Aug. 23, 1960 L. T. KING 2,950,450

ATTENUATORS OR SUPPRESSORS FOR ATTENUATING OR SUPPRESSING UNDESIRED OSCILLATIONS

Filed March 1, 1957

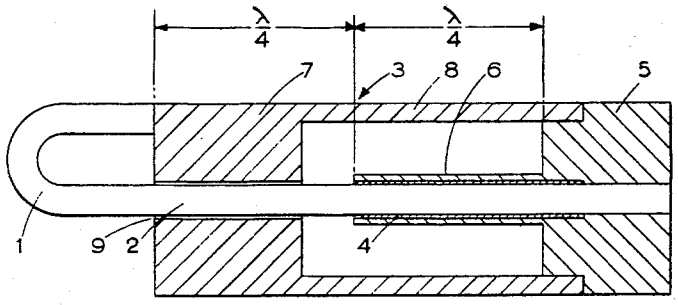


FIG. 1.

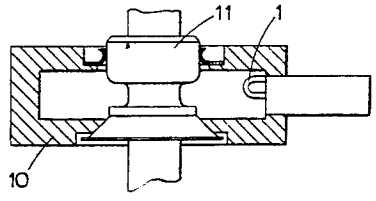


FIG. 2.

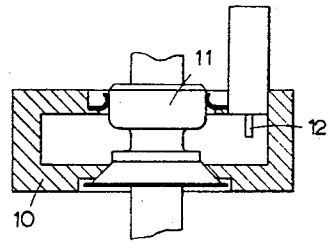


FIG. 3.

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United States Patent Office 2,950,450
Patented Aug. 23, 1960

2,950,450

ATTENUATORS OR SUPPRESSORS FOR ATTENUATING OR SUPPRESSING UNDESIRED OSCILLATIONS

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Filed Mar. 1, 1957, Ser. No. 643,380

Claims priority, application Great Britain Mar. 3, 1956

4 Claims. (Cl. 333—22)

This invention relates to attenuators or suppressors for attenuating or suppressing undesired oscillations such as may arise in cavity resonators and in waveguides. The invention is particularly applicable to attenuating or suppressing undesired oscillations which may be set up in cavity resonators employed in conjunction with oscillation generators of the reflex klystron type.

The resonators employed in such oscillators usually have a toroidal form and in operation an electric field is set up substantially parallel to the axis of the resonator and a magnetic field transverse with respect to said axis. It is well-known, however, that such cavity resonators have a large number of frequency modes in which oscillation is possible. With a toroidal resonator oscillating in the lowest frequency or fundamental mode, which is usually termed the $\lambda/4$ mode, the electric field has one nodal surface at the outer boundary wall of the resonator, and the next higher frequency mode, i.e. the $3\lambda/4$ mode, has two nodal surfaces, one at the outer boundary wall and another between the centre of the cavity where the electric field is at a maximum and the outer boundary wall. The next higher mode, i.e. the $5\lambda/4$ mode, has three nodal surfaces, and so on. In many applications it is important to attenuate, or if possible suppress, all modes of frequency other than the desired mode. Thus, in the case of a reflex klystron where the reflector voltage ranges, corresponding to the modes in which the resonator is likely to oscillate, overlap, interference between the different modes will occur unless the unwanted modes are attenuated or suppressed. Interference, if the unwanted modes are not attenuated, produces a hysteresis effect of the reflector voltage/power characteristic of the klystron which is undesirable. In the case where it is desired to excite a cavity resonator in a harmonic mode in order to maintain dimensions of the cavity within reasonable size, the above-mentioned difficulties are particularly pronounced, although it will of course be appreciated that similar difficulties are encountered when the wanted frequency mode is the fundamental frequency mode of the cavity.

The object of the present invention is to provide an improved attenuator or suppressor for attenuating or suppressing undesired oscillations which has substantially little effect in attenuating desired oscillations.

According to the invention there is provided an attenuator or suppressor comprising coupling means for coupling said attenuator or suppressor to a source of desired and undesired oscillations of different frequencies, a two-conductor transmission line one of the conductors of which screens the other and having the screened conductor connected to said coupling means and having a length effectively equal to a quarter wavelength at the frequency of said desired oscillations, means short-circuiting the conductors of said line at their ends remote from said coupling means and a resistive load in series with said line, said resistive load being disposed at a point in said line where a current minimum is set up for said desired oscillations.

Preferably said transmission line is connected to said coupling means by a further section of transmission line of lower characteristic impedance than and in series with said first section and forming a circuit also tuned to the frequency of the desired oscillations, said sections serving to transform the high impedance of said first section to a low impedance at the point where said coupling means is connected to said further section and at the frequency of the desired oscillations.

In order that the said invention may be clearly understood and readily carried into effect, it will now be more fully described with reference to the accompanying drawings in which:

Figure 1 is a longitudinal cross-section through a suppressor in accordance with one embodiment of the invention,

Figure 2 illustrates the suppressor shown in Figure 1 as applied to the cavity resonator of a reflex klystron, and

Figure 3 of the drawings illustrates a modified suppressor in accordance with the invention also as applied to the cavity resonator of a reflex klystron.

As shown in Figure 1 of the drawings, the attenuator or suppressor comprises a loop **1** which is of low impedance and serves to couple the suppressor to a source of desired and undesired oscillations such as the cavity of a reflex klystron or a waveguide, the loop **1** being formed integrally with the centre conductor **2** of a coaxial transmission line the outer conductor of which is indicated at **3**. The transmission line terminates in a resistive load indicated at **4** which is composed of suitable resistive or lossy material such as a mixture of graphite and "Permalloy" iron dust which surrounds the end of the inner conductor **2** of the transmission line and is housed in a tubular recess formed in an end cap **5** and in a tubular extension **6** thereof which forms a screen for said load as shown. The coaxial transmission line is formed in two sections, the first section **7** adjacent the loop **1** being of low characteristic impedance, whilst the second section **8** is in series with the section **7** and is of high characteristic impedance the ratio of impedance being of the order of 10:1. Each section **7** and **8** is effectively approximately a quarter of a wavelength long at the desired frequency so that both sections are in effect circuits tuned to the desired frequency. The section **8** is short circuited at its end remote from the loop **1** by the cap **5**. The section **8** thus presents a high impedance at the desired frequency so that the load **4** is ineffective to damp the source of oscillations i.e. a cavity resonator or waveguide at the desired frequency but presents a lower impedance at the frequencies of undesired oscillations and so tends to damp the source and so suppress the undesired oscillations. The two sections function as transformers so that the high impedance of the section **8** is transformed by the section **7** so as to set up across the input to said suppressor indicated at the point **9** a very low impedance, so that for the desired frequency an effective short circuit is provided at the point **9** whereby desired frequencies are substantially prevented from passing to the resistive load **4**, whilst other frequencies are permitted to pass and to be absorbed in said load. Thus the resistive material **4** is disposed at a point of a current minimum of the oscillations of desired frequency, whilst other oscillations of undesired frequency have an appreciable current density at this point and are so heavily loaded that they either cease to oscillate or the oscillations are so feeble that substantially no interference or hyteresis is set up.

Figure 2 of the drawings indicates the suppressor shown in Figure 1 as applied to the cavity **10** of a reflex klystron **11**, the suppressor being inserted radially in the peripheral

wall of the cavity resonator with the loop 1 projecting in the position shown. Such a cavity resonator may be found to set up oscillations in the λ/4, 3λ/4 and 5λ/4 modes corresponding to frequencies of approximately 2,200, 9,000 and 11,000 megacycles per second respectively. In such an arrangement it may be desired to suppress undesired λ/4 and 5λ/4 modes without suppressing substantially the desired mode of 3λ/4. In order to suppress such undesired modes the suppressor may have the following dimensions:

The external diameter of the suppressor is 0.375", the internal diameter of the section 8, 0.290", the length of the sections 7 and 8, 0.300", the diameter of the loop or probe 1/10", the external diameter of the sleeve 6, 0.090", the internal diameter of the sleeve, 0.070" and the length of the sleeve 0.300", and the lossy material extends for a distance of 0.425". The characteristic impedance of the section 7 is about 7 ohms and the characteristic impedance of the section 8 about 70 ohms.

Figure 3 of the drawings illustrates a modified form of suppressor in which instead of employing the loop 1 the centre conductor 2 of the transmission line projects beyond the section 7 so as to form a probe 12 and with such an arrangement the suppressor is inserted through one of the side walls of the cavity resonator 10 so that the probe extends into the position shown in Figure 3.

Although the invention has been shown in the drawings as applied to the resonator of a reflex klystron, it will be understood that the invention can also be applied, for example, to the suppressing of unwanted frequency oscillations in waveguides.

What I claim is:

1. An attenuator comprising coupling means for coupling said attenuator to a source of desired and undesired oscillations of different frequencies, a coaxial transmission line having an inner and an outer conductor with the inner conductor connected to said coupling means and having a length effectively equal to a quarter of a wavelength at the frequency of said desired oscillations, means short-circuiting the conductors of said line at their ends remote from said coupling means, a resistive layer surrounding the inner conductor of said line, a tubular conductor surrounding said resistive layer and electrically connected to said means short-circuiting the conductors of said line and disposed between said inner and outer conductors, said resistive layer being situated at a point in said line where a current minimum is set up for said desired oscillations so that substantial attenuation of said undesired oscillations occurs with little attenuation of said desired oscillations.

2. An attenuator comprising coupling means for coupling said attenuator to a source of desired and undesired oscillations of different frequencies, a coaxial transmission line having an inner and an outer conductor with the inner conductor connected to said coupling means, said line comprising a first section adjacent said coupling means having a length effectively equal to a quarter wavelength at the frequency of said desired oscillations and having a low characteristic impedance, and a second section in series with said first section and having a length effectively equal to a quarter wavelength at the frequency of said desired oscillations and having a higher characteristic impedance than said first section, means short circuiting the conducotrs of said line at their ends remote from said coupling means, a resistive layer surrounding the inner conductor of said line, a tubular conductor surrounding said resistive layer and electrically connected to said means short circuiting the conductors of said line and disposed between said inner and outer conductors, said resistive layer being situated at a point in said line where a current minimum is set up for said desired oscillations so that substantial attenuation of said undesired oscillations occurs with little attenuation of said desired oscillations.

3. A cavity resonator provided with an attenuator somprising coupling means coupling said attenuator to said cavity resonator which constitutes a source of desired and undesired oscillations of different frequencies, a coaxial transmission line having an inner and an outer conductor with the inner conductor connected to said coupling means and having a length effectively equal to a quarter of a wavelength at the frequency of said desired oscillations, means short circuiting the conductors of said line at their ends remote from said coupling means, a resistive layer surrounding the inner conductor of said line, a tubular conductor surrounding said resistive layer and electrically connected to said means short circuiting the conductors of said line and disposed between said inner and outer conductors, said resistive layer being situated at a point in said line where a current minimum is set up for said desired oscillations so that substantial attenuation of said undesired oscillations occurs with little attenuation of said desired oscillations.

4. A cavity resonator provided with an attenuator comprising coupling means coupling said attenuator to said cavity resonator which constitutes a source of desired and undesired oscillations of different frequencies, a coaxial transmission line having an inner and an outer conductor with the inner conductor connected to said coupling means, said line comprising a first section adjacent said coupling means having a length effectively equal to a quarter wavelength at the frequency of said desired oscillations and having a low characteristic impedance, and a second section in series with said first section and having a length effectively equal to a quarter wavelength at the frequency of said desired oscillations and having a higher characteristic impedance than said first section, means short circuiting the conductors of said line at their ends remote from said coupling means, a resistive layer surrounding the inner conductor of said line, a tubular conductor surrounding and electrically connected to said means short circuiting the conductors of said line and disposed between said inner and outer conductors, said resistive layer being situated at a point in said line where a current minimum is set up for said desired oscillations so that substantial attenuation of said undesired oscillations occurs with little attenuation of said desired oscillations.

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