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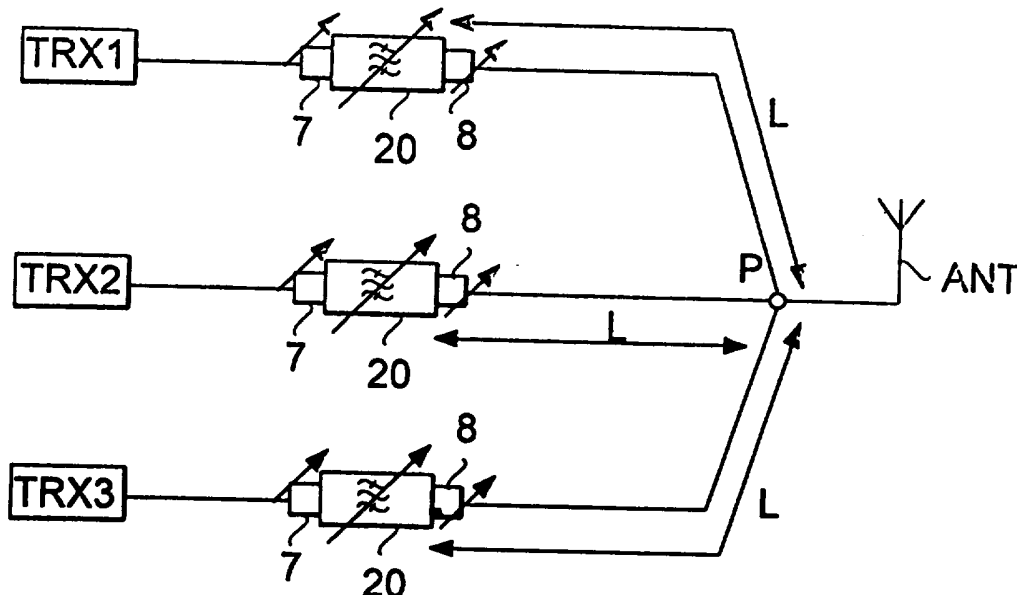
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(54) Title: METHOD FOR TUNING A SUMMING NETWORK OF A BASE STATION, AND A BANDPASS FILTER



(57) Abstract

The present invention relates to a method for tuning a summing network of a base station, which summing network consists of connectors, conductors and a filtering means (20, 20') which include input connectors (7) for receiving signals supplied by radio transmitters (TRX1-TRX3) of the base station, and output connectors (8) for feeding the filtered signals further to an antenna means (ANT). For an easy and fast tuning of the summing network, the electric length of an output connector (8) of the filtering means (20) in the summing network is adjusted. The invention further relates to a bandpass filter (20).

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Method for tuning a summing network of a base station, and a bandpass filter

5 The present invention relates to a method for tuning a summing network of a base station, which summing network consists of connectors, conductors and a filtering means which include input connectors for receiving signals supplied by radio transmitters of the base station, and output connectors for feeding the filtered signals further
10 to an antenna means. The invention further relates to a bandpass filter comprising an input connector, an output connector and a resonating means.

The invention particularly relates to a summing network for combiner filters in a base station of a
15 cellular mobile communication network. A combiner filter is a narrow-band filter which resonates exactly on the carrier frequency of a transmitter coupled to it. The signals from the outputs of the combiners are summed by the summing network and fed further to the base station
20 antenna. The summing network usually consists of a coaxial cable leading to the base station antenna, to which coaxial cable the combiner filters are usually coupled by T-branches. In order that as much as possible of the transmitting power of the transmitters can be forwarded to
25 the antenna, the summing network should be tuned with regard to frequency channels used by the transmitters of the base station. Thus, the optimal electric length of the summing network is dependent on the wavelength of the carrier wave of the signal to be transmitted. Strictly
30 speaking, a summing network is thereby tuned on one frequency only, but the mismatch does not at first increase very fast when the frequency changes away from the optimum. Thus, base stations of cellular communication systems can usually use the summing network on a frequency
35 band whose width is approximately 1 - 2 % of the center

frequency of the frequency band used by the base station. This sets very high requirements for the mechanical length of the summing network and its cabling, because the transmission lines must be of precisely the correct length in order for the summing network to be optimized on the correct frequency. In addition, the usable frequency band of a summing network is too narrow for the frequency channels of the base station transmitters to be changed very much without having to deal with the tuning of the summing network. As especially such combiner filters that are automatically tuned (by remote control) have become more common, need has arisen for simple and fast change in the tuning of the summing network. The prior art solution, according to which it was necessary for an engineer to visit the base station site and to replace the summing network cabling with a new cabling measured for the new frequency band, is understandably too expensive and time consuming a procedure.

It is an object of the present invention to solve the aforementioned problem and to provide a method for an easy and simple tuning of a summing network of a base station. This object is achieved by a summing network of the invention, which is characterized in that the electric length of an output connector of a filtering means in the summing network is adjusted.

The invention is based on the idea that it is, in conjunction with tuning of the summing network, altogether unnecessary to deal with the fixed summing network of the base station when the base station uses combiner filters or a combiner filter with an output connector whose electric length can be adjusted. Such an adjustment compensates for a wavelength error caused by different wavelengths in the fixed summing network, whereby by adjusting the electric length of the output connector it is possible to maintain the combined electric length of

the cable connected to the summing point of the summing network and the connector of the filter always correct, i.e. $L=n*\lambda/4$ where $n = 1, 3, 5 \dots$, and $\lambda =$ the wavelength in the cable. Thus, the most significant advantage of the method of the invention is that the mechanical length of the summing network cabling becomes less significant, because errors in the cable measures can be corrected by adjusting the output connector of the filter. This makes the tuning of the summing network easier and faster, and, furthermore, the costs of cabling decrease due to less strict tolerance requirements.

The invention further relates to a bandpass filter which is characterized in that the bandpass filter comprises adjusting means for changing the electric length of the connector belonging to it. In the filter of the invention, advantageously at least the electric length of the output connector is adjustable. In addition, the input connector of the filter may be adjustable as well, whereby it is in some cases possible to improve other parameters (passband attenuation, bandwidth and group propagation delay) of the filter to remain constant.

In a preferred embodiment of a filter according to the present invention, the filter connector interacts with the resonating means through a microstrip conductor. Consequently, the electric length of the connector depends on the electric length of the microstrip conductor, which, in turn, depends on its effective dielectric constant. Thus, the electric length of the filter connector can be changed very simply, i.e. by influencing the effective dielectric constant of the microstrip conductor.

In a second preferred embodiment of the filter according to the present invention, the effective dielectric constant of the microstrip conductor is adjusted mechanically, i.e. the microstrip conductor is arranged between an object made of an insulating material

and an object made of dielectric, advantageously ceramic, material. Consequently, the main portion of the electromagnetic field of the microstrip conductor appears between the microstrip conductor and the ground plane ($Z_0 \leq 50$ Ohm), and the rest above it. If the weaker stray field above the microstrip conductor is changed, for example by changing the dielectric constant of the medium effecting the stray field by means of introducing in it ceramic material with a high dielectric constant, the effective dielectric constant of the microstrip conductor also changes, and, consequently, so does its electric length. So, by moving said ceramic material by means of, for example, an adjusting screw, so that the area of the microstrip conductor covered by it alters, the electric length of the connector of the filter can be changed. This type of mechanical adjusting according to the invention is very advantageous in conjunction with a dielectric resonator, because the same adjusting screw can be used for changing the resonance frequency of the resonator and the electric length of the connector.

In a third preferred embodiment of the filter according to the invention, the effective dielectric constant of the microstrip conductor is adjusted by an electric adjustment. This means that the microstrip conductor is arranged against the surface of an object at least partly made of material whose dielectric constant depends on the field strength of a surrounding electric field. As the dielectric constant of said object alters, the effective dielectric constant of the microstrip conductor consequently changes. So, by adjusting the field strength of the electric field surrounding the microstrip conductor, the electric length of the connector of the filter can be changed.

The preferred embodiments of the method and the bandpass filter of the invention are disclosed in the

attached dependent claims 2 and 4 - 9. In the following, the invention will be described in closer detail by means of some preferred embodiments of the bandpass filter according to the invention, with reference to the accompanying drawings in which

figure 1 shows a block diagram of a summing network of a base station,

figure 2 illustrates the first preferred embodiment of the filter according to the invention,

figure 3 shows the filter illustrated in figure 2 cut along line III - III of figure 1,

figure 4 illustrates the second preferred embodiment of the filter according to the invention,

figure 5 shows the circuit board illustrated in figure 4 cut along line V - V.

Figure 1 is a block diagram of a summing network of a cellular communication system, such as the GSM. Transmission units TRX1 - TRX3 of figure 1 use a common antenna ANT for transmitting and receiving radio signals. For each transmitter, a separate combiner filter 20 is arranged in the base station. Said combiner filter 20 consists of a tunable bandpass filter, and the transmitters feed the RF signals to be transmitted to its input connector 7. The output connectors 8 of the bandpass filters 20 are connected by coaxial cables to a summing point P from which the signals supplied by the transmitters are further fed to the antenna ANT.

In the summing network of figure 1, tunable combiner filters 20 are used, whereby the operator is able to change the resonance frequency of the filters to correspond to the center frequency of the frequency band used by the transmitter unit coupled to it. Alternatively, a control unit which automatically adjusts the filters may be located in connection with the filters.

In addition, the electric length of the input and

output connectors 7 and 8 of the filters in figure 1 is adjustable. Consequently, the cabling of the summing network in figure 1 need not be changed in order to tune the summing network. In figure 1, the tuning of the summing network is carried out by adjusting the electric length of the output connector 8 of each combiner filter 20 so that the combined electric length of the output connector and the coaxial cable interconnecting the output connector of said filter to the summing point P is $L = n \cdot \lambda / 4$, where $n = 1, 3, 5 \dots$, and $\lambda =$ wavelength in the coaxial cable. Adjusting the electric length of the input and output connectors 7 and 8 may in the case of figure 1 be automatically carried out in connection with changing the tuning frequency of the filter 20, for example by remote control from the control room of the system.

Figure 2 illustrates the first preferred embodiment of the filter according to the invention, in which the electric length of the connectors of the filter 20 is adjusted mechanically. Figure 1 shows a side view of the bandpass filter 20 whose frame structure consists of a closed metal casing 1 which is connected to ground potential. Figures 2 and 3 show the casing 1 cut open. An adjustable dielectric resonator consisting of two ceramic disks, 2 and 3, has been arranged in casing 1. The disks have been placed one above the other so that their surfaces face one another. The term disk in this context refers to an essentially cylindrical object which may, however, have tabs or other minor deviations from the cylindrical form.

In figure 2, the lower, an essentially cylindrical disk 2 is bonded to the casing 1 by means of circuit board 5 attached to the casing 1 wall. The circuit board is made of an insulating material, but its top and bottom surface may contain areas that are made of conductive material and connected to ground potential (as in figure 3). The upper

disk 3 can be moved above the lower disk 2 by means of the adjusting screw 4 which goes through the casing 1 wall. As the screw 4 is turned, the upper disk in figure 1 moves horizontally. As a response to said movement, the resonance frequency of the dielectric resonator changes. The structure, operation and the ceramic materials the adjustable dielectric resonators are made of are described, for example, in the following publications, which are incorporated herein by reference:

(1) "Ceramic Resonators for Highly Stable Oscillators", Gundolf Kuchler, Siemens Components XXXIV (1989) No. 5, p. 180-183

(2) "Microwave Dielectric Resonators", S. Jerry Fiedziuszko, Microwave Journal, September 1986, p. 189-.

(3) "Cylindrical Dielectric resonators and Their Applications in TEM Line Microwave Circuits", Marian W. Pospieszalski, IEEE Transactions on Microwave Theory and Techniques, Vol. MTT-27, No. 3, March 1979, p. 233-238.

(4) Finnish Patent 88 227, "Dielektrinen resonaattori".

Figure 3 shows the filter illustrated in figure 2 cut along the line III - III of figure 2, i.e. figure 3 shows the filter from above. Figure 3 shows that there is a hole in the circuit board 5 to which the resonator disks 2 and 3 are arranged. In addition, figure 3 shows that the tabs of the upper disk 3 slide along the surface of the circuit board 5.

The input and output connectors 7 and 8 of the filter are connected to the microstrip conductors 9 and 10 on the surface of the circuit board 5. The microstrip conductors 9 and 10 can be made of some highly conductive material, such as copper, aluminum or gold alloys. In figure 3, the tabs 6 of the upper disk 3 cover a portion of the surface area of the microstrip conductor. The effective dielectric constant and the electric length of the microstrip conductors depend on the size of said area.

As the adjusting screw 4 is turned, the upper disk 3 moves with regard to the fixed lower disk 2, and consequently the tabs 6 move with regard to the microstrip conductors 9 and 10 causing said area to alter. Thus, the tuning frequency of the bandpass filter 20, and the electric length of its input connector 7 and output connector 8 simultaneously changes by one single adjusting means, i.e. the screw 4.

Figure 4 illustrates a second preferred embodiment of the filter according to the present invention. The bandpass filter 20' is housed in a metal casing 1. The lower disk 2 of the dielectric resonator within the filter is essentially cylindrical and attached to a fixed position with regard to the bottom 11 of the casing 1 by means of a support made of dielectric material (not shown in the figure). The upper disk 3 of the resonator is arranged to be moved with regard to the lower disk 2, as in figure 2. The upper disk can be moved by means of the adjusting screw 4 which is operated by a stepping motor 12 under control of a control unit 13.

In figure 4, in connection with the input and output connectors there are two circuit boards 14 having a bedded structure arranged on the casing wall, and the microstrip conductors 9 and 10 are arranged on the surface of the circuit boards. A portion of the circuit board 14 surface is covered with conductive boards 21 that are connected to the grounding by the casing wall. Below the circuit boards there are similar boards 18 (cf. figure 5). The boards above and below are coupled in points indicated by dots on boards 21.

Below the microstrip conductors 9 and 10 there is in the circuit boards 14 a layer made of ferroelectric material, the dielectricity of which layer depends on the magnitude of the surrounding electric field. Such material, Ba-Sr-TiO₃-based, for example, is commercially

available. In order to create an electromagnetic field, there are feedthrough capacitors 15 arranged in the casing 1 wall for feeding the DC signal VC produced by the control unit 13 to the feed coils 16 which are connected to the microstrip conductors 9 and 10, and additionally decoupling capacitors 17, whose one pole is grounded by the boards 21, are arranged in the ends of the microstrip conductors.

Figure 5 illustrates a section of the circuit board 14 of figure 4 cut along the line V - V. Thus, the circuit board has been cut at the microstrip conductor 10. Figure 5 shows that the circuit board 14 is comprised of a dielectric layer 17 with a conductive layer 18 made of ferroelectric material and connected to the grounding arranged on its bottom surface. On the top surface of the dielectric layer 17, a ferroelectric layer 19 is arranged, and on said layer 19 another copper layer is arranged, i.e. the microstrip conductor 10, which is coupled to the feed coil 16 in order to produce a positive charge.

The ferroelectric layer 19 is thus located in a electromagnetic field produced between the copper surface layers (electrodes) 18 and 10, whereby the control unit 13 may change its dielectric constant by adjusting the DC signal VC. Consequently, the effective dielectric constant and, as a result, the electric length of the microstrip conductor 10 change.

It should be understood that the description and the attached drawings are only meant to illustrate the present invention. Different kinds of variations and modifications will be obvious for a person skilled in the art without departing from the scope and spirit of the attached claims. Thus, it is obvious for a person skilled in the art that, instead of a dielectric resonator, another kind of a resonator may be used in a bandpass filter according to the invention, for example, a

waveguide resonator or a coaxial resonator, and that the adjustment of the filter output connector may also be carried out by adjusting means arranged outside of the filter casing.

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Claims

1. A method for tuning a summing network of a base station, which summing network consists of connectors, conductors and a filtering means (20, 20') which include input connectors (7) for receiving signals supplied by radio transmitters (TRX1-TRX3) of the base station, and output connectors (8) for feeding the filtered signals further to an antenna means (ANT), characterized in that the electric length of an output connector (20, 20') of a filtering means in the summing network is adjusted.

2. A method as claimed in claim 1, characterized in that the electric length of the output connector (8) is adjusted by changing the effective dielectric constant of a microstrip conductor (10) belonging to it.

3. A bandpass filter (20, 20') comprising an input connector (7), an output connector (8) and a resonating means (2, 3), characterized in that the bandpass filter (20, 20') comprises adjusting means (3, 4, 6, 12, 13, 15-17) for changing the electric length of the connector (7, 8) belonging to it.

4. A bandpass filter as claimed in claim 3, characterized in that said connector (7, 8) interacts with the resonating means (2, 3) through the microstrip conductor (9, 10), whereby said adjusting means (3, 4, 6, 12, 13, 15-17) is arranged to change the effective dielectric constant of a microstrip conductor (9, 10) in order to change the electric length of the connector (7, 8).

5. A bandpass filter as claimed in claim 4, characterized in that the filter (20) comprises an object (5) of an insulating material onto whose surface the microstrip conductor (9, 10) is

arranged, and that the adjusting means comprise a displaceable dielectric object (3) which is arranged to the opposite side of the microstrip conductor (9, 10) with regard to the object (5) of the insulating material so that it covers at least a portion of the area of the microstrip conductor (9, 10), and that the adjusting means further comprises means (4) for moving the displaceable object (3) with regard to the microstrip conductor (9, 10) in order to alter said area so that the effective dielectric constant and the electrical length of the microstrip conductor (9, 10) change.

6. A bandpass filter as claimed in claim 5, characterized in that the resonating means is a dielectric resonator consisting of two disks (2, 3) made of dielectric material and arranged so that their surfaces face each other, that one of the disks (3) can be moved radially with regard to the other disk (2) in order to adjust the resonance frequency of the resonator, and that said displaceable object consists of the disk (3) which can be moved, and which covers at least a portion of the area of said microstrip conductor (9, 10).

7. A bandpass filter as claimed in claim 5 or 6, characterized in that said dielectric material is a ceramic material, and that said object (5) of the insulating material is a circuit board.

8. A bandpass filter as claimed in claim 4, characterized in that the microstrip conductor (9, 10) is arranged on the surface of such an object (14) which is at least partly made of material (19) whose dielectric constant depends on the field strength of a surrounding electromagnetic field, whereby the adjusting means comprises means (13, 15 - 17) for producing a magnetic field with adjustable field strength.

9. A bandpass filter as claimed in any one of claims 4 - 9, characterized in that the

bandpass filter (20, 20') is housed in a casing (1) made of a conductive material, advantageously of metal.

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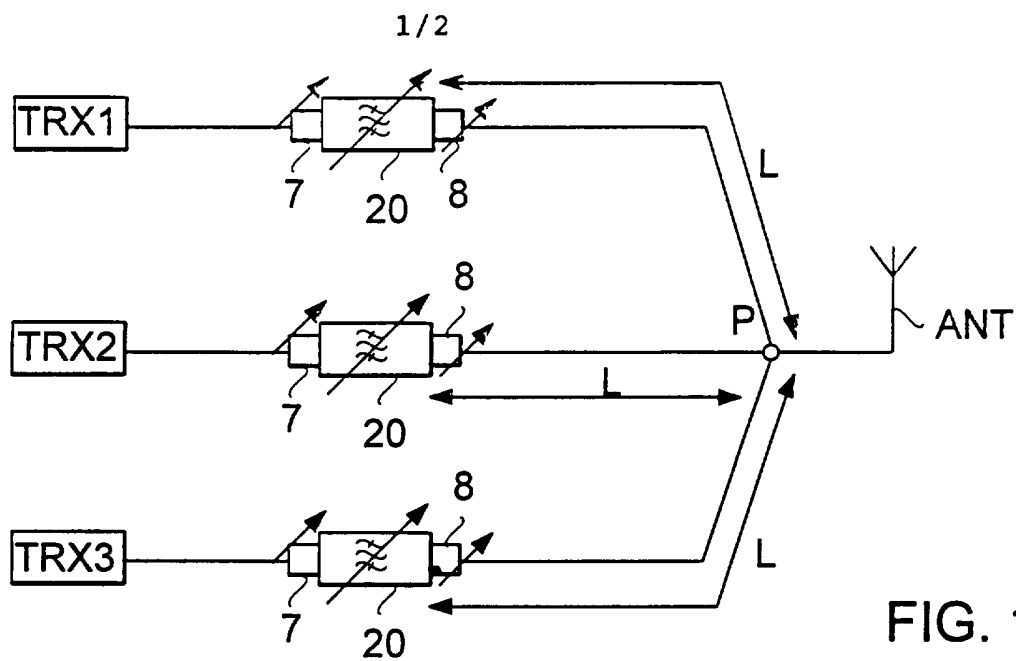


FIG. 1

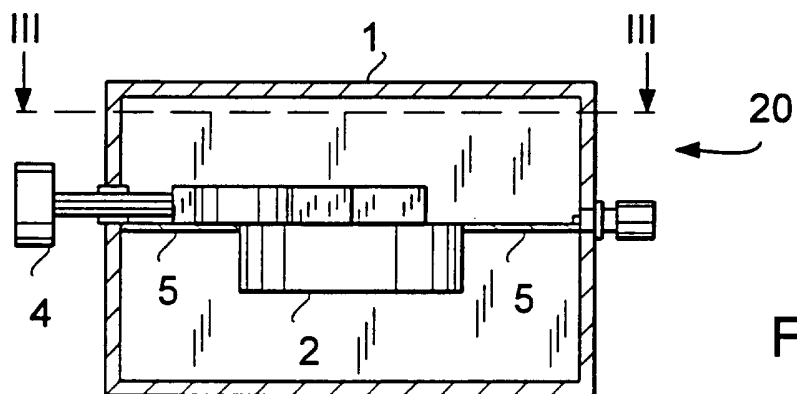


FIG. 2

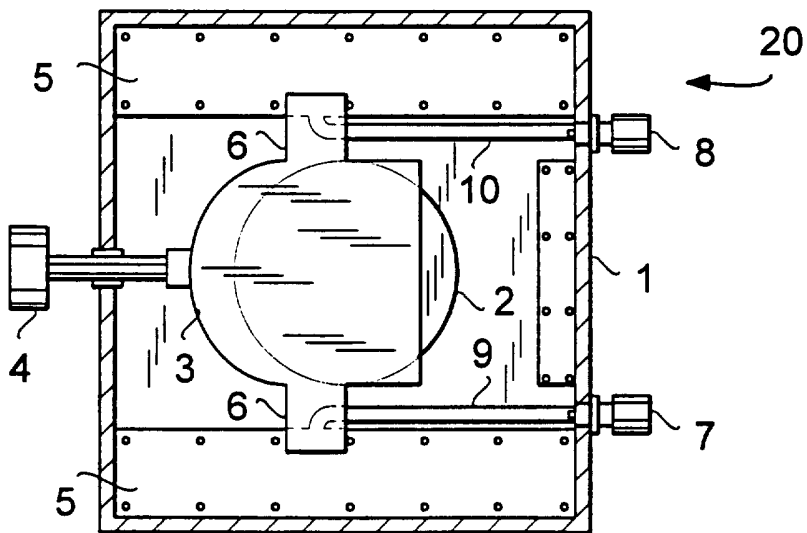


FIG. 3

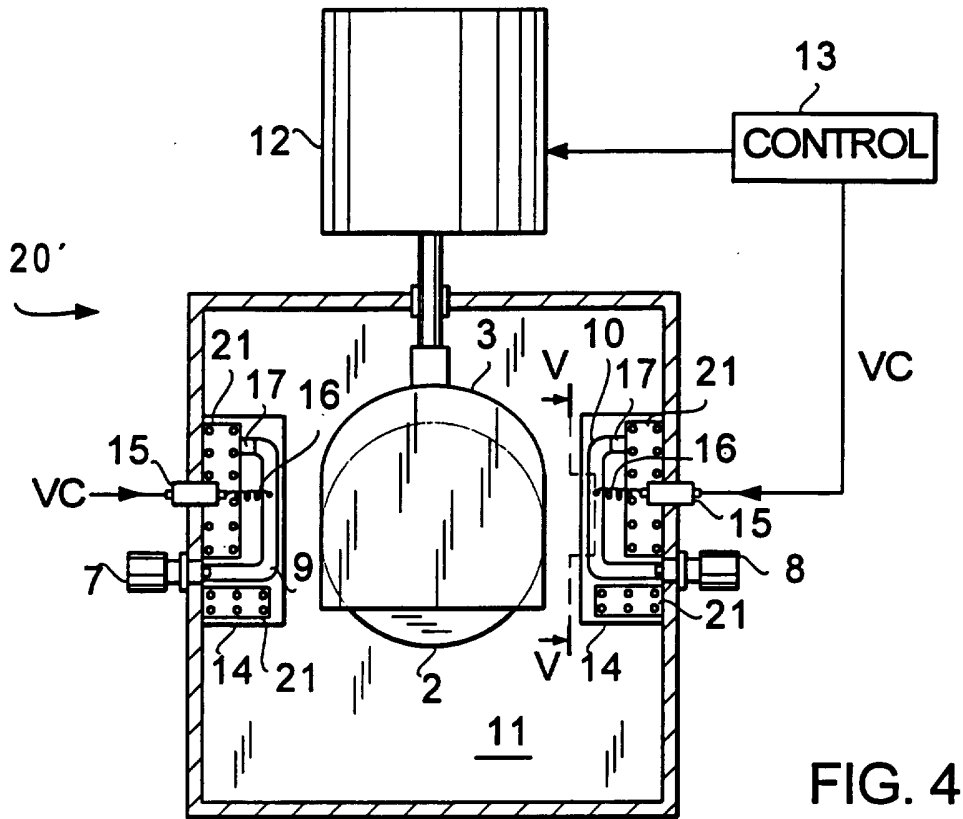


FIG. 4

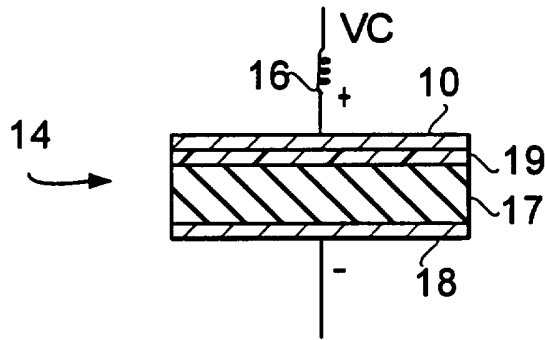


FIG. 5