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Hutchinson

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[54] HIGH FREQUENCY ELECTRICAL NETWORK WITH FREQUENCY DEPENDENT CHARACTERISTICS HAVING A CONSTANT INPUT RESISTANCE

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[52] **U.S. Cl.** .... **333/10;** 333/73 W
[51] **Int. Cl.** **H01p 5/14**
[58] **Field of Search** .... 333/83 R, 73 W, 10, 11

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Assistant Examiner—Wm. H. Punter
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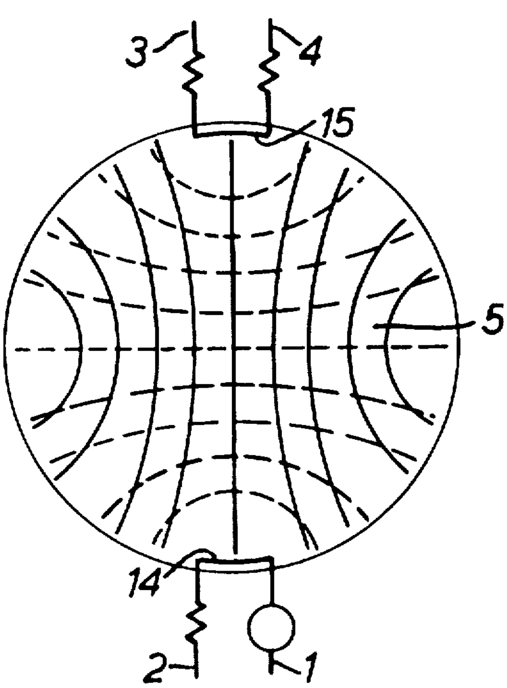
[57] **ABSTRACT**

A constant resistance network which exhibits frequency dependent characteristics consists of a cavity resonator having two coupling loops mounted transverse to the natural direction of propagation of resonant waves within the cavity. The network is less bulky and cheaper to produce than hitherto known equivalent networks.

10 Claims, 8 Drawing Figures



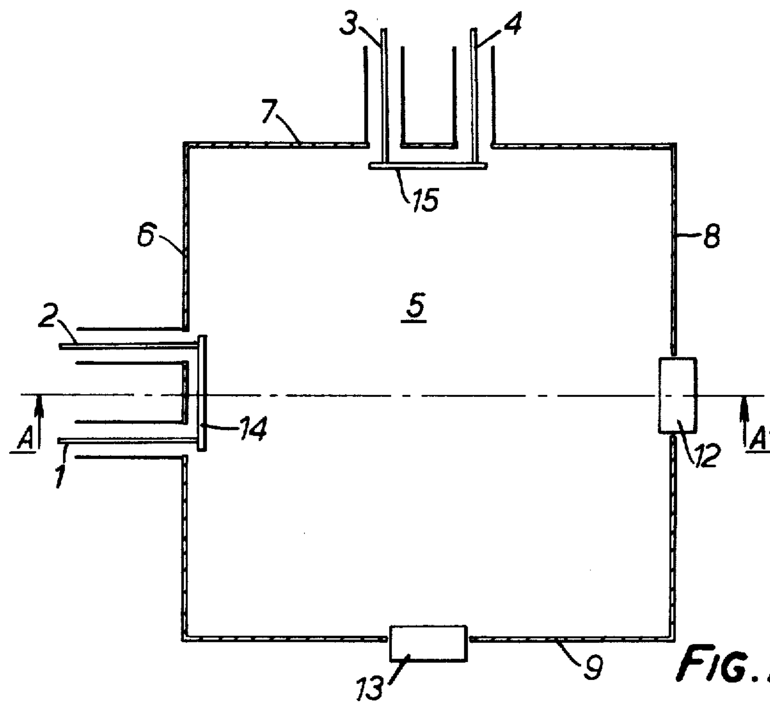


FIG. 1A.

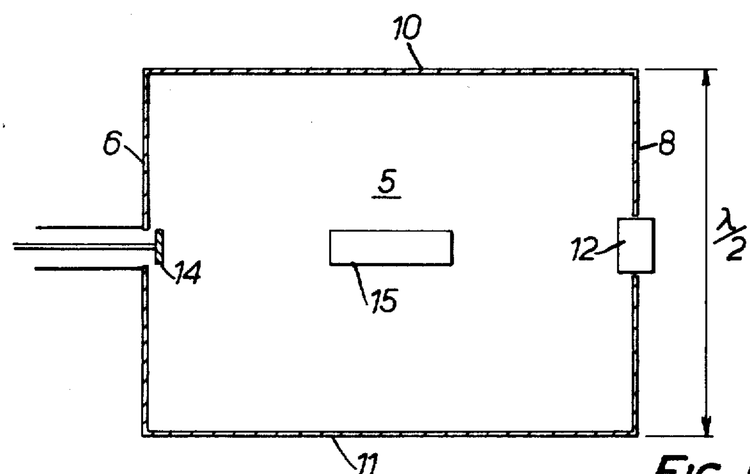


FIG. 1B.

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SHEET 2

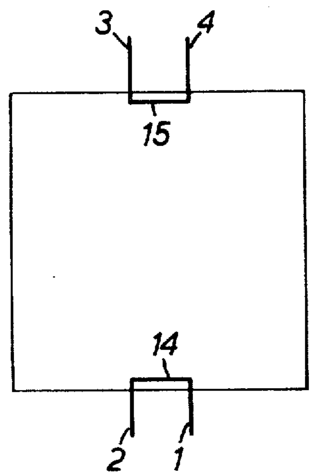

FIG. 2.

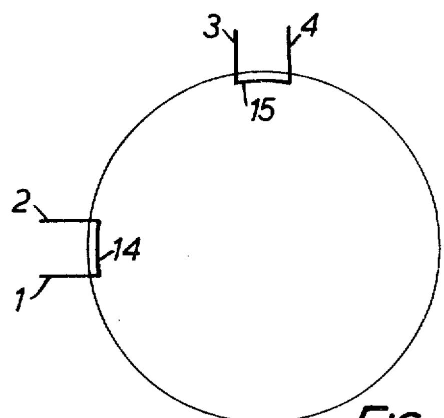

FIG. 3.

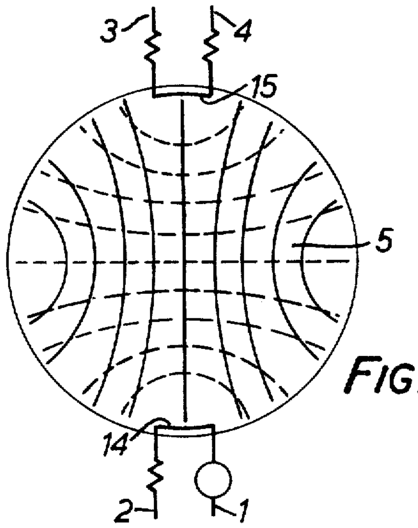

FIG. 4.

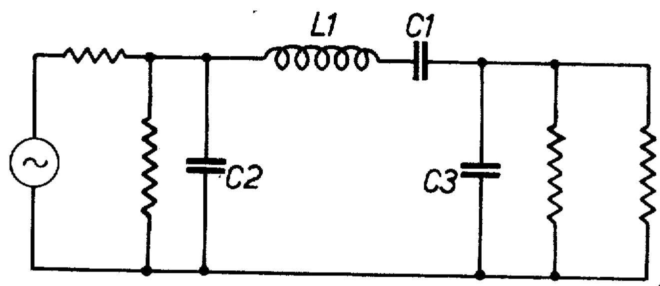

FIG. 5.

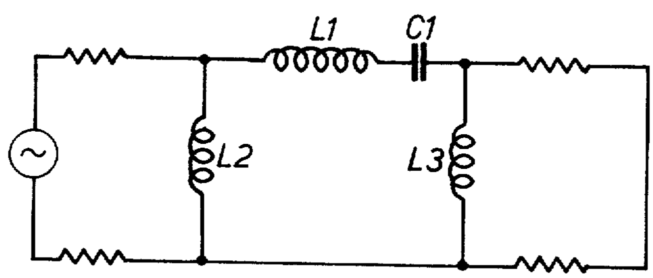

FIG. 6.

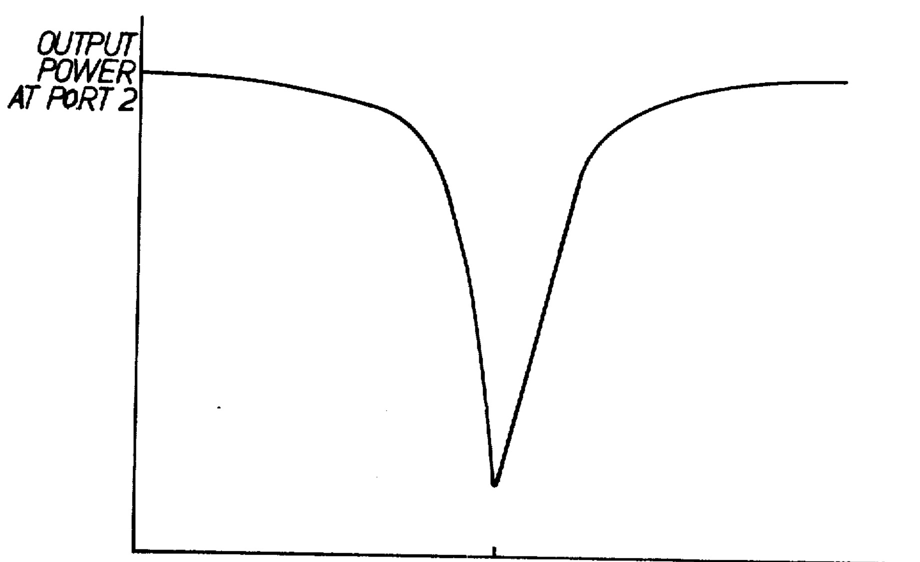

FIG. 7.

HIGH FREQUENCY ELECTRICAL NETWORK WITH FREQUENCY DEPENDENT CHARACTERISTICS HAVING A CONSTANT INPUT RESISTANCE

This invention relates to electrical networks for use at high frequencies, that is to say, frequencies of the order of 1 MHz and greater and more specifically to electrical networks exhibiting frequency dependent characteristics, e.g. filter networks. The invention is primarily applicable to so-called constant resistance circuits, that is to say, to circuits which ideally exhibit a constant input and/or output resistance which is independent of frequency and contains no reactive component. Circuits of this kind may be constructed of coaxial lines but the necessary inclusion within such circuits of diplexers results in a complex, bulky and expensive structure. Similarly circuits of this kind may instead be composed of waveguide structures. However, as is known, waveguides are particularly bulky and expensive items and the present invention seeks to provide an electrical network which is inherently simpler or less expensive to construct than previously known circuits of this kind.

According to this invention an electrical network exhibiting frequency dependent characteristics includes a cavity resonator and two coupling loops with each loop mounted adjacent the wall of the cavity so as to be electrically insulated therefrom with the two ends of each loop passing through the resonator wall for connection to the inner terminal of a different coaxial line and with each loop being transverse to the natural direction of propagation of resonant waves within the cavity.

Preferably each coupling loop comprises an electrically conductive member mounted substantially parallel to and spaced apart from the inner wall of the cavity.

Preferably again each conductive member comprises a thin sheet conductor.

Preferably the cavity comprises a short waveguide section each end of which is bounded by a flat electrical conductor. The cavity may have a circular or a square cross section.

Whilst the two loops may be mounted on a common axial line of the cavity, preferably they are displaced relative to one another around the perimeter of the cavity. Preferably again the two loops are so positioned around the perimeter of the cavity as to subtend approximately a right angle at the centre of the cavity. This positioning results in the least direct coupling between the two coupling loops.

Preferably the length of the cavity in the natural direction of wave propagation is approximately half a wavelength at the resonant frequency. In such a case preferable each loop is mounted approximately halfway along the length of the cavity in this direction, as this results in maximum coupling between the loop and the cavity.

The invention is further described, by way of example, with reference to the accompanying drawings in which:

FIGS. 1*a*, 1*b* and 2–4 represent diagrammatically circuits in accordance with the present invention, and

FIGS. 5 to 7 are explanatory diagrams.

Referring to FIG. 1 the upper drawing, labelled "FIG. 1A" consists of a plan sectional view of a circuit consisting of four ports **1**, **2**, **3**, **4**, and a cavity **5** to which the ports are coupled. Each of the ports **1**, **2**, **3** and **4** consists of a length of coaxial line. A sectional side view taken on the line AA^1 is shown in FIG. 1B. The cavity **5** consists of a short section of waveguide the wall of which comprises four wall portions **6**, **7**, **8** and **9** bounded by top and bottom end plates **10** and **11**. The length of the wall portions **6**, **7**, **8** and **9** determines the resonant frequency of the cavity in accordance with well known theory. The length of the cavity is equal to half the wavelength at the natural resonant frequency, the transverse dimensions of the waveguide section being greater than half the wavelength in order to support the required oscillation mode. In view of the practical difficulties of manufacturing a waveguide cavity to precisely the correct dimensions tuning plugs **12** and **13** are provided in adjacent walls **8** and **9** respectively. Each tuning plug consists of a flat ended conductor the flat end of which is movable into or out of the cavity at will. Additional tuning plugs may be provided if needed. Ports **1** and **2** are mounted on the wall portion **6** and are linked together by means of a coupler **14** consisting of a thin conductive sheet. Similarly ports **3** and **4** are mounted on the wall portion **7** and are provided with a coupler **15**. The couplers **14** and **15** are mounted parallel to but spaced apart from their respective walls **6** and **7**, so as not to make electrical contact therewith. The ends of each coupler are connected to the centre conductor of the coaxial line to form a coupling loop within the cavity. For normal operation each of the coaxial lines forming the ports **1**, **2**, **3**, and **4** is terminated with its characteristic impedance. It is not essential for the couplers **14** and **15** to be mounted in adjacent wall portions and FIG. **2** illustrates an alternative arrangement in which the couplers **14** and **15** are mounted on opposite wall portions. Instead of the cavity consisting of a short length of square sectioned waveguide it may consist of a circularly sectioned waveguide portion having a cylindrical wall. An example of this kind is shown in FIG. **3**, in which the couplers **14** and **15** are shown mounted at right angles to one another. FIG. **4** shows a further arrangement in which the couplers **14** and **15** are mounted opposite one another on a circularly sectioned waveguide.

FIG. **4** is also used to illustrate the mode of coupling between the four ports **1**, **2**, **3** and **4** and the cavity **5**. Port **1** is isolated from Port **3** and port **2** is isolated from port **4**. Power which is not at the resonant frequency of the cavity and which is fed into port **1** is normally delivered to port **2** and similarly power fed into port **3** is normally delivered to port **4**. However, when power is fed into port **1** at the resonant frequency of the cavity then power is delivered to port **4** and not to port **2**. Similarly, at the resonant frequency power fed into port **3** is delivered to port **2**. The behavior of the circuit may be explained in terms of the components of a circularly polarised waveguide mode. Referring to FIG. **4**, power fed into port **1** causes a voltage to appear between the coupler **14** and the cavity wall by virtue of the capacitance present between the coupler **14** and the wall. At resonance oscillations are set up within the cavity with the electric field normal to the plane of the coupler as is shown by the solid line of FIG. **4**. A voltage of equal magnitude is induced in the corresponding coupler **15** on the opposite side of the cavity. The equivalent circuit is shown in FIG. 5 in which inductance and the capacitance represent the reactance of the cavity **5**. The capacitances C2 and C3 respectively represent the capacitance between the couplers **14** and **15** with the cavity wall and C1 represents the remaining capacitance of the cavity. When the two couplers and the two terminating resistors are identical the circuit is symmetrical and the magnitudes of the voltages are equal. In a similar manner current flowing in the coupler **14** sets up oscillations within the cavity with the electric field in the plane of the coupler as represented by the broken line on FIG. **4.** The equivalent circuit is shown in FIG. **6,** in this case the couplers **14** and **15** being represented by inductances L2 and L3 respectively. The total inductance of the cavity is represented by the sum of inductances L1, L2 and L3. Again, when the two couplers and the terminating loads are identical the circuit is symmetrical and the magnitude of the voltages are equal. If the loops are terminated in resistive loads equal to the characteristic resistance it follows that the two oscillation modes are of equal magnitude and in time and space quadrature and that a circularly polarised field exists with the cavity with the resultant electric vector rotating about the axis of the cavity. From this it follows that the relative positions of the two couplers is not critical and that the circuit behaves as a directional coupler of varying sensitivity which is determined by the resonator characteristic. The circuits shown in FIGS. **1, 2** and **3** behave in identical fashion to that of FIG. **4,** the arrangements shown in FIGS. **1** and **3** being preferred however since in this arrangement direct coupling between the two couplers **14** and **15** is avoided and the only coupling between the two couplers **14** and **15** is via the induced circularly polarised field. This results in improved isolation between the two couplers at non-resonant frequencies. The network presents a constant resistance to ports **2** and **3,** the value of which is independent of the frequency applied to port **1** and which, when the couplers are correctly dimensioned, contains no reactive component.

When ports **2, 3** and **4** are terminated with their characteristic impedances and a source of variable frequency is applied to port **1** as represented symbolically in FIG. **4,** a transfer characteristic is obtained which is illustrated in FIG. **7.** The transfer characteristic shows the variation of output power at port **2** against frequency. At frequencies well below resonance the whole of the power applied to terminal **1** is passed to terminal **2,** the coupling within the cavity being negligible. As the frequency increases to the resonant frequency of the cavity (represented at R) whole of the energy is transferred to coupler **15** and is passed out to port **4.** No energy is passed to either of ports **2** or **3** under this condition. As the input frequency increases above resonant frequency the power fed to port **4** reduces until the whole of the power is again obtained at port **2.** By careful design and tuning of the cavity and coupling the sides of the slope of the transfer characteristic in the region of the resonant frequency R may be made very steep. This results in a circuit having a very high Q factor. The resonance frequency has a wavelength λ where $\lambda/2$ is the length of the resonant cavity **5,** as mentioned previously.

The invention is most advantageously applicable to the combination of two signals, for example, the combination of a vision carrier signal with the audio carrier signal at the final stage of a television transmitter. The audio carrier frequency is applied to port **1** of a cavity **5** resonant at that frequency and the vision carrier signal is applied to terminal **3.** The separation of the carrier frequencies of the sound and vision signals respectively is sufficiently great such that the cavity **5** is essentially non resonant at the vision carrier frequency. This means that the vision carrier frequency is passed to port **4** substantially unmodified. However, as indicated previously, virtually the whole of the energy applied to port **1** is coupled to port **4** also, and thus a combined output is obtained from port **4.** Typically the output of port **4** would be radiated directly from a common radiator. The advantage of this kind of circuit is that in practice substantially no energy from port **1** is coupled to port **3** and conversely substantially no energy applied to port **3** is coupled to port **1.** In this way a very high isolation is maintained between the sound and vision transmission systems. Furthermore, because the circuit exhibits the constant resistance characteristics, the power of the radiated signal does not vary with frequency. Previously circuits of this kind have been excessively cumbersome and complicated. As will now be appreciated, the present invention provides a particularly advantageous construction since the coaxial lines connected to ports **1, 2, 3** and **4** may be relatively simple and compact and suitable for direct connection to the circuits which precede them.

By combining two or more resonant cavities together transfer characteristics can be obtained which are more complex than that shown in FIG. **7.** For example two cavities coupled together in which one of the cavities contains both couplers provides two attenuation peaks, one at the resonant frequency of each cavity.

I claim:

1. A constant resistance electrical network comprising in combination:

a cavity resonator;

a pair of separate couplers disposed within said cavity resonator in electrically insulated relation thereto, and each coupler having the same characteristic resistance;

a first input coaxial line and a first output coaxial line leading to said cavity resonator and each having a center conductor connected to opposite ends of one coupler to form a first coupling loop within said cavity resonator;

a second input coaxial line and a second output coaxial line leading to said cavity resonator and each having a center conductor connected to the opposite end of the other coupler to form a second coupling loop within said cavity resonator;

each coupling loop being disposed in a plane transverse to the natural direction of propogation of resonant waves excited within the cavity resonator by said couplers and means terminating each of said output coaxial lines in said characteristic resistance, whereby when energy is applied to either input coaxial line none is reflected thereby and the energy is directed substantially only to the corresponding output coaxial line except when the energy is substantially at the resonant frequency of said cavity resonator whereupon the energy is directed substantially only to the other output coaxial line.

2. A network as claimed in claim **1** wherein each coupling loop comprises an electrically conductive member mounted substantially parallel to and spaced apart from the inner wall of the cavity.

3. A network as claimed in claim **2** wherein each conductive member comprises a thin sheet conductor.

4. A network as claimed in claim **1** wherein the cavity comprises a short waveguide section each end of which is bounded by a flat electrical conductor.

5. A network as claimed in claim **4** in which the cavity has a circular or a square cross section.

6. A network as claimed in claim **1** wherein the two loops are displaced relative to one another around the perimeter of the cavity.

7. A network as claimed in claim **6** wherein the two loops are so positioned around the perimeter of the cavity as to subtend approximately a right angle at the centre of the cavity.

8. A network as claimed in claim **1** wherein the length of the cavity in the natural direction of wave propagation is approximately half a wavelength at the resonant frequency.

9. A network as claimed in claim **8** wherein each loop is mounted approximately halfway along the length of the cavity in said natural direction.

10. A constant resistance electrical network as claimed in claim **1** wherein the two input coaxial lines are also each terminated by the characteristic resistance.

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