

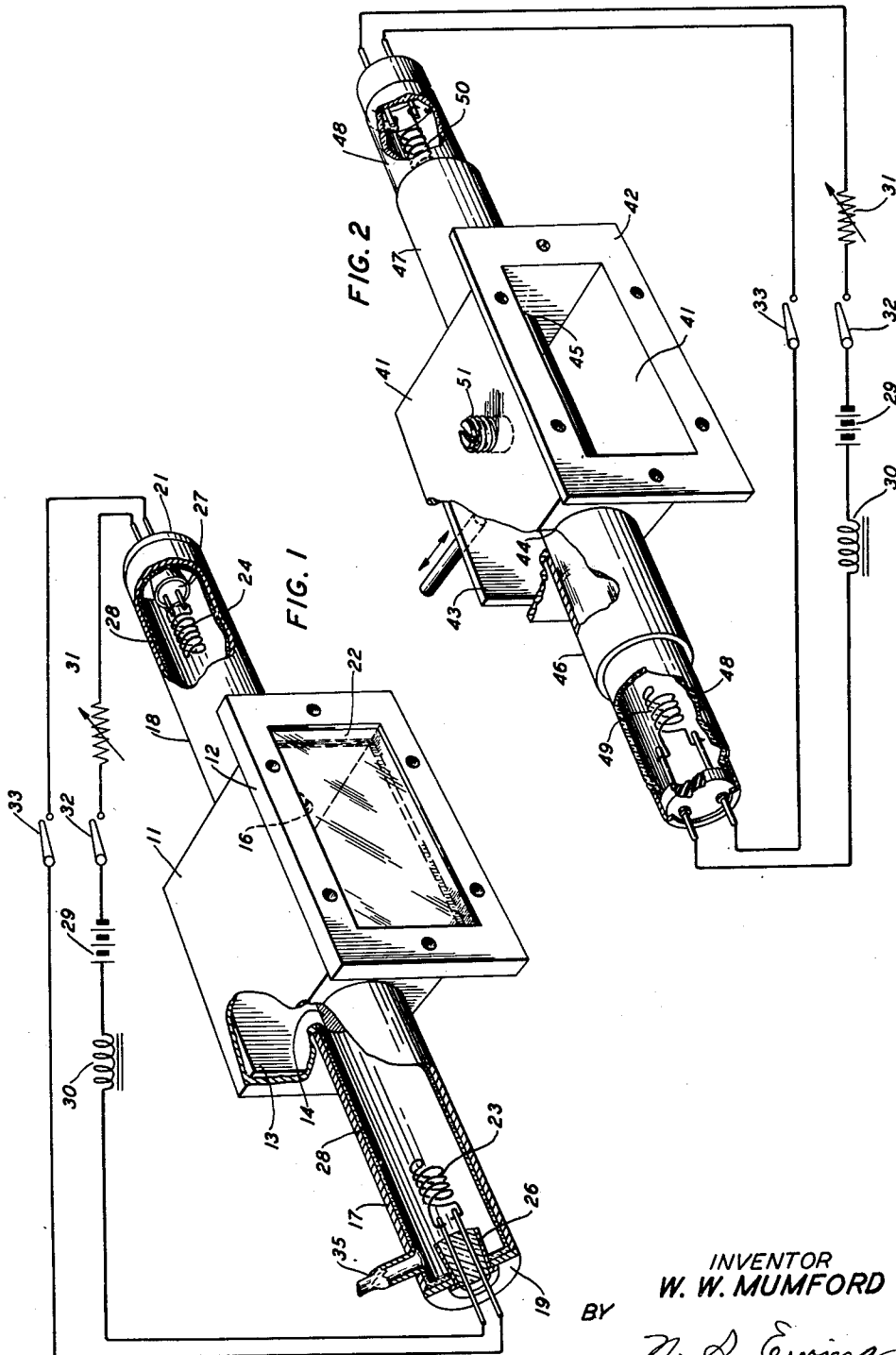
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BROAD BAND MICROWAVE NOISE SOURCE

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BROAD BAND MICROWAVE NOISE SOURCE

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This invention relates to microwave transmission systems and more particularly to a broad-band microwave noise source therefor.

It is well known in the art that certain measurements of electrical transmission systems, for example, the noise figure or the gain of radio receiver and repeater circuits may be made most expeditiously by the use of standard noise generators. A noise generator suitable therefor must produce, among other factors, a dependable volume of noise energy substantially unaffected by ambient conditions, have an output frequency band width substantially larger than the band width of the device under test, and be capable of being impedance matched to the input of the device over the entire wide band of frequencies. In the short wave and ultra-short wave regions, devices such as thermal resistance noise sources and temperature limited diodes have been used, but these have not proved entirely satisfactory at microwave frequencies. The former involves prohibitively high temperatures at which the thermal source must operate in order to generate a sufficient volume of microwave noise for certain measurements and the latter suffers from the difficulty of obtaining a satisfactory impedance match over a wide band width at microwave frequencies.

It is therefore an object of the present invention to produce broad-band microwave noise energy.

Another object of the present invention is to produce such microwave noise energy substantially independent of the generator operating current and ambient temperature variations.

It is a further object of the invention to produce broad-band microwave noise energy capable of being efficiently coupled to a microwave transmission system by maintaining a good impedance match between the noise source and said transmission system over substantially the entire broad frequency band.

In accordance with the invention, noise energy is derived from an electrical gas discharge and applied directly from the body of the discharge to a microwave transmission system.

In the simple embodiments of the invention to be hereinafter described in detail, microwave noise energy is generated by isolating microwave energy produced by the positive column of an electrical gas discharge which is developed laterally across a section of microwave guide between two electrodes located in tubular extensions of the wave-guide walls on either side of the wave-guide section.

In a first embodiment, the wave-guide section is sealed at one end across its cross-section by a metallic plunger and at the other end by a sheet of dielectric material. The resulting cavity is filled with the gaseous discharge medium. Microwave energy generated in the cavity by the positive column discharge is transmitted through the dielectric sheet to the connected transmission system. In another embodiment of the invention the discharge medium is confined in an elongated diode structure, for example, a commercial fluorescent lamp, extending laterally across the section through two holes in the wave-guide walls. The portions of the structure containing the electrodes project on each side beyond the walls and are enclosed in the tubular extensions.

The nature of the present invention, its various objects, features and advantages will appear more fully upon consideration of the embodiments illustrated in

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the accompanying drawings and the following detailed description thereof.

In the drawings:

Fig. 1 shows pictorially a noise generator in accordance with the first embodiment of the invention; and

Fig. 2 illustrates pictorially the second embodiment of the invention.

Many of the characteristics and phenomena of electrical gas discharges have been known for some time, although it has not always been possible to give a complete explanation of the observable phenomena. It is known, for example, that when a tube containing a pair of plane parallel electrodes between which is contained a fixed quantity of gas at a low pressure, for example, a few millimeters of mercury, is connected by means of the electrodes to a source of potential, the gas in the tube will begin to glow, the color of the luminous region being a function of the gas or gases contained in the tube. If the gas in the tube is ionized by means of a suitably large potential applied, or by means of heat applied at the electrodes, the gas will break down and readily conduct current. This characteristic is known as a discharge, and is visually characterized by brightly lighted, but differently colored, luminous regions in the gas. These regions are known as follows:

Very close to the cathode there is a narrow dark region known as the "Aston dark space." Adjacent to this is a brightly colored region known as the "cathode glow." The "Crookes dark space" extends outward for some distance from the cathode glow. Adjacent to the Crookes dark space is a luminous region known as the "negative glow," which starts quite abruptly and gradually fades into the region known as the "Faraday dark space." The Faraday dark space merges into the luminous "positive column." This terminates in the "anode glow" which is separated from the anode by a narrow "anode dark space."

The largest portion of the glow is the positive column in which region there appears to be substantially an equal number of positive ions and electrons so that the net charge in this region is zero.

In accordance with the objects of the invention, it has been determined that microwave noise energy is radiated by the positive column portion of the discharge. The noise power is substantially independent of the current flowing through the discharge tube. It is affected very little by temperature changes of the gas, apparently having a negative temperature coefficient of approximately .055 decibel per degree Centigrade. It has been determined that the noise spectrum is substantially flat or constant over the large frequency band from at least 3700 to 4500 megacycles. Furthermore, the noise energy is constant with respect to time and may be reproduced accurately in different tubes.

The same is not necessarily true of energy radiated by the other regions of the discharge. In certain of these regions located on either side of the positive column, noise energy is variously affected by current, temperature, pressure of the gas and the impedance is adversely affected by the nearby presence of the electrodes. It would, therefore, appear that the level and quality of noise energy radiated by the positive column depends upon some invariant physical property of the atoms and ions within the positive column of the discharge. It is thus a purpose of the present invention to isolate and utilize microwave noise energy developed by such a positive column of a gas discharge.

Referring now to Fig. 1, an integrally constructed noise generator is shown comprising wave-guide section 11 having one end closed and sealed by metallic piston structure 13, the other end closed and sealed by a sheet of dielectric material 22. Openings 14 and 16 are cut in opposite side walls of section 11. Tubular extension members 17 and 18 are integrally connected to the walls of section 11 around the perimeter of each of openings 14 and 16, respectively, and extend perpendicularly away from the walls of section 11.

Wave-guide section 11 may be as shown, a hollow pipe guide of rectangular cross section constructed of an electrically conducting material, or it may be a hollow pipe guide of circular cross section. In either

event one end of the guide is provided with an integrally connected flange member 12 for providing ready means of coupling the noise generator to an associated wave transmission system.

The end of section 11 contiguous to flange 12 is sealed across its cross-sectional area by a sheet of dielectric material 22. Sheet 22 may be, for example, plastic or glass, and may be fitted inside the contiguous end of section 11, and thus sealed in place across the cross section of the guide to allow microwave energy to pass there-through while at the same time remaining impervious to the gaseous material.

The end of section 11 opposite the flange end is covered in its cross section by metallic piston structure 13. Piston 13 is initially located in the guide section 11 at a position which will later be described in detail and then sealed in guide 11 to provide a joint impervious to the gaseous material.

Openings 14 and 16 are cut in the narrower walls of wave guide 11 and are coaxially arranged in said walls so as to provide opposite apertures in either a wave guide of rectangular or circular cross section.

Tubular extensions 17 and 18 are shown as cylindrical metal members each closed at one end by integral end caps 19 and 21, respectively, and each open at the other end. The open end of extension 17 is integrally connected to the wall of section 11 around the periphery of opening 14, and in like manner, the open end of 18 is connected around opening 16. Extensions 17 and 18 may be of rectangular cross section if desired, rather than circular as shown. In either event they should have cross-sectional dimensions substantially smaller than section 11 cross section in order that they may appear as wave guides beyond cut-off for all energy in the band to be delivered to the connected transmission system. For example, assume that it is desired to generate a band of noise energy by means of the discharge device in the band between a first frequency and a second higher frequency. Wave-guide section 11 must be of such cross-sectional dimensions that it will sustain all energy of frequency above the first frequency. Tubular extensions 17 and 18 must be of such cross-sectional dimensions to appear as wave guides beyond cut-off for all energy of frequency below the second frequency. The exact purpose of such proportions will immediately become apparent.

Filamentary electrodes 23 and 24 are located in the extremities of extensions 17 and 18, respectively, which electrodes comprise a small coil of wire, the conducting leads of each being brought out through end caps 19 and 21 by means of insulating eyelets 26 and 27 sealed in the end caps 21 and 19. Eyelets 26 and 27 permit the leads to be brought out through the end caps while at the same time maintaining an air-tight structure.

The interiors of the tubular extensions 17 and 18 are covered with a non-conducting surface 28. Surface 28 may be a layer of glass, porcelain or any other similar material providing substantial insulation to direct currents, fused to the inside surfaces of extensions 17 and 18 and end caps 19 and 21. This surface is provided to prevent the electrical discharge from shorting to the metallic walls of 17 and 18 and thus to require the discharge to extend across the cavity of wave-guide section 11.

The entire resulting cavity is filled with a gaseous material of any of the types known to support an electrical gas discharge. This includes substantially all gases or combinations thereof and suitable proportions required to sustain a positive column electric gas discharge therein are well known to all familiar with gas discharge devices. Among the several gases in common use in many commercial discharge devices are neon, helium, argon, sodium vapor and mercury vapor. This is, however, by no means an exclusive list. A suitable volume of gas is inserted by means of inlet 35, shown by way of illustration as a pinch-type inlet located in tubular extension 17. The proper volume of a particular gas required to sustain a positive column discharge portion in a chamber of a given size is also well known by those familiar with gas discharge devices.

The external circuit connected to the filamentary electrodes 23 and 24 is quite conventional, being that commonly used in commercial fluorescent lamp circuits. It consists of a source of direct-current potential 29 connected in series with an iron core inductance 30, a varia-

ble resistance 31, switches 32 and 33 and the electrodes 23 and 24. In order to start the electric discharge, switch 32 is closed. Starting switch 33 is then closed, which completes the series circuit through filaments 23 and 24 and the source of potential 29. After the filaments have become sufficiently hot to produce partial ionization of the surrounding gas, switch 33 is opened and the inductive kick due to iron core inductance 30 causes the electrical discharge to extend through the tubular extensions 17 and 18 and across the cavity of section 11 from electrode 23 to electrode 24. Resistance 31 is provided to control the discharge current after it is started.

In accordance with the invention, microwave noise energy produced by the positive column portion of the gas discharge is isolated from noise produced by other portions of the discharge. Thus, the positive column portion, or the portion of the discharge occupying the center region intermediate the electrodes 23 and 24, extends across the cavity of section 11, while the electrode effects, i. e., the dark spaces, the glow discharge effects and the other portions of the discharge which occur on either side of the center portion, are confined in the portion of the cavity enclosed by tubular extensions 17 and 18. Since extensions 17 and 18 are of such diameter to operate as wave guides beyond cut-off for all noise energy below the upper frequency limit of the desired test band, any energy in the test band produced by the electrode effects will not be sustained by the extensions or passed by them into the chamber of section 11. Conversely, energy within the test band sustained in cavity 11 cannot pass out through extensions 17 and 18. Thus the source of microwave noise energy generated by the electric discharge is effectively confined to that part of the discharge which appears inside the main wave guide 11, or in other words, the source of microwave noise is confined to the positive column portion of the electrical discharge.

This provides a dependable source of microwave noise energy having a large range of frequencies. The noise power is substantially independent of the current through the discharge and the ambient temperature of the gas. The same amount of energy may be accurately reproduced from generator to generator depending only upon the physical dimensions of the generator.

The volume of noise generated in a particular chamber appears to depend to some slight extent upon the orientation of the discharge path through the chamber. Thus, when used in connection with a rectangular cross-sectional wave guide as shown in Fig. 1, the discharge path might well be oriented in a vertical position across the smaller dimension of the wave-guide section, rather than horizontal position across the larger dimension of the section as shown, with a corresponding slight decrease in the volume of the generated noise. This is possible since the noise energy produced by the discharge has components polarized in all directions.

A particular feature of the invention resides in the means for matching the characteristic impedance of the noise generator to the characteristic impedance of the connected transmission system. It has been determined that the conductance of such a gaseous discharge device varies directly with the direct current of the discharge while the susceptance thereof depends directly upon the mechanical size of the cavity. Thus, the susceptance of the generator may be adjusted for a minimum by the proper placing of piston 13 within the wave guide 11.

The conductance of the device is controlled by varying the direct current of the discharge by means of resistor 31. The magnitude and frequency of the noise is unaffected by either of these adjustments since the magnitude and frequency of noise energy depends directly upon the physical properties of the discharge medium as has already been pointed out.

The method and manner of utilizing these adjustments of the susceptance and conductance of the noise source are well known to those familiar with the art. It appears that a position of piston 13 approximately one-quarter wavelength of the mean frequency of the connected transmission system behind the axis of the electric discharge path affords the minimum absolute value of susceptance. A position closer to the plane of the discharge path causes a negative change in the susceptance value, and a position farther from the plane of

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the discharge path causes a positive change in the susceptance value.

A familiar type of match meter or standing wave detector may be inserted in the connecting transmission system to aid in adjusting the value of conductance. As the direct current through the discharge is increased, the value of conductance of the generator is increased and, conversely, as the current is decreased the conductance is decreased.

The above-described noise generator is particularly adapted for large scale commercial manufacture due to its unitary and simple construction. It is noted that the cavity must be tightly sealed in order to contain discharge medium. This requirement substantially limits the variability of tuning so far as susceptance is concerned as piston 13 must be tightly sealed after initial adjustments have been made.

Referring now to Fig. 2, a second embodiment of the invention is shown which illustrates how these difficulties may be overcome by providing a generator the susceptance of which may be readily adjusted for any impedance match. The generator comprises a wave-guide section 41 having a flange connection 42 connected at one end and a variable piston 43 in the other end thereof. Openings 44 and 45 are placed in the side walls and tubular extensions 46 and 47 are connected thereto around the periphery of the openings. To this extent the structure shown in Fig. 2 is substantially identical to that of Fig. 1. Tubular extensions 46 and 47 may be open at their extended ends, and the internal surfaces thereof need not be covered with insulating material.

A self-contained gaseous discharge diode 48 having an envelope of glass or other dielectric material is extended laterally across the tuned wave-guide section 41 through the two holes 44 and 45. The portions of the tube 48 containing electrodes 49 and 50 project on each side beyond the wave-guide walls. As in Fig. 1 the tubular extension members 46 and 47 are of cross-sectional dimensions sufficiently smaller than those of wave-guide section 41 to form wave guides beyond cut-off for energy appearing in wave guide 41. Adjusting screw 51 is located in a wall of section 41 and provides an exact means of varying the cavity volume.

The external circuit shown on Fig. 2 is identical to that of Fig. 1 and corresponding reference numerals have been employed. The method of starting and sustaining the electric arc discharge is also identical to that described in relation to Fig. 1.

The discharge medium is entirely confined in the diode tube 48, which feature provides numerous structural advantages. For example, tube 48 may be a commercial fluorescent lamp of a type readily purchased on the market. Since the source of microwave noise energy lies chiefly in the gaseous discharge rather than in any fluorescent coating, any of the variety of lamps producing colored light, or types manufactured for germicidal purposes, may be used with equal facility. In particular, a General Electric type T-5, 6-watt, daylight fluorescent lamp has proved completely satisfactory.

Since the wave-guide structure need not be sealed in order to contain the gaseous material, piston 43 may remain variable to tune out the susceptance at each application of the generator and adjusting screw 51 provides a further and more delicate adjusting means.

Tubular extension members 46 and 47 need not extend the entire length of diode 48, rather an extended length of approximately three times their cross-sectional diameter is sufficient to prevent substantially any microwave energy in the wave-guide section 41 from leaving the chamber or preventing any disturbing effects from the electrode portion of the discharge from entering the chamber.

In all cases it is to be understood that the above-described arrangements are illustrative in specific embodiments of the application of the principles of the invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. A microwave noise generator comprising a wave-guide section having a symmetrical cross-section, said wave-guide section having a pair of coaxially arranged and oppositely located openings each in a wall of said section, said openings having cross-sectional dimensions smaller than said wave-guide cross-section, tubular mem-

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bers of electrically conducting material having one end of each connected to one of said walls of said section around the periphery of said openings and extending perpendicularly away from said section, an electrode means located in each of said members, and means for maintaining an electrical arc discharge between said electrodes, said arc discharge having a positive column portion, the dimension of said wave-guide cross-section measured between said opposite openings being less than the length of said positive column portion.

2. A microwave noise generator comprising a metallic structure forming a chamber having a symmetrical cross-section, said metallic structure having a pair of coaxially arranged and oppositely located openings each in a wall of said structure, a tubular fluorescent lamp extending through said openings having a center portion thereof included within said chamber and having each of the remaining end portions thereof extending external to said chamber one on each side thereof, cylindrical metal shields of cross-sectional dimensions smaller than said chamber cross-section fitted around each of said end portions, and each of said shields connected at one end to said structure walls.

3. A standard signal generator for producing a constant volume of noise energy substantially unaffected by ambient conditions, said generator comprising a diode filled with a gaseous discharge medium, means for establishing a positive column type discharge through said medium, and means for isolating electrical energy radiated exclusively by the positive column portion of said discharge.

4. A standard signal generator for producing a constant volume of noise energy substantially unaffected by ambient conditions, said generator comprising a tubular gas filled structure, a pair of electrodes located in the ends of said structure, means for establishing between said electrodes an electrical discharge of the type having a center positive column region bounded on either side by electrode effect regions, a wave-guide section having a symmetrical cross-section no greater in a dimension thereof than the length of said center region, said tubular structure extending across said wave-guide section with portions thereof including said electrode effect regions extending outside said section.

5. A microwave noise generator comprising a tubular gas filled structure, a pair of electrodes located in the ends of said structure, means for establishing between said electrodes an electrical discharge of the type having a center region of net zero charge bounded on either side by electrode effect regions, a wave-guide section having a symmetrical cross-section no greater in a dimension thereof than the length of said center region, said wave-guide section having a pair of openings each in a wall of said section, said tubular structure extending through said openings with the portion thereof including said electrode effect regions extending beyond on each side of said section, and cylindrical metal shields of cross-sectional dimensions smaller than said wave-guide cross-section fitted around each of said extended portions and connected at the periphery of said openings to said section walls.

6. A generator of microwave noise of a broad frequency band and substantially constant amplitude, said generator comprising a tubular gas-filled structure, a pair of electrodes located in the ends of said structure, means for establishing between said electrodes an electrical discharge of the type having a center positive column region bounded on either side by electrode effect regions, a first conductively bounded microwave transmission structure surrounding the portion of said tubular structure including said positive column region with the portions of said tubular structure including said electrode effect regions extending outside said transmission structure, said transmission structure having a cut-off frequency for wave energy substantially equal to the lower frequency of said broad frequency band, second and third conductively bounded microwave transmission structures surrounding respectively the portions of said tubular structure extending outside said first transmission structure, said second and third transmission structures each having a cut-off frequency for wave energy at least as great as the higher frequency of said broad frequency band, whereby energy within said band is substantially restricted to energy of dependable amplitude and stable characteristics radiated by said positive column region of said

discharge to the exclusion of energy of unstable characteristics radiated by said electrode effect regions.

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