

(19)



Europäisches Patentamt

European Patent Office

Office européen des brevets



(11)

EP 0 565 943 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:

15.10.1997 Bulletin 1997/42

(51) Int Cl.⁶: **H01P 5/107**

(21) Application number: **93105295.5**

(22) Date of filing: **30.03.1993**

(54) **Guide-microstrip transition integrating a polarization filter in hermetic active modules with high packing and associated modules**

Hohlleiter-Mikrostreifenleiterübergang mit integrierter Polarisationsweiche in hermetischen aktiven Modulen mit hoher Packungsdichte und assoziierte Module

Transition guide d'ondes-ligne à microruban incorporant un filtre de polarisation dans des modules hermétiques actifs à hautes densités et modules associés

(84) Designated Contracting States:
DE ES FR GB GR IT NL SE

(30) Priority: **15.04.1992 IT MI920913**

(43) Date of publication of application:
20.10.1993 Bulletin 1993/42

(73) Proprietor: **Italtel s.p.a.**
20149 Milano (IT)

(72) Inventors:

- **Bonecchi, Fulvio**
I-20097 San Donato Milanese (Milano) (IT)
- **Negri, Luigi**
I-20097 S. Angelo Lodigiano (Milan) (IT)

(56) References cited:

FR-A- 956 487 **GB-A- 1 190 496**
US-A- 4 152 666

- **PATENT ABSTRACTS OF JAPAN vol. 11, no. 81**
(E-488)(2528) 12 March 1987 & JP-A-61 234 601

EP 0 565 943 B1

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

Description

The present invention relates to the field of circuit module engineering for equipment operating at micro-waves, and in particular concerns a guide-microstrip transition integrating a polarization filter in hermetic active modules with high packing, and associated modules obtained by using said transitions.

As is known, recent developments in the technology of manufacturing gallium arsenide electronic devices for applications in the microwave field, have allowed provision of field effect transistors (GaAsFET) capable of amplifying signals included in the SHF and EHF bands. Said transistors are generally used to provide solid state power amplifiers (SSPA).

Power amplification in these frequency bands was usually actuated by traditional Travelling Wave Tube Amplifiers (TWTAs) but the advantages of solid state amplifiers are considerable in terms of reliability, linearity and size reduction, which are extremely useful characteristics for certain advanced applications such as space and avionics applications.

However, the power obtainable from single GaAsFETs in said frequency bands are still limited and therefore, in applications in which fair signal power is necessary, it becomes necessary to use several solid state amplification modules with parallel outlets. One generally adopted solution for summing the individual powers is to use a wave guide power combiner taking the individual amplified signals at the output of each amplifier module and conveying them into a single wave guide. The combination of the individual modules behaves like a single SSPA module of greater power.

For an amplifier obtained as above, it is useful to adopt all technical provisions capable of reducing the overall dimensions of the combination, if it is desired to hold unchanged the above advantages, especially when the amplifier is located on board a telecommunications satellite.

A microwave amplification module, called also active module, is generally made up of a microwave integrated circuit (MIC) housed in a metal package. The MIC is made up of a dielectric substrate supporting a GaAsFET transistor and optionally other discrete active and/or passive components. On both faces of the substrate are deposited appropriate thin film metallizations in the form of lines or planes whose peculiar and mutual arrangement provides individual passive circuits with distributed constants and transmission lines. The latter can be the microstrip, slotline, etc. type.

Because of its peculiar embodiment technique, the MIC is also called 'Hybrid Thin Film Microwave Circuit'. The term MIC is used hereinafter to simplify the description and express said terminology.

The hermetic metal package acts as a rigid support for the MIC and simultaneously as a shield against electromagnetic disturbances.

The low level microwave signal and the amplified

power signal enter and leave the amplification module by means of respective three-dimensional wave guide sections. The electromagnetic coupling between the signals travelling in the wave guide and the MIC circuits and vice versa takes place by means of appropriate 'guide-microstrip transitions'. The latter comprise generally a component similar to a very short section of co-axial line having reduced diameter called 'glass bead' which interconnects a microstrip of the MIC to a probe which acts as an antenna directly within the cavity of a wave guide. The electrical operation of said transitions is of the reciprocal type, i.e. depending on the origin of the signal, a guide-microstrip transition can act as a microstrip-guide transition.

The electric power supplies for polarization of the active components are carried inside the module by means of one or more connectors connected to respective power sources.

FIG. 1 shows a top view of a combination of two microwave amplification modules 1, 2 of known type for providing a single amplification module with double power. The modules 1 and 2 are connected to two wave guides 3 and 4 respectively used to convey an identical low power level microwave signal to the two GaAsFETs belonging to respective MICs of the modules 1 and 2. Only to illustrate the known art as concerns the field of application of the present invention it is not indispensable to detail the circuit structure of the MICs, which therefore is not specifically shown in FIG. 1. Coupling of the input signals between the guides 3 and 4 and the respective MICs takes place by means of guide-microstrip transitions of the type described above and indicated in the figures by reference numbers 5 and 6.

The power amplified signals from the GaAsFETs are taken from two microstrip-guide transitions 7 and 8 identical to the above and taken outside the respective amplification modules by means of two other wave guides 9 and 10. The latter belong to a wave guide power combiner which adds together the two identical amplified signals to provide a single signal with double power.

The power sources for polarization of the GaAsFETs are connected to the modules 1 and 2 by means of power connectors indicated by 1A, 1B and 2A, 2B which, inside the modules 1 and 2, are in turn connected to conductive lines of the respective MICs which reach the electrodes of the GaAsFETs, connecting them to the power sources. But first the power supplies are filtered by means of appropriate decoupling filters of the type diagrammed in FIG. 2 and placed in series with the power supplies. The decoupling filters, called also polarization filters, are included in the MICs of the modules 1 and 2. They prevent the radio frequency signal from reaching the power supply connectors.

As may be seen in FIG. 1, the transitions 5 and 7 of the module 1 are arranged along a common longitudinal axis, while the power supply connectors 1A and 1B of the same module are perpendicular to said axis. An

analogous arrangement also exists concerning the transitions 6 and 8 and the connectors 2A and 2B of the module 2.

The above arrangement is not arbitrary, but is required by the fact that the cross dimensions of each module 1 and 2 are approximately equal to the cross dimensions of the wave guide to which they are connected. Consequently, on the walls of the modules connected to the wave guides there is no remaining space to house also the power supply connectors. This is true generally because the growing miniaturisation in the field of microwave modules makes cross dimensions of the latter unavoidably comparable to those of the wave guides with which they are interconnected.

The greatest shortcoming of the modules of FIG. 1 is that they do not allow packing thereof capable of minimising the space occupied when several modules are connected in parallel. This is due to the fact that between two side by side modules it is necessary to leave an appropriate distance to allow connection of the cables to the power supply connectors. The disadvantages due to the above mentioned shortcoming are particularly evident in the space field, e.g. when several modules of the type of those of FIG. 1 are used to provide on board amplifiers for telecommunications satellites. In this case the larger spaces occupied by the equipment translate immediately into a considerable increase in mission costs.

Accordingly the purpose of the present invention is to overcome the above mentioned shortcomings and indicate a guide-microstrip transition integrating a polarization filter, particularly suitable for providing a high degree of packing of hermetic active modules operating at microwaves.

To achieve said purposes the present invention has for its object a guide-microstrip transition for active modules hermetic operating at microwaves as set forth in claims 1 to 4.

The transition which is the object of the present invention comprises a coaxial microline which, while maintaining the hermetic quality of the module, couples electromagnetically a microstrip belonging to an active circuit placed in a niche of the module, to a probe acting as an antenna inside a resonating cavity communicating with a three-dimensional wave guide conveying a radio frequency signal.

The probe comprises in addition a cylindrical conductor of small diameter connected to an armature of a discoid capacitor outside the resonating cavity and to a power supply connector connected to a pole of a battery. Coaxial microline, cylindrical conductor, discoid capacitor and power supply connector are aligned along the same longitudinal symmetry axis.

The electrical length of the cylindrical conductor is equal to one-fourth the wavelength at the centre band frequency of the radio frequency signal, and therefore it presents a high impedance to said signal which is short-circuited to ground by the discoid capacitor. The assem-

bly of the cylindrical conductor and the discoid capacitor constitutes a polarization filter for an active device connected to said microstrip.

The guide-microstrip transition which is the object of the present invention, including the power supply aligned on the same axis as the coaxial microline, allows use of only two opposing walls of the hermetic module for input/output of the radio frequency signal and simultaneously for introduction of the electric power supply for the GaAsFET. The other two opposing side walls remain free. It is thus possible to place the modules side by side while spacing them only enough for draining off of the heat produced and thus obtain the highest level of packing.

The transition which is the object of the present invention allows expansion in an innovative manner of the definition of active module (in particular amplification), overcoming the concept of 'single' module and combination of 'single' modules. Indeed, as is better explained below, an SSPA power amplifier obtained from the paralleling of several identical amplifiers using the guide-microstrip transitions in accordance with the present invention appears mechanically as a single module providing multiple amplification.

Another object of the present invention is therefore a multiple active module including a multiplicity of guide-microstrip transitions which are the object of the present invention as set forth in claims 5 to 9.

From the above considerations it is clear that the transition in accordance with the present invention contributes in a significant manner to reduction of the space occupied by the equipment operating with microwaves. The advantages which it brings are considerable and can be better appreciated in the space field, where a reduction of space occupied means greater reliability of equipment and greater economy in the costs of orbiting and operational maintenance of the satellite.

Additional objects and advantages of the present invention are made clear by the detailed description given below of an example of embodiment thereof and the annexed drawings given merely by way of nonlimiting example and wherein:

FIG. 1 shows a top view of a combination of two microwave amplification modules in accordance with the known art,

FIG. 2 shows an electrical diagram of a typical decoupling filter,

FIG. 3 shows an overall view of a triple amplification module in accordance with the present invention, and

FIG. 4 shows a detailed cross section along plane A-A of the guide-microstrip transition of FIG. 3 in accordance with the present invention.

FIG. 1 does not require further comment because it is adequately explained in the introduction.

FIG. 2 shows the typical configuration of a low pass

filter with one LC cell. The filter shown is generally placed in series with the power supply battery of an active circuit, for decoupling of the power supply from a radio frequency signal RF_{in} (RF_{out}) transiting in the circuit.

The diagram comprises an inductor L connected to one end of a capacitor C which has its other end grounded. As may be seen below, L and C are the type suited for microwave operation. The radio frequency signal comes from (or comes out of) a first port P1 of the filter. A second port P2 of the filter is connected to the common point of the connection of L with C and to a power supply source not visible in the figures which supplies a direct voltage indicated by DC1 (or DC2). In operation, the values of L and C are such that the passage of the radio frequency signal to the port P2 is prevented while the direct current delivered by the power supply source passes through the inductor L and reaches the port P1 without obstacle.

With reference to FIG. 3 in which the symbols RF_{in} , RF_{out} , DC1 and DC2 are those of FIG. 2, 11 indicates a triple amplification module of the SSPA type, so-called because it comprises three SSPA amplifiers integrated in a single structure.

The triple module 11 consists of a metal package 11' which acts as a housing and electromagnetic shield to a predominantly electrical part comprising three MIC amplification circuits, not visible in the figure, six guide-microstrip transitions, of which only one is visible, six electrical connectors shown in exploded view and used for connection of the MICs to the power supply sources.

The triple module 11 is also rigidly connected and electromagnetically coupled with a three-dimensional waveguide part, not visible in the figures. Excluding the guide part, the module 11 appears as a parallelepiped with dimensions 6mm x 30mm x 50mm. The metal package 11' is made from a single metal block by appropriate precision machining.

Along the centre line of the upper face of the module are visible three identical rectangular niches 12, 13 and 14 used for housing of an equal number of MICs. The power supply connectors, all identical and indicated generally by the symbol CNT, are aligned along the axis of respective housing holes 15 visible on two opposing side faces of the module 11. The number of said connectors depends on the fact that to each MIC arrive two different polarization voltages of the GaAsFETs.

After assembly of all the components, the niches 12, 13 and 14 are closed hermetically by means of an equal number of covers not visible in the figures. Therefore the triple module 11 appears like an actual single block having great compactness and mechanical strength.

In the figures is shown a cross section along plane A-A which cuts the thickness of the module 11 parallel to a side face not involved with the power supply connectors and passing through the centre line of the niche 12. The cross section shows the exact location of a

guide-microstrip transition in accordance with the present invention, indicated generally by TRANS and placed on the input side of a MIC. An identical transition is placed on the output side of the same MIC. As may be seen from the figure, each amplifier has a longitudinal symmetry axis along which are aligned two power supply connectors, two transitions and one MIC.

The symmetry of such a configuration allows, as mentioned above, minimization of the reciprocal distance between the amplifiers, reducing it enough to allow thermal dissipation of the heat produced by the active devices.

On the lower face of the module and not visible in the figures are present six rectangular windows indicated by F in the cross section view and placed at the sides of the niches 12, 13 and 14 opposite the transitions. Said windows place the module in communication with the wave guides and allow completion of the transitions with the parts in input and output wave guide. The dimensions of the windows F coincide with those of the cross sections of the respective wave guides.

The guides used are those indicated in the standards by the initials WR42 to which corresponds a cross section of 10.8mm x 4.5mm. The three output wave guides are interfaced with a power combiner in a three-way guide of known type. The combiner used in the triple module of the example is described in the article entitled, 'Low-loss Power Combiners at Mm-Wave Frequencies for Onboard Solid State Power Amplifiers' by Fulvio Bonecchi, published in the Proceedings of an International Workshop on 'Solid State Power Amplifiers for Space Applications', 15-16 November 1989 ESA/ESTEC, Noordwijk, The Netherlands, pages 171-178.

It is clear that by using the production criteria of the invention described it is possible to provide a multiple amplification module in which the number of amplifiers is increased on the basis of the overall power requirements.

With reference to FIG. 4, in which the same elements as in FIG. 3 are indicated by the same symbols, there is noted the metal package 11' with the rectangular niche 12 and the side hole 15. The niche 12 houses a MIC 16 and in the hole 15 is introduced a power supply connector CNT.

Between the niche 12 and the hole 15 is included a resonant cavity 17 open at the bottom corresponding with the rectangular window F. A wave guide 18 with rectangular cross section is rigidly connected to the lower face of the package 11' and communicates with the resonant cavity 17 through the rectangular window F.

In the cross section shown in the figures it can be seen that the resonant cavity 17 extends upward for nearly the entire thickness of the module. A cross section of the module along a plane perpendicular to that of the figure would show that the dimensions of said cavity in this plane coincide with those of the window F and therefore with those of a cross section of the wave guide 18. The hole 15 is in communication with the resonant

cavity 17 and allows introduction of everything needed to realise the transition. The cavity 17 does not however remain open at the sides because, as seen below, the opening communicating with the hole 15 will be appropriately closed.

In the metal wall dividing the rectangular niche 12 from the resonant cavity 17 is made a hole 19 in which is inserted a coaxial microline 20 of known type, e.g. that manufactured by Wiltron and indicated as a type K100 'glass support bead'. The microline 20 possesses a central conductor 21 whose ends penetrate inside the niche 12 and the cavity 17 respectively. Therefore, and due to the fact that the dielectric of the microline 20 is a glass cylinder 22, the latter is called also 'glass bead'. A metallization 23 extending to the side surface of the dielectric cylinder 22 is the external coaxial conductor of the microline 20. The ends of the central conductor 21 are welded to a microstrip of the MIC 16 connected to the electrodes of a GaAsFET 24 and to a metal probe 25 inside the resonant cavity 17 respectively. The metallization 23 is welded to the package 11'.

The probe 25 is a single cylindrical body made up of three parts having different diameters. A first part 25 placed between the other two and of greater diameter than the latter, is the actual probe. A second part 25', of intermediate diameter, has a hole in which is introduced and welded the central conductor 21 of the microline 20. Finally, a third part 25'', of smaller diameter than the above, is a cylindrical conductor of diameter 0.2mm extending to approximately 3/4 the depth of the hole 15.

In the resonant cavity 17 is introduced a protective Teflon cap 26 comprising a smaller diameter extension 26' extending for part of the hole 15. The cap 26 has a central passing hole 27 in which it receives the probe 25 complete with its parts 25' and 25''. The hole 27 is restricted opposite the conductor 25''.

In the hole 15 is screwed a threaded coaxial metal support 28 having a passing central hole 29 consisting of two adjoining sections of different diameter. After screwing in, the coaxial support 28 nearly completely closes the opening of the resonant cavity 17 communicating with the hole 15. The resonant cavity 17 now communicates with the exterior only through the hole 29.

Inside the smaller diameter hole section 29 is visible the extension 26' of the Teflon cap 26 with in its centre the cylindrical conductor 25''. The latter emerges from the Teflon to extend inside the hole section 29 of greater diameter where it traverses the centre of a discoid capacitor housed there. A first armature of the capacitor 30 is in electric contact with the cylindrical conductor 25'' and with the power supply connector CNT. The latter is cylindrical and has a central hole 31 in which is introduced and welded therein the cylindrical conductor 25''. A second armature of the capacitor 30 is in contact with the coaxial metal support 28 at the point where the hole 29 changes diameter.

The end of the connector CNT in contact with the first armature of the capacitor 30 has a diameter slightly

greater than that of the remaining cylindrical body to aid the electrical contact. An insulating plug 32 drilled in the centre closes the hole 29 hermetically. An electrical wire 33 welded to the power supply connector CNT connects the latter to a pole of a battery, not visible in the figures, which supplies the direct voltage DC1 adapted to the polarization of the GaAsFET 24 and the required current. The other pole of the battery is connected to the metal package 11' which constitutes the common reference ground for the module circuits.

As regards the seal of the module, it may be noted that the microline 20 hermetically closes the hole 19. A similar closing takes place provided by an identical microline (not shown in the figures) located on the opposite side of the MIC 16. The two microlines together with a cover 34 welded to a cornice 35, in turn welded to the walls of the niche 12, seal hermetically the MIC 16 in said niche.

From all the above considerations, and as may be seen in FIG. 4, the transition which is the object of the present invention is made up of predominantly cylindrical elements connected together so as to be aligned along a common longitudinal symmetry axis. The latter coincides with the symmetry axis of the coaxial microline 20, probe 25, discoid capacitor 30, power supply connector CNT, coaxial support 28 and also the Teflon cap 26 and the holes 19, 27, 15, 29 and 31. The MIC 16 is parallel to said longitudinal symmetry axis which is perpendicular to the window F and consequently to the cross section of the wave guide 18 at the connection point thereof with the module 11.

In operation, the transition of FIG. 4 couples the radio frequency signal RF_{in} to the input electrode of the GaAsFET 24 allowing voltage and current polarization to said transistor. More precisely, the direct current necessary for operation of the MIC 16 runs through the electric wire 33, power supply connector CNT, cylindrical conductor 25', probe 25 and in its extension 25'', central connector 21 of the coaxial microline 20, and lastly the microstrip of the MIC 16, reaching the drain electrode of the GaAsFET 24. The above elements are all in electrical contact with each other and subjected to the same voltage DC1 applied between the source and drain electrodes of the GaAsFET 24, polarizing it.

The radio frequency signal RF_{in} , carried by the wave guide 18, is electromagnetically coupled with the resonant cavity 17 which resonates at the working frequency of 20GHz. The probe 25, which acts as an antenna inside the cavity 17, takes the signal RF_{in} and transfers it to the coaxial microline 20. Thence it runs through the microstrip of the MIC 16 and reaches the source electrode of the GaAsFET 24. The way to the power supply connector CNT is closed to the RF_{in} signal by a decoupling filter consisting of the cylindrical conductor 25'' together with the discoid capacitor 30.

The filtering configuration is that of FIG. 2 in which the inductor L corresponds to the section of the cylindrical conductor 25'' lying between the probe 25 and the

capacitor 30. The capacitor C is the capacitor 30. The port P1 corresponds to the connecting point of the conductor 25" with the probe 25, and lastly the port P2 is the connecting point of the wire 33 to the power supply connector CNT.

The electrical length of the section of conductor 25" lying between the probe 25 and the first armature of the capacitor 30 is one-fourth the wave length of the RF_{in} at the operating frequency of 20GHz. As is known, 'electrical length' is a number expressing the phase displacement introduced by a transmission line. Its expression is found by multiplying the phase constant β of the line by the physical length l thereof. The constant β depends on the speed of propagation of the signal along the line. It should be stated that the speed of propagation of the signal travelling along the conductor 25" changes in correspondence of the Teflon extension 26'. Indeed, it constitutes the entire insulating core of a coaxial line whose central conductor is 25" and the coaxial conductor is the metal wall of the smaller diameter section of the hole 29. Calculation of the physical length of the one-fourth wave section consisting of the conductor 25" allows for an average propagation speed.

The above section has high impedance at the signal RF_{in} , obstructing passage of the signal currents to the connector CNT. In addition, because of its very small diameter and peculiar location in the cavity 17, it does not disturb the cavity at all.

The discoid capacitor 30 behaves like an ideal short circuit for the signal RF_{in} , discharging to ground the residual signal current which traverses the conductor section 25". The probe 25, as concerns the signal RF_{in} , is perfectly decoupled from the power supply connector CNT. Indeed, the short circuit represented by the capacitor 30 is reported by the conductor section 25", one-fourth wave long, as an open circuit at the connection point with the probe.

The probe 25 is dimensioned so as to maximize energy transfer, in the useful band of the radio frequency signal RF_{in} , from the resonant cavity 17 to the coaxial microline 20. The dimensions of the probe depend on the centre band frequency and the overall geometry of the transition. A study of the field radiated inside the resonant cavity 17 carried out by means of the Green functions provides a first solution of the problem. Theoretical considerations useful for this purpose are set forth, for example, in the volume entitled 'Microwave Transition Design', by J. Izadian, published by Artech House in 1988; or 'Field Theory of Guided Waves', by R. Collin, published by McGraw-Hill in 1960.

Measurements of the insertion losses performed between the input and the output of a circuit configuration comprising a guide-microstrip transition placed in series with a microstrip-guide transition, supplied an attenuation of only 0.2dB at 20GHz.

Measurements of the frequency response of said circuit configuration, showed a flat response in an entire frequency interval extended beyond the limits of f_0

$\pm 10\%$, where f_0 is the central frequency of 20GHz.

Measurements of the return losses of the same configuration, supplied a value lower than -17dB in the entire above frequency interval.

Significant tests were also performed on the individual amplifiers of the module 11 and no instability was found.

All of the measurements performed show further significant advantages of the guide-microstrip transition described, and in particular: low losses, broad operating band, and excellent impedance matching.

Claims

1. Guide-microstrip transition in active modules (11) operating at microwaves and comprising a coaxial microline (20) which, while maintaining seal of the module, electromagnetically couples a microstrip of an active thin film circuit (16) placed inside a module niche (12) to a probe (25) acting as an antenna inside a resonant cavity (17) communicating with a three-dimensional wave guide carrying a radio-frequency signal, characterized in that:

said probe (25) comprises a cylindrical conductor of small diameter (25") placed mainly in the resonant cavity (17) and connected to a first armature of a discoid capacitor (30) outside the resonant cavity;

in that a power supply connector (CNT), connected to a pole of a battery having its other pole grounded, is also connected to said first armature of the discoid capacitor (30), a second armature of the capacitor being connected to ground;

in that said coaxial microline (20), said cylindrical conductor (25"), said discoid capacitor (30) and said power supply connector (CNT) are aligned along a same longitudinal symmetry axis; and

in that a section of said cylindrical conductor (25") lying between the probe (25) and the first armature of the discoid capacitor (30) has an electrical length equal to one-fourth the wave-length at the centre-band frequency of said radio frequency signal (RF_{in}, RF_{out}), said section having high impedance to said signal and constituting together with the discoid capacitor (30) a polarization filter for an active device (24) connected to said microstrip.

2. Guide-microstrip transition in accordance with claim 1 characterized in that it also comprises a coaxial metal support (28) integral with the module and aligned along said longitudinal symmetry axis and having a first passing central hole (29) communicating with the outside of the module and with an

aperture of said resonant cavity (17) from which emerges said cylindrical conductor (25"), said first hole (29) receiving also said discoid capacitor (30) and said power supply connector (CNT).

3. Guide-microstrip transition in accordance with claim 2, characterized in that:

said first hole (29) comprises two contiguous sections of different diameter in which a section of smaller diameter communicates with said resonant cavity (17) and houses said cylindrical conductor (25") and a section of larger diameter communicates with the outside of the module and houses said discoid capacitor (30) and said power supply connector (CNT),

said second armature of the capacitor (30) is in contact with said coaxial metal support (28) at the point where said first hole (29) changes diameter, and

said cylindrical conductor passes through a second central hole of said capacitor (30) penetrating into a third central hole (31) of said power supply connector (CNT).

4. Guide-microstrip transition in accordance with claim 1 or 3, characterized in that said resonant cavity (17) includes a probe protective cap of dielectric material (26) comprising an extension (26') extending inside the section of smaller diameter of said first hole (29) and said protective cap (26, 26') having a fourth central hole (27) in which is located said probe (25) including said cylindrical conductor (25").

5. Active multiple module (11) operating at microwaves, characterized in that it comprises:

2N first holes (15) made along two opposing side faces of the module and said holes terminating within first apertures of respective 2N opposing resonant cavities (17) having second apertures communicating with 2N wave guides (18) carrying radio frequency input and output signals (RF_{in} , RF_{out}) connected to one face of the module perpendicular to said side faces, N niches (12, 13, 14) housing as many N circuits active with microwaves in planar technology (16) and each niche lying between two of said opposing resonant cavities,

2N coaxial microlines (20) which, maintaining the seal of the module, electromagnetically couple 2N microstrips of said N active circuits (16) to as many 2N probes (25) acting as antennas inside said 2N resonant cavities (17) and each probe (25) comprising in addition a cylindrical conductor of small diameter (25') emerging from the first aperture of the respec-

tive resonant cavity (17),

2N discoid capacitors (30) located within said 2N first holes (15) outside the resonant cavities (17) and having first armatures connected to said cylindrical conductors (25") and second armatures connected to ground,

2N power supply connectors (CNT) placed inside said first holes (15) outside the resonant cavities (17) which are also connected to said first armatures of the discoid capacitors (30) and also connected to a pole of a battery having its other pole grounded,

said multiple module being further characterized in that the sections of said cylindrical conductors (25") lying between the probes (25) and said first armatures of the discoid capacitors (30) have an electrical length one-fourth the wave length at the centre-band frequency of the respective radio frequency signals (RF_{in} , RF_{out}), and said sections having high impedance to said signals and constituting together with the respective discoid capacitors (30) as many polarization filters for active devices (24) connected to said microstrips.

6. Active multiple module in accordance with claim 5, characterized in that it also comprises 2N coaxial metal supports (28) inserted in said 2N first holes (15) and integral with the module and having along their axis respective second holes (29) communicating with the outside of the module and with said 2N first apertures of said 2N resonant cavities (17) from which emerge said cylindrical conductors (25"), said 2N second holes (29) receiving also said 2N discoid capacitors (30) and said 2N power supply connectors (CNT).

7. Active multiple module in accordance with claim 6, characterized in that:

said 2N second holes (29) comprise two respective contiguous sections of different diameter of which 2N sections of smaller diameter communicate with said 2N resonant cavities (17) and house said 2N cylindrical conductors (25"), and 2N sections of larger diameter communicate with the outside of the module and house said 2N discoid capacitors (30) and said 2N power supply connectors (CNT),

said second armatures of the capacitors (30) are in contact with said coaxial metal supports (28) at the points where said second holes (29) change diameter, and

said cylindrical conductors (25") pass through respective third holes made in the centre of said discoid capacitors (30), penetrating into respective fourth holes (31) made along the axis of said power supply connectors (CNT).

8. Active multiple module in accordance with claim 5 or 7, characterized in that said 2N resonant cavities (17) include 2N respective probe protective caps of dielectric material (26) comprising as many extensions (26') extending inside the sections of smaller diameter of said second holes (29) and said protective caps (26,26') having along their axis respective fifth holes (27) inside which are housed said probes (25) including their cylindrical conductors (25").
9. Multiple active module in accordance with claim 5, characterized in that it is a multiple amplification module in which said N active circuits (16) are N identical amplifiers to whose inputs arrive N identical low power level radio frequency signals and at whose outputs are present N identical amplified signals reaching N wave guides which are part of a wave guide power combiner.

Patentansprüche

1. Im Mikrowellenbereich arbeitender Wellenleiter-Mikrostreifenübergang in aktiven Modulen (11), bestehend aus einem Koaxial-Mikroleiter (20), welcher bei Beibehaltung der Dichtigkeit des Moduls den Mikrostreifenleiter eines in einer Nische (12) des Moduls untergebrachten Dünnschicht-Mikrowellenschaltkreises (16) elektromagnetisch mit einer Sonde (25) verkoppelt, die innerhalb eines Resonanzhohlraums (17) als Antenne fungiert, welcher mit einem dreidimensionalen Wellenleiter kommuniziert, der ein Hochfrequenzsignal überträgt, gekennzeichnet durch folgende Eigenschaften:
- zur besagten Sonde (25) gehört ein zylindrischer Leiter mit kleinem Durchmesser (25"), der vorwiegend im Resonanzhohlraum (17) platziert ist und an die erste Belegung eines discoidalen Kondensators (30) außerhalb des Resonanzhohlraums angeschlossen ist;
 - ein Stromquellensteckverbinder (CNT), der an den Pol einer Batterie angeschlossen ist, deren zweiter Pol geerdet ist, und der außerdem an besagte erste Belegung des discoidalen Kondensators (30) sowie an eine zweite Belegung des geerdeten discoidalen Kondensators angeschlossen ist;
 - der besagte Koaxial-Mikroleiter (20), der besagte zylindrische Leiter (25"), der besagte discoidale Kondensator (30) und der besagte Stromquellensteckverbinder (CNT) liegen an einer gemeinsamen symmetrischen Längsachse;
 - die elektrische Länge des zylindrischen Leiters (25"), der zwischen der Sonde (25) und der ersten Belegung des discoidalen Kondensators (30) installiert ist, beträgt ein Viertel der Wellen-

länge der Mittelbandfrequenz des besagten Hochfrequenzsignals RF_{in} (RF_{out}), wobei der besagte Abschnitt zu diesem Signal eine hohe Impedanz hat und zusammen mit dem discoidalen Kondensator (30) einen Polarisationsfilter für ein aktives Modul (24) darstellt, welches an besagten Mikrostreifenleiter angeschlossen ist.

2. Wellenleiter-Mikrostreifenübergang, wie unter Inanspruchnahme 1) beschrieben, jedoch gekennzeichnet dadurch, daß er zusätzlich einen metallischen Koaxialträger (28) enthält, der als fester Bestandteil in das Modul eingebaut ist, ebenfalls an besagter Längsachse installiert ist und eine erste Durchgangsbohrung hat (29), welche mit der Außenseite des Moduls sowie mit einer Öffnung des besagten Resonanzhohlraums (17) in Verbindung steht, aus welchem der besagte zylindrische Leiter (25") heraustritt, wobei die besagte erste Bohrung (29) den besagten discoidalen Kondensator (30) sowie den besagten Stromquellensteckverbinder (CNT) aufnimmt.
3. Wellenleiter-Mikrostreifenübergang, wie unter Inanspruchnahme 2) beschrieben, jedoch gekennzeichnet dadurch:
- in der besagten ersten Bohrung (29) zwei aneinandergrenzende Abschnitte mit unterschiedlichem Durchmesser präsent sind, von denen der Abschnitt mit dem kleineren Durchmesser mit dem besagtem Resonanzhohlraum (17) in Verbindung steht und den besagten zylindrischen Leiter (25") enthält, während der zweite Abschnitt mit größerem Durchmesser mit der Außenseite des Moduls in Verbindung steht und den besagten discoidalen Kondensator (30) sowie den besagten Stromquellensteckverbinder (CNT) enthält;
 - die besagte zweite Belegung des Kondensators (30) mit dem besagten metallischen Koaxialträger (28) an der Stelle in Kontakt steht, an der sich der Durchmesser der besagten ersten Bohrung (29) verändert;
 - der besagte zylindrische Leiter durch eine zweite zentrale Bohrung des besagten discoidalen Kondensator (30) läuft und in eine dritte zentrale Bohrung (31) des besagten Stromquellensteckverbinders (CNT) eintritt.
4. Wellenleiter-Mikrostreifenübergang, wie unter Inanspruchnahme 1) bzw. 3) beschrieben, jedoch gekennzeichnet dadurch, daß zu besagtem Resonanzhohlraum (17) eine SONDENSCHUTZKAPPE aus nichtleitendem Material (26) gehört, zu der ein Verlängerungsstück (26') gehört, welches sich innerhalb des Abschnittes mit kleinem Durchmesser der

besagten ersten Bohrung (29) ersteckt, und gekennzeichnet dadurch, daß besagte SONDENSCHUTZKAPPE (26, 26') eine vierte zentrale Bohrung (27) besitzt, in der die besagte Sonde (25) untergebracht ist, zu welcher der besagte zylindrische Leiter (25") gehört.

5. Im Mikrowellenbereich arbeitendes multiples Aktivmodul (11), dadurch gekennzeichnet, daß es folgende Teile enthält:

- 2N erste Bohrungen (15), plaziert in den beiden gegenüberliegenden Seitenflächen des Moduls sowie zwei besagte Bohrungen, die in einer ersten Öffnung der entsprechenden 2N gegenüberliegenden Resonanzhöhlräume (17) enden, welche zweite Öffnungen haben, die mit den 2N Wellenleitern (18) kommunizieren, welche Hochfrequenz-Eingangs- und Ausgangssignale RF_{in} (RF_{out}) übertragen und mit einer Seite des Moduls verbunden sind, die sich vertikal zu den besagten Seitenflächen befindet;
- N Nischen (12, 13, 14), in denen ebenso viele N gegenüber Mikrowellen aktive Schaltkreise in Flachbauweise (16) untergebracht sind, wobei jede dieser Nischen zwischen zwei der besagten gegenüberliegenden Resonanzhöhlräume liegt;
- 2N Koaxial-Mikroleiter (20), welche bei Beibehaltung der Dichtigkeit des Moduls 2N Mikrostreifenleiter der besagten N aktiven Schaltkreise (16) mit ebenso vielen 2N Sonden (25) elektromagnetisch verkoppeln, welche innerhalb der besagten Resonanzhöhlräume (17) als Antenne fungieren, wobei jede Sonde (25) zusätzlich einen zylindrischen Leiter (25') mit kleinem Durchmesser enthält, der aus der ersten Öffnung des jeweiligen Resonanzhohlraumes (17) heraussteht;
- 2N discoidale Kondensatoren (30), untergebracht in den besagten 2N ersten Bohrungen (15) außerhalb der Resonanzhöhlräume (17) mit ersten Belegungen, die an die besagten zylindrischen Leiter (25") angeschlossen sind, während die zweiten Belegungen an Erde angeschlossen sind;
- 2N Stromquellensteckverbinder (CNT), plaziert in den besagten ersten Bohrungen (15) außerhalb der Resonanzhöhlräume (17), welche ebenfalls an die ersten Belegungen der discoidalen Kondensatoren (30) sowie an den Pol einer Batterie angeschlossen sind, deren zweiter Pol geerdet ist;
- das besagte multiple Aktivmodul ist des weiteren dadurch gekennzeichnet, daß die Abschnitte der besagten zylindrischen Leiter (25") zwischen den Sonden (25) und den besagten ersten Belegungen der discoidalen Kondensato-

ren (30) liegen, und daß die elektrische Länge der besagten ersten Belegungen der discoidalen Kondensatoren (30) gleich einem Viertel der Wellenlänge bei Mittelbandfrequenz der entsprechenden Hochfrequenzsignale (RF_{in} , RF_{out}) ist, wobei die besagten Abschnitte zu diesen Signalen eine hohe Impedanz haben und zusammen mit den entsprechenden discoidalen Kondensatoren (30) ebenso viele Polarisationsfilter für die an die besagten Mikrostreifenleiter angeschlossenen aktiven Module (24) darstellen.

6. Multiples Aktivmodul (11), wie unter Inanspruchnahme 5) beschrieben, jedoch dadurch gekennzeichnet, daß es außerdem 2N metallische Koaxialträger (28) enthält, die in den besagten 2N ersten Bohrungen (15) untergebracht sind, fest mit dem Modul verbunden sind und längs ihrer Achse zweite Bohrungen (29) haben, welche mit der Außenseite des Moduls sowie mit den besagten 2N ersten Öffnungen der besagten 2N Resonanzhöhlräume (17) in Verbindung stehen, aus denen die besagten zylindrischen Leiter (25") hervortreten, wobei die 2N zweiten Bohrungen (29) außerdem die besagten 2N discoidalen Kondensatoren (30) sowie die besagten 2N Stromquellensteckverbinder (CNT) aufnehmen.

7. Multiples Aktivmodul, wie unter Inanspruchnahme 6) beschrieben, jedoch dadurch gekennzeichnet, daß

- die besagten zweiten Bohrungen (29) zwei aneinandergrenzende Abschnitte mit unterschiedlichem Durchmesser haben, von denen 2N Abschnitte mit dem kleineren Durchmesser mit den besagten Resonanzhöhlräumen (17) in Verbindung stehen und die besagten zylindrischen Leiter (25") enthalten, während 2N zweite Abschnitte mit größerem Durchmesser mit der Außenseite des Moduls in Verbindung stehen und die besagten discoidalen Kondensatoren (30) sowie die besagten Stromquellensteckverbinder (CNT) enthalten;
- die besagten zweiten Belegungen der Kondensatoren (30) mit den besagten metallischen Koaxialträgern (28) an den Stellen in Kontakt stehen, an denen sich der Durchmesser der besagten zweiten Bohrungen (29) verändert;
- die besagten zylindrischen Leiter (25") durch eine dritte zentrale Bohrung der besagten discoidalen Kondensatoren (30) laufen und entlang der Achse der besagten Stromquellensteckverbinder (CNT) in vierte zentrale Bohrungen (31) eintreten.

8. Multiples Aktivmodul, wie unter Inanspruchnahme

5) bzw. 7) beschriebenen, jedoch dadurch gekennzeichnet, daß die besagten 2N Resonanzhohlräume (17) je 2N Sondenschutzkappen aus nichtleitendem Material (26) enthalten, zu denen ebenso viele Verlängerungsstücke (26') gehören, welche sich innerhalb der Abschnitte mit kleinem Durchmesser der besagten zweiten Bohrungen (29) ausdehnen, und gekennzeichnet dadurch, daß die besagten Sondenschutzkappen (26, 26') längs ihrer Achse fünfte zentrale Bohrungen (27) haben, in denen die besagten Sonden (25) sowie die besagten zylindrischen Leiter (25'') untergebracht sind.

9. Multiples Aktivmodul, wie unter Inanspruchnahme 5) beschrieben, jedoch dadurch gekennzeichnet, daß es sich um ein Vielfachverstärkermodul handelt, in dem die besagten N aktiven Schaltkreise (16) N identische Verstärker sind, an deren Eingängen N identische Hochfrequenzsignale mit niedrigem Pegel ankommen, während an den Ausgängen dieser Verstärker N identische verstärkte Signale präsentiert sind, die an die N Wellenleiter übertragen werden, welche Bestandteil eines Wellenleiter-Leistungskombinators sind.

Revendications

1. Transition guide-lignes à bandes parallèles en modules actifs (11) fonctionnant aux microondes, comprenant une microligne coaxiale (20) qui, tout en gardant l'étanchéité du module, accouple électromagnétiquement une ligne à bandes parallèles d'un circuit actif en film mince (16), logé à l'intérieur d'une niche du module (12), avec une sonde (25) servant d'antenne à l'intérieur d'une cavité résonnante (17) en communication avec une guide d'onde tridimensionnelle qui transporte un signal à radiofréquence, caractérisée par le fait que:

ladite sonde (25) comprend un conducteur cylindrique de petit diamètre (25''), logé essentiellement à l'intérieur de la cavité résonnante (17), relié à une première plaque d'un condensateur discoïde (30) à l'extérieur à la cavité résonnante;

par le fait qu'un connecteur d'alimentation (CNT), relié à un pôle d'une batterie dont l'autre pôle est mis à la terre, est - lui aussi - relié à ladite première plaque du condensateur discoïde (30), une deuxième plaque du condensateur étant reliée à la terre;

par le fait que ladite microligne coaxiale (20), ledit conducteur cylindrique (25''), ledit condensateur discoïde (30), et ledit connecteur d'alimentation (CNT) sont alignés le long du même axe de symétrie longitudinale; et par le fait qu'une section dudit conducteur cy-

lindrique (25''), comprise entre la sonde (25) et la première plaque du condensateur discoïde (30), a une longueur électrique égale à un quart de la longueur d'onde à la fréquence du centre de la bande dudit signal à radiofréquence (Rf_{in} , Rf_{out}), ladite section présentant une haute impédance au signal susdit et constituant, avec le condensateur discoïde (30), un filtre de polarisation pour un dispositif actif (24) relié à la ligne à bandes parallèles susdite.

2. Transition guide-ligne à bandes parallèles selon la revendication 1, caractérisée par le fait qu'elle comprend, de plus, un support métallique coaxial (28) solidaire au module et aligné le long dudit axe de symétrie longitudinale, ayant un premier trou central passant (29) qui communique avec l'extérieur du module et avec une ouverture de ladite cavité résonnante (17) de laquelle sort ledit conducteur cylindrique (25''), ledit premier trou (29) logeant, de plus, ledit condensateur discoïde (30) et ledit connecteur d'alimentation (CNT).

3. Transition guide-ligne à bandes parallèles selon la revendication 2, caractérisée par le fait que:

ledit premier trou (29) comprend deux sections contigües avec diamètres différents, où une section au diamètre plus petit est en communication avec ladite cavité résonnante (17) et loge ledit conducteur cylindrique (25''), et une section au diamètre plus grand qui est en communication avec l'extérieur du module et loge ledit condensateur discoïde (30) et ledit connecteur d'alimentation (CNT);

par le fait que ladite deuxième plaque du condensateur (30) est en contact avec ledit support métallique coaxial (28) dans l'endroit où ce premier trou (29) change son diamètre;

et par le fait que ledit conducteur cylindrique traverse un deuxième trou central dudit condensateur (30) en pénétrant dans un troisième trou central (31) dudit connecteur d'alimentation (CNT).

4. Transition guide-ligne à bandes parallèles selon les revendications 1 ou 3, caractérisée par le fait que ladite cavité résonnante (17) comprend une corne de protection en matériel diélectrique (26), comprenant à son tour un prolongement (26') s'étendant à l'intérieur de la section au diamètre plus petit dudit premier trou (29); ladite corne de protection (26, 26') ayant un quatrième trou central (27) à l'intérieur duquel ladite sonde (25) est logée, comprenant aussi ledit conducteur cylindrique (25'').

5. Module actif multiple (11) fonctionnant aux microondes, caractérisé par le fait qu'il comprend:

2N premiers trous (15) percés le long de deux faces latérales opposées du module, lesdits trous aboutant dans les premières ouvertures de 2N cavités résonnantes opposées respectives (17) ayant de deuxièmes ouvertures communiquant avec 2N guides d'onde (18), qui transportent des signaux à radiofréquence en entrée ou en sortie (Rf_{in} , Rf_{out}), reliées à une face du module perpendiculaire auxdites faces latérales;

N niches (12, 13, 14) qui logent autant de N circuits actifs aux microondes en technologie planaire (16), chaque niche étant comprise entre deux desdites cavités résonnantes opposées; 2N microlignes coaxiales (20) qui, en gardant l'étanchéité du module, accouplent électromagnétiquement 2N lignes à bandes parallèles desdits N circuits actifs (16), à d'autant 2N sondes (25) servant d'antennes à l'intérieur desdites 2N cavités résonnantes (17), chaque sonde (25) comprenant, en outre, un conducteur cylindrique de petit diamètre (25") qui sort de la première ouverture de la cavité résonnante respective (17);

2N condensateurs discoïdes (30), logées dans lesdits 2N premiers trous (15) à l'extérieur des cavités résonnantes (17), ayant les premières plaques reliées auxdits conducteurs cylindriques (25"), et les deuxièmes plaques reliées à la terre;

2N connecteurs d'alimentation (CNT), logés à l'intérieur desdits premiers trous (15) à l'extérieur des cavités résonnantes (17), et reliés - eux aussi - auxdites premières plaques des condensateurs discoïdes (30) et reliés aussi à un pôle d'une batterie qui a l'autre pôle relié à la terre;

ledit module multiple étant ultérieurement caractérisé par le fait que les sections desdits conducteurs cylindriques (25") compris entre les sondes (25) et lesdites premières plaques des condensateurs discoïdes (30) ont une longueur électrique égale à un quart de la longueur d'onde à la fréquence du centre de la bande desdits signaux à radiofréquence respectifs (Rf_{in} , Rf_{out}), lesdites sections présentant une haute impédance auxdits signaux et constituant, avec les condensateurs discoïdes respectifs (30), autant de filtres de polarisation pour des dispositifs actifs (24) reliés à ces lignes à bandes parallèles.

6. Module actif multiple selon la revendication 5, caractérisé par le fait qu'il comprend, en outre, 2N supports métalliques coaxiaux (28) inserés dans lesdits 2N premiers trous (15) et solidaires au module, ayant de deuxièmes trous respectifs (29) le long de leur axe qui sont en communication avec l'extérieur

du module et avec lesdites 2N premières ouvertures desdites 2N cavités résonnantes (17), d'où sortent lesdits conducteurs cylindriques (25"); lesdits 2N deuxièmes trous (29) accueillant, en outre, lesdits 2N condensateurs discoïdes (30) et lesdits 2N connecteurs d'alimentation (CNT).

7. Module actif multiple selon la revendication 6, caractérisé par le fait que:

lesdits 2N deuxièmes trous (29) comprennent deux sections respectives contigües avec diamètres différents, dont 2N sections avec un diamètre plus petit sont en communication avec lesdites 2N cavités résonnantes (17) et logent ledits 2N conducteurs cylindriques (25"), et 2N sections avec un diamètre plus grand sont en communication avec l'extérieur du module et logent ledites 2N condensateurs discoïdes (30) et ledits 2N connecteurs d'alimentation (CNT); par le fait que lesdites deuxièmes plaques des condensateurs (30) sont en contact avec ledits supports métalliques coaxiaux (28) aux endroits où ledits deuxièmes trous (29) changent leur diamètre;

et par le fait que ledits conducteurs cylindriques (25") traversent des troisièmes trous respectifs, percés dans le centre desdits condensateurs discoïdes (30), en pénétrant dans des quatrièmes trous respectifs (31) percés le long de l'axe desdits connecteurs d'alimentation (CNT).

8. Module actif multiple selon les revendications 5 ou 7, caractérisé par le fait que lesdites cavités résonnantes (17) comprennent 2N cornes de protection respectives en matériel diélectrique (26), comprenant autant de prolongements (26') s'étendant à l'intérieur des sections au diamètre plus petit desdits deuxièmes trous (29); lesdites cornes de protection (26, 26') ayant des cinquièmes trous respectifs (27) le long de leur axe, avec lesdites sondes (25), y compris leur conducteurs cylindriques (25"), logées à l'intérieur de ces cinquièmes trous.

9. Module actif multiple selon la revendication 5, caractérisé par le fait qu'il s'agit d'un module d'amplification multiple où lesdits N circuits actifs (16) sont N amplificateurs identiques aux entrées desquels arrivent N signaux identiques à radiofréquence à un bas niveau de puissance, et aux sorties desquels sont présents N signaux amplifiés identiques qui atteignent N guides d'onde qui appartiennent à un combinateur de puissance en guide d'onde.

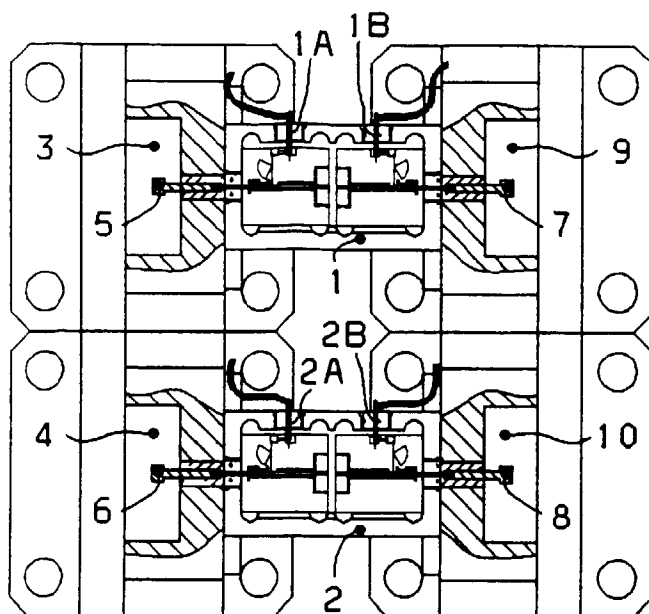


Fig. 1

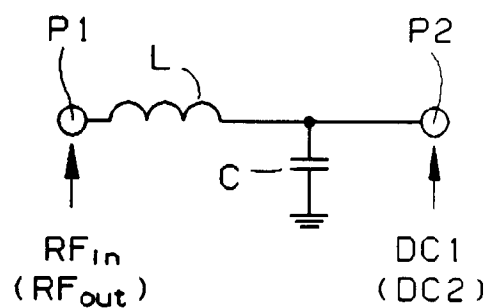


Fig. 2

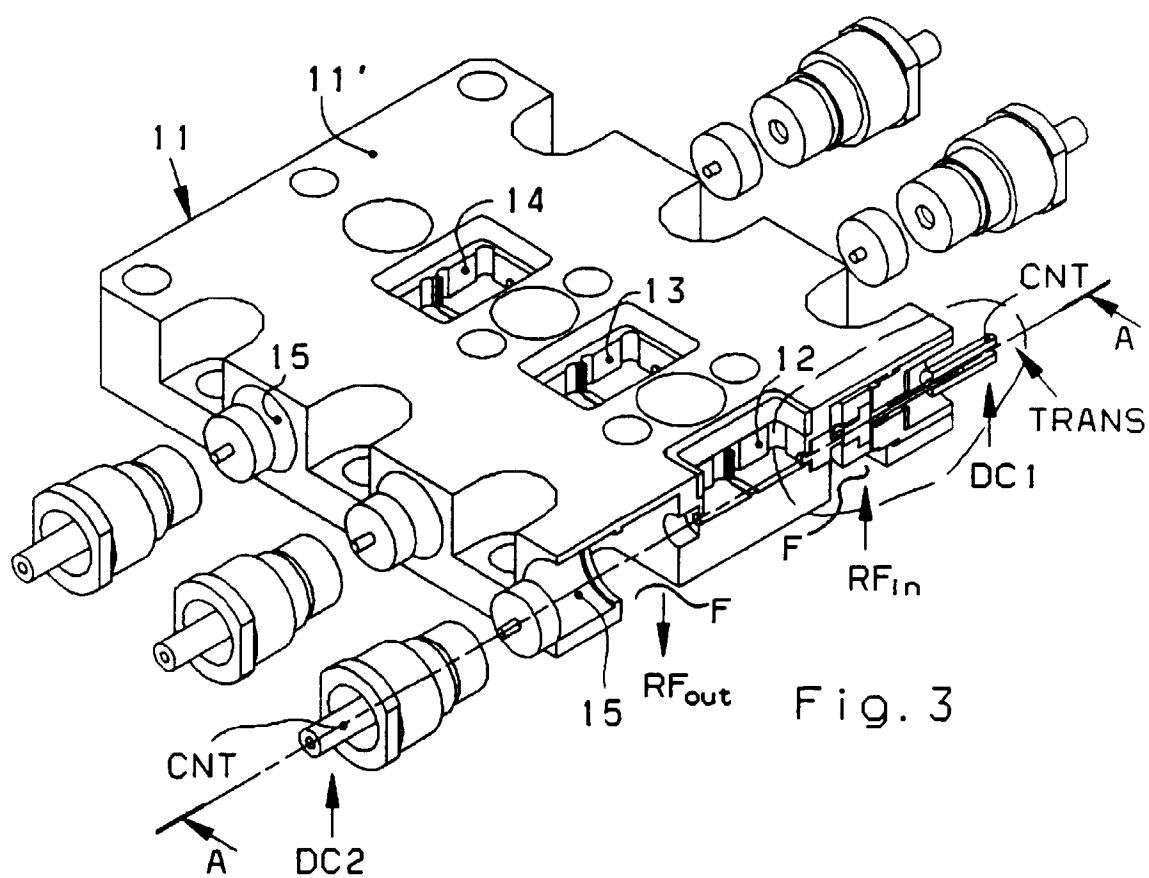


Fig. 3

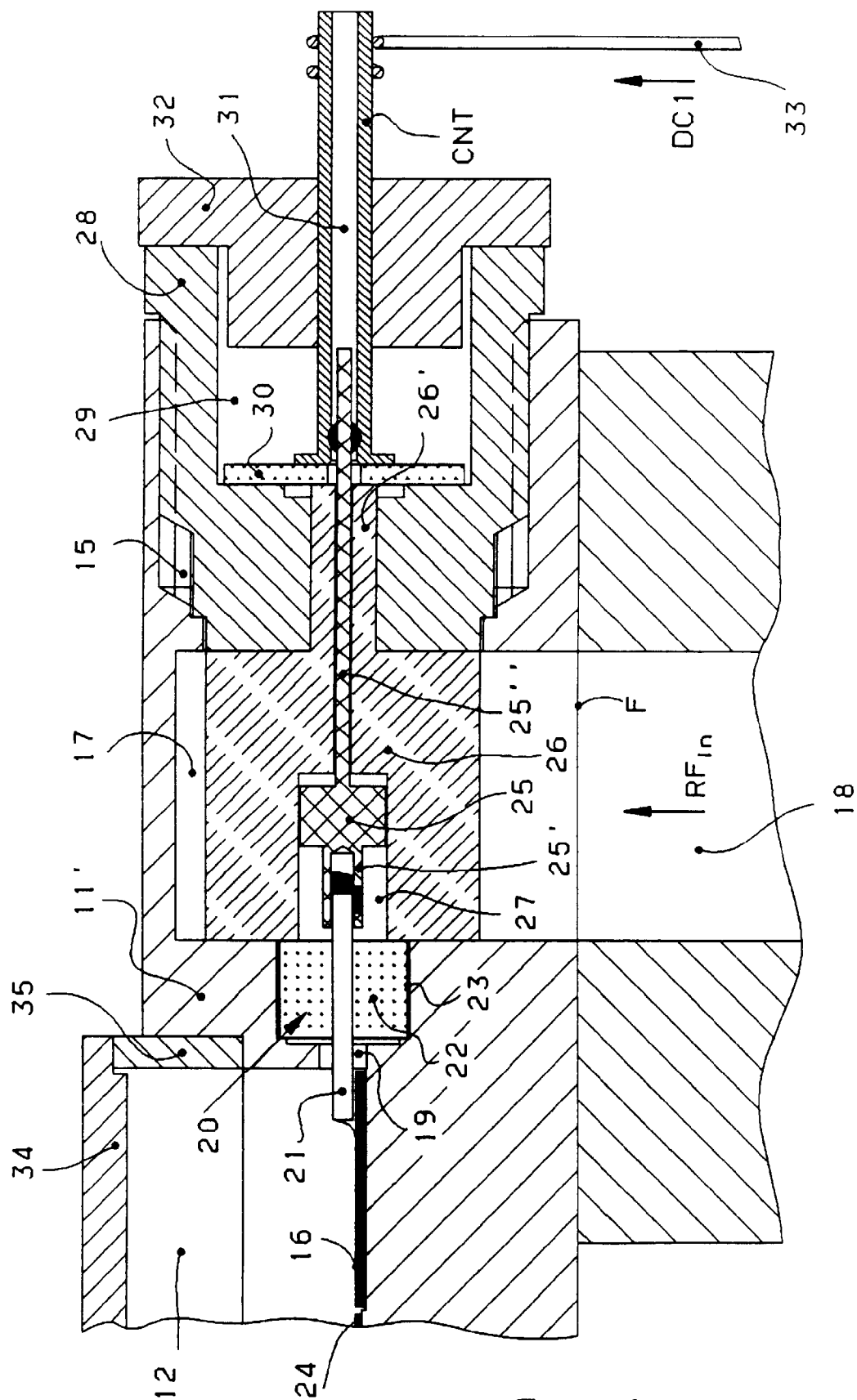


Fig. 4