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J. M. WOLF
ELECTRICAL RESONATOR
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2,566,050

Fig. 1

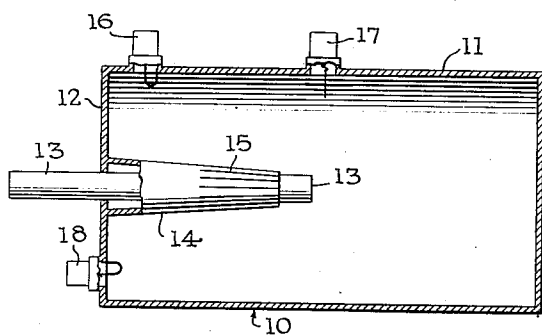


Fig. 2

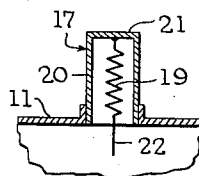


Fig. 3

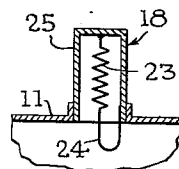


Fig. 6

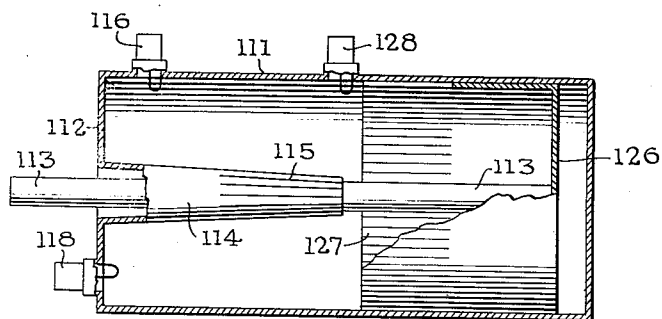


Fig. 4

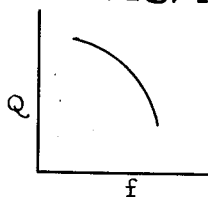


Fig. 5

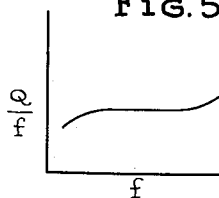
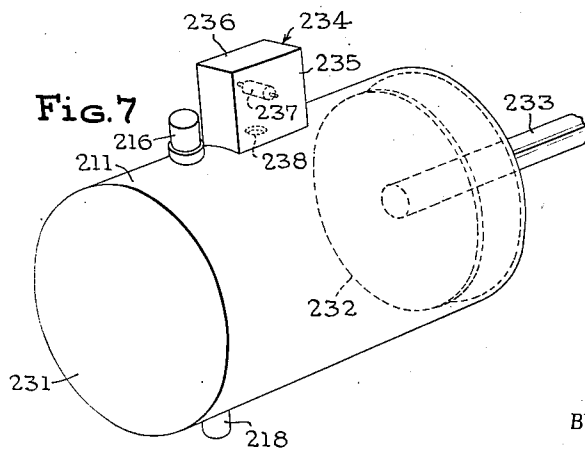


Fig. 7



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ELECTRICAL RESONATOR

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5 Claims. (Cl. 178-44)

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This invention relates to loading devices for electrical resonators of the type having distributed electrical constants. It is capable of application either to the cavity type of resonator or to the coaxial line type of resonator. These resonators are well known to the art and form no part of the present invention. The loading devices forming the subject matter of this invention are applicable broadly to resonators as described above and as such are useful throughout the entire field of application of resonators with distributed electrical constants.

The invention is best described by reference to the attached drawings given as examples which illustrate the principles involved as applied to coaxial line type resonators, but it should be clearly understood that the invention is not limited to this use.

It is an object of this invention to provide resistive loading devices for resonators having distributed electrical constants. (The term "distributed electrical constants" as used herein means the antithesis of lumped constants. Both terms are well known to the art.)

It is a further object to so locate these devices that the natural relation between the Q factor of the resonator and the frequency at which it is resonant is altered.

The attached drawings are illustrative of typical applications of this invention.

Figure 1 shows a schematic representation in axial section of a coaxial line type resonator, an odd number of quarter wavelengths long, with the location of the loading devices indicated thereon.

Figure 2 is a detail of a probe type of loading device.

Figure 3 is a detail of a loop type of loading device.

Figure 4 is a curve which is typical of the natural relation between the Q factor and the resonant frequency of a coaxial resonator.

Figure 5 is a curve showing one desired relation between Q factor and resonant frequency which can be achieved with my invention.

Figure 6 is a schematic representation in axial section of a coaxial line type resonator, an even number of quarter wavelengths long, with the location of the loading devices indicated thereon.

Figure 7 is a schematic representation in perspective of a cavity type resonator an even number of quarter wavelengths long and shows a different type of loading device applied thereto.

With reference to Figure 1 of the attached drawings:

The quarter-wave coaxial-line type resonator

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10 shown by way of example in Figure 1 consists of a hollow cylindrical conducting member 11, closed at an end by a conducting plate 12. The electrical length of this resonator is assumed in the following description to be one quarter wave, but may be any odd number of quarter wavelengths. The tuning element comprises a rod 13, also of conducting material, which slides through a guide tube 14 fixed on the end plate 12. Spring fingers 15 are formed in the tube 14, to insure good electrical contact between the rod and the tube in all positions of the rod. As is well known to the art, suitable mechanism may be provided to gradually adjust the position of the rod and, consequently, the resonant frequency of the resonator.

An input loop indicated at 16 typifies means for coupling electrical energy to the resonator. The two resistive loading devices indicated at 17 and 18 are shown in detail in Figures 2 and 3.

The loading device 17 shown in Figure 2 includes a resistor 19 of the well known carbon type having a lead at each end thereof. The resistor is coaxially mounted in a hollow cylindrical tube of conducting material 20 which tube is closed at its outer end by a conducting plate 21. One lead of the resistor is connected to plate 21. The other lead is merely extended beyond the end of the cylindrical member 20 to form a probe 22.

Probes for coupling to short wave energy in tunable resonators are known. Their primary function is to act as capacitive couplers to an electric field. The tube 20 makes a sliding fit with a guide sleeve provided for it on the outer conductor member 11 of the resonator. It is adjustable in a direction which is radial to the axis of the cylindrical member 11. The further the device is inserted into the interior of the resonator, the greater will be the coupling effect.

The loading device 18, shown in Figure 3, is similar in most respects to the one shown in Figure 2. However, instead of a probe 22, the lower lead of resistor 23 takes the form of a loop 24, one end of which is connected to the cylindrical tube 25. Loops used as energy pick-up devices are known. Their primary function is to act as inductive couplers to magnetic fields. The tube 25 is adjustable in a guide sleeve just as is tube 20.

It will be apparent to those skilled in the art that the device shown in Figure 1 can be made to resonate at a number of different fixed frequencies. The sliding adjustment of rod 13 controls the resonant frequency. As the resonant frequency is increased, the Q factor will decrease

in a manner generally shown by the curve of Figure 4 if the resonator is not equipped with the resistive loading devices described above. The device 18 is located, as shown, at a point where the field within the resonator is substantially independent of frequency at resonance. The inductive loop 24 serves to couple resistor 23 to the field within the resonator, and its effect is to lower the curve of Figure 4, without materially affecting its form. By moving the loading device 18 in and out, the amount that the curve is lowered can be accurately controlled.

Loading device 17, when located substantially as shown in Figure 1, will couple its resistor to the electric field at that point. The location need not be exact, but it should be approximately opposite the end of member 13 when the latter member is set at some operating point. Again, the extent of insertion of the probe into the resonator controls the degree of coupling. The field at this point, however, is not independent of frequency. Consequently the degree of coupling of loading device 17 is a function also of the frequency at which the resonator is operated. The lower the frequency, the greater will be the degree of coupling. It is thus possible to obtain by proper adjustment a wide alteration of the natural relation of the Q factor to the frequency. In the event that the resonator is to be used as an echo box for radar testing, the relationship shown in Figure 5 would be desirable and could be achieved.

Figure 6 shows a similar arrangement to that shown in Figure 1, except that here the loading devices both of the loop type are shown in connection with a half-wave type of resonator having distributed electrical constants. As in the former case, the resonator need not be one-half wavelength, but may be any even number, or quarter wave lengths long. Tuning rod 113 is extended to connect with a cup-shaped member 126. This member is made of conducting material and slides through member 111. Spring fingers 127 are provided to insure good electrical contact between 126 and 111. As in the previous case, one loading device 118 is placed at a point near the fixed end plate 112 where the field is substantially frequency-independent at resonance. The loading effect produced is similar to that previously described with reference to device 18 in Figure 1. The other loading device 128 is located at a point which is opposite the center of the cavity when the resonator is tuned to its maximum frequency. Since in a half-wave type resonator, the magnetic field would be at a null at this point, the loading device will have no effect. As the frequency is decreased, however, the loading device is no longer at the center of the cavity and, therefore, no longer at a null in the field. Loading will increase with decrease in resonant frequency. As in the case previously described with reference to Figure 1, radial adjustments of the respective loading devices will vary the degrees of coupling and produce a wide alteration of the natural relation between the Q factor of the resonator and the resonant frequency.

Figure 7 shows another possible application of the principles of this invention. The resonator here is of the cavity type. As shown, it is one wavelength long, but could be any even number of quarter wavelengths. The operating mode for the resonator as shown would be TE₀₁₂. It consists of a hollow cylinder of conducting material 211, closed at one end by a conducting plate 231. The

opposite end is open to receive a plunger type tuner consisting of a conductive plate 232 mounted on a rod 233. In this case, the plate 232 does not make electrical contact with cylinder 211, but is mounted coaxially therewith, together with suitable mechanism adapted to adjust its position in the direction of the axis of the cylinder. A coupling means of a known type is provided at 216 to couple a source of short wave electrical energy to the resonator. Adjustable loading means 218 is similar to means 18, shown in Figure 3 and could be mounted either as shown or on the fixed end plate 231. As in the previously described cases, the field at or near the end plate is substantially independent of frequency at resonance. The degree of loading at any frequency to which the resonator is tuned is dependent on the in and out adjustment of the loading device and the greater the degree of coupling, the lower would be the curve of Q versus frequency shown in Figure 4.

The compensating loading device 234, although structurally different from those previously shown and described has an identical principle of operation. It comprises a section of wave guide 235 closed at its outer end by a plate 236 of conducting material. The inner end of the guide is open and is fitted to the surface of the outer conductor of the resonator 211. At the center of the intersection of these two spaces, is an aperture 238 in the member 211 affording a window type coupling. Mounted across the short dimension of the wave guide at a point substantially as shown is the loading resistor 237. It will be apparent that while the location of the latter is not critical, it should nevertheless be mounted a substantial electrical distance from the plate 236. The wave guide and window will be located at a point on the resonator opposite the center of the cavity when the cavity is tuned to some frequency at which it will resonate. At that point and at that frequency, the magnetic field will be at a null and no coupling will result. As the frequency is changed, however, the loading device will no longer be situated at a null point and more or less coupling will result. In this example, no adjustment of the compensating loading device is afforded. The particular loading effect desired would be predetermined and the coupling designed accordingly. It should be understood that the compensating loading device could also be located at any null in the magnetic field, for example, that which occurs opposite plunger disc 232.

From the foregoing, it will be apparent that I have shown and described a novel combination of resonator and loading device in which any type of resonator having distributed electrical constants can be used. The structures shown in the attached drawings are merely illustrative and should not be construed as limiting the scope of my invention.

I claim:

1. The combination of a tunable resonator of the type having distributed electrical constants; means for coupling a source of short-wave electrical energy to said resonator; a first loading means including an energy pick-up device and a lumped resistive load connected in circuit with one another, said first loading means being located on said resonator where the field therein is substantially independent of frequency at resonance; a second loading means including an energy pick-up device and a lumped resistive load connected in circuit with one another, said second

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loading means being located on said resonator where the field therein is frequency dependent, said energy pick-up devices coupling said resistive loads to said field, whereby the natural relationship between the Q factor of the resonator and the resonant frequency is altered.

2. The combination of a tunable resonator of the coaxial line type, having an electrical length equal to an odd number of quarter wavelengths; means for coupling a source of short wave energy to said resonator, whereby a field is set up therein; a first loading means including an energy pick-up device and a lumped resistive load connected in circuit with one another, said means being located on said resonator where the field therein is a maximum and substantially frequency independent at resonance; a second loading means including an energy pick-up device and a lumped resistive load connected in circuit with one another, said second means being located at a fixed position on the outer conductor of the resonator near the point of discontinuity in the line where the amplitude of the field is frequency dependent, said pick-up devices coupling said loading means to said field whereby the natural relationship between the Q factor of the resonator and the resonant frequency is altered.

3. The combination of a tunable resonator of the type having distributed electrical constants, said resonator having an electrical length equal to an even number of quarter wavelengths; means for coupling a source of short wave electrical energy to said resonator; a first loading means including an energy pick-up device and a lumped resistive load connected in circuit with one another, said means being located on the outer conductor of said resonator where the field therein is substantially frequency independent at resonance; a second loading means including an energy pick-up device and a lumped resistive load connected in circuit with one another, said second loading means being located at a fixed position on the outer conductor of the resonator near a null in the field at a frequency within the tunable range of the resonator; said pick-up devices coupling said loading means to said field

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whereby the natural relationship between the Q factor of the resonator and the resonant frequency is altered.

4. The combination of a tunable resonator of the cavity type, said resonator having a length equal to an even number of quarter wavelengths; means for coupling a source of short wave electrical energy to said resonator; a first loading means including an energy pick-up device and a lumped resistive load connected in circuit with one another, said means being located on the outer conductor of said resonator where the field therein is substantially frequency independent at resonance; a second loading means, including an energy pick-up device of the wave-guide window-coupled type, and a resistive load connected across the short dimension of said guide, said means being located at a fixed position on the outer conductor of the resonator near a null in the magnetic field at a frequency within the tunable range of the resonator, said pick-up devices coupling said loading means to said field whereby the natural relationship between the Q factor and the resonant frequency of the resonator is altered.

5. In a tunable resonator as defined by claim 1, in which a window type coupler is provided in the outer conductor thereof, a resistance loading device comprising: a section of wave guide closed at one end; and a lumped resistive element connected inside said guide and across the short dimension thereof, said resistive element being located in the middle region of said guide.

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