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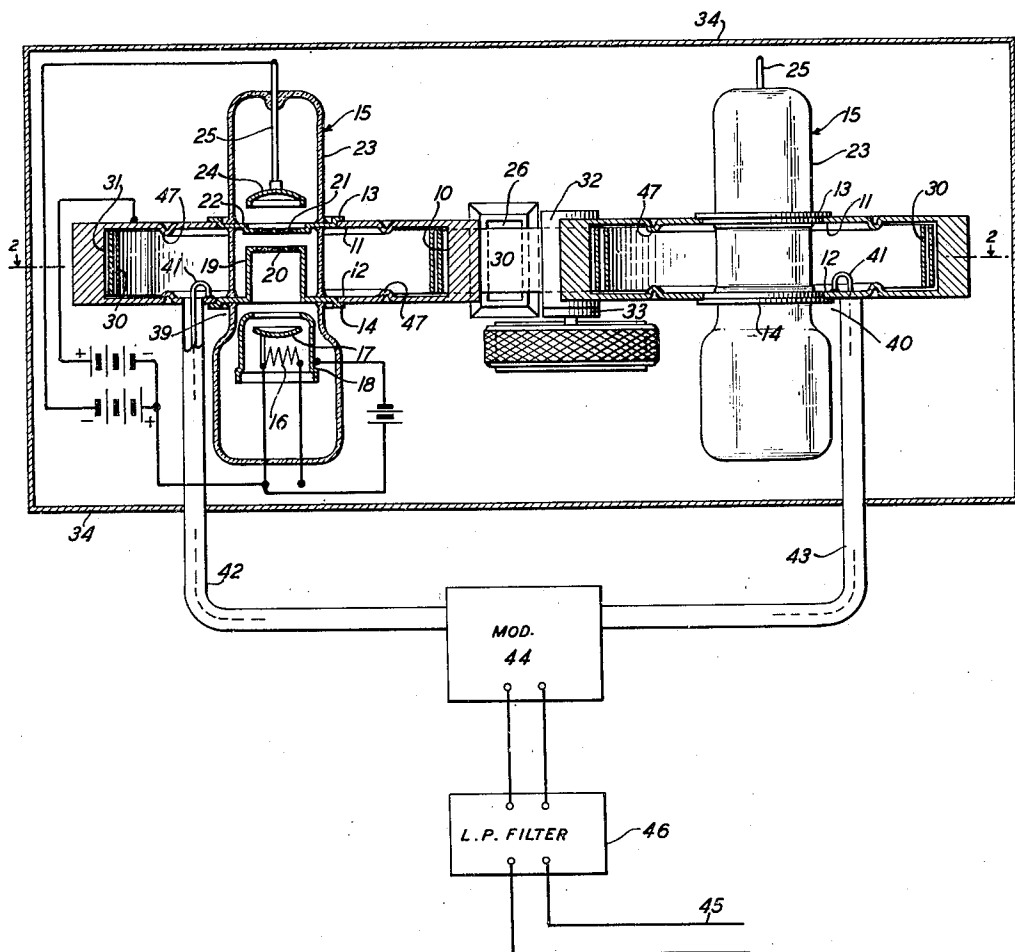
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FREQUENCY SELECTIVE ELECTRICAL DEVICE

Filed June 1, 1946

2 Sheets-Sheet 1

FIG. 1.



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2 Sheets-Sheet 2

FIG. 2.

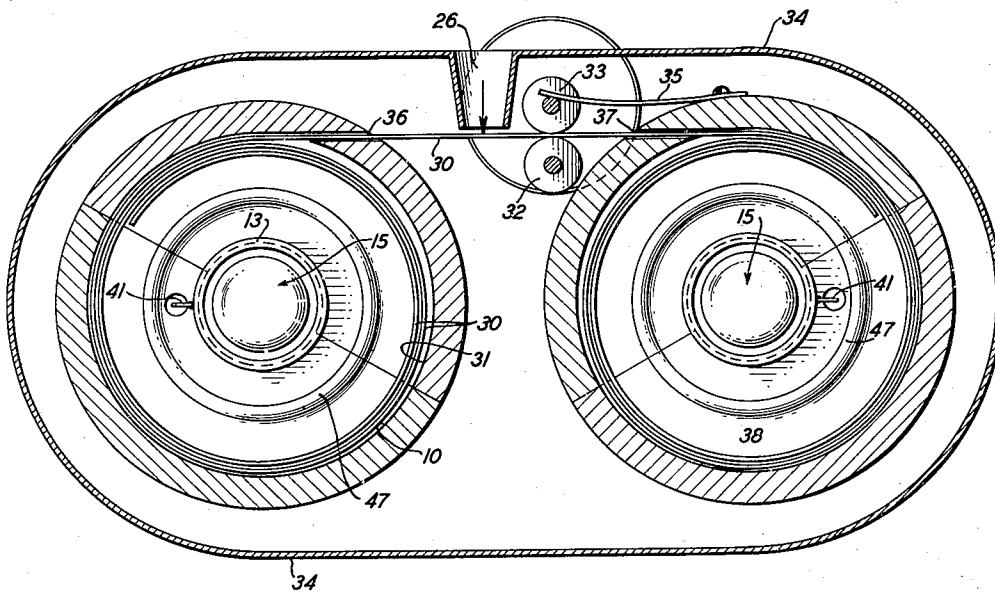
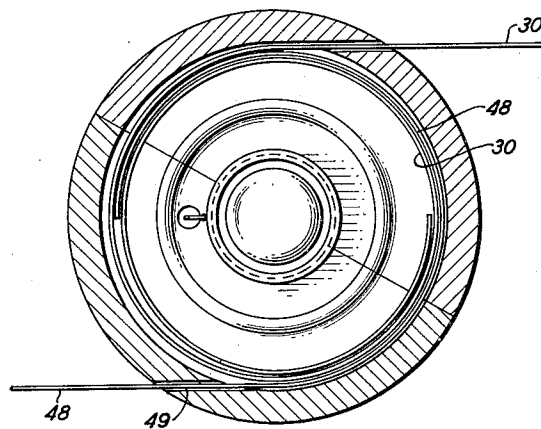


FIG. 3.



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FREQUENCY SELECTIVE ELECTRICAL
DEVICE

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11 Claims. (Cl. 250—36)

1

This invention relates to frequency selective electrical devices and more particularly to cavity resonators capable of resonance frequency variation over a continuous frequency range.

An object of the invention is to provide a variable frequency resonator with a minimum of mechanism.

Another object of the invention is to vary the effective volume of the cavity resonator without the necessity of providing moving end walls with their cumbersome supports and guides.

A further object of the invention is to enable matching characteristics of a lot of cavity resonators which differ in their internal dimensions without introducing a factor of dissymmetry in the resonators.

Another object of the invention is to produce relatively low frequency oscillations and to stabilize their frequency by space resonators which are of moderate dimensions.

In accordance with one embodiment of the invention a cavity resonator in the form of a wide circular cylinder has as its interior circular wall the surface of a coiled flat spring which may be withdrawn from the cylinder through a tangential slot to increase the diameter of the resonator thus reducing the natural resonance frequency of the resonator. As the spring is withdrawn it may be introduced through a tangential slot into an adjacent similar cylinder which may serve merely as a magazine or storage device or may, itself, constitute a second resonator, the interior diameter of which decreases as that of the first resonator increases. An electron discharge device may be associated with the first resonator to constitute an oscillator. If both cylinders are resonators provided with electron discharge devices the whole system may be used to produce beat frequency oscillations which may be rapidly varied in frequency since the frequency of one resonator increases as that of the other falls. In order to insure matching of the characteristics of two resonators having different interior diameters an additional coiled spring may be introduced into the resonator with the larger diameter to reduce its diameter effectively to that of the diameter of the smaller resonator.

In the drawing:

Fig. 1 is a section of apparatus and a schematic diagram of associated circuits of a system constituting one embodiment of applicant's invention in which beat frequency oscillations are produced;

Fig. 2 is a sectional view along the plane passing through the dash line 2—2 of Fig. 1; and

2

Fig. 3 illustrates a modification of the resonance chamber of Figs. 1 and 2.

Referring to the drawing, a two-part resonant cavity 10 of cylindrical conformation having a short length and a relatively large diameter comprises a substantially closed resonance chamber having an interior surface of highly electrically conducting substance such as copper or silver. The end walls of the cylindrical structure are provided with central apertures having inwardly extending peripheral portions 11 and 12 which serve as seats for the outwardly extending metallic flanges 13 and 14 respectively of an electron discharge tube 15 which may be of the type manufactured by Western Electric Company, Incorporated and designated as 707A. The discharge tube includes a heater 16, a cathode 17, a shielding or guard ring 18 which may be suitably negatively polarized to collimate the beam from the cathode 17 and a highly positive cylindrical anode 19 integral with the flange 14. The cathode 17, collimator 18 and anode 19 constitute an electron gun. Extending across the outer end of the anode 19 is a screen 20 which faces a closely adjacent screen 21 supported by an annular electrode 22 which is integral with the flange 13. The peripheral electrode 22 extends outwardly through the dielectric wall 23 of the tube 15 and is accordingly maintained electrically insulated from the remaining electrodes. A repeller or target electrode 24 is supported by a stem 25 passing through the end wall of the tube 15 opposite the electron gun. By virtue of the annular gap between the inner margins of the peripheries of the screen 20 and the screen electrode 21 the electric field within the resonator 10 may interact with the electron stream passing from the electron gun across the gap toward the repeller electrode 24. To velocity-vary the stream in such manner as to accelerate the electrons when the field within the resonator makes the potential of the seat 11 positive with reference to the seat 12 to retard the electrons when the potential of the seat 11 is negative with reference to the seat 12, the electron stream of the electron discharge tube is coupled to the electromagnetic field within the resonator 10 by virtue of the mutually shared space between the screens 20 and 21. The discharge tube 15 together with the resonator 10 and the energizing sources with their external circuits, not shown, constitute a "reflex" or "repeller" oscillator of the type disclosed at Fig. 3 of the article "Reflex Oscillators" by J. R. Pierce, published at page 113 of the Proceedings of the I. R. E., February 1945. The res-

3

onator 10 serves as the frequency determining element of the oscillator. Reference is made to that article for a description of the external polarizing circuits of the present invention and of the theory of operation of such oscillators.

The resonator 10, as indicated by the sectioning of the outer wall in Fig. 2, consists of two semi-cylindrical structures, these structures being clamped or held together in any desired manner. It contains a coiled flat metallic spring 30 which resembles a clock spring and tends to remain tightly in contact with the interior cylindrical wall 31 of resonator 10. The spring 30 is a flexible metallic ribbon made with a slight lateral convexity or concavity in a manner to give it a slight tendency to straighten itself. It is just wide enough to fit within the cylindrical resonator without binding. Because of its tendency to straighten, it will hug the inner cylindrical wall of the resonator. The spring may be unwound or rewound by a drive mechanism consisting of friction rollers 32 and 33, the former of which is rotatably mounted on a shaft on a support integral with the external casing 34 of the apparatus and the latter of which is impelled by a stiff leaf spring 35 toward roller 32 and in contact with the spring 30. The outer end of the spring 30 passes from the resonator 10 through a tangential slot 36 and between rollers 32 and 33 and thence in through another tangential slot 37 into the interior of the two-part magazine 38 which may be a mere storage space for the unreeled portion of spring 30 or which may be, as illustrated, a duplicate of resonator 10.

The resonator 38 may serve with an associated electron discharge device similar to tube 15 as a second reflex oscillator. For each of the two oscillators 39 and 40, loop output couplers 41 projecting into the resonator field space may provide output energy transducers associated respectively with the coaxial circuits 42 and 43 which are connected to the input of a modulator or frequency converter 44 designed to derive the difference frequency or beat frequency of the two oscillators. To the output of the modulator 44 a beat frequency current circuit 45 may be connected through an intermediate low-pass filter 46 which may serve to restrict the transmitted frequency range to the difference frequency produced in the combiner or modulator 44. Since the coiled spring 30 in one cavity resonator moves in such a manner as to increase the frequency in one resonator at the same time that it decreases that in the other, the beat frequency varies very rapidly. Frequency calibration of the beat frequency oscillator may be effected by marking the portion of the spring tape 30 which passes in front of the window 26 of the casing 34.

To prevent pile-up of the spring 30 to such an extent as to contact with or interfere with the loop coupler 41, the inner wall of the resonator 10 may be provided with an inwardly projecting circumferential rib 47 which limits the amount of the spring which may be wound into that particular resonator.

In order to compensate for manufacturing variations in the resonators it may be desirable to provide means for insuring that the initial resonances of all the resonators are alike. This may be had by the use of a second coiled spring 48 similar to the spring 30 but very much shorter and which winds in such manner as to interleave with the spring 30. This auxiliary or compensating spring may be introduced into the

4

resonator through a tangential slot 49 as shown in Fig. 3. The spring 48 may be supplied with any desired propelling and holding device (not shown) mounted on the exterior of the resonator.

The compensating spring may be introduced into the resonator having the larger effective internal diameter and may be fixed in position so as to maintain initial resonance frequencies of the various resonators alike. This expedient is also of use in single resonator apparatus to adjust the natural resonance frequency of a cylindrical resonator.

It will be apparent that the beat frequency oscillator apparatus is relatively compact and is free from the more elaborate piston or plunger supporting mechanism customarily required in the case of wide range tuning of cavity resonators.

What is claimed is:

1. An electrical resonator comprising a closed circular chamber having electrically conducting walls, means for varying the frequency thereof comprising an electrically conducting lining member within said chamber and contiguous to said walls, said walls having a slot, and means for withdrawing said lining member in a gradual manner through said slot.

2. A pair of electrical resonators each comprising an electrically resonant chamber having walls of electrically conducting material, a wall of each of said chambers having slots which are aligned with each other, means for varying the frequency of said chambers oppositely comprising a flexible electrically conducting spring ribbon extending through said slots and terminating in a coil in each chamber, and means for withdrawing said ribbon gradually from one chamber and introducing it into the other.

3. In combination, two microwave oscillation generators each comprising a frequency determining chamber resonator having an electron beam traversing it and interacting with the field thereof, and movable tuning means simultaneously extending into each of said chambers for varying their respective resonance frequencies in opposite sense.

4. The combination in accordance with claim 3, characterized in this, that the resonance frequency of one chamber is increased as that of the other is decreased.

5. A cavity resonator comprising a closed cylindrical conducting chamber and means for tuning said resonator comprising a flat spring coiled therewithin fitting closely against the interior cylindrical wall and variably extensive in length within said chamber which varies the natural resonance frequency of said resonator.

6. A pair of similar cavity resonators each comprising a fixed cylindrical chamber and having electrically conducting walls and means for matching their resonance frequencies comprising a coiled spring fitting tightly against the wall of the chamber having the lower natural resonance frequency, said spring having a length adjustable to increase the resonance frequency of the chamber to equal the natural resonance frequencies of the second chamber.

7. A cavity resonator of high Q comprising a closed conductive cylinder, tuning means therefor comprising a coiled metal member in close-fitting contact within said cylinder and adapted to be withdrawn from said cavity to vary the internal diameter thereof, and means for exciting said resonator into electrical oscillation.

8. The structure of claim 7, where said mem-

5

ber is a flat spring and said exciting means is an electron beam traversing said resonator.

9. The structure of claim 3, wherein said tuning means comprises a flexible, conductive spring terminating in a coil in each chamber, separate electron beams for exciting each chamber into electrical oscillation, and means for deriving beat frequency oscillations over an extended frequency range from said chamber oscillations.

10. A pair of similar cavity resonators each comprising a fixed cylindrical chamber having electrically conducting walls, each of said walls having tangential slots, variable tuning means for said chambers comprising a spring-like member the ends of which extend respectively through said slots into each of said chambers and coil therewithin and means for simultaneously withdrawing a portion of said member from one of said chambers to decrease the resonance frequency thereof and introducing a like portion into the other of said chambers to increase the resonance frequency thereof.

11. The structure of claim 10 including sec-

6

ond and third spring-like members extending separately through said slots into each of said chambers and coiled therewithin interleaving with portion of said first member within each of said chambers to adjust separately the initial resonance frequency of each of said chambers.

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