

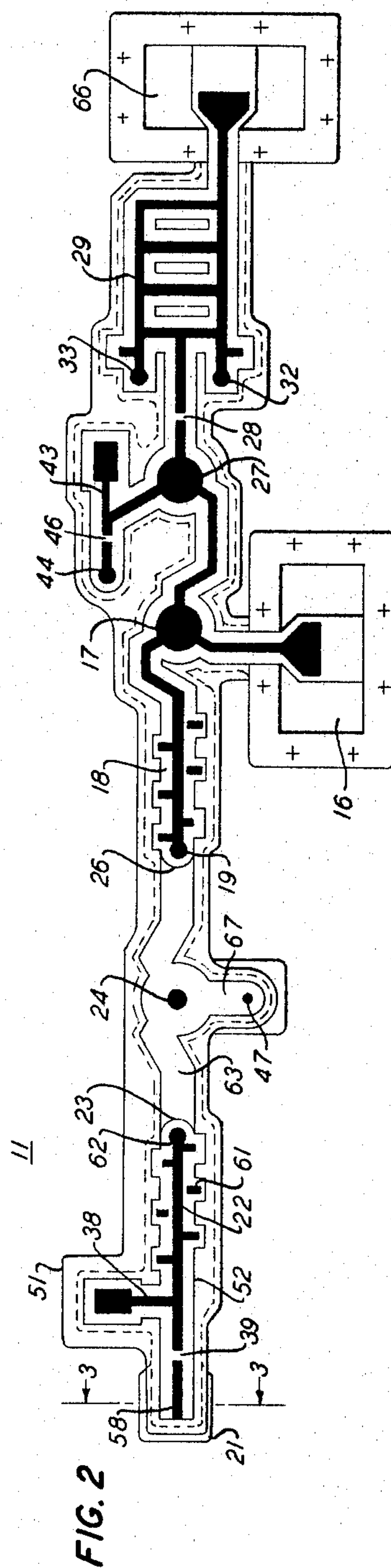
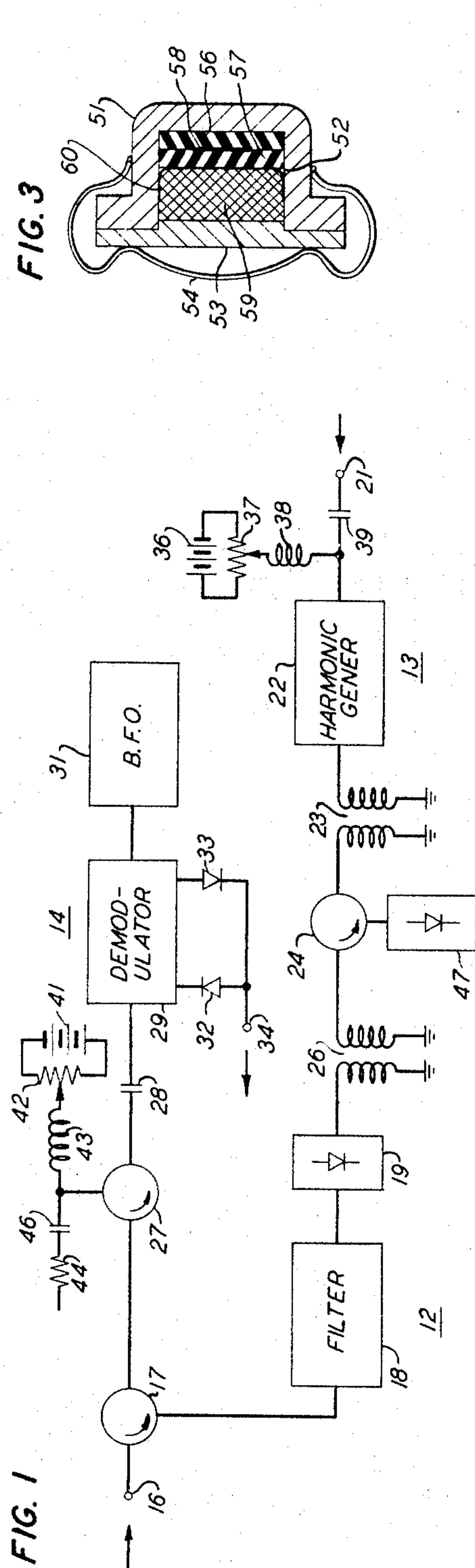
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HIGH FREQUENCY AMPLIFIER

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3,392,338

HIGH FREQUENCY AMPLIFIER

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ABSTRACT OF THE DISCLOSURE

A parametric amplifier includes an impedance mismatch between the pump and the variable reactor. A monitor circuit is connected to receive reflections from the mismatch and give an indication of the location of malfunctions in the pump or amplifier. The entire circuit is housed in a cast metallic member forming stripline and waveguide sections.

This invention relates to microwave receivers, and, more particularly, to parametric type microwave receivers using strip transmission lines.

Strip transmission lines in microwave circuitry in general possess certain advantages in comparison to waveguides or coaxial transmission lines. The strip line is more suited to large scale manufacture than the other types of lines, and is considerably more economical. In addition, strip line configurations are usually much more compact than the waveguide or coaxial cable arrangements.

A strip transmission line usually comprises a pair of dielectric sheets having copper cladding on one side. The copper cladding forms the ground planes of the line. Sandwiched between the two sheets is a flat conducting strip whose width is somewhat less than the width of the dielectric sheets. The entire assembly is held together by means of rows of rivets on either side of the center conducting strip, which also prevent propagation of waveguide modes along the line and minimize power leakage.

Dielectric materials currently in use generally have a large temperature coefficient and plastic flow which results in expansion and contraction due to temperature cycling and external pressure. As a consequence, the rivets become loosened and cause erratic performance of active elements as well as variations in the characteristic impedances and losses of the line. The rivets, to prevent propagation in a waveguide mode must be located at a proper distance from the center conductor. For example, at a frequency of 12 gigacycles (10^9 cycles per second), the rivets are approximately one-tenth of an inch from the middle of the center conductor. Such distances necessitate the use of very small rivets which introduce, because of their small size and spacing, a considerable amount of inductance.

The use of large numbers of such small rivets materially complicates manufacture by necessitating the drilling of hundreds of closely spaced holes. Where the configuration is large, an additional factor of warpage and physical distortion is introduced.

It is an object of the present invention to eliminate the foregoing enumerated drawbacks of conventional strip lines through the elimination of the rivets, temperature cycling and pressure sensitivity, and distortion and warpage.

In single port reflection type parametric amplifiers where circulators are used to separate the signals, the insertion loss of the amplifier resulting from failure of the pump or varactor diode is quite small, being of the order of 3 decibels or less for a pump failure and less than 1 decibel for a varactor failure. When the amplifier is used in a radio relay system as part of a receiver, for example, such failures do not interrupt the system operation and, consequently, are quite difficult to detect.

It is another object of this invention, therefore, to detect

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failures in the amplifier or receiver and to identify the type of failure.

These and other embodiments of the present invention are realized in an illustrative embodiment thereof which comprises a microwave receiver having both strip line and waveguide components.

The entire amplifier circuit is formed in a cast or pressed light weight two-part metal housing. One of the housing members has slots or grooves formed therein, the side walls of which form the side walls of the waveguide sections and the shields of the strip line sections. These grooves are, in the case of the strip line sections, filled with a sandwich of a conducting member between two dielectric members, while the waveguide sections are filled with dielectric material. The two parts of the metal housing, therefore, form the ground planes and shield members of the strip line and the walls of the waveguide. The assembly is held together by means of screws which do not affect the electrical characteristics of the system. Such an arrangement eliminates pressure and temperature sensitivity in the receiver circuit and, as a consequence, insures stable performance.

In order that the pump circuits and the parametric amplifier circuit may be monitored to ascertain the condition of the active elements, i.e., diodes, a diode monitor is connected in a waveguide circuit between the pump strip line circuit and the amplifier strip line circuit. The monitor diode indicates, as will be explained more fully hereinafter, whether either active element, i.e., pump diode or amplifier diode, has failed and identifies which element is faulty.

It is a feature of the present invention that the receiver-amplifier circuit is a combination of strip line and waveguide lines formed in a cast or pressed metal member which defines the dimensions of the lines and functions as part of both the strip lines and the waveguides.

It is another feature of the present invention that a diode monitor is connected in the receiver-amplifier circuit for monitoring and identifying faulty active elements in the circuit.

These and other objects and features of the present invention will be more readily apparent from the following detailed description, taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a schematic diagram of the receiver circuit of the present invention;

FIG. 2 is a plan view of a receiver-amplifier circuit embodying the principles of the invention;

FIG. 3 is a cross-section view taken along the line 3—3 of FIG. 1.

Turning now to FIG. 1, there is depicted the circuit arrangement of the receiver of the present invention. The receiver 11 comprises an R.F. amplifier section 12, a pump generator section 13, and an I.F. section or demodulator 14. The input signal is introduced into input coupler 16, through circulator 17, band reject filter 18, and into the varactor diode amplifier 19. At the same time, carrier frequency energy is introduced through input 21 into a harmonic generator or frequency tripler 22. The increased frequency energy is inductively coupled to the diode amplifier 19 through transformer 23, circulator 24 and transformer 26, where it functions to pump the diode amplifier 19.

The amplified signal energy passes back through filter 18 to circulator 17. Filter 18 prevents any pump and idler energy from reaching circulator 17. The idler frequency, which in this embodiment is approximately twice the signal frequency, is, therefore, trapped at the diode and dissipated. From circulator 17 the amplified signal energy passes through a circulator 27 and a D.C. blocking capacitor 28 to a demodulator 29. A beat frequency oscillator 31 supplies beat frequency energy to demodula-

tor 29, which includes a pair of diodes 32, 33, and the I.F. signal is extracted at output coupler 34.

A D.C. bias source 36 supplies a D.C. bias through a potentiometer 37 and choke 38 to the harmonic generator 22. The bias voltage is prevented from feeding back through input 21 by a D.C. blocking capacitor 39. Bias voltage for amplifier 19 is supplied by a source 41 through a potentiometer 42, choke 43, circulators 27 and 17 and filter 18. Energy from source 41 is prevented from reaching demodulator 29 by blocking capacitor 28.

Any R.F. energy that is reflected from demodulator 29 is directed by circulator 27 to a dissipating resistance 44 through a D.C. blocking capacitor 46.

In order that the conditions of the varactor diode 19 and the frequency tripler, which is preferably also a diode, may be checked, a monitor diode 47, biased by suitable means, not shown, is connected to one arm of circulator 24. This diode 47 provides in a manner to be explained more fully hereinafter, a signal indicating a malfunction of either the amplifier or the tripler and identifies which element is malfunctioning.

In operation, signal energy at, for example, a frequency of 3.7 to 4.2 gigacycles per second (gc.) is introduced at input coupler 16. At the same time, carrier frequency energy at a frequency of from 3.7 to 4.2 gc. is introduced at input 21. The carrier frequency energy is tripled in frequency to from approximately 11 to 12.5 gc. in harmonic generator 22. This increased frequency passes through transformer 23, circulator 24, transformer 26, and acts to pump varactor diode 19. This pump energy is prevented from reaching circulator 17 by band reject filter 18, which, in this example, rejects a band from 6 to 13 gc.

The signal energy is directed by circulator 17 through filter 18 to amplifier 19 where it is amplified and reflected back to circulator 17. The signal energy is prevented from passing to circulator 24 by the characteristics of the transmission line connecting transformers 26 and 23, as will be explained more fully hereinafter. The amplified signal passes through circulator 27 to demodulator 29 where it is mixed with the energy from the beat frequency oscillator 31. Typically, the BFO frequency differs from the signal frequency by ± 70 megacycles per second. Thus, for a center signal frequency of 3.750 gc. the BFO frequency is 3.820 gc. or 3.680 gc. The mixer output from diodes 32 and 33 at output 34 is a signal having a center frequency of 70 mc.

Inasmuch as the parametric amplifier of the circuit of FIG. 1 is a single port reflection type where input and output signals are separated by a circulator, the insertion loss of the amplifier due to a pump varactor or amplifier varactor failure is quite small; less than 3 db for a pump failure and less than 1 db for an amplifier failure. As a consequence, in a radio relay system, a failure in the amplifier circuit of FIG. 1 does not interrupt the system operation except under severe fading conditions, and hence cannot easily be detected from the performance of the over-all system. As a consequence, in the circuit of the present invention, diode monitor 47 is utilized to monitor the condition of both the amplifier and harmonic generator diodes.

There is a slight mismatch at transformer 26 to the pump power, hence a small fraction of the pump power is reflected back to circulator 24 and directed to diode 47. A mismatch VSWR (voltage standing wave ratio) of 1.3 or 1.4 (approximately 2% reflected power) is sufficient to produce a detectable current in diode 47. If the amplifier diode is shorted or open, substantially all of the pump power is reflected back to diode 47, and it draws a large current. On the other hand, if the diode in the tripler 22 fails, no power is received at the diode 47. As a consequence, therefore, with the system in operation, if there is no detectable current in diode 47, it is a reliable indication of a failure of the tripler 22. On the other hand, if there is an excessive current through diode 47, it is an

indication that the amplifier diode is defective, or has failed. What constitutes an excessive current is determined by the particular operating conditions and degree of mismatch used in transformer 26. A warning signal circuit can comprise simply an indicating meter with high and low current limits indicated on the face, or high and low current switches for actuating a warning signal. With such an indicating meter, any readings between the low current indication of proper operating conditions and the high current limit indicate detuning of the pump circuit, the amount of current drawn being dependent on the degree of detuning. Hence diode 47 detects failure of either the amplifier or generator diode and identifies the faulty one. In addition, it detects more than an allowable detuning of the pump circuit.

In FIGS. 2 and 3 there is depicted a combination strip line waveguide configuration of the circuit of FIG. 1. For simplicity, elements of the arrangement of FIG. 2 are given the same reference numerals as their counterparts in FIG. 1.

The structure of FIGS. 2 and 3 comprises a cast or pressed metallic base member 51 of aluminum or other suitable conducting material in which grooves 52 are formed. As previously pointed out, and as best seen in FIG. 3, the grooves 52 form the side walls and one ground plane of the strip line, and three walls of the waveguide. A metallic cap member 53 is held in place by spring clips 54, or by screws or other suitable means. The grooves 52 in the strip line portions contain a sandwich of first and second dielectric members 56, 57, with a thin flat conducting strip 58 between them. In order to provide proper pressure to the dielectric members 56, 57 with regard to ambient temperature and to absorb leaked power from the lines, the remainder of the groove is filled with suitable loose dielectric material 59, as are the waveguide portions of the circuit. A metallic member 60 is in pressure contact with the surface of dielectric member 57 and forms the upper ground plane of the line and the fourth wall of the waveguide.

In FIG. 2, carrier frequency energy is introduced through a coaxial cable (not shown) to input 21. Capacitance 39 is formed by a break in the thin strip conductor 58, and choke 38 is formed by a conducting strip one quarter wavelength long at the carrier frequency. The harmonic generator or tripler 22 comprises a band reject filter 61 and a tripler diode 62. Filter 61 passes carrier frequency energy to the diode 62, but prevents the tripled and doubled frequencies from passing back to input 21. The pump frequency energy, i.e., the output of tripler 22, passes through transformer 23, which is a strip line to waveguide transition, into a waveguide section 63 and to circulator 24 which may take any of a number of forms known in the art, and generally comprises a disc of gyromagnetic material biased by suitable magnetic means, not shown.

From circulator 24 the pump energy passes through transformer 26, a waveguide to strip line transition, slightly mismatched in accordance with known techniques for the reasons stated in the foregoing, to varactor diode 19.

Signal energy is introduced at a waveguide to strip line coupler 16, and passes through circulator 17, filter 18, to diode 19, where it is amplified. The characteristics of waveguide 63 are such that signal frequency energy cannot pass therethrough, while a filter 18 effectively blocks pump and idler frequency energies. The amplified signal energy then passes to demodulator 29 which is supplied with beat frequency energy through a waveguide to strip line coupler 66. The output of demodulator 29 is taken from diodes 32 and 33 by means of suitable coupling 34, which may be coaxial cable couplers or the like.

Monitor diode 47 is mounted in a waveguide arm 67 of circulator 24 and is biased by any suitable means not shown.

From the foregoing, it can readily be seen that the struc-

ture of the receiver, as shown in FIGS. 2 and 3, is such that the pressure sensitivity, erratic behavior, distortion and warpage common to most strip line configurations is eliminated. In addition, in operation, the monitor diode affords a continuing check of the condition of the tripler and amplifier diodes and the degree of mismatch in the system, and readily identifies a malfunction when it occurs.

The foregoing description has been by way of illustration of the principles of the invention. Various modifications and changes may occur to workers skilled in the art without departing from the spirit and scope of the present invention.

What is claimed is:

1. An amplifier circuit comprising a metallic housing member and a cover plate therefor, said housing member having a plurality of grooves therein, a portion of said grooves being partially filled with dielectric material having at least one flat conducting member suspended therein and spaced from the walls of said grooves and from said housing and cover plate, a variable reactance amplifier device in one of said grooves, means for applying pump energy and signal energy to said reactance device, said means for applying pump energy including means forming a partial impedance mismatch with said reactance device, and means for monitoring the condition of said reactance device comprising a semiconductor diode in another of said grooves between the pump supplying means and said variable reactance device, said diode being so connected in the circuit as to receive energy reflected from said mismatch means.

2. An amplifier circuit comprising a conductive metallic housing member and a cover plate therefor, said housing member having a plurality of grooves therein, a portion of said grooves being partially filled with dielectric material having at least one flat conducting member suspended therein and spaced from the walls of said grooves and from said housing and cover plate to form a strip transmission line, another portion of said grooves being at least partially filled with dielectric material to form a waveguide transmission line, a variable reactance amplifier device in one of the strip line containing grooves, a source of pump frequency energy in another of said strip line containing grooves, said source and said device being

connected by a waveguide section of transmission line for supplying pump energy to said device, there being a partial impedance mismatch between said waveguide section and the strip line portion containing said variable reactance device, means for supplying signal energy to said device, and means for monitoring the condition of said reactance device and said pump frequency source comprising a diode connected to said waveguide section between the pump source and said reactance device, said diode being so connected in the circuit as to receive energy reflected from the impedance mismatch.

3. An amplifier circuit as claimed in claim 2 and further including a circulator in said waveguide section in series with said pump source and said reactance device, said diode being connected to one arm of said circulator.

4. An amplifier circuit comprising a variable reactance amplifier device, means for applying signals to be amplified to said device, means for applying pump frequency energy from a pump frequency source to said device, a partial impedance mismatch between said pump frequency source and said device, and means for monitoring the condition of said device comprising a diode connected between said pump source and said device in a manner to receive energy reflected from said mismatch.

5. An amplifier circuit comprising a circulator, a variable reactance amplifier device connected to one arm of said circulator, means producing a partial impedance mismatch between said circulator and said device, means for applying pump frequency energy to said device comprising a source of pump frequency energy connected to another arm of said circulator, and means for monitoring the condition of said amplifier device and said pump source comprising a diode connected to a third arm of said circulator in a manner to receive energy reflected from the impedance mismatch means.

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