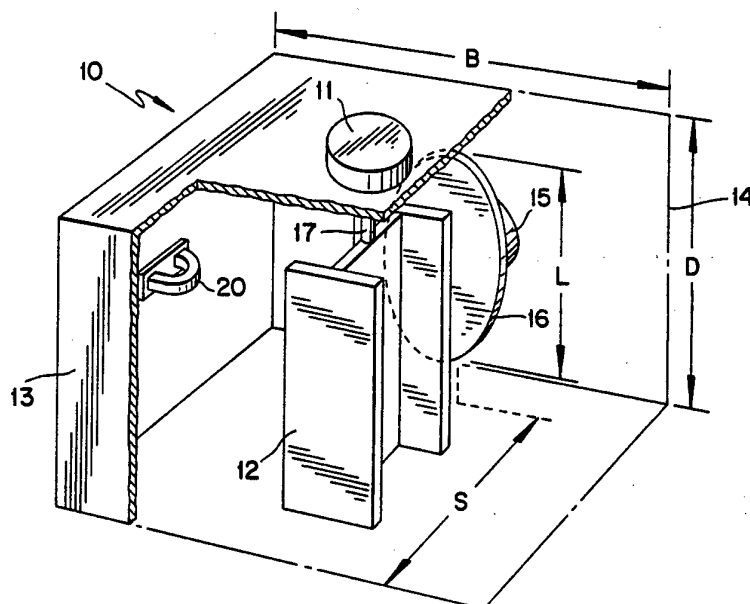




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<p>(51) International Patent Classification ⁵ : H01P 7/04</p>	<p>A1</p>	<p>(11) International Publication Number: WO 94/08359 (43) International Publication Date: 14 April 1994 (14.04.94)</p>
<p>(21) International Application Number: PCT/SE93/00769 (22) International Filing Date: 23 September 1993 (23.09.93) (30) Priority data: 957,383 7 October 1992 (07.10.92) US (71) Applicant: TELEFONAKTIEBOLAGET LM ERICSSON [SE/SE]; S-126 25 Stockholm (SE). (72) Inventor: AHLBERG, Max, Christer ; Adolf Zetheliusgata 1, S-724 54 Västerås (SE). (74) Agents: LÖVGREN, Tage et al.; Telefonaktiebolaget LM Ericsson, S-126 25 Stockholm (SE).</p>		<p>(81) Designated States: AU, BR, CA, FI, JP, KR, NO, NZ, RU, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i></p>

(54) Title: COMBINER RESONATOR HAVING AN I-BEAM SHAPED ELEMENT DISPOSED WITHIN ITS CAVITY



(57) Abstract

In a combiner filter for a cellular telephone system, there is a coaxial resonator which includes a rectangular cavity. Within the rectangular cavity, there is a central conductor having an oval shaped plate. The central conductor and oval shaped plate are displaced within the rectangular cavity to establish the fundamental resonator frequency. Adjacent to the central conductor plate is a rotatable I-beam shaped element which is preferably rotated by a shaft coupled to a stepper motor. The rotation of the I-beam shaped element provides frequency adjustment or tuning for the coaxial resonator.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	FR	France	MR	Mauritania
AU	Australia	GA	Gabon	MW	Malawi
BB	Barbados	GB	United Kingdom	NE	Niger
BE	Belgium	GN	Guinea	NL	Netherlands
BF	Burkina Faso	GR	Greece	NO	Norway
BG	Bulgaria	HU	Hungary	NZ	New Zealand
BJ	Benin	IE	Ireland	PL	Poland
BR	Brazil	IT	Italy	PT	Portugal
BY	Belarus	JP	Japan	RO	Romania
CA	Canada	KP	Democratic People's Republic of Korea	RU	Russian Federation
CF	Central African Republic	KR	Republic of Korea	SD	Sudan
CG	Congo	KZ	Kazakhstan	SE	Sweden
CH	Switzerland	LI	Liechtenstein	SI	Slovenia
CI	Côte d'Ivoire	LK	Sri Lanka	SK	Slovak Republic
CM	Cameroon	LU	Luxembourg	SN	Senegal
CN	China	LV	Latvia	TD	Chad
CS	Czechoslovakia	MC	Monaco	TG	Togo
CZ	Czech Republic	MG	Madagascar	UA	Ukraine
DE	Germany	ML	Mali	US	United States of America
DK	Denmark	MN	Mongolia	UZ	Uzbekistan
ES	Spain			VN	Viet Nam
FI	Finland				

**COMBINER RESONATOR HAVING AN I-BEAM
SHAPED ELEMENT DISPOSED WITHIN ITS CAVITY**

Field of the Invention

5 The present invention relates to a tuning arrangement for coaxial radio frequency (RF) combiner filters, and more especially to $\lambda/4$ resonators.

Background of the Invention

10 A coaxial resonator includes a cavity such as a rectangularly shaped cavity, and the cavity's fundamental frequency, referred to as f_0 , is usually set by selecting the relationship between a center conductor and the center conductor's closing cover (cap) which are disposed within the cavity. The closing cover and the opposite wall of the resonator cavity constitute the plates of a capacitor. The RF input signal, which is input to the cavity, produces an electric field between these capacitor plates and a magnetic field that is orthogonal to the electric field with maximum strength around the center conductor. The resonator's fundamental frequency is strongly determined by the center conductor's closing cover. The area of the closing cover determines the capacitance. The resonator is usually tuned, i.e., the resonator's fundamental frequency is selected, by adjusting the length of the center conductor, thereby changing the capacitance. This tuning is usually accomplished indirectly by moving an adjustment screw disposed in opposition to the center conductor. A pick-up loop, which is usually situated on one of the resonator's walls, is provided in the resonator. The loop picks up the tuned signal frequency (for setting the resonator, this frequency is the desired f_0).

35 A problem with the above-described conventional coaxial resonators is the difficulty of adjustment over a wide RF-bandwidth, e.g., 10 megahertz (MHz) around a center frequency of 465 MHz. Such wideband operation in connection with common adjustment means normally requires

- 2 -

the use of bulky resonators. In a typical cellular telephone base station, there are, for example, eight resonators each handling two channels. If not all the resonators are used in the system, it is necessary to
5 park the frequency for the unused resonators outside the active frequency band in order not to disturb other channels. The bulkiness and associated adjustment arrangements for the conventional resonators are so unsatisfactory, that there is a need for an entirely new
10 design in order to alleviate the bulkiness associated with conventional designs.

Summary of the Invention

The present invention provides a compact design for a coaxial resonator that is easy to adjust and
15 provides a wider frequency tuning range. The coaxial resonator includes, in one embodiment, a rectangular cavity having a center conductor and an oval closing cap disposed within the rectangular cavity. The length and dimension of the center conductor and the shape of the
20 closing cap determine the fundamental frequency of the coaxial resonator. Also disposed within the rectangular cavity is a rotatable I-beam shaped element. Preferably, a stepper motor and a connecting shaft rotate the I-beam shaped element. The rotation of the I-beam shaped
25 element tunes the coaxial resonator. The I-beam shaped element may also be displaced laterally between the wall of the resonator and the closing cap to further facilitate the tuning of the resonator.

Brief Description of the Drawings

30 Fig. 1 is a perspective view of the coaxial resonator of the present invention;

Fig. 2 is a cross sectional perspective view taken along the line 2-2 of Fig. 1; and

35 Fig. 3 is a plan view of the coaxial resonator with the top removed.

Detailed Description of the Invention

Referring now to Fig. 1 there is a perspective view of one embodiment of the coaxial resonator of the present invention. The coaxial resonator includes a cavity such as the rectangular cavity 10. Disposed on the top of the rectangular cavity 10 is a stepper motor 11 or some other adjustment device such as an adjustment screw. Preferably, the stepper motor 11 is capable of being laterally displaced in the direction of the double arrow A-A.

Referring now to Fig. 2, a cross sectional perspective view taken along the line 2-2 of Fig. 1 is provided. Disposed within the rectangular cavity 10, there is an RF output coil 20 and an I-beam shaped element 12 orthogonally placed against the electrical field between the plates that make up the capacitor. The plates of the capacitor include the front wall 13 of the rectangular cavity 10 and the closing plate 16. The I-beam shaped element 12 has the property of introducing frequency adjustment (tuning) over a wide span when rotating the I-beam in the field. To achieve the same tuning span with prior art resonators, one would have to increase the length of the center conductor 15 in order to, for example, broaden the distance (S) between the capacitor plates 13, 16.

Referring now to Fig. 3, a plan view illustrates the rectangular cavity 10 with the top wall removed. An RF signal is input to the rectangular cavity via a coaxial cable 21 and a RF input loop 19. An RF signal is output from the rectangular cavity via a coaxial cable 22 and a RF output loop 20. The fundamental resonator frequency f_0 of the cavity 10 is settled through the adjustment length (L) of a coaxial center conductor 15 and/or its closing plate 16. The design and/or dimensions of the closing plate 16 also affect the adjustment of the fundamental resonator frequency f_0 . According to the present invention, the

- 4 -

rotation of the I-beam 12 is achieved with e.g., the stepper-motor 11, an adjustment screw or other known adjustment means which is attached to an isolated shaft 17.

5 A 90° rotation of the I-beam 12 adjusts the resonance frequency between maximum and minimum i.e., between f_{max} and f_{min} on a 360° rotation. The relation between the height and the width of the I-beam 12 when achieving maximum Δf should be preferably 0.5. The
10 diagonal dimension of the I-beam 12 is settled through the formula $S - (2 * (\geq 10 \text{ mm}))$ in order to accomplish maximum Δf and good voltage flash-over resistance. The diagonal dimension is depicted in Fig. 3 by the dotted line a-b. The statement placed in the parenthesis is
15 power related, meaning $< 10 \text{ mm}$ for less power (high power being approximately 50w).

The oval design of the closing plate or top-capacitance 16 improves the voltage isolation distance i.e, the S-measure increases. Improved Δf through the
20 oval shape of closing plate 16 is a consequence resulting from the increased projected surface of the I-beam 12. The design of the oval closing plate 16 is related to the resonator cavity dimensions through the equations, $b/B=k$, $k*D=1$, where k is a constant.

25 The present invention also makes it possible to move laterally the adjusting device 11 (See the double arrow A-A of Fig. 1 which illustrates the movement of the stepper motor), thereby causing the attached I-beam 12 to move laterally between the capacitor plates 13, 16. This
30 lateral movement of the I-beam 12 facilitates the 'catch' of the correct frequency range including the location of f_0 via the so called parking frequency. Accordingly, the present invention provides a resonator, such as a $\lambda/4$ -resonator, with a simple frequency adjustment means 11
35 which includes either a manual rotating device and/or an automatically driven device, for example, one driven by the stepper motor.

- 5 -

While the invention has been described in its preferred embodiments, it is understood that the words that have been used are words of description rather than of limitation, and that changes within the purview of the present claims may be made without departing from the true scope of the invention in its broader aspects.

CLAIMS:

1. (Amended) - A coaxial resonator, comprising:
a cavity;
5 a conductive element, having a predetermined shaped plate, which is disposed within the cavity to provide a fundamental frequency for the coaxial resonator;
an I-beam shaped element disposed within the cavity between the plate and an opposing cavity wall,
10 said plate and opposing cavity wall forming a capacitance, said I-beam shaped element being provided to tune the coaxial resonator; and
means for rotating the I-beam shaped element within the cavity.
- 15 2. (Amended) A coaxial resonator according to claim 1 wherein the cavity having a rectangular shape.
3. (Amended) A coaxial resonator, comprising:
a rectangular shaped cavity;
20 a conductive element, having a predetermined oval shaped plate, which is disposed within the cavity,
an I-beam shaped element disposed within the cavity between the plate and an opposing cavity wall, said plate and opposing cavity wall forming a capacitance; and
25 means for rotating the I-beam shaped element within the cavity.
4. A coaxial resonator according to claim 3 wherein the means for rotating includes a stepper motor coupled to the I-beam shaped element via an isolated
30 shaft.
5. A coaxial resonator according to claim 3 wherein the means for rotating includes a manually

- 7 -

adjustable member coupled to the I-beam shaped element
via an isolated shaft.

SEARCHED

5 6. A coaxial resonator according to claim 4
wherein the means for rotating includes a manually
adjustable member coupled to the isolated shaft as an
alternate means for rotating the I-beam shaped element.

10 7. A coaxial resonator according to claim 3
wherein the means for rotating is laterally moveable such
that the lateral movement of the means for rotating
laterally displaces the I-beam shaped element.

8. A coaxial resonator according to claim 2
wherein the plate is oval shaped.

15 9. A coaxial resonator according to claim 1
wherein the means for rotating includes a stepper motor
coupled to the I-beam shaped element via an isolated
shaft.

20 10. A coaxial resonator according to claim 1
wherein the means for rotating includes a manually
adjustable member coupled to the I-beam shaped element
via an isolated shaft.

11. A coaxial resonator according to claim 10
wherein the means for rotating includes a manually
adjustable member coupled to the isolated shaft as an
alternate means for rotating the I-beam shaped element.

25 12. A coaxial resonator according to claim 1
wherein the means for rotating is laterally moveable such
that the lateral movement of the means for rotating
laterally displaces the I-beam shaped element.

1/2

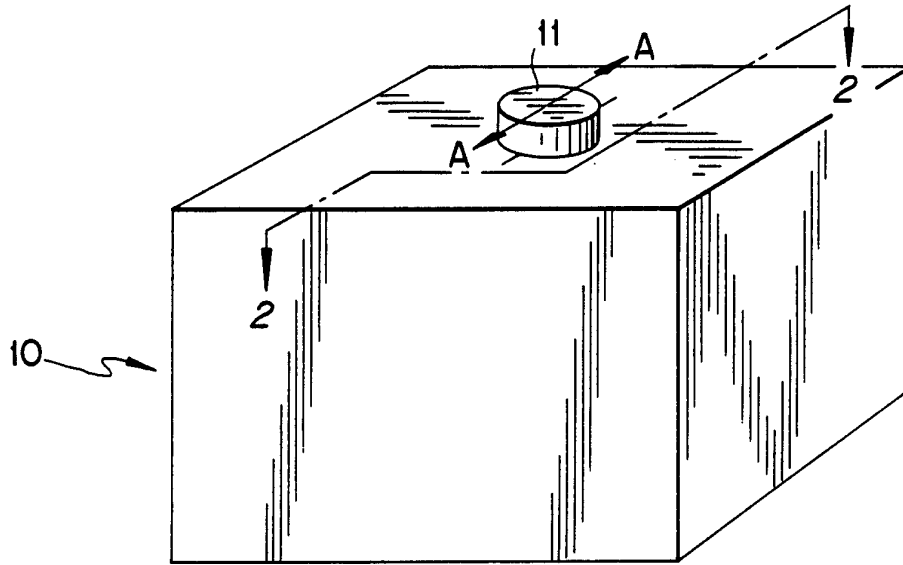


FIG. 1

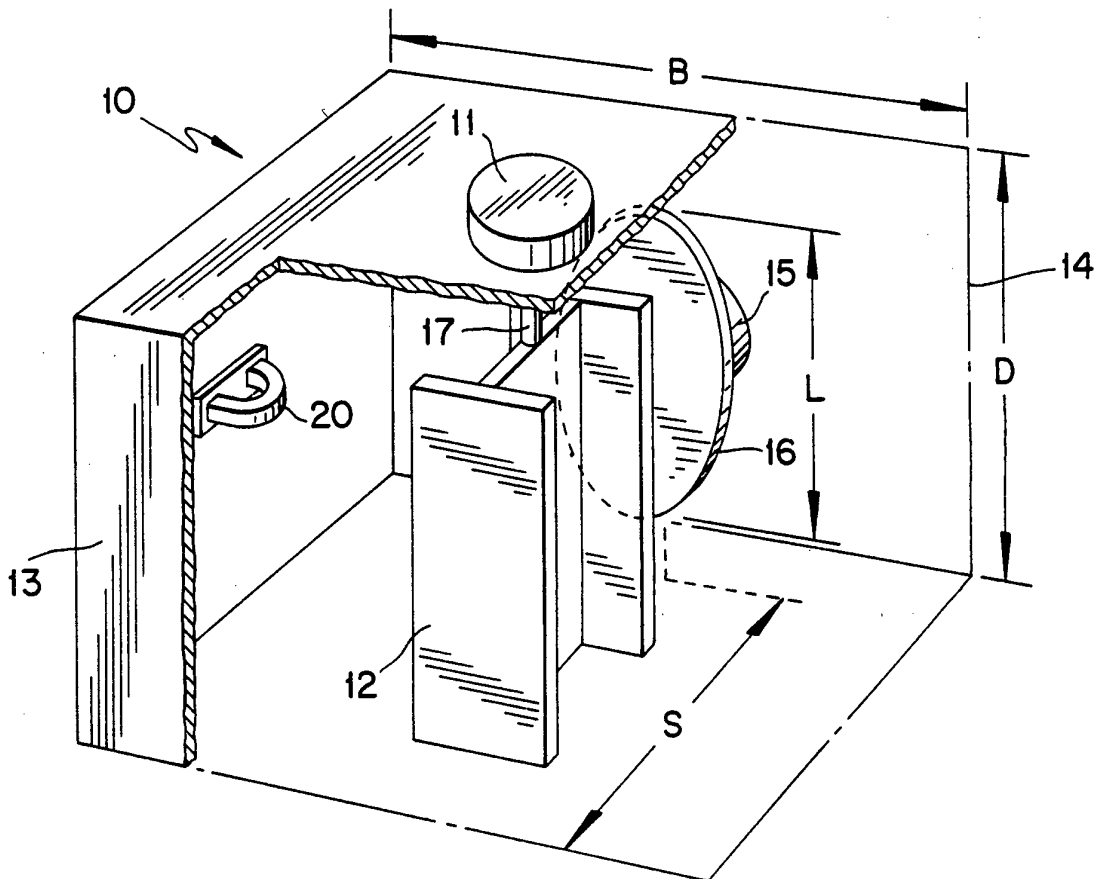


FIG. 2

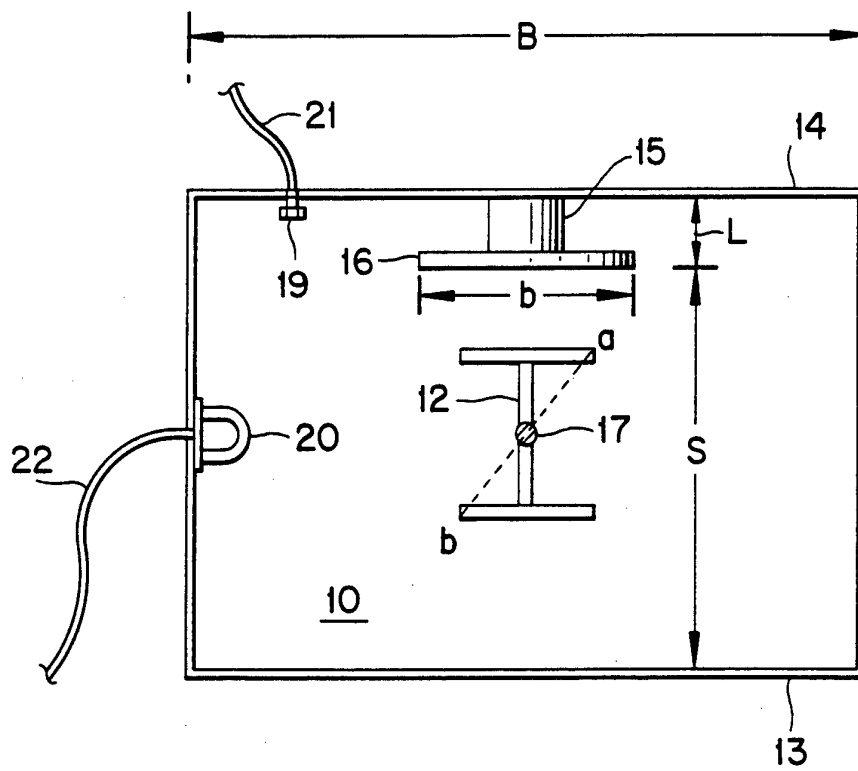


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 93/00769

A. CLASSIFICATION OF SUBJECT MATTER		
IPC5: H01P 7/04 According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
IPC5: H01P		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
SE,DK,FI,NO classes as above		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 4389624 (YUKICHI AIHARA ET AL), 21 June 1983 (21.06.83), column 1, line 39 - column 2, line 5 --	1-12
A	US, A, 4521754 (JOSEPH C. RANGHELLI ET AL), 4 June 1985 (04.06.85), column 1, line 20 - line 60, figure 1 --	1-12
A	DE, A1, 4026062 (ANT NACHRICHTENTECHNIK GMBH), 20 February 1992 (20.02.92), column 1, line 36 - line 52, figure 1 -- -----	1-12
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
28 December 1993		12 -01- 1994
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86		Authorized officer Göran Magnusson Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT
Information on patent family members

27/11/93

International application No.
PCT/SE 93/00769

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 4389624	21/06/83	JP-C- 1479185 JP-A- 56141601 JP-B- 63025523	10/02/89 05/11/81 25/05/88
US-A- 4521754	04/06/85	NONE	
DE-A1- 4026062	20/02/92	NONE	