(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 312 011 A2**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 88116936.1

(51) Int. Cl.4: H01P 1/205

(22) Date of filing: 12.10.88

(30) Priority: 15.10.87 JP 261072/87

(43) Date of publication of application: 19.04.89 Bulletin 89/16

(84) Designated Contracting States: DE FR SE

(71) Applicant: MURATA MANUFACTURING CO., LTD.
26-10, Tenjin 2-chome
Nagaokakyo-shi Kyoto-fu(JP)

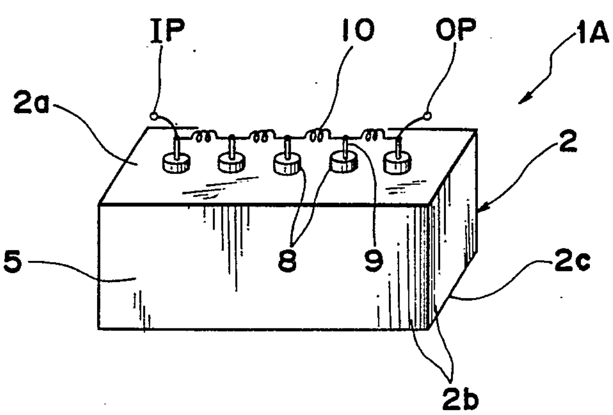
(72) Inventor: Yorita, Tadahiro
1-1, Yokogawa
Kanazawa-shi Ishikawa-ken(JP)

(74) Representative: Glawe, Delfs, Moll & Partner
Patentanwälte
Postfach 26 01 62 Liebherrstrasse 20
D-8000 München 26(DE)

(54) Dielectric filter.

(57) A dielectric filter which functions as a band elimination filter for attenuating only a signal of a particular frequency region, and includes a dielectric block formed with a plurality of through-bores in it in a parallel relation to each other, inner-conductor layers respectively formed within the through-bores, an outer-conductor layer formed at least on an outer side face of the dielectric block, so as to constitute a plurality of resonators, coupling members respectively disposed within the through-bores for capacitive coupling with the inner conductor layers, and a concentrated constant line respectively connecting neighboring ones of the coupling members.

Fig. 1



EP 0 312 011 A2

DIELECTRIC FILTER

BACKGROUND OF THE INVENTION

The present invention generally relates to an electrical filter, and more particularly, to a dielectric filter which functions as a band elimination filter, and is especially so arranged to be compact in an external size and capable of achieving a low cost through simplification of the manufacturing process.

Conventionally, there has been provided a filter as shown in Figs. 8 and 9 for a dielectric filter which functions as a band elimination filter for attenuating only a signal in a specific frequency region. In Figs. 8 and 9, the dielectric filter 30 comprises a plurality of resonators 35 disposed side by side and each including a cylindrical member 31 of a ceramic material formed with a through-bore 32 extending therethrough along its axis, an inner-conductor layer 33 formed within the through-bore 32 and an outer conductor layer 34 formed over an outer peripheral surface of the cylindrical member 31 except for its end face 31a at an open end side thereof, a capacitor 36 constituted by forming electrode films on opposite main faces of a ceramic disc, and electrically connected to the end face 31a side at the open end of the through-bore 32 of each resonator 35, and a coaxial cable 37 having an electrical length of λ/4 wavelength, provided to connect the neighboring resonators 35 to each other thorugh said capacitors 36.

However, sicne the conventional dielectric filter 30 as described above adopts a construction is which the resonators 35 are connected to each other by the coaxial cable 37 having the length at λ/4 wavelength, i.e. through couping by a so-called distribution constant line, there is such a problem that the external size of the dielectric filter 30 inevitably increases by the length of said coaxial cable 37. Moreover, due to the fact that there is involved in its manufacture, such a complicated work that the single unit of the resonator 35 is prepared in a pluarlity of pieces so as to be connected by the λ/4 transmission line, troublesome procedures are required by that extent, with a consequent rise in the manufacturing cost.

SUMMARY OF THE INVENTION

Accordingly, an essential object of the present invention is to provide an improved dielectric filter which is capable of decreasing an external size thereof, with a simultaneous reduction of cost through simplification in the manufacturing process.

Another object of the present invention is to provide a dielectric filter of the above described type which is simple in construction and stable in functioning at high reliability.

In accomplishing these and other objects, according to one preferred embodiment of the present invention, there is provided a dielectric filter which functions as a band elimination filter for attenuating only a signal of a particular frequency region, and comprises a dielectric block formed with a plurality of through-bores therein in a parallel relation to each other, inner-conductor layers respectively formed within said through-bores, and outer-conductor layer formed at least on an outer side face of said dielectric block, thereby to constitute a plurality of resonators, coupling members respectively disposed within said through-bores for capacitor coupling with said inner conductor layers, and a concentrated constant line respectively connecting neighboring ones of said coupling members.

For the concentrated constant line as referred to above, for example, air-core coils, pattern forming coils, etc. may be employed, while the capacitor coupling can be realized, for example, by inserting a metallic pin in an axial direction of a resinous pin forced into each of said through-bores.

In the dielectric filter according to the present invention as described above, since the respective resonators are connected through the concentrated constant line, the length for connection between said resonators may be shortened to a large extent, while the respective resonators conventionally disposed as single units through intervals equivalent to λ/4 wavelength therebetween, may be formed by one block member for reduction of the external size by that extent.

Furthermore, owing to the concentrated constant arrangement, the troublesome work conventionally required to be effected by maintaining a required length of the line for connecting the resonators at high accuracy can be simplified, and moreover, since it is not necessary to prepare a plurality of individual resonators, labor and the number of parts during manufacture can be reduced to a large extent, thereby to decrease the cost by that extent for improvement of productivity.

Subsequently, the reason why the conventional distribution constant line may be replaced by the concentrated constant line in the above band elimination filter will be explained.

Reference is made to equivalent circuit diagrams shown in Figs. 6(a), 6(b), 6(c), 6(d), 6(e), 6(f), 6(g), 6(h), and 6(i) for explaining the course through which the present invention was realized.

In the first place, the λ/4 wavelength transmission line may be replaced by the concentrated constant of a coil L and capacitors C under the conditions as follows at a certain frequency f (Figs. 6(a), 6(b)).

$\omega L = Za \cdot \sin\theta$

$\omega C = (1/Za) \tan\theta/2$

where Za: Characteristic impedance of the line,

θ : Electrical angle of the line,

$\omega = 2\pi f$.

For example, upon setting as f = 400Mhz, Za = 50 , and $\theta = 90^\circ$,

$L = (Za/2\pi \cdot f) \sin\theta = 50/(2 \cdot \pi \cdot 400 \times 10^6) \times 1 = 1.99 \times 10^{-8}$ [H]

$C = (1/2\pi \cdot f \cdot Za) \tan\theta/2 = 1/(2\pi \cdot 400 \times 10^6 \times 50) \times 1 = 7.958 \times 10^{-12}$ [F]

Accordingly, the above transmission line may be converted as shown in Figs. 6(c) to 6(d).

Here, upon consideration of the resonator as an L-C parallel resonance circuit, the circuit shown in Fig. 6(d) can be converted into the equivalent circuit as shown in Fig. 6(e).

Meanwhile, in Fig. 6(e), when Y-Δ conversion is effected by $C\text{-}C'\text{-}Ce$ ($2C\text{-}C'\text{-}Ce$), the equivalent circuits as shown in Figs. 6(f) to 6(h) are obtained.

Thus, the relations will be:

$C_1 = (CC' + C'Ce + CeC)/C'$

$C_2 = (CC' + C'Ce + CeC)/Ce$

$C_3 = (CC' + C'Ce + CeC)/C$

$L'' = L' - (1/\omega^2 C_3)$

Therefore, the relation will be represented by the equivalent circuit as shown in Fig. 6(i), and consequently, the distribution constant line will be replaced by the concentrated constant line.

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 schematic perspective view showing a dielectric filter according to one preferred embodiment of the present invention,

Fig. 2 is a fragmentary side sectional view of the dielectric filter of Fig. 1,

Fig. 3(a) is a fragmentary perspective view of the dielectric filter of Fig. 1 further provided with reactance elements,

Fig. 3(b) is an equivalent circuit of the dielectric filter of Fig. 3(a),

Fig. 4(a) is a fragmentary top plan view showing a dielectric filter according to a modification of the embodiment of Fig. 1,

Fig. 4(b) is a fragmentary side elevational view of the modification of Fig. 4(a),

Fig. 5 is a fragmentary side sectional view of a dielectric filter according to a further modification of the embodiment of Fig. 1,

Figs. 6(a) through 6(i) are equivalent circuit diagrams for explaining the course through which the present invention was realized (already referred to),

Fig 7 is a perspective view showing one example in which the dielectric filter in the above embodiment and a band pass filter are constituted as one unit,

Fig. 8 is an equivalent circuit diagram showing construction of a conventional dielectric filter (already referred to), and

Fig. 9 is a fragmentary perspective view partly in section, showing the conventional dielectric filter of Fig. 8 (already referred to).

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.

Referring now to the drawings, there is shown in Figs. 1 and 2, a dielectric filter 1A which functions as a band elimination filter according to one preferred embodiment of the present invention, which generally includes a dielectric block 2 of a ceramic material in cubic rectangular box-like configuration and formed therein with, for example, five through-bores 3 through a predetermined interval therebetween and in a parallel relation to each other, an inner conductor layer 4 formed on the inner peripheral face of each of said through-bores 3, an outer conductor layer 5 formed on four side walls 2b of said dielectric block 2 except for an end face 2a at an open end side (i.e. upper face 2a in Fig. 1), a short-circuiting conductive layer 6 formed on a bottom face 2c of said dielectric block 2 for short-circuiting between the outer conductor layer 5 and the inner conductor layers 4 for generating a resonance mode of λ/4 wavelength, thereby to constitute five resonators 7, a resinous pin 8 forced into each of said through-bores 3 at the end face 2a on the open end side of the block 2, a metallic pin 9 inserted into the center of each resinous pin 8 in its axial direction as a coupling member for capacitive coupling with the inner conductor layer 4, with the upper end of said metallic pin 9 projecting upwardly from the open end face 2a to a certain extent, and air-core coils 10 as a concentrated constant line for connecting neighboring ones of said metallic pins 9 as illustrated (in Fig. 1, IP indicates a circuit symbol showing an input terminal and OP represents a circuit symbol showing an output terminal).

Subsequently, the function and effect of the dielectric filter 1A in the embodiment of the present invention as described above will be explained.

Since the dielectric filter 1A of the present embodiment functions as a band elimination filter for attenuating only the signal in the particular frequency region, it may be employed, for example, for an antenna duplexer, filter diplexer, etc., in which more than two filters 1A are combined.

As described above, according to the dielectric filter of the present embodiment, since the resonators 7 neighboring each other are connected by the air-core coil 10 through the metallic pins 9, i.e. since the distribution constant line is replaced by the concentrated constant line, the conventional construction in which a plurality of single resonators are arranged side by side, may be accommodated in one block, and thus, the connecting length between the resonators 7 may be remarkably reduced as compared with that in the conventional transmission line, thereby reducing the size of the filter by that extent.

Moreover, since the troublesome connecting work conventionally required for achieving the electrical length of λ/4 may be omitted for facilitation of the connecting procedure, and furthermore, only one block may be prepared for the filter, the process during manufacture can be simplified so as to reduce the cost by that degree, with a consequent improvement of productivity.

It is to be noted here that, in the dielectric filter 1A as described so far, although the capacity component to be produced by the replacement of the transmission line with the concentrated constant, may be absorbed by the resonators, this is limited to a theoretical assumption, and in the actual practice, such capacity component can not necessarily be absorbed entirely.

Therefore, in a modified dielectric filter 1B as shown in Figs. 3(a) and 3(b), a reactance element Z is connected between a junction of the metallic pin 9 and the air-core coil 10 and the outer conductor layer 5 for fine adjustment of the filter characteristics. In the above case, such reactance element Z may be added to all of the connecting portions or to the connecting portions arbitrarily selected, and the reactive element of a capacitive nature or inductive nature may be provided singly or in combination.

Additionally, in the dielectric filter 1A in Fig. 1, there is a case where a fringing capacity is generated at the open side end face 2a of the inner conductor layer 4 of the resonator 7, thereby to produce a capacitive coupling between the neighboring resonators 7, which may be, however, advantageously absorbed through variation of the value for the air-core coil 10.

It should also be noted here that, in the foregoing embodiment, although the case where the air-core coils 10 are employed for the concentrated constant line, is described as one example, the arrangement may be, for example, so modified as in a modification 1C in Figs. 4(a) and 4(b) in which the air-core coils 10 are replaced by a coil line pattern plate CL, which includes an insulative substrate 15, and a coil line pattern 16 formed thereon. For attachment onto the block 2, the substrate 15 with the coil line pattern 16 is applied onto the metallic pins 9 through corresponding holes formed in the substrate 15, and the pins 9 and the coil line pattern 16 are connected by soldering for fixing. in this case also, effects similar to those in the foregoing embodiment may be obtained.

furthermore, the metallic pin 9 described as employed in the foregoing embodiment for the capacitor coupling member, may be replaced by a capacitor member 13 constituted by forming electrode layers 12 on opposite main faces of a cylindrical ceramic member 11 as shown in a further modification 1D in Fig. 5. In this case, a cylindrical metallic capacitor base 14 is inserted into the through-bore 3 instead of the resinous pin 8, and the lower face of said capacitor member 13 is connected to the upper face of said capacitor base 14, while the air-core coil 10 is connected to the electrode layer 12 on the upper face of said capacitor member 13.

It may further be so arranged to connect the dielectric filter of the foregoing embodiment in series with other filter, so as to accommodate such series-connected filters in a casing for application as a shared unit, or to form a conventional band-pass filter 21 and the dielectric filter 1 in the foregoing embodiment into one unit in a single dielectric block 20 as shown in Fig. 7.

It should further be noted that, in the foregoing embodiment, although the λ/4 wavelength resonator is taken up as one example, the present invention is also applicable to a λ/2 wavelength resonator as well.

As is clear from the foregoing description, according to the dielectric filter of the present invention, the resonators are constituted by forming a plurality of through-bores in the dielectric block, and forming the inner conductor layers and the outer conductor layer within the through-bores and the outer side walls of the block respectively, while the neighboring resonators are connected to each other through the capacitor coupling members by the concentrated constant line, and therefore, not only the connecting length between the resonators can be reduced, but also a plurality of resonators are integrally formed in one block-member, with a consequent reduction of the filter size by that extent. Additionally, troublesome work while maintaining the predetermined electrical length may be dispensed with for saving labor during manufacture to a large extent, and also for decreasing of the number of parts involved, with a corresponding reduction in cost.

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 filter which functions as a band elimination filter for attenuating only a signal of a particular frequency region, said dielectric filter comprising a dielectric block formed with a plurality of through-bores therein in a parallel relation to each other, inner-conductor layers respectively formed within said through-bores, an outer-conductor layer formed at least on an outer side face of said dielectric block, thereby to constitute a plurality of resonators, a coupling means respectively disposed within said through-bores for capacitive coupling with said inner conductor layers, and a concentrated constant line means for respectively connecting neighboring ones of said coupling means.

2. A dielectric filter as claimed in Claim 1, wherein said coupling means includes metallic pins respectively inserted in an axial direction, into resinous pins forced into said through-bores.

3. A dielectric filter as claimed in Claim 1, wherein said coupling means includes capacitor members each constituted by forming electrode layers on opposite main faces of a cylindrical ceramic member, and connected at its under face, with an upper face of a cylindrical metallic capacitor base inserted in each of said through-bores.

4. A dielectric filter as claimed in Claim 1, wherein said concentrated constant line means includes air-core coils each connecting neighboring ones of said coupling means.

5. A dielectric filter as claimed in Claim 1, wherein said concentrated constant line means includes a coil line pattern plate constituted by an insulative substrate and a coil line pattern formed thereon so as to connect neighboring ones of said coupling means.

6. A dielectric filter as claimed in Claim 1, further including a reactance element means connected between junctions of said coupling means and said concentrated constant line means, and said outer conductor layer for fine adjustment of the filter characteristics.

Fig. 1

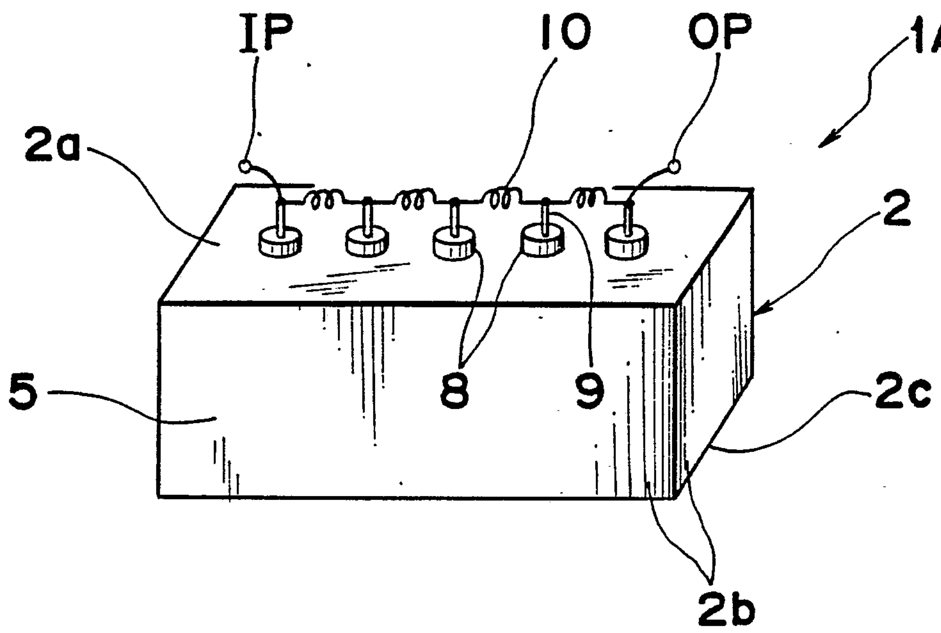


Fig. 2

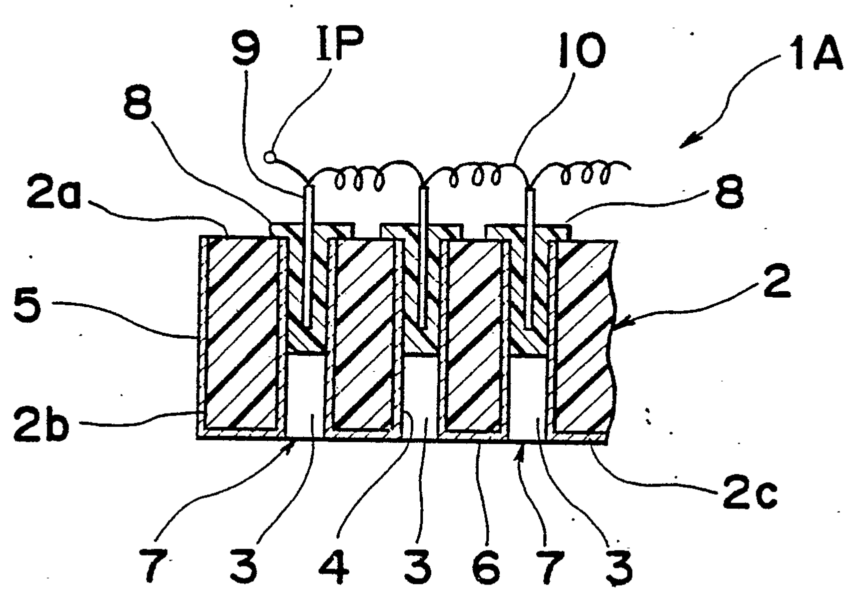


Fig. 3(a)

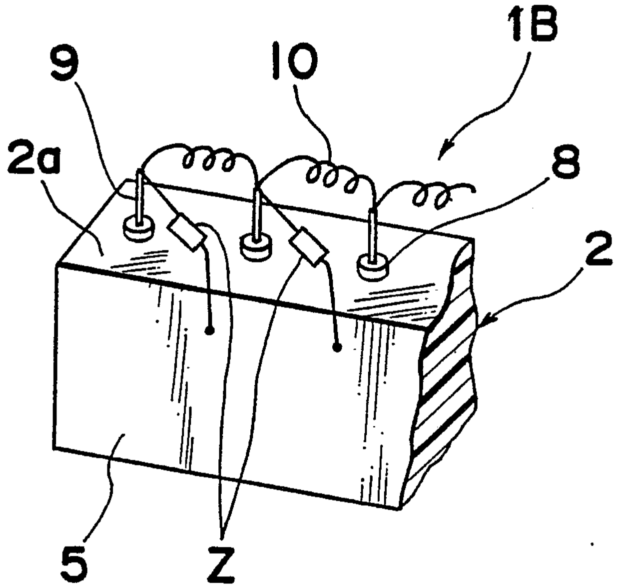


Fig. 3(b)

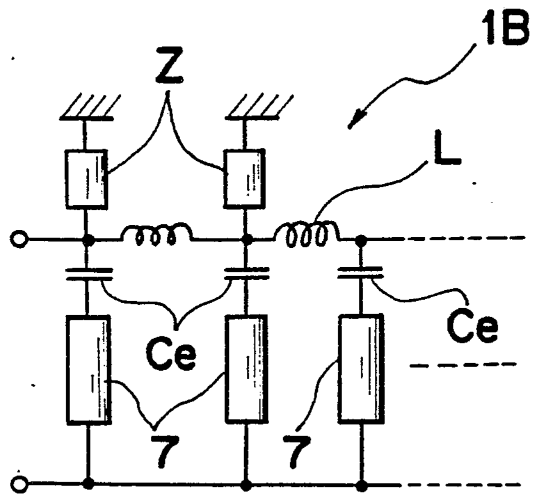


Fig. 4 (a)

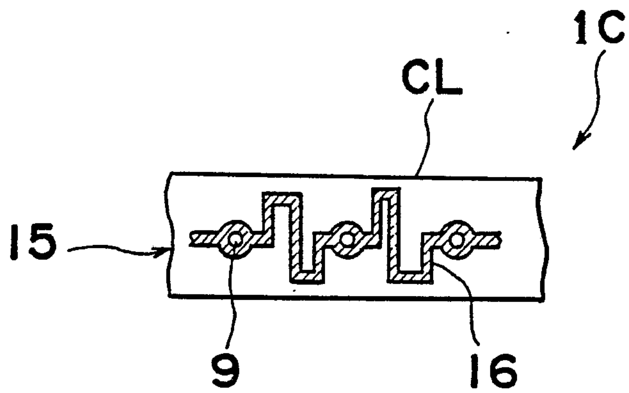


Fig. 5

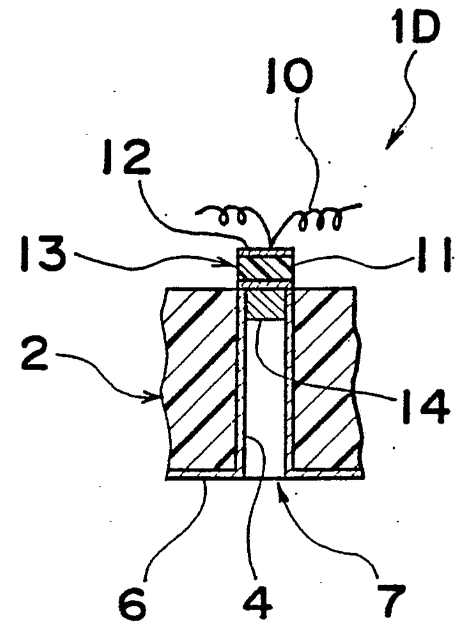


Fig. 4 (b)

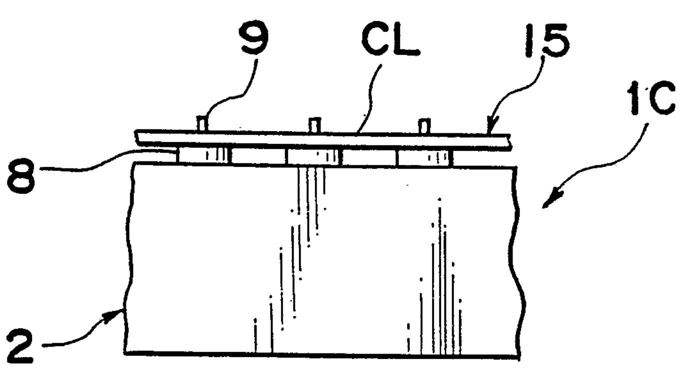


Fig. 6(a)

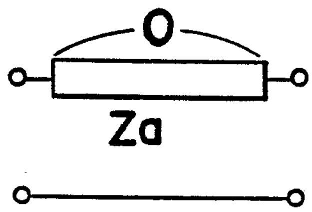


Fig. 6(b)

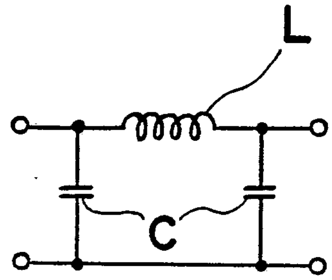


Fig. 6(c)

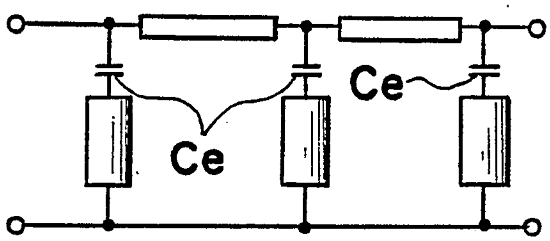


Fig. 6(d)

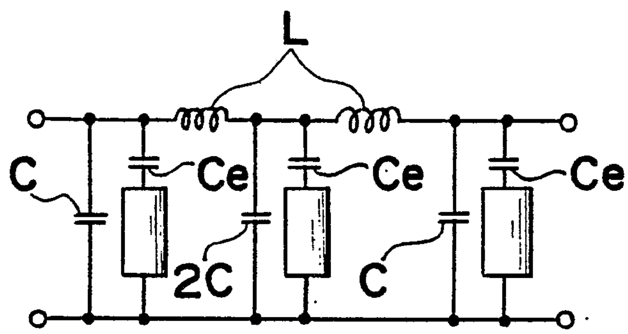


Fig. 6(e)

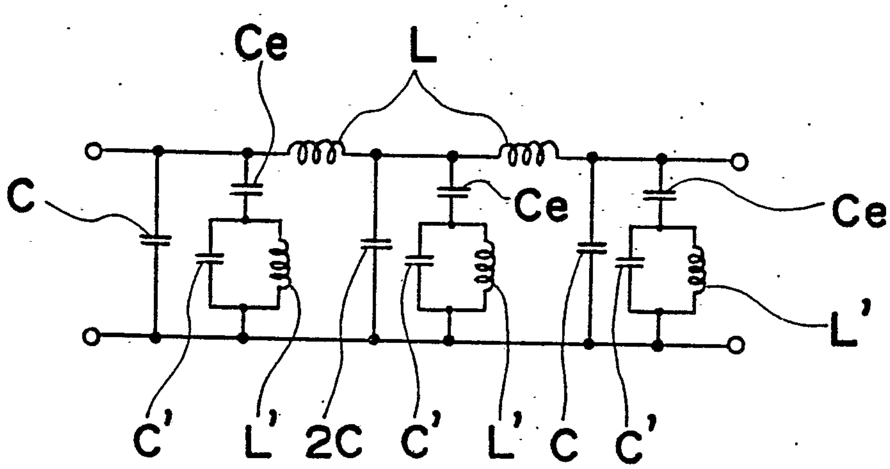


Fig. 6(f)

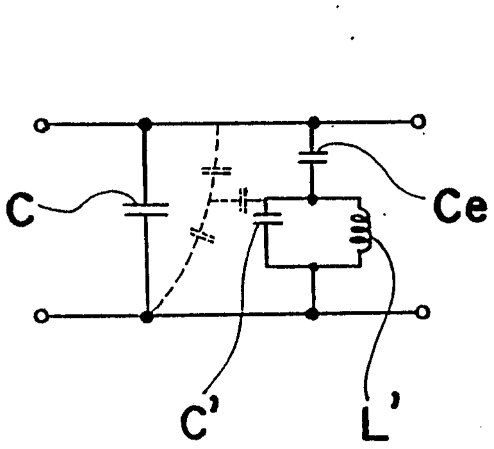


Fig. 6(g)

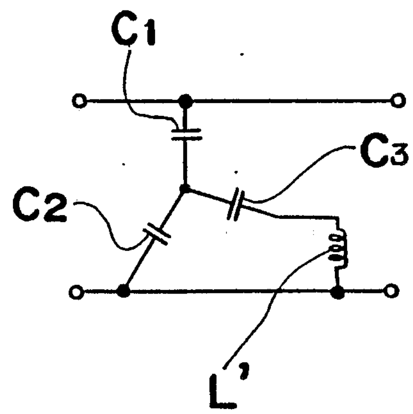


Fig. 6(h)

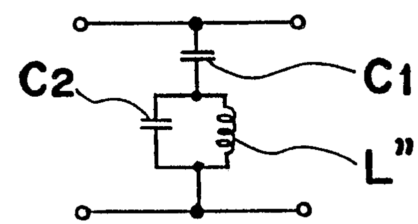


Fig. 6(i)

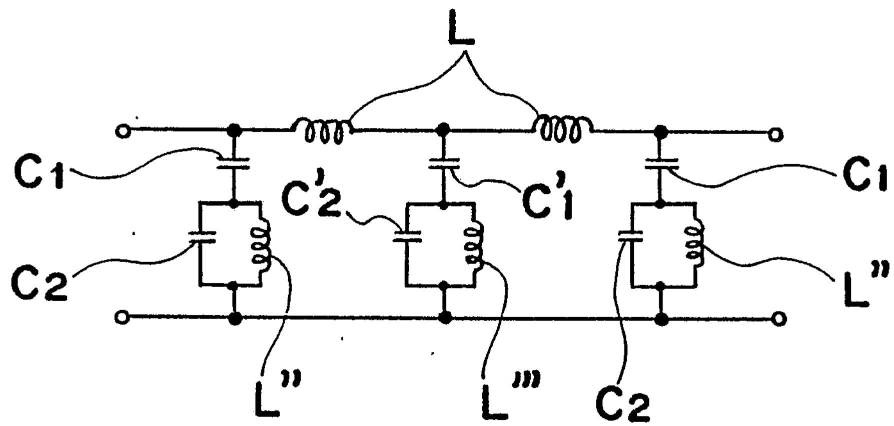


Fig. 7

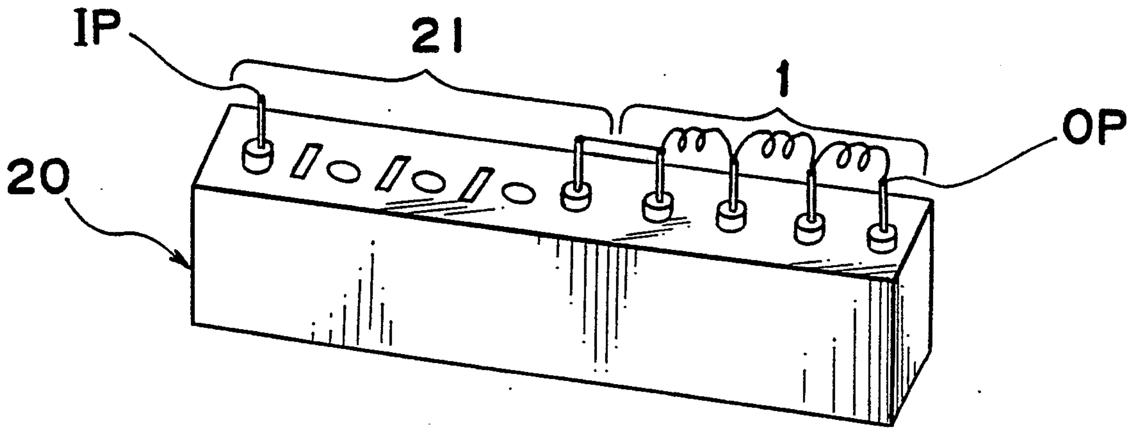


Fig. 8 PRIOR ART

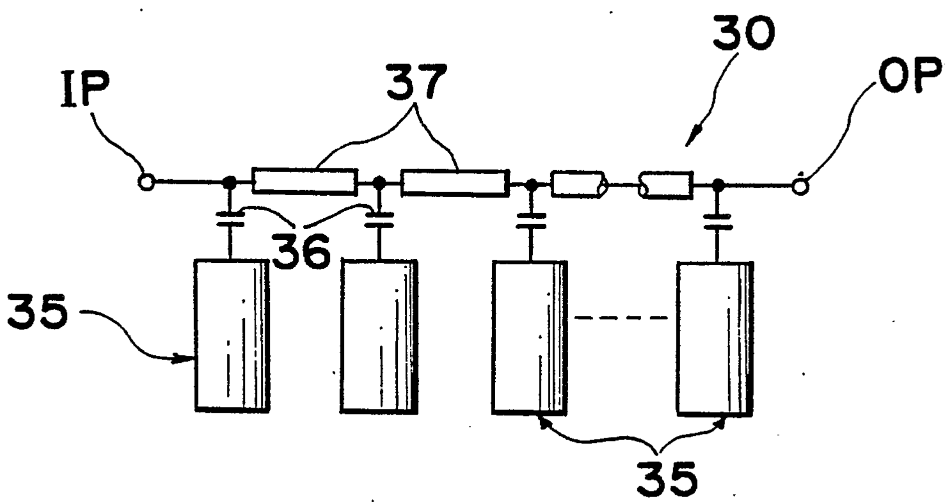


Fig. 9 PRIOR ART