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(54) **FILTER APPARATUS AND METHOD OF USE THEREOF**

(57) Filter apparatus is provided including a housing with two or more resonant cavities defined therein. Each of the two or more resonant cavities have resonator means provided therein. Each of the resonator means has a first resonator portion and a second resonator portion. A first end of the first resonator portion is located on a wall of the resonant cavity. The second resonator portion is provided at a second end of the first resonator portion. The second resonator portion defines a channel or an inverted channel therein. An opening of the channel or inverted channel is arranged to face towards the wall of the resonant cavity on which the first end of the first resonator portion is located. An outer wall of the second resonator portion has an aperture, slot or cut-out defined therein.

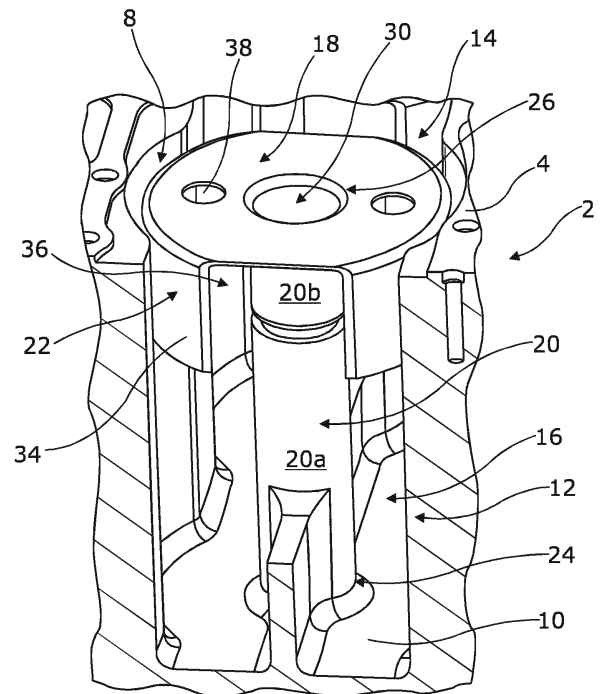


Figure 1c

Description

[0001] This invention relates to filter apparatus and a method of use thereof.

[0002] A filter apparatus is typically used in a telecommunication system to compensate for disturbances, such as interference, that may affect one or more transmission signals being sent and/or received by the telecommunication system. The filter apparatus is designed to remove unwanted components from the transmit and/or receive signals and/or enhance the desired transmit and/or receive signals.

[0003] Telecommunication systems, such as broadcast radio, television, wireless communication systems (i.e. mobile phones, Wi-Fi etc) and/or the like which transmit and/or receive signals in the medium to high frequency ranges (i.e. in the megahertz and gigahertz frequency ranges) typically use radio frequency (RF) and microwave filter assemblies in order to filter their transmit and/or receive signals. An example of conventional RF or microwave filter apparatus typically includes a conductive housing defining one or more resonant cavities therein with one or more resonators located in each cavity. A resonator is an electronic component that exhibits resonance for a narrow range of frequencies. Two or more resonators within the filter are typically electromagnetically coupled together to provide the filter with a required set of performance characteristics.

[0004] The performance of filter apparatus can be measured by its Quality or Q factor. The Q factor is proportional to the energy stored to the power lost in the resonator. The Q factor is also a measure of a resonator's bandwidth relative to its centre frequency. A filter consisting of high Q resonators will have a relatively sharp transition from passband to stop band and have relatively small power loss in the passband. The Q factor of filter apparatus typically increases as the size of the cavity in which the resonator is located also increases. However, it is normally desirable to have the smallest filter size possible with the highest Q factor, so as to reduce costs associated with manufacturing the filter apparatus and to reduce the size of the apparatus required to be operated, transported and/or stored. This is particularly the case when the filter apparatus is to be installed, either directly or as an integral part of another device such as a tower mounted amplifier (TMA) or remote radio head (RRH), on a mast or tower.

[0005] A further desirable characteristic of filter apparatus is to have low transmission losses. As the operating frequency of a microwave cavity filter is decreased, the height of the resonant cavity and the associated resonator typically needs to be increased. As such, filters having cavities and resonators arranged to resonate at lower frequencies tend to be larger than filters having cavities and resonators arranged to resonate at higher frequencies. One method to improve the space efficiency of filter apparatus is to make the resonators "mushroom" shaped. This increases the surface area of the resonator

that is in close proximity to a side wall and top wall of the cavity, thereby increasing the capacitance between the resonator and an electrical ground plane of the resonator cavity. Increasing the capacitance in the resonator cavity reduces the resonant frequency of the cavity. Using this method, the cavity height for a given resonant frequency can be greatly reduced compared to a resonator of constant cross section, such as a cylindrical shaped resonator. Although there is a reduction in the Q factor of the resonant cavity, which leads to increased losses in the filter, this is small compared to the reduction in cavity volume and there is an overall improvement in space efficiency (Q/vol).

[0006] Examples of mushroom shaped resonators are disclosed in WO2011/126950. For example, each resonator includes a hollow conductive body having a first end coupled to the cavity housing and a second end with an outer portion folded down towards the first end to form a generally inverted U-shaped portion. A tuning screw can be provided in the lid of the cavity which extends into the second end of the resonator body. A problem associated with mushroom shaped resonators is that as the length of the folded outer portion increases, the maximum coupling bandwidth that can be achieved between two adjacent resonators within a filter housing decreases. This means there is a trade-off when using mushroom resonators in filter apparatus between the improvement in space-efficiency within the apparatus versus the bandwidth that can be achieved using the filter apparatus.

[0007] It is an aim of the present invention to provide filter apparatus that overcomes the abovementioned problems.

[0008] It is a further aim of the present invention to provide a method of using filter apparatus that overcomes the above mentioned problems.

[0009] It is a yet further aim of the present invention to provide a telecommunication system including filter apparatus and/or a method of using a telecommunication system including filter apparatus.

[0010] It is a yet further aim of the present invention to provide a resonator for use in filter apparatus that overcomes the abovementioned problems and/or a method of using a resonator.

[0011] According to a first aspect of the present invention there is provided filter apparatus, said filter apparatus including a housing with two or more resonant cavities defined therein, each of said two or more resonant cavities having resonator means provided therein, each of said resonator means having a first resonator portion and a second resonator portion, a first end of the first resonator portion located on a wall of the resonant cavity, the second resonator portion provided at a second end of the first resonator portion, the second resonator portion defining a channel or an inverted channel therein, an opening of the channel or inverted channel arranged to face towards the wall of the resonant cavity on which the first end of the first resonator portion is located, characterised in that an outer wall of the second resonator por-

tion has an aperture, slot or cut-out defined therein.

[0012] The aperture, slot or cut-out defined in the second resonator portion of the resonator means allows the electromagnetic fields of two adjacent resonator means to interact in an unhindered manner. This increases the electromagnetic coupling between adjacent resonator means within the filter apparatus, thereby increasing the coupling bandwidth therebetween, and hence increasing the bandwidth of the filter apparatus.

[0013] The aperture, slot or cut out defined in the outer wall of the second resonator portion is distinct/different to the opening of the channel or inverted channel defined in the second resonator portion, although it will be appreciated that the opening can be in fluid communication with the aperture, slot or cut out.

[0014] Preferably the provision of the aperture, slot or cut-out in the outer wall of the second resonator portion, together with and the arrangement of the resonant cavities is such so as to provide a "line of sight" between the first resonator portion of one resonator means in one resonant cavity and the first resonator portion of an adjacent resonator means in an adjacent resonant cavity. This allows the electromagnetic fields of the two adjacent resonator means to interact in a more efficient manner.

[0015] The applicants have found there is no significant reduction in capacitance of the resonator means to an electrical ground plane of the resonant cavity because there is no resonant cavity wall adjacent the adjacent resonator means. Hence, there is no significant change in resonant frequency of the resonant means as a result of including the aperture, cut-out or slot in an outer wall of the second resonator portion.

[0016] In one embodiment the second resonator portion consists of an inverted channel or tray element. The aperture, slot or cut out is defined in a wall of the inverted channel or tray element, and preferably in a side wall or walls of the inverted channel or tray element.

[0017] In one embodiment two or more apertures, slots or cut outs are defined in an outer wall or walls of the second resonator portion. This allows one resonator means to have a "line of sight" or be electromagnetically coupled to two or more adjacent resonator means.

[0018] Preferably the two or more apertures, slots or cut outs are separate and distinct from each other, and further preferably are provided a spaced distance apart from each other on the outer wall or walls of the second resonator portion.

[0019] In one embodiment at least two apertures, slots or cut outs are defined on opposite side walls of the resonator means and/or are directly opposite to each other.

[0020] Preferably whatever the arrangement, the positioning of the one or more apertures, slots or cut outs on the resonator means will be such so as to allow a "line or sight" or electromagnetic coupling with the adjacent resonator means. For example, the two apertures, slots or cut outs could be offset from each other on a particular resonator means but still provide a line or sight.

[0021] In one embodiment an aperture, slot or cut out

is defined in or extends over two or more outer walls of the second resonator portion. The two or more outer walls of the second resonator portion are typically immediately adjacent each other. For example, the two outer walls could be arranged perpendicular or substantially perpendicular to each other.

[0022] In one embodiment the aperture, slot or cut out defined is a chord of a circle or is planar with respect to the second resonator portion.

[0023] In one embodiment the aperture, slot or cut out defined is provided on a curved wall and is non planar with respect to the second resonator portion.

[0024] Preferably the two apertures, slot or cut outs defined in the second resonator portion can be of the same size and/or shape or can be of different size and/or shape.

[0025] In one embodiment the one or more apertures, cut-outs or slots is/are open to a free peripheral edge of the second resonator portion, side wall or outer wall closest to the first end of the first resonator portion.

[0026] Preferably the outer wall in which the aperture, cut out or slot is defined in perpendicular, substantially perpendicular or transverse to the wall of the resonant cavity on which the first end of the first resonator portion is located.

[0027] In one embodiment the aperture, cut-out or slot is defined a spaced distance apart from the free peripheral edge of the second resonator portion, side wall or outer wall closest to the first end of the first resonator portion and is not open with the same (i.e. the aperture, cut-out or slot is entirely enclosed within an outer wall of the second resonator portion).

[0028] In one embodiment the aperture, cut-out or slot is an inverted U-shape or substantially inverted U-shape, with the opening of the U facing towards the first end of the resonator means. In one embodiment the aperture, slot or cut out is L-shaped, substantially L-shaped, C shaped or substantially C-shaped. However, the aperture, cut-out or slot could be any shape, such as for example v-shaped or substantially v-shaped if required.

[0029] In one embodiment the aperture, slot or cut-out is provided along the entire length and/or width of the outer wall, a side wall or skirt of the second resonator portion from a base wall to an opposite peripheral free edge and/or from a side wall to an opposing side wall.

[0030] Preferably the first resonator portion protrudes outwardly from the wall of the resonator cavity on which it is located.

[0031] Preferably the first resonator portion is coupled to, joined to, integrally formed with, attached or detachably attached to a wall of the resonant cavity.

[0032] Further preferably the first resonator portion is arranged to protrude outwardly transversally, perpendicular to or substantially perpendicular to the wall of the resonant cavity on which it is located.

[0033] Preferably the first resonator portion is coupled to a base or electrical ground plane of the resonant cavity.

[0034] In one embodiment the first resonator portion

is in the form of an upright post, rod or body or a vertical post, rod or body.

[0035] The first resonator portion can comprise or consist of a single integral member or can include two or more members joined together.

[0036] Preferably the first resonator portion is coupled to, joined to, attached or detachably attached to a wall of the resonant cavity via solder, adhesive, welding, friction fit, push fit, one or more clips, screws, nuts and bolts, inter-engaging members and/or the like.

[0037] Preferably the resonator means, the first resonator portion and/or the second resonator portion is hollow, substantially hollow or has a hollow section defined therein.

[0038] In one embodiment the second resonator portion is integral with the first resonator portion. For example, the second resonator portion can comprise a folded back portion provided at the second end of the first resonator portion.

[0039] In an alternative embodiment the second resonator portion is joined to the first resonator portion via suitable joining means, such as for example via solder, welding, adhesive and/or the like.

[0040] In one embodiment the outer wall of the second resonator portion having the aperture, cut-out or slot defined therein is parallel to substantially parallel to the first resonator portion.

[0041] Preferably the channel or inverted channel defined by the second resonator portion is further defined between the first and second resonator portions.

[0042] In one embodiment the channel or inverted channel defined in the second resonator portion is U-shaped or substantially U-shaped in form.

[0043] In one embodiment the second resonator portion provides a skirt to the resonator means or the second end of the first resonator portion.

[0044] Preferably the aperture, cut-out or slot is defined in the skirt of the resonator means.

[0045] Preferably the skirt or outer wall of the second resonator portion having the aperture, cut-out or slot is a spaced distance apart from the first resonator portion.

[0046] Preferably the first end of the first resonator portion is opposite to the second end of the first resonator portion.

[0047] In one embodiment the second resonator portion includes a first wall section and a second wall section. In one example the first wall section forms a top of the resonator means and the second wall section forms the outer wall, a side wall or skirt of the resonator means.

[0048] Preferably the first or top wall section of the second resonator portion is opposite and/or parallel to the wall of the resonant cavity to which the first end of the first resonator portion is located.

[0049] Preferably the second or outer wall section of the second resonator portion is parallel or substantially parallel to one or more side walls of the resonant cavity and/or first resonator portion.

[0050] Further preferably it is the second outer wall

section of the second resonator portion that the aperture, cut-out or slot is defined in.

[0051] Preferably the one or more walls of the filter housing defining the resonant cavities are formed from electrically conductive material and/or have an electrically conductive coating provided thereon.

[0052] Preferably the first end of the first resonator portion is coupled to, attached or detachably attached, directly or indirectly, to the wall of the resonant cavity via fixing means in the form of any or any combination of solder, welding, adhesive, push fit connection, friction fit connection, one or more screws, nuts and bolts, clips, inter-engaging members and/or the like.

[0053] Preferably the fixing means are formed from or have an external coating or electrically conductive material.

[0054] Preferably the second end of the first resonator portion is a spaced distance apart from the walls of the resonant cavity. For example, if the first end of the first resonator portion is provided on a base of the resonant cavity, the second end of the first resonator portion is a spaced distance apart from a lid provided opposite to the base of the resonant cavity.

[0055] Preferably each resonant cavity is defined between a base wall and side walls of the filter housing.

[0056] Preferably the resonant cavity has an opening opposite to the base wall.

[0057] Preferably a lid or cover means is provided on or over the opening of the resonant cavity and/or filter housing in use. The lid or cover means acts to wholly or at least partially close the opening of the resonant cavity.

[0058] In one embodiment one or more tuning means or tuning screws are provided on or associated with the resonator means for tuning the resonant frequency of the resonator means in use.

[0059] Preferably the one or more tuning means or tuning screws are provided on or associated with a lid or cover means of the resonant cavity.

[0060] Preferably at least part of the tuning means or tuning screw is arranged to move towards or away from the second end of the first resonator portion in use.

[0061] Preferably at least part of the tuning means or tuning screw is arranged to be located at least partly within a hollow part of the first resonator portion or the second end of the first resonator portion in use.

[0062] Preferably the first top wall of the second resonator portion is provided parallel or substantially parallel to a lid or cover means of the resonant cavity.

[0063] In one embodiment tuning means are provided in, between or associated with two adjacent resonator cavities in order to tune the coupling bandwidth between two adjacent resonator means located in said resonator cavities. For example, the tuning means could be at least partially located in the gap, iris, window or aperture between two adjacent resonator cavities.

[0064] The tuning means in any location within the apparatus could be in the form of a tuning element, tuning screw and/or the like and which is capable of allowing

tuning of the resonant frequency and/or the coupling bandwidth of or between the resonator means.

[0065] In one embodiment the resonator means is formed from, consists of or is covered by an electrically conductive material, such as a metal or a metal coating.

[0066] Preferably the first resonator portion has a channel defined therethrough. An opening to the channel is defined at the second end of the first resonator portion.

[0067] Preferably at least part of the tuning means or tuning screw is able to move within and/or relative to the channel or hollow section defined in the first resonator portion.

[0068] Preferably the skirt, second part, side wall or outer wall of the second resonator portion having the one or more apertures, cut-outs or slots defined therein is of a length less than the length of the first resonator portion, and further preferably is less than half the length of the first resonator portion.

[0069] Preferably the wall or walls between two adjacent resonant cavities has an aperture or iris defined therein and the aperture, cut-out or slot of the second resonator portion is aligned, substantially aligned or at least partially aligned with the aperture or iris of the adjacent resonant cavities, thereby allowing a line of sight between adjacent resonator means.

[0070] In one embodiment the aperture, cut-out or slot of the second resonator portion is equal to, substantially equal to or smaller in dimensions than the aperture or iris defined between the two adjacent resonant cavities.

[0071] Preferably the resonator means is mushroom shaped or is umbrella shaped. For example, the first resonator portion forms the stem of the mushroom and the second resonator portion forms the top or canopy of the mushroom.

[0072] The resonant cavity and/or resonator means can be any suitable size, shape and/or dimensions. For example, square, circular, hexagonal and/or the like.

[0073] In one example, the resonator means in top plan view (i.e. the first part of the second resonator portion) is circular in shape with one or more segments removed therefrom taken along a chord of the circle. The removed segment is adjacent the aperture, cut-out or slot of the second resonator portion.

[0074] In other examples, the resonator means in top plan view (i.e. the first part of the second resonator portion) is square, circular, hexagonal and/or the like.

[0075] In one embodiment the filter apparatus has a plurality of resonant cavities defined in the housing, the resonator means within the resonant cavities are preferably electromagnetically coupled together to resonate at a pre-determined frequency or frequency range.

[0076] Preferably the resonator means is any means or member which exhibits resonance or resonant behaviour at a particular frequency or frequency range.

[0077] According to a second aspect of the present invention there is provided a method of using filter apparatus, said filter apparatus including a housing with two or more resonant cavities defined therein, said method

including the steps of providing each of said two or more resonant cavities with resonator means therein, each of said resonator means having a first resonator portion and a second resonator portion, locating a first end of the first resonator portion on a wall of the resonant cavity, providing the second resonator portion at a second end of the first resonator portion, the second resonator portion defining a channel or an inverted channel therein, arranging the second resonator portion so that an opening of the channel or inverted channel faces towards the wall of the resonant cavity on which the first end of the first resonator portion has been located, characterised in that an outer wall of the second resonator portion has an aperture, slot or cut-out defined therein.

[0078] According to further independent aspects of the present invention there is provided a resonator for use with filter apparatus and/or a method of using a resonator.

[0079] Embodiments of the present invention will now be described with reference to the following figures, wherein:

Figures 1a-1c show a perspective view, top plan view and a side view of part of a filter apparatus according to an embodiment of the present invention respectively; and

Figure 2 is a perspective view of part of filter apparatus according to a further embodiment of the present invention.

[0080] Referring firstly to figures 1a-1c, there is illustrated part of filter apparatus 2 comprising a filter housing 4 having a plurality of resonant cavities defined therein (only two resonant cavities 6, 8 are shown in the drawings for clarity purposes). The filter housing 4 and resonant cavities are formed from electrically conductive material or have an outer electrical conductive coating provided thereon.

[0081] Each resonant cavity 6, 8 is defined between a base 10 and side walls 12 within the filter housing 4. An opening 14 is provided at the top of the cavity and is typically covered by a lid (not shown) when the filter apparatus 2 is fully assembled to close the cavity 6, 8 in use.

[0082] An aperture or iris 16 is defined in the side wall 12 between adjacent resonant cavities 6, 8 to provide fluid communication between the resonant cavities 6, 8.

[0083] A resonator 18, 18' is provided in each resonant cavity 6, 8. Each resonator 18, 18' includes a first resonator portion in the form of a hollow upright post 20 and a second resonator portion 22 in the form of an outwardly extending skirt. More particularly, the post 20 has a first end 24 located on base 10 and a second end 26 opposite and a spaced distance apart from first end 24. The second end 26 is arranged to be adjacent to but a spaced distance apart from a lid that is fitted over the resonant cavity in use.

[0084] In the illustrations, the post 20 is shown to comprise two parts 20a and 20b, which are joined together

via a fixing screw 28. The part 20a is integrally formed with the resonant cavity. However, it will be appreciated that the post 20 could be a single integral member or could include more than 2 parts joined together. The post 20 could also be joined directly to the base 10 of the resonant cavity via any suitable means, such as via solder, welding, adhesive, one or more screws, inter-engaging members, push fit connection and/or the like.

[0085] At least part 20b of post 20 is hollow to allow the fixing screw 28 to be inserted therethrough via an opening 30 provided at the second end 26 of post 20. However, the post 20 could be hollow along its entire length or the post could be solid. The opening 30 in the second end 26 of the resonator may also not be provided in some embodiments.

[0086] The second resonator portion 22 is integrally formed with the first resonator portion at the second end 26 of the first resonator portion. The second resonator portion 22 includes a first section 32 and a second section 34. The first section 32 extends transversally from the second end 26 of the post 20 to create a top surface of the resonator 18, 18'. In the illustrations, the first section 32 is perpendicular to the post 20. The second section 34 protrudes outwardly from and extends transversally to the first section 32. The second section 34 points towards the first end 24 of the post 20. In the illustrations, the second section 34 is perpendicular to the first section 32 and is parallel to the post 20. Thus, the second section 34 provides a skirt to the second resonator portion 20.

[0087] Thus, the combination of the first resonator portion 20 and the second resonator portion 22 provides a mushroom shaped resonator. The top of the resonator folds back on itself to create an inverted U-shaped channel, the opening of which faces towards the base of the resonant cavity. It is known to provide mushroom shaped resonators. However, in accordance with the present invention, an aperture 36 is defined in the second part 34 or skirt of the resonator 18, 18'. The aperture 36 in the resonator is aligned with the iris 16 defined between two adjacent resonant cavities 18, 18'. This provides a line of sight between the first upright posts 20 of the adjacent resonators 18, 18', thereby allowing an area between the adjacent resonators unhindered by the presence of any walls or shields to the electromagnetic fields created by the resonators to allow the electromagnetic fields of the two adjacent resonators to interact with each other. This increases the electromagnetic coupling between the adjacent resonators 18, 18' and allows an increased bandwidth to be provided by the resulting filter apparatus in which the resonators are located.

[0088] Each of the resonators 18, 18' can be provided with two apertures 36 on opposite sides of the resonators to allow electromagnetic coupling of each resonators with adjacent resonators on both sides of the same. It will be appreciated that the apertures 36 do not have to be directly opposite to each other and the position of the apertures 36 typically depend on the location of the iris 16 of the adjacent resonant cavity.

[0089] In the illustrations, the first part 32 of the resonators 18, 18' are shown with apertures 38 defined therein. These apertures 38 are to help with positioning and/or connecting the resonator in the resonant cavity in use. However, the apertures 38 are not essential to the invention and the first part 32 of the resonator 18, 18' could be provided as a continuous surface without any apertures defined therein. The apertures 38 are preferably distinct and separate to the apertures 36 of the second resonator portion.

[0090] In the illustrations, it is also noted that the first part 32 of the resonators 18, 18' appears to be circular in top plan view with minor segments of the circle cut off by a chord in the area immediately adjacent the apertures 36. This is typically arranged in this manner so as to fit the design of the filter housing. However, the first part 32 of the resonator in top plan view can be any shape, such as square, hexagonal, circular and/or the like.

[0091] Although only two resonators are shown for clarity purposes. More than two resonators could be coupled together to provide the filter apparatus.

[0092] Thus, in one example, the coupling bandwidth that is possible using the present invention is 23Mhz compared to a coupling bandwidth of 10.7Mhz when using a mushroom resonator without a cut-out provided in the outer flange wall.

[0093] Referring to figure 2, there is illustrated part of filter apparatus 102 according to a further embodiment of the present invention.

[0094] In this embodiment, a first resonator 104 is provided in a first resonant cavity 106, a second resonator 108 is provided in a second resonant cavity 110, and a third resonator 112 is provided in a third resonant cavity 114.

[0095] The second resonator portion 116 of the first resonator 104 has a single aperture 118 in the outer side wall of the same.

[0096] The second resonator portion 120 of the second resonator 108 has an enlarged aperture 122 that extends over two outer side walls of the same and is L shaped.

[0097] The second resonator portion 124 of the third resonator 112 has a single aperture 126 in the outer side walls of the same.

[0098] Iris 130 is provided between the first and second resonant cavities 106, 110 and iris 132 is provided between the second and third resonant cavities 110, 114.

[0099] The L-shaped extended aperture 122 is in the line of sight or is aligned with both the aperture 118 of the first resonator 104 and the aperture 126 of the third aperture.

[0100] Thus, it is not essential for the present invention for every resonator to have two separate apertures in the second resonator portion or for the apertures in the second resonator portion to be provided opposite to each other.

Claims

1. Filter apparatus, said filter apparatus including a housing with two or more resonant cavities defined therein, each of said two or more resonant cavities having resonator means provided therein, each of said resonator means having a first resonator portion and a second resonator portion, a first end of the first resonator portion located on a wall of the resonant cavity, the second resonator portion provided at a second end of the first resonator portion, the second resonator portion defining a channel or an inverted channel therein, an opening of the channel or inverted channel arranged to face towards the wall of the resonant cavity on which the first end of the first resonator portion is located, **characterised in that** an outer wall of the second resonator portion has an aperture, slot or cut-out defined therein. 5
2. Filter apparatus according to claim 1 wherein two or more apertures, slots or cut outs are defined on an outer wall or walls of the second resonator portion, and said two or more apertures, slots or cut outs are provided a spaced distance apart from each other and/or are arranged to be opposite each other on the second resonator portion. 10 20 25
3. Filter apparatus according to claim 1 wherein the aperture, slot or cut out is defined on or extends over two or more outer walls of the second resonator portion. 30
4. Filter apparatus according to claim 1 wherein the aperture, slot or cut out is open to a free peripheral edge of the outer wall of the second resonator portion. 35
5. Filter apparatus according to claim 1 wherein the aperture, slot or cut out is located within the outer wall of the second resonator portion and is not open to a free peripheral edge of the second resonator portion. 40
6. Filter apparatus according to claim 1 wherein the wall of the resonant cavity on which the first resonator portion of the resonator means is located is a base or electrical ground plane of the resonant cavity. 45
7. Filter apparatus according to claim 1 wherein the first resonator portion of the resonator means is in the form of an upright post, a vertical post, a rod or body. 50
8. Filter apparatus according to claim 1 wherein the first resonator portion of the resonator means consists of a single integral member or includes two or more members joined together. 55
9. Filter apparatus according to claim 1 wherein the resonator means, the first resonator portion and/or the second resonator portion are hollow, substantially hollow or have a hollow section defined therein.
10. Filter apparatus according to claim 1 wherein the outer wall of the second resonator portion in which the aperture, cut out or slot is defined is parallel or substantially parallel to the first resonator portion.
11. Filter apparatus according to claim 1 wherein the second resonator portion includes a first wall section and a second wall section; the first wall section forming a top of the resonator means and the second wall section forming the outer wall or a skirt of the resonator means.
12. Filter apparatus according to claim 1 wherein one or more tuning screws or tuning means are provided on or associated with the resonator means and/or a lid or cover of the resonant cavity for tuning the resonant frequency of the resonator means in use.
13. Filter apparatus according to claim 12 wherein at least part of the tuning screw or tuning means is arranged to move towards or away from the second end of the first resonator portion in use, is arranged to be located at least partly within a hollow part of the first resonator portion or the second end of the first resonator portion, and/or is arranged to move within and/or relative to a channel or hollow part defined in the first resonator portion.
14. Filter apparatus according to claim 1 wherein a wall or walls between two adjacent resonant cavities has an aperture or iris defined therein and the aperture, cut out or slot of the second resonator portion is aligned, substantially aligned or at least partially aligned with the aperture or iris of the adjacent resonant cavities.
15. A method of using filter apparatus, said filter apparatus including a housing with two or more resonant cavities defined therein, said method including the steps of providing each of said two or more resonant cavities with resonator means therein, each of said resonator means having a first resonator portion and a second resonator portion, locating a first end of the first resonator portion on a wall of the resonant cavity, providing the second resonator portion at a second end of the first resonator portion, the second resonator portion defining a channel or an inverted channel therein, arranging the second resonator portion so that an opening of the channel or inverted channel faces towards the wall of the resonant cavity on which the first end of the first resonator portion has been located, **characterised in that** an outer wall of the second resonator portion has an aperture, slot or cut-out defined therein.

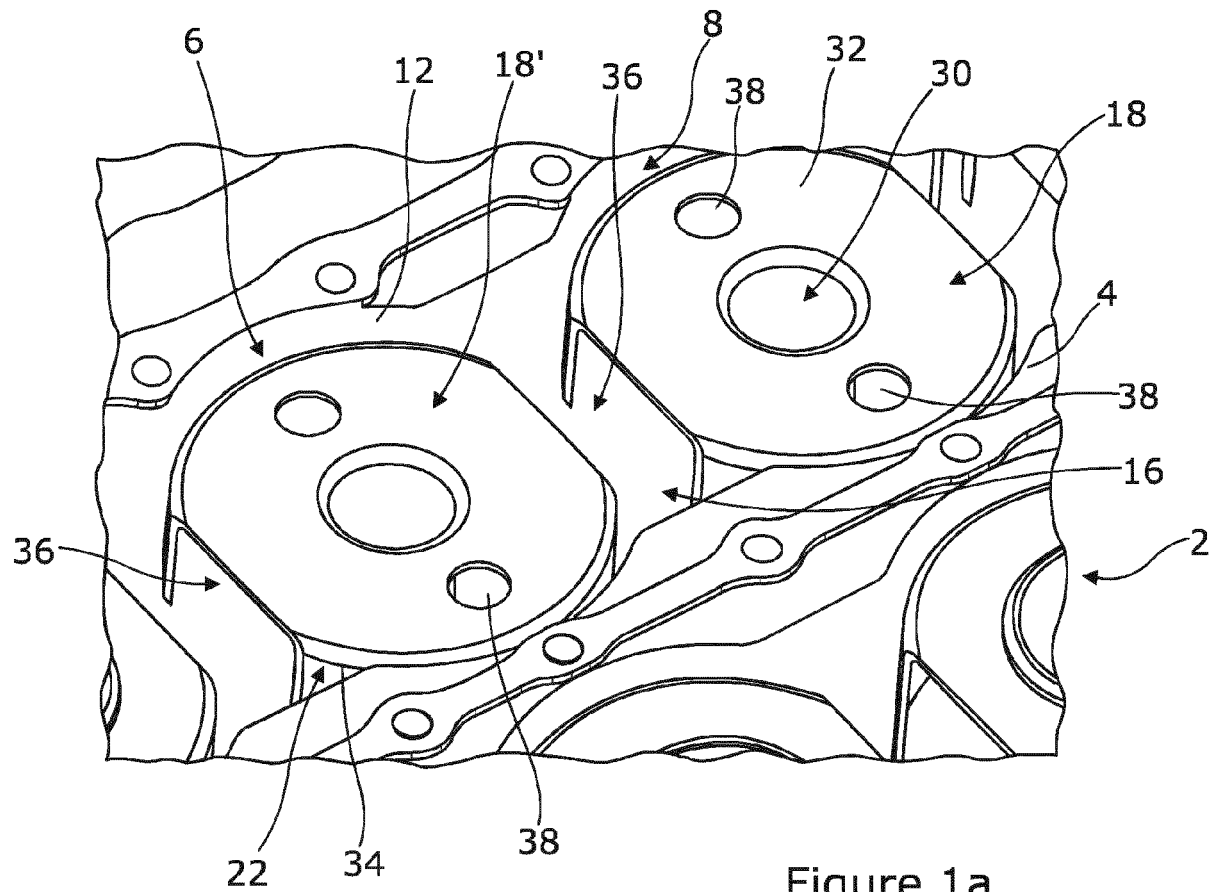


Figure 1a

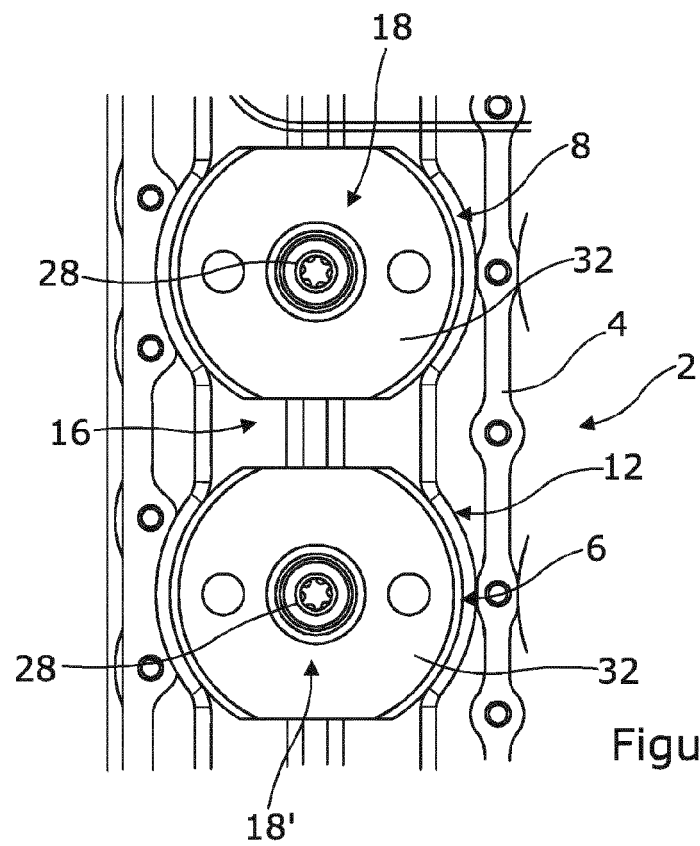


Figure 1b

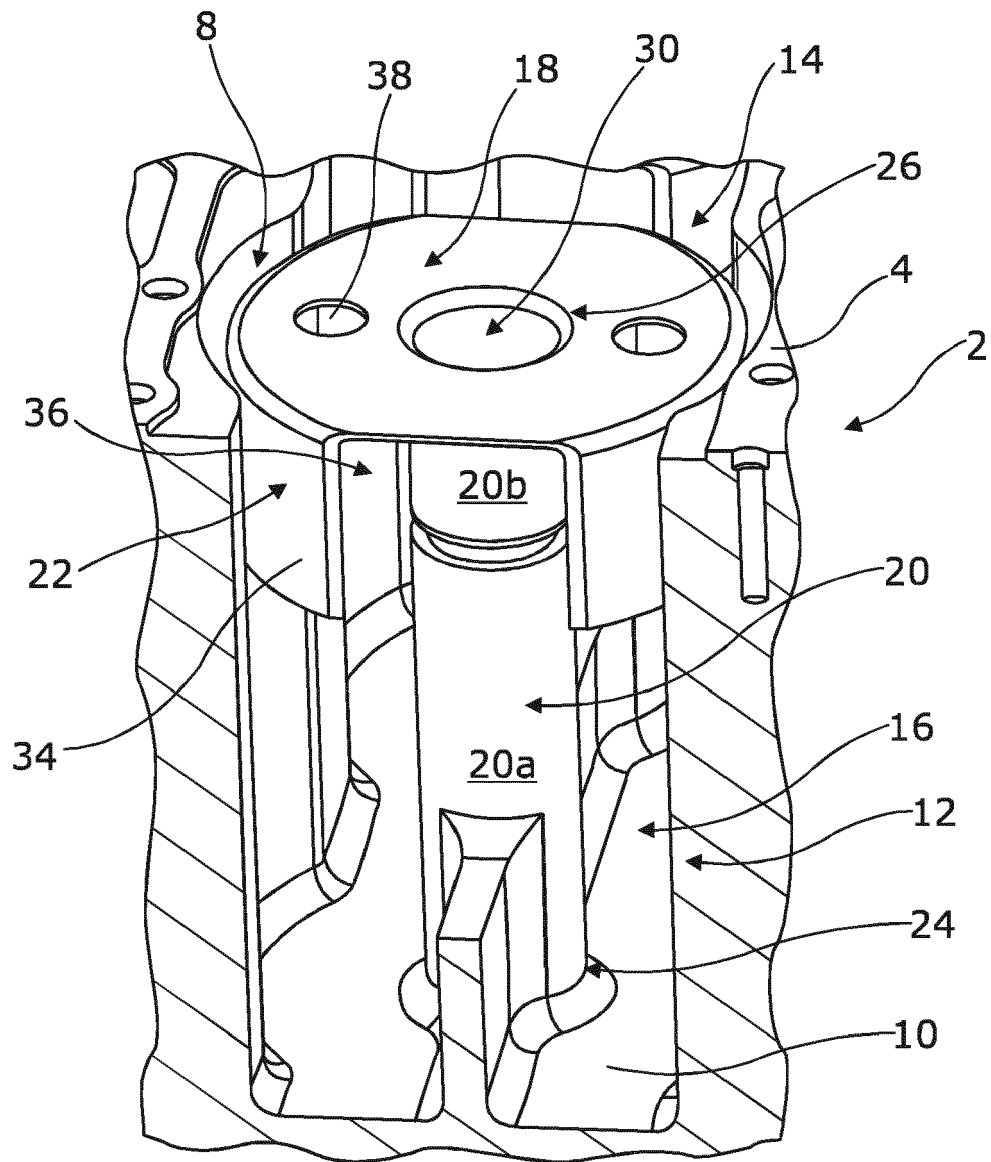


Figure 1c

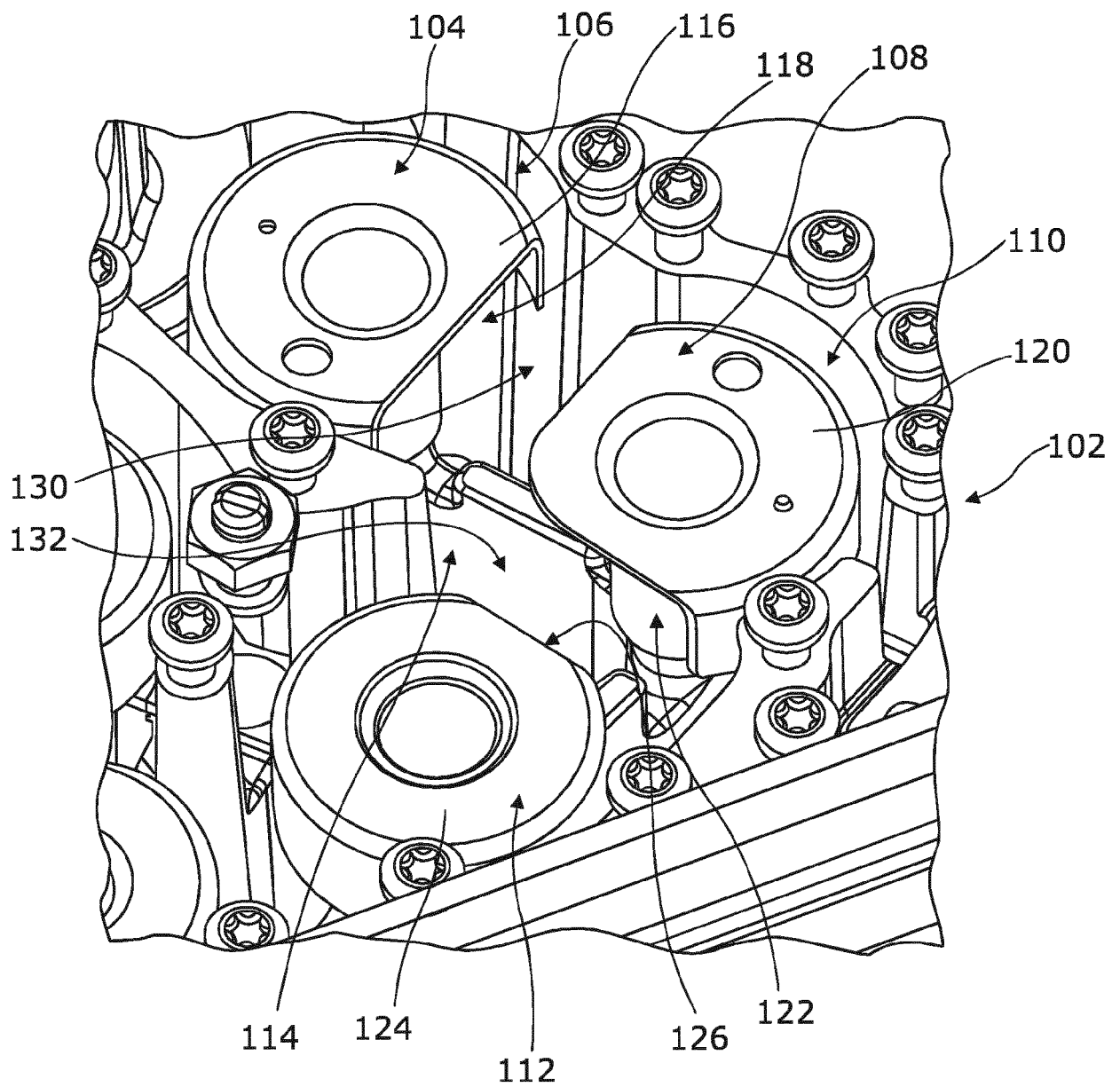


Figure 2



EUROPEAN SEARCH REPORT

Application Number
EP 20 27 5072

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 3 September 2020	Examiner Hueso González, J
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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