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(51) INT CL^6
H01P 7/10

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H1W WGX W3B1 W5 W7
U1S S2092

(56) Documents Cited
GB 2129228 A **EP 0601371 A1** **EP 0352628 A2**
EP 0026086 A1 **WO 93/09575 A1** **WO 92/20116 A1**

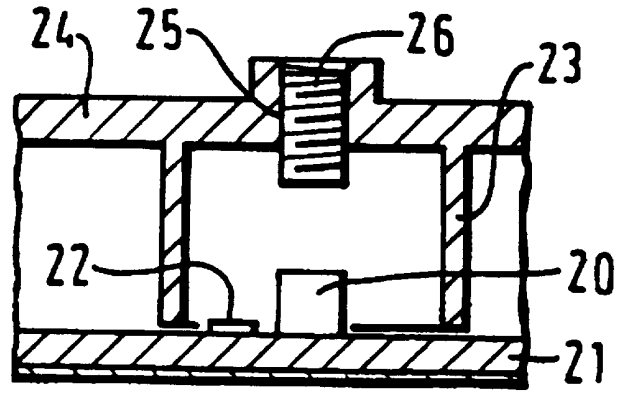
(58) Field of Search
UK CL (Edition O) **H1W WGP WGX**
INT CL^6 **H01P 7/10**

(54) Dielectric resonator

(57) A dielectric resonator 20 is positioned symmetrically within a chamber, the chamber being formed by a housing 23 having a wall comprising one or more of:
(i) a reflecting material;
(ii) a partially reflecting/absorbing material;
(iii) an absorbing material, or
(iv) a transparent or partially transparent (lossy) material.

The housing may be cylindrical and formed of stainless steel fibres and plastics material. A controlled, and preferably uniform, electrical and magnetic field environment is thereby provided for the dielectric resonator. The resonator is mounted on a printed circuit board 21 adjacent a stripline 22 and may operate as an oscillator.

FIG. 5



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

FIG. 1(b)

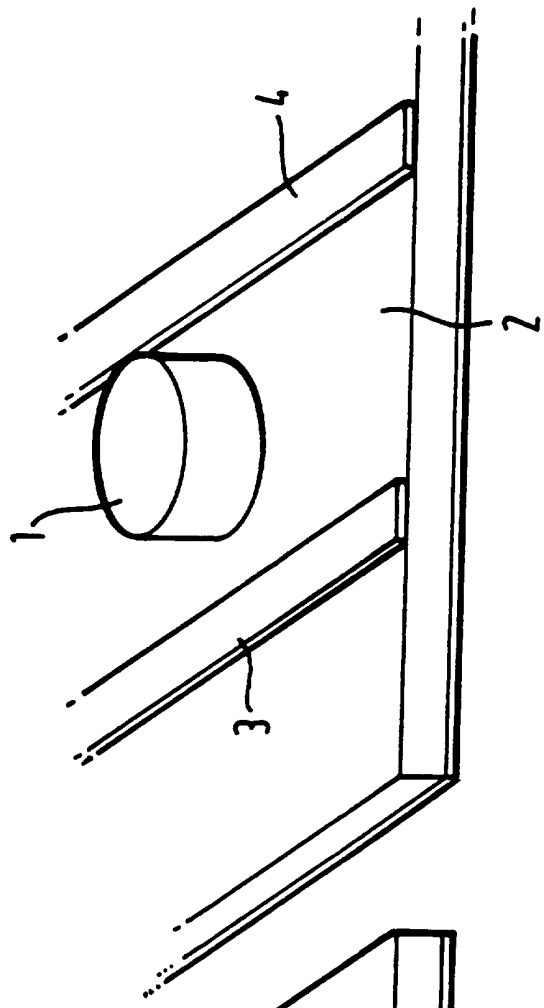


FIG. 1(a)

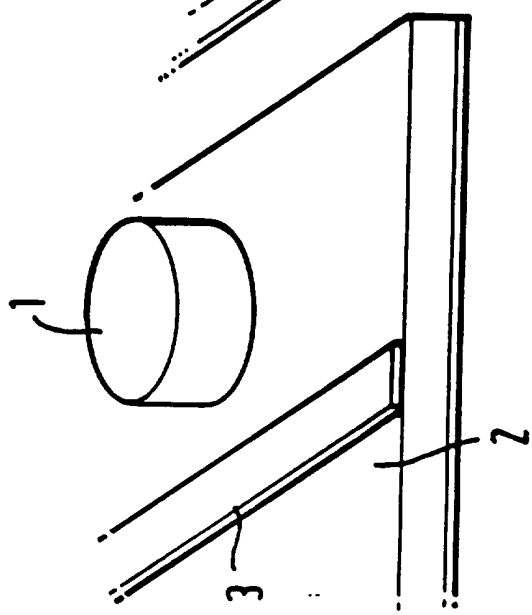


FIG. 2 (PRIOR ART)

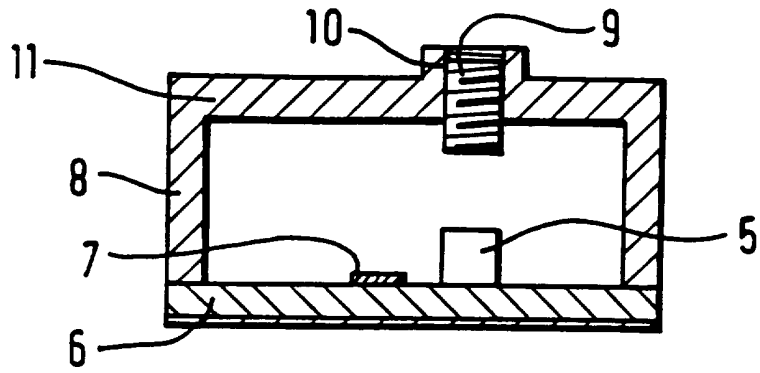


FIG. 3 (PRIOR ART)

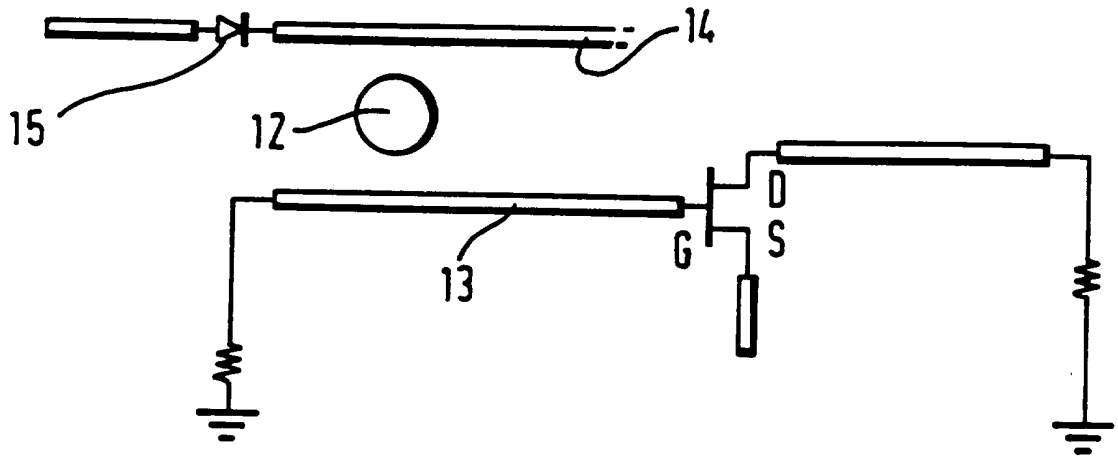


FIG. 5

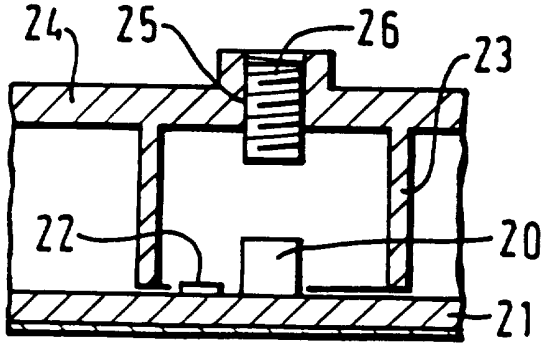


FIG. 6

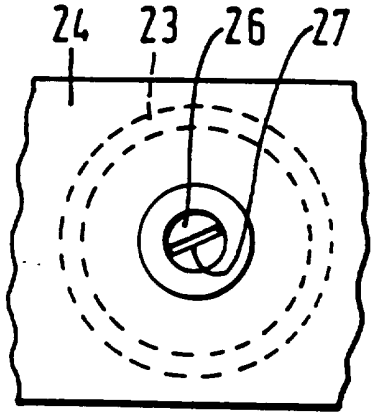


FIG. 4

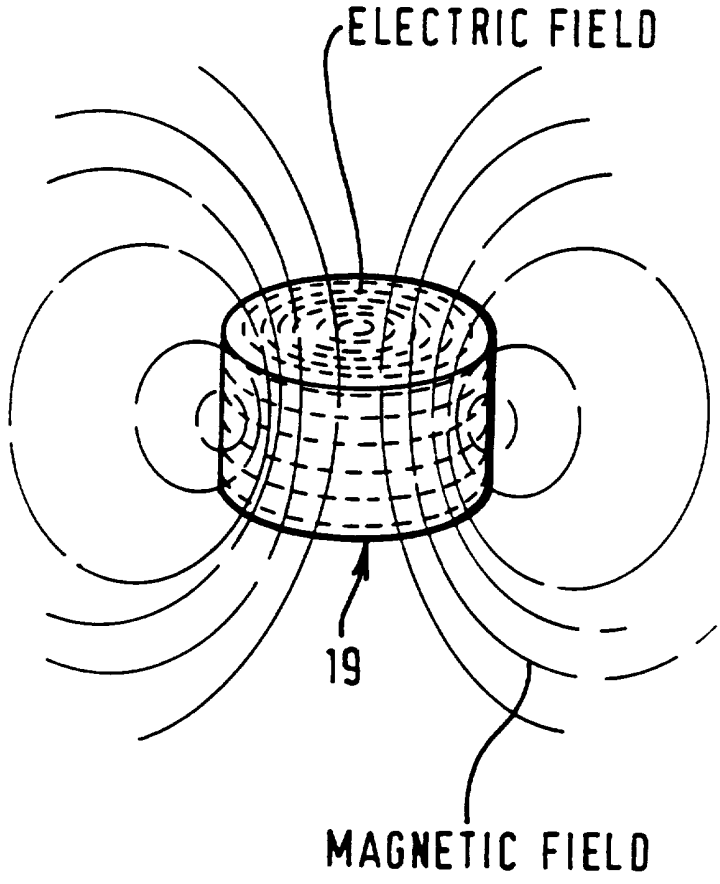


FIG. 7

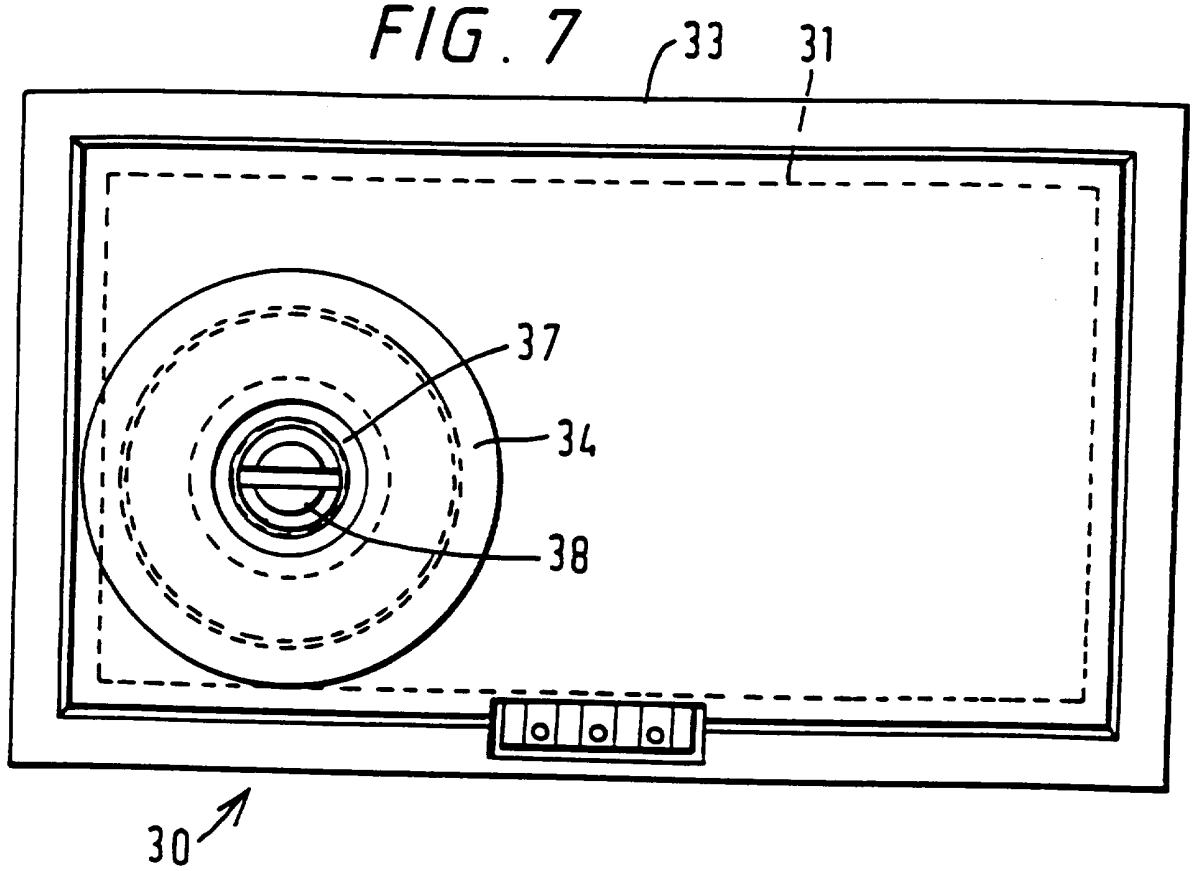
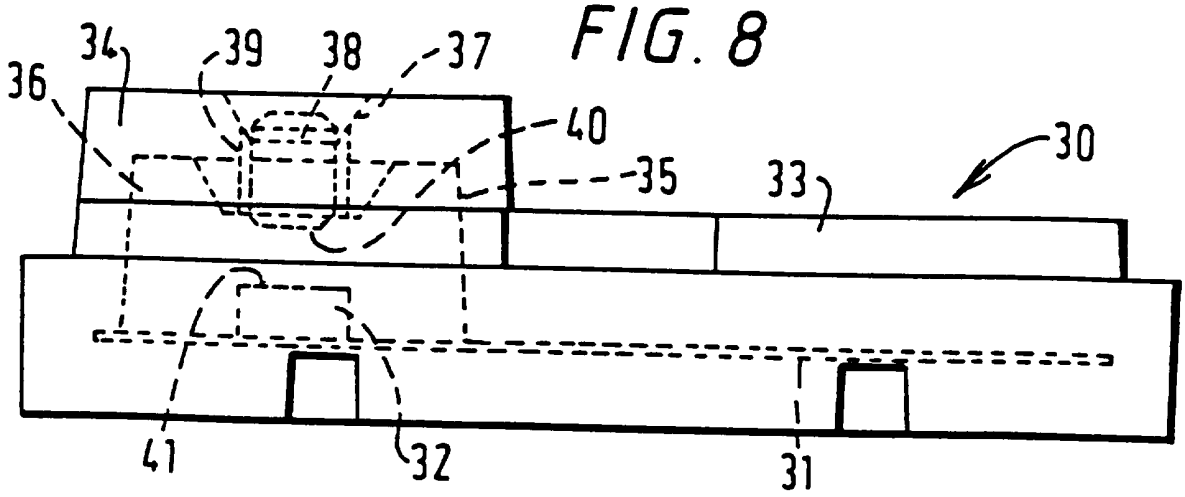


FIG. 8



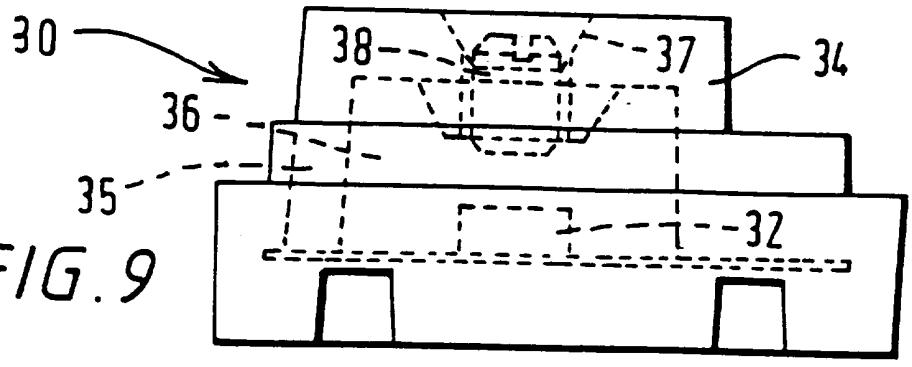
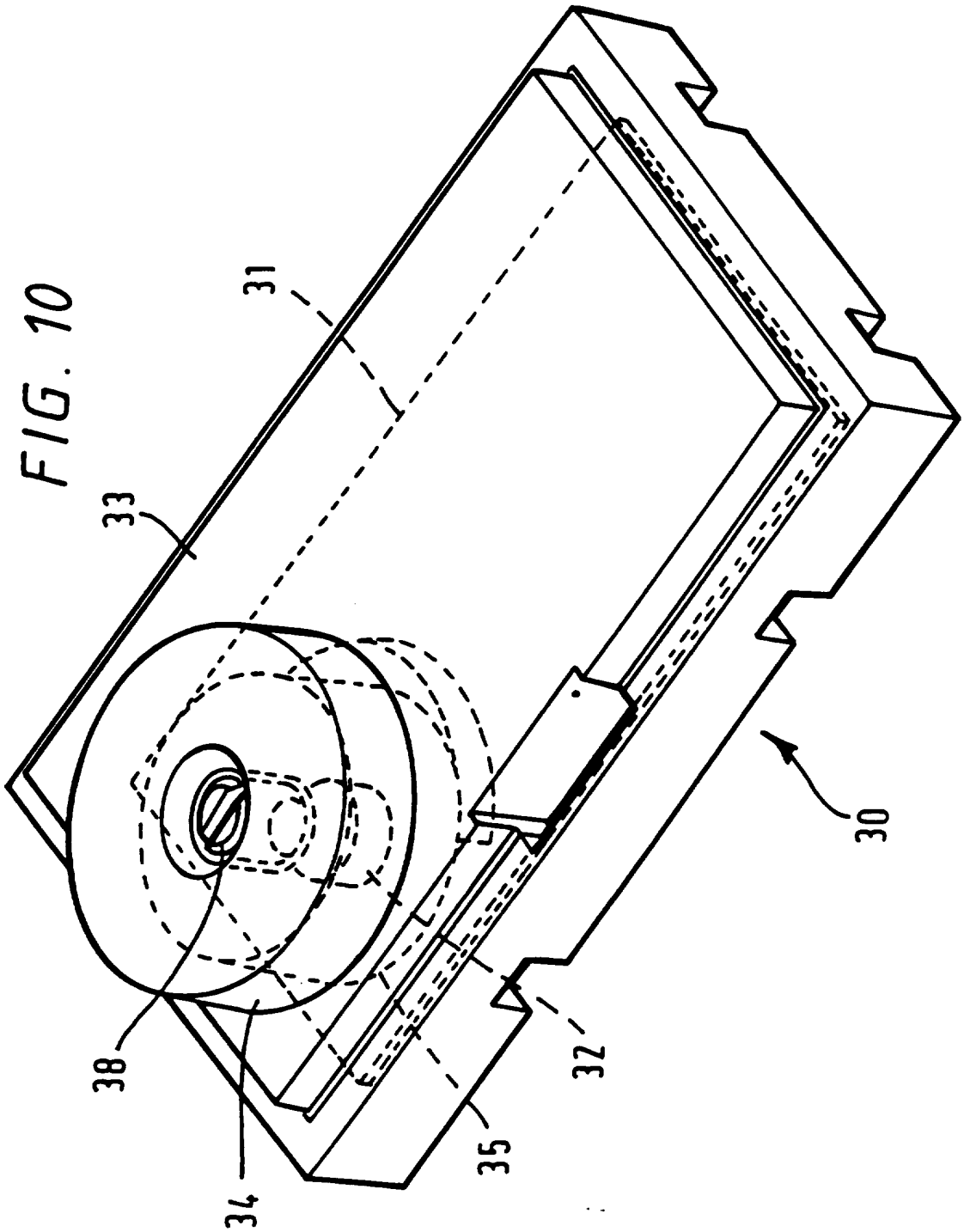


FIG. 9

FIG. 10



DIELECTRIC RESONATOR

This invention relates to dielectric resonators and more particularly to a dielectric resonator employed, for example, in an oscillator circuit.

It is known to employ a dielectric resonator as a frequency determining element in an oscillator, either as the stabilising element in a free-running transistor oscillator, or in the feed-back network of a series or parallel feed-back oscillator. The dielectric resonator, hereinafter occasionally referred to as a puck, is usually mounted on a substrate, for example, a printed circuit board, closely adjacent to, or overlapping, one or more striplines. When coupled to a single stripline, the puck open-circuits the line at its resonant frequency. When coupled to two or more striplines, the puck can be operated in transmission mode at its resonant frequency.

The resonant frequency of the puck is a function of the dielectric constant of the material from which it is made, its physical dimensions, and the boundary conditions set by any surrounding cavity or components. Frequency tuning can be accomplished by mechanical means, for example, by varying the distance between the puck and a component such as a metal member, which can, for example, be located directly above it. Frequency tuning

can also be accomplished by electrical means, for example, by coupling the puck to a second resonator circuit, such as a varactor and stripline combination, and varying the varactor capacitance.

The commonly used resonant mode for most dielectric resonator applications is the $TE_{01\delta}$ mode, in which the magnetic fields lie in the axial plane of the puck and the electric fields lie in concentric circles around the puck axis. The puck can support an infinite number of other TE modes as well as TM and TEM modes and therefore care must be taken in selecting the desired mode.

The puck and its associated circuitry are normally housed in a cavity, preferably formed by a housing provided with an electrically conducting wall, firstly to prevent radiated emissions, and secondly to prevent radiation losses from reducing the Q value of the puck. In conventional microwave circuitry design it is generally recommended that the separation between the puck and the walls of the housing or components forming the cavity is equivalent to at least one puck diameter in any direction, and preferably significantly more, in order to prevent the proximity of the walls of the housing or components exerting undue influence on the puck characteristics. In many microwave devices this requirement is in conflict with the need to keep the circuit dimensions to a minimum. The need to reduce the

circuit size often results in the puck being mounted asymmetrically within the cavity so that the distances from the puck to each of the walls of the housing or components providing the cavity are different. This has the effect of distorting the fields around the puck, and, depending on the geometry, can suppress the desired $TE_{01\delta}$ mode or excite other, unwanted modes.

It is an object of the present invention to provide a circuit comprising a dielectric resonator, for example, an oscillator circuit, in which the puck is positioned within a controlled, and preferably uniform, field environment without any abrupt changes, such that improved consistency and improved resonator performance can be obtained.

According to a first aspect, the present invention provides a circuit comprising a dielectric resonator wherein the dielectric resonator is positioned within a chamber, the chamber being formed by a housing having a wall comprising one or more of:

(i) a reflecting material;

(ii) a partially reflecting/absorbing material;

(iii) an absorbing material; or

(iv) a transparent or partially transparent (lossy) material.

the position of the dielectric resonator relative to the wall or walls, and the dimensions of the chamber,

providing a controlled, and preferably uniform, electrical and magnetic field environment for the dielectric resonator.

In another aspect, the invention provides a circuit comprising a dielectric resonator wherein the dielectric resonator is positioned within a symmetrical chamber formed by a housing, the wall or walls of the chamber comprising one or more of:

(i) a reflecting material;

(ii) a partially reflecting/absorbing material;

(iii) an absorbing material; or

(iv) a transparent or partially transparent (lossy) material.

In a further aspect the invention provides a dielectric resonator oscillator wherein the dielectric resonator is positioned within a chamber, the chamber being formed by a housing having a wall or walls comprising one or more of:

(i) a reflecting material;

(ii) a partially reflecting/absorbing material;

(iii) an absorbing material; or

(iv) a transparent or partially transparent (lossy) material.

The oscillator of the invention can be a free-running transistor oscillator, or a series or parallel feed back oscillator.

The dielectric resonator or puck can be of any suitable size and shape, but will usually be cylindrical or disc-shaped.

Preferably the dielectric resonator or puck is disposed symmetrically, and more preferably, centrally with respect to the chamber. Preferably the chamber and housing are specifically dedicated to the dielectric resonator, that is to say, the chamber is preferably free of other components which would affect the uniformity of the field environment. In a preferred embodiment the housing providing the chamber exclusively surrounds the dielectric resonator on all sides, apart from its mounting surface, and no other circuit components are present within the chamber.

The chamber is preferably cylindrically shaped, although other geometrically curved shapes, for example, conical chambers and elliptical chambers, are not excluded, provided that they can provide a controlled, and preferably uniform, electrical and magnetic field environment, without abrupt changes, for the dielectric resonator.

It is found that, by using the present invention, the dimensions of the chamber can be made very small, and, for example, it has been found that the separation between the puck and the housing wall can be reduced to substantially less than one puck diameter.

It will be appreciated that placing any object within close proximity to the puck will change the puck resonant frequency and the housing of the present invention is no exception to this. This change in frequency can be compensated for, however, by changing the dimensions of the puck, or by providing mechanical or electrical frequency tuning means as previously described. Preferably the housing is provided with mechanical frequency tuning means which can comprise, for example, a turn screw positioned in a threaded hole in the wall of the housing.

Where the dielectric resonator is part of a circuit of a microwave device, the housing may be moulded integrally with the casing for the device, or affixed to the casing as a separate component. Alternatively, where the dielectric resonator is mounted on a printed circuit board the housing can be affixed thereto. In a preferred configuration, the housing is moulded integrally with, or affixed to, the casing, and extends from the casing to the printed circuit board or to a position adjacent the surface thereof.

Suitable materials for the wall or walls of the housing are as follows:

(i) microwave reflecting materials; for example, metals (brass, aluminium etc) or metal plated plastics materials.

(ii) partially reflecting/absorbing materials; for example, metal loaded plastic materials.

(iii) microwave absorbing materials; for example lossy foams or magnetically loaded rubber materials.

(iv) microwave transparent or partially transparent (lossy) materials; for example, engineering plastics materials, such as ABS and polycarbonate plastics.

In preferred embodiments of the invention, wherein the puck operates within a substantially uniform electrical and magnetic field environment, it is found that many of the conditions that can suppress the desired $TE_{01\delta}$ mode, or excite unwanted modes, can be substantially reduced or eliminated. The use of a cylindrical or conical chamber, in accordance with a preferred aspect of the invention, can enable puck performance in terms of tuning range and circuit Q to be improved, and can also provide additional screening to help reduce radiated emissions. The use of a cylindrical or conical chamber also permits the overall size to be reduced substantially.

Whilst the invention has been described in terms of a dielectric resonator oscillator it will be appreciated that it is not limited thereto, and could be applied to other circuits such as, for example, dielectric resonator filters.

An embodiment of a dielectric resonator oscillator in accordance with the invention will now be described, by way of example only, with reference to the accompanying Drawings in which:

Figures 1(a) and (b) show, in perspective view, two arrangements for mounting a puck on a printed circuit board;

Figure 2 shows, in sectional side elevation, a conventional housing provided with mechanical frequency tuning means;

Figure 3 shows, in diagrammatic form, a dielectric resonator provided with electrical frequency tuning means;

Figure 4 illustrates diagrammatically the magnetic and electrical field distribution for a puck operating in the $TE_{01\delta}$ mode;

Figure 5 shows in sectional side elevation a dielectric resonator situated within a cylindrical chamber in accordance with the invention;

Figure 6 shows the arrangement of Figure 5 in plan view;

Figure 7 shows a microwave device incorporating a dielectric resonator oscillator according to the invention in plan view;

Figure 8 shows a side elevation of the device of Figure 7, partly in section;

Figure 9 shows an end elevation of the device of Figure 7, partly in section; and

Figure 10 shows a perspective view of the device of Figure 7.

Referring firstly to Figures 1(a) and (b), there is shown a dielectric resonator or puck 1 mounted on a printed circuit board 2. The puck is of generally cylindrical or disc-shaped construction, and is mounted in coupling relationship to a strip line 3, in Figure 1(a), and in coupling relationship to a pair of strip lines 3 and 4, in Figure 1(b). In Figure 1(a) the puck open-circuits the strip line 3 at its resonant frequency,

and in Figure 1(b) the puck operates in transmission mode between the strip lines 3 and 4 at its resonant frequency.

Referring to Figure 2, there is shown a typical prior art arrangement. The puck 5 is shown mounted on a printed circuit board 6 and coupled to a strip line 7. The puck and the stripline are surrounded by a rectangular housing 8 and the puck is mounted asymmetrically with respect to the housing. A screw or plunger 9 set in a hole 10 in the top surface 11 of the housing 8 is situated immediately above the puck 5. The screw or plunger 9 can be moved towards or away from the puck 5 in order to alter the resonant frequency of the puck.

Referring now to Figure 3, there is shown a further prior art arrangement. The puck 12 is positioned between strip lines 13 and 14 on a printed circuit board. Strip line 14 is connected to a varactor 15 and by varying the varactor capacitance the puck can be tuned to the desired resonant frequency.

The electric and magnetic fields of the $TE_{01\delta}$ made of an isolated puck 16 are depicted in Figure 4.

Referring now to Figure 5, there is shown, in diagrammatic form, a puck provided with a cylindrical

cavity in accordance with the invention. The cylindrical puck 20 is mounted on a printed circuit board (pcb) 21 and is coupled to a stripline 22. The puck 20 is mounted co-axially within a cylindrical housing 23 which is integrally moulded with a casing 24. A threaded hole 25 in the casing 24 is provided with a turn screw 26, the arrangement being such that the screw is immediately above the puck 20.

The cylindrical housing 23 is formed from a compound of stainless steel fibres and plastics material. The housing 23 extends from the casing 24 to a point just above the pcb substrate 21.

By mounting the puck 20 at the centre of the cylindrical cavity formed by the housing 23 it is found that the puck is subjected to a highly uniform field environment. Frequency tuning of the puck can be accomplished by varying the distance between the puck 20 and the turn screw 26. The turn screw 26 is provided with a slot 27 (see figure 6) whereby its height can be adjusted by means of a screwdriver.

In Figures 7 to 10 there is shown a microwave motion detection device comprising a dielectric resonator oscillator in accordance with the present invention. The circuit of the microwave motion detection device is described in detail in our co-pending UK patent

application number GB9513251.0 filed 29 June 1995, the entire disclosure of which is incorporated herein by reference for all purposes.

Referring firstly to Figure 7, the device, illustrated generally at 30, is provided with a printed circuit board 31 upon which various components are mounted. Referring to Figure 8 the dielectric resonator or puck is shown at 32, mounted on the printed circuit board 31. The device 30 is provided with a casing 33 having a raised conical portion 34 which is co-axial with the puck 32. The raised conical portion 34 of the casing 33 contains a conical housing 35 which extends from the raised portion 34 downwardly until it almost touches the printed circuit board 31. The housing forms a cylindrical chamber 36 which is co-axial with the puck 32. The raised portion 34 has a chamfered recess 37 within which there is situated a turn screw 38 in a threaded hole 39. The screw 38 is co-axial with the puck 32, and by turning the screw the distance between its lower end 40 and the upper surface 41 of the puck 32 can be varied for frequency tuning purposes.

As will be apparent from the drawings, the walls of the chamber 36, which are made of a compound of stainless steel fibres and plastics material are equidistant from the puck 32 in any direction.

The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of the foregoing embodiments. The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any

novel one, or any novel combination, of the steps of any method or process so disclosed.

CLAIMS

1. A circuit comprising a dielectric resonator wherein the dielectric resonator is positioned within a chamber, the chamber being formed by a housing having a wall comprising one or more of:

(i) a reflecting material;

(ii) a partially reflecting/absorbing material;

(iii) an absorbing material; or

(iv) a transparent or partially transparent (lossy) material.

The position of the dielectric resonator relative to the wall or walls, and the dimensions of the chamber, providing a controlled, and preferably uniform, electrical and magnetic field environment for the dielectric resonator.

2. A circuit comprising a dielectric resonator wherein the dielectric resonator is positioned within a symmetrical chamber formed by a housing, the wall or walls of the chamber comprising one or more of:

(i) a reflecting material;

(ii) a partially reflecting/absorbing material;

(iii) an absorbing material; or

(iv) a transparent or partially transparent (lossy) material.

3. A circuit according to Claim 1, wherein the chamber is symmetrical.

4. A circuit according to any of the preceding claims, in which the dielectric resonator is positioned symmetrically with respect to the chamber.

5. A circuit according to any of the preceding claims, wherein the dielectric resonator is positioned centrally with respect to the chamber.

6. A circuit according to any of the preceding claims, wherein the chamber is free of circuit components other than the dielectric resonator.

7. A circuit according to any of the preceding claims, wherein the separation between the dielectric resonator and the housing wall is less than the diameter of the dielectric resonator.

8. A circuit according to any of the preceding claims, in which the dielectric resonator is cylindrical or disc-shaped.

9. A circuit according to any of the preceding claims, which is part of a microwave device having a casing, and in which the housing is moulded integrally with

the casing or affixed to the casing as a separate component.

10. A circuit according to Claim 9, in which the dielectric resonator is mounted on a printed circuit board and the housing extends from the casing to the printed circuit board or to a position adjacent to the surface thereof.

11. A circuit according to any of the preceding claims, wherein the material of the wall of the housing comprises:

(i) a metal or a metal plated plastics material;

(ii) a metal loaded plastics material;

(iii) a lossy foam material or a magnetically loaded rubber material; or

(iv) an engineering plastics material.

12. A circuit according to any of the preceding claims, in which the housing is provided with mechanical tuning means for the dielectric resonator.

13. A circuit according to any of the preceding claims, substantially as hereinbefore described with reference to figures 5 to 10 of the accompanying Drawings.

14. A circuit comprising a dielectric resonator and a chamber substantially as hereinbefore described.

15. A dielectric resonator oscillator wherein the dielectric resonator is positioned within a chamber, the chamber being formed by a housing having a wall or walls comprising one or more of:

(i) a reflecting material;

(ii) a partially reflecting/absorbing material;

(iii) an absorbing material; or

(iv) a transparent or partially transparent (lossy) material.

16. An oscillator according to Claim 15, which comprises a free-running transistor oscillator, or a series or parallel feedback oscillator.

17. An oscillator according to Claim 15 or 16 comprising a circuit according to any of Claims 1 to 14.

18. An oscillator according to any of Claims 15 to 17, substantially as hereinbefore described with reference to and as illustrated in figures 7 to 10 of the accompanying Drawings.

19. A dielectric resonator oscillator comprising a dielectric resonator positioned within a cavity substantially as hereinbefore described.

Patents Act 1977 Examiner's report to the Comptroller under Section 17 (The Search report)	Application number GB 9523550.3
Relevant Technical Fields (i) UK Cl (Ed.O) H1W (WGX, WGP) (ii) Int Cl (Ed.6) H01P 7/10	Search Examiner MISS J E EVANS Date of completion of Search 25 JANUARY 1996
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii)	Documents considered relevant following a search in respect of Claims :- 1-19

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X	GB 2129228 A	(MURATA) whole document	1-6, 8, 9, 11, 12, 15
X	WO 93/09575 A1	(DU PONT) see Figures 1, 7-10 and 14	1-6, 8, 9, 11, 15
X	WO 92/20116 A1	(TELENOKIA) see Figures 1 and 2	1-9, 11, 12, 15
X	EP 0601371 A1	(ANT) see Abstract and Figures 1-6	1-9, 11, 15
X	EP 0352628 A2	(MURATA) see Abstract and Figures 1, 2, 5 and 6	1-6, 8, 9, 11, 15
X	EP 0026086 A1	(WESTERN) see Abstract and Figures 1-3	1-9, 11, 12, 15

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