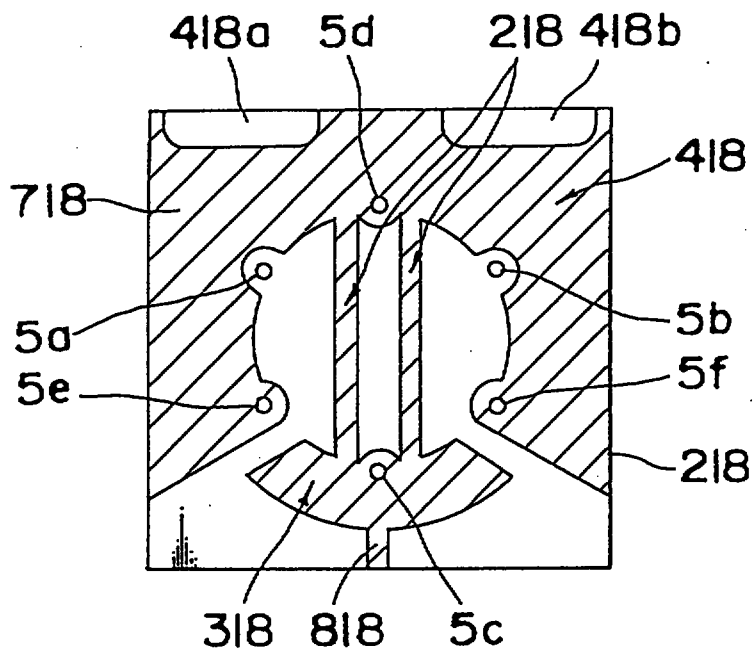


Fig. 40



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Fig. 41



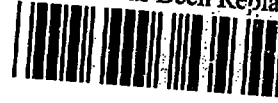


Fig. 42

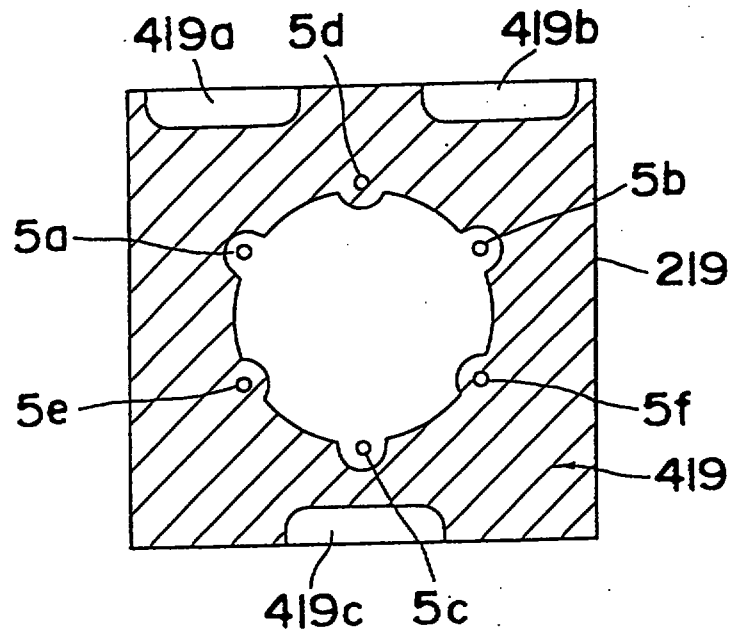
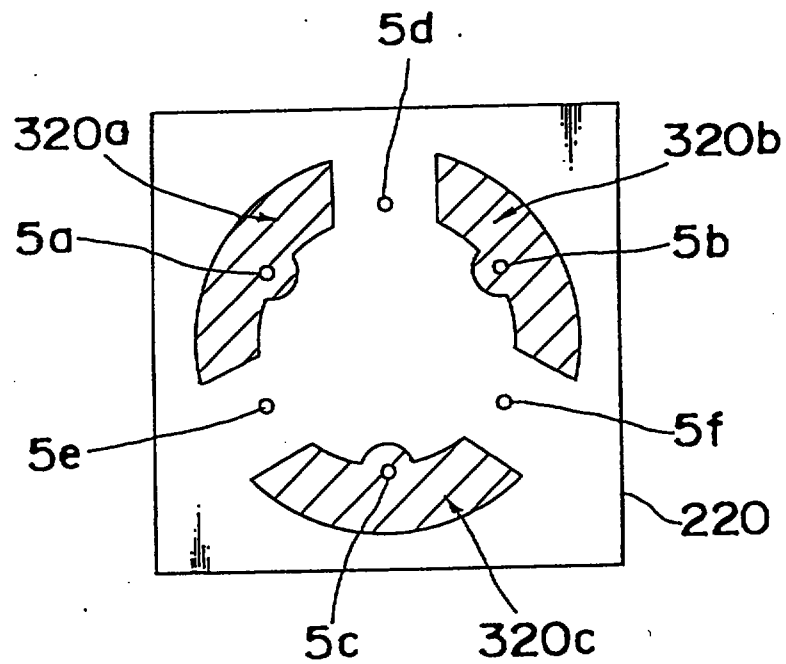


Fig. 43



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Fig. 44

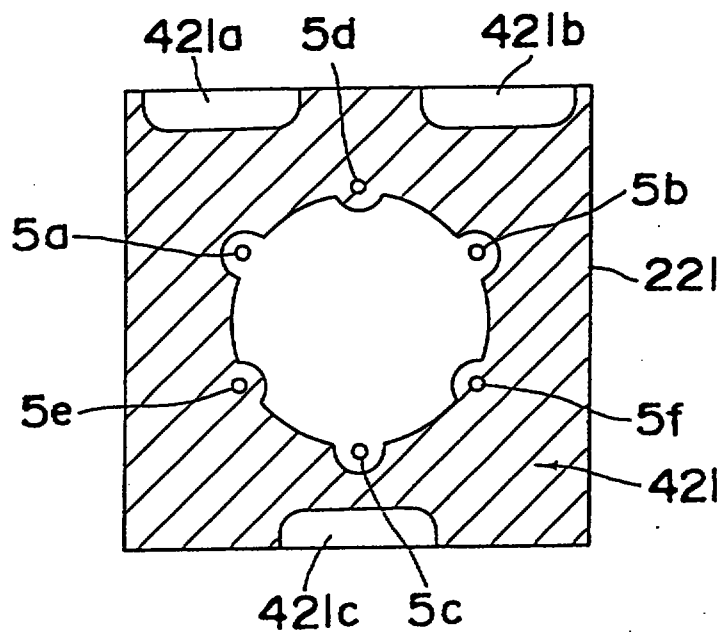
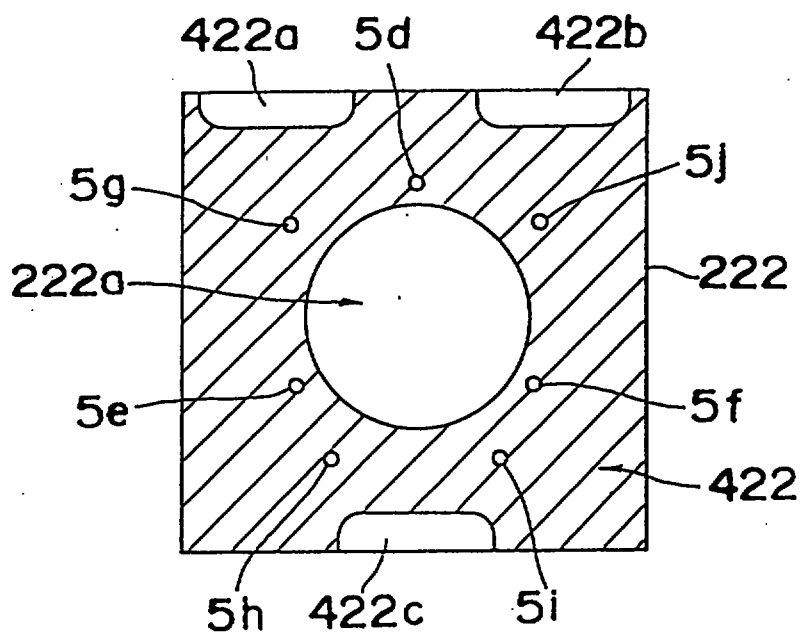


Fig. 45



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Fig. 46

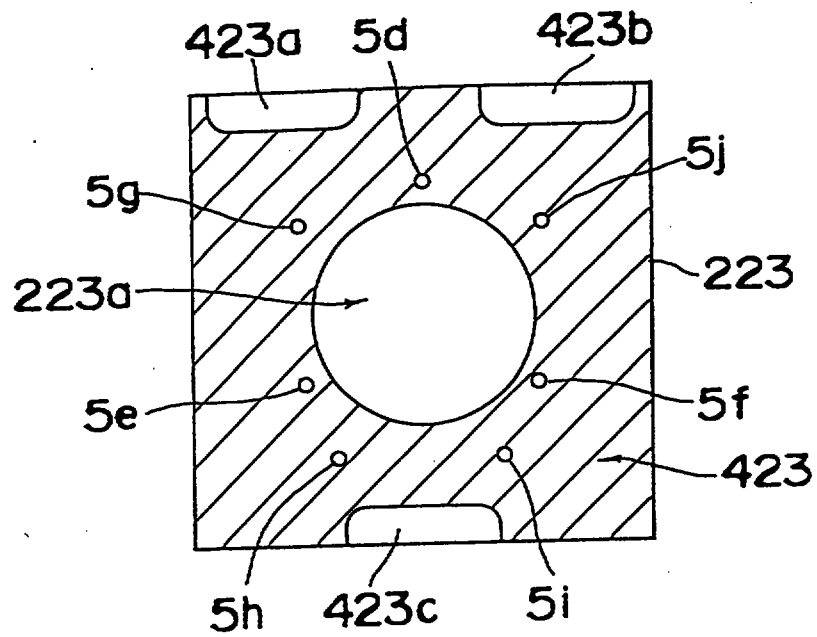
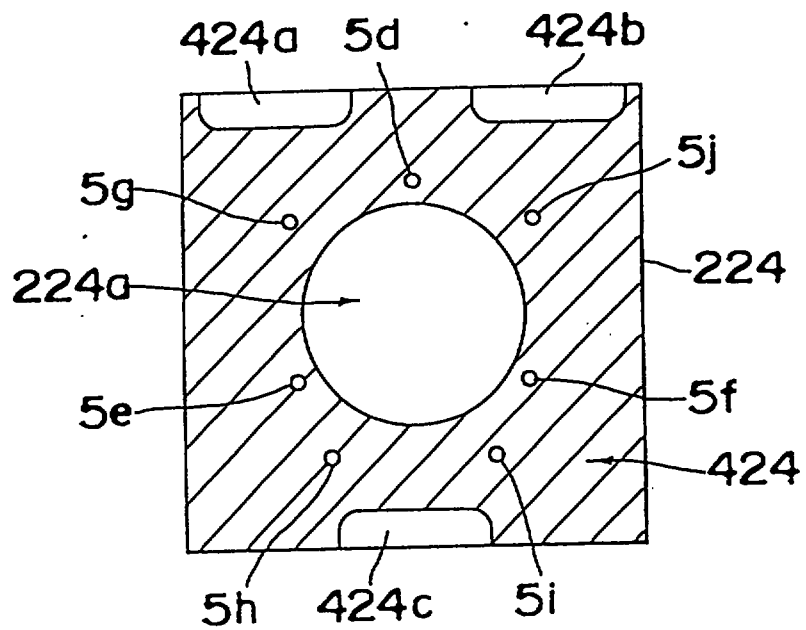


Fig. 47





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Fig. 50

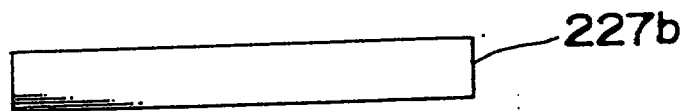
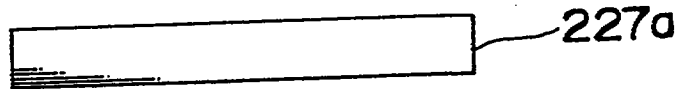
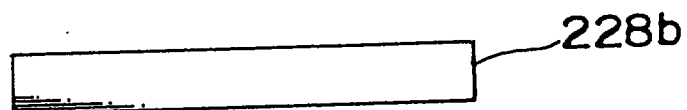
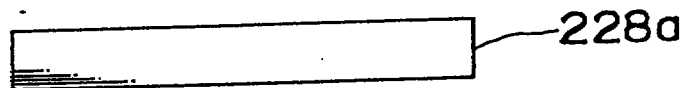


Fig. 51



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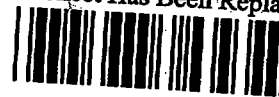


Fig. 52

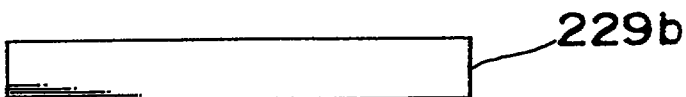
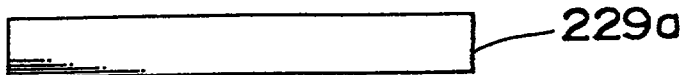
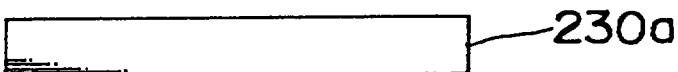


Fig. 53



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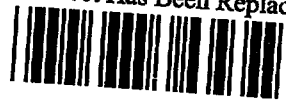


Fig. 54

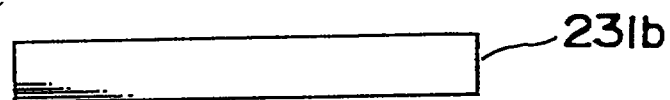
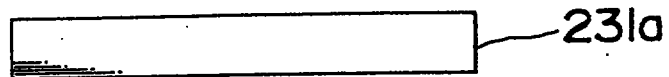
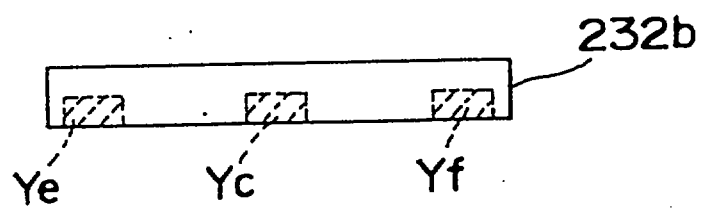
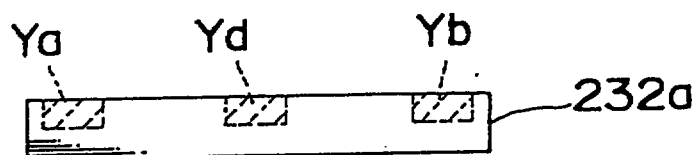


Fig. 55



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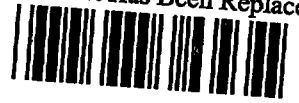


Fig. 56 PRIOR ART

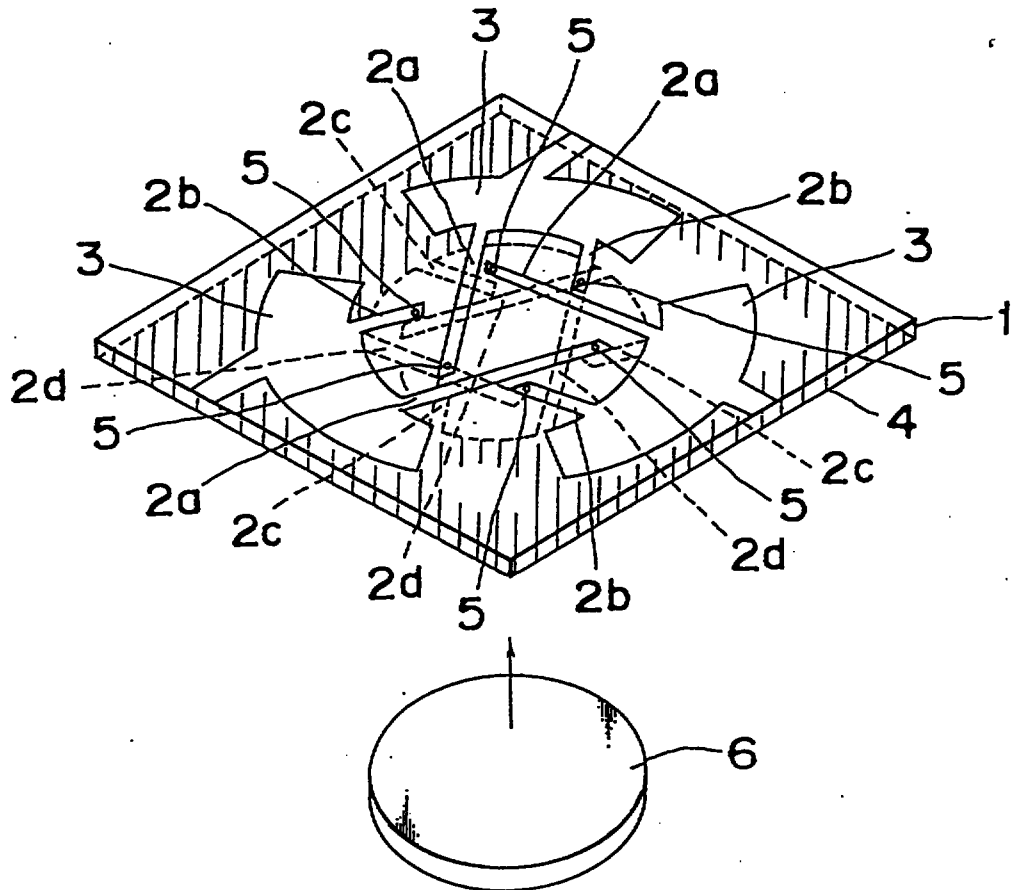
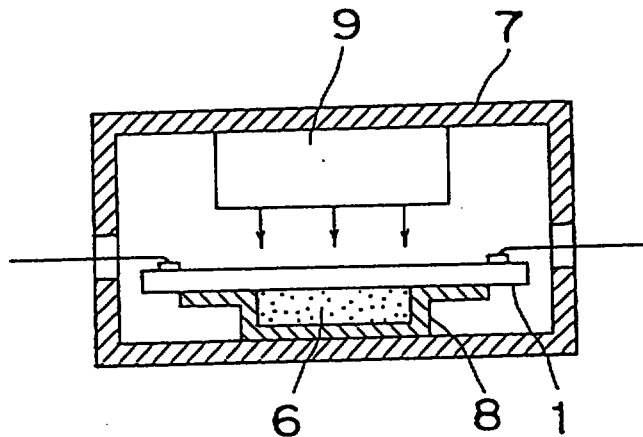
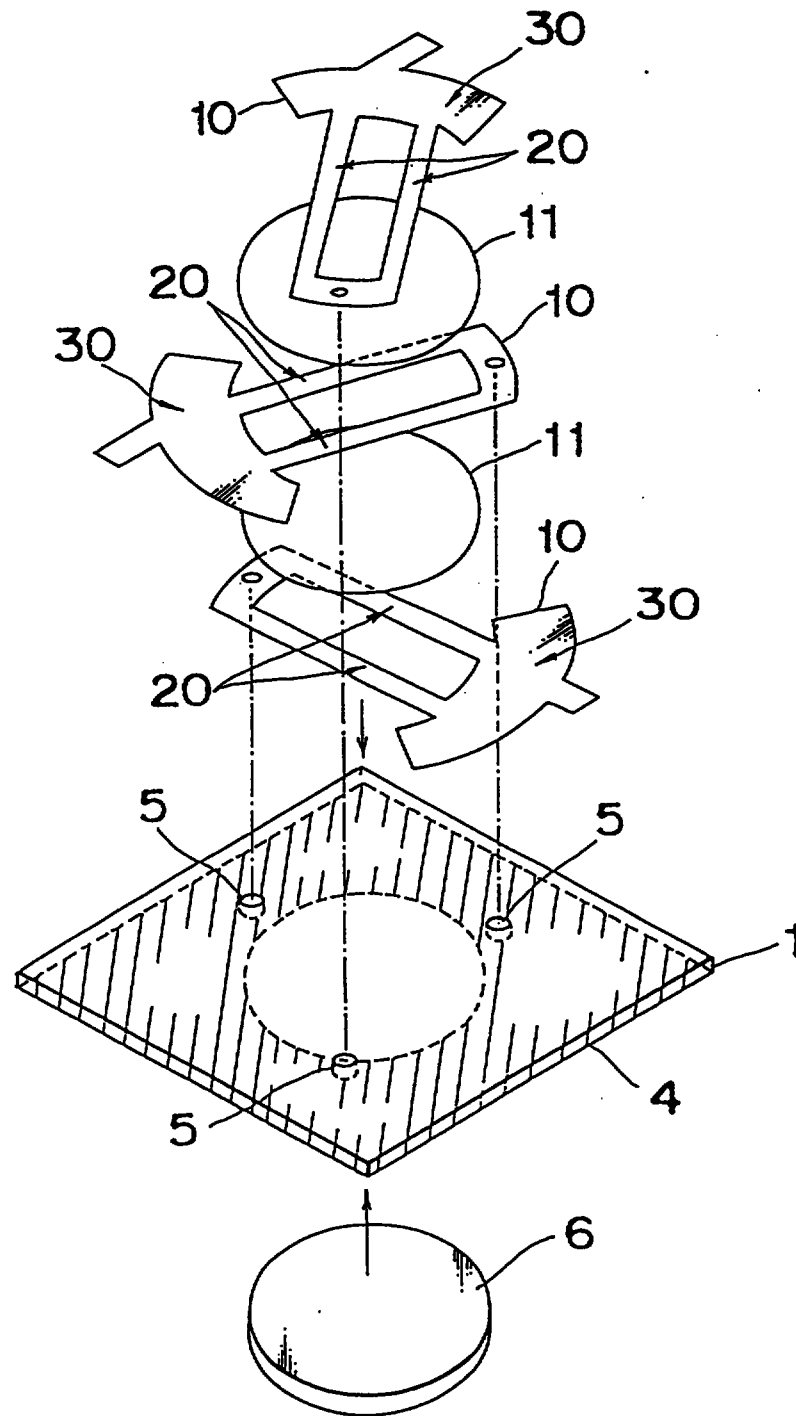


Fig. 57 PRIOR ART



*Fig. 58 PRIOR ART*

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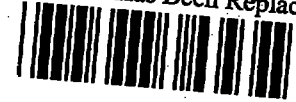


Fig. 59 PRIOR ART

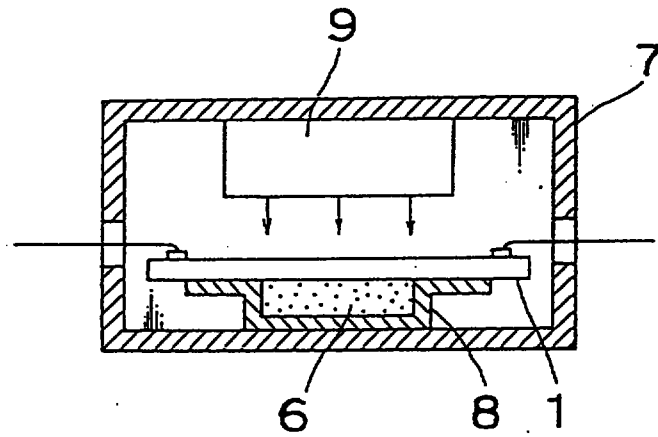
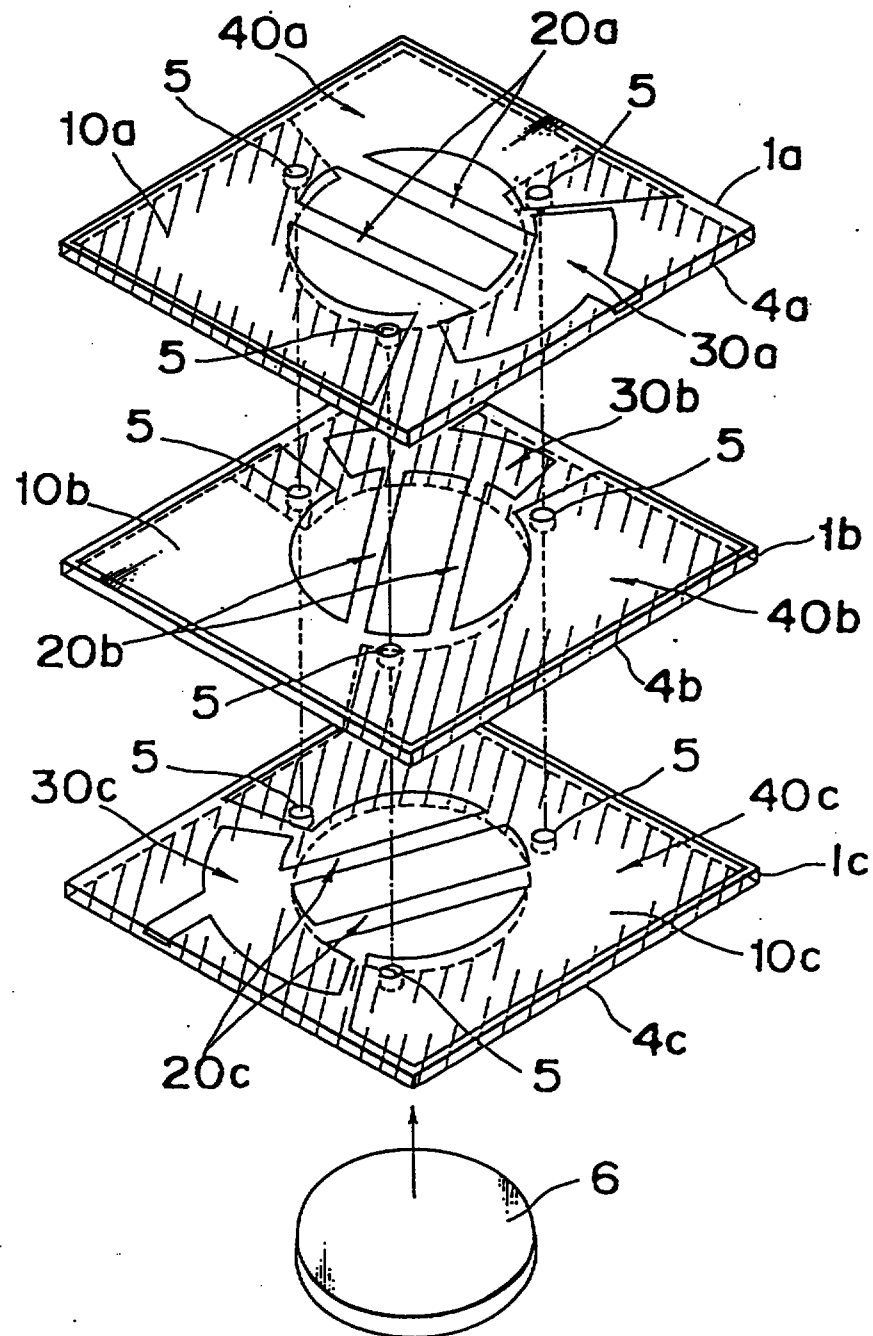


Fig. 60 PRIOR ART

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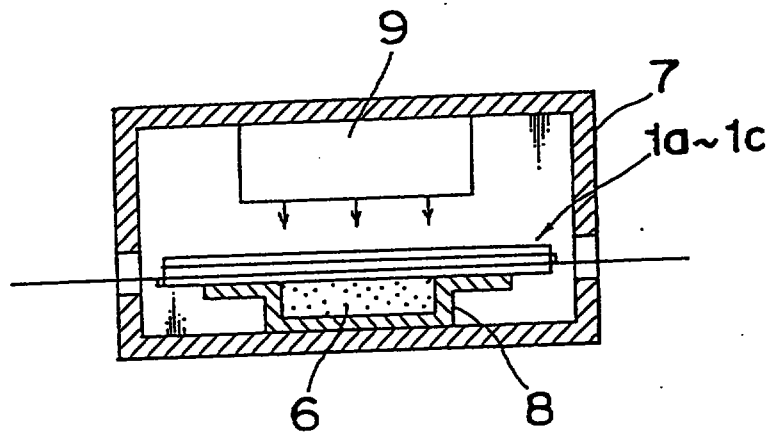


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Fig. 61 PRIOR ART



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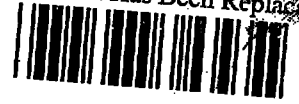
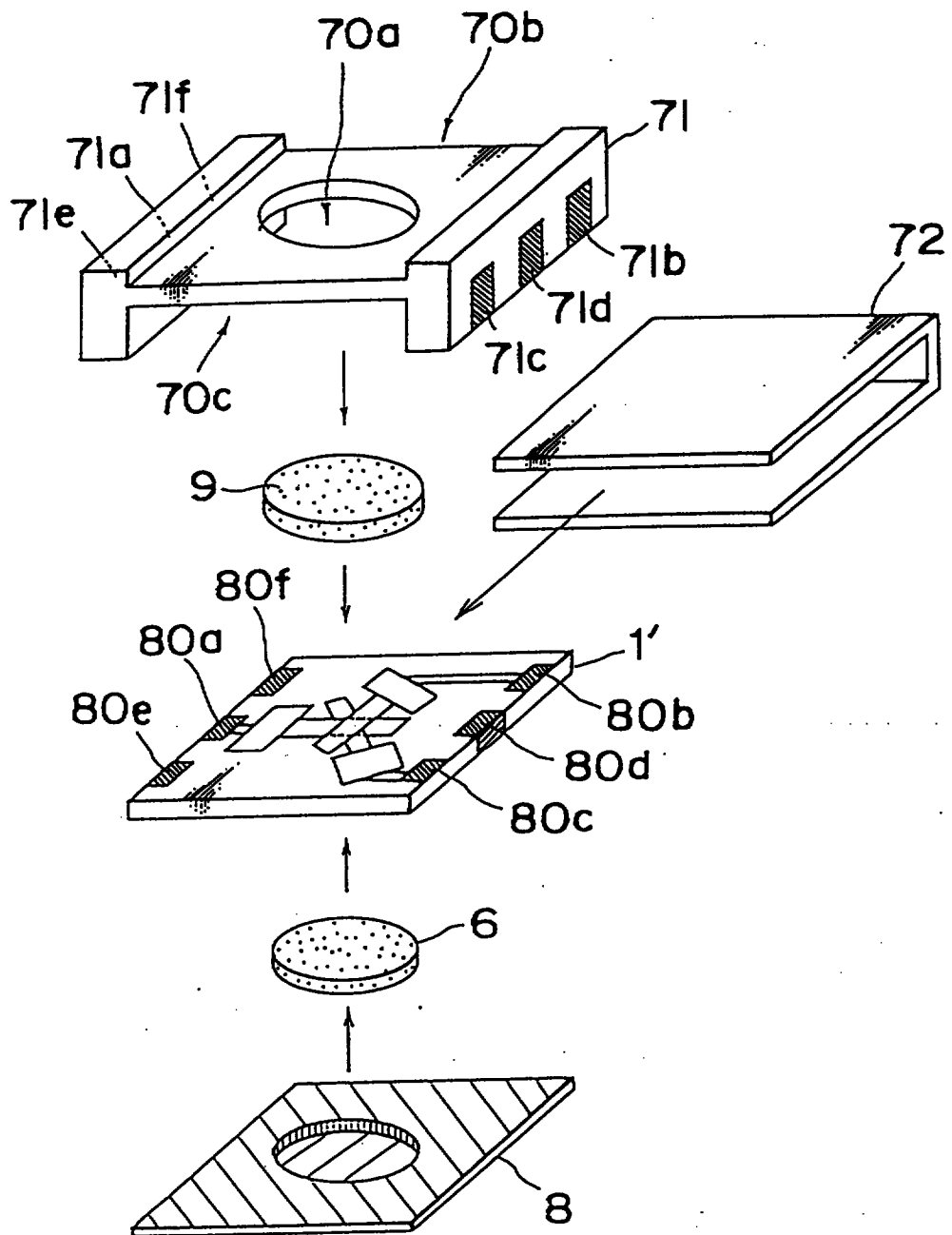


Fig. 62 PRIOR ART



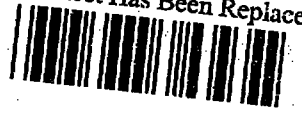
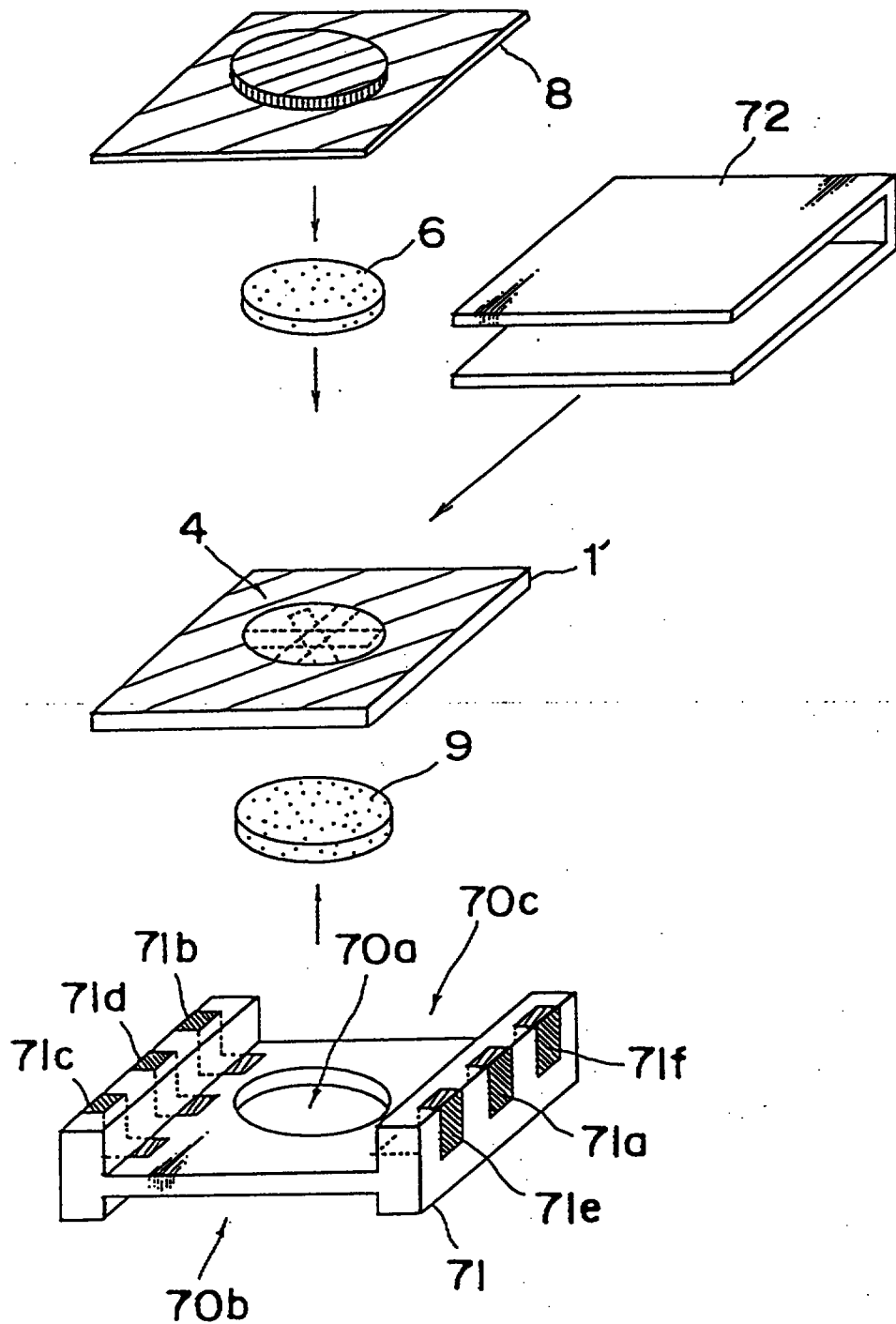


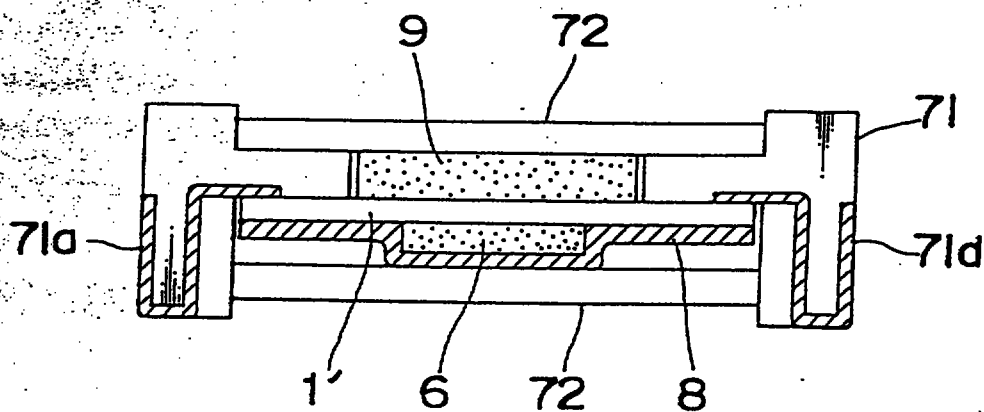
Fig. 63 PRIOR ART



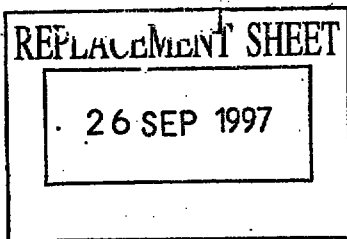
39/39

Fig. 64 PRIOR ART

This Sheet Has Been Replaced



0-20500-3



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☐ Abstract :	paged to paged
DATE OF RECEIPT 26.09.97	

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NON-RECIPROCAL CIRCUIT ELEMENTS AND METHOD THEREOF

The present invention generally relates to non-reciprocal circuit elements and a method of manufacturing them, and more particularly, the improved construction of non-reciprocal circuit elements to be adopted as high-frequency parts of a microwave band such as isolators, circulators, and a method of manufacturing them.

Generally, non-reciprocal circuit elements such as isolators, circulators or the like have such a function as the attenuation is hardly effected in the transmission direction of signals, and the attenuation becomes larger in an opposite direction to it. The non-reciprocal circuit elements are adopted in a transmission circuit portion of a mobile transmission appliance such as portable telephone, automobile telephone or the like to be used in, for example, a UHF band. Non-reciprocal circuit elements to be adopted in the mobile communication appliance is demanded to be smaller in size and lighter in weight, considering the uses thereof. Conventionally the methods of intensively disposing central electrodes and matching circuits on one basic plate are variably proposed. The construction of such a non-reciprocal circuit element will be described hereinafter.

(1) First Prior Art

Fig. 56 and Fig. 57 are views showing the construction in a first example (hereinafter referred to as a first prior art) of the conventional circulator. Especially,

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Fig. 56 is a perspective view of the essential portions thereof, and Fig. 57 is a sectional view thereof. Three sets of central electrodes 2a, 2b are disposed at given angle intervals so that they may not come into contact against one another, and may not cross with respect to one another, as shown in Fig. 56, on the surface of the dielectric basic plate 1 of ceramic or the like. Three sets of central electrodes 2c, 2d are disposed at given angle intervals, so that they may not come into contact against one another, and may not cross with respect to one another similarly, on the reverse face of the dielectric basic plate 1 of ceramic. The respective central electrodes 2a, 2b are respectively connected with the respective central electrodes 2c, 2d of the reverse face corresponding through a through hole 5. Three capacity electrodes 3 are formed integrally with the central electrodes 2a, 2b around the respective central electrodes 2a, 2b on the surface of the dielectric basic plate 1. An earthing electrode 4 is formed integrally with the central electrodes 2c, 2d around the respective central electrodes 2c, 2d on the reverse face of the dielectric basic plate 1. The respective capacity electrodes 3 become opposite to the earthing electrode 4 with the dielectric basic plate 1 being existed between them so as to constitute a capacitor for matching circuit use.

As shown in Fig. 57, the dielectric basic plate 1

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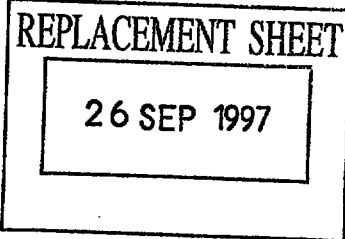
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is accommodated into the interior of a metallic made yoke 7. An earth plate 8 is disposed in the lower portion of the dielectric basic plate 1 in contact with the earth electrode 4 on the reverse face of the dielectric basic plate 1. An concave portion is provided in the central portion of the earth plate 8 with a ferrite plate 6 being engaged into the concave portion. The ferrite plate 6 is positioned in the lower portion of the respective central electrodes so as to help the inductive coupling of the respective central electrodes. A magnet 9 is fixed onto the inner ceiling face of the yoke 7. The magnet 9 applies a direct current magnetic field with respect to each of the central electrodes.

(2) Second Prior Art

Fig. 58 and Fig. 59 show the construction of a second example (hereinafter referred to as a second prior art) of the conventional circulator. Especially, Fig. 58 is a perspective view of the essential portions thereof, and Fig. 59 is a sectional view thereof. An earth electrode 4 is formed as shown in Fig. 58 on the reverse face of an dielectric basic plate 1 such as ceramic or the like. Three electrode film of pattern shapes 10 and two insulating sheets 11 are alternately formed by the repetition of printing and co-firing operations to be sintered on the surface of the dielectric basic plate 1. Each of the electrode films of pattern shapes 10 has a central electrode portion 20 and a



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capacity electrode portion 30. One end of each of the central central electrodes 20 is connected with the earth electrode 4 on the reverse face respectively through a through hole 5. Each of the capacity electrode portions 30 is opposite to the earth electrode 4 with the dielectric basic plate 1 being existed therebetween so as to constitute a capacitor for matching circuit use.

The sectional construction of a second prior art is similar to the sectional construction of the above described first conventional art as shown in Fig. 59.

(3) Third Prior Art

Fig. 60 and Fig. 61 are views showing the construction of a third example (hereinafter referred to as to a third prior art) of the conventional circulator. Especially, Fig. 60 is a perspective view of the essential portions thereof, and Fig. 61 is a sectional view thereof. Electrode films of pattern shapes 10a, 10b and 10c are respectively formed by the printing operation on the surfaces of the dielectric basic plates 1a, 1b and 1c of a ceramic or the like. The earth electrodes 4a, 4b and 4c are respectively formed by the printing operation on the reverse face of the dielectric basic plates 1a, 1b and 1c. The electrode films of pattern shapes 10a, 10b and 10c respectively include central electrode portions 20a, 20b and 20c, capacity electrode portions 30a, 30b and 30c, earth electrode portions

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40a, 40b and 40c. The dielectric electrode basic plates 1a, 1b and 1c are individually fired, and thereafter are adhered under pressure into a multi-layer basic plate. The earth electrode portions 40a, 40b, 40c, and earth electrodes 4a, 4b, 4c are connected with respect to one another through through holes 6. Each of the capacity electrode portions 30a, 30b and 30c respectively become opposite to the earth electrodes 4a, 4b and 4c with the dielectric basic plates 1a, 1b and 1c being existed therebetween so as to constitute a capacitor for matching circuit use.

The sectional construction of a third prior art is almost similar to the sectional construction of the above described first prior art as shown in Fig. 61.

(4) Fourth Conventional Art

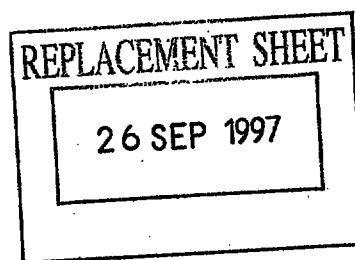
Fig. 62 through Fig. 64 are views showing the construction of a fourth example (hereinafter referred to as to a fourth prior art) of the conventional circulator. Especially Fig. 62 is an explosive perspective view seen from the top side thereof. Fig. 63 is an explosive perspective view seen from below. Fig. 64 is a sectional view thereof. Referring now to Fig. 62 through Fig. 64, a central electrode, and a capacitor for matching circuit use and so on are formed on the dielectric basic plate 1' as in the above described first through third prior arts. Input, output terminals 80a, 80b, 80c formed on the surface of the dielectric basic plate

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1' are connected with the one side electrode of each capacitor for matching circuit use. The earth terminals 80d, 80e, 80f are connected with the earth electrode 4 formed on the reverse face of the dielectric basic plate 1'. A case 71 composed of resin moldings is selected into an approximately "H" character in sectional shape with a through hole 70a for inserting a magnet 9 being formed in the central portion thereof. A dielectric basic plate 1' is disposed in the lower side concave portion 70c of the case 71. A ferrite plate 6 and an earth plate 8 are disposed further under the dielectric basic plate. A metallic made magnetic yoke 72 is engaged into the upper, lower concave portions 70b, 70c of the case 71 so as to have a magnet 9, a dielectric basic plate 1', a ferrite plate 6 and an earth plate 8 existed therebetween. Thereafter, the magnetic yoke 72 is fixed to the case 71. External connecting terminals 71b, 71c, 71d are formed on the one side side face of the case 71, and external connecting terminals 71a, 71e, 71f are formed on the other-way side face. The respective external connecting terminals 71a through 71f go round onto the reverse face of the case 71 as shown in Fig. 63 and Fig. 64, thereafter, extend through the interior of the case 71 and are exposed onto the ceiling face of the lower side concave portion 70c of the case 71. The input, output terminals 80a through 80c respectively come into contact against the external connecting terminals 71a through 71c.



The earth terminals 80d through 80f respectively come into contact against the external connecting terminals 71d through 71f.

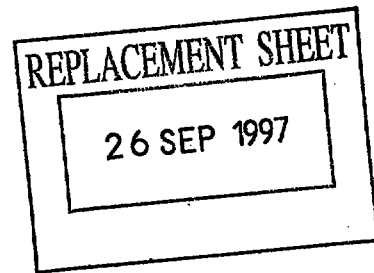
According to the construction of the above described fourth prior art, the circulator can be mounted on the external circuit basic plate without a bothersome wiring operation. Namely, the respective external connecting terminals 71a through 71f have only to be soldered onto the circuit basic plate with the case 71 being placed on the external circuit basic plate. The fourth prior art is capable of surface mounting operation onto the circuit basic plate in this manner.

The first through fourth prior arts described hereinabove have such various problems as described herein-after.

(1) First Prior Art Problem

a. Through holes are required without fail for a crossing operation so that the respective central electrodes may not be short-circuited with respect to one another, thus resulting in complicated construction and higher cost.

b. Width of the central electrode has to be made narrower in order to prevent the short-circuiting operation among the central electrodes. Therefore, the loss at the central electrode increases, thus resulting in deteriorated electric characteristics.



c. The capacity electrodes 3 are disposed around the respective central electrodes 2a, 2b. Area of the capacity electrodes 3 has to be made larger in order to obtain necessary capacity values so that the construction of the whole elements is made larger in size.

d. Twice co-firing steps to be sintered, namely, a co-firing step to be sintered of a dielectric basic plate 1, and a co-firing step to be sintered of an electrode printed on the dielectric basic plate 1 are required, thus resulting in complicated manufacturing step and longer manufacturing time.

e. A wiring operation is required between the dielectric basic plate and the circuit basic plate in the mounting operation on the external circuit basic plate, thus resulting in complicated and troublesome mounting operation..

(2) Second Prior Art Problem

a. Capacity electrode portions 30 are disposed around the respective central electrode portions 20. Area of the capacity electrode portions 30 has to be made larger so as to obtain the necessary capacity value, thus resulting in larger size in the whole element.

b. The co-firing step to be sintered of the respective electrode films of pattern shapes 10 and the respective insulating sheets 11 are repetitively required to be effected, thus resulting in complicated manufacturing step and longer manufacturing time.

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c. A wiring operation is required between the dielectric basic plate and the circuit basic plate in the mounting operation on the external circuit basic plate, thus resulting in complicated and troublesome mounting operation.

(3) Third Prior Art Problem

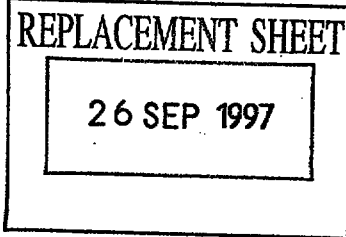
a. The capacity electrodes 30a through 30c are disposed around the respective central electrodes 20a through 20c. Area of the capacity electrodes 30a through 30c has to be made larger in order to obtain the necessary capacity value so that the construction of the whole element is made larger in size.

b. The co-firing step to be sintered for each of the respective dielectric basic plates 1a through 1c is repetitively required to be effected, thus resulting in complicated manufacturing step and longer manufacturing time. .

c. Connecting locations are so more that reliability is inferior. _

d. It is difficult to make thinner each of the dielectric basic plates 1a through 1c. Therefore, the thickness of the whole element becomes larger and the intervals between the central electrodes located on the lower layer and the upper layer become too far, so that the mutual electric equivalent property (balance) of the central electrodes are deteriorated.

e. A wiring operation is required between the dielectric basic plate and the circuit basic plate in the mounting operation of non-reciprocal circuit element on the external



circuit basic plate, thus resulting in complicated and troublesome mounting operation.

(4) Fourth Prior Art Problems

a. Similar problems to the above described first through third prior arts are caused due to the construction of the dielectric basic plate 1' and the respective electrode films of pattern shapes to be formed on it.

b. Although such troublesome wiring operation as in the first through third prior arts becomes unnecessary because of possible surface mounting, the input, output terminals 80a through 80f on the dielectric basic plate 1' have to be soldered to the external connecting terminals 71a through 71f of the case 71 so as to increase the assembling steps, thus becoming higher in cost. As there is a risk of disengaging the soldered portions or melting them with heating, the reliability is lowered.

c. As the number of the parts is more, the elements become larger in size, thus becoming higher in price.

SUMMARY OF THE INVENTION

Accordingly, the present invention has been developed with a view to substantially eliminating the above discussed problems provided in the above described first through fourth prior arts, and has for its essential object to provide improved non-reciprocal circuit elements.

Another important object of the present invention

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is to provide improved non-reciprocal circuit elements which are smaller in size, lower in price, higher in reliability and easier to manufacture, and a method of manufacturing them.

Accordingly the present invention provides a non-reciprocal circuit element for high frequency use which has a small attenuation degree in a signal transmission direction and a larger attenuation degree in an opposite direction, the circuit element comprising a plurality of dielectric sheets having electrode films of pattern shapes formed thereon, the dielectric sheets being laminated and co-fired to form a dielectric basic plate and at least one of the dielectric sheets comprising a capacitor electrode pattern without a central electrode pattern.

In such construction, the smaller size and higher performance of the whole element are designed by the laminating disposition of a plurality of electrode films of pattern shapes within one dielectric basis plate. Namely, as the internal circuit disposed conventionally in plane can be disposed with microwave within the dielectric basic plate, the circuit area of the whole element can be made smaller. As the respective electrode films of pattern shapes can be crossed without mutual contact within the interior of the dielectric basic plate, the insertion loss can be reduced without requirement of the narrower central electrode width as in the first prior art. As the construction is integral,

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sufficiently larger strength can be retained even if the arrangement is made with the intervals among the respective electrode films of pattern shapes are made extremely close. As a result, the electric symmetrical property among the respective central electrodes can be maintained in better condition.

The electrode films of pattern shapes include at least one central electrode pattern, at least one capacitor electrode pattern, at least one earth electrode pattern and, in the interior of the dielectric basic plate, the capacitor electrode films of pattern shapes and the earth electrode films of pattern shapes are alternately disposed with dielectric material existing between them, the respective capacitor electrode films of pattern shapes are connected in common and connected with the corresponding central electrode films of pattern shapes, and the respective earth electrode films of pattern shapes are connected in common, so that at least one matching circuit capacitor is disposed in lamination among the central electrode films or pattern shapes and the earth electrode films of pattern shapes.

In such construction, the capacitor electrode films of pattern shapes and the earth electrode film of pattern shapes are alternately disposed with dielectrics being inserted therebetween, the respective capacitor electrode films of pattern shapes are connected in common and are connected with the corresponding central electrode films of pattern shapes, further one matching circuit capacitor

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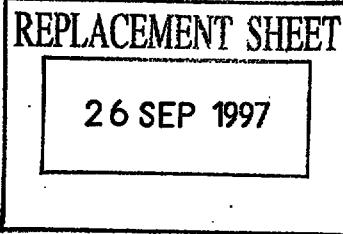
or more are disposed in lamination between the central electrode films of pattern shapes and the earth electrode films of pattern shapes by the common connection between the respective earth electrode films of pattern shapes. Capacity value necessary as the matching circuit can be retained with smaller circuit area so that the smaller size of the whole element can be designed.

The invention further provides a non-reciprocal circuit element for high frequency use which has a small attenuation degree in a signal transmission direction and a larger attenuation degree in an opposite direction, the circuit element comprising a dielectric basic plate formed by the integration of a plurality of co-fired dielectric green sheets adhered under pressure in lamination, a plurality of electrode films of pattern shapes formed on the dielectric green sheets and disposed in lamination within the dielectric basic plate, a plurality of external connecting terminals formed on the dielectric green sheets and connected to the given electrode films of pattern shapes and disposed so that an exposing operation is effected on the outer periphery of the dielectric basic plate, so that the internal circuits and the external connecting terminals are integral with the dielectric basic plate and at least one of the dielectric sheets has a capacitor electrode pattern without a central electrode pattern.

In such construction, a plurality of external connecting terminals connected with a plurality of

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electrode films of pattern disposed in lamination and a plurality of external connecting terminals connected with the given electrode films of pattern shapes are fired simultaneously with a plurality of dielectric green sheets pressed under pressure in lamination and are integrated with one dielectric basic plate so as to design smaller size of the elements, lower cost, higher reliability and simplifier operation of the assembling steps. As not only the electrode films of pattern shapes, but also the external connecting terminals are also integrated on one dielectric basic plate, the number of the parts can be considerably reduced and the smaller size of the element can be made. As the number of assembling steps is reduced, the cost can be lowered. As the connecting locations with the soldering operations can be considerably reduced, the reliability can be improved. As the internal circuit conventionally disposed in plane can be disposed with microwave within the dielectric basic plate, the circuit area of the whole element can be reduced. As the respective electrode films of pattern shapes can be crossed without mutual contacting within the dielectric basic plate, the insertion loss can be reduced without narrower width of the central electrode as in the first conventional art. As the construction is integral, sufficiently larger strength can be retained even if the arrangement is made with the intervals among the respective electrode films of pattern shapes are made extremely close. As a result,



the electric symmetrical property among the respective central electrodes can be maintained in better condition. As the dielectric basic plate, the respective electrode films of pattern shapes, and the respective external connecting terminals are formed at the same time in one co-firing step to be sintered, the manufacturing time can be considerably shortened.

The dielectric basic plate has a first main side surface and an opposite main side surface, and a first concave portion for engaging a magnet for applying a direct current magnetic field is formed on the first main side surface.

In such construction, a compacter non-reciprocal circuit element is provided by the formation of a first concave portion for engaging a magnet for direct current magnetic field applying use on one side main surface of the dielectric basic plate.

The dielectric basic plate has a first main side surface and an opposite main side surface, and a concave portion for engaging a ferrite plate for inductive coupling use of the internal circuits is formed on the opposite main side surface.

In such construction, a second concave portion for engagement of the inductive coupling ferrite plate of the internal circuit is formed in the other-way main surface of the dielectric basic plate so that a non-reciprocal circuit element which is compacter and lower in price can be obtained.

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The invention further provides a method of manufacturing a non-reciprocal circuit element for high frequency use having a small attenuation degree in a signal transmission direction and a larger attenuation degree in an opposite direction, comprising adhering under pressure in lamination a plurality of dielectric green sheets with given electrode films of pattern shapes being formed respectively on them so as to obtain the green sheet laminating bodies, co-firing the green sheet laminating bodies so as to integrate them as one dielectric basic plate to form a non-reciprocal circuit element with internal circuits disposed in lamination within the one dielectric basic plate and at least one of the dielectric green sheets having a capacitor electrode pattern without a central electrode pattern.

The method may further comprise forming a central electrode and the dielectric basic plate at the same time by sintering in the one co-firing step.

In such construction, a plurality of dielectric green sheets with given electrode films of pattern shapes being formed on each of them are fired collectively after being adhered under pressure in lamination so as to be integrated in one dielectric basic plate. As the dielectric basic plate and the internal circuit are simultaneously formed by one co-firing step to be sintered, the manufacturing time can be considerably reduced.

The method may further comprise forming a central electrode, a matching circuit to be connected with it and the dielectric basic plate at the same time by sintering in said one co-firing step.

In such construction, the central electrodes and the dielectric basic plates are formed at the same time by one co-firing step to be sintered.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and features of the present invention will become apparent from the following description taken in conjunction with the preferred embodiment thereof with reference to the accompanying drawings, in which:-

Fig. 1 is a perspective view of the essential portions of a circulator in accordance with a first embodiment of the present invention;

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Fig. 2 is a sectional view of a circulator in accordance with the first embodiment of the present invention;

Fig. 3 shows illustrating views for illustrating the manufacturing step of a dielectric basic plate to be used in one embodiment of the present invention, showing the condition of a ceramic green sheet before the lamination and co-firing operations to be sintered;

Fig. 4 is a top face view of a first ceramic green sheet;

Fig. 5 is a top face view of a second ceramic green sheet;

Fig. 6 is a top face view of a third ceramic green sheet;

Fig. 7 is a top face view of a fourth ceramic green sheet;

Fig. 8 is a top face view of a fifth ceramic green sheet;

Fig. 9 is a top face view of a sixth ceramic green sheet;

Fig. 10 is a top face view of a seventh ceramic green sheet;

Fig. 11 is a top face view of an eighth ceramic green sheet;

Fig. 12 is a top face view of a ninth ceramic green sheet;

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Fig. 13 is a top face view of a tenth ceramic green sheet;

Fig. 14 is a top face view of an eleventh ceramic green sheet;

Fig. 15 is a top face view of a twelfth ceramic green sheet;

Fig. 16 is a top face view of a thirteenth ceramic green sheet;

Fig. 17 is a top face view of a fourteenth ceramic green sheet;

Fig. 18 is a bottom face view of the fourteenth ceramic green sheet;

Fig. 19 is an explosive perspective view of a circulator in accordance with a second embodiment of the present invention;

Fig. 20 is a sectional view of a circulator in the second embodiment of the present invention;

Fig. 21 is a perspective view of the essential portions of a circulator in accordance with a third embodiment of the present invention;

Fig. 22 is a sectional view of a circulator in accordance with a third embodiment of the present invention;

Fig. 23 shows illustrating views for illustrating a manufacturing step of a dielectric basic plate to be used in the third embodiment of the present invention, showing the

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laminating relation of the ceramic green sheet before the co-firing operation to be sintered;

Fig. 24 is a top face view of a first ceramic green sheet;

Fig. 25 is a top face view of a second ceramic green sheet;

Fig. 26 is a top face view of a third ceramic green sheet;

Fig. 27 is a top face view of a fourth ceramic green sheet;

Fig. 28 is a top face view of a fifth ceramic green sheet;

Fig. 29 is a top face view of a sixth ceramic green sheet;

Fig. 30 is a top face view of a seventh ceramic green sheet;

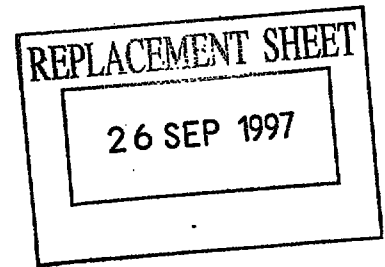
Fig. 31 is a top face view of an eighth ceramic green sheet;

Fig. 32 is a top face view of a ninth ceramic green sheet;

Fig. 33 is a top face view of a tenth ceramic green sheet;

Fig. 34 is a top face view of an eleventh ceramic greens sheet;

Fig. 35 is a top face view of a twelfth ceramic



green sheet;

Fig. 36 is a top face view of a thirteenth ceramic green sheet;

Fig. 37 is a top face view of a fourteenth ceramic green sheet;

Fig. 38 is a top face view of a fifteenth ceramic green sheet;

Fig. 39 is a top face view of a sixteenth ceramic green sheet;

Fig. 40 is a top face view of a seventh ceramic green sheet;

Fig. 41 is a top face view of an eighteenth ceramic green sheet;

Fig. 42 is a top face view of a nineteenth ceramic green sheet;

Fig. 43 is as top face view of a twentieth ceramic green sheet;

Fig. 44 is a top face view of a twenty first ceramic green sheet;

Fig. 45 is a top face view of a twenty second ceramic green sheet;

Fig. 46 is a top face view of a twenty third ceramic green sheet;

Fig. 47 is a top face view of a twenty fourth ceramic green sheet;

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Fig. 48 is a top face view of a twenty fifth ceramic green sheet;

Fig. 49 is a top face view of a twenty sixth ceramic green sheet;

Fig. 50 is a top face view of a twenty seventh ceramic green sheet;

Fig. 51 is a top face view of a twenty eighth ceramic green sheet;

Fig. 52 is a top face view of a twenty ninth ceramic green sheet;

Fig. 53 is a top face view of a thirty ceramic green sheet;

Fig. 54 is a top face view of a thirty first ceramic green sheet;

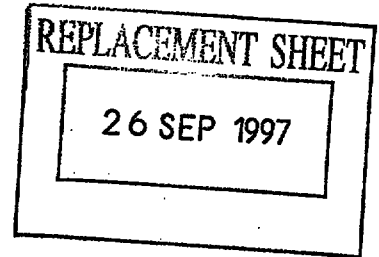
Fig. 55 is a top face view of a thirty second ceramic green sheet;

Fig. 56 is a perspective view of the essential portions of a circulator in accordance with a first conventional art;

Fig. 57 is a sectional view of a circulator in accordance with the first conventional art;

Fig. 58 is an explosive perspective view of the essential portions of a circulator in accordance with a second conventional art;

Fig. 59 is a sectional view of a circulator in



accordance with the second conventional art;

Fig. 60 is a perspective view of the essential portions of a circulator in accordance with a third conventional art;

Fig. 61 is a sectional view of a circulator in accordance with the third conventional art;

Fig. 62 is an explosive perspective view of the essential portions seen from the top side of a circulator in accordance with a fourth conventional art;

Fig. 63 is an explosive perspective view seen from the reverse side of a circulator in accordance with the fourth conventional art; and

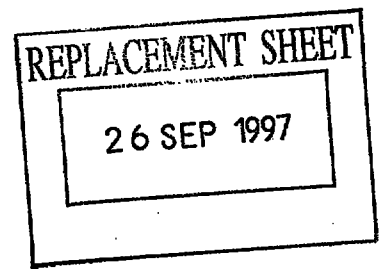
Fig. 64 is a sectional view of a circulator in accordance with the fourth conventional art.

DETAILED DESCRIPTION OF THE INVENTION

Before the description of the present invention proceeds, it is to be noted that like parts are designated by like reference numerals throughout the accompanying drawings.

(First Embodiment)

Fig. 1 through Fig. 18 are views showing the construction of a circulator in accordance with a first embodiment of the present invention. Especially Fig. 1 is a perspective view of the essential portions of a circulator. Fig. 2 is a sectional view of a circulator. Fig. 3 is a perspective view for illustrating a manufacturing step of a

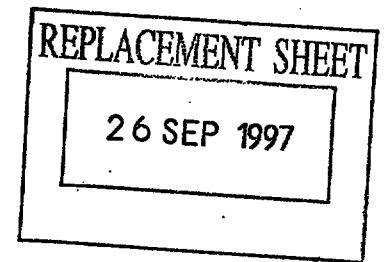


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dielectric basic plate. Fig. 4 through Fig. 18 are plan views showing an electrode pattern in each ceramic green sheet. One embodiment of the present invention will be described hereinafter with reference to these Fig. 1 through Fig. 18.

As shown in Fig. 1 and Fig. 2, a dielectric basic plate 100 is accommodated in the interior of a metallic made yoke 7. An earth plate 8 is disposed under the dielectric basic plate 100, with the earth plate 8 being in contact against the earth electrode 4 on the reverse face of the dielectric basic plate 100. A concave portion is provided in the central portion of the earth plate 8, with a ferrite plate 6 being engaged into the concave portion. The ferrite plate 6 is positioned in the lower portion of each central electrode so as to help the inductive coupling of each central electrode. A magnet 9 is secured to the internal ceiling face of the yoke 7. The magnet 9 applies a direct current magnetic field with respect to each central electrode.

The above described dielectric basic plate 100 is collectively fired and composed as shown in Fig. 3 after a plurality of ceramic green sheets 101 through 114 with given electrode films of pattern shapes being formed respectively on them are laminated, and adhered under pressure. The ceramic green sheets are thin type (normally of several 10 μ or so) of sheet shaped member having flexibility to be obtained by, for example, an extrusion molding with ceramic



powder unfired or temporarily fired being mixed, kneaded with an organic solvent which is a binder. A material having Q high in high frequency region and high $\epsilon\tau$ (for example, $\epsilon\tau = 20$ through 100), for example, dielectric material of MgTiO_3 - CaTiO_3 series, ZrO_2 - SnO_2 - TiO_2 series, BaTi_4O_9 series, $\text{Nd}_2\text{Ti}_2\text{O}_7$ - (BaPbTiO_3 - TiO_2 series is used as a ceramic green sheet material. The formation of the respective electrode pattern is formed by, for example, printing, evaporating operations and so on with Pd, Pt and so on in terms of sintering temperature of the dielectric material. The respective ceramic green sheets 101 through 114 are fused, integrated after collective co-firing operation to be sintered into one dielectric basic plate 100.

As shown in Fig. 4, Fig. 6, Fig. 8, Fig. 10, Fig. 12, Fig. 16, earth electrode films of pattern shapes 401, 403, 405, 407, 409, 413 on the same form are formed respectively on the surfaces of the ceramic green sheets 101, 103, 105, 107, 109, 113. As shown in Fig. 18, an earth electrode pattern 414 on the same form as the respective earth electrode films of pattern shapes is formed on the reverse face of the ceramic green sheet 114. As shown in Fig. 5, Fig. 7, Fig. 9, Fig. 11, Fig. 17, capacity electrode films of pattern shapes 302a through 302c, 304a through 304c, 306a through 306c, 308a through 308c, 314a through 314c on the same form are formed respectively on the surfaces of ceramic green sheets 102, 104,

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106, 108, 114.

Electrode films of pattern shapes 710, 711, 712 on approximately the same form are formed respectively on the surfaces of the ceramic green sheets 110, 111, 112. Respective electrode films of pattern shapes 710 through 712 are disposed each being shifted at an angular interval of 120° with respect to one after. The electrode pattern 710 includes a central electrode portion 210, a capacity electrode portion 310, an earth electrode portion 410, a wiring portion 810. The electrode pattern 711 includes a central electrode portion 211, a capacity electrode portion 311, an earth electrode portion 411, a wiring portion 811. An electrode pattern 712 includes a central electrode portion 212, a capacity electrode portion 312, an earth electrode portion 412, a wiring portion 812. Capacity electrode portions 310, 311, 312 are respectively connected with one end of the central electrode portions 210, 211, 212. Earth electrode portions 410, 411, 412 are respectively connected with the other end of the central electrodes 210, 211, 212. Capacity electrode portions 310, 311, 312 are respectively drawn out so far as the end portions of the ceramic green sheets 110, 111, 112 through the wiring portions 810, 811, 812.

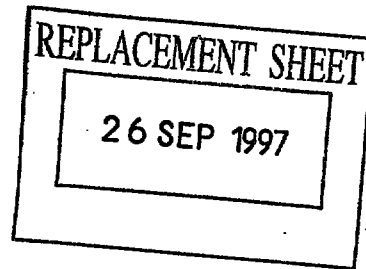
Capacity electrode films of pattern shapes 302a, 304a, 306a, 308a, 314a and the capacity electrode portion 310 are connected with each other through a through hole 5a.

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Capacity electrode films of pattern shapes 302b, 304b, 306b, 308b, 314b and the capacity electrode portion 311 are connected with each other through a through hole 5b. The capacity electrode films of pattern shapes 302c, 304c, 306c, 308c, 314c and the capacity electrode 312 are connected with each other through a through hole 5c. The earth electrodes films of pattern shapes 401, 403, 405, 407, 409, 413, 414 and the earth electrode portions 410, 411, 412 are connected with each other through through holes 5d, 5e, 5f.

In such construction as described hereinabove, the capacity electrode pattern 302a forms a first capacitor by the opposition between the earth electrode films of pattern shapes 401 and 403. The capacity electrode pattern 304a forms a second capacitor by the opposition between the earth electrode films of pattern shapes 403 and 405. The capacity electrode pattern 306a forms a third capacitor by the opposition between the earth electrode films of pattern shapes 405 and 407. The capacity electrode pattern 308a forms a fourth capacitor by the opposition between the earth electrode films of pattern shapes 407 and 409. Capacity electrode 310 forms a fifth capacitor by the opposition between the earth electrodes portions 409 and 411. The capacity electrode pattern 314a forms a sixth capacitor by the opposition between the earth electrode films of pattern shapes 413 and 414. The first through sixth capacitors for constituting a matching circuit



are connected in parallel between one end of the central electrode portion 210 and the earth, and are inserted. This is because the respective one side electrodes 302a, 304a, 306a, 308a, 310, 314a of the first through sixth capacitors are connected with one end of the central electrode portion 210 in common through a through hole 5a. The respective other-way electrodes 401, 403, 405, 407, 409, 411, 412, 413, 414 of the first through sixth capacitors are commonly connected with the earth through through holes 5d, 5e, 5f. Similarly, six capacitors for matching circuit use are connected in parallel and inserted between the central electrode portion 211 and the earth, and six capacitors for matching circuit use are connected in parallel and are inserted between the central electrode portion 212 and the earth.

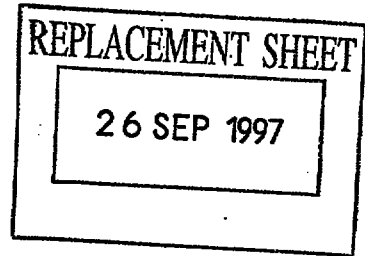
- As a plurality of capacitors connected in parallel are laminated and disposed between the one end of the respective central electrode portions 210 through 212 and the earth as described hereinabove, the capacity value necessary as the matching circuit can be retained with small circuit area. Accordingly, the construction of the whole element can be made smaller in size. In the above described embodiment, the co-firing operation to be sintered of the dielectric basic plate, the central electrode, the matching circuit can be completed by one co-firing step to be sintered so that the

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manufacturing step is simplified, and the manufacturing time can be considerably reduced. As a plurality of ceramic green sheet are integrated on one dielectric basic plate 100 by the co-firing operation to be sintered in the above described embodiment, the thickness of the respective ceramic green sheet, namely, the interval among the respective central electrode portions 210 through 212 can be extremely narrowed without strength problem. As a result, the electrical symmetry of the respective central electrode portions 210 through 212 can be made better.

As shown in Fig. 1, side face electrodes 800a, 800b, 800c are formed on the side face of the dielectric basic plate 100. The side face electrode 800a is connected with the wiring portion 810 of Fig. 13, the side face electrode 800b is connected with the wiring portion 811 of Fig. 14, the side face electrode 800c is connected with the wiring portion 812 of Fig. 15. In the respective ceramic green sheets, blank portions 401a, 403a, 405a, 407a, 409a, 411a, 412a, 413a, 414a are formed, on the earth electrode pattern or the earth electrode portion, so as to surround the periphery of the side face electrode 800a. Blank portions 401b, 403b, 405b, 407b, 409b, 410b, 412b, 413b, 414b are formed so as to surround the periphery of the side face electrode 800b. Blank portions 401c, 403c, 405c, 407c, 409c, 410c, 411c, 413c, 414c are formed so as to surround the periphery of the side face



electrode 800c. A blank portion 8a is formed on the earth plate 8 so as to surround the periphery of the side face electrode 800a. A blank portion 8b is formed so as to surround the periphery of the side face electrode 800b. A blank portion 8c is formed so as to surround the periphery of the side face electrode 800c. The short circuiting operation among the respective side face electrodes and the respective earth electrode films of pattern shapes, the respective earth electrode portions and the earth plate 8 are prevented.

An operation of a circulator shown in Fig. 1 and Fig. 2 will be described hereinafter. When a high frequency signal is inputted into the side face electrode 800a, a high frequency magnetic field to be caused around the central electrode portion 210 is rotated by a given angle by the direct current magnetic field from the magnet 9 so as to cause an induced current in, for example, the right-hand adjacent central electrode portion 211 by the inductive coupling through the ferrite plate 6. The high frequency signal to be inputted from the side face electrode 800a is transmitted to the right-hand adjacent side face electrode 800b, but is not transmitted to the left-hand adjacent side face electrode 800c. A high frequency signal to be inputted from the side face electrode 800b is transmitted to the right-hand adjacent side face electrode 800c, but is not transmitted to the left-hand adjacent side face electrode 800a. A high frequency

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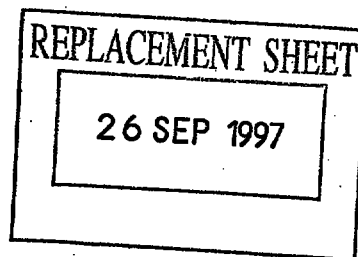
signal to be inputted from the side face electrode 800c is transmitted to the right-hand adjacent side face electrode 800a, but is not transmitted to the left-hand adjacent side face electrode 800b.

A circulator shown in Fig. 1 and Fig. 2 can be used as an isolator if a terminal resistor is connected between any one of wiring portions or the side face electrode (for example, a wiring portion 812 or a side face electrode 800c) and the earth. In this case, the isolator transmits a high frequency signal only in one side direction from the remaining one side side face electrode (for example, a side face electrode 800a) to the remaining other-way side face electrode (for example, a side face electrode 800b).

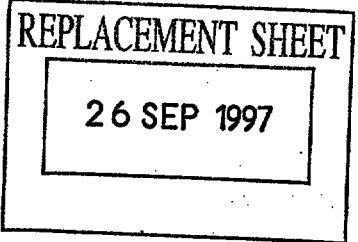
(Second Embodiment)

Fig. 19 and Fig. 20 shows views each showing the construction of a circulator in accordance with a second embodiment of the present invention. Especially, Fig. 19 is an explosive perspective view of a circulator and Fig. 20 is a sectional view of a circulator. The other embodiment of the present invention will be described hereinafter with reference to Fig. 19 and Fig. 20.

In the drawings, a dielectric basic plate 100' is collectively fired, integrated after a plurality of ceramic green sheets with given electrode films of pattern shapes being formed respectively on them are adhered under pressure



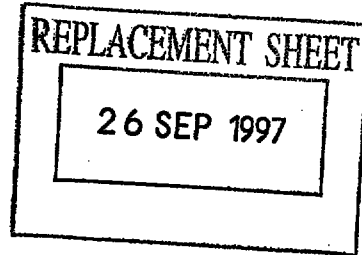
in lamination as in the dielectric basic plate 100 shown in Fig. 1. The connection among the respective capacity electrode films of pattern shapes and the respective capacity electrode portions in the dielectric basic plate 100' are effected through the side face electrodes 800a through 800c without provision of the through holes. Capacity electrode films of pattern shapes 302a, 304a, 306a, 308a, 314a shown in Fig. 5, Fig. 7, Fig. 9, Fig. 11, Fig. 17 and the capacity electrode portion 310 shown in Fig. 13 are respectively provided with wiring portions, and are composed to be exposed on the side face corresponding to the side face electrode 800a. Similarly, the capacity electrode films of pattern shapes 302b, 304b, 306b, 308b, 314b and the capacity electrode portion 311 shown in Fig. 14 are provided respectively with the wiring portions, and are composed so as to be exposed on the side face corresponding to the side face electrode 800b. The capacity electrode films of pattern shapes 302c, 304c, 306c, 308c, 314c and the capacity electrode portion 312 shown in Fig. 15 are respectively provided with wiring portions, and are composed so as to be exposed on the side face corresponding to the side face electrode 800c. Blank portions are provided so as to surround the peripheries of the side face electrodes 800a through 800c on the earth electrode films of pattern shapes 401, 403, 405, 407, 409, 413, 414 and the earth electrode portions 410, 411, 412 on the dielectric basic plate



100' so as to prevent the short-circuiting operation among the respective capacity electrode films of pattern shapes and the respective capacity electrode portions.

The connections of the earth electrode films of pattern shapes 401, 403, 405, 407, 409, 413, 414 and the earth electrode portions 410, 411, 412 are effected through the side face electrodes 800d through 800f without provision of the through holes as in the connection of the capacity electrode pattern and the capacity electrode. The respective side face electrodes 800a through 800c, and 800d through 800f go round the surface of the dielectric basic plate 100' so as to effect the connections among the input, output terminals 71a through 71c and the connecting terminals 71d through 71f formed on the case 71. The surface electrodes 80a through 80c, and 80d through 80f are formed respectively on the surface of the dielectric basic plate 100'.

A case 71 composed of resin moldings is selected into approximately "H" character shape in the sectional shape with a through hole 70a for inserting a magnet being formed in the central portion thereof. The dielectric basic plate 100' is disposed in the concave portion 70c on the lower side of the case 71, and further a ferrite plate 6 and an earth plate 8 are disposed under it. A metallic made magnetic yoke 72 is engaged into the upper, lower concave portions 70b, 70c of the case 71 with the magnet 9, the dielectric basic plate

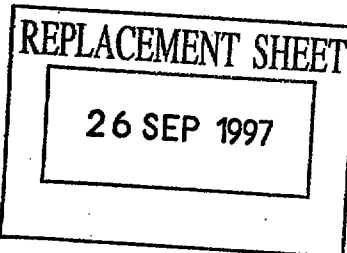


100', the ferrite plate 6 and the earth plate 8 being existed therebetween. Thereafter, the yoke 72 is secured to the case 71.

Input, output terminals 71b, 71c and the earth terminal 71d are formed on one side side face of the case 71. An input, output terminal 71a and the earth terminals 71e, 71f are formed on the other-way side face. (In Fig. 19, as the other-way side face of the case 71 is hidden, the input, output terminal 71a and the earth terminals 71e, 71f are not shown.) The respective input, output terminals 71a through 71c and the earth terminals 71d through 71f extend into the interior of the case 71 as shown in Fig. 20 and are exposed to the ceiling face of the concave portion 70c on the lower side of the case 71. The surface electrodes 80a through 80c are respectively in contact with the input, output terminals 71a through 71c. The surface electrodes 80d through 80f are respectively in contact with the earth terminals 71d through 71f.

A circulator shown in Fig. 19 and Fig. 20 constructed as described hereinabove functions as in a circulator shown in Fig. 1 and Fig. 2, and can be used as an isolator.

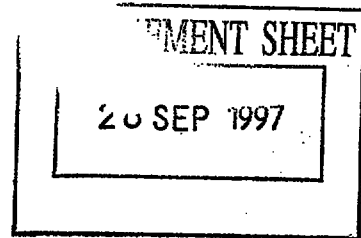
In the embodiment shown in Fig. 19 and Fig. 20, the connections among the respective capacity electrode films of pattern shapes and the respective capacity electrode portions, and the connections among the respective earth electrode films



of pattern shapes and the respective earth electrode portions are designed to be effected with the use of the side face electrode. As in the embodiment shown in Fig. 1 and Fig. 2, these connections can be effected with the through holes.

As a plurality of electrode films of pattern shapes are adapted to be disposed in lamination within one dielectric basic plate in accordance with the invention of the above described embodiment, the smaller size and higher performance of the whole element can be intended. As the internal circuit disposed conventionally in plane can be disposed with microwave within the dielectric basic plate, the circuit area of the whole elements can be made smaller in size. As the respective electrode films of pattern shapes can be crossed without mutual contact within the interior of the dielectric basic plate, the insertion loss can be reduced without the requirement of the narrower width of the central electrode. As the construction is integral, sufficiently larger strength can be retained if the interval among the respective electrode films of pattern shapes are extremely narrowed. Therefore, the electric symmetry among the respective central electrodes is retained in a better condition.

As one capacitor for matching circuit use or more can be disposed in lamination between the central electrode pattern and the earth electrode pattern in accordance with the invention of the above described embodiment, the capacity.

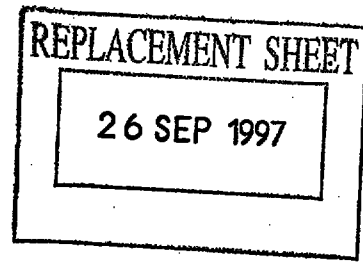


value necessary as the matching circuit can be retained in small circuit area and the size of the whole element can be made smaller.

As a plurality of dielectric green sheets are fired collectively and are integrated into one dielectric basic plate after a plurality of dielectric green sheets are adhered under pressure in lamination with given electrode films of pattern shapes being formed on them in accordance with the invention of the above described embodiment, the dielectric basic plate and the inner circuit can be formed with one co-firing step to be sintered and the manufacturing time can be considerably shortened.

(Third Embodiment)

Fig. 21 through Fig. 55 are views showing the construction of a circulator in accordance with one embodiment of the present invention. Especially, Fig. 21 is a perspective view of the essential portions of the circulator. Fig. 22 is a sectional view of the circulator. Fig. 23 is a perspective view showing the lamination relation of the ceramic green sheet before the co-firing operation to be sintered thereof. Fig. 24 through Fig. 55 are plan views showing the electrode films of pattern shapes in the respective ceramic greens sheets. A third embodiment of the present invention will be described with reference to the Fig. 21 though Fig. 55.



As shown in Fig. 21 and Fig. 22, circular concave portion 200a is formed in the surface central portion of the dielectric basic plate 200, and a circular concave portion 200b is formed in the reverse face central portion. A stage difference concave portion 200c is formed on the reverse face of the dielectric basic plate 200. External connecting terminals Ta through Tf are formed on the side face of the dielectric basic plate 200. A magnet 9 is engaged with the concave portion 200a, and is secured to the dielectric basic plate 200 with binding or the like. A ferrite plate 6 is engaged with the concave portion 200b and is secured to the dielectric basic plate 200 with bonding or the like. The metallic made magnetic yoke 72 is engaged with the dielectric basic plate 200 so as to exist the magnet 9 and the ferrite plate 6 therebetween. As the magnetic yoke 72 is engaged into the stage difference concave portion 200c on the reverse face of the dielectric basic plate 200 at this time, the height of the formed portion of the external connecting terminals Ta through Tf becomes higher than the height of the surface of the magnetic yoke 72 on the reverse face of the dielectric basic plate 200. This makes the surface mounting operation possible to effect onto the circuit basic plate.

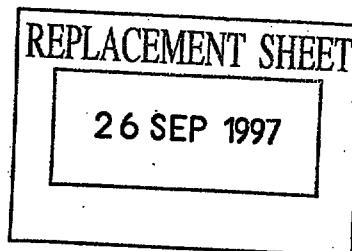
The above described dielectric basic plate 200 is collectively fired and composed as shown in Fig. 23 after a plurality of ceramic green sheets 201 through 232a, 232b with

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given electrode films of pattern shapes being formed are laminated, and adhered under pressure. The ceramic green sheets are thin type (normally of several $10\ \mu$ or so) of sheet shaped member having flexibility to be obtained by, for example, an extrusion molding with ceramic powder unfired or temporarily fired being mixed, kneaded with an organic solvent which is a binder. A material having Q high in high frequency region and high ϵ_r (for example, $\epsilon_r = 20$ through 100), for example, dielectric material of MgTiO_3 - CaTiO_3 series, ZrO_2 - SnO_2 - TiO_2 series, BaTi_4O_9 series, $\text{Nd}_2\text{Ti}_2\text{O}_7$ - $(\text{BaPb})\text{TiO}_3$ - TiO_2 series is used as a ceramic green sheet material. The formation of the respective electrode pattern is formed by, for example, printing, evaporating operations and so on with Pd, Pt and so on in terms of sintering temperature of the dielectric material. The respective ceramic green sheets 201 through 232 are fused, integrated after collective co-firing operation to be sintered into one dielectric basic plate 200.

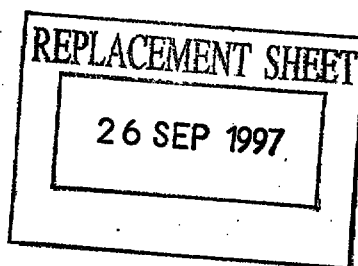
As shown in Fig. 24 through Fig. 29, circular through holes 201a through 206a are formed in the respective central portions in approximately square shaped ceramic green sheets 201 through 206. When the ceramic green sheets 201 through 206 have been laminated, these through holes 201a through 206a form a concave portion 200a for receiving the magnet 9. On the surface of the ceramic green sheet 201, electrodes Xa, Xd, Xb are formed near the left-hand side, and electrodes Xe, Xc,



Xf are formed near the right-hand side.

As shown in Fig. 30, Fig. 32, Fig. 34, Fig. 36, Fig. 38, Fig. 42, Fig. 44, earth electrode films of pattern shapes 407, 409, 411, 413, 415, 419, 421 on the same shape are formed respectively on the surfaces of the ceramic green sheets 207, 209, 211, 213, 215, 219, 221. As shown in Fig. 31, Fig. 33, Fig. 35, Fig. 37, Fig. 43, capacity electrode films of pattern shapes 308a through 308c, 310a through 310c, 312a through 312c, 314a through 314c, 320a through 320c on the same form are formed respectively on the surfaces of ceramic green sheets 208, 210, 212, 214, 220.

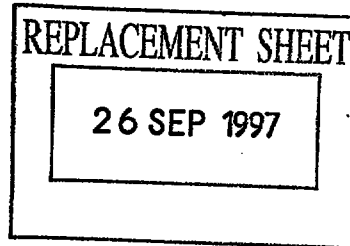
Electrode films of pattern shapes 716, 717, 718 on approximately same form are formed respectively on the surfaces of the ceramic green sheets 216, 217, 218. Respective electrode films of pattern shapes 716 through 718 are disposed each being shifted at an angular interval of 120° with respect to one after. The electrode pattern 716 includes a central electrode portion 216, a capacity electrode portion 316, an earth electrode portion 416, a wiring portion 816. The electrode pattern 717 includes a central electrode portion 217, a capacity electrode portion 317, an earth electrode portion 417, a wiring portion 817. An electrode pattern 718 includes a central electrode portion 218, a capacity electrode portion 318, an earth electrode portion 418, a wiring portion 818. Capacity electrode portions 316, 317, 318 are respec-



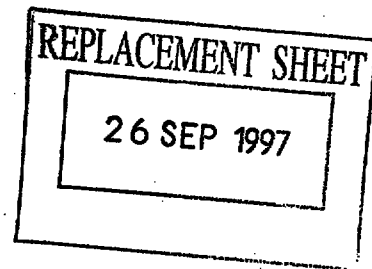
tively connected with one end of the central electrode portions 216, 217, 218. Earth electrode portions 416, 417, 418 are respectively connected with the other end of the central electrodes 216, 217, 218. Capacity electrode portions 316, 317, 318 are respectively drawn out so far as the end portions of the ceramic green sheets 216, 217, 218 through wiring portions 816, 817, 818.

Capacity electrode films of pattern shapes 308a, 310a, 312a, 314a, 320a and the capacity electrode portion 316 are connected with each other through a through hole 5a. Capacity electrode films of pattern shapes 308b, 310b, 312b, 314b, 320b and the capacity electrode portion 317 are connected with each other through a through hole 5b. The capacity electrode films of pattern shapes 308c, 310c, 312c, 314c, 320c and the capacity electrode 317 are connected with each other through a through hole 5c. The earth electrode films of pattern shapes 407, 409, 411, 413, 415, 419, 421 and the earth electrode portions 416, 417, 418 are connected with each other through through holes 5d, 5e, 5f.

When such ceramic green sheets 210 through 224 as described hereinabove have been laminated, the capacity electrode pattern 308a forms a first capacitor by opposition between the earth electrode films of pattern shapes 407 and 409. The capacity electrode pattern 310a forms a second capacitor by the opposition between the earth electrode films



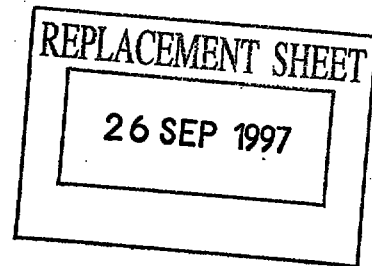
of pattern shapes 409 and 411. The capacity electrode pattern 312a forms a third capacitor by the opposition between the earth electrode films of pattern shapes 411 and 413. The capacity electrode pattern 314a forms a fourth capacitor by the opposition between the earth electrode films of pattern shapes 413 and 415. The capacity electrode portion 316 forms a fifth capacitor by the opposition between the earth electrode pattern 415 and the earth electrode portion 417. The capacity electrode pattern 320a forms a sixth capacitor by the opposition between the earth electrode films of pattern shapes 419 and 421. These first through sixth capacitors for composing the matching circuit are connected in parallel between one end of the central electrode portion 216 and the earth, and are inserted. This is because the respective one side electrodes 308a, 310a, 312a, 314a, 316, 320a are connected with one end of the central electrode portion 216 in common through a through hole 5a. The respective other-way electrodes 407, 409, 411, 413, 415, 417, 419, 421 of the first through sixth capacitors are connected with the earth in common through the through holes 5d, 5e, 5f. Similarly, six capacitors for matching circuit use are connected in parallel between the central electrode portion 217 and the earth, and are inserted, and the six capacitors for matching circuit use are connected in parallel between the central electrode portion 218 and the earth, and are interposed. As a plurality



of capacitors connected respectively in parallel are laminated, disposed among one end of the respective central electrode portions 216 through 218 and the earth, capacity value necessary as the matching circuit can be retained with small circuit area. Accordingly, the construction of the whole element can be made smaller in size.

Approximately same shaped earth electrode films of pattern shapes 222 through 226 are formed on the surface of the ceramic green sheets 222 through 225 and the reverse face of the ceramic green sheet 226 as shown in Fig. 45 through Fig. 49. Through holes 222a through 226a are formed in the central portions of the respective ceramic green sheets 222 through 226. The through holes 222a through 226a form the concave portion 200b for receiving the ferrite plate 6 when the ceramic green sheets 222 through 226 have been laminated. The earth electrode films of pattern shapes 222 through 226 are connected with the above described earth electrode films of pattern shapes 407, 409, 411, 413, 515, 419, 421 and the earth electrode portions 416 through 418 are connected through the through holes 5d through 5f and also, are connected with one another through the through holes 5d through 5j.

Four earth electrode films of pattern shapes 222 through 225 are provided between the earth electrode pattern 221 and the earth electrode pattern 226 and further, four through holes 5g through 5j are increased in number as



described hereinabove so as to effect connecting operations among the respective earth electrode films of pattern shapes 222 through 226. The reasons why the connections are effected are as follows. Namely, a ferrite plate 6 is mounted as described in the concave portion 200b to be formed by the through holes 222a through 226a, and many high frequency magnetic fields are caused by high frequency signals flowing through the respective central electrode portions 216 through 218 on the periphery of the ferrite plate 6. Therefore, the periphery of the ferrite plate 6 becomes an environment for high frequency induced current to be easier to flow. Assume that a connecting operation is effected between the earth electrode pattern 221 and the earth electrode pattern 226 only by three through holes 5d through 5f under such environment, impedance between the earth electrode pattern 221 and the earth electrode pattern 226 is increased by increase in the resistance component and the impedance component, thus resulting in larger loss. The resistance component and the impedance component are reduced with the increased provision of the through holes 5g through 5j, thereby reducing the impedance. The capacity components are caused in parallel with through holes 5d through 5j by the disposition of four earth electrode films of pattern shapes 222 through 225 between the earth electrode pattern 221 and the earth electrode pattern 226, whereby the reduction of the high

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frequency impedance is further reduced.

Band shaped ceramic green sheets 227a through 232a are laminated near the left-hand side, and band shaped ceramic green sheets 227b through 232b are laminated near the right-hand side on the reverse face of the ceramic green sheet 226 as shown in Fig. 50 through 55. Electrodes Ya, Yd, Yb are formed on the reverse face of the ceramic green sheet 232a, and the electrodes Ye, Yc, Yf are formed on the reverse face of the ceramic green sheets 232b. These ceramic green sheets 227a through 232a and ceramic green sheets 227b through 232b form a stage difference concave portion 200c for receiving the magnetic yoke 72 when they have been laminated.

The above described ceramic green sheets 201 through 232a, 232b are laminated, and thereafter are adhered under pressure into a ceramic green sheet laminated body. Continuously a copper electrode composed of copper paste or the like is printed with pressure film on three locations on the left side face of the ceramic green sheet laminated body and on three locations on the right side face, whereby external connecting terminals Ta through Tf are formed. Although the copper paste is protruded onto the surface of the ceramic green sheet 201 and the reverse face of the ceramic green sheets 232a, 232b in the pressure film printing step, the protruded portion is absorbed and equalized by electrode Ya through Yf formed on the surface of the ceramic green sheet

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201 and the electrodes Ya through Yf formed on the ceramic green sheets 232a, 232b. Namely, if the copper paste is protruded onto the surface of the ceramic green sheet 201 and is protruded onto the reverse faces of the ceramic green sheets 232a, 232b by the pressure film printing operation, the area of the protruded portion is generally smaller than the areas of the above described electrode Xa through Xf and Ya through Yf. Therefore, in the respective external connecting terminals Ta through Tf, the area of the extruded onto the surface of the ceramic green sheet 201 becomes equal respectively to the area of the electrodes Xa through Xf. The area of the portion extruded onto the reverse faces of the ceramic green sheets 232a, 232b becomes respectively equal to the area of the electrodes Ya through Yf. As the area of the electrode Xa through Xf are mutually equal, and the area of the electrode Ya through Yf becomes also equal with respect to one another, the area of the portion extruded onto the surface of the ceramic green sheet 201 become equally equal, and also, the areas of the portion extruded onto the reverse faces of the ceramic green sheets 232a, 232b become equal with respect to each other in the respective external connecting terminals Ta through Tf. As a result, the electric symmetry can be maintained properly without the provision of inequality in the area of the respective external connecting terminals Ta through Tf on the surface of the ceramic green sheet 201 and

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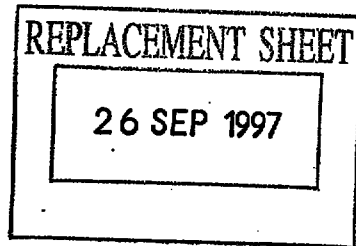
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the reverse face of the ceramic green sheets 232a, 232b.

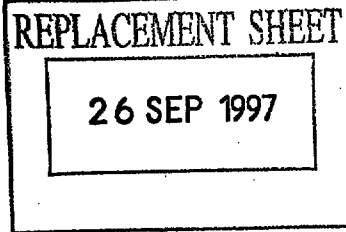
The above described ceramic green sheet laminated bodies are collectively fired. As a result, the respective ceramic greens sheets are fused, integrated into one dielectric basic plate 200. At this time, the respective electrode films of pattern shapes and the respective external connecting terminals are also integrated into dielectric basic plate 200. After the co-firing step to be sintered, a Ni plating portion is effected on the surfaces of the respective external connecting terminals Ta through Tf so as to prevent the copper electrode, which becomes the foundation of the external connecting terminals Ta through Tf at the soldering operation, from being diffused during the soldering operation. A Sn plating operation is effected upon the above described Ni plating so as to improve the soldering property of the respective external connecting terminals Ta through Tf.

As the dielectric basic plate, central electrode, matching circuit and the external connecting terminal can be fired at the same time by one co-firing step to be sintered in the present embodiment, the manufacturing step is simplified and the manufacturing time can be considerably contracted. As not only the central electrode, the matching circuit, but also the external connecting terminal is also integrated into the dielectric basic plate 200, the number of the parts can be reduced as compared with the conventional circulator



and the size can be made smaller. As the ferrite plate 6 can be accommodated in the concave portion 200b formed on the reverse face of the dielectric basic plate 200 in the circulator in the present embodiment, the magnetic yoke 72 comes into direct contact with the earth pattern 426 (see Fig. 49) formed on the reverse face of the dielectric basic plate 200. Therefore, in the conventional circulator, the earth plate 8 (for example, see Fig. 57) which was required can be made unnecessary, the number of the components can be further reduced, and the size can be made much smaller. In the present embodiment, a problem can not be caused in terms of strength even if the respective ceramic green sheets is made extremely thinner in thickness, because a plurality of ceramic green sheets can be integrated into one dielectric basic plate 200 by the co-firing to be sintered thereof. As a result, the interval among the respective central electrode portions 216 through 218 can be made extremely made narrower, and the electric symmetrical property of the respective central electrode portions 216 through 218 can be improved.

Blank portions 407a, 409a, 411a, 413a, 415a, 417a, 418a, 419a, 421a, 422a, 423a, 424a, 425a, 426a are formed, so as to surround the periphery of the external connecting terminal Ta, on the earth electrode pattern or the earth electrode portion in the given ceramic green sheet. Blank portions 407b, 409b, 411b, 413b, 415b, 416b, 418b, 419b, 421b,



422b, 423b, 424b, 425b, 426b are formed so as to surround the periphery of the external connecting terminal Tb, blank portions 407c, 409c, 411c, 413c, 415c, 416c, 417c, 419c, 421c, 422c, 423c, 424c, 425c, 426c are formed so as to surround the periphery of the external connecting terminal TC. These blank portions prevents the short-circuiting between the external connecting terminals Ta through Tc which become input, output terminals, and the respective earth electrode films of pattern shapes and the respective earth electrode portions. As the external connecting terminals Td through Tf are earth terminals, such blank portions as described hereinabove are not provided on theses peripheries.

The circulator in the present embodiment constructed as described hereinabove is placed on the external circuit basic plate (not shown), and the external connecting terminals Ta through Tf are soldered directly with the connecting terminal on the circuit basic plate side. Accordingly, the circulator in the present embodiment can be mounted on the surface onto the external circuit basic plate, thus making it unnecessary to have the troublesome wiring operation.

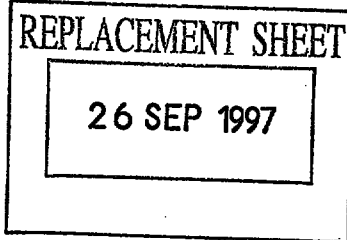
The operation of the circulator shown in Fig. 21 and Fig. 22 will be described. When the high frequency signal is inputted into the external connecting terminal Ta, the high frequency magnetic field to be caused round the central electrode portion 216 is rotated by the given angle by the

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direct current magnetic field from the magnet 9 so as to cause the induced electric current in, for example, the right-hand adjacent central electrode portion 217 by the inductive coupling through the ferrite plate 6. The high frequency signal to be inputted from the external connecting terminal Ta is transmitted to the right-hand adjacent external connecting terminal Tb, but are not transmitted to the left-hand adjacent external connecting terminal Tc. Similarly, the high frequency signal to be inputted from the external connecting terminal Tb is transmitted to the right-hand adjacent external connecting terminal Tc, but are not transmitted to the left-hand adjacent external connecting terminal Ta. The high frequency signal to be inputted from the external connecting terminal Tc is transmitted to the right-hand adjacent external connecting terminal Ta, but is not transmitted to the left-hand adjacent external connecting terminal Tb.

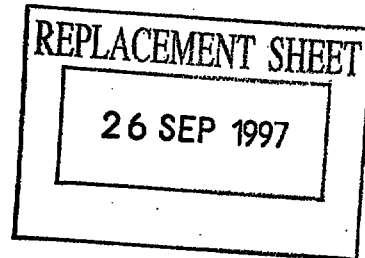
The circulator shown in Fig. 21 and Fig. 22 can be used as an isolator if the terminal resistor is connected between any one of the wiring portions or the external connecting terminal (for example, the wiring portion 818 or the external connecting terminal Tc). In this case, the isolator transmits the high frequency signal only in one side direction to the the remaining other external connecting terminal (for example, external connecting terminal Tb) from



the remaining one side external connecting terminal (for example, external connecting terminal Ta).

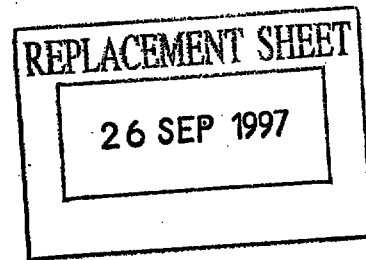
Although the connection among the respective capacity electrode films of pattern shapes and the respective capacity electrode portions, and the connections among the respective earth electrode films of pattern shapes and the respective earth electrode portions are adapted to be effected with the use of the through holes in the embodiments shown in Fig. 21 through Fig. 55, these connections may be effected with the use of the side face electrodes.

As is clear from the forgoing description, according to the inventions in the above described embodiments, a plurality of electrode films of pattern shapes and a plurality of external connecting terminals for constructing the central electrodes and the matching circuits are fired simultaneously with a plurality of dielectric green sheets adhered under pressure in lamination and are integrated with one dielectric basic plate, so that smaller size, lower cost, higher reliability of the elements and the simplification of the assembling steps can be designed. As not only the central electrodes and the matching circuits, but also the external connecting terminal are integrated into one dielectric basic plate, the number of the components can be considerably reduced, and the size of the elements can be made smaller. As the number of the assembling steps becomes less by the



reduction in the number of the components, the cost can be reduced. The connecting locations by the soldering operation and so on are reduced considerably, the reliability is improved. As the internal circuits which were disposed conventionally on plane can be arranged with microwave within the dielectric basic plate, the circuit area of the whole element can be reduced. As the respective electrode films of pattern shapes can be crossed without mutual contact within the dielectric basic plate, the insertion loss can be reduced without the requirement of making the width of the central electrode narrower as in the first conventional art. As the construction is integral, sufficiently larger strength can be retained even if the arrangement is made with the intervals among the respective electrode films of pattern shapes are made extremely close. As a result, the electric symmetrical property property among the respective central electrodes can be maintained in better condition. As the dielectric basic plate, the respective electrode films of pattern shapes, and the respective external connecting terminals are formed at the same time in one co-firing step to be sintered, the manufacturing time can be considerably shortened.

According to the invention of the above described embodiment, a compacter non-reciprocal circuit element is provided by the formation of a first concave portion for engaging a magnet for direct current magnetic field applying



use on one side main surface of the dielectric basic plate.

According to the invention in the above described embodiment, a second concave portion for engagement of the inductive coupling ferrite plate of the internal circuit is formed on the other-way main surface of the dielectric basic plate so that a non-reciprocal circuit element which is compacter and lower in price can be obtained. As the magnetic yoke can be used as an earth plate used with the conventional non-reciprocal circuit element, the number of the parts is reduced, and a non-reciprocal circuit element which is much smaller in size and lower in price can be obtained.

Although the present invention has been fully described by way of example with reference to the accompanying drawings, it is to be noted here that various changes and modifications will be apparent to those skilled in the art. Therefore, unless otherwise such changes and modifications depart from the scope of the present invention, they should be construed as included therein.

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CLAIMS

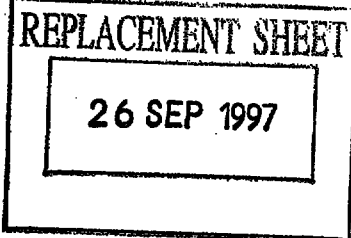
1. A non-reciprocal circuit element for high frequency use which has a small attenuation degree in a signal transmission direction and a larger attenuation degree in an opposite direction, the circuit element comprising a plurality of dielectric sheets having electrode films of pattern shapes formed thereon, the dielectric sheets being laminated and co-fired to form a dielectric basic plate and at least one of the dielectric sheets comprising a capacitor electrode pattern without a central electrode pattern.
2. A non-reciprocal circuit element as claimed in claim 1, wherein the electrode films of pattern shapes include at least one central electrode pattern, at least one capacitor electrode pattern, at least one earth electrode pattern and, in the interior of the dielectric basic plate, the capacitor electrode films of pattern shapes and the earth electrode films of pattern shapes are alternately disposed with dielectric material existing between them, the respective capacitor electrode films of pattern shapes are connected in common and connected with the corresponding central electrode films of pattern shapes, and the respective earth electrode films of pattern shapes are connected in common, so that at least one matching circuit capacitor is disposed in lamination among the central electrode films or pattern shapes and the earth electrode films of pattern shapes.

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3. A non-reciprocal circuit element for high frequency use which has a small attenuation degree in a signal transmission direction and a larger attenuation degree in an opposite direction, the circuit element comprising a dielectric basic plate formed by the integration of a plurality of co-fired dielectric green sheets adhered under pressure in lamination, a plurality of electrode films of pattern shapes formed on the dielectric green sheets and disposed in lamination within the dielectric basic plate, a plurality of external connecting terminals formed on the dielectric green sheets and connected to the given electrode films of pattern shapes and disposed so that an exposing operation is effected on the outer periphery of the dielectric basic plate, so that the internal circuits and the external connecting terminals are integral with the dielectric basic plate and at least one of the dielectric sheets has a capacitor electrode pattern-without a central electrode pattern.

4. A non-reciprocal circuit element as claimed in claim 3, wherein the dielectric basic plate has a first main side surface and an opposite main side surface, and a first concave portion for engaging a magnet for applying a direct current magnetic field is formed on the first main side surface.





5. A non-reciprocal circuit element as claimed in claim 3 or 4, wherein the dielectric basic plate has a first main side surface and an opposite main side surface, and a concave portion for engaging a ferrite plate for inductive coupling use of the internal circuits is formed on the opposite main side surface.



6. A method of manufacturing a non-reciprocal circuit element for high frequency use having a small attenuation degree in a signal transmission direction and a larger attenuation degree in an opposite direction, comprising adhering under pressure in lamination a plurality of dielectric green sheets with given electrode films of pattern shapes being formed respectively on them so as to obtain the green sheet laminating bodies, co-firing the green sheet laminating bodies so as to integrate them as one dielectric basic plate to form a non-reciprocal circuit element with internal circuits disposed in lamination within the one dielectric basic plate and at least one of the dielectric green sheets having a capacitor electrode pattern without a central electrode pattern.

7. A method of manufacturing a non-reciprocal circuit element as claimed in claim 6, further comprising forming a central electrode and the dielectric basic plate at the same time by sintering in the one co-firing step.

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8. A method of manufacturing a non-reciprocal circuit element as claimed in claim 6, comprising forming a central electrode, a matching circuit to be connected with it and the dielectric basic plate at the same time by sintering in said one co-firing step.

9. A non-reciprocal circuit element substantially as hereinbefore described with reference to figures 1 to 55 of the accompanying drawings.

10. A method of manufacturing non-reciprocal circuit elements substantially as hereinbefore described with reference to figures 1 to 55 of the accompanying drawings.



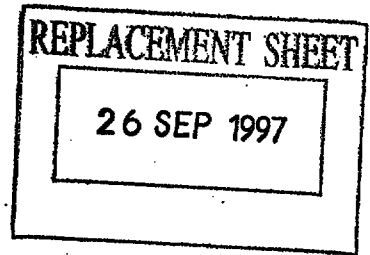
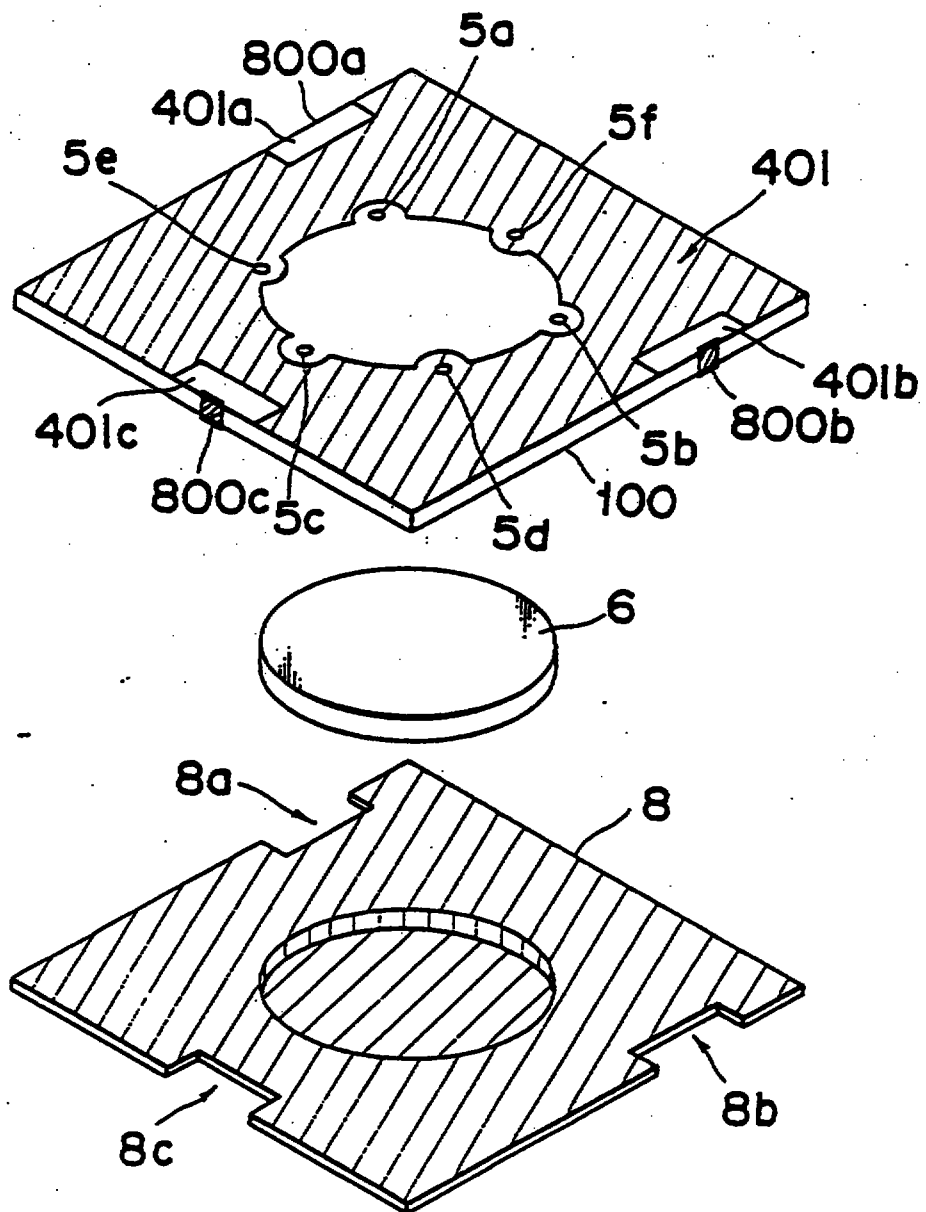


Fig. 1



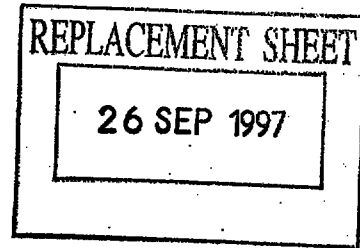
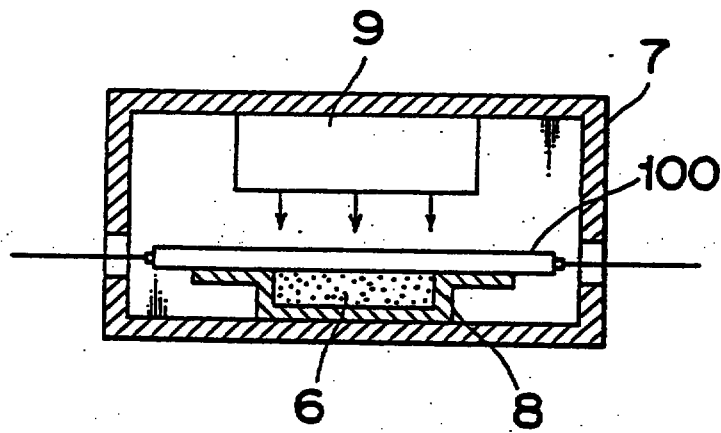


Fig. 2



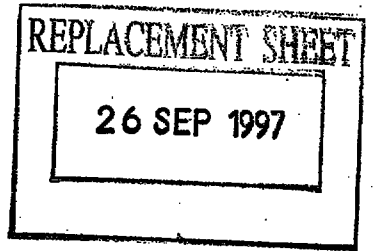
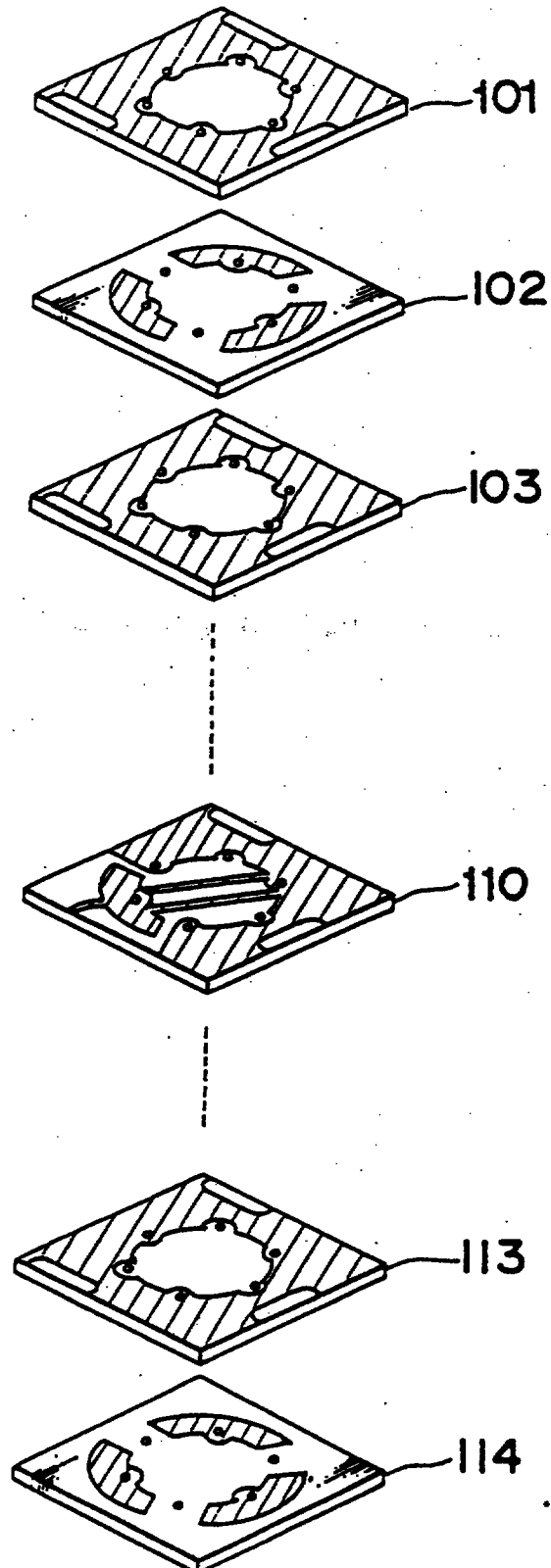


Fig. 3



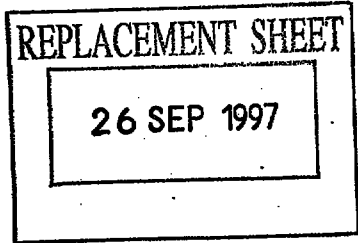


Fig. 4

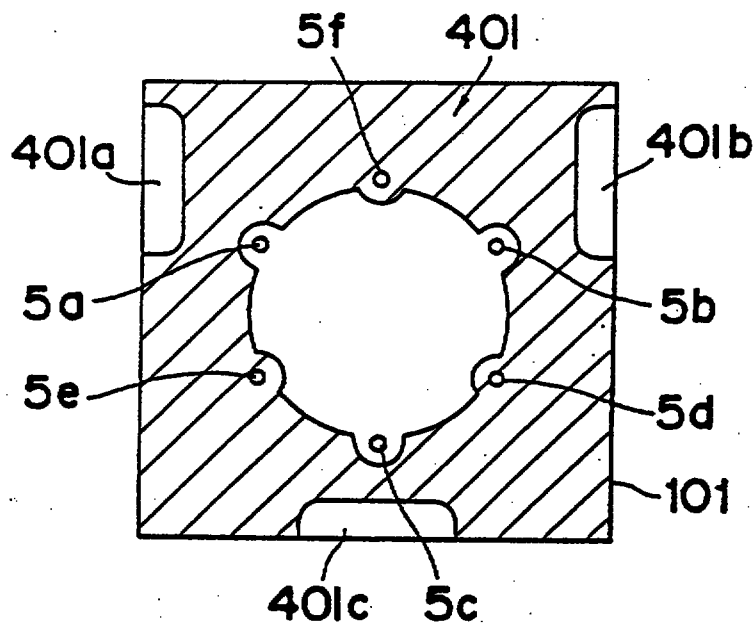
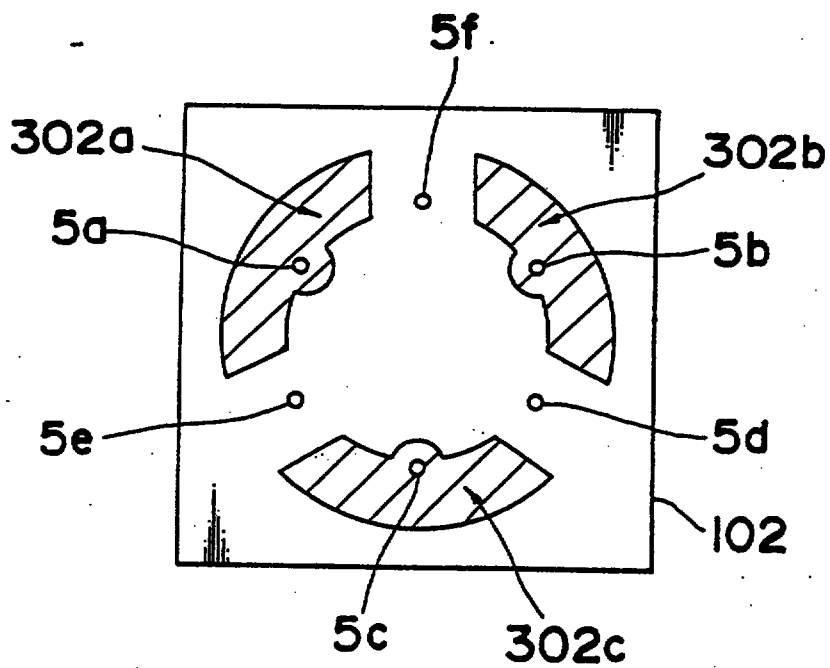


Fig. 5



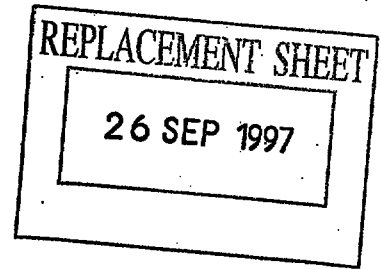


Fig. 6

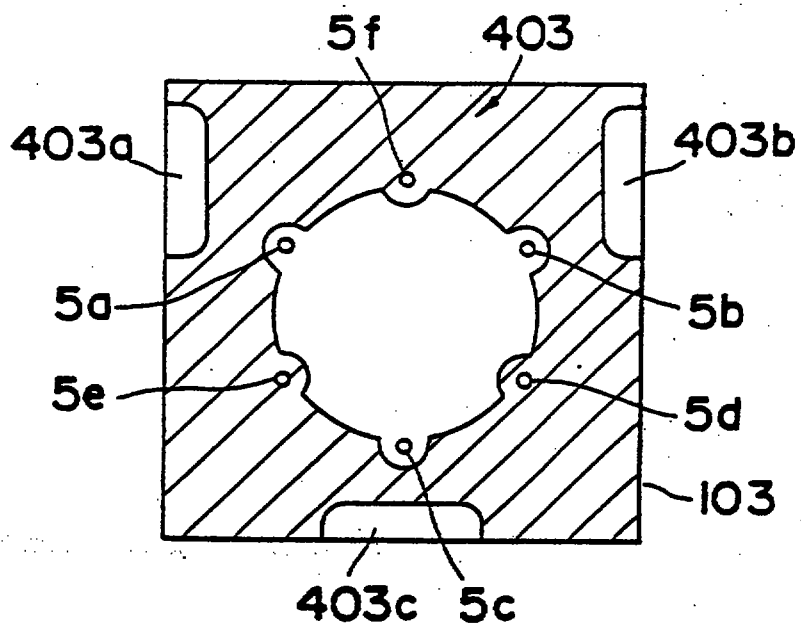


Fig. 7

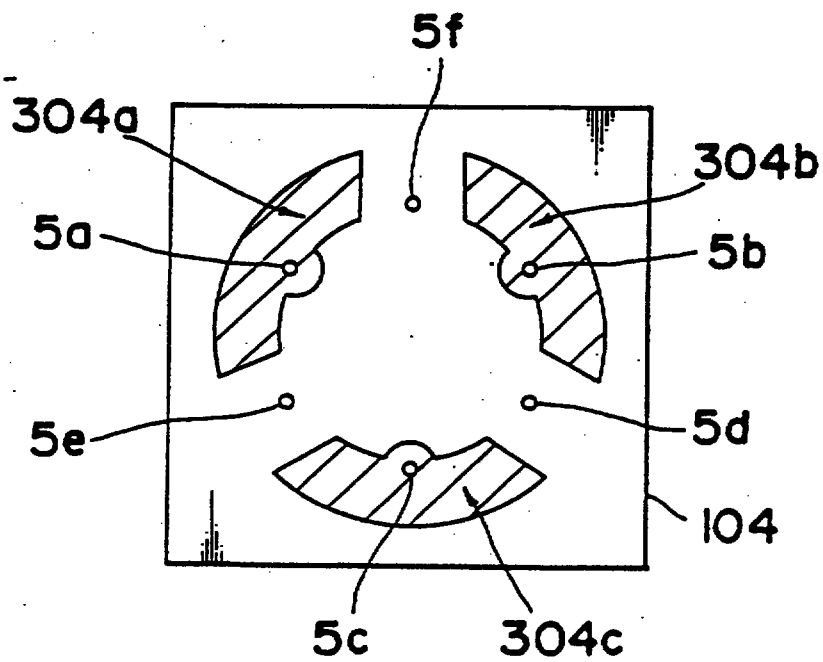


Fig. 8

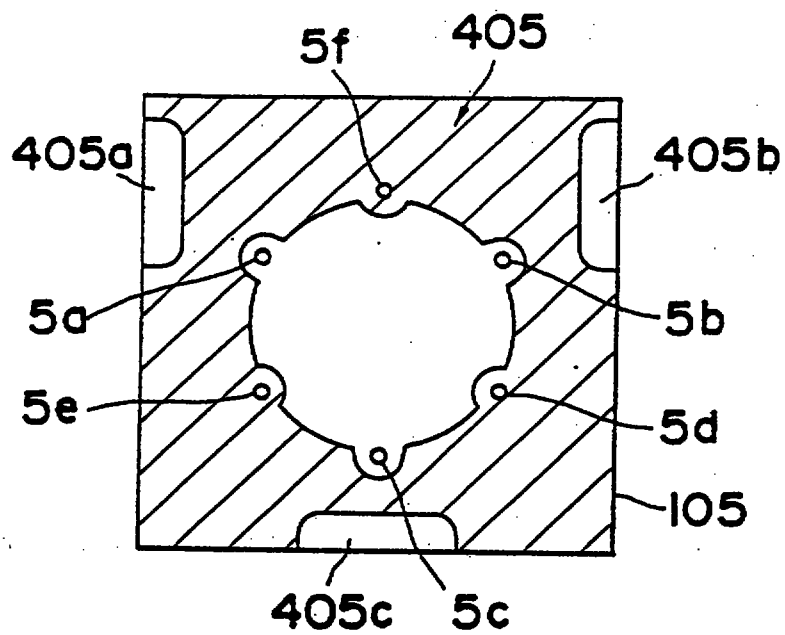
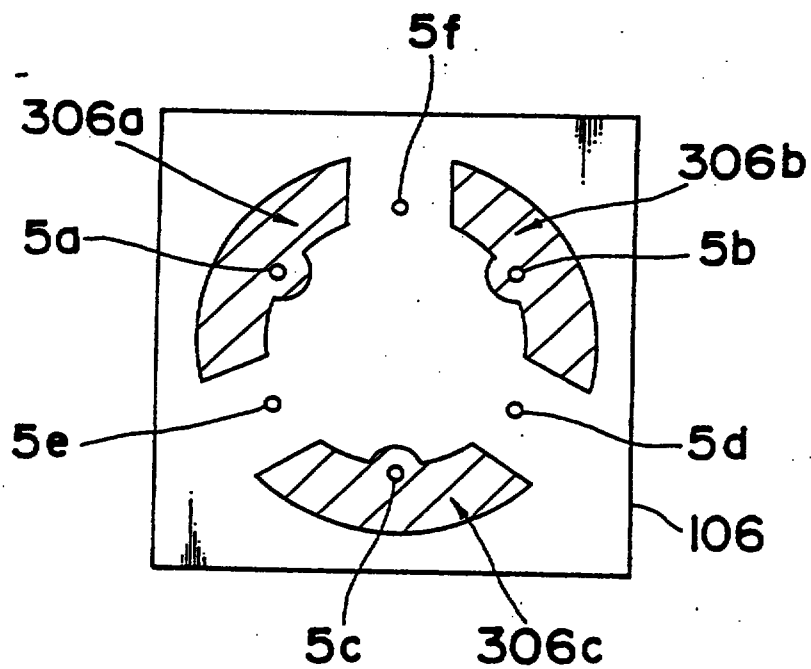


Fig. 9



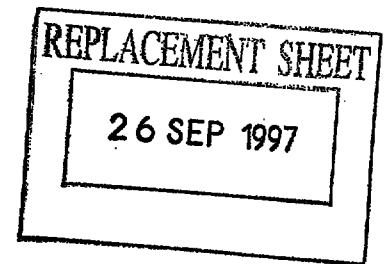


Fig. 10

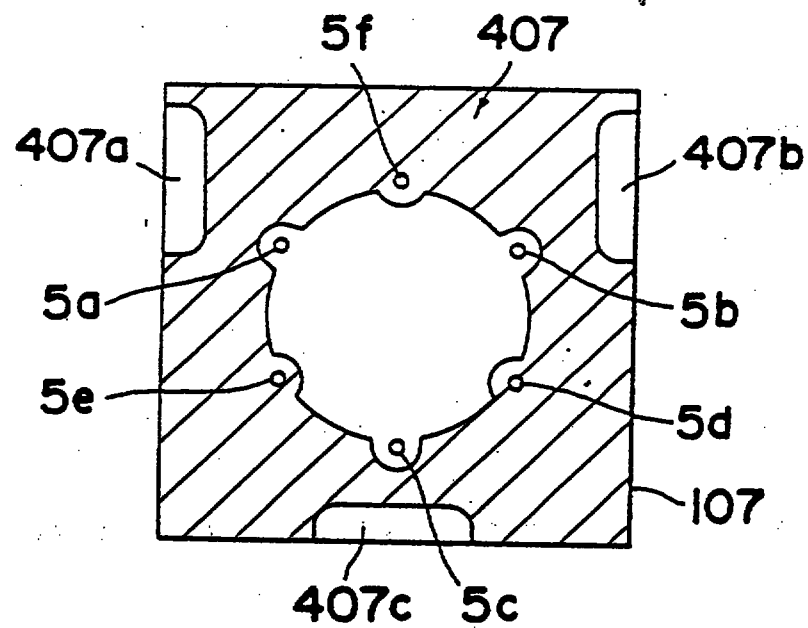
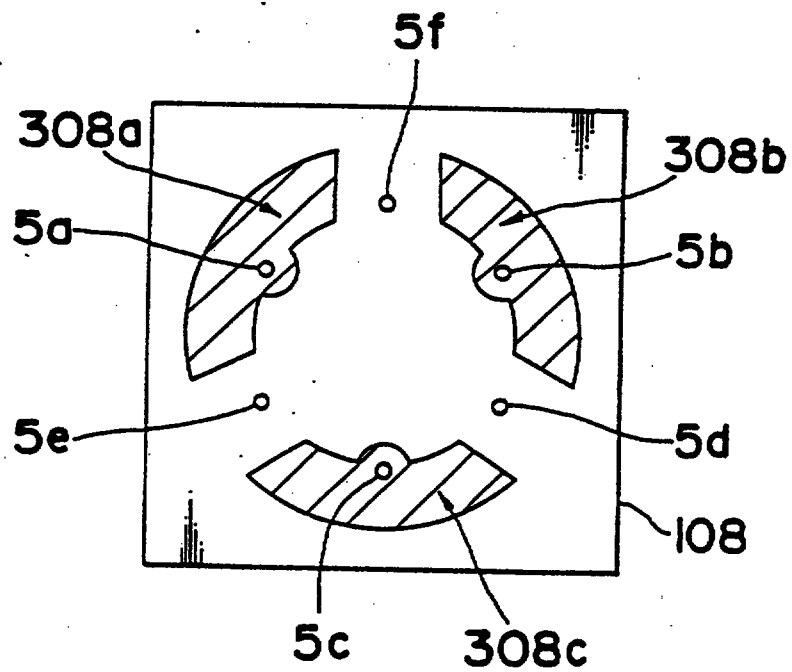


Fig. 11



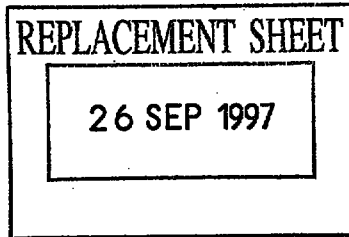


Fig. 12

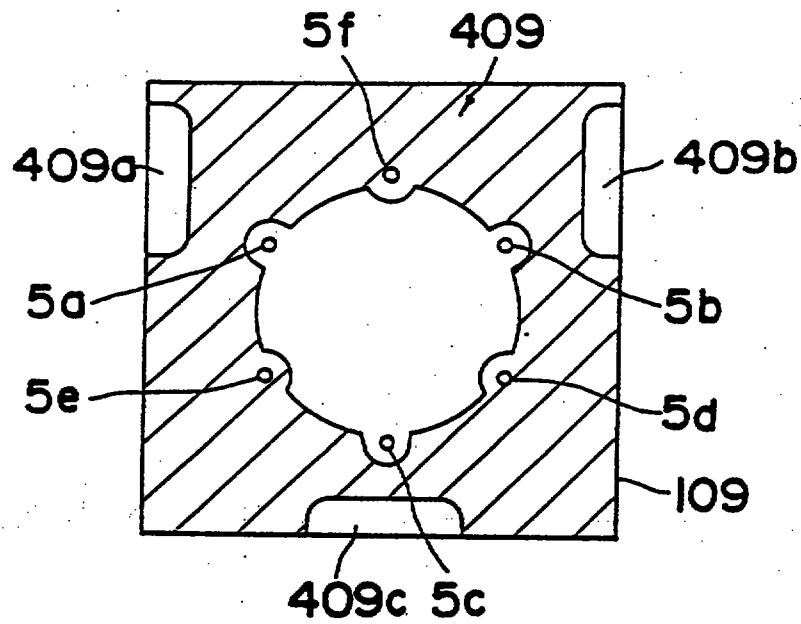
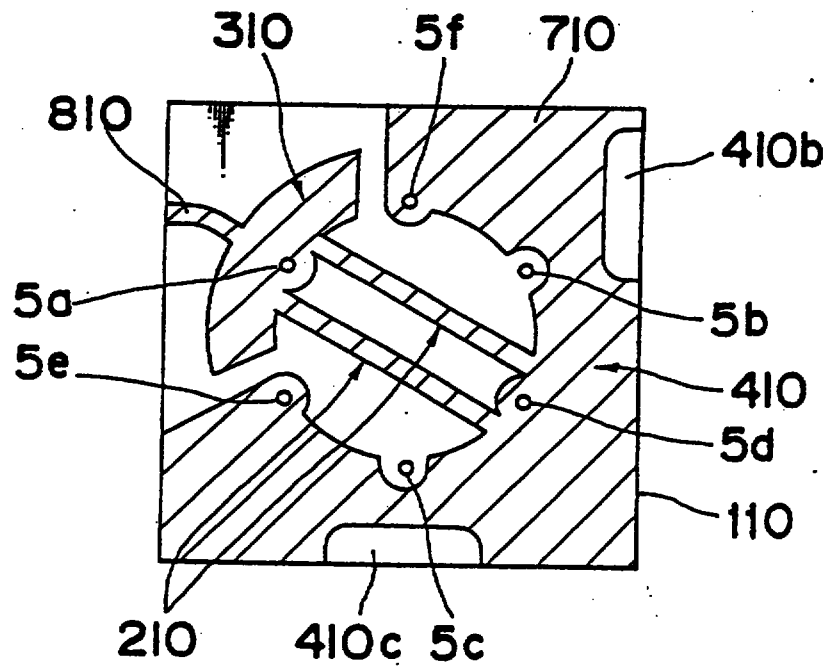


Fig. 13



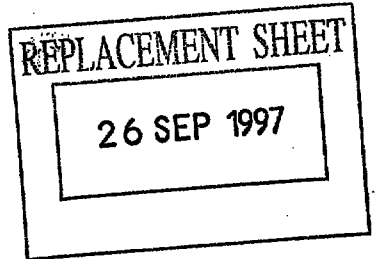


Fig. 14

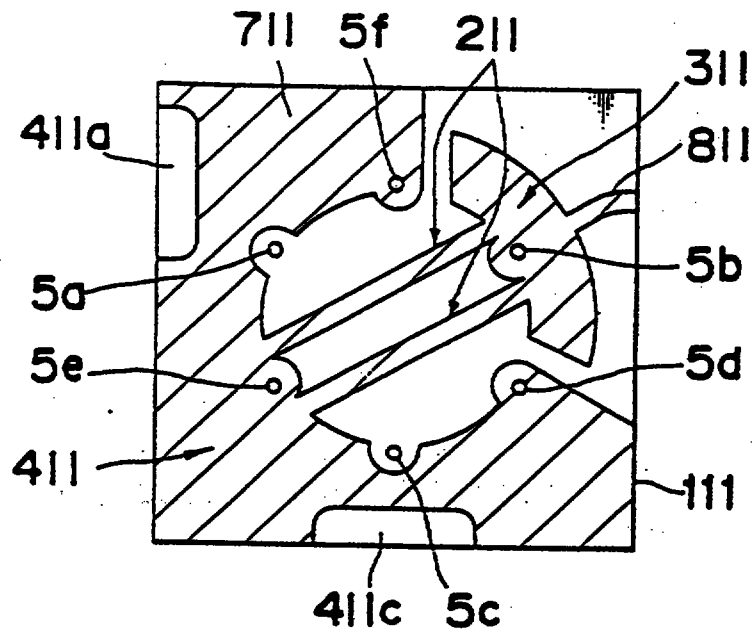
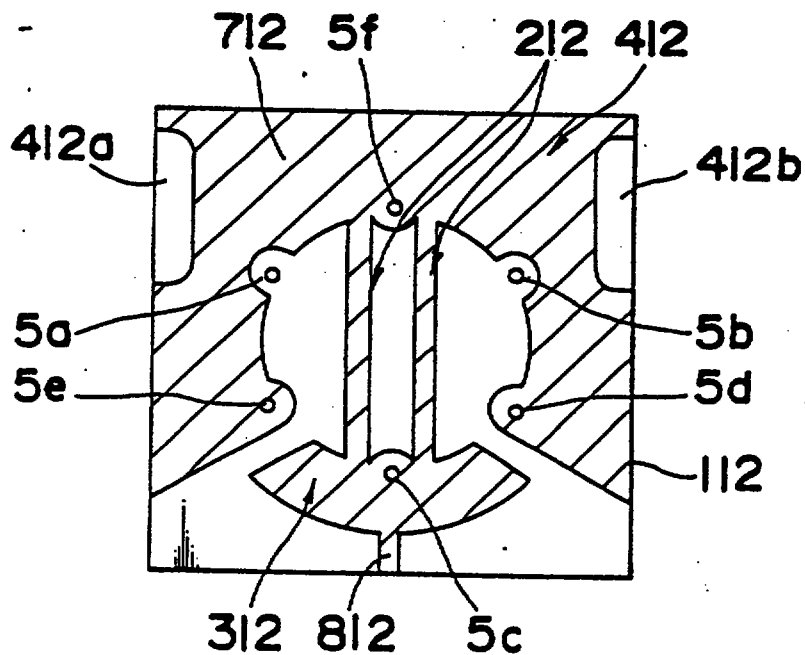


Fig. 15



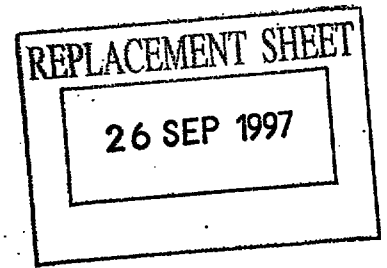


Fig. 16

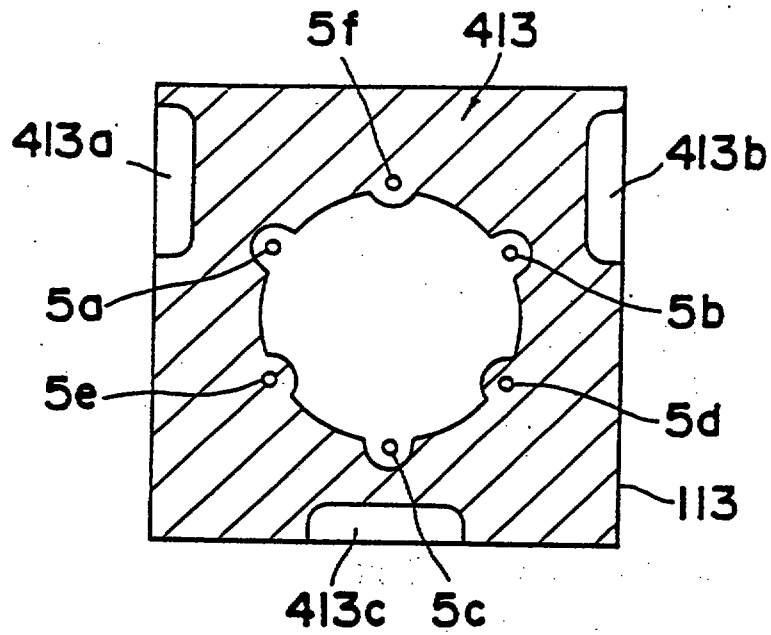


Fig. 17

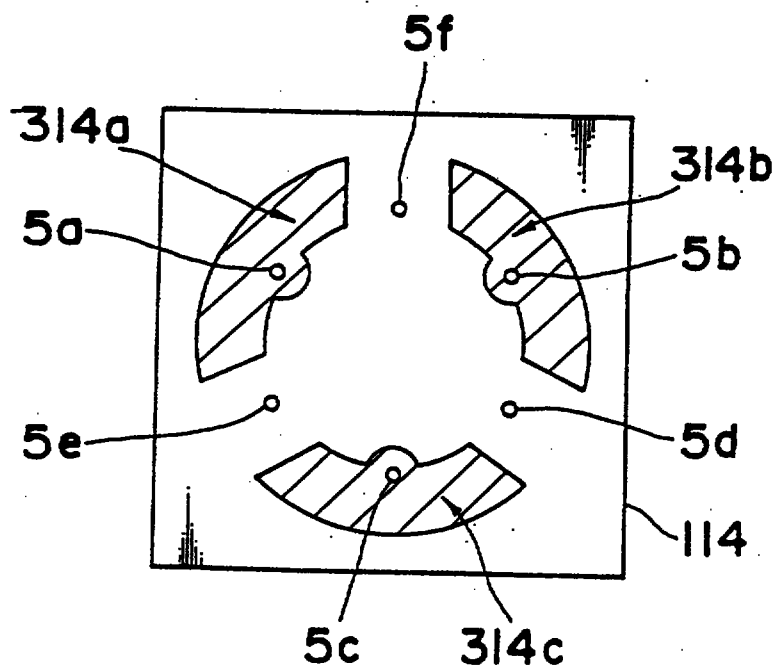
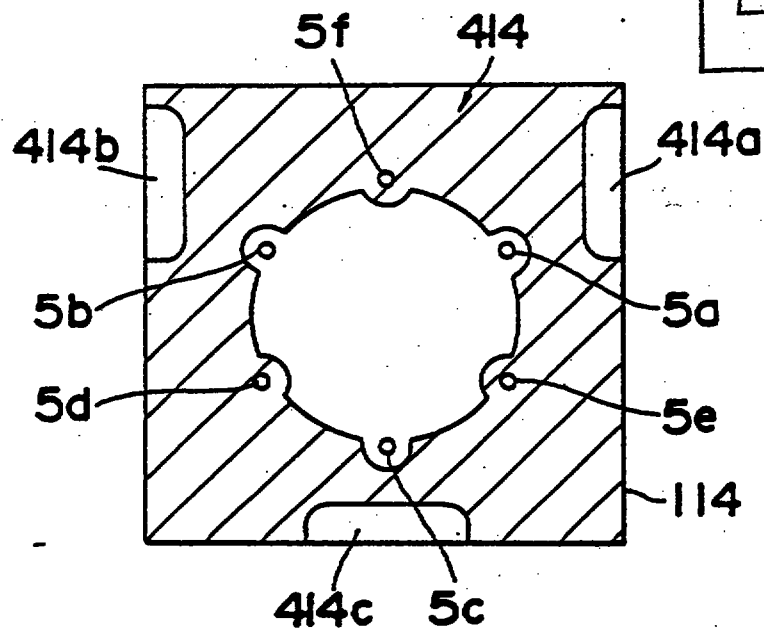
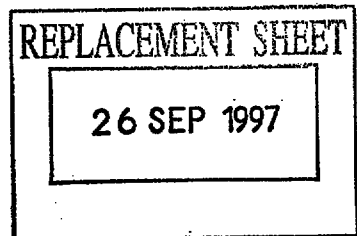


Fig. 18



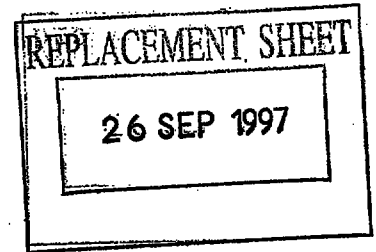
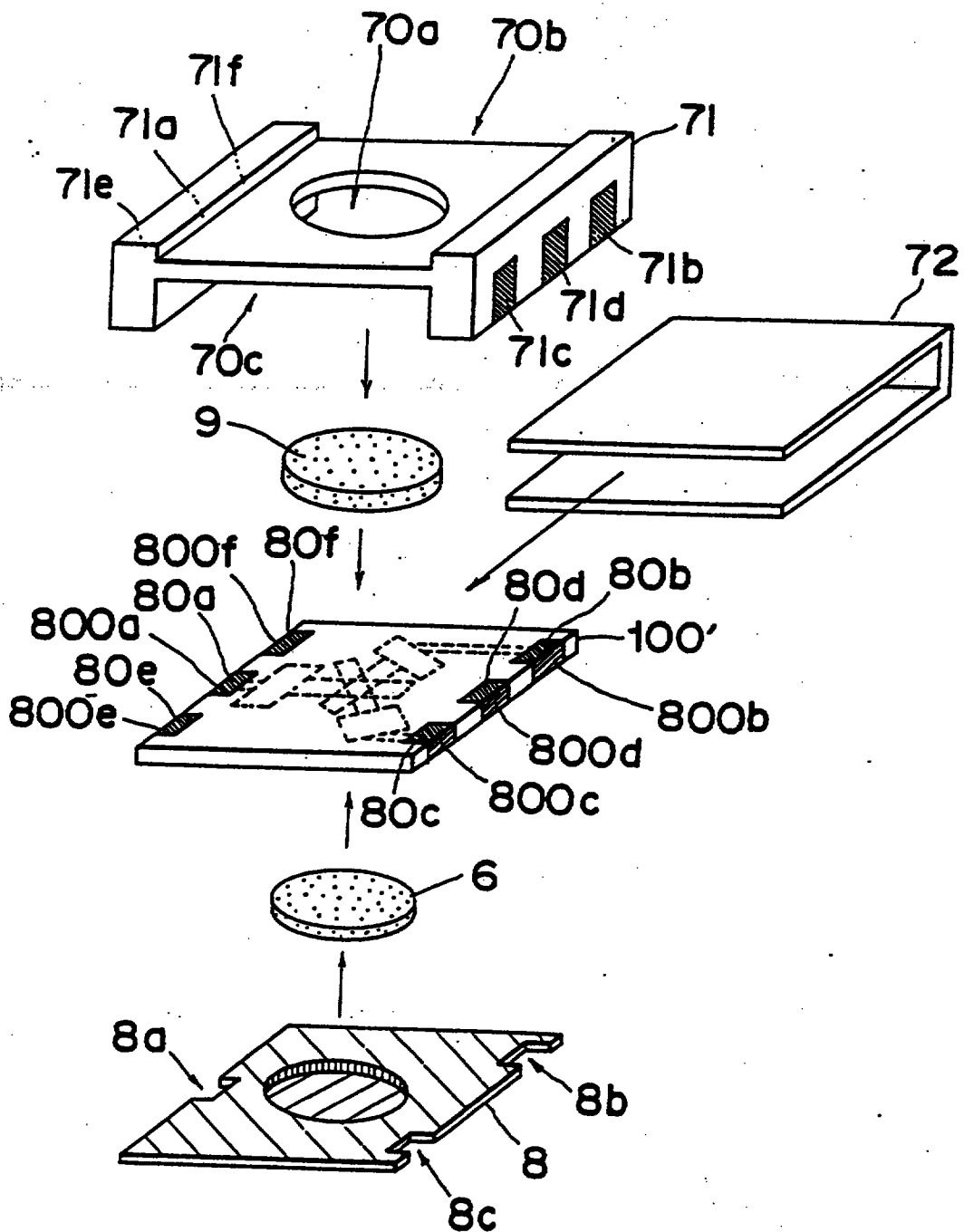


Fig. 19



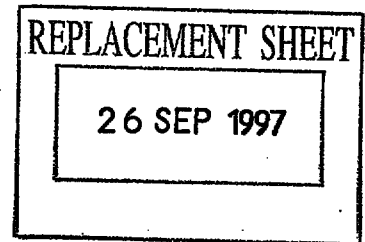
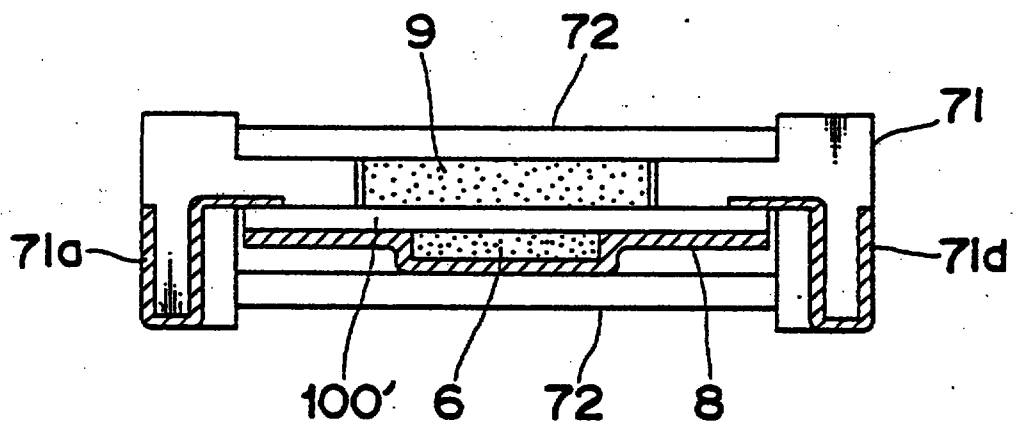
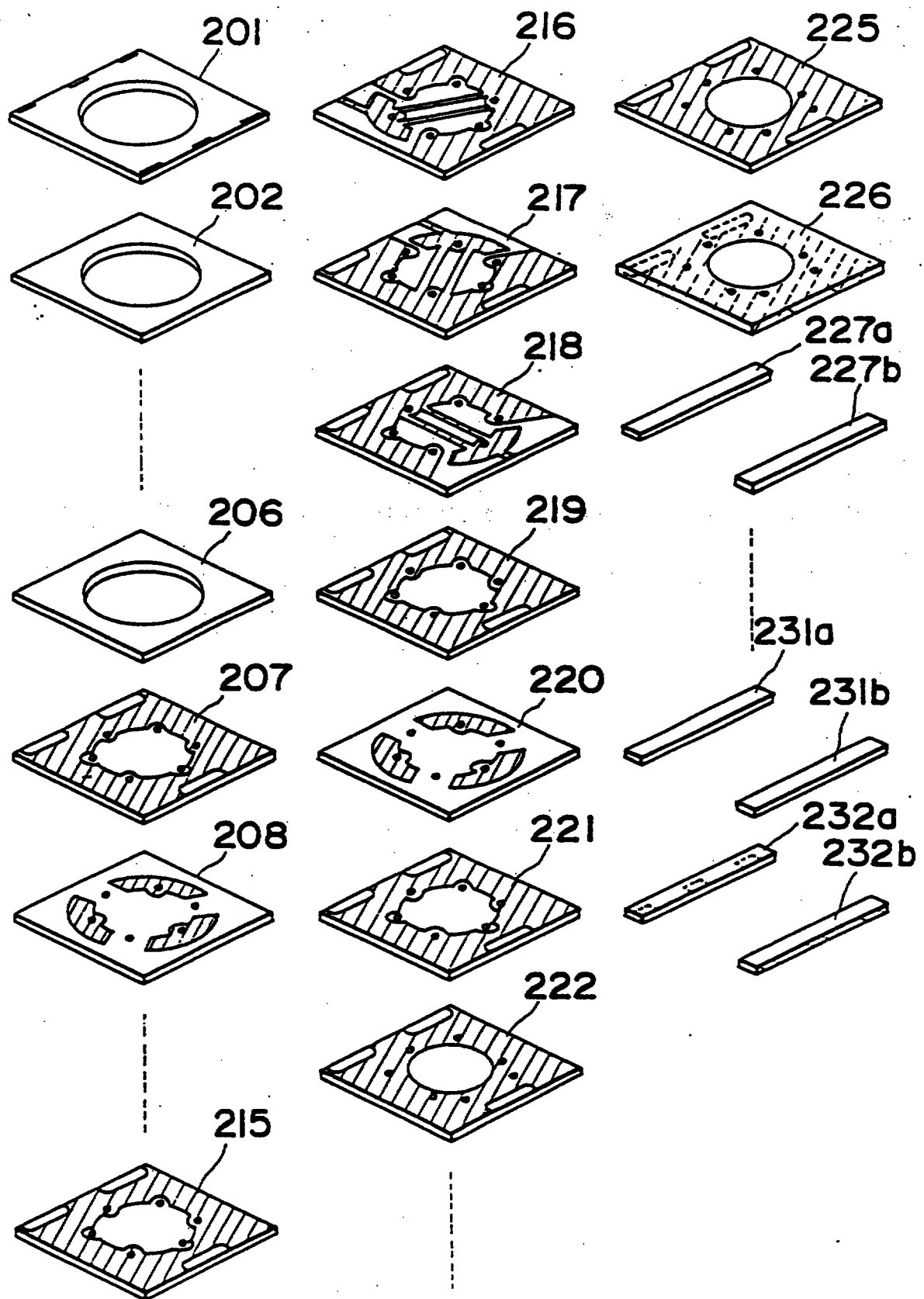


Fig. 20



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Fig. 23



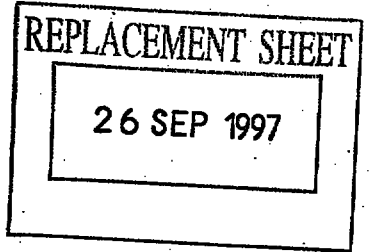


Fig. 24

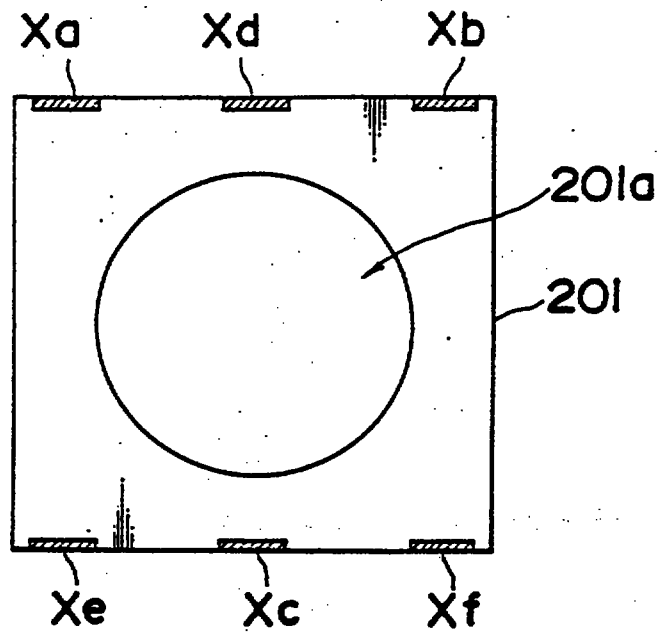
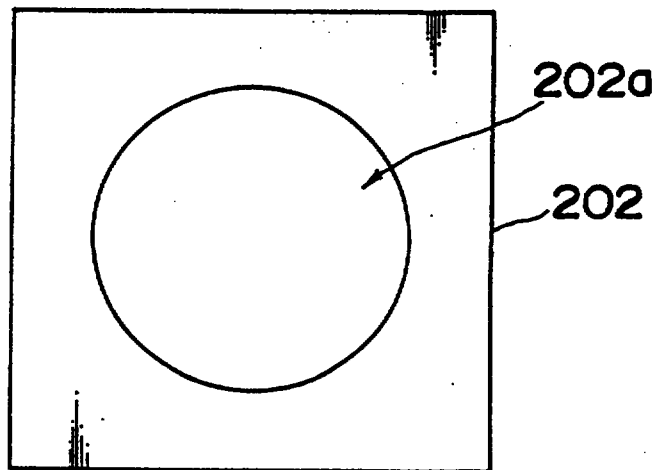


Fig. 25



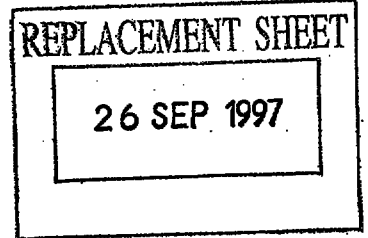


Fig. 26

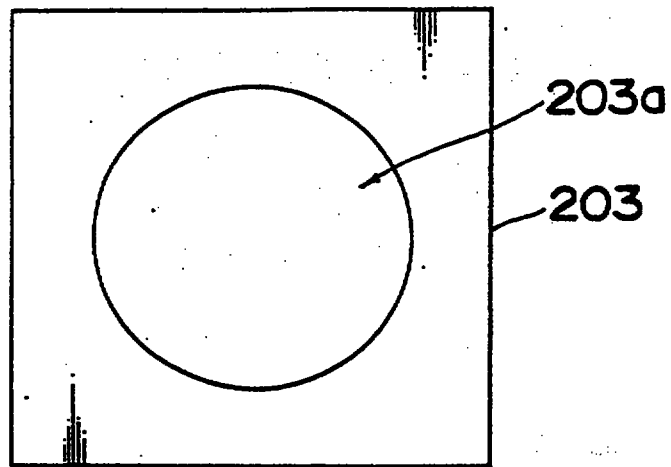
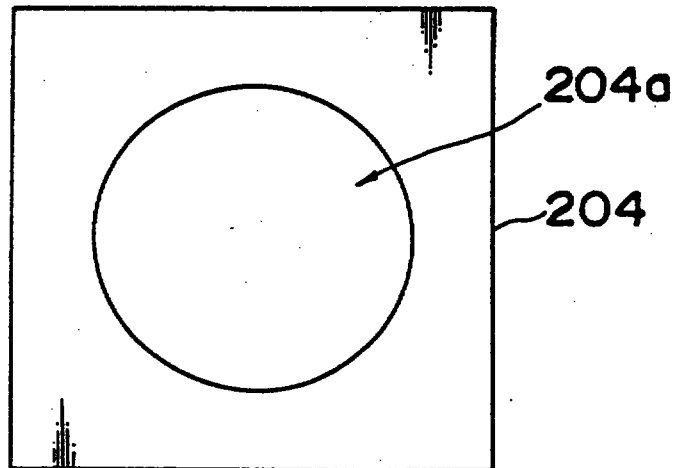


Fig. 27



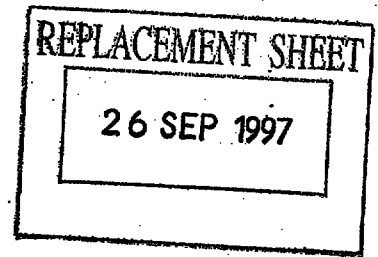


Fig. 28

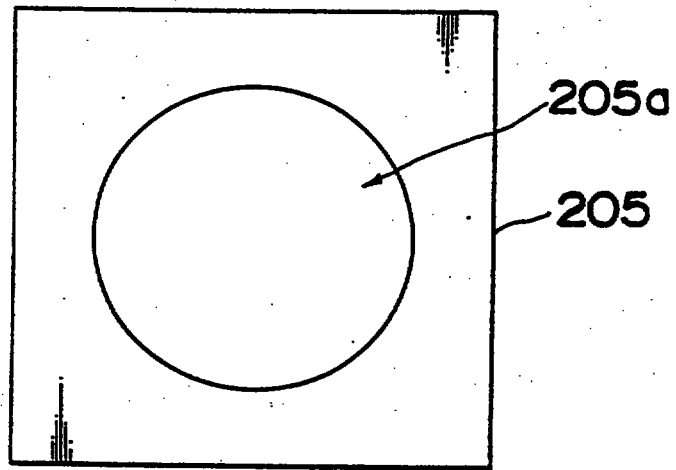
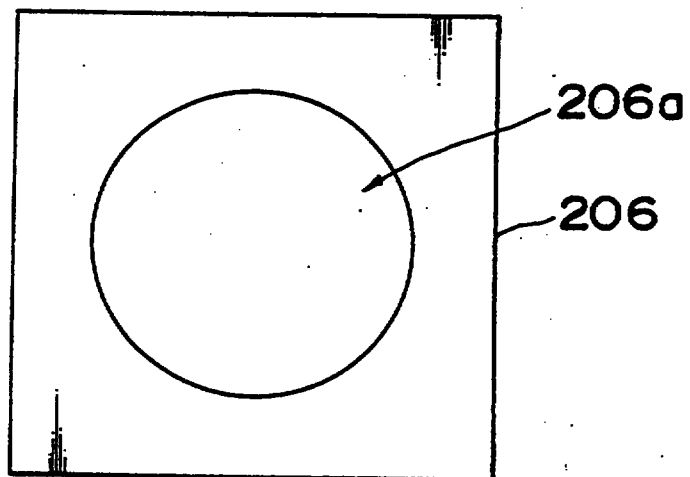


Fig. 29



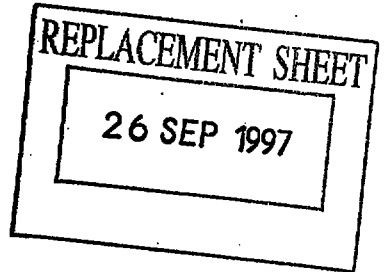


Fig. 30

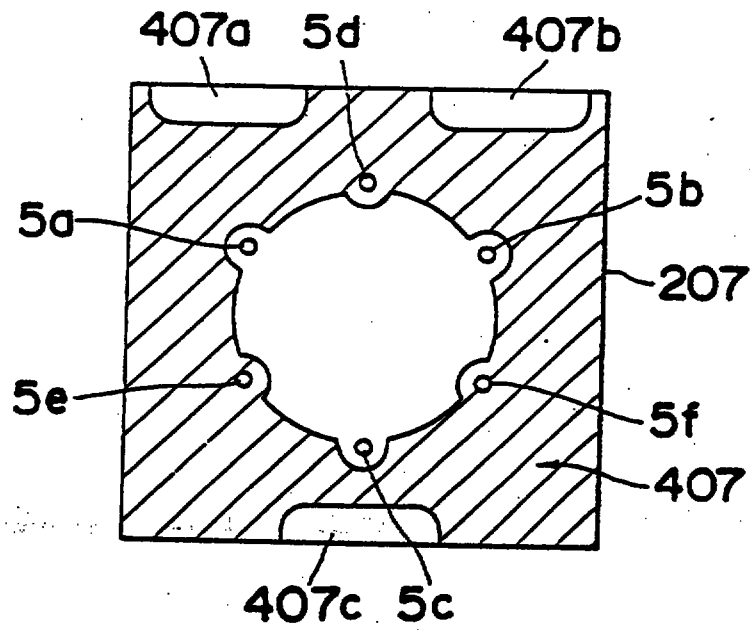
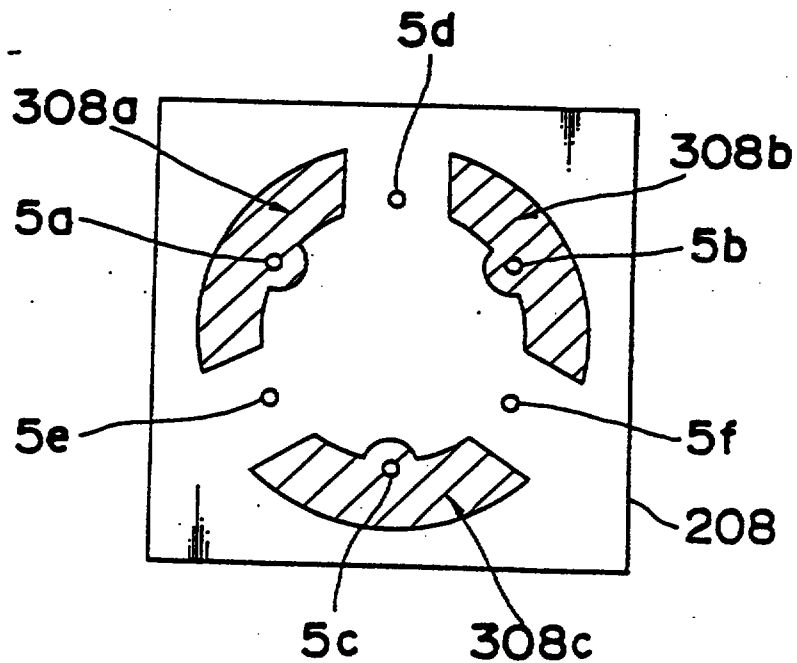


Fig. 31



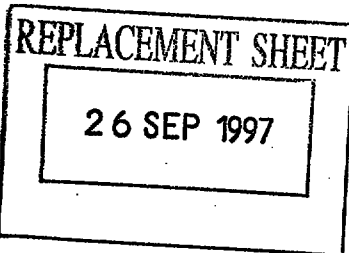


Fig. 32

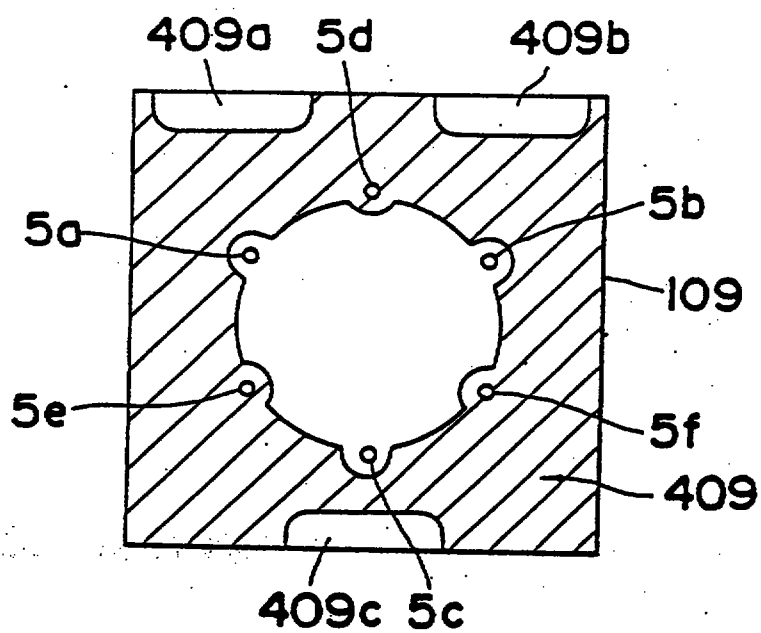
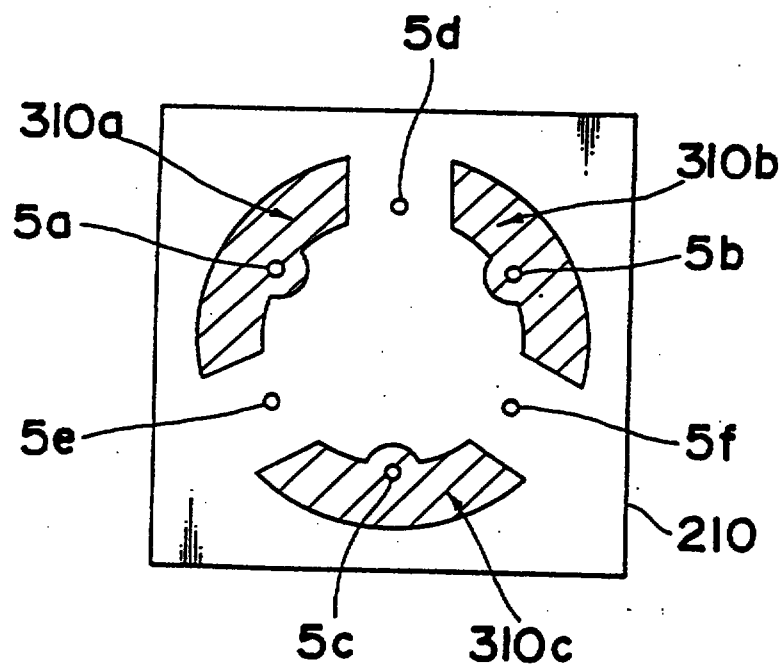


Fig. 33



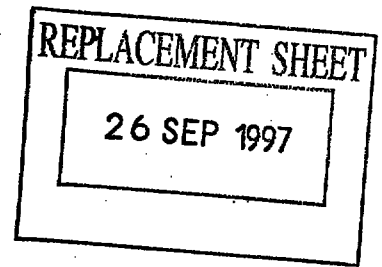


Fig. 34

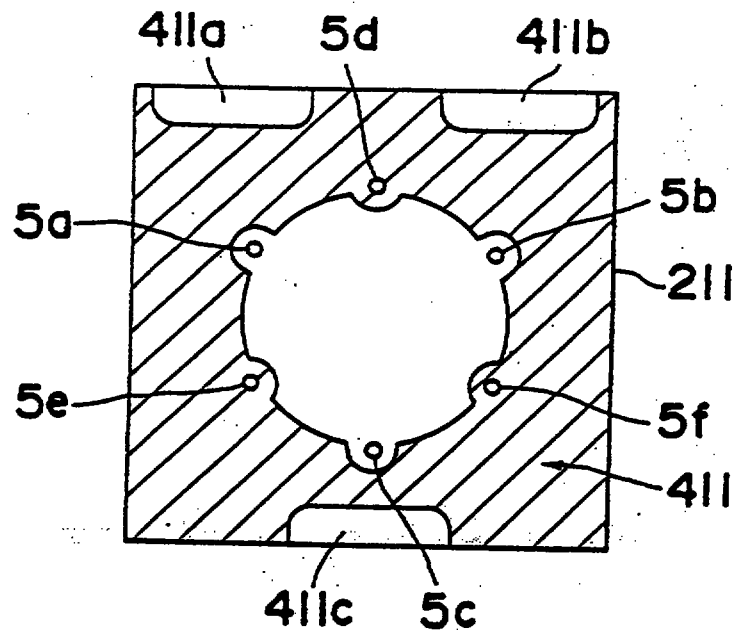
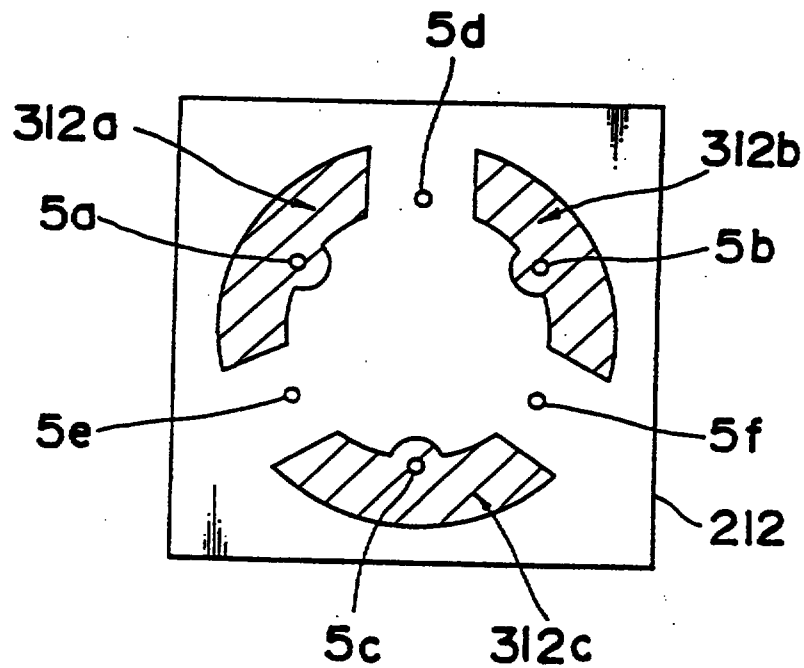


Fig. 35



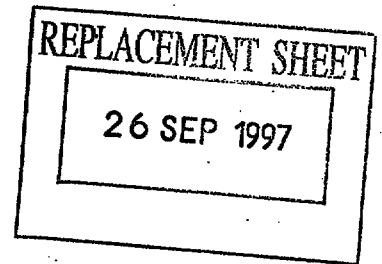


Fig. 36

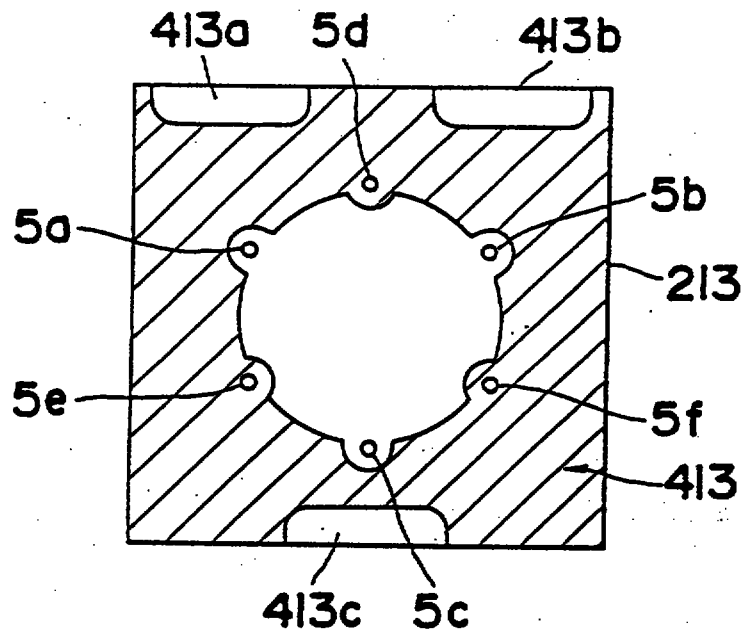
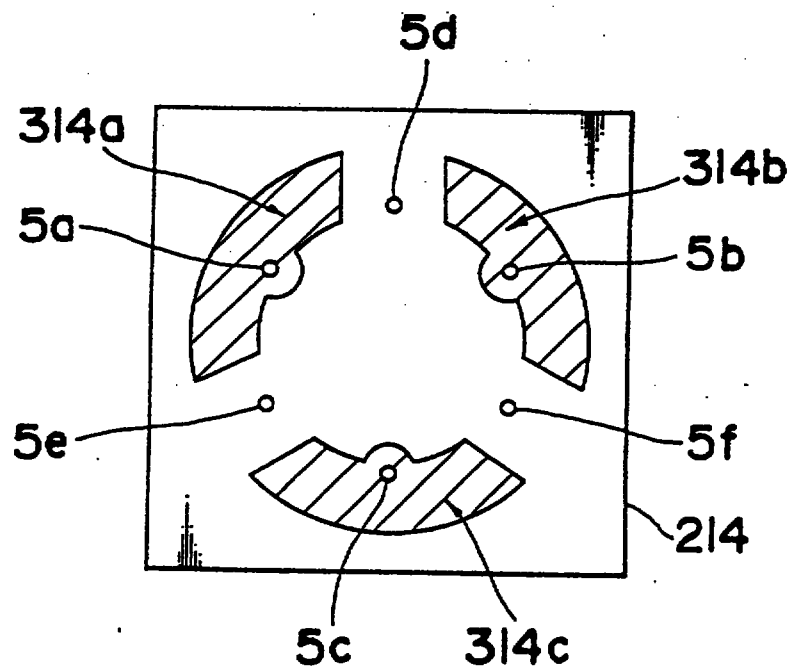


Fig. 37



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Fig. 38

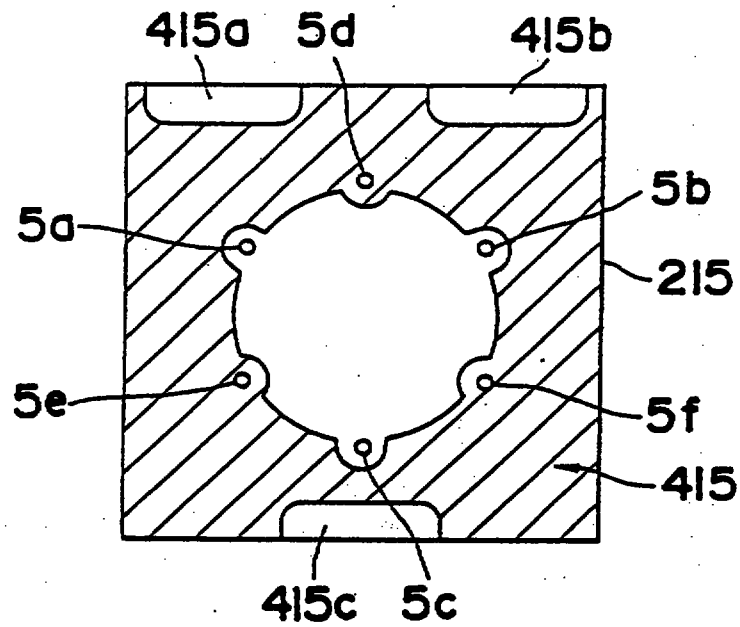
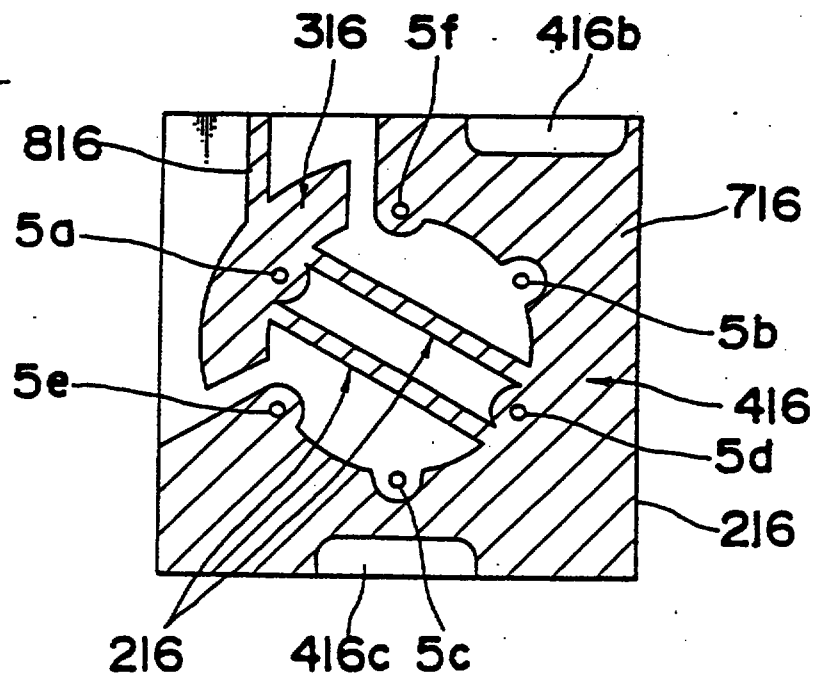


Fig. 39



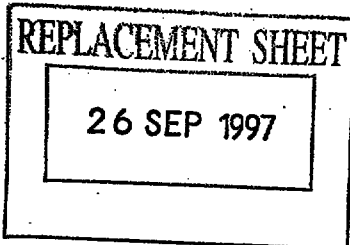


Fig. 40

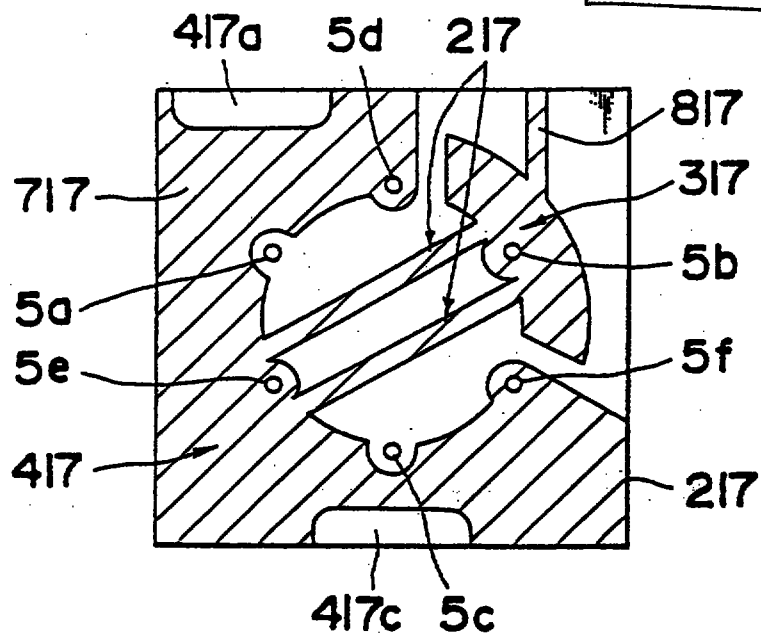
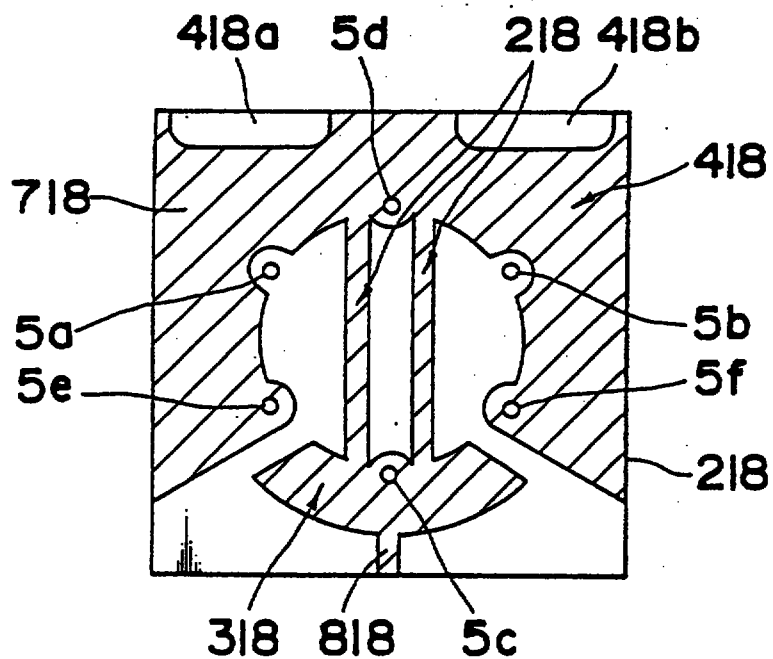


Fig. 41



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Fig. 42

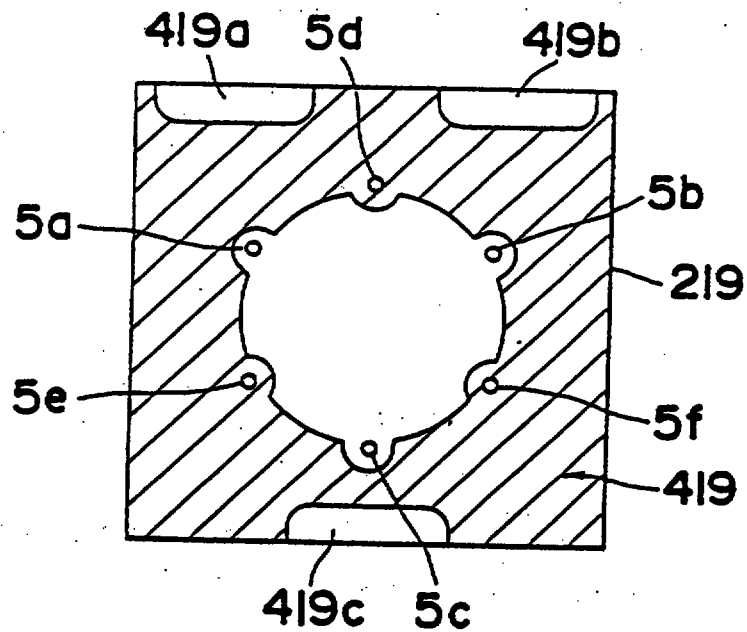
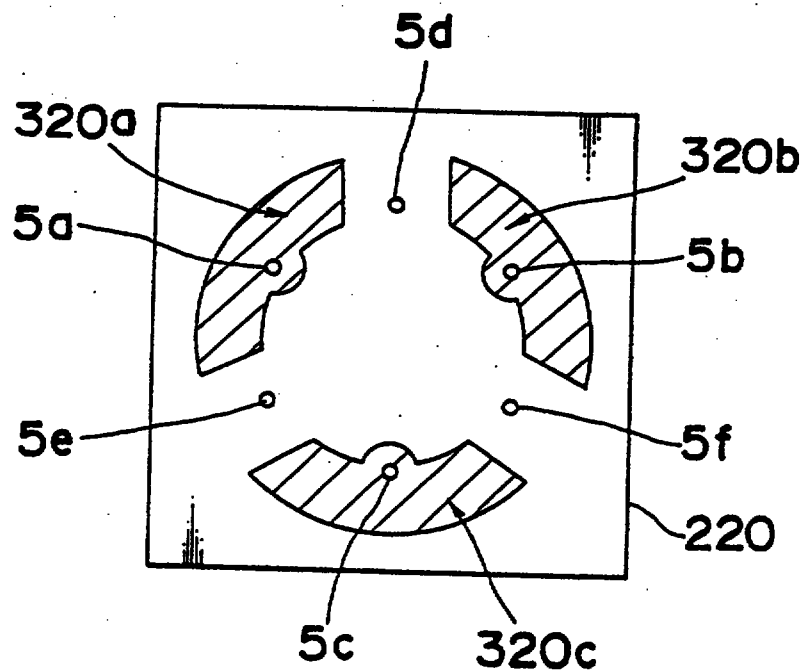


Fig. 43



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Fig. 44

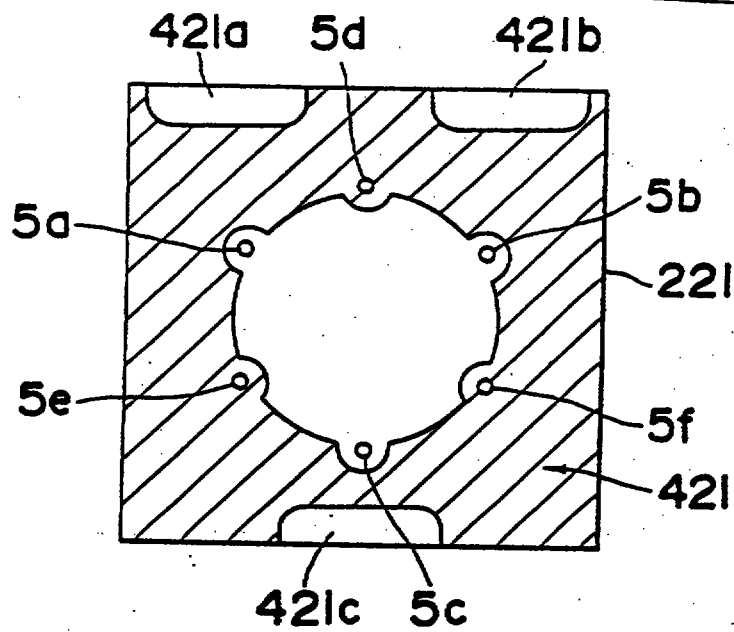
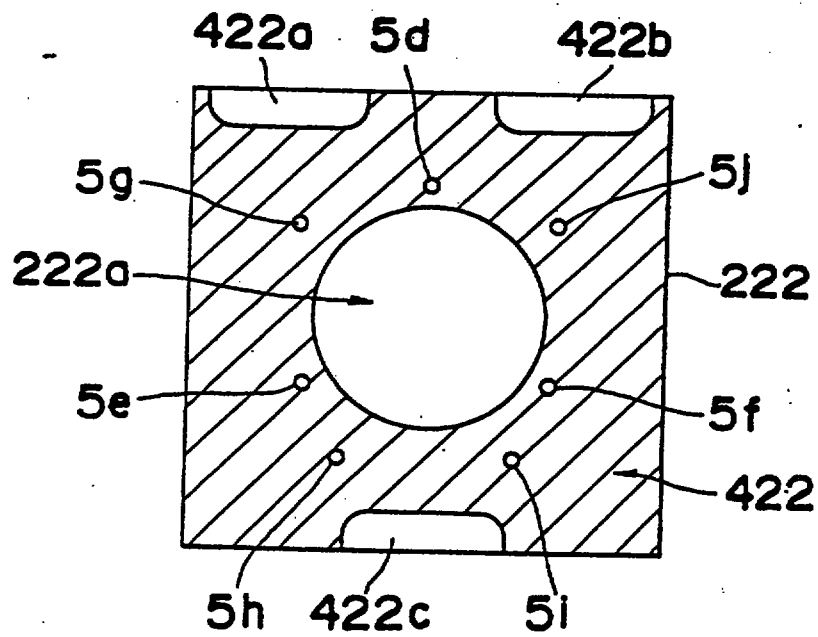


Fig. 45



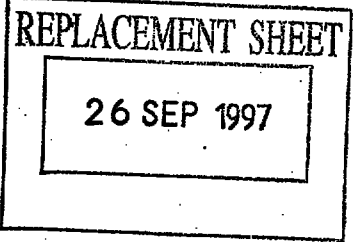


Fig. 46

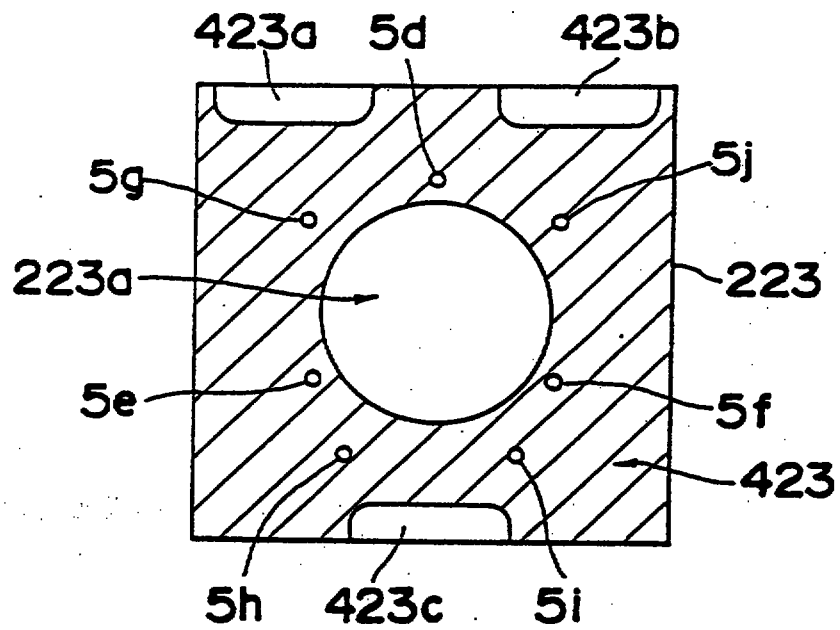


Fig. 47

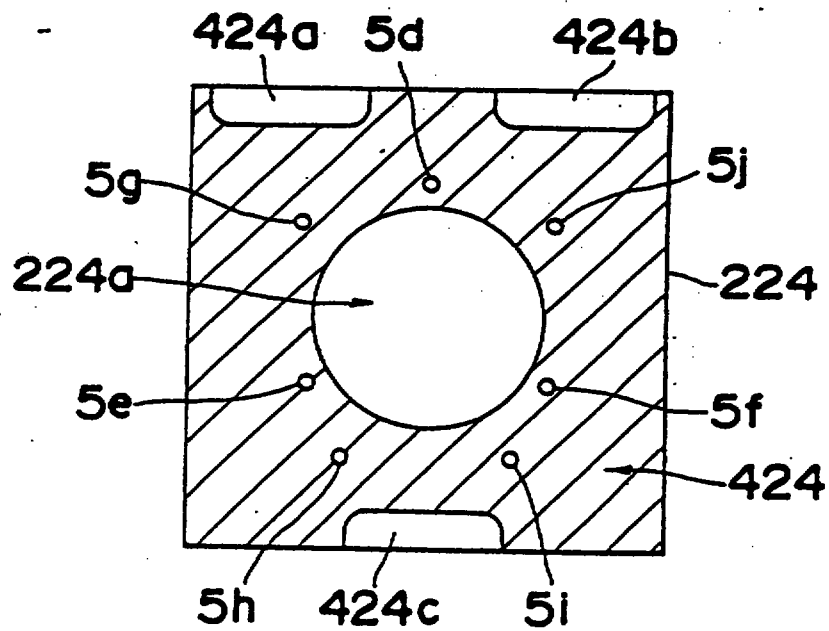


Fig. 48

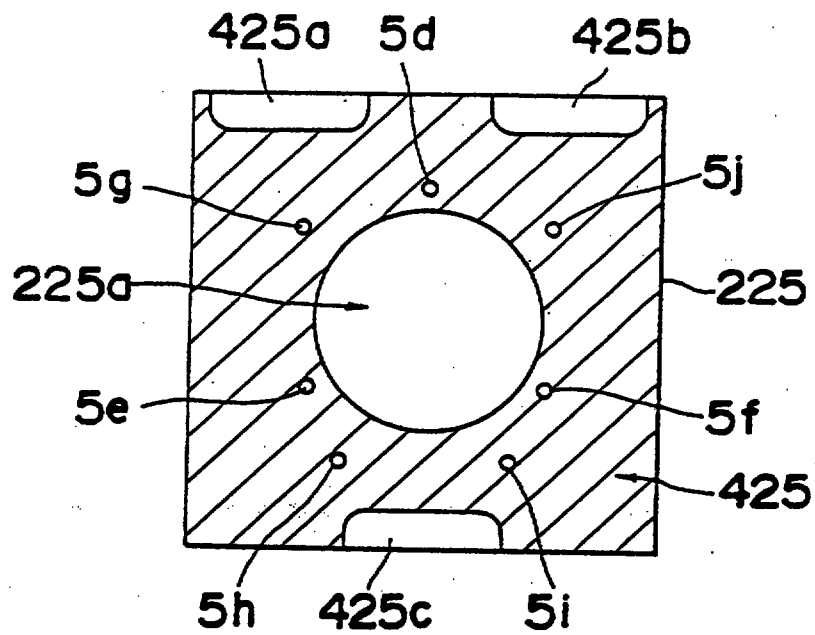
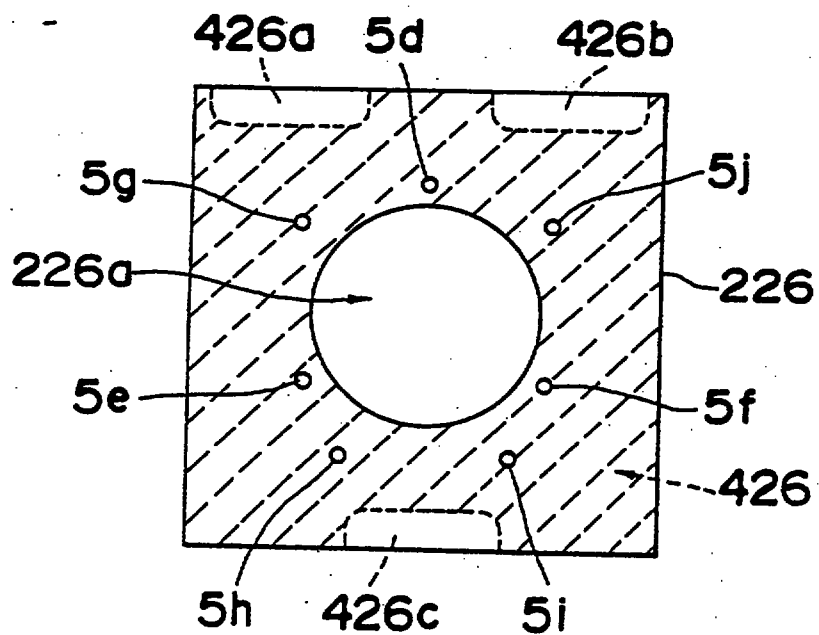


Fig. 49



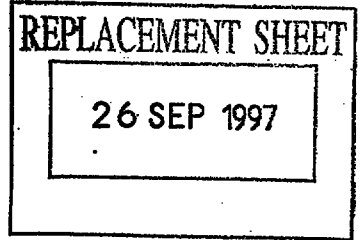


Fig. 50

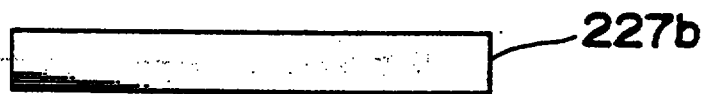
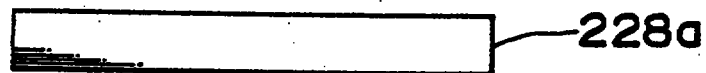


Fig. 51



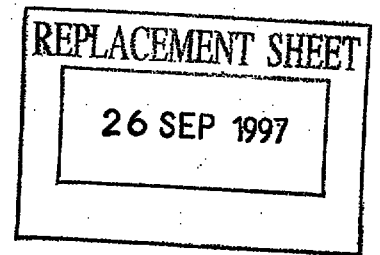


Fig. 52

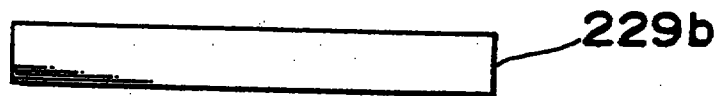
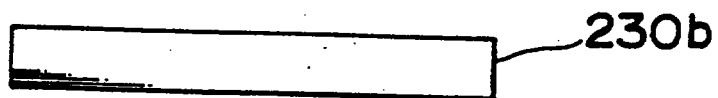


Fig. 53



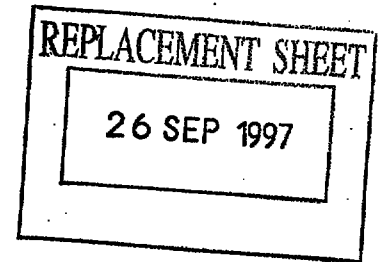


Fig. 54

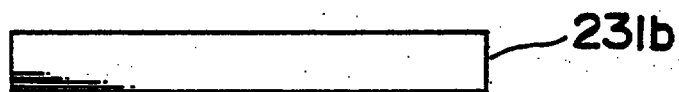
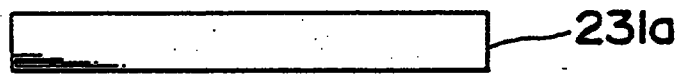
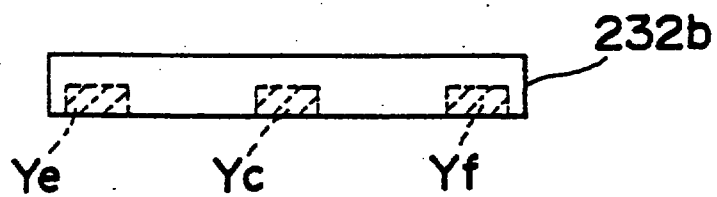
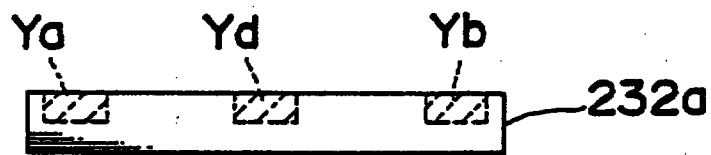


Fig. 55



REPLACEMENT SHEET

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Fig. 56 PRIOR ART

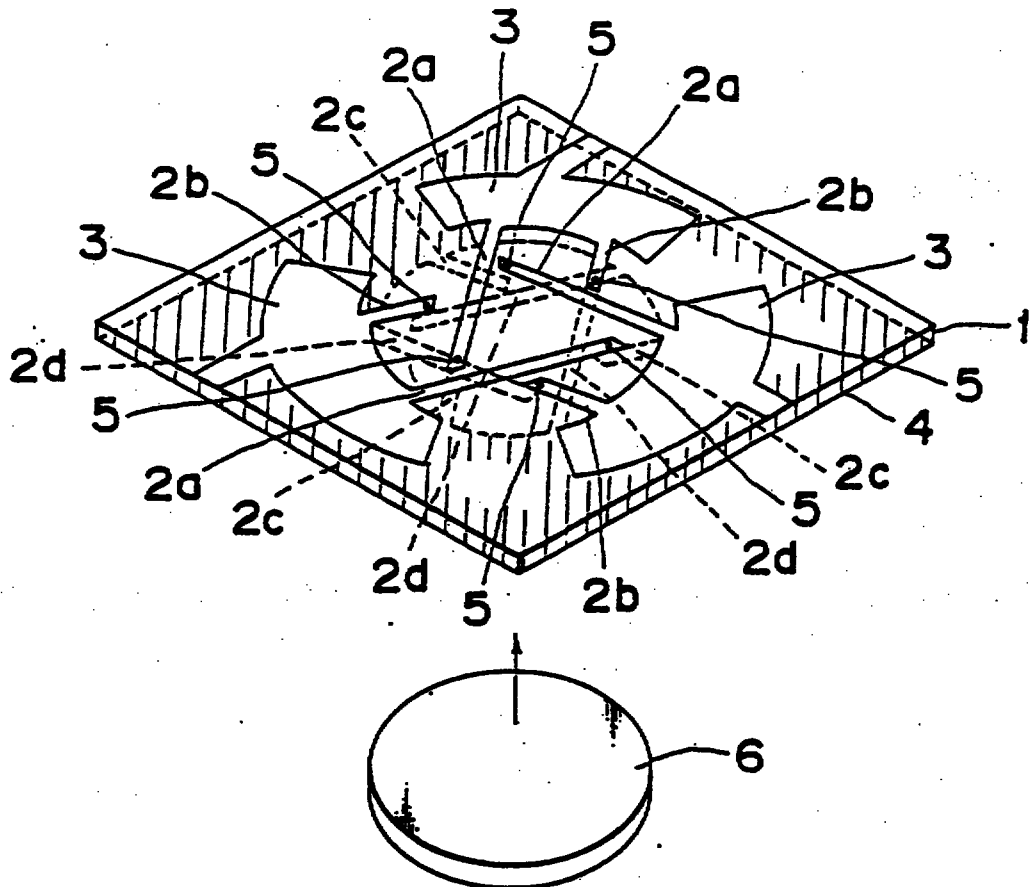


Fig. 57 PRIOR ART

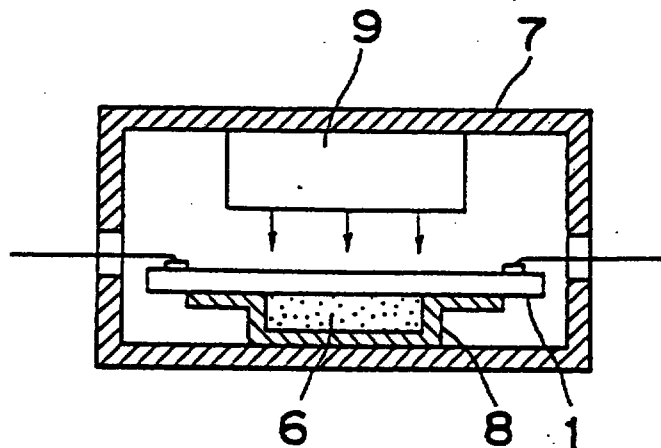
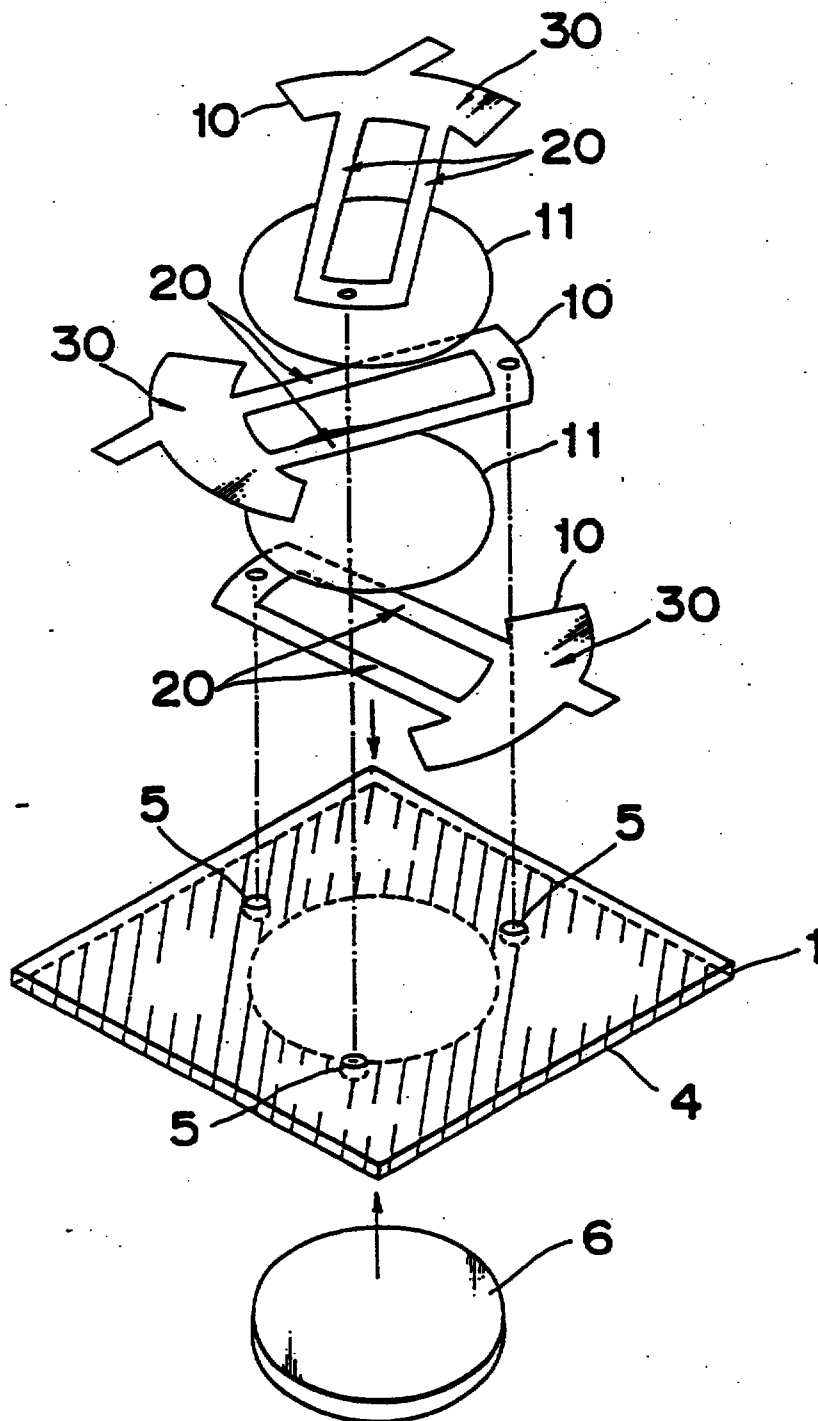


Fig. 58 PRIOR ART



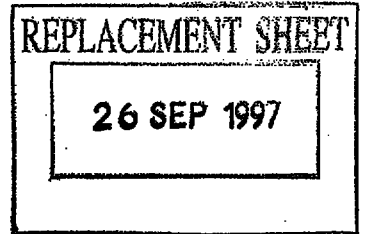
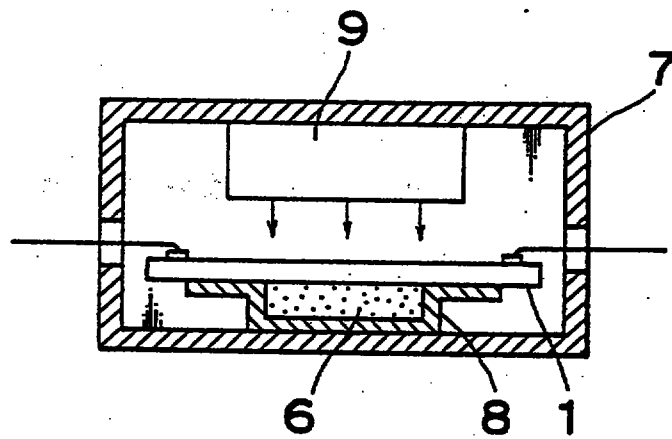
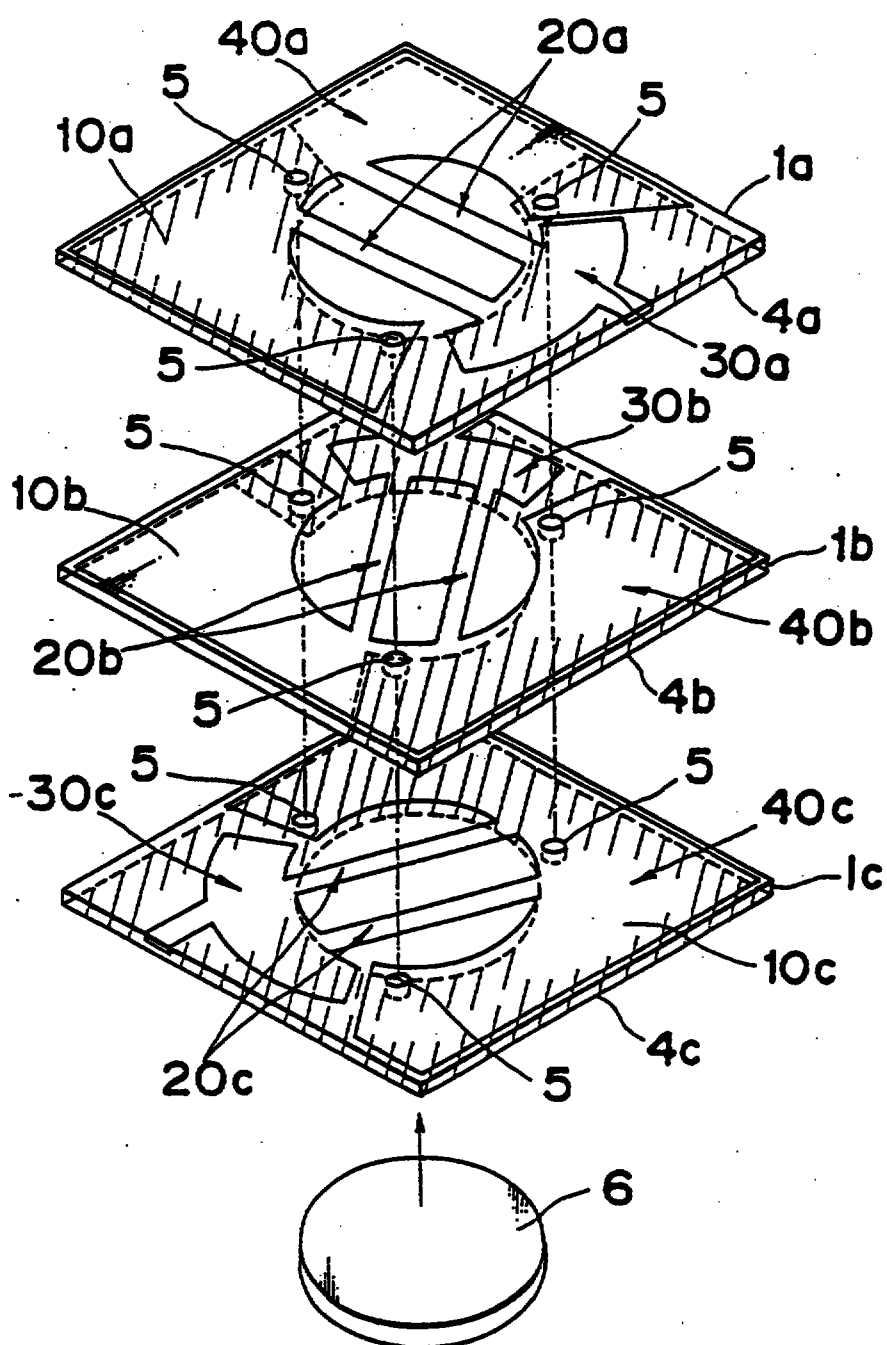


Fig. 59 PRIOR ART



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Fig. 60 PRIOR ART



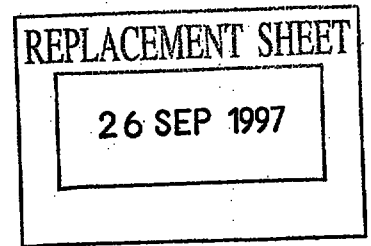
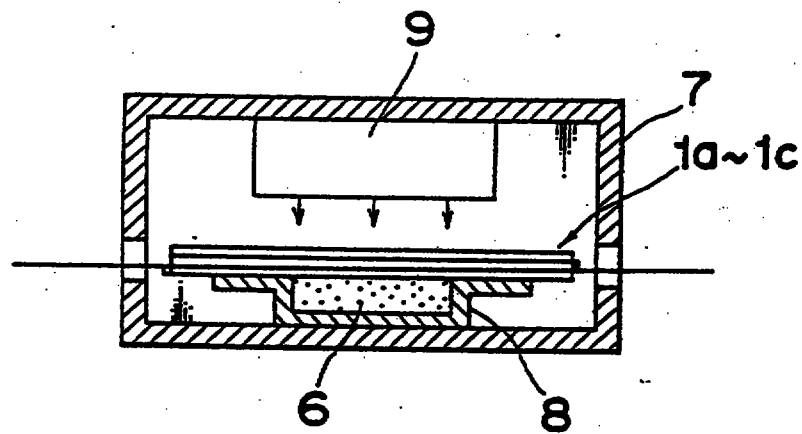


Fig. 61 PRIOR ART



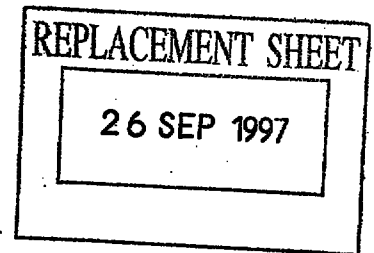
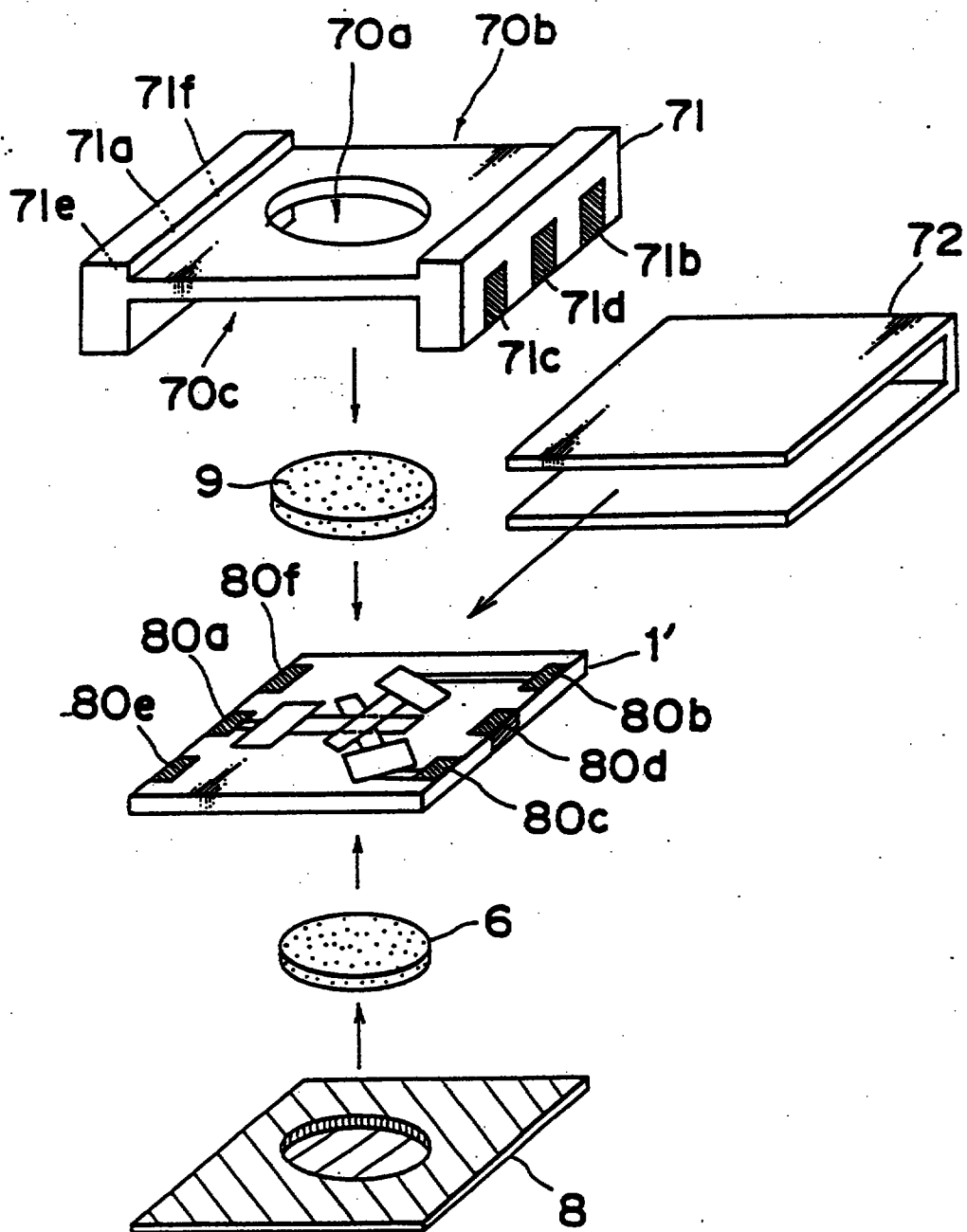


Fig. 62 PRIOR ART



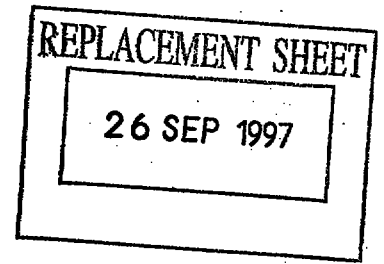
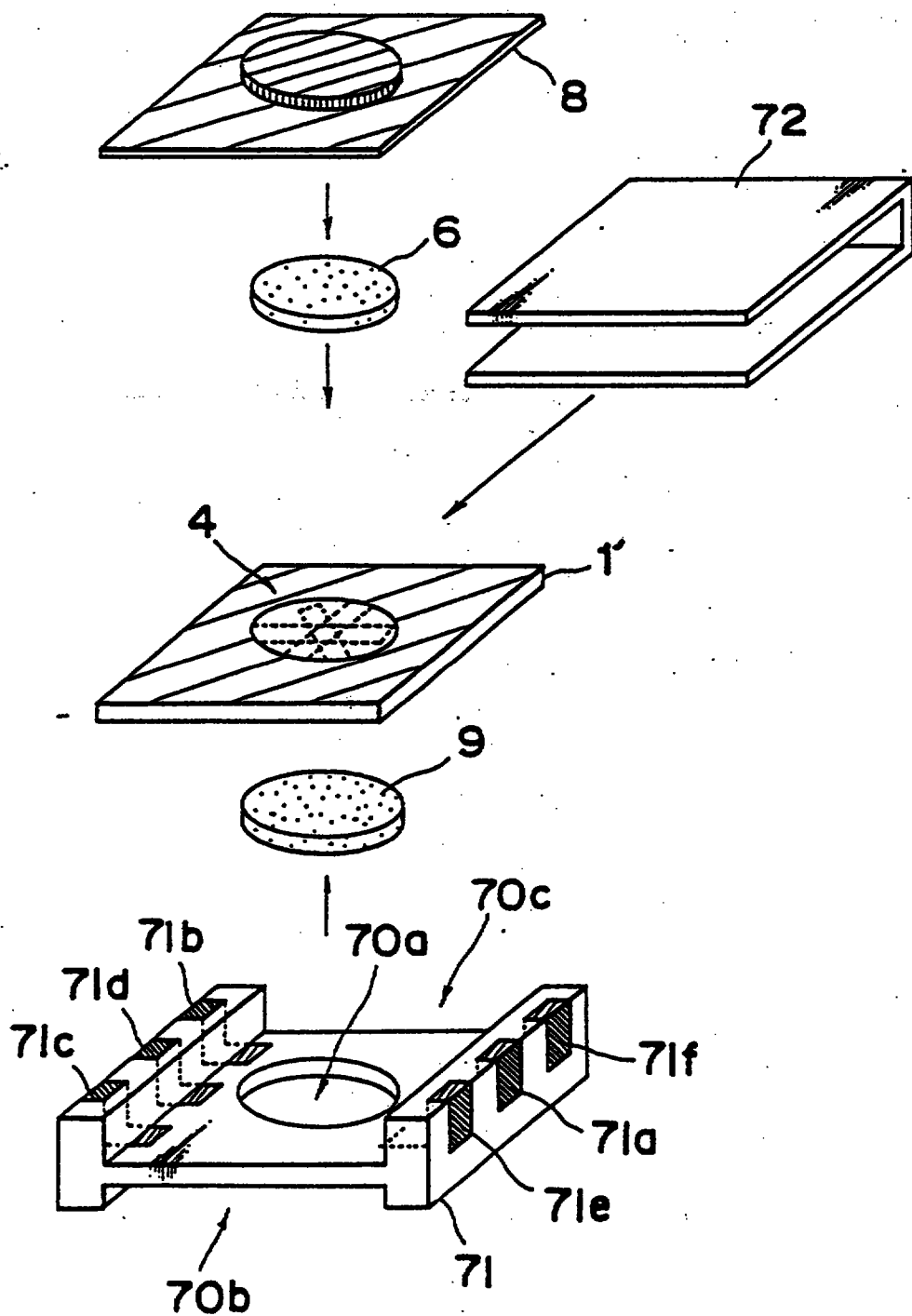


Fig. 63 PRIOR ART



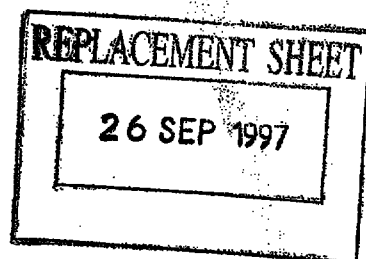
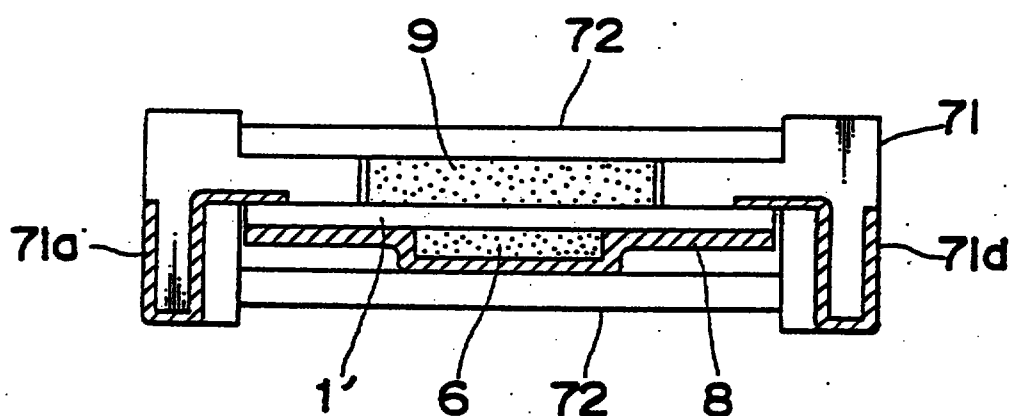
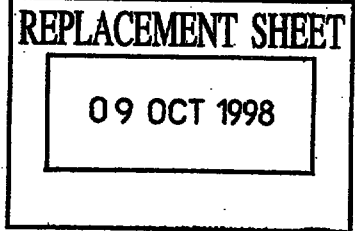


Fig. 64 PRIOR ART





ABSTRACT

NON-RECIPROCAL CIRCUIT ELEMENTS AND METHOD THEREOF

Non-reciprocal circuit elements, wherein a plurality of ceramic green sheets (101 to 114) through with given electrode films of pattern shapes being formed respectively on them are collectively fired and integrated into one dielectric basic plate (100) after they have been adhered under pressure in lamination, and a plurality of electrode films of pattern shapes are laminated within one dielectric basic plate, so that the internal circuit of the central electrode, the matching circuit and so on are disposed with microwave, resulting in that they can be smaller in size, higher in performance and easier to manufacture.

Figure 1.