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

(11) EP 2 530 781 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
05.12.2012 Bulletin 2012/49

(21) Application number: **10844829.1**

(22) Date of filing: **14.10.2010**

(51) Int Cl.:
H01P 5/04 *(2006.01)*

(86) International application number:
PCT/RU2010/000585

(87) International publication number:
WO 2011/093739 (04.08.2011 Gazette 2011/31)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **28.01.2010 RU 2010102804**

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(54) COUPLER FOR A COAXIAL CABLE

(57) The coupler comprises a section of coaxial line which is coupled to a coaxial cable. The central conductor of the section of coaxial line with a dielectric insulator is coupled electrically to the inner conductor of the coaxial cable via an opening formed in the dielectric jacket, in the outer conductor, in the insulating layer and in the inner conductor of the coaxial cable, in such a way as to make it possible to fit the central conductor with the dielectric insulator of the section of coaxial line in the opening formed in the inner conductor of the coaxial cable. A metallic plate with an inner surface turned towards the dielectric jacket of the coaxial cable is introduced and is designed in terms of shape and dimensions so as to correspond to the shape and dimensions of the dielectric jacket of the coaxial cable. The opening is formed with a diameter equal to the outer diameter of the dielectric insulator. The metallic plate and the outer conductor of the section of coaxial line are connected to one another and are free from a DC-isolated contact with the outer conductor of the coaxial cable. Therefore, all of the DC-isolated connections are replaced by capacitive connections in the device.

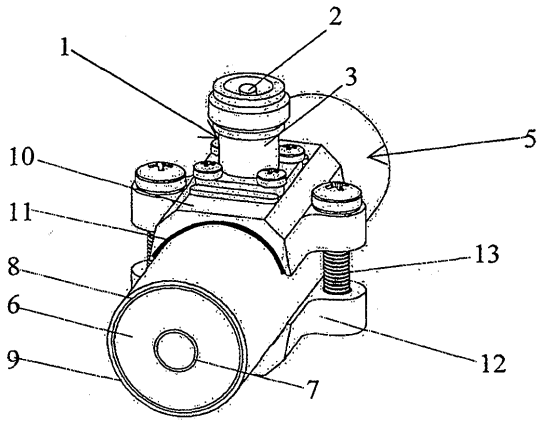

Fig. 1

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Description

Field of the Invention

[0001] The invention relates to radio engineering and may be used as a device for tapping electromagnetic energy, primarily in coaxial trunk cables.

Description of Prior Art

[0002] Various coaxial couplers are known, which comprise a coaxial line made of an inner conductor and an outer conductor, and a coaxial line section made of a central conductor and an external conductor, wherein the central conductor is electrically coupled to the inner conductor of the coaxial line, and the external conductor is connected to the outer conductor (GB, 607200, H01P 5/04, publ. 25.08.1948), (US, 4700145, H01P 5/12, publ. 13.10.1982), (JP, 1103003, H01P 5/12, publ. 20. 04.1989).

[0003] These devices are disadvantageous in that they are stationary, require coaxial couplers to be connected to a coaxial cable via connectors. The external conductor of the coupler coaxial line section is electrically coupled to the outer conductor of the coaxial cable via mechanical contact therebetween. Moreover, these devices are non-adjustable, and an electromagnetic energy tapping factor is a pre-set one and is ensured directly by structural characteristic dimensions of coaxial couplers and by coupling therebetween.

[0004] When designing radio communication systems, in particular cellular communication systems, for buildings and structures (such as trade centers, big office buildings, multilevel parkings, etc.) a task of building a distributed antenna-feeder system connected to transceiving equipment emerges. This task requires use of a plurality of couplers (dividers) having different electromagnetic energy redistribution factors. Furthermore, due to structural features of buildings, the main trunk line (s) distributing high-frequency (HF) signal is desired to be made of a single piece of a coaxial cable at minimum losses (without using a great number of connectors), provided the necessity of installing additional equipment does not exist. This requires, accordingly, use of rather great number of couplers (dividers) for connecting additional, e.g., antenna equipment, to the main line via a break in the coaxial cable and mounting connector mating parts on sections of a coaxial cable, which proportionally results in increasing losses and lowering the whole system reliability. Here, it is advisable to use different tapping factors for tapping electromagnetic energy in order to optimize distribution of HF signal sufficient for operating some or other additional antenna equipment to be connected.

[0005] In order to tap HF signal from a trunk cable an electromagnetic energy coaxial coupler (CT7810-850) may be used that is manufactured by Radio Frequency Systems (RFS). Trade Catalogue WDCS, Edition 1, 06.02.050, KB 17/00197-01, P78. This coaxial coupler comprises a section of a coaxial line with the central conductor connected to the inner conductor of a coaxial cable via a dielectric insert with pre-set dimensions. The dielectric insert is pressed by the central conductor to the coaxial cable inner conductor from its outer surface. This solution, however, may ensure only the tapping factor technically established by the designer (minus 10 dB for the RFS coupler). Its disadvantages are: a narrow product line, the requirement of high precision for geometric dimensions of mounting connections, which increases mounting complexity and poses higher requirements to mounting personnel. If there is a necessity to use any other (different from 10 dB) tapping factors, this structure is not adjustable at all due to instability of reproducible parameters.

[0006] A coupler for a coaxial cable is known, which comprises a coaxial line section made of a central conductor and an external conductor with a dielectric insulator arranged therebetween, wherein the central conductor of the coaxial line section is for electric coupling with the inner conductor of a coaxial cable, and the external conductor is for electric coupling with the outer conductor of a coaxial cable, the coaxial cable being made with an insulating layer between the inner conductor and the outer conductor and having a dielectric jacket on the outer conductor, the central conductor of the coaxial line section being electrically coupled to the inner conductor of the coaxial cable via an opening made in the dielectric jacket, the outer conductor, the insulating layer and the inner conductor of the coaxial cable with the possibility of installing the central conductor of the coaxial line section in the opening made in the inner conductor of the coaxial cable (SU, 1517082, H01K 11/20, publ. 23.10.1989).

[0007] This technical solution has the central conductor of the coaxial line section made as a needle. It includes a housing with a clamp cover, with a groove for a cable and with two contact needles of different heights, the bigger one being insulated from the housing and the lesser one being connected to the housing. The housing has arms installed thereon and an additional contact needle connected thereto and having a height that is equal to that of the said lesser needle. Grooves for the arms are made in the housing, the lesser needles are arranged symmetrically to the bigger needle between the grooves. The cover is made in the L-shape and is installed hingedly with the possibility of interacting with the arms. When the arms are turned, the central needle is pushed into the inner conductor of a coaxial cable, and the lesser needles are pushed into the outer conductor. Thus, mechanical and electrical contact is established between the conductors of the coaxial line section and the conductors of a coaxial cable.

[0008] Disadvantages of this device are: possibility of using it only for coaxial cables having small diameters, since at

great diameters the contact needles (especially the central one) may be broken; use of galvanic (mechanical) contacts leads to poor serial reproducibility of such devices in their technical parameters, i.e., to a large spread of tapping factors; use of galvanic contacts results in reduced reliability and service life of the device; the whole structure is rather complicated due to the presence of the arms, the special housing and the cover.

[0009] The closest to the invention is a coupler for a coaxial cable, which comprises a coaxial line section made of a central conductor and an external conductor, a dielectric insulator arranged between the conductors, the central conductor of the coaxial line section being intended for electric coupling with the inner conductor of a coaxial cable, and the external conductor being intended for the outer conductor of a coaxial cable, a coaxial cable, as intended for use in the coupler, is made with an insulating layer between its inner conductor and its outer conductor and with a dielectric jacket on the outer conductor, the central conductor of the coaxial line section with the dielectric insulator is electrically coupled with the inner conductor of the coaxial cable via an opening made in the dielectric jacket, the outer conductor, the insulating layer and the inner conductor of the coaxial cable, with the possibility of positioning the central conductor with the dielectric insulator of the coaxial line section in an opening made in the inner conductor of the coaxial cable (RU, 56072, U1, H01P 5/04, publ. 27.08.2006).

[0010] This device is advantageous in that electric (capacitive) coupling, rather than a mechanical connection, is used between the central conductor of the coaxial line section and the inner conductor of a coaxial cable, as well as in that the possibility exists for moving the central conductor of the coaxial line section along the longitudinal axis of an opening made in the inner conductor of a coaxial cable, which enables to change a tapping factor value. At the same time, the external conductor of the coaxial line section is electrically and mechanically connected to the outer conductor of a coaxial cable through a spring element, i.e., electric contact or galvanic coupling is used in this known technical solution.

[0011] This device is limited by the following: quality of electric contact is deteriorated as time passes due to the use of the spring element (mechanical contact), which results in non-linearity of resistance and, consequently, in intermodulation interference and a change in its tapping factor; complexity of installation since it is required to remove a part of a coaxial cable dielectric jacket for installing the spring element.

Summary of the Invention

[0012] This invention is based on the task of improving reproduction accuracy of a set tapping factor, expanding a tapping range, simplifying the structure, shortening time required for tuning and simplifying the mounting works, raising performance.

[0013] According to this invention, in order to reach the stated task, a metal plate is introduced into the known coupler for a coaxial cable, which comprises a coaxial line section made of a central conductor and an external conductor and a dielectric isolator arranged therebetween, the central conductor of the coaxial line section being intended for electrical coupling with the inner conductor of a coaxial cable and the external conductor being intended for electrical coupling with the outer conductor of the coaxial cable, wherein a coaxial cable, as intended for use therein, is made with an insulating layer between its inner conductor and its outer conductor and with a dielectric jacket on the outer conductor, the central conductor of the coaxial line section with a dielectric insulator is electrically coupled to the inner conductor of a coaxial cable via an opening made in the dielectric jacket, the outer conductor, the insulating layer and the inner conductor of a coaxial cable, the inner surface of the metal plate, which faces the dielectric jacket of a coaxial cable, is made in its shape and dimensions so as to correspond to the shape and dimensions of the coaxial cable dielectric jacket, the metal plate being made at least with one connection element ensuring its mounting directly to the coaxial cable dielectric jacket, the opening in the dielectric jacket, the outer conductor, the insulating layer and the inner conductor of a coaxial cable is made with the diameter equal to the outer diameter of the dielectric insulator, the metal plate and the external conductor of the coaxial line section are connected to each other and have no galvanic (electric) contact with the outer conductor of the coaxial cable.

[0014] Additional embodiments of the device are possible, wherein:

- the central conductor of the coaxial line section is installed with the possibility of moving it along the longitudinal axis of the opening made in the inner conductor;
- the outward protruding end of the coaxial line section is made as a coaxial connector;
- the metal plate is installed on the dielectric jacket of the coaxial cable by means of a connection element - adhesive layer;
- a second plate is introduced which inner surface, as facing the dielectric jacket of the coaxial cable, is made as to its form and dimensions so as to correspond the form and dimensions of the dielectric jacket of the coaxial cable, the second plate being installed on the dielectric jacket of the coaxial cable opposite to the metal plate and with the

possibility of forming a connection element - a clamp - by mounting the metal plate and the second plate with screws;

- the central conductor of the coaxial line section is provided with a capacitive element made as a gap in the central conductor or in the form of a dielectric insert thereto;

- the central conductor of the coaxial line section is provided with an inductive element made as the wavy outer surface of the central conductor or in the form of a helical spiral installed in the central conductor gap.

[0015] The above advantages as well as specific features of this invention are explained hereinbelow on its best embodiments with reference to the accompanying drawings.

Brief Description of the Drawings

[0016]

Figure 1 shows the claimed device, external view;

Figure 2 - the same as Figure 1, a cross-section view;

Figure 3 - the same as Figure 2, an embodiment with a capacitive element;

Figure 4 - the same as Figure 2, an embodiment with an inductive element;

Figure 5 - the same as Figure 2, another embodiment with an inductive element;

Figure 6 - results of measuring VSWR of the coupler with the use of a AFS tester "Site Master S332B" in the range from 1,500 to 2,500 MHz;

Figure 7 shows frequency dependence of the tapping factor in the operating range of cellular communication networks of GSM 1800 and UMTS standards.

Description of the Best Embodiment of the Invention

[0017] The coupler for a coaxial cable (Figures 1, 2) comprises a section 1 of a coaxial line, which is made of the central conductor 2 and an external conductor 3 with a dielectric insulator 4 arranged therebetween. A coaxial cable 5, as intended for the use in the coupler, is made with an insulating layer 6 between its inner conductor 7 and the outer conductor 8 and with a dielectric jacket 9 on the outer conductor 8. The central conductor 2 of the section 1 of the coaxial line with the dielectric insulator 4 is electrically coupled to the inner conductor 7 of the coaxial cable 5 via an opening made in the dielectric jacket 9, the outer conductor 8, the insulating layer 6 and the inner conductor 7 of the coaxial cable 5 with the possibility of installing the central conductor 2 with the dielectric insulator 4 of the section 1 of the coaxial line in the opening made in the inner conductor 7 of the coaxial cable 5.

[0018] A metal plate 10 is introduced, which inner surface facing the facing the dielectric jacket 9 of the coaxial cable 5, is made as to its shape and dimensions so as to correspond to the shape and dimensions of the dielectric jacket 9 of the coaxial cable 5. The metal plate 10 is made at least with one connection element 11 ensuring its mounting directly to the dielectric jacket 9 of the coaxial cable 5. The opening in the dielectric jacket 9, the outer conductor 8, the insulating layer 6 and the inner conductor 7 of the coaxial cable 5 is made with the diameter equal to the diameter of the dielectric insulator 4. The metal plate 10 and the external conductor 3 of the section 1 of the coaxial line are connected between each other and have no electric contact with the outer conductor 8 of the coaxial cable 5.

[0019] Similarly to the closest analogous solution, the central conductor 2 of the section 1 of the coaxial line is installed with the possibility of moving it along the longitudinal axis of the opening made in the inner conductor 7 for the purpose of changing the tapping factor value.

[0020] Furthermore, the outward protruding end of the section 1 of the coaxial line may be made as a coaxial connector for installing any additional equipment.

[0021] The metal plate 10 may be installed on the dielectric jacket 9 of the coaxial cable 5 by means of the connection element 11 - an adhesive layer (Figures 1, 2).

[0022] Furthermore, a second plate 12 may be introduced, which inner surface facing the dielectric jacket 9 of the coaxial cable 5 is made as to its shape and dimensions so as to correspond to the shape and dimensions of the dielectric jacket 9 of the coaxial cable 5. The second plate 12 is installed on the dielectric jacket 9 of the coaxial cable opposite

to the metal plate 10 with the possibility of forming the connection element 11 - a clamp - by mounting the metal plate 10 and the second plate 12 with the use of screws 13 (Figures 1-5).

[0023] The central conductor 2 of the section 1 of the coaxial line (Figure 3) may be provided with a capacitive element 14 for the purpose of correcting frequency dependence of the tapping factor. The capacitive element 14 may be made as a gap in the central conductor 3 or in the form of a dielectric insert in the gap (commercially produced capacitors may be used as well).

[0024] In order to correct frequency dependence of the tapping factor, the central conductor 2 of the section 1 of the coaxial line may be provided with an inductive element 15 made as a wavy outer surface of the central conductor 2 (Figure 4). The inductive element 15 may be in the form of a helical spiral (Figure 5) installed in the gap in the central conductor 2. (Standard inductive elements may be used that are produced commercially).

[0025] The device (Figures 1, 2) may be mounted as follows. An opening, which is passed through the dielectric jacket 9, the outer conductor 8, the insulating layer 6 and into the inner conductor 7, is drilled in the coaxial cable 5 (e.g., in a trunk cable) in a connection point for additional equipment. A diameter of this opening is selected so as the central conductor 2 with the dielectric insulator 4 fits the opening with small interference. In comparison to the closest analogous solution, it is not required to remove the dielectric element 9 for a spring element, and, to the contrary, it is required to preserve it in the point of contact with the dielectric insulator 4 for the purpose of improving electric capacitive coupling.

[0026] The central conductor 2 of the section 1 may be installed (together with the dielectric insulator 4) directly in the opening made in the inner conductor 7 of the coaxial cable, in order to achieve maximum values of the tapping factor. Furthermore, the central conductor 2 may be moved along the longitudinal axis of the opening made in the inner conductor 7. The tapping factor of electromagnetic energy is adjusted by a depth to which the central conductor 2 of the section 1 of the coaxial line penetrates into the coaxial cable 5.

[0027] The metal plate 10, which is connected to the external conductor 3 of the section 1 of the coaxial line, is pressed to the dielectric jacket 9 of the coaxial cable 5 and is attached to it by the connection element 11, for example, by an epoxy adhesive layer (Figures 1, 2). In order to improve the connection reliability, the second plate 12 may be introduced, which inner surface, facing the dielectric jacket 9 of the coaxial cable 5, is made as to its shape and dimensions so as to correspond to the shape and dimensions of the dielectric jacket 9 of the coaxial cable 5. The second plate 12 is installed on the dielectric jacket 9 of the coaxial cable opposite to the metal plate 10 with the possibility of forming the connection element 11 - a clamp - by installing the metal plate 10 and the second plate 12 with the use of the screws 13 (Figures 1-5).

[0028] The external conductor 3 may be the outer body of a coaxial connector. Thus, the outward protruding end of the section 1 of the coaxial line may be made as a coaxial connector. This will enable to reduce the dimensions and simplify the device for the purpose of connecting any equipment thereto.

[0029] In order to correct frequency dependence of the tapping factor, the central conductor 2 of the section 1 of the coaxial line may be provided with a capacitive element 14 or an inductive element 15, which can be made in accordance with the above-described means (Figures 3-5). For this no changes in the diameter of the opening in the coaxial cable 5 or any additional adjustments are required, and correction may be made by replacing the respective capacitive elements 14 or inductive elements 15 (Figures 3-5). Frequency dependence correction may be necessary when the frequency range of the coaxial coupler is expanded for the purpose of stabilizing its performance.

[0030] The claimed device lacks direct electro-mechanical contacts between the conductors of the section 1 of the coaxial line and of the coaxial cable 5 (capacitive electric coupling is used), which ensures long-term stability of the coupler performance and guarantees the absence of intermodulation interference. Furthermore, the claimed device is more convenient for mounting, since it does not require to remove the dielectric jacket 9 of the coaxial cable 5 for the purpose of installing any spring element or other mechanical means for providing electric contacts.

[0031] As tests show, this device, when installed directly to a trunk coaxial cable, ensured a wide range of signal tapping (from -5 to -40 dB). A tapping factor, which is required in practice for achieving a necessary level of HF energy for additional equipment, may be determined at an installation site, e.g., by connecting a power meter to the coupler or by using a known dependence of the tapping factor on the length of the central conductor 2 of the section 1.

[0032] The technical characteristics for several ratings of the claimed coupler are summarized in the following table.

Table

Ftapp. (dB)	VSWR	Cable diameter (inches)	Weight (g)	HF connector type
-5	1.5	1/2 (7/8, 5/4)	91 (96, 120)	N
-7	1.3	1/2 (7/8, 5/4)	91 (96, 120)	N
-11	1.2	1/2 (7/8, 5/4)	91 (96, 120)	N
-15	1.1	1/2 (7/8, 5/4)	91 (96, 120)	N

(continued)

Ftapp. (dB)	VSWR	Cable diameter (inches)	Weight (g)	HF connector type
-40	1.05	1/2 (7/8, 5/4)	91 (96, 120)	N

[0033] Figures 6 and 7 show the test results for an example coupler (OK) with the tapping factor (Ftapp.) -7 dB for the coaxial cable 5 having diameter of 1/2" (LCF 12-50 cable manufactured by RFS). The coupler is developed for the frequency range from 1,710 to 2,170 MHz used for cellular communication networks of GSM1800 and UMTS (3G) standards.

[0034] The operating range (Figure 6) is marked by M1 and M2. Ftapp. is less than 1.3 within this operating range, which complies with the Russian requirements to AFS elements of cellular communications 1.5. A growth in Ftapp. at frequencies above 2,170 MHz may be compensated by means of using the coupler embodiments shown in Figures 4 and 5.

[0035] It can be seen in Figure 7 that the tapping factor grows with an increase in frequency. Correction may be made also by using the embodiments shown in Figures 4 and 5.

[0036] The ultimate simplicity of the structure and convenience of mounting as well as low sensitivity of the tapping factor dependence on the geometrical dimensions determine practical significance of the claimed device.

Industrial Applicability

[0037] The claimed coupler for a coaxial cable may be most successfully applied industrially for realizing complex, multi-branch antenna-feeder systems, may be used for building cellular and wireless communication networks and other communication systems in big buildings and structures (such as stadiums, trade centers, underground parkings, subway, etc.).

Claims

1. A coupler for a coaxial cable, comprising: a coaxial line section made of a central conductor and an external conductor with a dielectric isolator arranged therebetween; a coaxial cable intended for use in the coupler is made with an insulating layer between its inner conductor and its outer conductor and with a dielectric jacket on the outer conductor, the central conductor of the coaxial line section being intended for electric coupling with the inner conductor of the coaxial cable, and the external conductor being intended for electric coupling with the outer conductor of the coaxial cable; the central conductor of the section of the coaxial line with the dielectric insulator is electrically coupled to the inner conductor of the coaxial cable via an opening made in the dielectric jacket, the outer conductor, the insulating layer and the inner conductor of the coaxial cable with the possibility of arranging the central conductor with the dielectric insulator of the coaxial line section in the opening made in the inner conductor of the coaxial cable, **characterized in that** a metal plate is introduced, which inner surface facing the dielectric jacket of the coaxial cable is made as to its shape and dimensions so as to correspond to the shape and dimensions of the dielectric jacket of the coaxial cable, the metal plate being provided at least with one connection element ensuring its mounting directly to the dielectric jacket of the coaxial cable, the opening in the dielectric jacket, the outer conductor, the insulating layer and the inner conductor of the coaxial cable being made with the diameter equal to the outer diameter of the dielectric insulator, the metal plate and the external conductor of the coaxial line section being connected therebetween and having no galvanic contact with the outer conductor of the coaxial cable.

2. A coupler according to Claim 1, **characterized in that** the central conductor of the coaxial line section is installed with the possibility of moving it along the longitudinal axis of the opening made in the inner conductor.

3. A coupler according to Claim 1, **characterized in that** the outward protruding end of the coaxial line section is made as a coaxial connector.

4. A coupler according to Claim 1, **characterized in that** the metal plate is installed on the dielectric jacket of the coaxial cable by means of the connection element - an adhesive layer.

5. A coupler according to Claim 1, **characterized in that** a second plate is introduced, which inner surface facing the dielectric jacket of the coaxial cable is made as to its shape and dimensions so as to correspond to the shape and dimensions of the dielectric jacket of the coaxial cable, the second plate being installed on the dielectric jacket of

the coaxial cable opposite to the metal plate with the possibility of forming a connection element - a clamp - by means of mounting the metal plate and the second plate with the use of screws.

6. A coupler according to Claim 1, **characterized in that** the central conductor of the coaxial line section is provided with a capacitive element made as a gap in the central conductor or in the form of a dielectric insert thereto.

7. A coupler according to Claim 1, **characterized in that** the central conductor of the coaxial line section is provided with an inductive element made as a wavy outer surface of the central conductor or in the form of a helical spiral arranged in the gap of the central conductor.

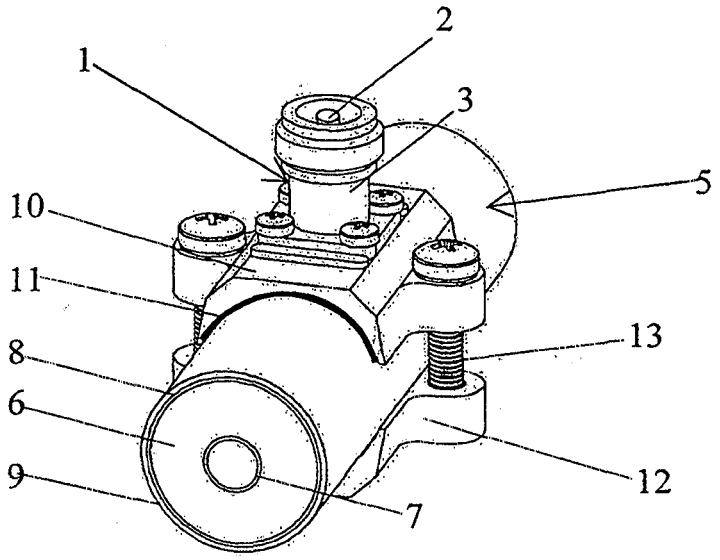


Fig. 1

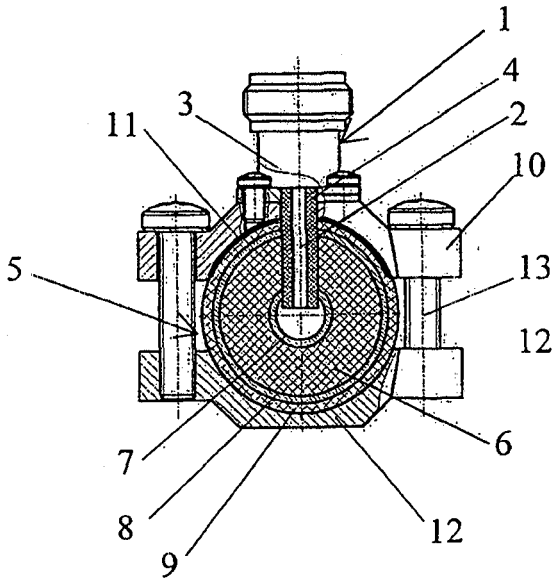


Fig. 2

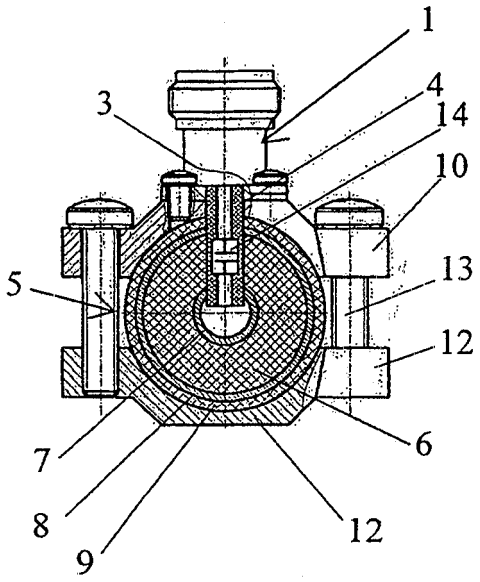


Fig. 3

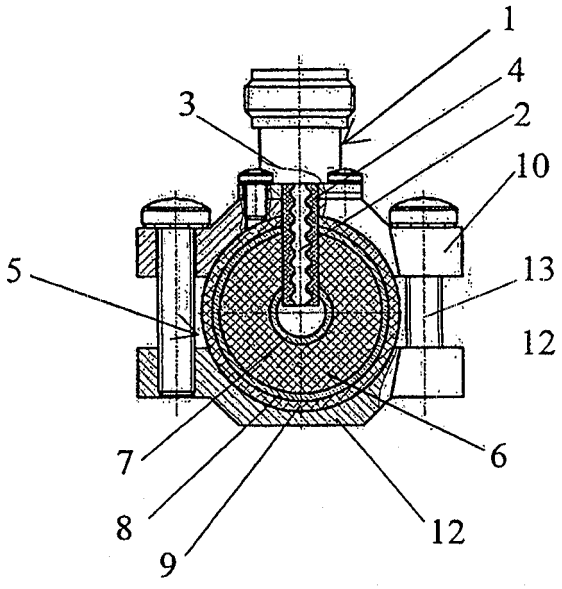


Fig. 4

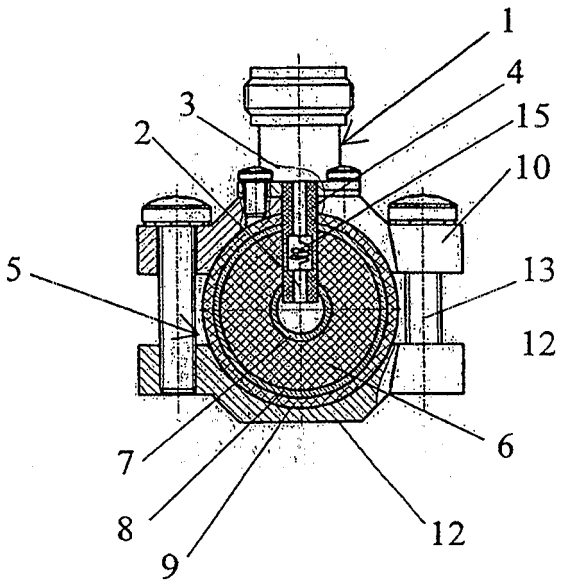
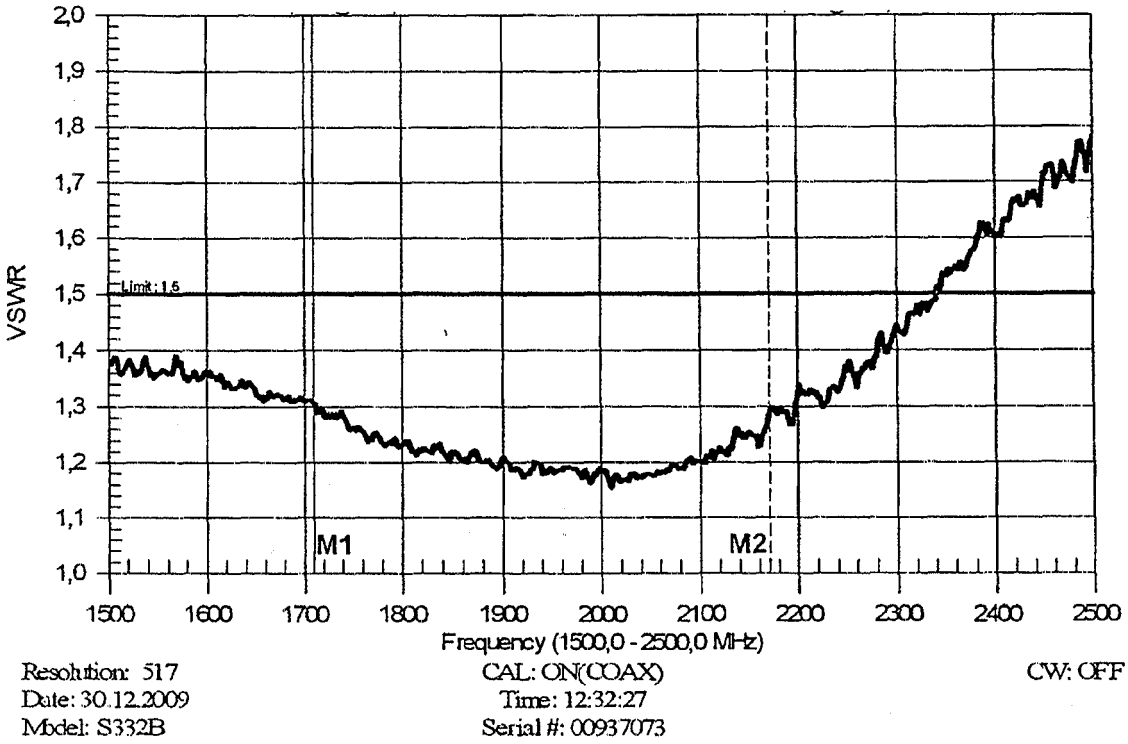


Fig. 5


VSWR
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1,8
1,7
1,6
1,5
1,4
1,3
1,2
1,1
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M2
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1900
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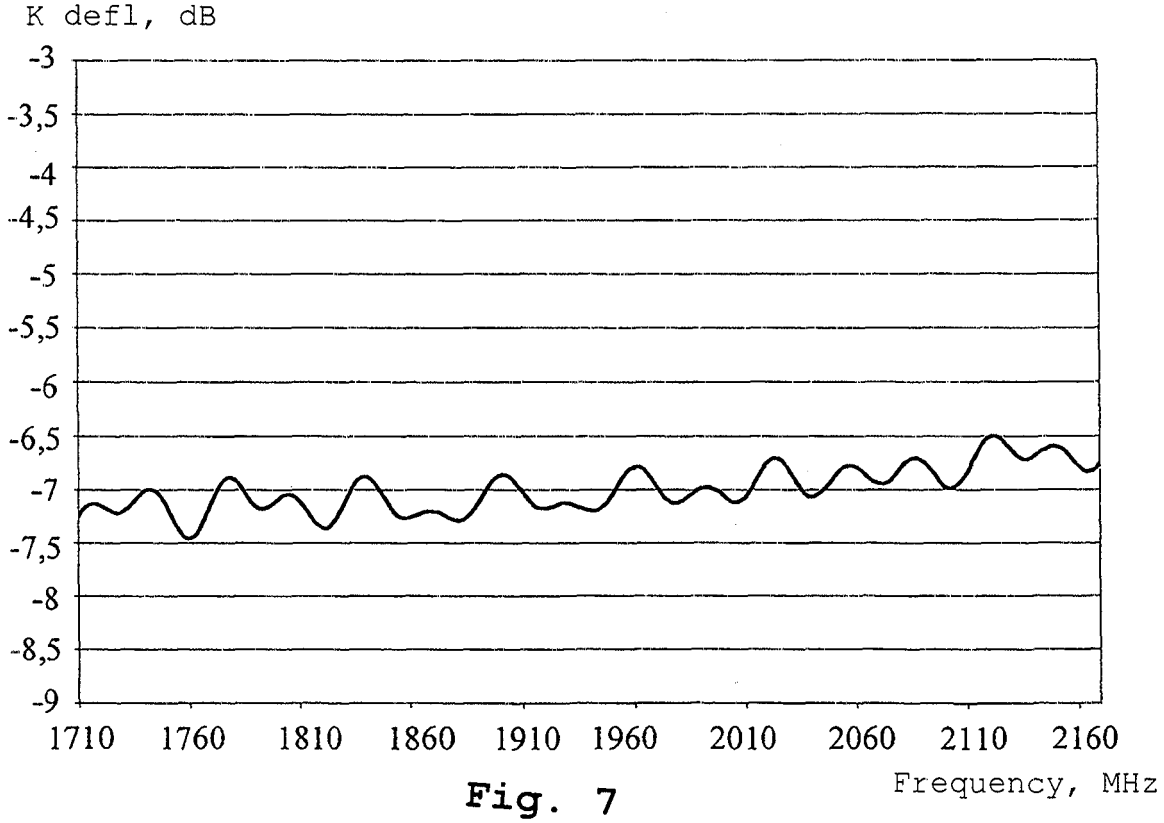
Fig. 6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-8
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-9
1710
1760
1810
1860
1910
1960
2010
2060
2110
2160
Frequency, MHz

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/RU 2010/000585

A. CLASSIFICATION OF SUBJECT MATTER

H01P 5/04 (2006.01)

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)

H01P 5/00-5/22

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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	RU 56072 U1 (ZAKRYTOE AKTSIONERNOE OBSCHESTVO "AVTOMATIZIROVANNYE NIFORMATSINNYE SISTEMY I TELEKOMMUNIKATSY) 27.08.2006	1-8
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A	JP 9275307 A (DAIICHI DENPA KOGYO KK) 21.10. 1997	1-8

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
15 March 2011 (15.03.2011)	24 March 2011 (24.03.2011)
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