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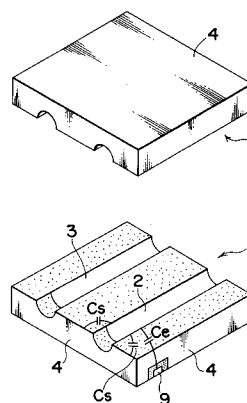
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(54) **Dielectric resonator and its characteristic adjusting method.**

(57) Dielectric resonator (1) wherein an internal conductor non-formed portion is provided near one open face of the internal conductor formed holes, and signal input, output electrodes (9,10) are provided on one portion of the external conductor (4), whereby electromagnetic field leakage is restrained, because the open face is not formed, and individual parts such as signal input, output pins and so on are not required.

Fig. 5

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BACKGROUND OF THE INVENTION

The present invention generally relates to a dielectric resonator, with an internal conductor being formed within a dielectric, and an external conductor being formed on the outside face of the dielectric, and its characteristic adjusting method.

A dielectric resonator, where a resonator electrode is formed within a dielectric block, an earth electrode is formed on the outside face of the dielectric block, and a so-called tri-plate type of dielectric resonator with strip lines being opposite to each other by the use of a dielectric basic plate with a strip line being formed on one main face, and an earth electrode being formed on the other main face are used as a band passing filter and so on in, for example, the microwave band.

Fig. 39 shows as an explosive perspective view the construction of the conventional general dielectric resonator using the dielectric block. In Fig. 39, reference numeral 40 is approximately six-face unit shaped dielectric block with three internal conductor shaped holes 46, 47, 48 and coupling holes 49, 50 being provided among the respectively internal conductor formed holes. The internal conductor is formed on the inside face of the internal conductor formed holes 46, 47, 48, and an external conductor is formed on the other five faces except for an open face 52. Reference numerals 53, 54 are so-called resin pins each being composed of resin portions 53a, 54a and signal input, output terminals 53b, 54b. Two resin pins 53, 54 are inserted into the internal conductor formed holes 46, 48 from the open face side of the dielectric block so that the terminals 53b, 54b are coupled in capacity to the internal conductor within the internal conductor formed holes 46, 48. Reference numeral 55 is a case for retaining the dielectric block 40 and the resin pins 53, 54 and also, covering the open face portion of the dielectric block. The resin pins 53, 54 are respectively inserted into the dielectric block 40 so as to cover the case 55, and also, the whole is integrated by the soldering of the dielectric block 40 with the external conductor 51. In the mounting operation of the dielectric resonator, the projection portions 55a, 55b of the case 55 are functioned as an earth terminal.

As shown in Fig. 39, many components such as input, output terminals, case and so on are necessary if a plurality of resonators are formed on a single dielectric block. The assembling steps thereof become complicated and also, completed products have to be mounted as electronic components with a lead wire attached to it having to be mounted even in the mounting operation of the completed product on the circuit basic plate. The surface mounting operation can not be effected as in the other electronic components to be mounted

on the same circuit basic plate so that a lower height operation is hard to effect. If the case 55 is adapted not to be used by the direct connection of the external conductor 51 of the dielectric block 40 on the earth electrode on the circuit basic plate, the open face 52 is exposed, and the electromagnetic field leakage is caused in this portion. When the metallic member approaches to the open face, the influences by the metallic member is received. Also, the resonator is connected with the electromagnetic field of the outside so that the given characteristics as the dielectric resonator can be obtained no more.

SUMMARY OF THE INVENTION

Accordingly, the present invention has been developed with a view to substantially eliminating the above discussed drawbacks inherent in the prior art, and has for its essential object to provide an improved dielectric resonator.

Another important object of the present invention is to provide an improved dielectric resonator which can effect a surface mounting operation on the circuit basic plate without the use of resin pins 23, 24 and a case 25 as such individual parts as shown in Fig. 39.

Still another object of the present invention is to provide a dielectric resonator where the electromagnetic field leakage between the inside and the outside near the opening portion is restrained so as to remove a problem caused by the above described electromagnetic field leakage.

A further object of the present invention is to provide a characteristic adjusting method of a dielectric resonator capable of adjusting the given resonator characteristics with ease and high accuracy.

A still further object of the present invention is to provide a dielectric resonator which is easier to obtain floating capacity by the comparative simple working or molding operation.

In accomplishing these and other objects, according to a dielectric resonator in accordance with a first invention, a non-formed portion of the internal conductor near at least one open face of the above described internal conductor formed holes is provided, and signal input, output electrodes for effecting capacity connection with the above described internal conductor is provided on one portion of the outer conductor, in a dielectric resonator where a plurality of internal conductor formed holes within the dielectric are provided so as to form the external conductor on the outside face of the above described dielectric.

In the dielectric resonator of the first invention, a non-formed portion of the internal conductor is provided near at least one open face of the internal

conductor formed hole of the dielectric resonator, and signal input, output electrodes for effecting capacity connection with the internal conductor are provided on one portion of the external conductor. A tip end capacity is caused in the non-formed portion of the internal conductor in the internal conductor formed hole so as to effect column-in coupling or interdigital connection between the adjacent resonators. In the construction, the conductor on the open face of the internal conductor formed holes is not opened, so that the large electromagnetic field leakage is not caused. As the coupling holes are not required to be provided, the whole can be easily made smaller in size. As the signal input, output electrodes are provided in one portion of the outer conductor so as to effect a capacity connection with the internal conductor, the signal input, output terminals as individual parts are not required. The external conductor is connected with the earth electrode on the circuit basic plate by the surface mounting operation on the circuit basic plate, and also, the signal input, output electrodes can be connected with the signal line on the circuit basic plate.

A dielectric resonator of a second invention described in accordance with the first invention is characterized in that the above described dielectric resonator is an approximately six-face unit in shape so as to form the above described signal input, output electrodes only on the circuit basic plate mounting face.

In the dielectric resonator of the second invention, the above described signal input, output electrodes are formed only on the mounting face with respect to the circuit basic plate. Therefore, the electromagnetic field leakage of the signal input, output electrodes is reduced with the dielectric resonator being mounted on the circuit basic plate, changes in the resonator characteristics by the influences of the metallic member and so on of the peripheral portion are less, and unnecessary connection with the other circuit portion is required no more so as to simplify the circuit designing operation. Further, the pattern formation is simplified, because the signal input, output electrodes have only to be formed within one plane.

A dielectric resonator of a third invention, where a plurality of internal conductor formed holes within the dielectric are provided, an external conductor is formed on the outside face of the above described dielectric resonator, one open face of the above described internal conductor formed holes is made a short-circuit face, and also, a non-formed portion of the internal conductor is provided near the other open face, signal input, output electrodes for effecting capacity connection with the above described internal conductor are provided on one portion of the external conductor, the deletion por-

tions of the conductor and the dielectric are formed in one portion of the above described short-circuit face, the above described other open face or both the faces.

In the dielectric resonator of the third invention, one open face of the above described internal conductor formed holes is made a short-circuit face, and also, a non-formed portion of the internal conductor is provided near the other open face, signal input, output electrodes for effecting capacity connection with the above described internal conductor are provided on one portion of the external conductor, the deletion portions of the conductor and the dielectric are formed in one portion of the open face where the non-formed portion of the internal conductor is provided or the short-circuit face or both the faces. If one portions of the conductor and the dielectric are deleted in the open face where the non-formed portion of the internal conductor is provided, the resonance frequency of the resonator can be raised. If the conductor and the dielectric between the open portions of the adjacent internal conductor formed holes in the short circuit face are deleted, the coupling between the resonators is weakened and also, the resonance frequency of the resonator can be lowered. If the conductor and the dielectric around the internal conductor formed holes except for between the open portions of the adjacent internal conductor formed holes are deleted, the resonance frequency of the resonator can be lowered. Therefore, the coupling adjusting and the frequency adjustment can be easily effected without coating addition and so on of the conductor on the non-formed portion of the conductor.

A dielectric resonator of a fourth invention where internal conductor formed holes with an internal conductor being formed on the inside face are provided on the dielectric so as to form the external conductor on the outside face of the dielectric, characterized in that hollows near the internal conductor formed holes in at least one open face of the internal conductor formed holes are formed so as to delete the internal conductor near the above described hollow formed portions.

In the dielectric resonator of the fourth invention, hollows with internal conductor formed hole as a center are formed on at least one open face of the internal conductor formed holes of the dielectric resonator, and the internal conductor near the hollow formed holes is deleted. Accordingly, the open portion of the internal conductor is formed in a location secluded from the opening face. Thus, the open portion of the internal conductor is caused on the inside from the open face of the internal conductor formed holes, and the electromagnetic field leakage between the inside and the outside of the dielectric resonator is improved so that the stable

resonator characteristics are obtained.

A dielectric resonator of a fifth invention where internal conductor formed holes with an internal conductor being formed on the inside face thereof are provided in the dielectric so as to form the external conductor on the outside face of the dielectric, one portion of the internal conductor is deleted near the open face of the internal conductor formed holes and in the location secluded from the open face.

In the dielectric resonator of the fifth invention, one portion of the internal conductor is deleted near the open face of the internal conductor formed holes and in the location secluded from the open face. As the open portion of the internal conductor is formed in the location secluded from the open face of the resonator in this manner, the electromagnetic field leakage is restrained.

A dielectric resonator of a sixth invention where internal conductor formed holes with an internal conductor being formed on the inside face are provided in the dielectric, and external conductors are formed on the outside face of the dielectric, characterized in that a throttle portion is formed in at least one open portion of the internal conductor formed holes, and the internal conductor is deleted near the throttle portion and on the internal conductor formed hole side.

In the dielectric resonator of the sixth invention, a throttle portion is formed on at least one open face of the internal conductor formed holes, and the internal conductor near the throttle portion and on the internal conductor formed hole side. Accordingly, the open portion of the internal conductor is formed in the location secluded from the open face of the internal conductor formed holes so as to restrain the electromagnetic field leakage.

A dielectric resonator of a seventh invention where internal conductor formed holes with an internal conductor being formed in the inside face are provided in the dielectric so as to form the external conductor on the outside face of the dielectric, a throttle portion is formed in a location near one open face of the internal conductor formed holes and secluded from the open face so as to delete the internal conductor of the above described throttle portion.

In a dielectric resonator of the seventh invention where a throttle portion is formed in a location near one open face of the internal conductor formed holes and secluded from the open face so as to delete the internal conductor of the above described throttle portion. Therefore, as the open portion of the internal conductor is formed in a location secluded from the open face of the internal conductor formed holes, the electromagnetic field leakage is restrained.

A dielectric resonator of an eighth invention for making resonant with given frequency by the inside conductor formed on the inside face of a hole of the dielectric and the outside conductor formed on the outside face of the above described dielectric, the concave portion is formed on the surface of the above described dielectric so as to cause the outside conductor in the bottom portion of the hollow portion to approach the above described inside conductor.

In the eighth invention, the outside conductor of the bottom portion of the concave portion formed on the surface of the dielectric is approached towards the above described inside conductor, the interval between the inside conductor of the hole of the dielectric and the outside conductor which becomes an earth electrode becomes shorter, and the floating capacity is likely to obtain. The floating capacity can be adjusted by the comparatively simple working or molding operation of size, depth and so on of the concave portion. In the comb-line type, the band width of the filter can be made larger by provision of, for example, larger floating capacity. The resonator length becomes shorter, and the size can be made smaller by the provision of, for example, larger floating capacity.

A dielectric resonator of a ninth invention where a taper portion is formed on the corner portion of the dielectric so as to cause the outside conductor of the taper portion to approach to the inside conductor.

In the ninth invention, the taper portion is formed on the corner portion of the dielectric so as to cause the outside conductor of the taper portion to approach to the inside conductor, so that the interval between the inside conductor of the hole interior of the dielectric and the outside conductor which becomes an earth electrode, and the floating capacity is likely to obtain as in the first invention. The floating capacity can be adjusted by the comparatively simple working or molding operation of the size, inclination and so on of the taper portion in the corner portion. In the comb-line type, the band width of the filter may be made larger by the provision of, for example, larger floating capacity. The resonator length becomes shorter and the size become smaller by the provision of, for example, the larger floating capacity.

A dielectric resonator of a tenth invention where a concave stage portion of approximately L type (in section) is provided in the corner portion of the dielectric so as to cause the outside conductor of the concave stage portion to approach to the inside conductor.

In the tenth invention, a concave stage portion of approximately L type (in section) is provided in the corner portion of the dielectric so as to cause the outside conductor of the concave stage portion

to approach to the inside conductor, so that the interval between the inside conductor of the hole interior of the dielectric and the outside conductor which becomes an earth electrode becomes shorter, and the floating capacity is likely to obtain. The floating capacity can be adjusted by the comparatively simple working or molding operation of the size, depth and so on of the concave sage portion in the corner portion. In the comb-line type, the band width of the filter may be made larger by the provision of, for example, larger floating capacity. The resonator length becomes shorter and the size becomes smaller by the provision of, for example, the larger floating capacity.

A characteristic adjusting method of a dielectric resonator of an eleventh invention where internal conductor formed holes with an internal conductor being formed on the inside face so as to form the external conductor on the outside face of the dielectric, comprising the steps of deleting the internal conductor to be formed near the above described hollow formed portion, adjusting the tip end capacity of the internal conductor with a hollow being formed in advance near the internal conductor formed hole in at least one open face of the above described internal conductor formed holes.

In the characteristic adjusting method of the dielectric resonator of the eleventh invention, a hollow is formed in advance, with the open portion of the internal conductor formed hole being provided as a center, on at least one open face of the internal conductor formed holes, and the internal conductor near the hollow formed portion is deleted. The internal edge portion of the internal conductor formed hole opening portion is not deleted by the deletion of the internal conductor near the hollow formed portion in this manner. One portion of the internal conductor and the dielectric can be deleted with high accuracy. As a result, the given resonator characteristics can be obtained with ease and for a short time by the adjustment of the resonator characteristics to the high accuracy.

A characteristic adjusting method of a dielectric resonator of a twelfth invention where an internal conductor formed holes with an internal conductor being formed on the inside face is provided in the dielectric so as to form the external conductor on the outside face of the dielectric, comprising the steps of forming a throttle portion in advance on one open face of the above described internal conductor formed holes, deleting the internal conductor formed on the above described throttle portion, adjusting the tip end capacity of the internal conductor.

In a characteristic adjusting method of a dielectric resonator of the twelfth invention, a throttle portion is formed in advance on one open portion of the internal conductor formed holes, the tip end

capacity of the internal conductor is adjusted by the deletion of the internal conductor formed on the throttle portion. As the internal conductor and the dielectric are deleted only in the throttled portion in the deleting operation of the internal conductor formed in advance on the throttled portion in this manner, the adjustment can be effected with high accuracy.

A characteristic adjusting method of a dielectric resonator of a thirteenth invention where internal conductor formed holes with an internal conductor being formed on the inside face are provided in the dielectric so as to form the external conductor on the outside face of the dielectric, comprising the steps of forming a throttle portion in advance in a location near one open face of the above described conductor formed holes and secluded from the open face, deleting the internal conductor formed on the above described throttle, adjusting the tip end capacity of the internal conductor.

In a characteristic adjusting method of the thirteenth invention, a throttle portion is formed in advance in a location near one open face of the internal conductor formed holes and secluded from the open face, the internal conductor formed on the throttle portion is deleted, the tip end capacity of the internal conductor is adjusted in this manner. The adjusting operation can be effected with high accuracy so as to delete the internal conductor formed in advance on the throttle portion in this manner.

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 a dielectric resonator being made in accordance with the a first embodiment;

Fig. 2 is a sectional view of the dielectric resonator being made in accordance with the first embodiment;

Fig. 3 is a sectional view of a dielectric resonator in accordance with the first embodiment;

Fig. 4 is a perspective view of a dielectric resonator in accordance with the first embodiment;

Fig. 5 is an explosive perspective view of the dielectric resonator in accordance with the first embodiment;

Fig. 6 is an equivalent circuit diagram of the dielectric resonator in accordance with the first embodiment;

Fig. 7 is a view showing the construction of the dielectric resonator in accordance with a second embodiment, (A) being a horizontal sectional

view, (B) being a front face view;

Fig. 8 is a front face view of the dielectric resonator in accordance with a third embodiment;

Fig. 9 is a front face view showing a conductor deleted embodiment for the characteristics measurement of the dielectric resonator in accordance with the third embodiment;

Fig. 10 is a partial front face view showing the conductor deleted embodiment for the characteristics measurement of the dielectric resonator in accordance with the third embodiment;

Fig. 11 is a graph showing the measurement result in the coupling coefficient changes of the dielectric resonator in accordance with the third embodiment;

Fig. 12 is a graph showing the measurement result in the resonance frequency changes of the dielectric resonator in accordance with the third embodiment;

Fig. 13 is a front face view of a dielectric resonator in accordance with a fourth embodiment;

Fig. 14 is a perspective view of a dielectric resonator in accordance with a fifth embodiment;

Fig. 15 is an explosive perspective view of a dielectric resonator in accordance with a sixth embodiment;

Fig. 16 is a perspective view of the dielectric resonator in accordance with the sixth embodiment;

Fig. 17 is a sectional view of the dielectric resonator in accordance with the sixth embodiment;

Fig. 18 is a sectional view of the dielectric resonator in accordance with the sixth embodiment;

Fig. 19 is a sectional view of the dielectric resonator in accordance with the sixth embodiment;

Fig. 20 is a sectional view of a dielectric resonator in accordance with a seventh embodiment;

Fig. 21 is a sectional view of a dielectric resonator in accordance with an eighth embodiment;

Fig. 22 is a sectional view of the dielectric resonator in accordance with the eighth embodiment;

Fig. 23 is a view showing the shape of a grindstone;

Fig. 24 is a view showing the shape of a grindstone;

Fig. 25 is a perspective view of one dielectric basic plate for constituting the dielectric resonator in accordance with a ninth embodiment;

Fig. 26 is a sectional view of the dielectric resonator in the ninth embodiment;

Fig. 27 is a sectional view of the dielectric resonator in accordance with the ninth embodiment;

Fig. 28 (a), (b) are a perspective view and a sectional view of the dielectric resonator in a tenth embodiment of the present invention;

Fig. 29 is a perspective view of a dielectric resonator of an eleventh embodiment of the present invention;

Fig. 30 (a), (b) are a perspective view and an essential portion sectional view of a dielectric resonator of a twelfth embodiment;

Fig. 31 (a), (b) are a perspective view and an essential portion sectional view of a dielectric resonator of a thirteenth embodiment;

Fig. 32 (a), (b) are a perspective view and an essential portion sectional view of a dielectric resonator of a fourteenth embodiment;

Fig. 33 (a), (b) are a perspective view and an essential portion sectional view of a dielectric resonator of a fifteenth embodiment of the present invention;

Fig. 34 is a perspective view of a dielectric resonator of a sixteenth embodiment thereof;

Fig. 35 is a perspective view of a dielectric resonator of a seventeenth embodiment thereof;

Fig. 36 is a perspective view of a dielectric resonator of an eighteenth embodiment of the present invention;

Fig. 37 is a perspective view of a dielectric resonator of a nineteenth embodiment thereof;

Fig. 38 is a sectional view of a dielectric resonator of a twentieth embodiment thereof; and

Fig. 39 is an explosive perspective view of the conventional dielectric resonator.

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)

The construction of a dielectric resonator and a characteristic adjusting method thereof in a first embodiment of the present invention will be described hereinafter in accordance with Fig. 1 through Fig. 6.

Fig. 1 is a perspective view of a dielectric resonator. In Fig. 1, reference numerals 5, 6 are internal conductor formed holes provided in an approximately six face unit shaped dielectric block. An internal conductor is formed in advance on inside faces of the internal conductor formed holes 5, 6. An external conductor 4 is formed on the outside face (six faces) of the dielectric block. A signal input, output electrodes shown in reference numerals 9, 10 are formed in the respective one portion of the external conductor 4.

Fig. 2 is a vertical sectional view passing through an internal conductor formed hole 6 in Fig. 1. An internal conductor shown at reference numeral 3 on the inside face of the internal conductor formed hole 6 is formed, on the whole face between two open portions. The non-formed portion (hereinafter referred to as an open portion) of the inner conductor is provided in one portion of the internal conductor when a dielectric resonator having given characteristics is obtained from such dielectric block. The internal conductor near one open portion of the internal conductor formed holes 5, 6 is deleted so as to adjust the resonance frequency and the coupling degree. Fig. 4 is a perspective view showing a condition after the deletion. Fig. 3 is a vertical sectional view thereof. In Fig. 3, the portion is made an open portion with the internal conductor near the open portion of the internal conductor formed hole as shown with A, B being deleted. Fig. 5 is a view where the dielectric resonator shown in Fig. 4 is cut, separated with a central horizontal face with signal input, output electrode formed faces being provided downward. A tip end capacity C_s is caused, between the tip end portion of the internal conductor 2 and the external conductor 4, in the open portion of, for example, the internal conductor 2, and an external coupling capacity C_e is caused between the tip end portion vicinity of the internal conductor 2 and the signal input, output electrodes 9. The tip end capacity is adjusted by a size S shown in Fig. 3 in this manner so as to thereby to adjust the coupling degree between the resonance frequency of the resonator and the resonator.

Fig. 6 is an equivalent circuit diagram of a dielectric resonator shown in Fig. 1 through Fig. 5. In Fig. 6, reference character R1 is a resonator with an internal conductor 2, reference character R2 is a resonator with an internal conductor 3. Reference character C_s is a tip end capacity to be formed in the open portion of the respective inner conductor. Reference character C_e is an external coupling capacity to be formed between the signal input, output electrodes 9, 10 and the open portions of the internal conductors.

(Second Embodiment)

The construction of a dielectric resonator in a second embodiment which is different in the opening portion formed position within the internal conductor formed hole is shown in Fig. 7. In Fig. 7, reference character (A) is a central horizontal sectional view of a dielectric block, reference character (B) is a front face view seen from the short-circuit face side of the dielectric block. The open portions of the internal conductors 2, 3 provided within the internal conductor formed holes in this manner are

provided in locations secluded from the opening portions of the internal conductor formed holes so as to form the tip end capacity C_s in the opening portions. Thus, the electromagnetic field leakage can be further restrained.

(Third Embodiment)

The construction of the dielectric resonator in accordance with a third embodiment where the resonance frequency and the coupling degree have been adjusted by the provision of the deletion portion of the conductor and the dielectric in one portion of the short-circuit face is shown in Fig. 8. Fig. 8 is a front face view seen from the short-circuit face side, with reference characters C, D being deletion portions of the conductor and the dielectric of the short-circuit faces. The resonance frequency of the resonator by the internal conductor formed hole 5 is lowered by the partial deletion of the conductor and the dielectric in the region of the S1 in Fig. 8. Similarly, if the conductor and the dielectric are partially deleted in the region of the S2, the resonance frequency of the resonator is lowered by the internal conductor formed hole 6. The coupling degree between both the resonators is lowered if the conductor and the dielectric are partially deleted in the region of the S12. Modified embodiment of the coupling coefficients by the deletion of the conductor and the dielectric are shown in Fig. 9 and Fig. 11. A conductor deletion portion of a width d is provided in the middle position of two coupling holes as shown in Fig. 9. Changes in the coupling coefficients are measured when the area S has been changed. In Fig. 9, $a = 2.0$ mm, $b = 4.0$ mm, $c = 5.0$ mm. Fig. 11 shows the change ratio of the coupling coefficients with the axis of abscissas being a conductor deletion area S , the axis of ordinates being K_0 in the coupling coefficient in the case of $S = 0$, the coupling coefficient after the conductor deletion being K_a . The coupling coefficient can be adjusted by the conductor deletion area among the internal conductor formed holes on the short-circuit face. Fig. 10 and Fig. 11 show the adjustment example of the resonance frequency. A conductor deletion portion of a length g with a width f is provided in a location away at a given interval from the internal conductor formed hole as in Fig. 10 so as to measure the resonance frequency when the length g has been changed. In Fig. 10, $a = 2.0$ mm, $e = 3.0$ mm, $f = 0.5$ mm. In Fig. 12, the axis of abscissas is a length g , the axis of ordinates shows the variation amount in the resonance frequency with the resonance frequency in the case of $g = 0$ being a reference. The resonance frequency can be adjusted by the conductor deletion of the internal conductor formed periphery on the short-circuit

face.

(Fourth Embodiment)

A fourth embodiment shown in Fig. 8 through Fig. 12 is that one portion of the conductor and the dielectric is deleted on the short-circuit face, and the capacity C_s is decreased, if the conductor and the dielectric on the open face on the internal conductor non-formed portion side are deleted, so that the resonance frequency can be adjusted in a higher direction.

Although two stages of dielectric resonator is shown in the examples shown in Fig. 8 through Fig. 12, the same things can be applied even to the dielectric resonator of three stairs or more. The coupling degree between the resonators are adjusted by the partial deletion of the conductor and the dielectric in the area S_{12} , S_{23} , ... S_{n-1n} among the open portions of the internal conductor formed holes on the short-circuit face as described in Fig. 13 in this case. The resonance frequency of the respective resonators can be adjusted by the partial deletion of the conductor and the dielectric in the regions of S_1 , S_2 , S_3 ... S_n .

(Fifth Embodiment)

The construction of the dielectric resonator in a fifth embodiment different in the shape of the signal input, output electrodes is shown in Fig. 14 as a perspective view. In Fig. 14, reference numerals 16, 17, 18 are internal conductor formed holes with the internal conductor and the open portions being formed on the inside face. External conductor 4 is provided on the outside face of the dielectric block, with the signal input, output electrodes 9, 10 being formed only on the top face in the drawing. The electrode 9 is coupled in capacity to the internal conductor within the internal conductor formed hole 16, and the electrode 10 is coupled in capacity to the internal conductor within the internal conductor formed hole 18. When the dielectric resonator is mounted on the circuit basic plate, the top face in the drawing is mounted on the surface opposed to the circuit basic plate.

(Sixth Embodiment)

The construction of the dielectric resonator and its characteristic adjusting method thereof in accordance with a sixth embodiment will be described hereinafter with reference to Fig. 15 through Fig. 19.

Fig. 15 is an explosive perspective view of the dielectric resonator. In Fig. 15, reference numerals 1a, 1b are respectively dielectric basic plates. The semicircular two line grooves in section are formed

respectively on one main face of the dielectric basic plates 1a, 1b and the internal conductor is formed on its inside face. Reference numerals 2b, 3b are internal conductors provided on the side of the dielectric basic plate 1b. Hollows 7a, 8a, 7b, 8b are respectively formed in one open of the grooves of the dielectric basic plates 1a, 1b. An external conductor 4a is provided on the main face and four side faces opposite to the internal conductor formed face of the dielectric basic plate 1a, an external conductor 4b is provided on the main face and the four side faces opposite to the internal conductor formed face of the dielectric basic plate 1b. Signal input, output electrodes 9, 10 are formed in one portion within the formed region of the external conductor 4a of the dielectric basic plate 1a.

Fig. 16 is a dielectric resonator before the characteristic adjustment with two dielectric basic plates shown in Fig. 15 being connected oppositely in internal conductors. Circular shaped internal conductor formed holes 5, 6 are constructed by the combination of semi-circular shaped grooves in this manner. Such step shaped hollows 7, 8 as shown are constructed by the hollow combination formed on one open face. The dielectric resonator shown in Fig. 16 is mounted in surface with the top face shown in the drawing being in contact against the basic plate for mounting use after the characteristic adjustment.

Fig. 17 is a sectional view through which the internal conductor formed hole 6 of the dielectric resonator shown in Fig. 16 extends.

Lines on the connection face of the dielectric basic plate are omitted (the views for reference are also the same in the subsequent description) because of the avoidance of the complicated views.

Fig. 18 and Fig. 19 are two embodiments where an open portion is formed in one portion of the internal conductor and the resonator characteristics are adjusted. In Fig. 18, reference characters A are locations where the respective one-portions of 3a, 3b are deleted near the hollow formed portions. Concretely, grinding tools such as Ryta with a grindstone shaped as shown in reference numeral 11 being mounted are used. The deleted portion is made an open portion with one portion of the internal conductor being deleted in this manner. As the deleted portion A of the internal conductor is formed in a location secluded from the open face F, the electromagnetic field leakage is restrained with respect to the interior from the open face F, or the resonator is hardly influenced by the electromagnetic field of the resonator periphery. If an metallic unit exists near the open face F, the characteristics are not disturbed by the influences from the metallic unit. When the adjusting operation is effected with the use of such a grinding tool as

shown in Fig. 18, the deletion amount of the internal conductors 3a, 3b is controlled by the insertion depth of the grinding tool so that the tip end capacity is adjusted. As the resonator frequency and the coupling degree of its adjacent resonator changes if the tip end capacity changes, the given resonator characteristics are obtained by the insertion depth adjustment of the grinding tool with respect to the internal formed hole. As shown in Fig. 18, the tip end capacity to be formed in the open portion of the internal conductor is large so that the coupling degree between the resonators is made large so as to easily make the band broader.

Fig. 19 shows the other adjustment characteristic method. In Fig. 19, reference characters B are locations where the dielectric have been deleted together with the internal conductor near the hollow formed portion. A grinding tool 11 provided with a grindstone having a scoop diameter larger than the inside diameter of the internal conductor formed hole is used so as to grind the dielectric together with the internal conductor in this manner. Accordingly, the grinding tool is inserted in an axial direction from the hollow formed portion with the grinding tool being set to the central shaft of the internal conductor formed hole so that the dielectric together with the internal conductor can be easily ground by a fixed amount.

(Seventh Embodiment)

Fig. 20 shows a sectional view of a dielectric resonator in accordance with a seventh embodiment. In Fig. 20, reference characters A, B show the deleted locations of the internal conductors. One portion of the internal conductor is ground near the open face of the internal conductor formed hole and in a location secluded from the opening face so that the open portion of the internal conductor is formed in a location secluded from the open face. Accordingly, the problem caused by the electromagnetic field leakage is removed. The grinding tool provided with a grindstone of comparatively small diameter is used for formation and adjustment of such open portion so that an inserting operation and a boring operation have only to be effected obliquely from the open portion. At this time, one portion of the dielectric is together ground and the tip end capacity can be adjusted by the depth thereof.

(Eighth Embodiment)

The construction of the dielectric resonator and its characteristic adjusting method in an eighth embodiment will be described hereinafter in accordance with Fig. 1, Fig. 22.

Fig. 21 is a sectional view in an internal conductor formed hole portion of the dielectric resonator. The basic construction is different from the sixth embodiment although it is almost similar to the construction of Fig. 15 and Fig. 16, and the throttle portion 13 is formed in one open portion of the internal conductor formed hole. Internal conductors 3a, 3b are formed on the inside face of the internal conductor formed hole and external conductors 4a, 4b are provided on the outside face of the dielectric resonator as shown in Fig. 21. A conductor film continuous to the external conductor from the internal conductor is formed even on the inside face of the throttle portion 11.

Fig. 22 is a view showing an example of formation of an open portion and an adjusting method. In Fig. 22, reference characters A are the deleted locations of the internal conductor and the dielectric. One portion of the internal conductor is deleted on the internal conductor shaped hole side of the throttled portion 13 in this manner, and the open portion of the internal conductor is formed in a location secluded from the open face. Therefore, the electromagnetic field leakage is restrained. In order to form such an open portion so as to effect the characteristic adjustment, a grindstone of Ryta is inserted from an opening portion where the throttle portion is not formed from the open portion of the internal conductor formed hole so as to adjust the grinding amount by the insertion depth thereof. The change proportion of the tip end capacity with respect to the insertion amount of the grindstone is different from the tip end shape of the grindstone. Such a shaped grindstone as shown in Fig. 23 and Fig. 24 may be used considering the efficiency and accuracy of the characteristic adjustment.

(Ninth Embodiment)

The construction and adjustment method of the dielectric resonator in accordance with a ninth embodiment will be described hereinafter in accordance with Fig. 25 through Fig. 27.

Fig. 25 is one basic plate for constituting a dielectric resonator. In Fig. 25, reference character 1b is a dielectric basic plate. Semicircular (sectional) two-line grooves are formed on one main face of the dielectric basic plate 1b with internal conductors 2b, 3b being formed on the inside face thereof. The single side of the throttle portion is formed in one portion of the groove. An external conductor 4b is formed on the other main face opposite to the internal conductor of the dielectric basic plate 1b and four side faces. A dielectric resonator is composed with the basic plate shaped the same as the basic plate being connected opposite to each other.

Fig. 26 is a sectional view thereof. In Fig. 26, reference numerals 15a, 15b constitute a throttle portion in one portion of the internal conductor formed hole. In a dielectric resonator having such a throttle portion in one portion of an internal conductor formed hole, a internal conductor formed on the inside face of the throttle portion is deleted with the use of grinding tool or the like from one open face of the internal conductor formed hole as shown in Fig. 27 so as to form an open portion in the internal conductor and effect a characteristic adjustment. In Fig. 27, reference characters A show the deleted portions hereof. The electromagnetic field leakage is restrained so as to form the open portion of the internal conductor in a location secluded from the open face in this manner. The adjusting operation is simplified, and the adjusting accuracy is also improved as the grinding range by the grinding tool and so on is restricted to the throttle portion. Although the sixth through the ninth embodiments have two dielectric basic plates superposed in the embodiment, such construction and the characteristic adjustment method as in the sixth through the ninth embodiment can be applied similarly even to an integral type dielectric resonator with an internal conductor formed hole being provided in a single dielectric block as in the first through the fifth embodiments. Such construction and characteristic adjustment method as in the first through the fifth embodiments have two dielectric basic plates superposed as in the sixth through the ninth embodiments, and can be applied similarly even about the dielectric resonator with the internal conductor formed holes being provided therein.

Although the present embodiment has a comb line-type of dielectric resonator as an example, even an interdigital type can be similarly applied.

(Tenth Embodiment)

Fig. 28 shows an embodiment 10. Groove shaped concave portions 28 are formed in approximately parallel with the end face 22a side of the dielectric 22 on both the sides of the hole 23 with inside conductor 24 of the dielectric 22 being formed on the inside face. An outside conductor 25 is formed across the outside face whole of the dielectric 22 including the concave portion 28. Accordingly, the interval between the outside conductor 25, which becomes an earth electrode of the bottom portion of the groove shaped concave portion 28, and the inside conductor 24 becomes shorter as shown in Fig. 28 (b), so that floating capacity Cs can be easily obtained.

The concave portion 28 can work the dielectric 22 or form it by a molding operation. Accordingly, the floating capacity Cs can be obtained by the comparatively simple working operation or the

molding operation. The adjustment of the floating capacity Cs (size of the floating capacity Cs) can be easily effected by the deletion of the size and depth of the concave portion 28 or one portion of the outside conductor 25.

In the comb-line type, the band width of the filter can be made larger by provision of, for example, the larger floating capacity Cs. The resonator length becomes shorter and the size can be made smaller by provision of, for example, the larger floating capacity Cs. Further, the floating capacity Cs can be easily obtained, and also, the adjustment of the floating capacity Cs can be easily effected even in the filter of the construction of interdigital coupling.

(Eleventh Embodiment)

Fig. 29 shows an embodiment 11, is different from the prior embodiment, with the groove shaped concave portion 28 being provided on the single side of the dielectric 22. Even in the embodiment, the floating capacity Cs can be easily obtained and the adjustment can be easily effected as in the prior embodiment.

(Twelfth Embodiment)

Fig. 30 shows an embodiment 12. In the present embodiment, the groove shaped concave portion 28 is formed on one side face of the dielectric 22. The outside conductor 25 of the bottom portion of the concave portion 28 is approached towards the inside conductor 24 within the hole 23 of the dielectric 22 so as to easily obtain the floating capacity Cs.

The interval t between the outside conductor 25 which becomes an earth electrode and the inside conductor 24, the width w of the concave portion 28, the depth d and so on are changed so as to control the floating capacity Cs.

The coupling between the resonators can be adjusted by the adjustment of the floating capacity Cs. The passing zone of the filter can be controlled without changes. The above described floating capacity Cs can be provided larger by the concave portion 28.

The shape can be standardized, a metal mold cost and a management cost can be reduced. In the embodiment shown in Fig. 30, the concave portion 28 is formed on one side face of the dielectric 22, and can be formed on both the side faces of the dielectric 22. In this case, the floating capacity Cs can be provided larger.

(Thirteenth Embodiment)

Fig. 31 shows an embodiment 13. Round hole shaped concave portions 28 are opened, in the same direction, near the hole 23. The concave portions 28 are respectively formed in accordance with the holes 23. The hole may become one or may be formed by the number of the holes 23 or more. The concave portion 28 may be provided correspondingly on both the sides of the hole 23. Many concave portions 28 may be formed.

(Fourteenth Embodiment)

Fig. 32 shows an embodiment 14. In the embodiment, the round hole shaped concave portion 28 is formed on the side face of the dielectric 22. The outside conductor 25 of the bottom portion of the concave portion 28 is near-by in parallel to the inside conductor 24. Even in the embodiment, the concave portion 28 is formed correspondingly to the hole 23. The number of the holes 23 may be one or may be three or more. In addition, the concave portion 28 may be formed in either face of the dielectric 22.

(Fifteenth Embodiment)

Fig. 33 shows an embodiment 15. Taper portions 29 are formed on both the sides of the corner portion on the open face 23 of the dielectric 22. The taper portion 29 is formed so that the interval between the inside conductor 24 within the hole 23 and the outside conductor 25 as an earth electrode of the taper portion 29, and the floating capacity Cs can be easily obtained as in the above described embodiment.

The size of the floating capacity Cs can be easily adjusted by the angle of the above described taper portion 29 and the size of the taper portion 9. The taper portion 29 is formed on the angle portion of the other face so that the floating capacity Cs may be obtained.

(Sixteenth Embodiment)

Fig. 34 shows an embodiment 16 where the taper portion 29 is formed on the single side of the dielectric 22. Even in the embodiment, the floating capacity Cs can be easily obtained by the taper portion 29.

(Seventeenth Embodiment)

Fig. 35 shows an embodiment 17. In the present embodiment, a taper portion 29 is formed with one portion instead of the whole face of the angle portion of the dielectric 22 being notched. In

Fig. 35, a concave portion 30 with a taper portion 29 being formed is formed by only one portion. Concave portions 30 may be formed by plurality on the single side or both the sides in accordance with the respective hole 23. The number of the concave portions 30 is not restricted.

The floating capacity Cs can be easily adjusted by the position and size of the concave portion 30.

(Eighteenth Embodiment)

Fig. 36 is an embodiment 18, where a concave portion 31 of approximately L type in a stage shaped section, instead of such a taper shaped section as in the prior embodiment, is formed on the single side of the corner portion on the top face of the dielectric 22. Even in this case, the interval between the inside conductor 24 within the hole 23 and the outside conductor 25 which becomes an earth electrode of the concave stage portion 31 becomes shorter so that the floating capacity Cs can be easily obtained.

Although the concave stage portion 31 is continuously formed in Fig. 36, it may be formed not continuously, in one portion or intermittent portions, in the corner portions on both the side portions of the dielectric 22. The size of the floating capacity can be easily adjusted by the size or the like of the concave stage portion 31.

(Nineteenth Embodiment)

The present embodiment 19 in Fig. 37 is an embodiment where the concave stage portion 31 is further made deeper as compared with the case of the above described embodiment 18. In an integrated type of dielectric resonator, the floating capacity Cs is obtained by the inside conductor 24 and the concave stage portion 31 is formed by a dielectric filter comb-line connected so that the outside conductor 25 is approached to the inside conductor 24 within the hole 23 so as to increase the floating capacity Cs.

The approached size W and the depth X of the concave stage portion 31 are adjusted so as to adjust the coupling. When the size of the dielectric 22 in the axial direction of the hole 23 is made L, $0 \leq X < L$.

The coupling coefficients of the dielectric resonator can be changed by the change in the above described size X, W so that the passing band of the filter can be controlled without the shape (metal mold).

The shape of the dielectric resonator can be standardized, and the metallic cost and the management cost can be reduced.

As the large coupling coefficient can be obtained without the pitch between the holes 3 being

narrowed, the pole of the high pass becomes far from the passing band, and the damping of the low pass is improved. The resonance electrode length becomes shorter with the floating capacity Cs being increased, so that the filter can be made smaller in size. Further, the filter larger in the specific band is obtained.

The dielectric resonator in each of the above described embodiments is not restricted to the number of the stages although the three-stage construction has been described. Namely, it can be applied to the dielectric resonator of one stage or three-stage or more.

The dielectric resonator of the present invention can be applied to a case where all the filters such as band pass filter, band elimination filter, high-pass filter, low-pass filter and so on are formed.

As is clear from the foregoing description, according to the arrangement of the present invention, the dielectric resonator of the present invention can be mounted on the surface on the circuit basic plate without the use of a special individual signal input, output terminals as the signal input, output electrodes are provided on one portion of the external conductor. As the conductor exists on the open face of the internal conductor formed hole so as to provide no open face, the electromagnetic field leakage is less so that influences by the electromagnetic field leakage are less if the dielectric resonator is mounted on the circuit basic plate in a condition as it is.

According to the dielectric resonator of the present invention, a dielectric resonator without coupling coefficients being adjusted between the resonator frequency of the resonator and the resonance without coating addition and so on with respect to the non-formed portion of the internal conductor.

According to the dielectric resonator of the present invention, the open portion of the internal conductor is formed in a location secluded from the open face of the internal conductor formed holes, the influences by the electromagnetic field leakage is less. Therefore, no couplings among the resonator, the other object near the resonator and the circuit are provided so that stable resonator characteristics are provided.

As is clear from the characteristic adjusting method of the dielectric resonator of the present invention, there are steps of providing an open portion in one portion of the internal conductor only by the movement of a grinding tool in the axial direction of the internal conductor formed hole with the deletion locations of the internal conductor and the dielectric being restricted, and also, easily adjusting the tip end capacity by the moving amount. Further, a dielectric resonator having given reso-

nance frequency and coupling amount can be easily obtained without the higher size accuracy to be demanded in the grinding working operation, because the tip end capacity is gradually lowered in spite of much grinding amount of the whole.

In a dielectric resonator for making resonant with the given frequency by an inside conductor formed on the inside face of the hole of the dielectric and an outside conductor formed on the outside face of the above described dielectric, the concave portion is formed on the surface of the above described dielectric, the outside conductor of the bottom portion of the concave portion is approached to the above described inside conductor so that the interval between the inside conductor of the hole interior of the dielectric and the outside conductor which becomes an earth electrode becomes shorter so as to easily obtain the floating capacity by the approaching operation between the outside conductor of the bottom portion of the concave portion formed on the surface of the dielectric and the above described inside conductor. The floating capacity can be adjusted by the comparatively simple working or molding operation of the size, depth and so on of the concave portion. In the comb-line type, the band width of the filter can be made larger by provision of, for example, larger floating capacity. Resonator length becomes shorter by the provision of, for example, the larger floating capacity with an effect that the size may be made smaller.

In the present invention, the taper portion is formed in the corner portion of the dielectric, and the outside conductor of the taper portion is approached to the inside conductor, the interval between the inside conductor of the hole interior of the dielectric and the outside conductor which becomes an earth electrode becomes shorter as in the case of the claim 1 so that the floating capacity is easier to obtain. The floating capacity can be adjusted by comparatively simple working or molding operation of the size, inclination and so on of the taper portion of the corner portion. In the comb-line type, the band width of the filter can be made larger by the provision of, for example, the larger floating capacity. The resonator length becomes shorter by provision of, for example, the larger floating capacity so that the size may be made smaller.

In the present invention, approximately L type of concave stage portion in section is provided in the corner portion of the dielectric, and the outside conductor of the concave stage portion is approached to the inside conductor so that the interval between the inside conductor of the hole interior of the dielectric and the outside conductor which becomes an earth electrode becomes shorter so as to easily obtain the floating capacity. The

floating capacity can be adjusted by comparatively simple working or molding operation of the size, depth and so on of the concave portion of the corner portion. In the comb-line type, the band width of the filter can be widened by provision of, for example, the larger floating capacity. The resonator length becomes shorter by provision of, for example, the larger floating capacity so that the size may be made smaller.

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.

Claims

1. A dielectric resonator comprising; a plurality of internal conductor formed holes provided within a dielectric so as to form an external conductor on the outside face of the above described dielectric, a non-formed portion of the internal conductor provided near at least one open face of the internal conductor formed holes, and signal input, output electrodes for effecting capacity connection with the internal conductor provided on one portion of the external conductor.
2. A dielectric resonator described in accordance with the claim 1, where the dielectric is an approximately six-face unit in shape so as to form the above described signal input, output electrodes only on a circuit basic plate mounting face.
3. A dielectric resonator comprising; a plurality of internal conductor formed holes provided within a dielectric so as to form an external conductor on the outside face of the dielectric, one open face of the internal conductor formed holes made a short-circuit face, and a non-formed portion of the internal conductor provided near the other open face, and signal input, output electrodes for effecting capacity connection with the above described internal conductor provided on one portion of the external conductor, the deletion portions of the conductor and the dielectric being formed in one portion of the short-circuit face, the other open face or both the faces.
4. A dielectric resonator comprising internal conductor formed holes with an internal conductor formed on the inside face in the dielectric, an

external conductor formed on the outside face of the dielectric, and hollows near the internal conductor formed holes on at least one open face of the internal conductor formed holes formed so as to delete the internal conductor near the hollow formed portions.

5. A dielectric resonator comprising internal conductor formed holes with an internal conductor formed on the inside face thereof so as to form the external conductor on the outside face of the dielectric, and one portion of the internal conductor deleted near the open face of the internal conductor formed holes and in the locations secluded from the open face.
6. A dielectric resonator comprising internal conductor formed holes with an internal conductor formed on the inside face are provided in the dielectric, an external conductor formed on the outside face of the dielectric, and a throttle portion formed on at least one open portion of the internal conductor formed holes, the internal conductor being deleted near the throttle portion and on the internal conductor formed hole side.
7. A dielectric resonator comprising internal conductor formed holes with an internal conductor formed on the inside face in a dielectric so as to form the external conductor on the outside face of the dielectric, a throttle portion formed in a location near one open face of the internal conductor formed holes and secluded from the open face so as to delete the internal conductor of the throttle portion.
8. A dielectric resonator for making resonant with a given frequency comprising an inside conductor formed on the inside face of a hole of a dielectric, an outside conductor formed on the outside face of the dielectric, a concave portion formed on the surface of the dielectric so as to cause the outside conductor of the bottom portion of the concave portion to approach to the inside conductor.
9. A dielectric resonator described in accordance with the claim 8, where a taper portion is formed on the corner portion of the dielectric so as to cause the outside conductor of the taper portion to approach to the inside conductor.
10. A dielectric resonator described in accordance with the claim 8, where a concave stage portion of approximately L type (in section) is provided on the corner portion of the dielectric

so as to cause the outside conductor of the concave stage portion to approach to the inside conductor.

11. A characteristic adjusting method of a dielectric resonator, comprising the steps of forming internal conductor formed holes with an internal conductor on the inside face in the dielectric so as to form the external conductor on the outside face of the dielectric, deleting the internal conductor to be formed near the hollow formed portion, and adjusting the tip end capacity of the internal conductor with a hollow being formed in advance near the internal conductor formed hole in at least one open face of the internal conductor formed holes. 5
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15

12. A characteristic adjusting method of a dielectric resonator, comprising the steps of forming internal conductor formed holes with an internal conductor on the inside face in the dielectric so as to form the external conductor on the outside face of the dielectric, forming a throttle portion in advance on one open face of the internal conductor formed holes, deleting the internal conductor formed on the throttle portion, and adjusting the tip end capacity of the internal conductor. 20
25

13. A characteristic adjusting method of a dielectric resonator, comprising the steps of forming internal conductor formed holes with an internal conductor on the inside face in the dielectric so as to form the external conductor on the outside face of the dielectric, forming a throttle portion in advance in a location near one open face of the internal conductor formed holes and secluded from the open face, deleting the internal conductor formed on the throttle portion, and adjusting the tip end capacity of the internal conductor. 30
35
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50

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Fig. 1

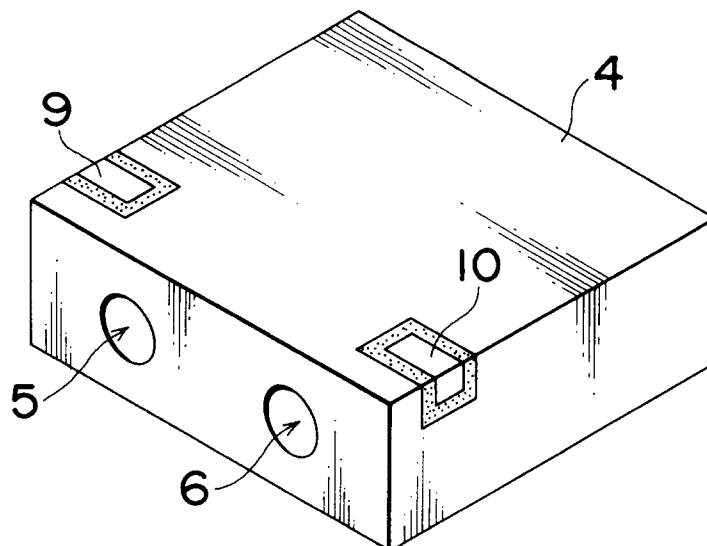


Fig. 2

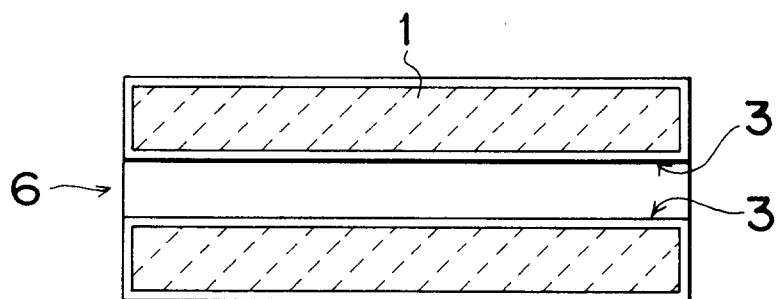


Fig. 3

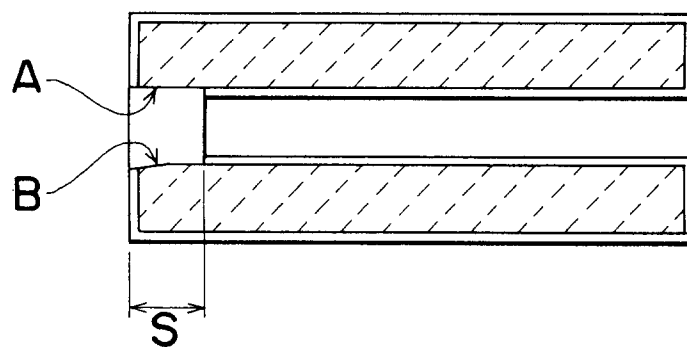


Fig. 4

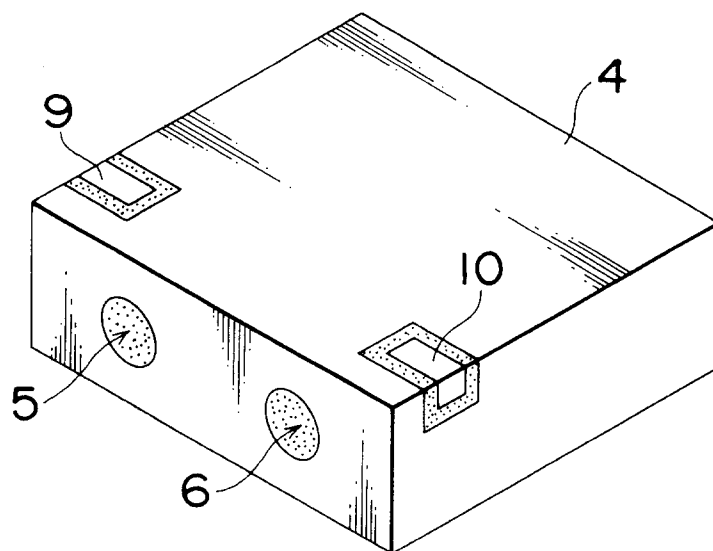


Fig. 5

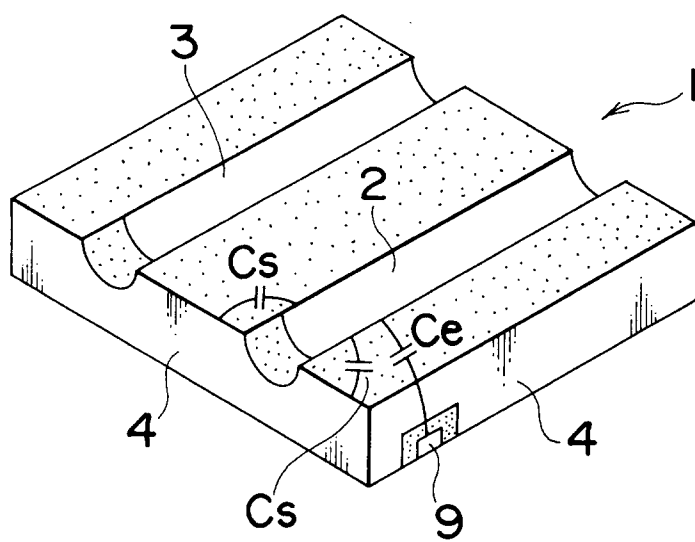
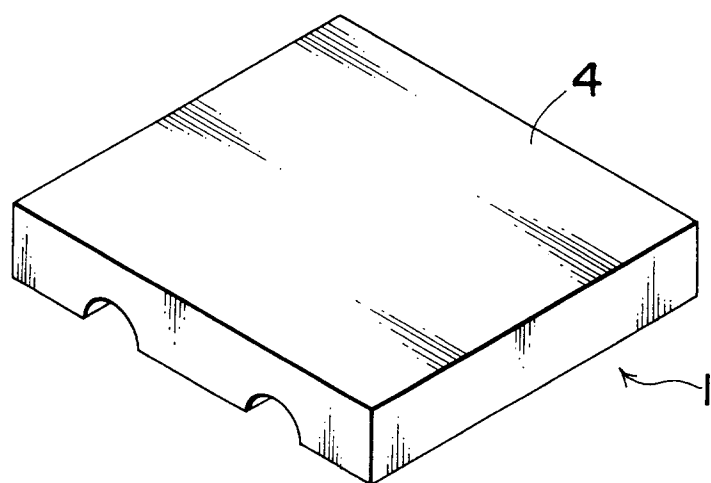


Fig. 6

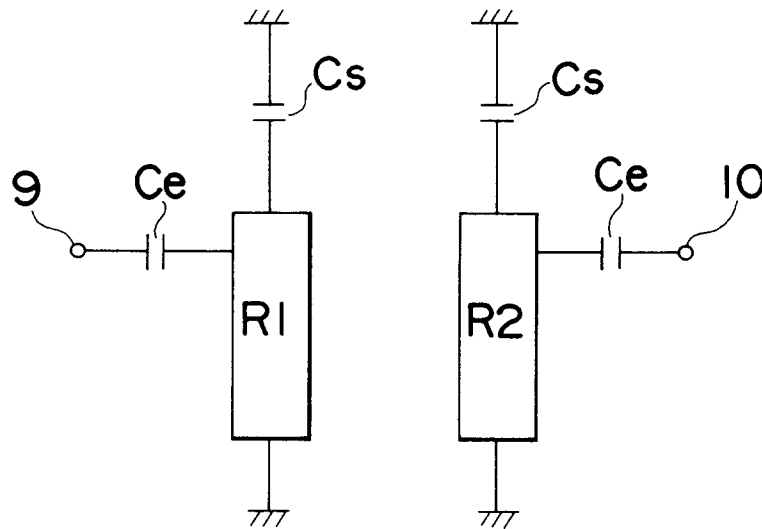


Fig. 7(A)

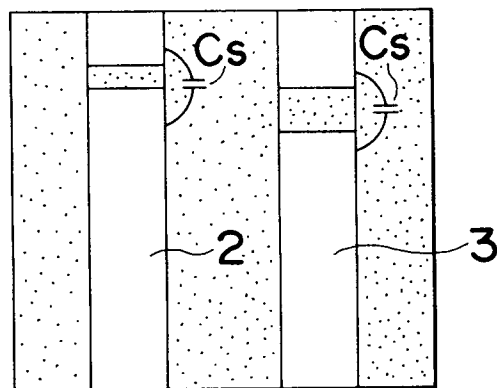


Fig. 7(B)

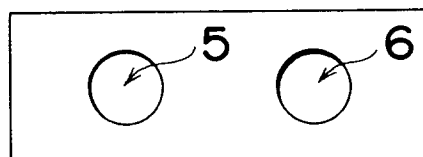


Fig. 8

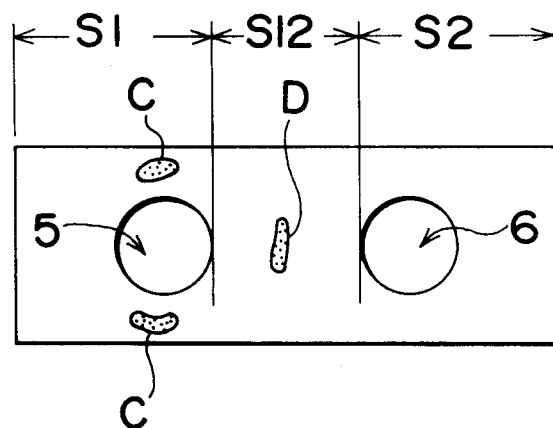


Fig. 9

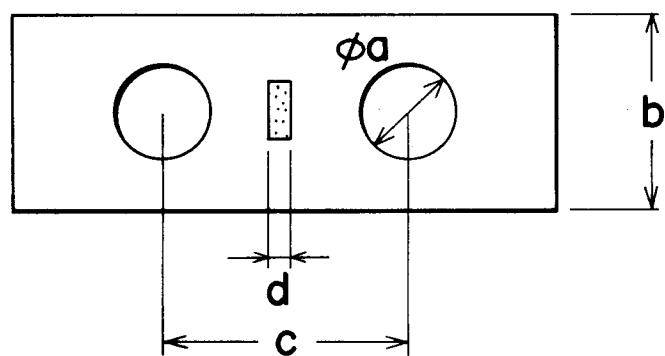


Fig. 10

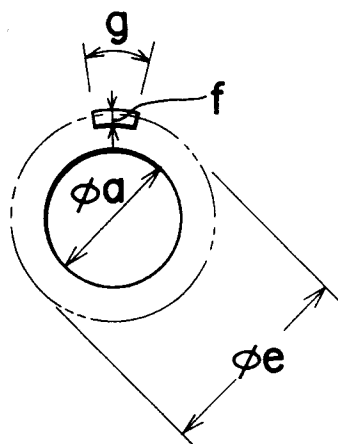


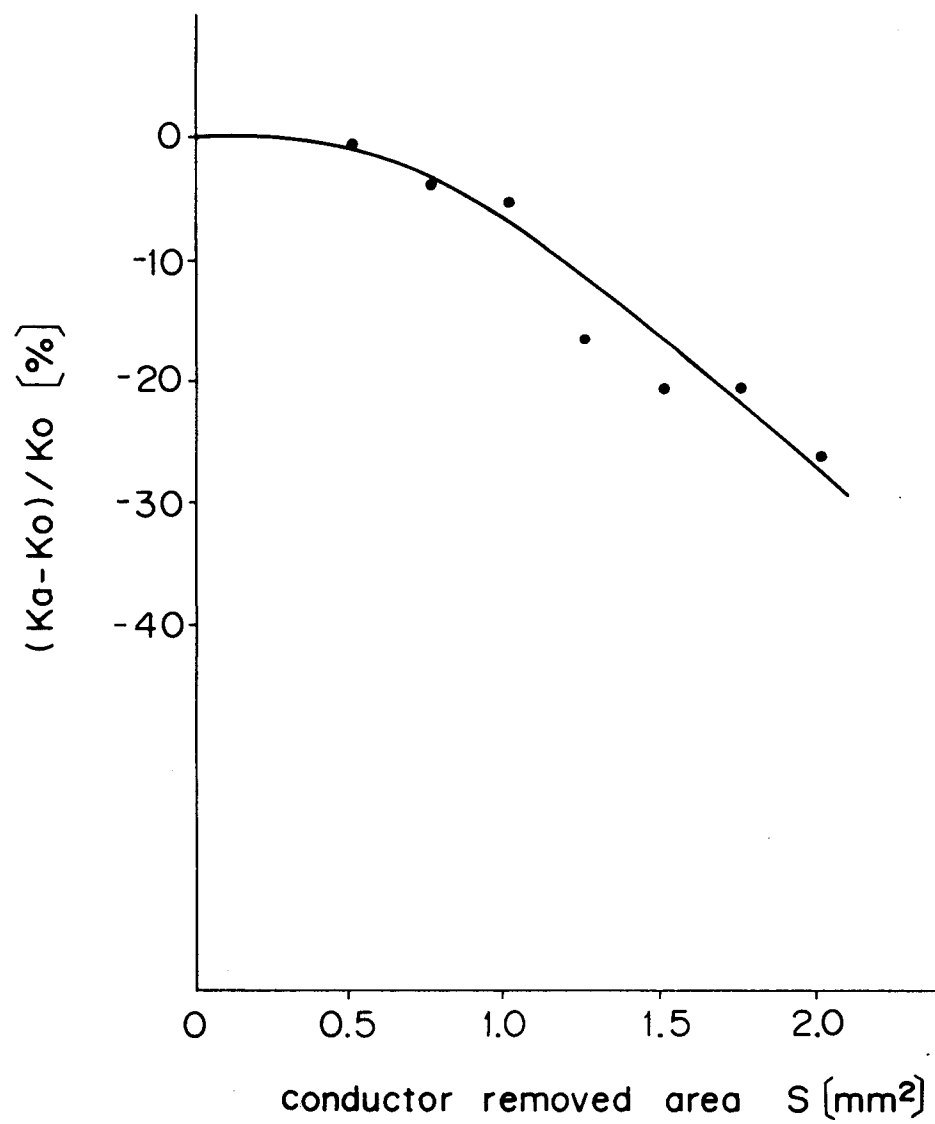
Fig. 11

Fig. 12

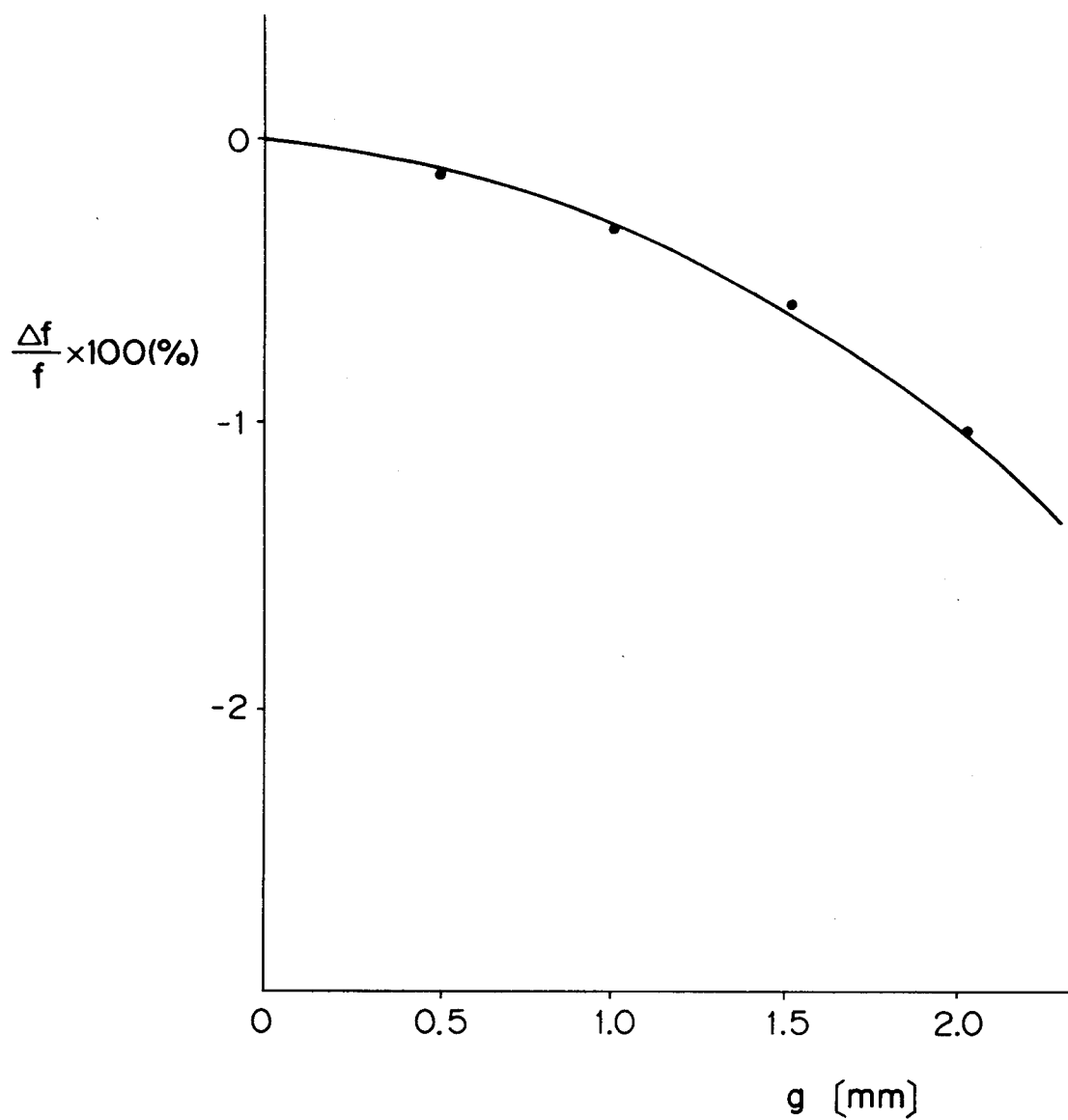


Fig. 13

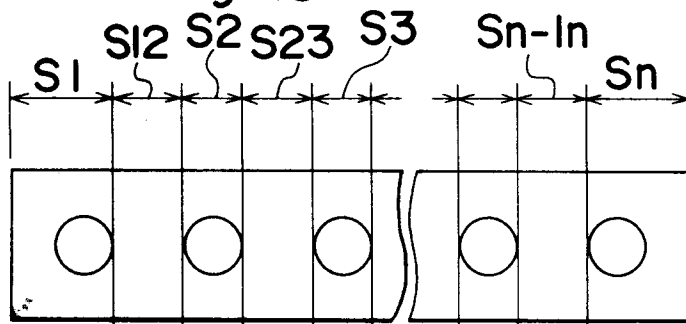


Fig. 14

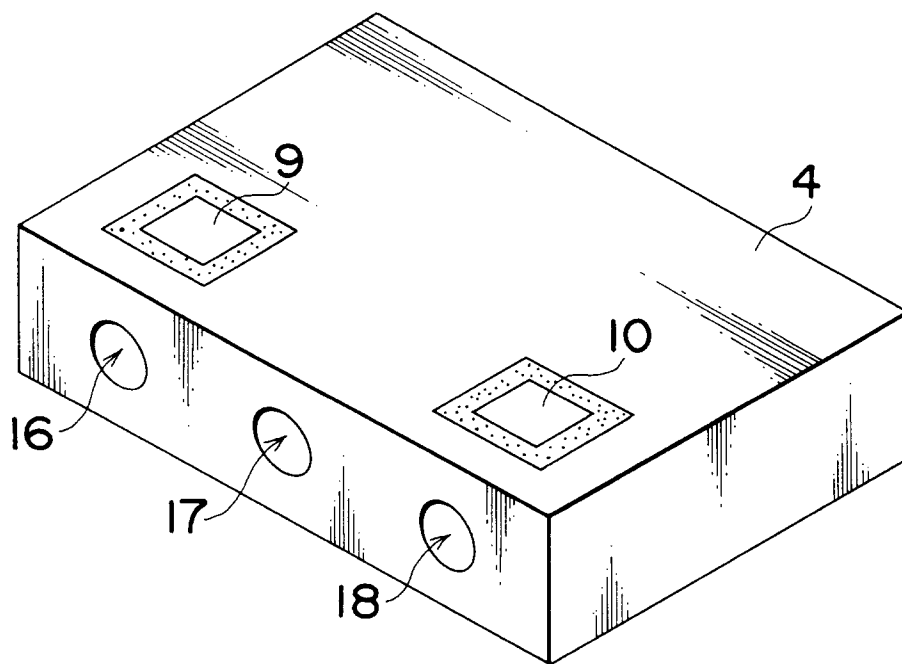


Fig. 15

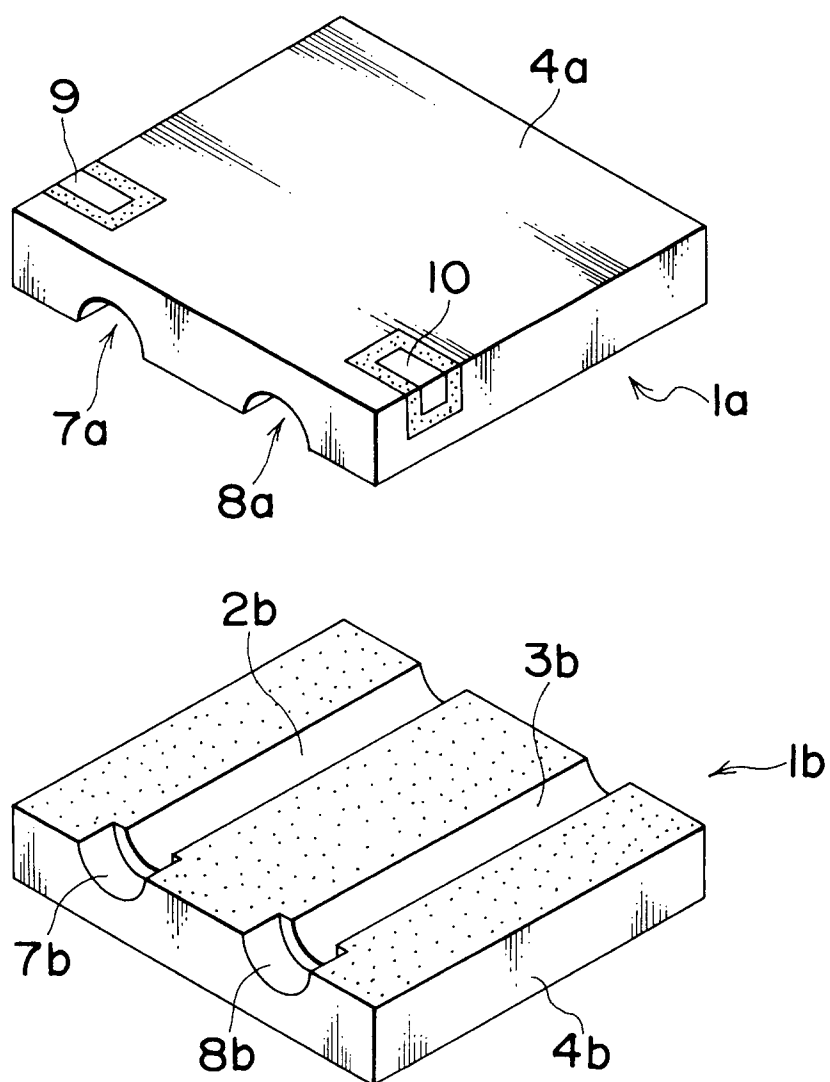


Fig. 16

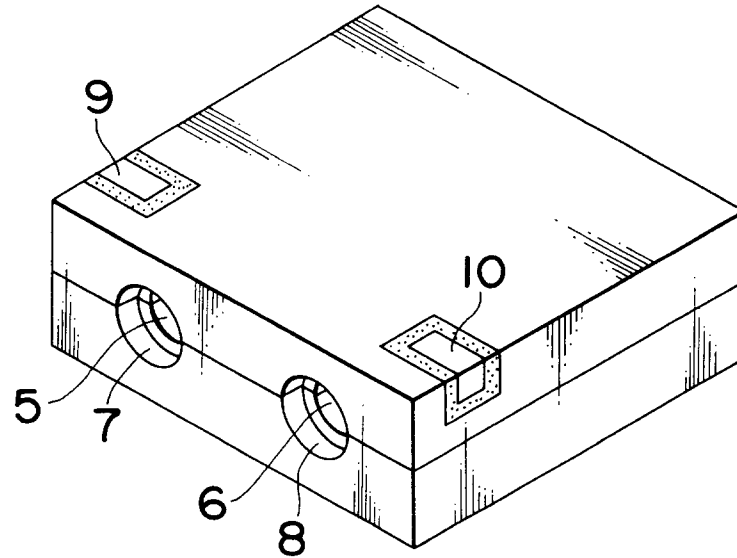


Fig. 17

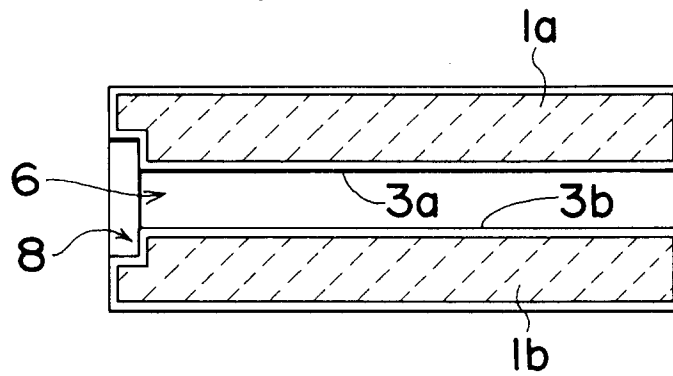


Fig. 18

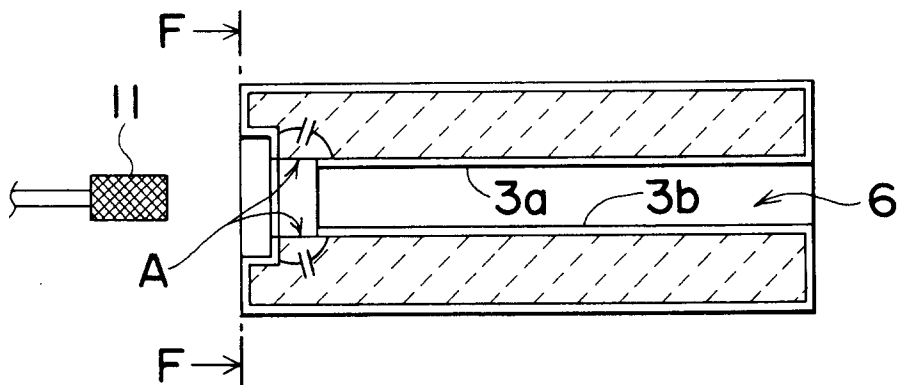


Fig. 19

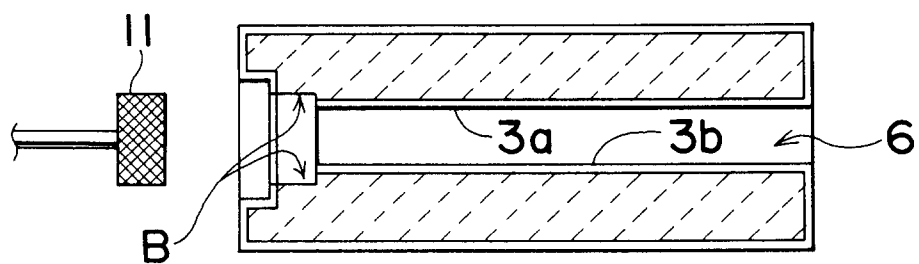


Fig. 20

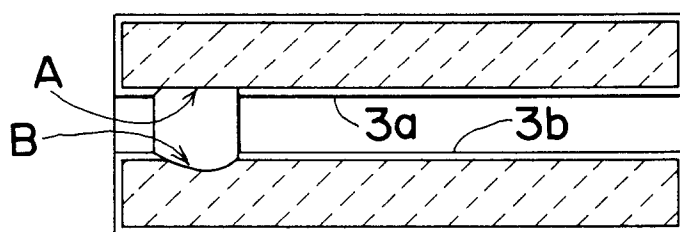


Fig. 21

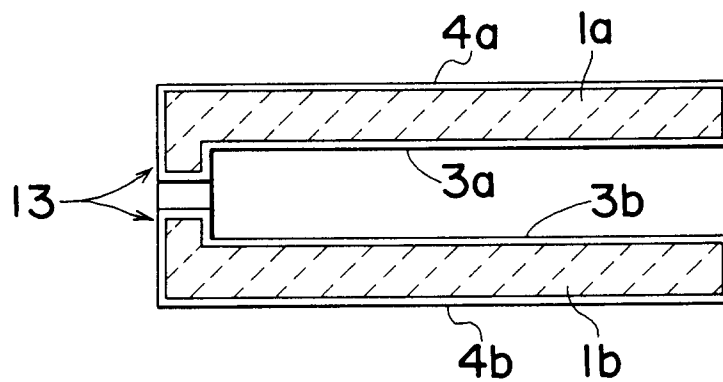


Fig. 22

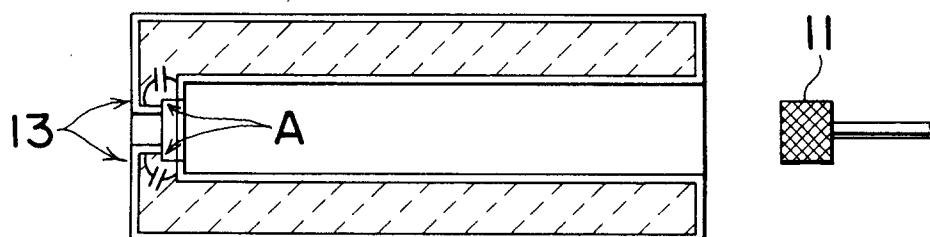


Fig. 23

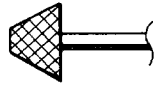


Fig. 24

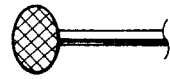


Fig. 25

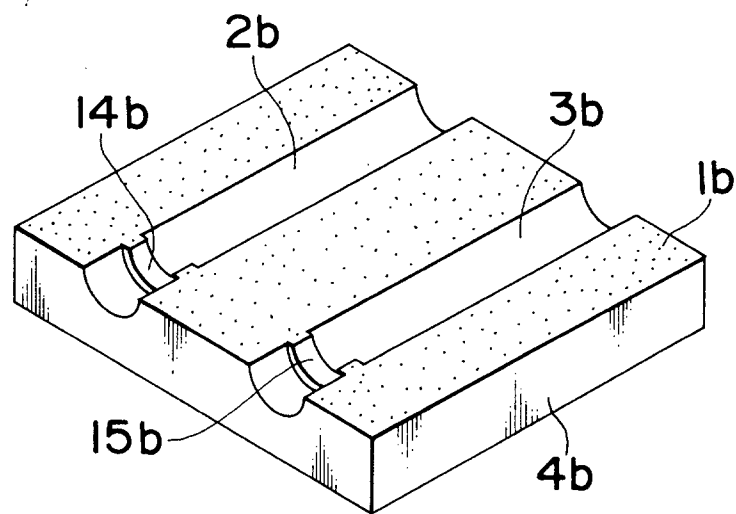


Fig. 26

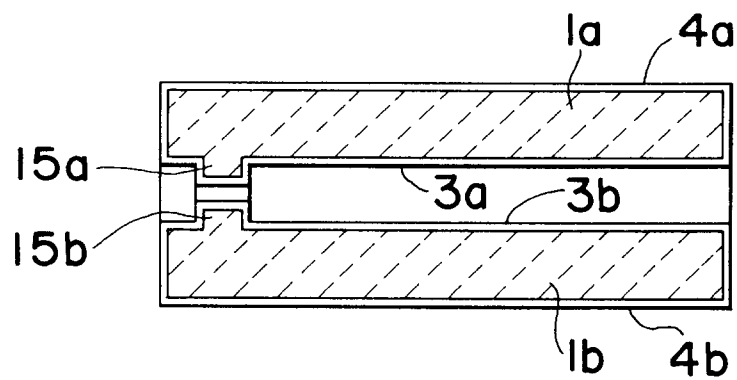


Fig. 27

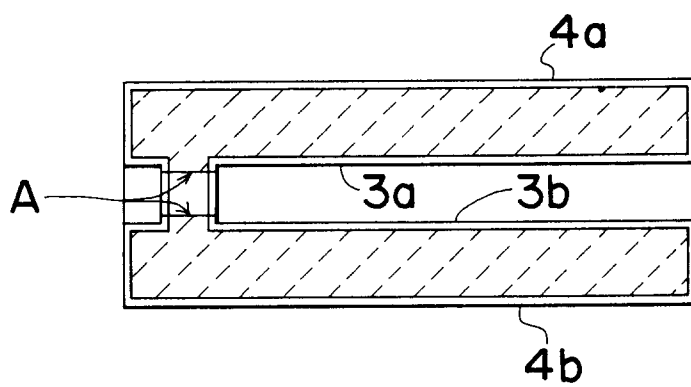


Fig. 28(a)

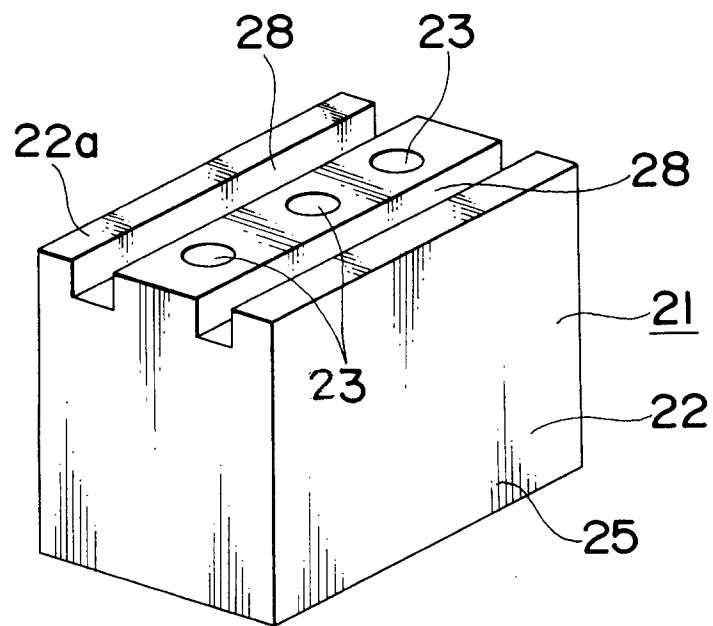


Fig. 28(b)

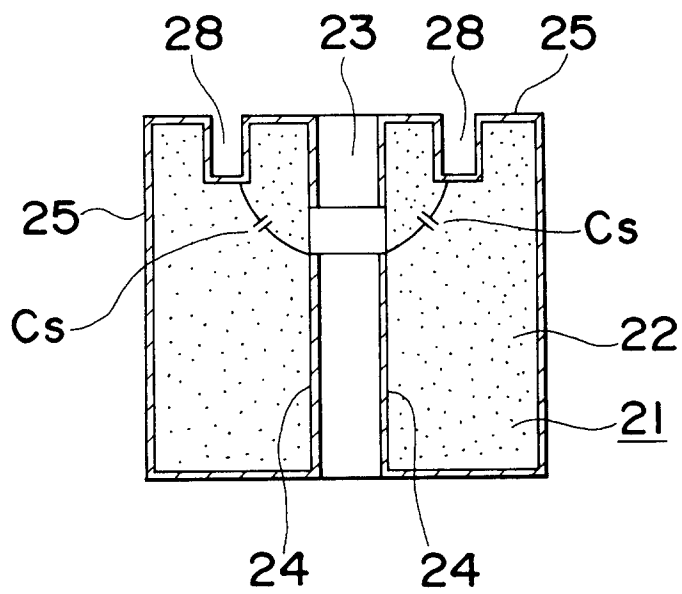


Fig. 29

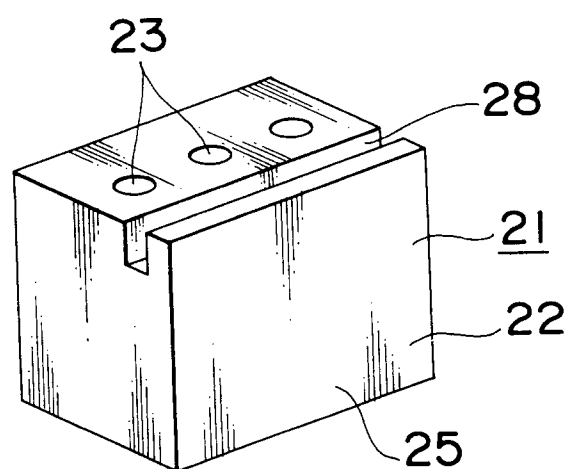


Fig. 30(a)

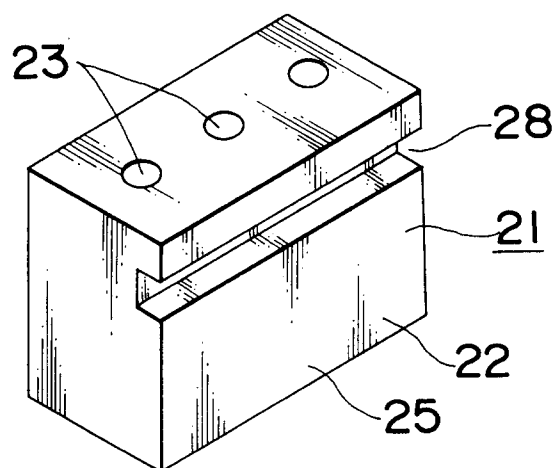


Fig. 30(b)

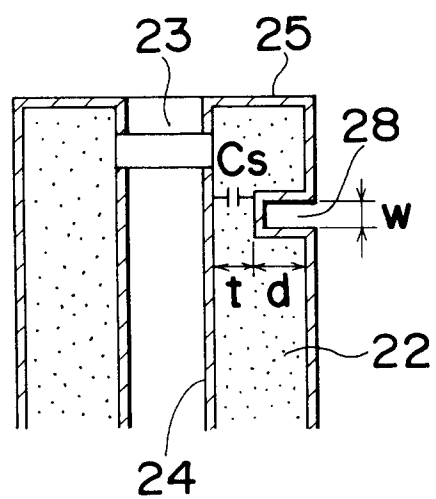


Fig. 31(a)

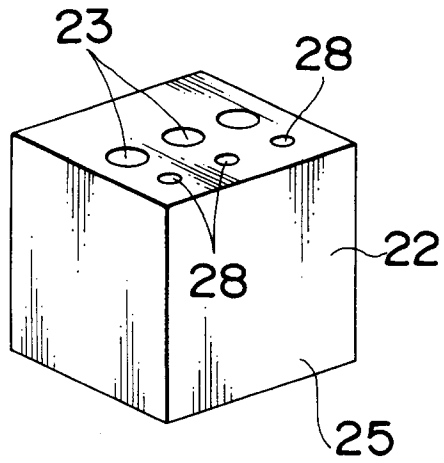


Fig. 31(b)

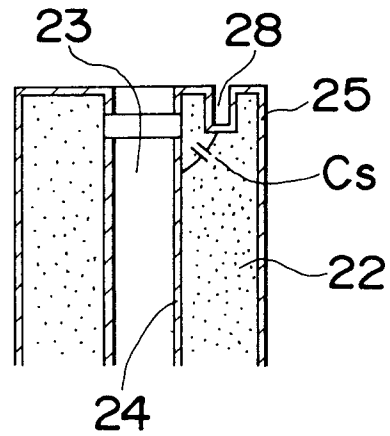


Fig. 32(a)

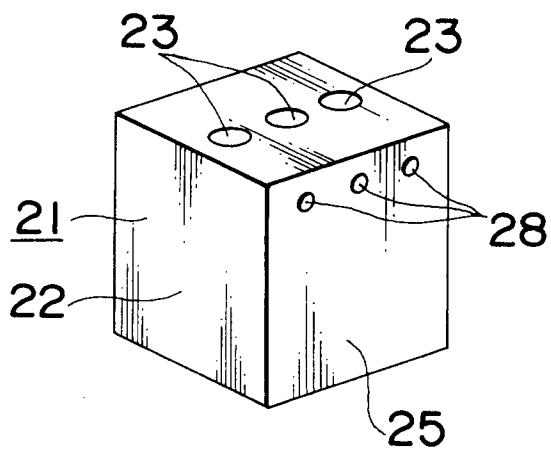


Fig. 32(b)

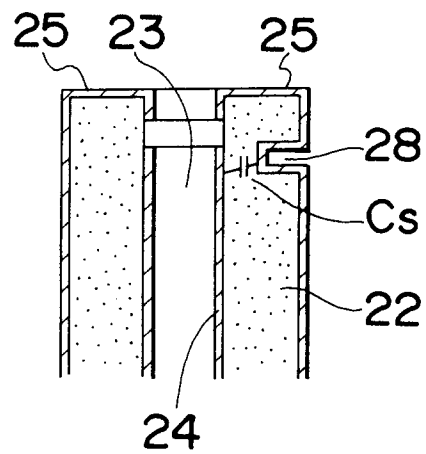


Fig. 33(a)

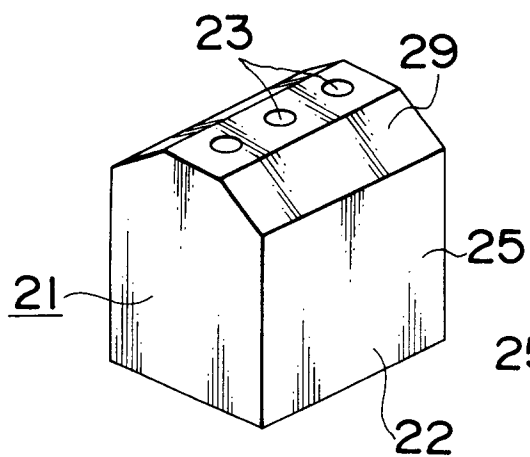


Fig. 33(b)

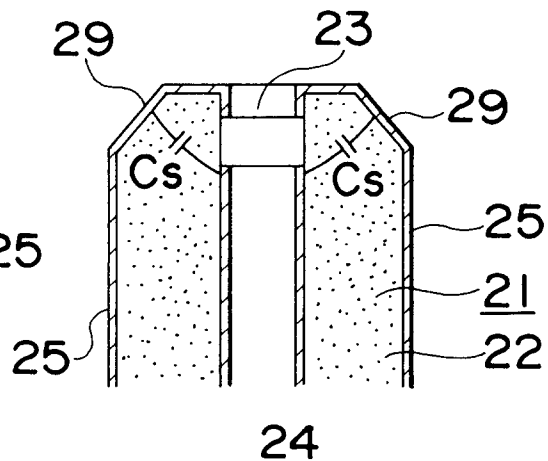


Fig. 34

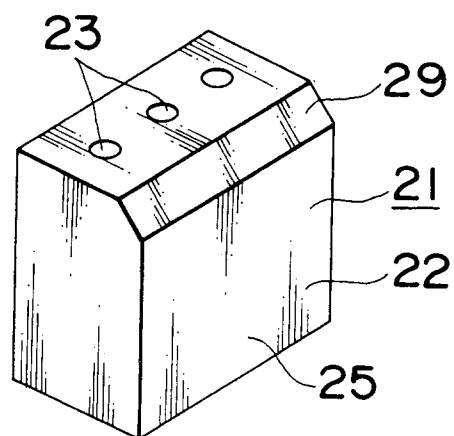


Fig. 35

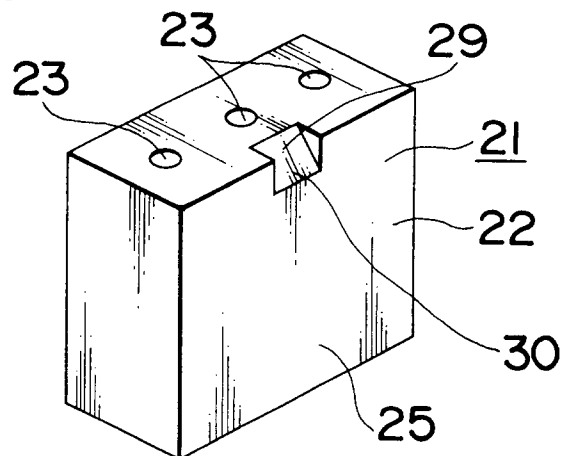


Fig. 36

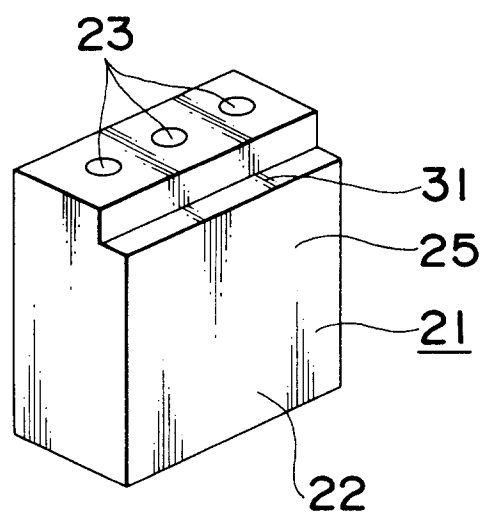


Fig. 37

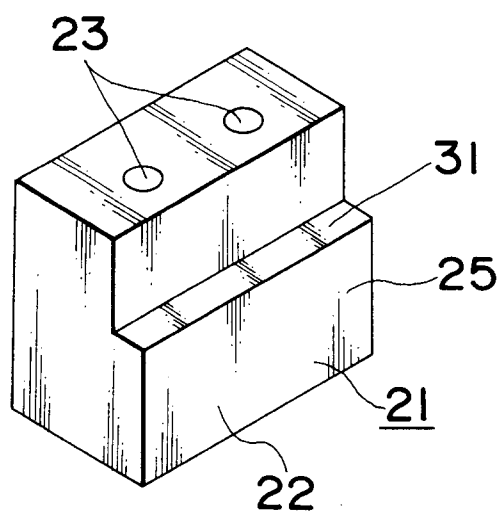


Fig. 38

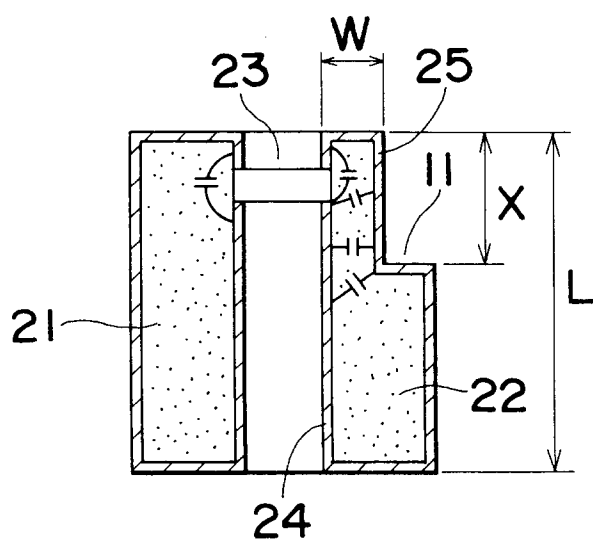


Fig. 39 PRIOR ART

