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(54) **ARRANGEMENT AND METHOD RELATING TO FILTERING OF SIGNALS**

ANORDNUNG UND VERFAHREN ZUR FILTERUNG VON SIGNALEN

CONFIGURATION ET METHODE CONCERNANT LE FILTRAGE DE SIGNAUX

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Description

TECHNICAL FIELD

[0001] The present invention relates to superconducting filter arrangements, particularly notch filters or band reject filters which comprise a superconducting dielectric resonator and a waveguide arrangement such as e. g. a microstrip line.

[0002] One of the applications of notch filters or band reject filters is within communications systems. A particular application of such relates to multichannel microwave communications systems which operate in high frequency bands in which the size of the components is highly important.

[0003] The invention also relates to a method for filtering signals incoming to a receiving arrangement in a multichannel communication system.

STATE OF THE ART

[0004] Since for example frequency multiplexers, band reject filters etc. are among the key elements in multichannel communication systems, efforts have been made to find a way to reduce the insertion losses and the size of these components. For multichannel microwave communication systems operating in the 1-3 GHz frequency band insertion losses are high for presently used devices.

[0005] It is known to use YIG (Yttrium Iron Garnet) notch filters in the front end of microwave receivers to blank out intermittent interfering signals. However, the insertion losses are high. Moreover the size of such filters is large. In "High-Temperature Superconducting Microwave Devices", by Shen, Artech House, 1994 the use of high temperature superconductors is discussed for providing new possibilities to reduce the size and to improve the performance of microwave components, for example filters.

[0006] European Patent Application EP-A-0 567 407 discloses superconducting notch filters with a fixed frequency wherein half wavelength, high temperature superconducting microstrip resonators are parallel coupled to the main high temperature superconducting microstrip line. The substrates of the resonators have dielectric constants of about 10-25 at frequencies between 1-3 GHz. The length of the filters is then about 2-6 cm; the filters are thus very large and they are also expensive.

[0007] In some communication systems tuneable (switchable) notch filters are required instead of fixed frequency notch filters e.g. in order to increase the flexibility of the system. US-A-4,834,498 shows a simple dielectric resonator. The resonator is passive and it is not itself tunable. To provide tunability additional tuning means are required such as a diode or similar. In other words, a separate biasing circuit is required. This considerably adds to the size of the arrangement. Further-

more, the device as such gets complex and the performance is not sufficiently high. In WO 93/00720 a superconducting notch filter with a microstrip resonator which is not tunable itself is illustrated. In this case optical means are used to provide tuning, which use semiconductor crystals in superconducting microstrip ring resonators coupled to the main superconducting microstrip. However, the dimensions of these arrangements are large and moreover the frequency tuning range is much too small. Both of the above mentioned documents show passive resonators and devices requiring a special bias network and additional tuning means which are coupled to a main microstrip line in the same way. The resonators cannot be in mechanical or electrical contact with the main microstrip line. If there is no coupling, there is no filter.

[0008] To summarize, both these devices need additional tuning means with a separate biasing circuit. That makes the designs large as well as complex. Furthermore, the electrical performance of the filter is negatively affected therethrough and it is also as such not as high as would be desired. E.g. for frequencies of about 1-3 GHz the devices as disclosed in these documents would be much too large and they cannot for example be used for telecommunication purposes.

[0009] It has also been found that microwave devices can be made smaller if high dielectric constant non-linear dielectric materials such as for example Strontium Titanate (STO) are plated with superconductors such as e.g. Y-Ba-Cu-O (YBCO). WO 94/13028 discloses the use of thin single crystalline dielectric films in combination with high temperature superconductors which as such however produce too high microwave losses and moreover such devices cannot be made small enough.

SUMMARY OF THE INVENTION

[0010] What is needed is therefore a superconducting notch filter arrangement which has low insertion losses, small dimensions and which is tuneable. Particularly an arrangement is needed which is tuneable within a large frequency range. Moreover an arrangement is needed which is cheap and easy to fabricate. Still further an arrangement is needed which has a high performance as stated above has low losses, particularly low microwave losses (in the case of microwaves); it can also be used for millimeter-waves.

[0011] A method for filtering signals incoming to for example receiving arrangements in a multichannel microwave communication system operating at high frequencies is needed through which intermittent and interfering signals can be blanked out in an efficient and reliable manner.

[0012] Therefore a superconducting notch filter arrangement is provided which comprises a resonator arranged on a microstrip line wherein the resonator is a parallel-plate resonator with a chip of a non-linear dielectric material on which superconductors are arranged.

The resonator is connected to connecting means of a microstrip line or a strip of the microstrip line in such a way that an ohmic contact is provided. Through the use of a parallel-plate resonator it can be arranged on top of a microstrip line, coupling is provided and the dimensions can be reduced. No special bias network is needed and no additional tuning means. The arrangement is particularly electrically tuneable, still more particularly through the application of a DC biasing voltage to the non-linear dielectricum of which the dielectric constant can be changed. In a particular embodiment a DC voltage is applied to normal conductors which may be arranged on the superconductors arranged on the dielectricum of the resonator. Advantageously contact means, also denoted coupling means, are arranged to provide for dielectrical contact between the resonator and the microstrip line. In an advantageous embodiment the contact means are formed by the central strip of the microstrip line.

[0013] In a particular embodiment a resonator comprises a rectangular (or some other shape) chip which is so oriented in relation to the microstrip line that the magnetic field lines of the microstrip line and the resonator substantially coincide in such a way that maximum inductive coupling is produced.

[0014] The inductive coupling is particularly controlled or given by the relation between the resonator and microstrip line. Even more particularly the strength of the inductive coupling is given by the width of the central microstrip. To obtain the desired strength of coupling, the width can thus be given the value which provides the desired coupling.

[0015] According to a particular embodiment at least a portion of the lower plate of the parallel-plate resonator and/or the microstrip connecting means, for example the central strip, has/have a first width that is smaller than a second width in order to provide an increased inductive coupling.

[0016] According to one embodiment the resonator is a dual mode resonator or even more particularly it is a multimode resonator.

[0017] However, dual mode operation is advantageously produced through the introduction of an asymmetry in the resonator. This asymmetry may for example comprise a cut away corner or a protrusion or anything else. According to another embodiment the resonator may be arranged so as to form an angle with the main microstrip line. The angle may for example take the value of approximately 45°.

[0018] According to still another embodiment the waveguiding arrangement may comprise a coplanar waveguide. The coupling strength is controlled by or given by the width of the central strip and of the coplanar waveguide slots.

[0019] The tuning is advantageously provided (which relates to all embodiments) through the application of a DC biasing voltage which may be applied between the upper plate of the resonator and the coupling means, e.

g. the central strip of the microstrip line.

[0020] According to an advantageous embodiment the area of the resonator may have a size between approximately 1 mm²-1 cm². However, these values are merely given for exemplifying reasons, the resonator may also have other proportions, smaller as well as somewhat bigger.

[0021] Furthermore a method is given for filtering signals incoming to for example a receiving arrangement of a multichannel communication system or similar. The method comprises the steps of: arranging a filter on the input side of a receiving arrangement, which filter comprises a parallel-plate resonator comprising a non-linear dielectricum on which superconductor plates are arranged, which is arranged on a waveguide, e.g. a microstrip line. The resonator and the waveguide arrangement are connected electrically in series through the use of coupling means. The coupling strength is given by how the resonator and the coupling means are arranged in relation to each other. A DC biasing voltage is applied to the resonator and the coupling means for frequency tuning. The steps are carried out so that intermittent interfering signals can be blanked out.

[0022] It is among others an advantage of the invention that it is possible to make notch or band reject filters having dimensions which are considerably smaller and more compact than hitherto known filters. It is also an advantage that the frequency tuning range is large. Furthermore, it is an advantage that the resonator is tunable itself so that no additional or separate tuning means are needed.

[0023] It is also an advantage that it is less complex than known arrangements and that it can be made small enough to be used in telecommunications systems.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] The invention will in the following be further described in a nonlimiting way under reference to the accompanying drawings in which:

- FIG 1 illustrates an example of a parallel-plate resonator,
- FIG 2 schematically illustrates a first embodiment of a tuneable notch microstrip filter,
- FIG 3 is a cross-section of the notch filter of Fig 2,
- FIG 4 illustrates an equivalent circuit of the notch filter of Fig 2,
- FIG 5 is a diagram illustrating the temperature dependence of the central frequency of a particular notch filter,
- FIG 6a schematically illustrates a cross-section of a second embodiment of a notch filter,

- FIG 6b is a longitudinal cross-section of the lower plate of the resonator,
- FIG 6c is a longitudinal cross-section of the central microstrip line of the filter according to Fig 6a,
- FIG 7 illustrates an embodiment of a two-pole notch filter,
- FIG 8 is a further embodiment relating to a two-pole notch filter, and
- FIG 9 schematically illustrates a coplanar waveguide notch filter.

DETAILED DESCRIPTION OF THE INVENTION

[0025] According to the invention a resonator is arranged on a waveguide arrangement. Fig 1 shows a first example of a parallel-plate resonator that can be used. The resonator 11 comprises a dielectricum 12 in the form of a rectangular chip of a non-linear dielectricum on both surfaces of which thin high temperature superconducting HTS films 13a, 13b are arranged. One of the plates of the resonator is connected electrically, DC, ($R=0$) to the microstrip line. Magnetic coupling means or DC contact means are arranged in such a way that the filter rejection band and central frequency can be electrically controlled. The superconducting films or plates 13a, 13b may advantageously be partly or completely covered by normal conducting films 14, 14 for example of Au thus forming ohmic contacts for DC biasing. According to an advantageous embodiment, the dielectric material comprises a non-linear dielectric bulk material since for bulk material the microwave losses are lower and the dielectric constant is higher than for example for thin dielectric films. Through the use of a non-linear dielectric material, electrical controlling is enabled.

[0026] The microwave losses of for example Strontium Titanate, hereinafter referred to as STO are close to minimum at the temperature of liquid nitrogen, N_{liq} which is discussed in "Dielectric properties of single crystals of Al_2O_3 , $LaAlO_3$, $NdGaO_3$, $SrTiO_3$ and MgO at cryogenic temperatures", by Krupka et al., in IEEE Trans. Microwave Theory Techn., 1994, Vol. 42, pp. 1886-1890. The dielectric constant of STO is about 2000 at the temperature of N_{liq} and it is strongly dependent on temperature and on applied electric DC fields. This is discussed in "1 GHz tuneable resonator on bulk single crystal $SrTiO_3$ plated with $YBa_2Cu_3O_{7-c}$ films", by O. Vendik in Electron. Lett., 1995, Vol. 31, No. 8, pp. 654-656. Since the dielectric constant is extremely high, the wavelength in a microwave transmission line based on STO at the temperature for N_{liq} in the frequency band 1-3 GHz is about 0.2-0.6 cm. The superconducting transition temperature T_c for HTS such as for example YBCO is well above the temperature of N_{liq} and it is also well known that HTS films grown on STO substrates

have a low surface resistance which is discussed in the article cited above by Shen. The resonator may advantageously comprise a non-linear bulk dielectric material 12 e.g. by STO which is covered by HTS films of e.g. YBCO. Of course it is also possible to make the resonators in other ways, but this relates to a particularly advantageous embodiment. If e.g. STO and superconductors are used, the microwave losses are very low. The superconducting films or plates 13a, 13b of the parallel-plate resonator are made slightly smaller than the dielectric chip 12 in order to account for mechanical tolerances and for the provision of an improved ability of controlling the resonant frequency. The thickness of the superconducting plates 13a, 13b exceeds the London penetration depth, the penetration depth being defined as the depth at which the field has decreased to $1/e$ of the value at the surface.

[0027] Fig 2 shows a first embodiment of a tuneable notch filter 10 according to the invention. The resonator 11 of Fig 1 is arranged on a waveguiding arrangement 15 in the form of a microstrip line. The resonator 11 is in this embodiment connected to or attached to the central strip 18 of the microstrip line 15 wherein said central strip 18 acts as the contact means or couplings means providing ohmic contact between the lower plate 13b of the parallel-plate resonator 11 and the microstrip line 15. No special bias network, no additional tuning means are required. The microstrip line 15 comprises a substrate e.g. of Al or any other known dielectricum for μw -strips. The ground plane 17 comprises e.g. Cu, Au or anything similar having normal conductivity. However, in a very advantageous embodiment the ground plane 17 and the central strip 18 comprise HTS films. The parallel-plate resonator chip 11 is so arranged in relation to the microstrip line 15 that the magnetic field lines of the microstrip 18 and the resonator 11 substantially coincide (c.f. Fig 3) thus ensuring a high degree of inductive coupling, or more precisely maximum inductive coupling. The width of the central microstrip 18 determines the coupling strength between the resonator 11 and the microstrip line 15 and thus the coupling strength can be controlled through choosing the appropriate width. The width can in advantageous embodiments be approximately in the range between 0.5-1 mm, but it can also have a smaller or larger width. Thus, in this way a series resonant circuit is introduced into the microstrip line 15 which then acts as a band reject filter, i.e. a notch filter for input microwave signals. Connection means 19, 19 are provided through which a DC biasing voltage can be applied between the microstrip and the upper plate 13a of the parallel-plate resonator 11. In this way electrical tuning is provided and the DC biasing voltage applied to the non-linear dielectric 12 changes the dielectric constant thereof and thus the resonant frequency of the parallel-plate resonator 11.

[0028] One of the resonator plates is advantageously in mechanical or electrical contact with the main microstrip line. The main microstrip is advantageously used

as a bias terminal for DC-biasing. This is in contrast to e.g. US-A-4,835,498 and WO-A-93/00720, wherein the resonator could not be in contact with a main microstrip line.

[0029] According to another embodiment, not further discussed herein, temperature controlled tuning can be applied either in addition to the electrical tuning or as an alternative thereto. Optical or mechanical (e.g. via piezoelectric means) tuning can of course also be used.

[0030] Fig 3 is a cross-sectional view of the notch filter 10 as illustrated in Fig 2. It shows how the resonator 11 is arranged on the central microstrip 18 of the microstrip line 15. H denotes the magnetic field lines of the resonator and of the microstrip line. As discussed above, the magnetic field lines substantially coincide thus providing a high degree of coupling between the resonator 11 and the microstrip line 15.

[0031] Fig 4 schematically shows an equivalent circuit of the notch filter 10 as illustrated in Figs 2 and 3 above. Z_0 indicates the impedance of the microstrip whereas the dashed line is the circuit representation of the resonator 11. In a particular embodiment, the resonator is a STO resonator plated with YBCO films as discussed above and the dielectricum in this particular embodiment has the dimensions $2.5 \times 2.5 \times 0.5 \text{ mm}^3$. In this embodiment the waveguide arrangement comprises a 50 Ohm copper microstrip on a 0.5 mm aluminium substrate. Of course this is only one example and other materials can be used, the dimensions can be different etc. Moreover, the parallel-plate resonator does not have to be rectangular but it can also take other forms, square shaped, an oval etc. However, Fig 5 shows a diagram of the temperature dependence of the center frequency of a notch filter having the above mentioned dimensions and no biasing voltage is applied.

[0032] In Fig 6a an alternate embodiment of a notch filter 20 is illustrated. A resonator 21, also in this case comprising a non-linear dielectric bulk material 22 plated with thin superconducting films 23a, 23b which in turn are covered by normal conducting layers 24a, 24b for example from Au, is arranged on a microstrip line 25. The microstrip line 25 comprises a substrate for example of Al. On one of its surfaces e.g. a copper microstrip 27 is arranged whereas on the other side of the substrate a central microstrip 28 is arranged. The central microstrip 28 forms the contact means or the connection means between the resonator 21 and the microstrip line 25. In this embodiment an inductive loading is provided through a second section 23b₂ of the lower resonator plate 23b having a smaller width than a first section 23b₁. Also the microstrip 28 is provided with a second section 28b the width of which is smaller than the width of the first section 28a. Figs 6b and 6c are longitudinal views seen from above of the lower plate of the resonator and the microstrip respectively, the arrangement which is illustrated in Fig 6a indicating the portions 23b₂ and 28b each having a smaller width.

[0033] Fig 7 very schematically illustrates a two-pole

notch filter. A resonator 31 (e.g. as discussed under reference to previous embodiments) is arranged on a microstrip line 35. One of the corners of the upper superconducting film 33a is cut away; thus producing an asymmetry in the resonator. 32 indicates the dielectricum. Since one of the corners of the upper superconducting film 33a is cut off, it is achieved that the resonator 31 can operate in a dual mode. Thus the width of the rejection band and its skirts can be adapted to the current needs.

[0034] Fig 8 shows still a further embodiment of a two-pole notch filter 40. In this case a resonator 41 (c.f. above) is arranged on the microstrip line 45 in such a way that it forms an angle with the microstrip line. In this particular case the parallel-plate resonator 41 forms an angle of 45° with the main microstrip. Since an asymmetry is introduced, the resonator also in this case operates in dual mode. The angle does of course not have to be 45° but it can take a higher as well as a lower value; in principle any angle but 90° .

[0035] The invention can in principle also be applied to multimode filters for example operating in three modes. Such an arrangement is illustrated in the at the same time filed Swedish Patent Application "Arrangements and methods relating to multiplexing/switching" having the same applicant, the subject matter of which is incorporated herein by reference.

[0036] Fig 9 schematically illustrates yet another embodiment comprising a coplanar waveguide (CPW) tuneable notch filter 50, which also can be dual mode operating. A superconducting parallel-plate resonator 51 is attached to the central strip 58 of a coplanar waveguide (CPW) 55 in order to provide for a higher degree of design flexibility. The coupling strength and the wave impedance of the coplanar waveguide 55 is given by the width of the central strip 58 and the slots 59 of the CPW. In general the width of the central strip can take the values as discussed earlier under reference to Fig. 2 (which also applies to the other embodiments) but in this case the flexibility is even higher. The width is generally chosen depending on the substrate thickness.

[0037] The invention is not limited to the shown embodiments but other materials can be used, for example it does not have to be a bulk dielectric material, in some cases also thin dielectric materials can be used. Moreover the form of the resonator can be of different kinds as well as the waveguiding means can take a number of different forms and it does not necessarily have to be a central strip of a microstrip line that forms the coupling means.

Claims

1. Superconducting notch or band reject filter arrangement (10;20;30;40;50;) comprising a superconducting dielectric resonator (11;21;31;41;51) and a waveguide arrangement (15;25;35;45;55) compris-

ing a microstrip line to which the resonator is connected,

characterized in

that the resonator (11;21;31;41;51) is a parallel-plate resonator made of a non-linear dielectric material (12;22;32) on which superconducting plates (13a,13b;23a,23b;33a) are arranged, and in that the waveguide arrangement comprises a microstrip line to which one of the plates of the resonator is connected via contact means or coupling means (18;28;58), the resonator (11;21;31;41;51) being connected to said contact means (18;28;58) of the waveguide arrangement in such a way that electric contact is provided and in that the filter arrangement is frequency tunable.

2. Superconducting filter arrangement (10;20;30;40;50;) according to claim 1,

characterized in

that it is electrically tunable.

3. Superconducting filter arrangement according to claim 2,

characterized in

that a DC biasing voltage via connection means (19,19) is directly or indirectly applied to the plates of the non-linear dielectricum to change the dielectric constant thereof.

4. Superconducting filter arrangement according to claim 3,

characterized in

that normal conductors are arranged on the resonator outer sides, i.e. on the superconductors and in that a DC biasing voltage is applied thereto.

5. Superconducting notch filter according to anyone of the preceding claims,

characterized in

that one of the resonator plates is electrically connected or magnetically coupled to the microstrip line.

6. Superconducting filter arrangement according to anyone of the preceding claims,

characterized in

that the contact means (18;28;58) comprises a central strip of the microstrip line and in that the resonator is connected to said central strip.

7. Superconducting notch filter arrangement according to anyone of the preceding claims,

characterized in

that the parallel-plate resonator (11;21;31;41;51) comprises a substantially rectangular chip.

8. Superconducting notch filter arrangement according to claim 7,

characterized in

that the resonator chip is so oriented in relation to the microstrip line that maximum inductive coupling is achieved.

9. Superconducting notch filter arrangement according to claim 8,

characterized in

that the resonator chip is so oriented in relation to the microstrip line (15;25) that the magnetic field lines of the microstrip and the resonators substantially coincide.

10. Superconducting notch filter arrangement according to anyone of the preceding claims,

characterized in

that the inductive coupling between the resonator and the microstrip line is given by the relation between the resonator and the microstrip and in that it is given by the relation between the physical dimensions thereof.

11. Superconducting notch filter arrangement according to claim 10,

characterized in

that the strength of the inductive coupling is given by the width of the contact means, e.g. the central microstrip line (18;28;58).

12. Superconducting notch filter arrangement according to anyone of the preceding claims,

characterized in

that in order to increase the inductive coupling between the resonator (21) and microstrip line (25), the lower plate (23b) of the parallel-plate resonator and/or the microstrip connecting means each comprises a second portion (23b₂;28b) having a width that is smaller than that of a first width portion (23b₁;28a), respectively.

13. Superconducting notch filter arrangement (30;40) according to anyone of the preceding claims,

characterized in

that the resonator (31;41) is a dual mode operating resonator and in that the filter arrangement comprises a two-pole filter.

14. Superconducting notch filter arrangement (30;40) according to claim 13,

characterized in

that the resonator (31;41) comprises an asymmetry to provide the dual mode operation.

15. Superconducting notch filter arrangement (30) according to claim 14,

characterized in

that the asymmetry comprises a cut-away corner of a plate (32a) of the resonator, a protruding portion

or similar.

16. Superconducting notch filter arrangement (40) according to claim 13,
characterized in
that the resonator (41) is arranged to form an angle with the main microstrip line (45).

17. Superconducting notch filter arrangement according to claim 16,
characterized in
that the resonator (41) forms an angle of about 45° with the main microstrip line (45).

18. Superconducting notch filter arrangement (50) according to anyone of claims 1-17,
characterized in
that the waveguide arrangement is a coplanar waveguide (55).

19. Superconducting filter arrangement (50) according to claim 18,
characterized in
that the coupling strength between the resonator (51) and the coplanar waveguide (55) is given by the width of the central strip (58) and of the slots (59,59) of the coplanar waveguide (55).

20. Superconducting filter arrangement according any one of the preceding claims,
characterized in
that a DC-biasing voltage is applied via connection means (19,19) between the upper plate (14) of the resonator (11) and the coupling means (18), e.g. the central strip.

21. Superconducting band reject or notch filter (10;20;30;40;50) for use e.g. in multichannel communications systems operating in high frequency bands comprising a waveguide arrangement (15;25;35;45;55) and at least one resonator (11;21;31;41;51),
characterized in
that the resonator (11;21;31;41;51) is a parallel-plate resonator comprising a non-linear dielectric material (12;22;32) on which superconducting plates are arranged, and in that the waveguide arrangement (15;25;35;45;55) comprises a microstrip line comprising contact means or coupling means (18;28;58), the resonator being so arranged in relation to the waveguide arrangement that a series resonant circuit is provided thus forming the filter, and in that connecting means (19) are provided through which the filter can be frequency tuned.

22. Filter according to claim 21,
characterized in
that via the connecting means (19) a DC-biasing voltage is applied.

23. Filter according to claim 21 or 22,
characterized in
that the microstrip line comprises a main microstrip line and a central microstrip (18;28;58) forming said coupling means.

24. Filter according to anyone of claims 21-23,
characterized in
that the resonator (11;21;31;41;51) comprises a non-linear dielectric bulk material plated with the superconducting plates (14;24a,24b), advantageously comprising high temperature superconductors.

25. Filter (30;40) according to anyone of claims 21-24,
characterized in
that the resonator (31;41) is a dual mode or a multimode resonator.

26. Filter (31;41) according to anyone of claims 21-25,
characterized in
that it comprises a two-pole notch filter.

27. Filter (10;20;30;40;50) according to anyone of claims 21-26,
characterized in
that the resonator (11;21;31;41;51) comprises a chip having an area of approximately between 1 mm² - 1 cm³ at frequencies of about 0,1-2 GHz.

28. Method for filtering signals incoming e.g. to a receiving arrangement in a multichannel communications system comprising the steps of:

- arranging a filter on the input side of the receiving arrangement wherein said filter comprises a parallel-plate resonator made of a non-linear dielectric material on which superconducting plates are arranged and which is arranged on a waveguide arrangement, contact means being provided between said resonator and said waveguide arrangement, e.g. a microstrip line, to provide a coupling in series of the resonator and the microstrip line,
- arranging the resonator and the coupling means so in relation to each other that the needed coupling strength is provided,
- applying a DC-biasing voltage between the resonator and the contact means for frequency tuning,

so that interfering signals are blanked out, i.e. not received in the receiving arrangement.

29. Method according to claim 28, comprising the step of giving the filter the desired coupling strength through giving the contact means or coupling

means, e.g. in the form of a central microstrip, such dimensions in relation to the resonator that the desired coupling strength is obtained and in that the resonator comprises a non-linear dielectric bulk material plated with HTS-films.

30. Use of a superconducting notch or band reject filter arrangement according to anyone of claims 1-27 for filtering signals incoming to a receiving arrangement in a multichannel communications system to prevent interfering signals from being received in the receiving arrangement.

Patentansprüche

1. Eine supraleitende Kerb- oder Bandsperrfilteranordnung (10; 20; 30; 40; 50), umfassend einen supraleitenden, dielektrischen Resonator (11; 21; 31; 41; 51) und eine Wellenleiteranordnung (15; 25; 35; 45; 55) mit einer Mikrostreifenleitung, mit der der Resonator verbunden ist, dadurch **gekennzeichnet**, dass der Resonator (11; 21; 31; 41; 51) ein Parallelplattenresonator ist, hergestellt aus einem nichtlinearen dielektrischen Material (12; 22; 32), auf dem supraleitende Platten (13a, 13b; 23a, 23b; 33a) angeordnet sind, und wobei die Wellenleiteranordnung einen Mikrostreifenleiter umfasst, mit der eine der Platten des Resonators über Kontaktmittel oder Kopplungsmittel (18; 28; 58) verbunden ist, wobei der Resonator (11; 21; 31; 41; 51) mit den Kontaktmitteln (18; 28; 58) der Wellenleiteranordnung auf solche Weise verbunden ist, dass ein elektrischer Kontakt bereitgestellt ist, und die Filteranordnungsfrequenz einstellbar ist.
2. Eine Halbleiterfilteranordnung (10; 20; 30; 40; 50) gemäß Anspruch 1, dadurch gekennzeichnet, dass sie elektrisch einstellbar ist.
3. Eine Halbleiterfilteranordnung nach Anspruch 2, dadurch gekennzeichnet, dass eine Gleichspannungsvorspannung (Biasspannung) über Verbindungsmittel (19, 19) direkt oder indirekt an die Platten des nicht-linearen Dielektrikums angelegt ist, um die dielektrische Konstante davon zu ändern.
4. Supraleitende Filteranordnung nach Anspruch 3, dadurch gekennzeichnet, dass normale Leiter auf den äußeren Seiten des Resonators angeordnet sind, d.h. auf den Supraleitern, und dass die Gleichspannungsvorspannung daran angelegt ist.
5. Supraleitender Kerbfilter nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, dass eine der Resonatorplatten elektrisch verbunden oder magnetisch gekoppelt ist mit der Mikrostri-

fenleitung.

6. Supraleitende Filteranordnung nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, dass die Kontaktmittel (18; 28; 58) einen Zentralstreifen der Mikrostreifenleitung umfassen, und der Resonator mit dem Zentralstreifen verbunden ist.
7. Supraleitende Kerbfilteranordnung nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, dass der Parallelplattenresonator (11; 21; 31; 41; 51) einen im Wesentlichen rechtwinkligen Chip umfasst.
8. Supraleitende Kerbfilteranordnung nach Anspruch 7, dadurch gekennzeichnet, dass der Resonatorchip so ausgerichtet ist mit Bezug auf die Mikrostreifenleitung, dass eine maximale induktive Kopplung erzielt wird.
9. Supraleitende Kerbfilteranordnung nach Anspruch 8, dadurch gekennzeichnet, dass der Resonatorchip mit Bezug auf die Mikrostreifenleitung (15; 25) so ausgerichtet ist, dass die magnetischen Feldlinien des Mikrostreifens und des Resonators sich im Wesentlichen decken.
10. Supraleitende Kerbfilteranordnung nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, dass die induktive Kopplung zwischen dem Resonator und der Mikrostreifenleitung gegeben ist durch die Beziehung zwischen dem Resonator und dem Mikrostreifen, und dass sie gegeben ist durch die Beziehung zwischen den physikalischen Dimensionen davon.
11. Supraleitende Kerbfilteranordnung nach Anspruch 10, dadurch gekennzeichnet, dass die Stärke der induktiven Kopplung durch die Breite der Kontaktmittel gegeben ist, z.B. der zentralen Mikrostreifenleitung (18; 28; 58).
12. Supraleitende Kerbfilteranordnung nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, dass zum Vermindern der induktiven Kopplung zwischen dem Resonator (21) und der Mikrostreifenleitung (25) die untere Platte (23b) des Parallelplattenresonators und/oder die Mikrostreifenverbindungsmittel jeweils einen zweiten Abschnitt (23b₂; 28b) umfassen, mit einer Breite, die kleiner als die eines jeweiligen ersten Breitenabschnitts (23b₁; 28a) ist.
13. Supraleitende Kerbfilteranordnung (30; 40) nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, dass der Resonator (31; 41) ein Doppelmode-arbeitender Resonator ist und die Filter-

anordnung einen Zweipolfilter umfasst.

14. Supraleitende Kerbfilteranordnung (30; 40) nach Anspruch 13, dadurch gekennzeichnet, dass der Resonator (31; 41) eine Asymmetrie umfasst, um den Doppelmodusbetrieb bereitzustellen. 5
15. Supraleitende Kerbfilteranordnung (30) nach Anspruch 14, dadurch gekennzeichnet, dass die Asymmetrie eine abgeschnittene Ecke einer Platte (32a) des Resonators, einen vortretenden Abschnitt oder ähnliches, umfasst. 10
16. Supraleitende Kerbfilteranordnung (40) nach Anspruch 13, dadurch gekennzeichnet, dass der Resonator (41) angeordnet ist, um einen Winkel mit der Hauptmikrostreifenleitung (45) zu bilden. 15
17. Supraleitende Kerbfilteranordnung nach Anspruch 16, dadurch gekennzeichnet, dass der Resonator (41) einen Winkel von ungefähr 45° mit der Hauptmikrostreifenleitung (45) bildet. 20
18. Supraleitende Kerbfilteranordnung (50) gemäß einem der Ansprüche 1 bis 17, dadurch gekennzeichnet, dass die Wellenleiteranordnung ein koplanarer Wellenleiter (55) ist. 25
19. Supraleitende Filteranordnung (15) nach Anspruch 18, dadurch gekennzeichnet, dass die Kopplungsstärke zwischen dem Resonator (51) und dem koplanaren Wellenleiter (55) gegeben ist durch die Weite des Zentralstreifens (58) und der Schlitze (59, 59) des koplanaren Wellenleiters (55). 30
20. Supraleitende Filteranordnung nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, dass eine Gleichspannungsvorspannung über Verbindungsmittel (19, 19) zwischen der oberen Platte (14) des Resonators (11) und den Kopplungsmitteln (18), z.B. dem Zentralstreifen, angelegt ist. 35
21. Supraleitender Bandsper- oder Kerbfilter (10; 20; 30; 40; 50) zur Verwendung beispielsweise in Multikanalkommunikationssystemen, die in Hochfrequenzbändern arbeiten, umfassend eine Wellenleiteranordnung (15; 25; 35; 45; 55) und mindestens einem Resonator (11; 21; 31; 41; 51), dadurch **gekennzeichnet**, dass der Resonator (11; 21; 31; 41; 51) ein Parallelplattenresonator ist, der ein nichtlineares dielektrisches Material (12; 22; 32) umfasst, auf dem supraleitende Platten angeordnet sind, und die Wellenleiteranordnung (15; 25; 35; 45; 55) eine Mikrostreifenleitung umfasst, mit Kontaktmitteln oder Kopplungsmitteln (18; 28; 58), wobei der Resonator so mit Bezug auf die Wellenleiteranordnung angeordnet ist, dass eine Serienresonanzschaltung bereitgestellt wird, womit der Filter gebildet wird, und Verbindungsmittel (19) bereitgestellt sind, durch die der Filter hinsichtlich der Frequenz eingestellt werden kann. 40
22. Filter nach Anspruch 21, dadurch gekennzeichnet, dass über die Verbindungsmittel (19) eine Gleichspannungsvorspannung (Bias-Spannung) angelegt wird. 45
23. Filter nach Anspruch 21 oder 22, dadurch gekennzeichnet, dass die Mikrostreifenleitung eine Hauptmikrostreifenleitung und einen zentralen Mikrostreifen (18; 28; 58) umfasst, die die Kopplungsmittel bilden. 50
24. Filter nach einem der Ansprüche 21 bis 23, dadurch gekennzeichnet, dass der Resonator (1; 21; 31; 41; 51) ein nichtlinear dielektrisches Bulk-Material umfasst, beschichtet mit den supraleitenden Platten (14; 24a; 24b), vorteilhaft Hochtemperatursupraleiter umfassend. 55
25. Filter (30; 40) nach einem der Ansprüche 21-24, dadurch gekennzeichnet, dass der Resonator (31; 41) ein Doppelmode- oder Multimoderesonator ist.
26. Filter (31; 41) nach einem der Ansprüche 21-25, dadurch gekennzeichnet, dass er einen Zweipol-Kerbfilter umfasst.
27. Filter (10; 20; 30; 40; 50) nach einem der Ansprüche 21-26, dadurch gekennzeichnet, dass der Resonator (11; 21; 31; 41; 51) einen Chip umfasst, mit einem Bereich von ungefähr zwischen 1 mm² - 1 cm² bei Frequenzen von ungefähr 0,1-2 GHz.
28. Verfahren zum Filtern von Signalen, die beispielsweise an einer Empfangsanordnung in einem Multikanalkommunikationssystem ankommen, die Schritte umfassend:
 - Anordnen eines Filters auf einer Eingangsseite der Empfangsanordnung, wobei der Filter einen Parallelplattenresonator umfasst, der aus einem nichtlinear dielektrischen Material hergestellt ist, auf dem supraleitende Platten angeordnet sind, und der auf einer Wellenleiteranordnung angeordnet ist, wobei Kontaktmittel bereitgestellt sind zwischen dem Resonator und der Wellenleiteranordnung, z.B. eine Mikrostreifenleitung, um eine Serienkopplung des Resonators und der Mikrostreifenleitung bereitzustellen,
 - Anordnung des Resonators und der Kopplungsmittel in Bezug aufeinander, so dass die erwünschte Kopplungsstärke bereitgestellt

wird,

- Anlegen einer Gleichspannungsvorspannung (-Bias-Spannung) zwischen dem Resonator und den Kontaktmitteln für eine Frequenzeinstellung, so dass interferierende Signale ausgelöscht werden, d.h. nicht in der Empfangsanordnung empfangen werden.

29. Verfahren nach Anspruch 28, den Schritt umfassend, dem Filter die erwünschte Kopplungsstärke zu geben, durch Bereitstellen der Kontaktmittel oder Kopplungsmittel, z.B. in der Form eines zentralen Mikrostreifens, mit solchen Dimensionen mit Bezug auf den Resonator, dass die erwünschte Kopplungsstärke erhalten wird, und dass der Resonator ein nichtlineares dielektrisches Bulk-Material umfasst, das mit HTS-Filmen beschichtet ist.

30. Verwendung einer supraleitenden Sperr- oder Bandsperrfilteranordnung nach einem der Ansprüche 1 bis 27 zum Filtern von Signalen, die an einer Empfangsanordnung in einem Multikanalkommunikationssystem ankommen, um zu verhindern, dass interferierende Signale an der Empfangsanordnung empfangen werden.

Revendications

1. Structure de filtre réjecteur ou coupe-bande supraconducteur (10; 20; 30; 40; 50) comprenant un résonateur diélectrique supraconducteur (11; 21; 31; 41; 51) et une structure de guide d'ondes (15, 25; 35; 45; 55) comprenant une ligne micro-ruban à laquelle le résonateur est connecté, caractérisée en ce que le résonateur (11; 21; 31; 41; 51) est un résonateur à lames parallèles formé par un matériau diélectrique non linéaire (12; 22; 32) sur lequel sont disposées des lames supraconductrices (13a, 13b; 23a, 23b; 33a), et en ce que la structure de guide d'ondes comprend une ligne micro-ruban à laquelle l'une des lames du résonateur est connectée par l'intermédiaire de moyens de contact ou de moyens de couplage (18; 28; 58), le résonateur (11; 21; 31; 41; 51) étant connecté à ces moyens de contact (18; 28; 58) de la structure de guide d'ondes de manière qu'un contact électrique soit établi, et en ce que la structure de filtre est accordable en fréquence.
2. Structure de filtre supraconducteur (10; 20; 30; 40; 50) selon la revendication 1, caractérisée en ce qu'elle est accordable de façon électrique.
3. Structure de filtre supraconducteur selon la reven-

dication 2, caractérisée

en ce qu'une tension continue de polarisation est directement ou indirectement appliquée, par l'intermédiaire de moyens de connexion (19, 19), aux lames du diélectrique non linéaire, pour changer sa constante diélectrique.

4. Structure de filtre supraconducteur selon la revendication 3, caractérisée en ce que des conducteurs normaux sont disposés sur les faces extérieures du résonateur, c'est-à-dire sur les supraconducteurs, et en ce qu'une tension continue de polarisation leur est appliquée.

5. Filtre réjecteur supraconducteur selon l'une quelconque des revendications précédentes, caractérisé en ce que l'une des lames de résonateur est connectée électriquement ou couplée magnétiquement à la ligne micro-ruban.

6. Structure de filtre supraconducteur selon l'une quelconque des revendications précédentes, caractérisée en ce que les moyens de contact (18; 28; 58) comprennent un ruban central de la ligne micro-ruban, et en ce que le résonateur est connecté à ce ruban central.

7. Structure de filtre réjecteur supraconducteur selon l'une quelconque des revendications précédentes, caractérisée en ce que le résonateur à lames parallèles (11; 21; 31; 41; 51) comprend une puce pratiquement rectangulaire.

8. Structure de filtre réjecteur supraconducteur selon la revendication 7, caractérisée en ce que la puce de résonateur est orientée par rapport à la ligne micro-ruban de façon à obtenir un couplage inductif maximal.

9. Structure de filtre réjecteur supraconducteur selon la revendication 8, caractérisée en ce que la puce de résonateur est orientée par rapport à la ligne micro-ruban (15; 25) de façon que les lignes de champ magnétique du micro-ruban et des résonateurs coïncident pratiquement.

10. Structure de filtre réjecteur supraconducteur selon l'une quelconque des revendications précédentes, caractérisée en ce que le couplage inductif entre le résonateur et la ligne micro-ruban est donné par la relation en-

tre le résonateur et le micro-ruban, et en ce qu'il est donné par la relation entre leurs dimensions physiques.

11. Structure de filtre réjecteur supraconducteur selon la revendication 10, caractérisée en ce que la force du couplage inductif est donnée par la largeur des moyens de contact, par exemple la ligne micro-ruban centrale (18; 28; 58). 5
12. Structure de filtre réjecteur supraconducteur selon l'une quelconque des revendications précédentes, caractérisée en ce que dans le but d'augmenter le couplage inductif entre le résonateur (21) et la ligne micro-ruban (25), la lame inférieure (23b) du résonateur à lames parallèles et/ou les moyens de connexion de micro-ruban comprennent chacun une seconde partie (23b₂; 28b) ayant une largeur qui est inférieure à celle d'une première partie de largeur (23b₁; 28a), respectivement. 10
13. Structure de filtre réjecteur supraconducteur (30; 40) selon l'une quelconque des revendications précédentes, caractérisée en ce que le résonateur (31; 41) est un résonateur fonctionnant selon deux modes, et en ce que la structure de filtre comprend un filtre à deux pôles. 15
14. Structure de filtre réjecteur supraconducteur (33; 40) selon la revendication 13 caractérisée en ce que le résonateur (31; 41) comprend une asymétrie pour procurer le fonctionnement selon deux modes. 20
15. Structure de filtre réjecteur supraconducteur (30) selon la revendication 14, caractérisée en ce que l'asymétrie comprend un coin coupé d'une lame (32a) du résonateur, une partie en saillie ou une caractéristique similaire. 25
16. Structure de filtre réjecteur supraconducteur (40) selon la revendication 13, caractérisée en ce que le résonateur (41) est disposé de façon à former un angle avec la ligne micro-ruban (45) principale. 30
17. Structure de filtre réjecteur supraconducteur selon la revendication 16, caractérisée en ce que le résonateur (41) forme un angle d'environ 45° avec la ligne micro-ruban principale (45). 35
18. Structure de filtre réjecteur supraconducteur (50) selon l'une quelconque des revendications 1 - 17, caractérisée en ce que la structure de guide d'ondes est un guide d'ondes coplanaire (55). 40
19. Structure de filtre réjecteur supraconducteur (50) selon la revendication 18, caractérisée en ce que la force de couplage entre le résonateur (51) et le guide d'ondes coplanaire (55) est donnée par la largeur du ruban central (58) et celle des rainures (59, 59) du guide d'ondes coplanaire (55). 45
20. Structure de filtre supraconducteur selon l'une quelconque des revendications précédentes, caractérisée en ce qu'une tension de polarisation continue est appliquée par l'intermédiaire de moyens de connexion (19, 19) entre la lame supérieure (14) du résonateur (11) et les moyens de couplage (18), par exemple le ruban central. 50
21. Filtre coupe-bande ou réjecteur supraconducteur (10; 20; 30; 40; 50) pour l'utilisation par exemple dans des systèmes de communication multicanaux fonctionnant dans des bandes de haute fréquence, comprenant une structure de guide d'ondes (15, 25; 35; 45; 55) et au moins un résonateur (11; 21; 31; 41; 51), caractérisé en ce que le résonateur (11; 21; 31; 41; 51) est un résonateur à lames parallèles comprenant un matériau diélectrique non linéaire (12; 22; 32) sur lequel sont disposées des lames supraconductrices, et en ce que la structure de guide d'ondes (15; 25; 35; 45; 55) comprend une ligne micro-ruban comprenant des moyens de contact ou des moyens de couplage (18; 28; 58), le résonateur étant disposé par rapport à la structure de guide d'ondes de façon qu'un circuit résonnant série soit établi pour former ainsi le filtre, et en ce qu'il existe des moyens de connexion (19) par l'intermédiaire desquels le filtre peut être accordé en fréquence. 55
22. Filtre selon la revendication 21, caractérisé en ce qu'une tension de polarisation continue est appliquée par l'intermédiaire des moyens de connexion (19). 60
23. Filtre selon la revendication 21 ou 22, caractérisé en ce que la ligne micro-ruban comprend une ligne micro-ruban principale et un micro-ruban central (18; 28; 58) formant les moyens de couplage. 65
24. Filtre selon l'une quelconque des revendications 21

- 23,
caractérisé
en ce que le résonateur (11; 21; 31; 41; 51) comprend un matériau massif diélectrique non linéaire revêtu des lames supraconductrices (14; 24a, 24b), consistant avantageusement en supraconducteurs à température élevée. 5
- 25.** Filtre (30; 40) selon l'une quelconque des revendications 21 - 24, caractérisé en ce que le résonateur (31; 41) est un résonateur à deux modes ou multimode. 10
- 26.** Filtre (31; 41) selon l'une quelconque des revendications 21 - 25, caractérisé en ce qu'il consiste en un filtre réjecteur à deux pôles. 15
- 27.** Filtre (10; 20; 30; 40; 50) selon l'une quelconque des revendications 21 - 26, caractérisé en ce que le résonateur (11; 21; 31; 41; 51) comprend une puce ayant une aire comprise approximativement entre 1 mm² - 1 cm² à des fréquences d'environ 0, 1 - 2 GHz. 20 25
- 28.** Procédé pour filtrer des signaux arrivant par exemple à une structure de réception dans un système de communication multicanal, comprenant les étapes suivantes : 30
- on dispose un filtre du côté d'entrée de la structure de réception, ce filtre comprenant un résonateur à lames parallèles constitué par un matériau diélectrique non linéaire sur lequel sont disposées des lames supraconductrices, et qui est disposé sur une structure de guide d'ondes, des moyens de contact étant placés entre ce résonateur et cette structure de guide d'ondes, par exemple une ligne micro-ruban, pour établir un couplage en série du résonateur et de la ligne micro-ruban, 35 40
 - on dispose mutuellement le résonateur et les moyens de couplage de façon à obtenir la force de couplage nécessaire, 45
 - on applique une tension de polarisation continue entre le résonateur et les moyens de contact pour l'accord de fréquence, 50
- de façon que des signaux brouilleurs soient éliminés, c'est-à-dire ne soient pas reçus dans la structure de réception. 55
- 29.** Procédé selon la revendication 28, comprenant l'étape qui consiste à donner au filtre la force de couplage désirée en donnant aux moyens de con-
- tact ou aux moyens de couplage, par exemple sous la forme d'un micro-ruban central, des dimensions par rapport au résonateur telles que la force de couplage désirée soit obtenue, et dans lequel le résonateur comprend un matériau diélectrique non linéaire massif revêtu de pellicules de supraconducteur à température élevée.
- 30.** Utilisation d'une structure de filtre réjecteur ou coupe-bande supraconducteur selon l'une quelconque des revendications 1 - 27 pour filtrer des signaux arrivant à une structure de réception dans un système de communication multicanal, pour empêcher que des signaux brouilleurs soient reçus dans la structure de réception.

FIG. 1

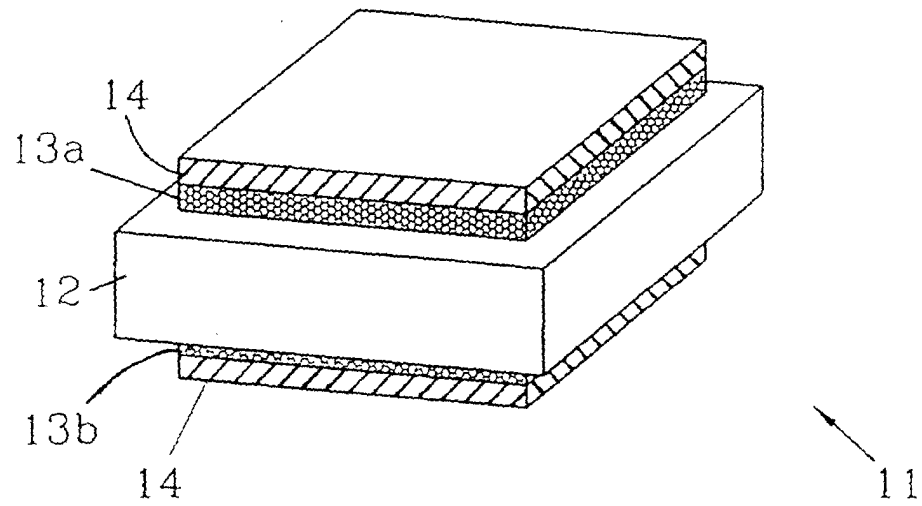


FIG. 2

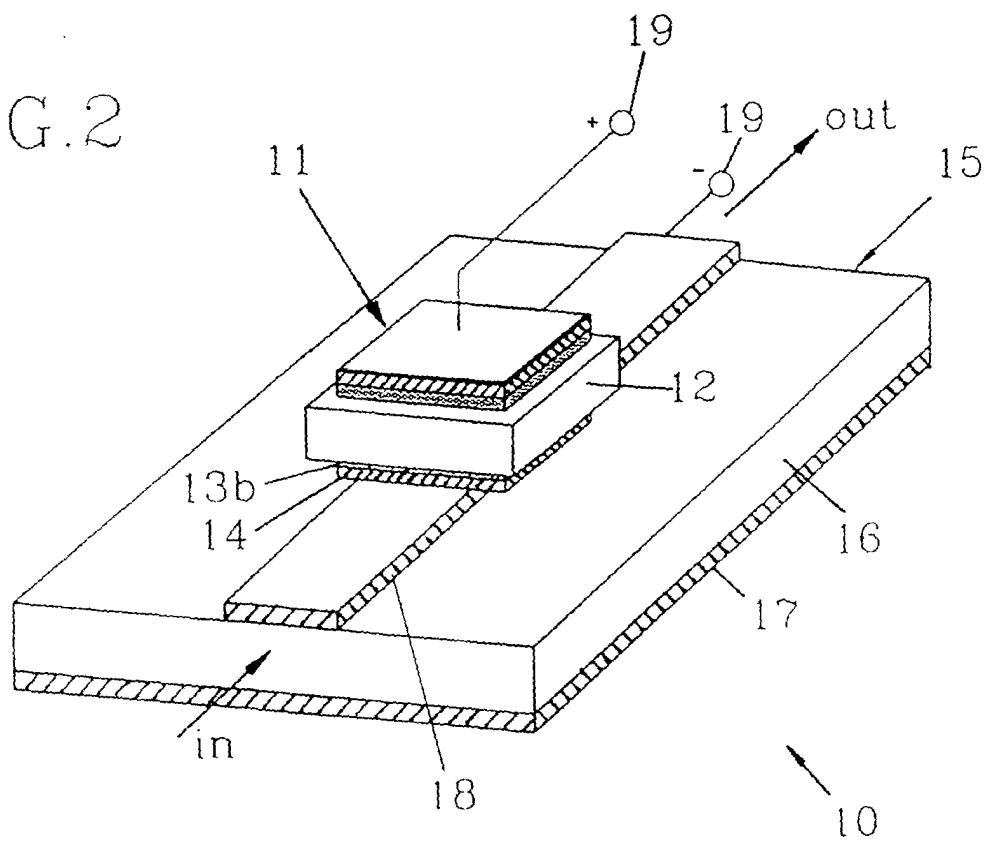


FIG.3

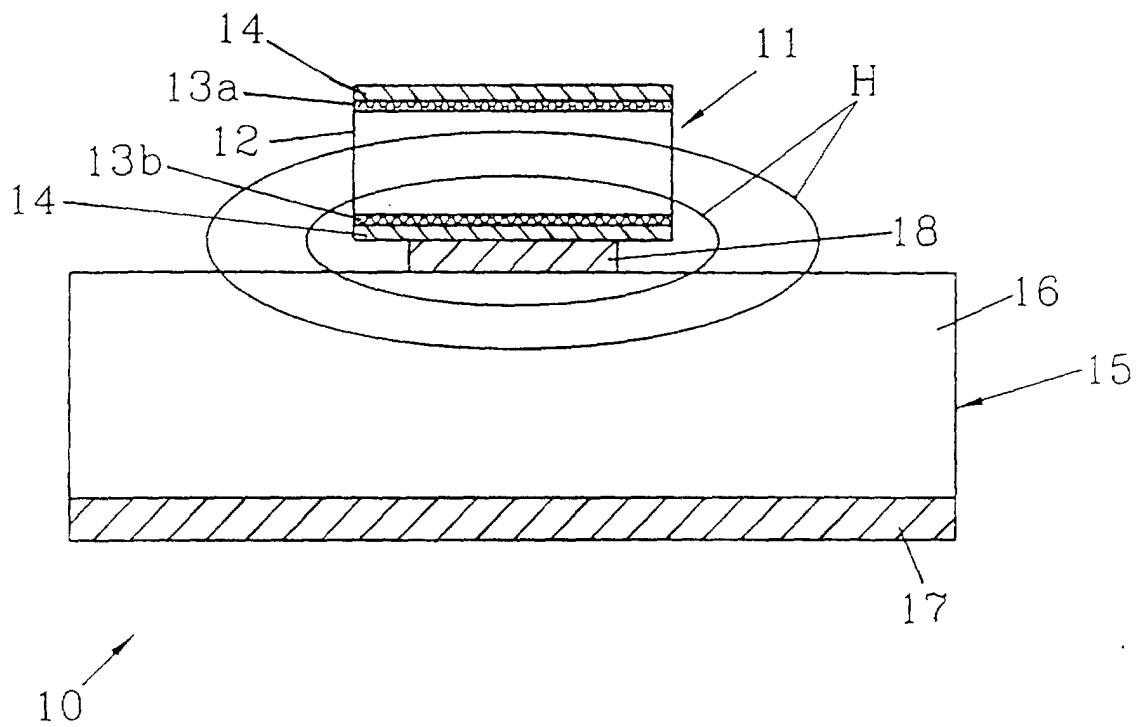


FIG.4

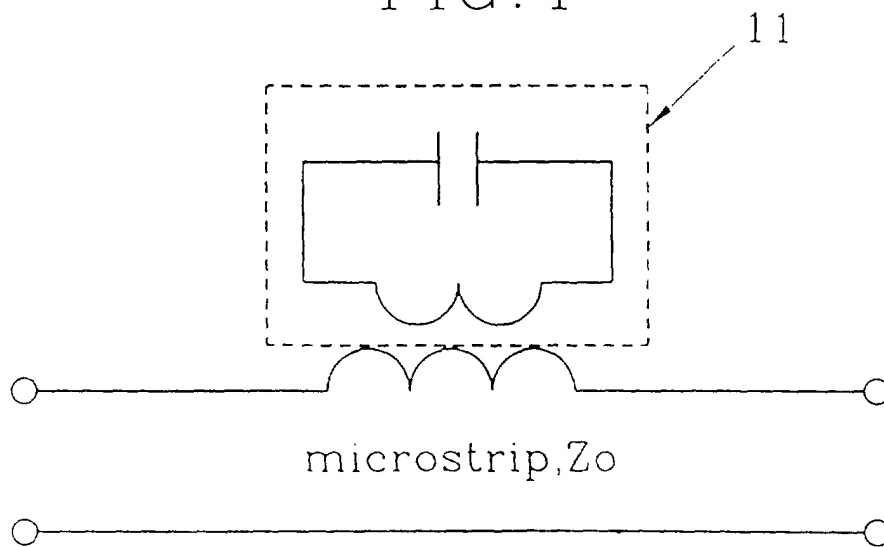


FIG. 5

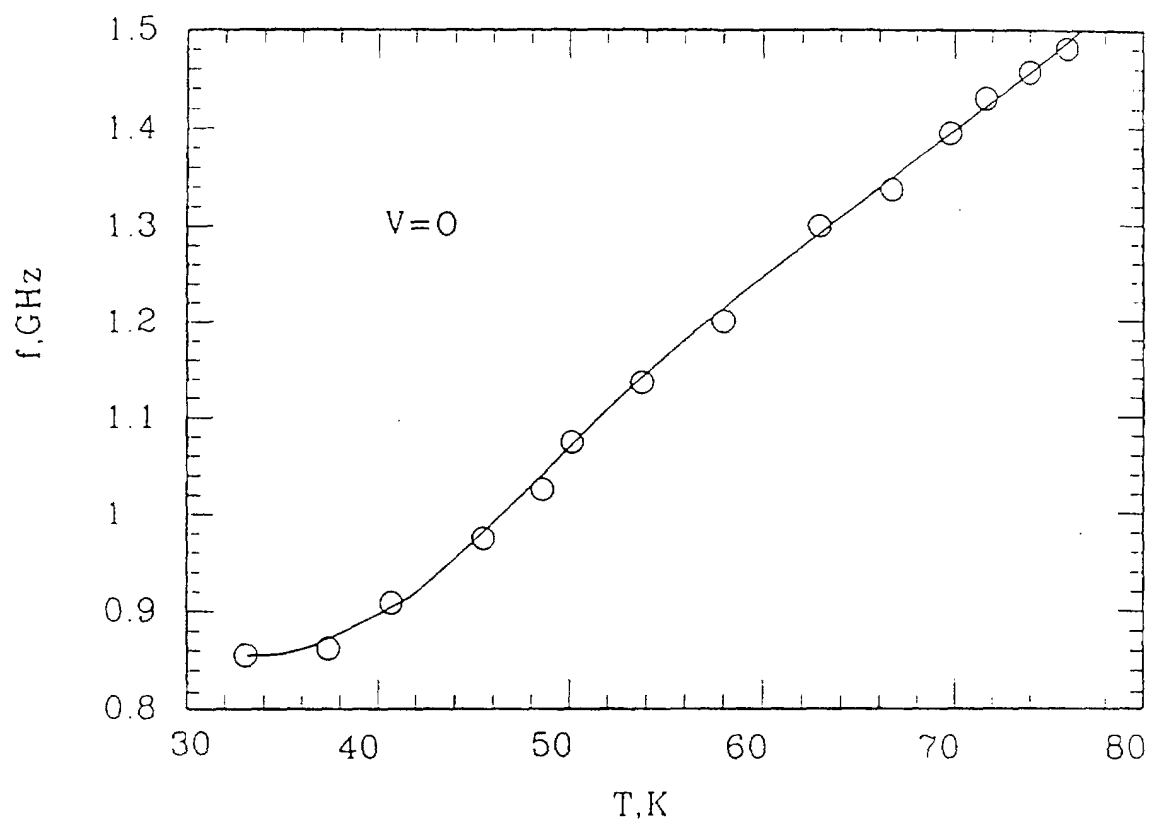


FIG. 6a

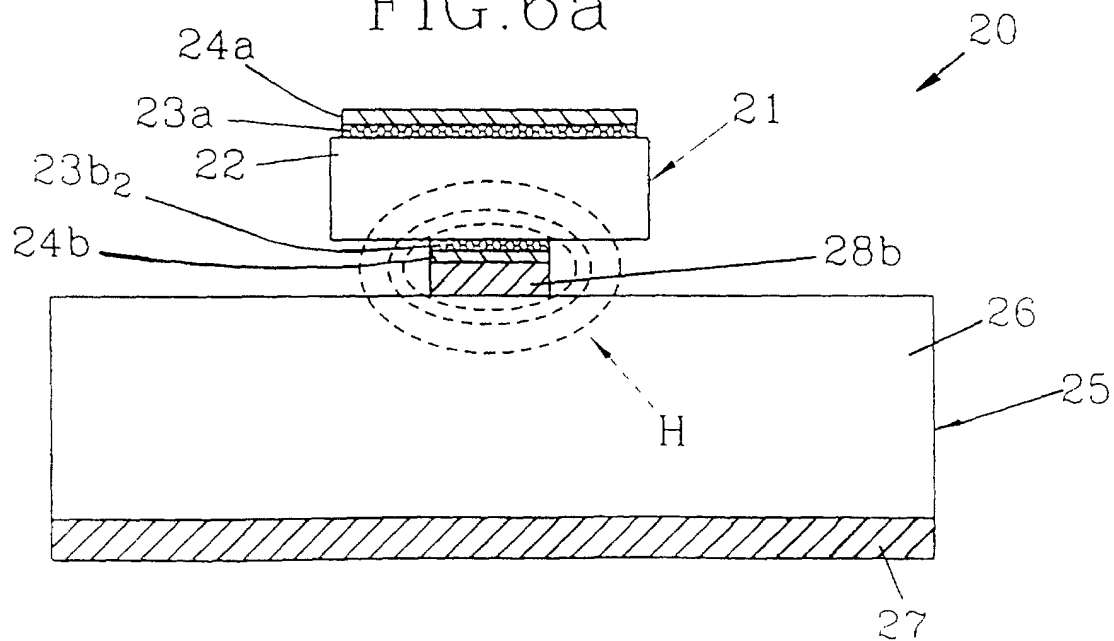


FIG. 6c

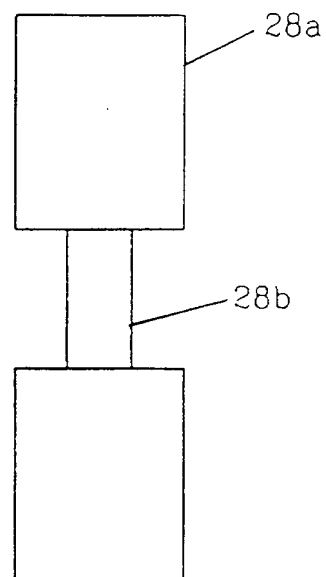


FIG. 6b

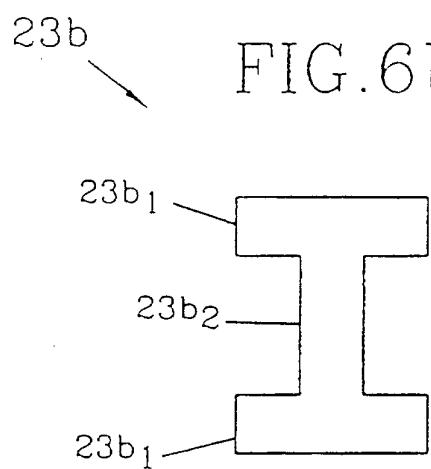


FIG. 7

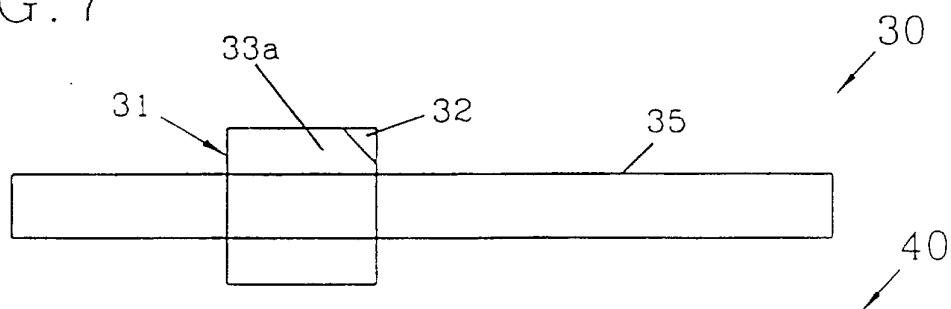


FIG. 8

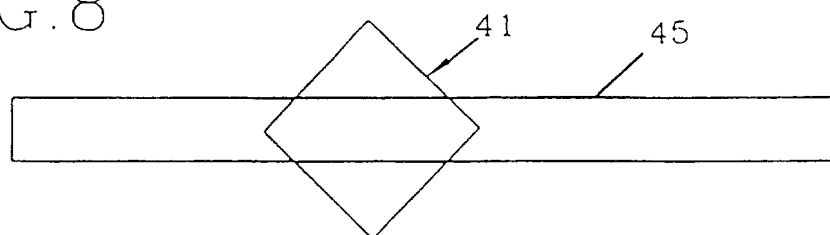


FIG. 9

