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HIGH-FREQUENCY TRANSMISSION SYSTEM

Original Filed Aug. 30, 1944

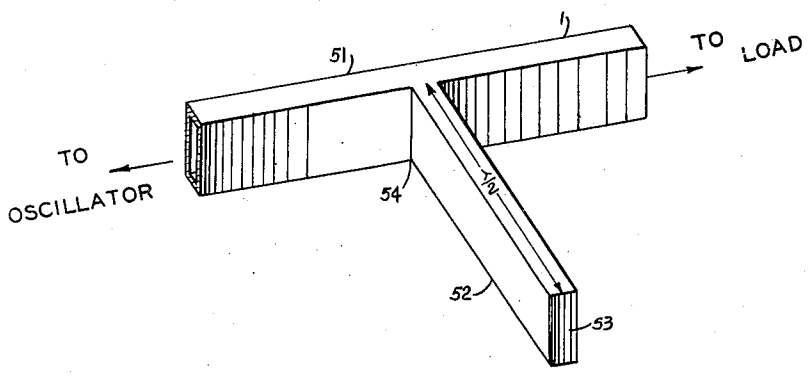


FIG. 1

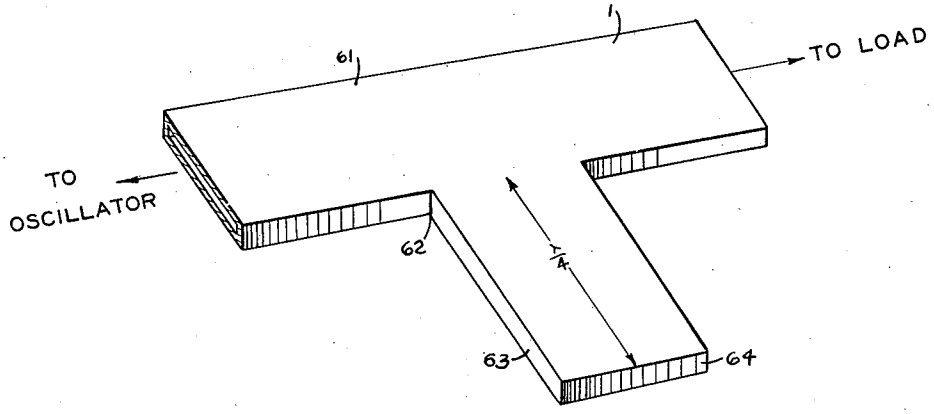


FIG. 2

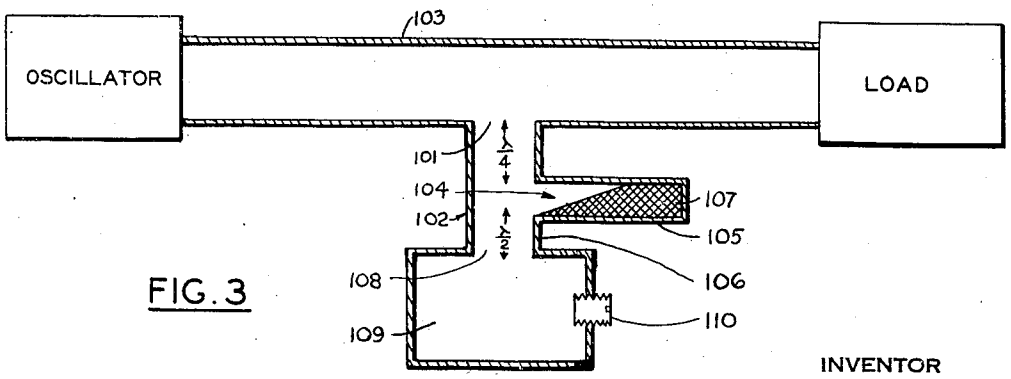


FIG. 3

INVENTOR
WILLIAM E. BRADLEY

BY Samuel Petrotsky
ATTORNEY

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HIGH-FREQUENCY TRANSMISSION SYSTEM

William E. Bradley, Swarthmore, Pa., assignor, by mesne assignments, to Philco Corporation, Philadelphia, Pa., a corporation of Pennsylvania

Original application August 30, 1944, Serial No. 551,951. Divided and this application August 31, 1944, Serial No. 552,175

12 Claims. (Cl. 250—36)

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This application, which is a division of application Serial No. 551,951, filed August 30, 1944, relates to a frequency stabilizing system and more particularly relates to a system for adjusting and stabilizing the frequency of high frequency oscillators as the voltage, current or load impedance varies.

In accordance with my invention, frequency stabilization is effected by reflecting a reactance into the line, in response to a shift in frequency from normal, of a kind that will tend to restore the frequency to its original value.

More specifically, in one form of my invention I connect a parallel reactance resonant to the frequency to be controlled across the transmission line. There are a number of points along the transmission line one half wave length apart, where an inductive reactance applied to the transmission circuit will elevate and a capacitative reactance will lower the frequency of the oscillator. At one of these points where this effect is maximum, I shunt my parallel resonant circuit across the transmission line which matches the impedance of the load.

If now the load impedance so changes that the frequency rises, a capacitance is presented by the parallel resonant circuit to the transmission line which lowers the frequency almost to its normal value.

If the load impedance so changes that the frequency falls, inductance is presented to the transmission line which raises the frequency almost to its normal value.

Halfway between the points along the transmission line referred to above, an inductive reactance will lower and a capacitative reactance will elevate the frequency. This reactance is secured by a resonant series inductance and capacitance connected in series in the system at one of these half way points.

If the frequency rises in response to a change in load impedance above the stabilizing value and therefore above resonance frequency, an inductance is presented by the series resonant circuit to the transmission line which lowers the frequency to its normal value.

If the load impedance so changes that the frequency falls, capacitance is presented to the transmission line which raises the frequency to its normal value.

In the discussion above, I have referred to a special network. This, as will be clear from the description to follow, can also be a network of wave guides and resonant cavities.

Accordingly, an object of my invention is to

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provide a novel network arrangement for effecting frequency stabilization of a system.

A further object of my invention is to provide a novel reactance network coupled to a circuit, the reactance reflected into the oscillating circuit being a function of the frequency fluctuations from normal to maintain the frequency of the system substantially constant.

Still another object of my invention is to provide a novel resonant parallel inductance capacitance circuit so connected in a transmission system that it presents capacitance to the line when the frequency rises to lower the frequency to normal and presents inductance to the line when the frequency drops to raise the frequency to normal.

Another object of my invention is to provide a novel resonant series inductance capacitance circuit so connected in a transmission system that it presents inductance to the line when the frequency rises to lower the frequency to normal and presents capacitance to the line when the frequency drops to raise the frequency to normal.

Still a further object of my invention is to provide a novel frequency controlled stabilizer which tends to maintain the load impedance substantially constant.

These and other objects of my invention will appear from the detailed discussion which follows in connection with the drawings, in which

Figure 1 shows an arrangement for connecting a wave guide in series in carrying out my invention.

Figure 2 shows an arrangement for connecting a wave guide in parallel in carrying out my invention.

Figure 3 shows in cross-section a specific construction of wave guide embodying my invention.

Referring now to Figure 1, I have shown a main and branch wave connected in series. Here the main wave guide 51 is a hollow tube of metal of rectangular cross-section and is connected at one end to an oscillator which may have two or more modes of oscillation such as a magnetron. The opposite end of the line is connected to a fluctuating impedance load. The wave guide is designed to carry the transverse electric mode with the lines of electric field parallel to the narrow dimension of the guide. The branch guide 52 of similar rectangular cross-section is an integral number of half wave lengths long opening into a cut in the large dimension of the main guide at the junction 54 and is closed at the end 53.

All the longitudinal current in the main guide must then flow in the branch guide and this

arrangement is spoken of as a series connection. The coupling junction 54 of the branch guide 52 to the main guide 51 is at such a point along the main guide that an increase in the effective capacitance of the load as viewed from this junction would cause the frequency to rise, and an increase in inductance lowers the frequency.

In order to secure this result, the distance from the junction 54 to the end of the branch wave guide 52 at its closed end 53 is made one half wave length. The impedance looking into this branch guide from the main wave guide is substantially a short circuit when the stabilizing frequency exists and the stabilizing unit has no effect upon a transmission through the main wave guide from the oscillator to the load.

If the impedance of the load is changed so that the impedance looking into the main wave guide at junction 54 appears to have a capacitance added to it, the frequency of the oscillator will rise.

As the frequency begins to increase, the impedance looking into the compensator no longer appears as a short circuit; instead it appears to be an inductance. This inductance acts in series with the equivalent capacitance seen looking towards the load and consequently tends to neutralize this capacitance. The net result of this action is to tend to hold the oscillator frequency substantially at predetermined value.

Correspondingly, and for reasons that now will be clear, when the frequency goes below the predetermined value, a corrective capacitance to increase the frequency is applied to the line.

A construction using a shunt wave guide section an odd number of quarter wave lengths long is shown in Figure 2. Here the main wave guide 61 is jointed at 62 to a branch wave guide 63 at a cut in both along the narrow edge of the guide providing a shunt connection. The junction here selected is half way between the junction available to be used for Figure 1 in relation to the oscillator and are those positions on the main wave guide 61 where the addition of a capacitance lowers the frequency a maximum amount and the addition of inductance raises the frequency.

The end 64 of the stub or branch guide 63 is closed off so that it presents an infinite impedance to the main wave guide 61 at normal frequency.

If now the load is changed so that the frequency tends to decrease, this stub line operates as a less than quarter wave line, and thus operates to add inductance to the line and therefore to raise and restore the frequency to its normal value.

Because of its position on the line, its action counteracts the change in load impedance. Conversely, if the load impedance so changes that it acts as an inductance at the junction point of the main line and stub and the frequency rises, the stub line operates as a greater than quarter wave line and thus adds capacitance to the line causing the frequency to restore itself.

A specific arrangement of my invention using wave guides is shown in Figure 3 in cross-section. This is a modification of Figure 1, the cross section being taken through the narrow width of the wave guide. The coupling junction 101 of the branch guide 102 to the main guide 103 is at such a point along the main guide that an increase in the effective capacitance of the load as viewed from this junction point would cause the frequency to rise. At the normal frequency, the branch guide system presents a short circuit

to the main guide at junction 101. In order that this may be so, the distance from junction 101 to junction 104 is made close to a quarter wave length. An open circuit at junction 104 would appear as a short circuit at junction 101 because of the well known impedance inversion properties of a quarter wave length of wave guide. At junction 104 the two sub-branches 105 and 106 are in series because they are joined along their broad faces. The impedance looking into sub-branch 105 is a resistance, because 105 is partially filled with a lossy material 107 which absorbs any energy which enters 105 at 104. As viewed from 104, sub-branch 106 appears to have whatever impedance is presented to it at junction 108 by cavity resonator 109, because of the well known impedance retaining property of the half wave length section of guide between 104 and 108. At the normal frequency, this cavity resonator is tuned by adjusting screw 110, which may be placed almost anywhere in the wall of the cavity, so that the impedance of the cavity as seen from junction 108 is infinite. Then the impedance of section 106 as seen from 104 is infinite, and the series addition of 105 is of no importance.

Consequently, the impedance as seen from junction 101 is zero. When the frequency is slightly raised, the impedance transformation properties of the wave guide sections do not change very much. However, the impedance of the cavity becomes a high capacitive reactance, which then places a high capacitive reactance in series with the lossy sub-branch 105 at junction 104. Again, the impedance of the lossy sub-branch is insignificant compared to the impedance in series with it, so the impedance as viewed from junction 101 becomes an inductive reactance because of the impedance inversion qualities of a quarter wave guide section. This is just what is needed in order that the regulatory action described in connection with Figure 2 may become effective. At frequencies far removed from normal, the impedance of the cavity as viewed from 108 becomes low, so the impedance as viewed from junction 104 becomes substantially the impedance of the lossy sub-branch 105. Consequently, a resistive impedance is presented to the main guide at 101 and the load is not disconnected, as it would be if the lossy guide section 105 were absent.

Experimental work with frequency stabilizers of this type indicate that they are also effective in reducing the frequency change caused by variations in voltage or current in the oscillator tube. They find application in radar systems where reflected waves, such as may come from the antenna housing, effect an impedance change in the antenna load.

Various modifications of the principles of my invention will now be evident to those skilled in the art. I therefore prefer not to be bound by the specific disclosures hereinabove set forth, but only by the appended claims.

I claim:

1. In a wave guide transmission system for connecting a source of high frequency to a load whose impedance changes, a main rectangular wave guide, a branch wave guide an integral number of quarter wave lengths long opening into a cut in the large dimension of the main wave guide, a stub wave guide opening into a cut along the large dimension of said branch wave guide an odd number of quarter waves length from said first mentioned opening, said stub

wave guide being partially filled with lossy material and a cavity resonator connected to the opposite end of said branch wave guide from the first mentioned open end, said cavity having infinite impedance at the frequency to be stabilized.

2. In a wave guide transmission circuit, a wave guide, a magnetron oscillator having two or more modes of oscillations connected to one end of said wave guide, a load whose impedance changes connected to the other end of said wave guide, said wave guide having a number of points therealong one-half wave length apart where reactance can be reflected into said oscillator in response to a shift in frequency from a predetermined value to restore the frequency of said oscillator to the predetermined value, and a frequency stabilizer comprising a stub an odd number of quarter waves long at the frequency to be controlled connected in parallel with said wave guide at a position along said guide where the addition of capacitance lowers the frequency of said oscillator.

3. In a wave guide transmission circuit, a wave guide, a magnetron oscillator having two or more modes of oscillations connected to one end of said wage guide, a load whose impedance changes connected to the other end of said wave guide, said wave guide having a number of points therealong one-half wave length apart where reactance can be reflected into said oscillator in response to a shift in frequency from a predetermined value to restore the frequency of said oscillator to the predetermined value, and a frequency stabilizer comprising a stub an odd number of quarter waves long at the frequency to be controlled connected in parallel with said wave guide at a position along said guide where the addition of capacitance lowers the frequency of said oscillator, said stub being less than a quarter of the wave length at a frequency below the desired oscillation frequency.

4. In a wave guide transmission circuit, a wave guide, a magnetron oscillator having two or more modes of oscillations connected to one end of said wave guide, a load whose impedance changes connected to the other end of said wave guide, there being a number of points along said transmission line one-half wave length apart where the addition of capacitive reactance applied to the line will lower the frequency of said frequency source, and a frequency stabilizer comprising a stub an odd number of quarter waves long at the frequency to be controlled connected in parallel with said wave guide at a position along said wave guide where the addition of capacitance lowers the frequency of the circuit, said stub in response to a rise in frequency being greater than an odd number of quarter waves long.

5. In a wave guide transmission system, a rectangular wave guide, a magnetron oscillator having two or more modes of oscillations connected to one end of said wave guide, a load whose impedance changes connected to the other end of said wave guide, there being a number of points along the transmission line one-half wave length apart whose capacitive reactance applied to the line will raise the frequency of said frequency source, and a frequency stabilizer comprising a branch guide having a cross-section similar to that of said wave guide connected in series therewith, said branch guide being connected at a point along said main guide where the addition of capacitance raises the frequency of said oscillation, and a stub wave guide opening into a cut along the larger dimension of said branch wave guide an odd number of quarter wave lengths from said first mentioned connection of said branch wave guide.

6. In a wave guide transmission system, a wave guide, a magnetron oscillator having two or more modes of oscillations connected to one end of said wave guide, a load whose impedance changes connected to the other end of said wave guide, there being a number of points along the transmission line one-half wave length apart whose capacitive reactance applied to the line will raise the frequency of said frequency source, and a frequency stabilizer comprising a branch guide having a cross-section similar to that of said wave guide connected in series therewith and being a half wave length long at the frequency to be controlled, said branch guide being connected at a point along said main guide where the addition of capacitance raises the frequency of said oscillator, said branch guide in response to a drop in frequency presenting capacitance to raise the frequency of said oscillator.

7. In a wave guide transmission system, a rectangular wave guide, a magnetron oscillator having two or more modes of oscillations connected to one end of said wave guide, a load whose impedance changes connected to the other end of said wave guide, and a frequency stabilizer comprising a branch guide having a cross-section similar to that of said wave guide connected in series therewith and being a half wave length long at the frequency to be controlled, said branch guide being connected at a point along said main guide where the addition of capacitance raises the frequency of said oscillator, said branch guide in response to a rise in frequency presenting inductance to lower the frequency of said oscillator, and a stub wave guide opening into a cut along the large dimension of said branch wave guide an odd number of quarter wave lengths from said first mentioned connection of said branch wave guide, said stub wave guide being filled with lossy material.

8. In a wave guide transmission system, a wave guide, a magnetron oscillator having two or more modes of oscillations connected to one end of said wave guide, a load whose impedance changes connected to the other end of said wave guide, there being a number of points along said wave guide one-half wave length apart where an inductive reactance reflected into said oscillator will lower and a capacitive reactance reflected into said oscillator will raise the frequency of said frequency source, and a frequency stabiilzer comprising a rectangular branch guide an integral number of half waves length long opening into a cut in the large dimension of the main guide and closed at its other end, said branch guide being connected to said wave guide at a point where inductive reactance most lowers the frequency and capacitative reactance most raises the frequency of said oscillator, and a stub presenting a series resistance connected to said branch wave guide.

9. In a wave guide transmission system, a wave guide, a magnetron oscillator having two or more modes of oscillations connected to one end of said wave guide, a load whose impedance changes connected to the other end of said wave guide, there being a number of points along said wave guide one-half wave length apart where an inductive reactance reflected into said oscillator will lower and a capacitive reactance reflected into said oscillator will raise the frequency of said

frequency source, and a frequency stabilizer comprising a rectangular branch wave guide an odd number of quarter waves length long connected to said main wave guide along the narrow edge of the wave guide and closed at its other end, said branch wave guide being connected to said main wave guide at a point where inductive reactance most raises the frequency and capacitative reactance most lowers the frequency of said oscillator.

10. In a wave guide transmission system, a wave guide, a source of high frequency oscillations whose frequency is subject to fluctuations in response to changes in load impedance and having two or more modes of oscillations, said source being connected to one end of said wave guide, a load whose impedance changes connected to the other end of said wave guide, said wave guide connecting said source of energy to said load, said wave guide having a number of points therealong one-half wave length apart where reactance can be reflected into said oscillator in response to a shift in frequency from a predetermined value to restore the frequency to the predetermined value, and a frequency stabilizer comprising a stub having a length related to the frequency of the oscillator and connected to the main wave guide at a point at which it presents reactance to said oscillator which compensates for the shift in reactance of the load to maintain the operating frequency of said oscillator substantially constant.

11. In a wave guide transmission system, a wave guide, a magnetron oscillator having two or more modes of oscillations connected to one end of said wave guide, a load whose impedance changes connected to the other end of said wave guide, said wave guide having a number of points therealong one-half wave length apart where

reactance can be reflected into the line in response to a shift in frequency from a predetermined value to restore the frequency to the predetermined value, and a frequency stabilizer comprising a stub having a length related to the frequency of the oscillator and connected to the main wave guide at a point along said wave guide at which an increase in the effective capacitance of the load as viewed from the junction would cause the frequency of said oscillator to rise, the stub being of a length to present a short circuit to the main wave guide at said junction.

12. In a wave guide transmission system, a wave guide, a magnetron oscillator having two or more modes of oscillations connected to one end of said wave guide, a load whose impedance changes connected to the other end of said wave guide, the frequency of said source being subject to fluctuations in response to changes in load impedance, a branch wave guide an integral number of quarter wave lengths long opening into a cut in the large dimension of the main wave guide at a point along said wave guide at which an increase in the effective capacitance of the load as viewed from the junction would cause the frequency of said oscillator to rise, the branch being of a length to present a short circuit to the main wave guide at said junction.

WILLIAM E. BRADLEY.

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