

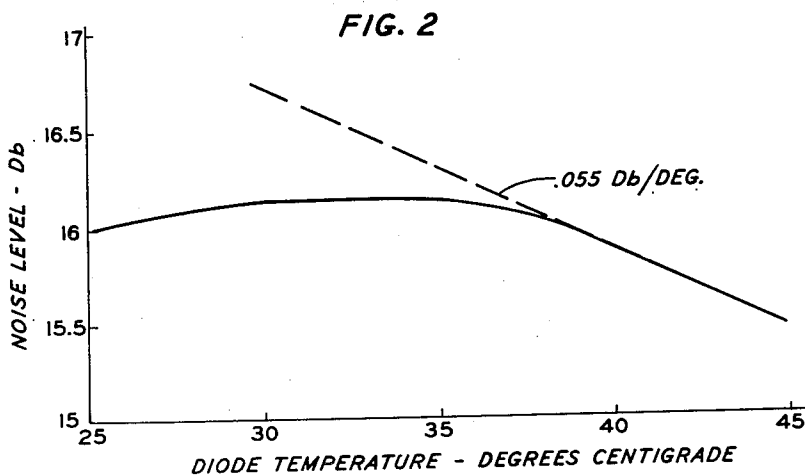
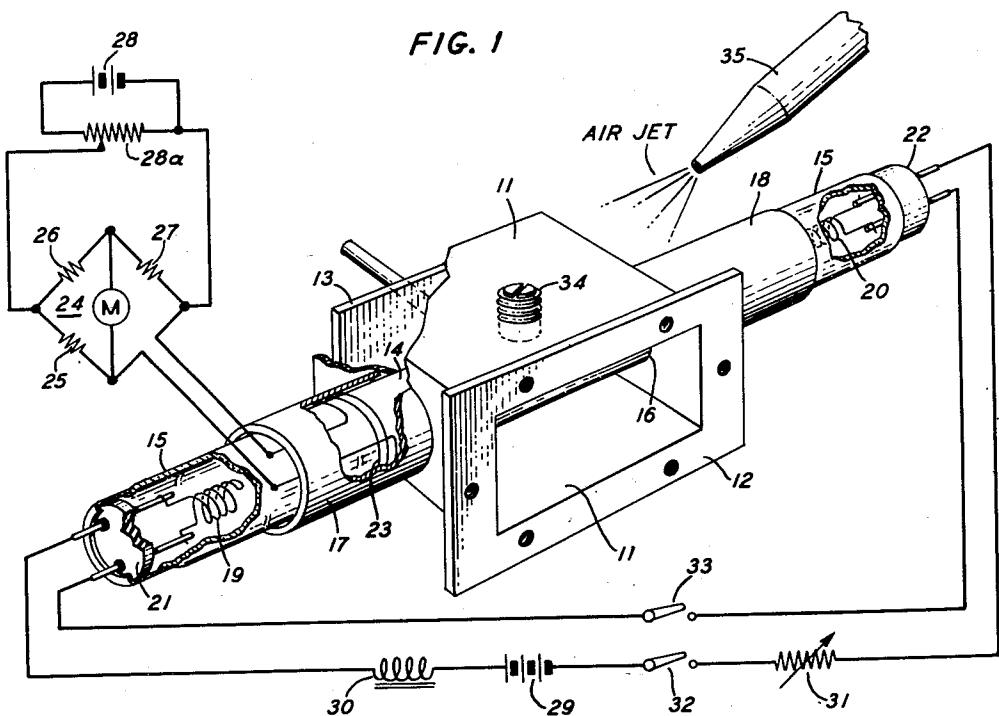
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NOISE SOURCE

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NOISE SOURCE

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6 Claims. (Cl. 250—36)

This application is a continuation in part of my copending application for United States patent, Serial No. 98,553, filed June 11, 1949, relating to transmission systems, and more particularly, to a broad-band noise source therefor.

In said copending application there is disclosed a noise source capable of producing noise energy of broad band and of sufficiently stable power level that it may be used as an energy standard. The power level of generated noise is substantially independent of generator operating current. It has a relatively small negative temperature coefficient giving a slight increase in noise power level per degree centigrade of ambient temperature decrease.

It is an object of the present invention to further improve the ambient temperature regulation of such a noise generator.

In accordance with the invention, noise energy is derived from an electrical discharge through a medium comprising a mixture of at least two substances, one of which is in a vaporous state and the other in a gaseous state.

In the specific embodiment of the invention to be hereinafter described in detail, microwave energy is generated by isolating microwave energy produced by the positive column of the above-described electrical discharge which is developed laterally across a section of microwave guide between two electrodes located beyond tubular extensions of the wave-guide walls on either side of the wave-guide section. The discharge medium is confined in an elongated diode structure, for example, such as a commercial fluorescent lamp, extending through two holes in the wave-guide walls. The portions of the diode structure containing the electrodes project on each side beyond the walls. The ambient temperature of the discharge medium is maintained within the general range wherein the vapor pressure of the substance in the vapor state decreases with decrease in the ambient temperature.

The nature of the present invention, its various objects, features and advantages will appear more fully upon consideration of the embodiment illustrated in the accompanying drawings and the following detailed description thereof.

In the drawings:

Fig. 1 shows pictorially a noise generator in accordance with the invention, the external electrical circuit thereof being indicated in schematic diagram form; and

Fig. 2 shows the noise level output versus ambient temperature characteristic of a noise generator in accordance with 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 or vapor 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 or vapor in the tube will begin to glow, the color of the luminous region being a function of the gas, gases or vapors 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,

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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 said copending application it was pointed out that noise energy is radiated by the positive column portion of a discharge of this type and that the power level of such energy is remarkably stable with respect to current flowing through the discharge, the character of the electrodes, and ambient temperature effects. Furthermore, this noise energy is constant over a large frequency band, it 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 medium 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.

The level of the noise energy radiated by the positive column of a discharge through a medium comprising a single vapor under ordinary circumstances appears to have, nevertheless, a small negative temperature coefficient. As the ambient temperature of the diode containing the medium is decreased, the level of the noise has been found to increase. This increase is an exceedingly small percentage of the total noise level, but it is nevertheless undesirable when the device is used for accurate measuring operations.

On the other hand, the level of noise energy radiated by a discharge through an actual gas, when the pressure of the gas is raised high enough to obtain a stable positive column, appears to depend to some extent upon the current through the discharge, although the level of the noise is not affected by the ambient temperature to the same extent as was the noise level of the vapor. At lower pressures the noise generated by an actual gas discharge is more independent of current, but the noise source is affected by the resulting instability of the positive column.

By a novel and unusual combination of at least one saturated vapor and at least one gas for the discharge medium, as will hereinafter be described in detail, the net temperature coefficient of the medium is made substantially zero over a conveniently wide range of ambient temperature variation to assure a constant level of noise. The presence of the vapor supports a stable positive column without the necessity of the undesirable high pressures necessary for positive column stability for the gas alone.

As used in the present specification and in the appended claims the term "gas" will refer to a substance in an aeriform state and in the temperature region above the critical temperature of that substance. In this region the substance substantially follows the general gas laws with respect to the relationships of pressure, volume and temperature. When referring to gas discharge media it is of course understood to include those substances under the above-defined conditions which are known to support electrical discharges. Most common in this class are argon, neon or helium, as well as the more seldom encountered gases which appear in group O of the periodic table of chemical elements, and hydrogen, all of

which have such very low critical temperatures that they are usually encountered in the gaseous state.

As used in the present specification and in the appended claims, the term "vapor" will refer to the saturated condition of a confined substance in an aeriform state and in a temperature region below the critical temperature. In this region the substance no longer follows the general gas laws, but rather, the pressure due to the vapor depends solely upon the saturated vapor pressure of the substance at a particular temperature regardless of the volume of the confined space. When referring to vapor discharge media, the term is understood to include the generally accepted group of metallic vapors which are known to support electrical discharges. Most common in this class are sodium vapor, potassium vapor, or caesium vapor, which are the most commonly encountered elements appearing in group I of the periodic table, and mercury vapor. Neither the list of pure gases nor the list of vapors is intended to be exclusive as other chemical substances are well known having the above-described identifiable characteristics. The term "aeriform" of course includes both a gas or a vapor or a mixture thereof, and the term "gaseous discharge" includes, as is already understood in the art, a discharge through either a gas or a vapor or a mixture thereof.

The necessity for an exact understanding of the physical state of the discharge medium with regard to temperature will later become apparent.

First, however, it will be necessary to review briefly the basic noise generator structure as disclosed in detail in the above-mentioned copending application Serial No. 98,553. Referring to Fig. 1, one embodiment is shown comprising wave-guide section 11 having one end closed by metallic piston structure 13. 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 the other 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.

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 open at both ends. One end of extension 17 is integrally connected to the wall of section 11 around the periphery of opening 14, and the other end extends perpendicularly away from the wall of section 11. In like manner, one 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.

Extending through tubular extensions 17 and 18, openings 14 and 16, and across the cavity of the wave-guide section 11 is placed an elongated tubular diode 15, comprising a closed cylinder of glass or other suitable material. Diode 15 may be, for example, in the form of a commercial fluorescent lamp tube. In the extremities of diode 15 are located filamentary electrodes 19 and 20 which comprise small coils of wire, the conducting leads of which are brought out through the ends 21 and 22 of the diode structure 15.

The diode 15 is filled with the discharge medium. Of first importance in this connection, as is pointed out in said copending application, is that the quantity and pressure of the discharge medium be chosen in accordance with well-known principles so that a positive column

portion will be developed of sufficient length to extend across the cavity 11.

For this purpose alone either a gas or a vapor may be used in suitable quantity, but other considerations such as the desirability of matching the impedance of the discharge to a connected wave-guide system and the desirability of delivering a constant level of noise to the system when the generator is subjected to different values of ambient temperature, must also be accounted for.

In accordance with the invention these considerations are satisfactorily met within a range of temperatures by mixing a gas with a vapor and employing the combination as the discharge medium. It may be demonstrated that the impedance of a vapor discharge may be accurately controlled by the magnitude of the direct current through the discharge. The value of current has substantially no effect upon the level of available noise. Further, it may be demonstrated that a decrease in ambient temperature, which decreases the vapor pressure, causes an increase in the available noise from the vapor discharge and also causes an increase in the impedance of the discharge.

On the other hand, the level of available noise from gas discharge and the impedance of the gas discharge, increase as the pressure is decreased, and are thus affected by ambient temperature variations, but to a less extent than were these same parameters of the vapor discharge, presumably since the pressure of the gas is not affected by temperature to such an extent as was the vapor pressure.

When the gas is mixed with the vapor in the discharge medium, the result may be likened in some respects to the result obtained when two sources having different internal impedances are connected in parallel across a load of a given impedance. In other words, the proportion of the total power delivered to the load by each source depends upon the degree of impedance match between that source and the load.

Since the pressure of the vapor in the confined space depends solely upon the ambient temperature, the exact amount of the substance producing the vapor is not of material importance if there remains an excess in the solid or liquid state after the confined space has become saturated with vapor. The volume of gas mixed in the discharge is chosen so that the pressure contributed by the gas to the medium is within the pressure range at which the combination will sustain a positive column portion as pointed out above. Furthermore the gas pressure is chosen so that the level of noise contributed by the gas alone is less, at that pressure, than the noise contributed by the vapor.

The resulting available noise level delivered to the load expressed in decibels above the power available from a resistance at room temperature versus the ambient temperature measured in degrees centigrade at the surface of the diode is shown in Fig. 2 for a typical discharge through a medium comprising a mixture of the gas and the vapor. In the region of higher temperature, the noise delivered represents the sum of the noise from both the vapor and the gas, and as the temperature is decreased the noise level increases in accordance with the expected negative temperature coefficient, reproducing more nearly the characteristic of the vapor than that of the actual gas. As the ambient temperature is decreased to the region of lower temperature on Fig. 2, the vapor will condense, decreasing the number of molecules of the vaporous material in the discharge, and thus lowering the pressure due to the vapor by transferring the molecules to liquid or solid state upon the walls of the diode. The gas of course does not condense within the temperature range. The impedance of the vapor source has increased to such an extent, that, although the level of the noise produced by the vapor has increased, little of it is delivered to the load. The power delivered to the load therefore is due substantially to the lower level gas noise alone. Between these two extremes is a temperature region, determined by the relative proportions of the gas and the vapor in the diode, in which the net temperature coefficient is substantially zero over a considerable range of temperatures. The position along the temperature scale at which the region of zero temperature will occur may be determined by pressure of the added gas.

The numerical values shown on Fig. 2 refer to a discharge medium having saturated mercury vapor and

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argon at approximately two millimeters of mercury pressure. It is seen that the range between 30 and 35 degrees centigrade measured at the diode wall has a substantially zero temperature coefficient, e. g., that the level of noise output remains constant over this range. If it were not for the compensating effect of the gas and the vapor, the characteristic would appear as represented by the broken line curve, having a temperature coefficient of approximately -0.055 decibel/degree centigrade or greater.

The invention has been above described with reference to a mixture of a gas and a vapor, referring to the states in which these substances are usually found at ordinary temperatures, since the principles of the invention are most readily applicable to a combination of these substances. It should be noted, however, that the principles are by no means limited to this mixture. For example, a mixture of two vapors might be used which have different temperatures of condensation. In this case the proper operating range for optimum value of temperature coefficient of noise would occur at a point below the temperature at which one vapor would begin to condense at a given rate, but above the temperature at which the other vapor would begin to condense at that rate. Finally it should be pointed out that several gases and/or vapors may be combined as a single discharge medium in suitable proportions to realize the principles of the invention.

The external circuit connected to the filamentary electrodes 19 and 20 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 variable 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 19 to electrode 20. 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 gaseous 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 19 and 20, 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 source of microwave noise energy having a large range of frequencies. The noise power is substantially independent of the current through the discharge, and when operated at temperatures within the range determined as above described, the level of noise is independent of ambient temperature variations. Thus the same amount of energy may be accurately reproduced from generator to generator depending only upon the physical dimensions of the generator.

Having determined the range of zero temperature coefficient, a resistance thermometer is provided to allow the operator to readily ascertain that the generator is operating within this range. This thermometer may

comprise several turns of temperature-sensitive alloy wire 23 wound around one end of diode structure 15. The winding 23 should be placed as near to wave-guide cavity 11 as possible without disturbing the microwave field. This consideration will place the winding under extension 17. The temperature-sensitive winding 23 comprises one arm of bridge circuit 24, the remaining three arms comprising temperature-insensitive resistances 25, 26 and 27. Direct-current potential is supplied from source 28, variable by means of rheostat 28a. Meter M is connected to indicate the degree of balance of bridge 24 and may thus be readily calibrated to indicate the temperature of the diode 15.

Should it happen that room temperature, or other factors determining the ambient temperature, are not such as to allow operation within the desired range, the noise generator temperature may be sufficiently controlled by simple means external to the diode 15 and wave-guide cavity 11. To illustrate this possibility on the drawing, a jet 35 of compressed air is shown located in such a position that the air stream will play upon diode 15 and cavity 11. Numerous other methods are of course possible. For example, the operating temperature of the diode structure 15 and the medium therein may be sufficiently lowered by swathing it with absorbent material saturated with water, alcohol or ether. Even operation outside the range of zero temperature coefficient will be satisfactory under certain circumstances if meter M is calibrated with respect to the noise output for each value of ambient temperature.

The manner in which the characteristic impedance of the noise generator is matched to the characteristic impedance of the connected transmission line is fully treated in the above-mentioned copending application, making use in general, of the current flow through the discharge to vary the conductance and of piston 13 and tuning screw 34 to vary the susceptance. Although the present invention has been particularly defined with reference to an embodiment having a self-contained diode structure, it is equally applicable to other specific configurations, for example, the embodiment shown in Fig. 1 of said copending application.

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, a pair of electrode means oppositely located outside said section and having the axis therebetween passing through said section, the space between said electrodes being filled with an aeriform mixture of at least two chemical substances, each of said substances being of the type capable of sustaining an electrical gaseous discharge in its evaporated state, at least two of said substances having different temperatures of condensation, temperature indicating means associated with said section for indicating the temperature of said mixture, temperature controlling means for maintaining the temperature of said mixture at a point between said condensation temperatures whereby one of said substances is in a partially evaporated state, and means for maintaining an electrical gaseous discharge through said mixture between said electrodes.

2. A standard signal generator for producing a constant volume of noise energy substantially unaffected by ambient temperature variations, said generator comprising a diode filled with an aeriform mixture of at least two chemical substances, at least one of said substances being in a state of partial condensation thereby having a vapor pressure, 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.

3. A standard signal generator for producing a constant volume of noise energy substantially unaffected by ambient temperature variations, said generator comprising a tubular structure filled with a mixture of a vapor and a gas, a pair of electrodes located in the ends of said structure, means for establishing between said electrodes an electrical discharge through said mixture of the type having a center positive column region bounded

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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 the portions thereof including said electrode effect regions extending outside said section.

4. A standard signal generator for producing a constant volume of noise energy substantially unaffected by ambient temperature variations, said generator comprising a diode filled with a gaseous mixture of at least a first chemical element in a vapor state and a second chemical element in a gaseous state, means for establishing a positive column type discharge through said mixture, and means for isolating electrical energy radiated exclusively by the positive column portion of said discharge.

5. The combination in accordance with claim 4 wherein said first chemical element is a vapor occurring in group I of the periodic table and wherein said second chemical element is a gas occurring in group O of the periodic table.

6. The combination in accordance with claim 4 where-

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in said first chemical element is mercury and wherein said second chemical element is one occurring in group O of the periodic table.

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