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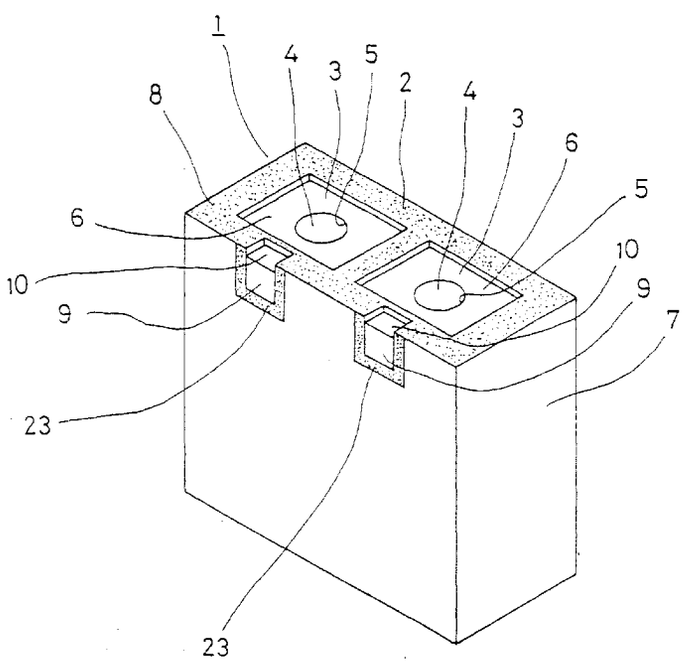
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(54) Method of forming electrodes of a dielectric filter

(57) There is disclosed a method of forming electrodes of a dielectric filter (1). First, a ceramic block (2) having concave portions (20a, 20b) is formed. The concave portions (20a, 20b) have planar shapes corresponding to those of auxiliary conductors (6) and extension conductors (10) to be formed. Subsequently, an electrode layer (21) is formed over the entire open end surface (8) through dipping or the like. After that, the open end surface (8) is ground to a depth smaller than the depth of the concave portions (20a, 20b) so as to leave the electrode layer (21) within only the concave portions (20a, 20b). Accordingly, the shapes of the conductors (6, 10) can be defined accurately by the concave portions (20a, 20b), and neither blur nor patchiness occurs.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

Field of the Invention:

The present invention relates to a method of forming electrodes of a dielectric filter comprising a plurality of resonators disposed in parallel.

Description of the Related Art:

There have been proposed various kinds of dielectric filters in which inner surfaces of through-holes of a dielectric ceramic block are coated with inner conductors so as to form a plurality of resonators in parallel, and the outer surface of the dielectric ceramic block is coated with an outer conductor except for the open end surface to which the through-holes are opened.

On the open end surface of such a dielectric filter, auxiliary conductors extend from the edges of open ends of, for example, two adjacent resonators such that an isolation gap is formed between facing edges of the auxiliary conductors for inter-stage capacitance coupling of the resonators. Moreover, input/output pads are formed on a side surface at positions facing the open ends of the resonators such that the input/output pads are electrically insulated from the outer conductor. If necessary, extension conductors are extended from the input/output pads toward the open end surface, so that isolation gaps are formed between the extension conductors and the auxiliary conductors. As a result, the input/output pads are connected to the resonators through the capacitances of the isolation gaps. In the dielectric filter, as described above, various kinds of conductor pattern are formed.

Conventionally, the above-described conductor pattern is formed by applying an electrode-forming material into a desired shape or pattern through use of screen pattern printing. However, use of the screen pattern printing causes generation of blur at the boundary of the pattern or patchiness due to variation in the concentration of ink. Moreover, if positioning of a screen is inadequate, the position of the conductor pattern relative to the block changes slightly, resulting in positional deviation. As a result, the characteristics of resulting filters greatly vary, requiring a step of adjusting the characteristics, thus leading to increased production time, difficulty in mass-production, and a low yield.

SUMMARY OF THE INVENTION

In view of the foregoing, an object of the present invention is to provide an improved method of forming electrodes of a dielectric filter in which the electrodes can be formed stably in a desired pattern.

To achieve the above object, the present invention provides an improved method of forming electrodes of a dielectric filter in which inner surfaces of through-holes of a dielectric ceramic block are coated with inner conductors so as to form a plurality of resonators in parallel; the outer surface of the dielectric ceramic block is coated with an outer conductor except for the open end surface to which the through-holes are opened; auxiliary conductors are formed on the open end surface of the dielectric filter such that they are connected to the inner conductors of the respective resonators; and input/output pads are formed on a side surface at positions facing the open ends of outermost resonators such that the input/output pads are electrically insulated from the outer conductor. The method comprises the steps of: forming a ceramic block having through holes and concave portions, the positions and planar shapes of the concave portions corresponding to the positions and planar shapes of the auxiliary conductors to be formed on the open end surface of the ceramic block; forming an electrode layer over the entire open end surface; and grinding the open end surface to a depth smaller than the depth of the concave portions so as to leave the electrode layer within only the concave portions.

In the case where extension conductors are formed to extend from the input/output pads toward the open end surface, concave portions having planar shapes corresponding to the shapes of the respective extension conductors are formed at positions corresponding to the positions of the respective extension conductors, in a manner similar to the case of the auxiliary conductors. Subsequently, the electrode layer forming step and the grinding step are carried out.

In the method according to the present invention, since parts of the electrode layer are left in the concave portions through the step of forming an electrode layer over the entire open end surface through dipping and the step of grinding the open end surface, the shapes of the auxiliary conductors and/or extension conductors can be defined accurately by the concave portions. Accordingly, unlike the case of screen printing, neither blur nor patchiness occurs, thereby enabling stable pattern formation.

The above-described concave portions may be formed through press forming performed simultaneously with formation of the peripheral shape of the block. In this case, since the positions and shapes of the concave portions are defined by dies, the concave portions can be formed with high accuracy and can be formed at desired positions with improved reproducibility.

Alternatively, the above-described concave portions may be formed by milling or the like after the ceramic block is sintered.

Accordingly, the input/output coupling capacitances and the inter-stage coupling capacitance become constant, so that dielectric filters having stable filter characteristics can be obtained.

BRIEF DESCRIPTION OF THE DRAWINGS

Various other objects, features and many of the attendant advantages of the present invention will be readily appreciated as the same becomes better understood by reference to the following detailed description of the preferred embodiment when considered in connection with the accompanying drawings, in which:

FIG. 1 is a perspective view of a dielectric filter;
FIG. 2 is a plan view of the dielectric filter shown in FIG. 1;
FIGS. 3A - 3C are vertically sectioned views of an upper portion of the dielectric filter, showing the steps of a method of forming conductors according to an embodiment of the present invention; and
FIG. 4 is an equivalent circuit of the dielectric filter.

DESCRIPTION OF THE PREFERRED EMBODIMENT

An embodiment of the present invention will be described with reference to the drawings. Identical portions are indicated by the same reference symbols throughout the drawings for the purpose of simplifying the description.

FIGS. 1 and 2 show a two-stage type dielectric filter 1 having two resonators 3. The dielectric ceramic block 2 of the filter 1 is made of a titanium oxide ceramic and substantially has the shape of a rectangular prism. The resonators 3 are formed parallel to each other. The resonators 3 are formed by coating the through-holes 4 with inner conductors 5, and the outer surface of the dielectric ceramic block 2 is coated with an outer conductor 7 except for an open end surface 8 to which the through-holes 4 are opened. The outer conductor 7 serves as a shield electrode. The resonators 3 have a length corresponding to $\lambda/4$, where λ is a resonant frequency.

Next, a description will be given of the main portion of the present invention.

As shown in FIG. 1, on the open end surface 8 of the dielectric ceramic block 2, auxiliary conductors 6 for inter-stage coupling extend from the open ends of the two adjacent resonators 3 such that auxiliary conductors 6 for inter-stage coupling are connected to the inner conductors 5 of the through-holes 4. The resonators 3 are coupled with each other through the capacitance C_1 (see FIG. 4) of an isolation gap g_1 formed between the auxiliary conductors 6 for inter-stage coupling.

Moreover, input/output pads 9 are formed on a side surface of the dielectric ceramic block 2 at positions facing the open ends of the resonators 3 such that the input/output pads 9 are electrically insulated from the outer conductor 7. The input/output pads 9 enable electrical connection with electrical paths on a printed circuit board. Extension conductors 10 are extended from the input/output pads 9 toward the open end surface so that isolation gaps g_2 are formed between the extension conductors 10 and the auxiliary conductors 6. As a result, the input/output pads 9 are connected to the auxiliary conductors 6 through the capacitances Co of the isolation gaps g_2 (see FIG. 4). When the dielectric filter 1 includes three or more resonators, the input/output pads 9 are formed such that they face the outermost resonators.

The auxiliary conductors 6 and the extension conductors 10 are formed through the method illustrated in FIGS. 3A - 3C.

First, powder of a titanium oxide is placed in a die, and press forming is carried out in order to obtain a green block 2' having a peripheral shape corresponding to that of the dielectric ceramic block 2. At this time, as shown in FIG. 3A, concave portions 20a' and 20b' are formed in the open end surface 8' of the green block 2' at positions corresponding to the positions of the respective auxiliary conductors 6 and the respective extension conductors 10 to be formed on the open end surface 8 of the dielectric ceramic block 2. The concave portions 20a' and 20b' have planar shapes corresponding to the shapes of the respective auxiliary conductors 6 and the respective extension conductors 10.

Upon removal of the green block 2' from the die, through-holes 4' are formed, followed by a sintering process. As a result, the dielectric ceramic block 2 is obtained. Subsequently, the dielectric ceramic block 2 is dipped in an electrode material paste in order to form an electrode layer 21 over the entire surface, as shown in FIG. 3B

Subsequently, as shown in FIG. 3C, the open end surface 8 is subjected to grinding operation. This grinding operation is carried out such that the grinding depth is less than the depth of the concave portions 20a and 20b (see line I-I in FIG. 3B). As a result, the electrode layer 21 covering the open end surface 8 of the dielectric ceramic block 2 is removed such that the electrode layer 21 in the concave portions 20a and 20b are left unground. The portions of the electrode layer 21 remaining in the concave portions 20a and 20b serve as the auxiliary conductors 6 and the extension conductors 10, respectively. Subsequently, in order to separate the input/output pads 9, which are integral with the extension conductors 10, from the outer conductor 7, square-C-shaped exposed portions 23 are formed through partial removal of the outer conductor 7.

Since the above-described concave portions 20a' and 20b' are formed through press forming performed simultaneously with formation of the peripheral shape of the green block 2', the positions of the concave portions 20a' and 20b' become always constant with respect to the peripheral shape of the green block 2', so that the concave portions 20a' and 20b' can be formed with improved reproducibility. Accordingly, the auxiliary conductors 6 and the extension conductors 10 formed in the concave portions 20a and 20b are defined by the concave portions 20a and 20b, so that the auxiliary conductors 6 and the extension conductors 10 can be formed with high accuracy and at desired positions.

Moreover, since the auxiliary conductors 6 and the extension conductors 10 can be formed through dipping, unlike the case of screen printing, the conductor pattern does not cause patchiness, and the boundary of the pattern becomes clearer and does not become blurred. Since none of blur, patchiness, and positional shift occurs, the pattern can be formed with high accuracy, thereby enabling the stable generation of capacitance coupling.

Moreover, since the concave portions 20a' and 20b' are formed through press forming performed simultaneously with formation of the peripheral shape of the green block 2', no additional step is required, so that the manufacture of the dielectric filter can be facilitated.

The above-described manufacturing method may be modified such that after the press forming of the green block 2', the concave portions 20a' and 20b' are formed by milling or the like simultaneously with the formation of the through-holes 4'. In this case as well, the auxiliary conductors 6 for inter-stage coupling can be formed without causing blur or patchiness.

Moreover, the concave portions 20a' and 20b' can be formed by milling or the like after the green block 2' is sintered.

The extension conductors 10 extended from the input/output pads 9 are not necessarily required, and the auxiliary conductors 6 may be extended further such that the auxiliary conductors 6 are coupled directly with the input/output pads 9 via insulation gaps g_2. In this case, the concave portions are formed at only locations where the auxiliary conductors are to be formed.

Obviously, numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the present invention may be practiced otherwise than as specifically described herein.

Claims

1. A method of forming electrodes of a dielectric filter in which inner surfaces of through-holes of a dielectric ceramic block are coated with inner conductors so as to form a plurality of resonators in parallel; the outer surface of the dielectric ceramic block is coated with an outer conductor except for the open end surface to which the through-holes are opened; auxiliary conductors are formed on the open end surface of the dielectric filter such that they are connected to the inner conductors of the respective resonators; and input/output pads are formed on a side surface at positions facing the open ends of outermost resonators such that the input/output pads are electrically insulated from the outer conductor, said method characterized by comprising the steps of:

   forming a ceramic block having through holes and concave portions, the positions and planar shapes of the concave portions corresponding to the positions and planar shapes of the respective auxiliary conductors to be formed on the open end surface of the ceramic block;
   forming an electrode layer over the entire open end surface; and
   grinding the open end surface to a depth smaller than the depth of the concave portions so as to leave the electrode layer within only the concave portions.

2. A method of forming electrodes of a dielectric filter in which inner surfaces of through-holes of a dielectric ceramic block are coated with inner conductors so as to form a plurality of resonators in parallel; the outer surface of the dielectric ceramic block is coated with an outer conductor except for the open end surface to which the through-holes are opened; auxiliary conductors are formed on the open end surface of the dielectric filter such that they are connected to the inner conductors of the respective resonators; input/output pads are formed on a side surface at positions facing the open ends of outermost resonators such that the input/output pads are electrically insulated from the outer conductor; and extension conductors are extended from the input/output pads such that the extension conductors face the auxiliary conductors via insulation gaps, said method characterized by comprising the steps of:

   forming a ceramic block having through holes and concave portions, the positions and planar shapes of the concave portions corresponding to the position and planar shapes of the respective auxiliary conductors to be formed on the open end surface and the respective extension conductors to be extended from the input/output pads to the open end surface of the ceramic block;
   forming an electrode layer over the entire open end surface; and
   grinding the open end surface to a depth smaller than the depth of the concave portions so as to leave the electrode layer within only the concave portions.

3. A method of forming electrodes of a dielectric filter according to Claim 1 or 2, characterized in that said concave portions are formed through press forming performed simultaneously with formation of the peripheral shape of the block.

4. A method of forming electrodes of a dielectric filter according to Claim 1 or 2, characterized in that said concave portions are formed after the ceramic block is sintered.

5. A method of forming electrodes (6) on a surface of a dielectric ceramic block (2) comprising: forming said dielectric ceramic block with concave portions (20a) in said surface (8), the positions and planar shapes of said concave portions corresponding to the positions and planar shapes of the required electrodes; forming a conductive layer (21) over said surface; and abrading said surface to a depth smaller than the depth of the concave portions so as to leave the conductive layer only within the concave portions on said surface.

6. A method according to Claim 5, said method being part of a process for the manufacture of a dielectric filter (1), wherein the block forming step includes forming through holes (4) in the block opening onto said surface (8), and the layer forming step includes forming said layer (21) also on the inner surfaces of said through holes and on the other outer surfaces of said ceramic block, the concave portions comprising auxiliary conductor-forming portions (20a) intersecting the openings of said through holes (4) so that auxiliary conductors (6) formed therein by the conductive layer portions remaining after the abrading step are connected to inner conductors (5) formed by the portions of the conductive layer on said inner surfaces of the through holes.

7. A method according to Claim 6, including forming input/output conductor pads (9) on a side surface of the ceramic block at positions corresponding to the auxiliary conductors (6), so that said pads are insulated from the conductive layer on said side surface, and capacitatively coupled to the respective auxiliary conductors.

8. A method according to claim 7, the capacitative coupling being by way of extension conductors (10) connected to the input/output pads and formed in further concave portions (20b) on the same surface of the ceramic block as the auxiliary conductors (6), said extension conductors also being formed from portions of the conductive layer remaining in the further concave portions (20b) after the abrading step.

FIG. 1

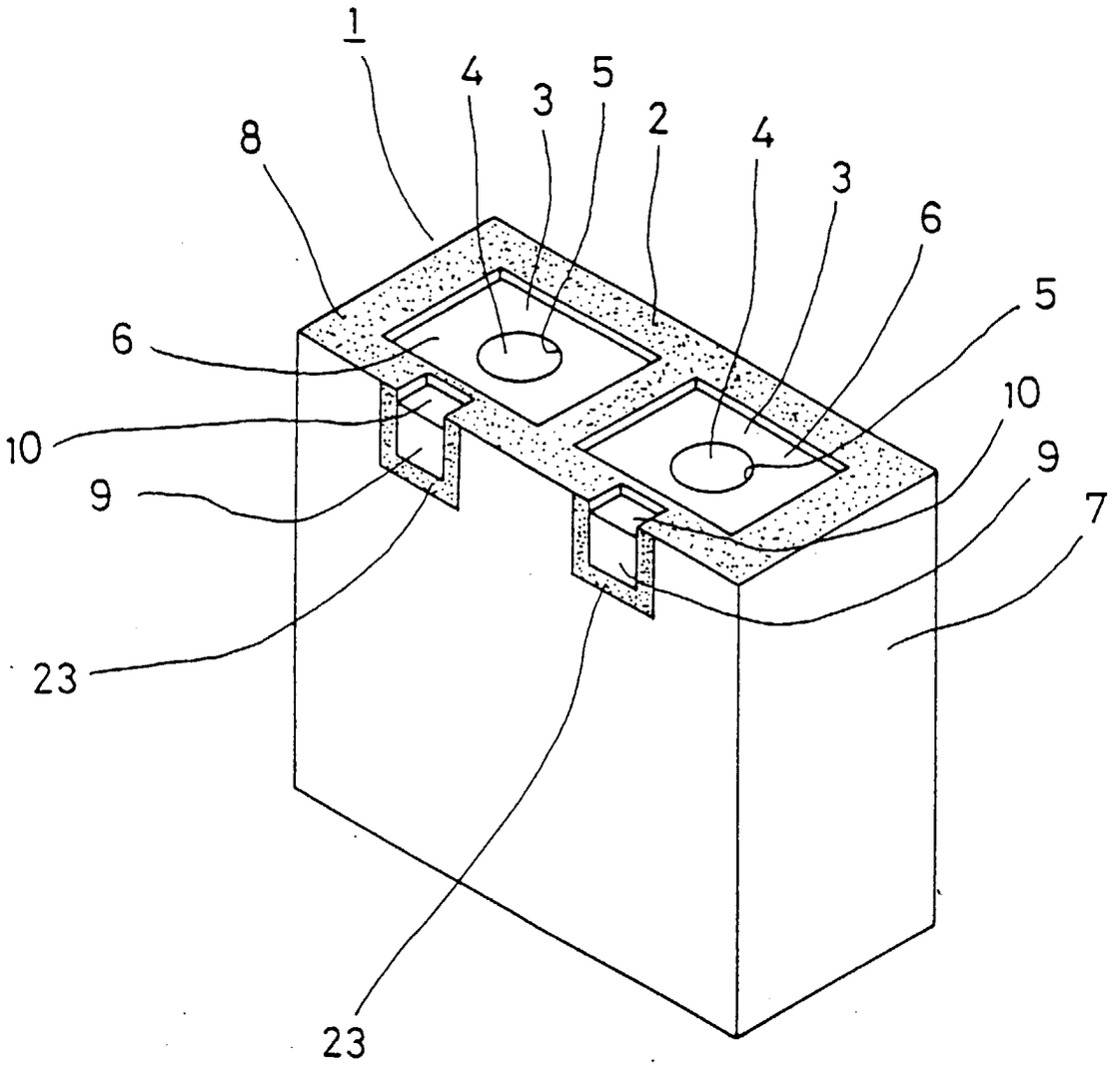


FIG. 2

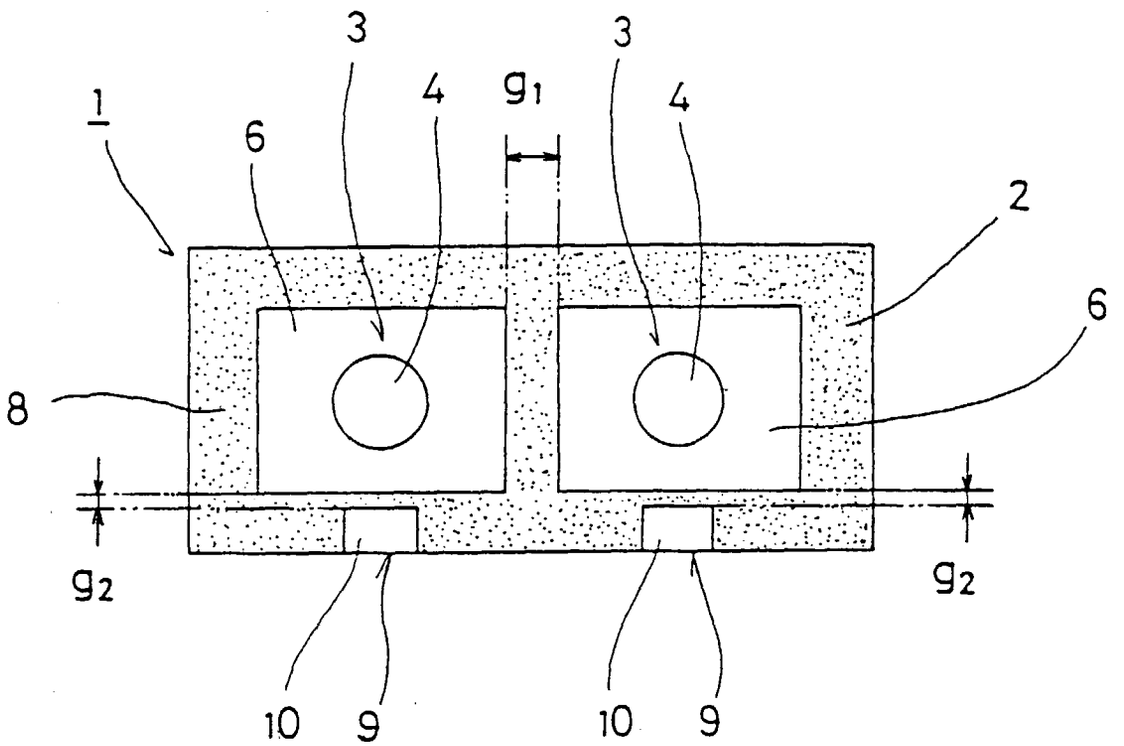


FIG. 3A

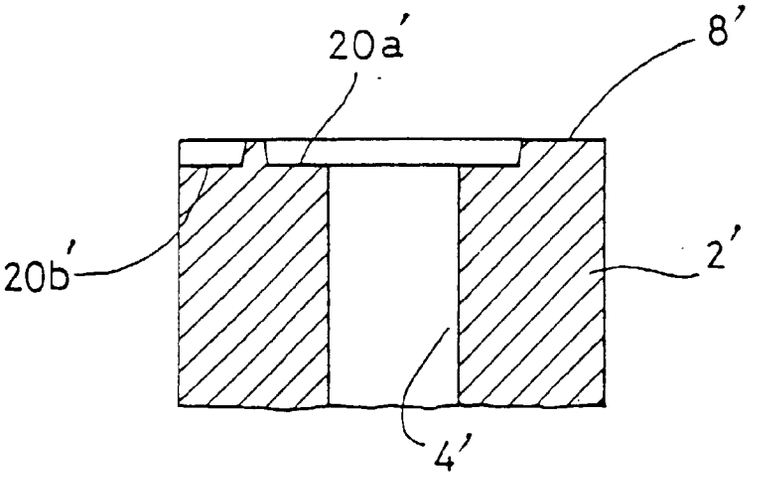


FIG. 3B

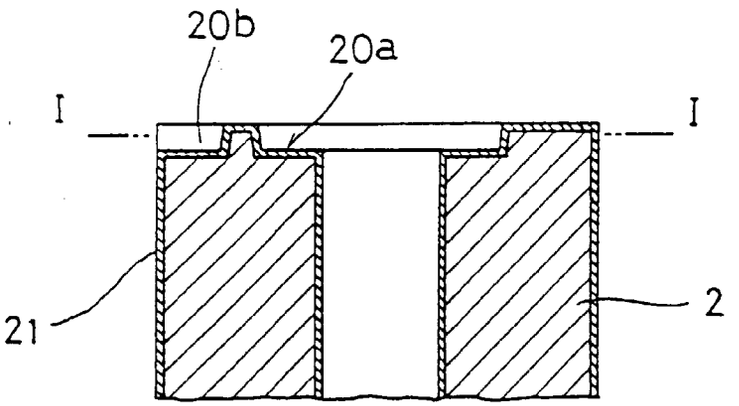


FIG. 3C

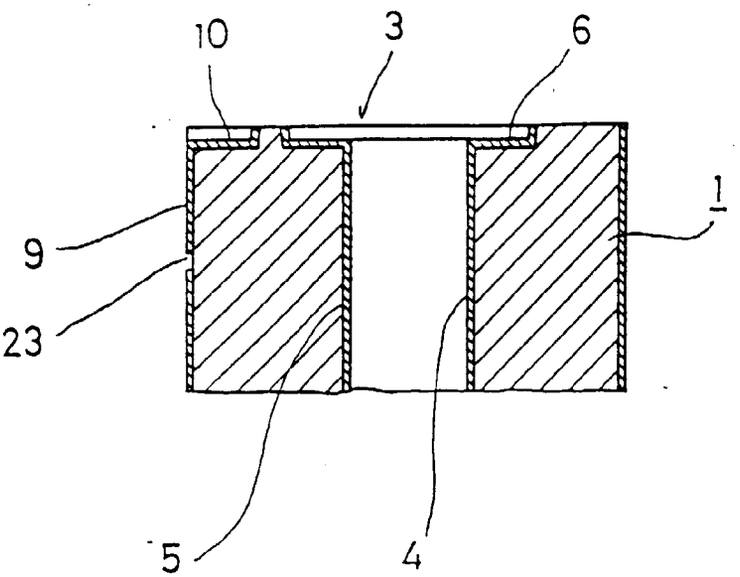


FIG. 4

